

Modernization of the irrigation system  
in MOUNSHAAT-AL-ASAD IRRIGATION SCHEME

MASSCOTE Workshop  
Aleppo - SYRIA  
18 to 28 April 2009

Results and plan for modernization





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## **ABBREVIATIONS, ACRONYMS, CURRENCY & MEASURES**

### **ABBREVIATIONS, ACRONYMS**

NRLW	Water Service of the Land and Water Development Division of FAO
CA	Command Area
CCA	Cultural Command Area
CR	Cross regulator
DO	Direct outlet
FAO	Food and Agriculture Organization
FO	Farmer Organization
GCA	Gross Command Area
ITRC	Irrigation Training and Research Centre (California Polytechnic University)
MASSCOTE	Mapping Systems and Services for Canal Operation Techniques
MASSLIS	Mapping Systems and Services for Lift Irrigation Systems
MCM	Million Cubic Meter
M&E	Monitoring and Evaluation
NCA	Net Command Area (irrigable)
O&M	Operations and Maintenance
OFWM	On-Farm Water Management
RAP	Rapid Appraisal Procedure
WUA	Water Users Association

### **CURRENCY EQUIVALENTS**

Currency Unit = Syrian Pound (SP)  
US\$1.0 = SP 46

### **MEASURES AND EQUIVALENTS**

1 meter	=	3.28 feet
1 ha	=	10000 m <sup>2</sup> = 2.47 acres
1 km	=	0.620 miles
1 cubic meter (m <sup>3</sup> )	=	35.310 cubic feet
1 Billion cubic meter (Bm <sup>3</sup> )	=	0.810 million acre foot (MAF)
1 cubic meter per second (m <sup>3</sup> /s)	=	1000 litre per second (l/s) = 35 cubic feet per second (ft <sup>3</sup> /s)
MCM	=	Million Cubic Meter

## SUMMARY

A regional training workshop on MASSCOTE was held at Aleppo, Syria from April 18<sup>th</sup> to April 30<sup>th</sup> 2009, in collaboration with the Syrian Ministry of Agriculture and Agrarian Reform. The workshop was conducted as part of FAO's activities on irrigation modernization in the Near East region. A total of twenty Irrigation and Agriculture engineers from Egypt, Jordan, and Syria participated in the training workshop focusing on MASSCOTE application in Mounshaat-Al-Asad scheme in Aleppo Governorate. The objectives of the workshop were manifold. These include launching of regional initiative on irrigation modernization; introducing MASSCOTE and RAP methodologies to irrigation and agriculture professionals in the region; developing insights into the irrigation management of Mounshaat-Al-Asad irrigation scheme and proposing related recommendations for improvements; producing food for thought for the decision makers in Syria on how to ensure a sound diagnosis and options for improvements before embarking upon modernization and investments plans; and preparing follow-up studies in Egypt and Jordan. This report presents the outcome of MASSCOTE application carried out in Mounshaat-Al-Asad irrigation scheme.

Mounshaat-Al-Asad irrigation scheme has a gross command area of 21,000 ha out of which 16832 ha is equipped with irrigation facilities. The scheme is more than 30 years old and has gone through several maintenance and repairs. A study of the scheme is being conducted for complete rehabilitation and modernization which is expected to result in expansion of the irrigated area to 35,000 hectares.

MASSCOTE application in Mounshaat-Al-Asad irrigation scheme revealed that although the infrastructure of the lift station and the canal network is in very good condition, there is high potential for improvements in management and operation of the irrigation scheme which will improve water delivery service to the farms which is poor in terms of flexibility and reliability and reduce costs. In particular water delivery to the tail portions of the irrigation system is significantly poorer than the water delivery in the head reaches of the canal network. With the existing level of water delivery service, the farm irrigation system can be improved neither through modern surface irrigation techniques nor through pressurised irrigation.

There is plenty of water available in the system. Average water supply per hectare is 20,000m<sup>3</sup>/ha which is twice to what actually is required (9,000 m<sup>3</sup>/ha). With no measurement devices available in the system, it is difficult to make accurate assessment of water balance, however a preliminary assessment ranks the efficiency as low (40%).

The recommendations for short-term improvements include the completion of the MASSCOTE application with better set of data and information (if available) in Mounshaat-Al-Asad irrigation scheme, improvements in operation, such as proper use of cross regulators, decrease in cost for pumping by improving water use efficiency, and monitoring of key aspects of operation and management, such as flowrates at key locations.

The recommendations for long-term interventions cover a wide range of issues including strategic, infrastructural and institutional aspects. Water delivery service needs to be defined clearly. It was recommended to establish WUA at the tertiary level and shift the irrigation management to WUA. Automation of the structure and installation of Telemetry for flow rate measurement and monitoring was proposed. In order to improve irrigation efficiencies, it was also proposed to shift to volumetric pricing of water and establishment of agricultural extension services.

## **Key outputs of MASSCOTE application in Mounshaat-Al-Asad irrigation scheme**

### **1. A well maintained infrastructure**

Infrastructure of Mounshaat-Al-Asad irrigation scheme is in good shape and well maintained, particularly at the pumping station, main canal, and second level canal. Some problems were identified in the hardware of tertiary and quaternary canals. Cross regulators and headgates of canal are also in good shape. Most of the gates at the main and the second canal levels are motorised, hence easy to operate.

### **2. The paradox: highly productive per area but low productive per m<sup>3</sup>**

The system is very productive (3562 \$/ha/year) and ranks first among the 28 systems surveyed recently by FAO. However the productivity ranks medium to low (0.15 \$/m<sup>3</sup>) when it is calculated against per unit of water used. This paradox of productivity is a clear indicator that while the agriculture systems are doing well - facing no constraints of any kind - the efficiency in managing water is low. When we know that energy to lift water is 80 % of the running cost, the issue of productivity per m<sup>3</sup> of water turns into an issue of energy and cost for pumping.

### **3. Irrigation inefficiencies**

Overall irrigation efficiency is very low (40% rainfall considered). Field observations (leakages, drainage-field practices) support this preliminary analysis that the overall project irrigation efficiencies are low.

### **4. Operational mode: proportional-rotational**

The system is operated currently on the basis of pre-established plan of the main inflow at lift station based on water demand (Climatic/cropping pattern), then shared proportionally before being rotated at quaternary levels. Adjustments are made to cope with local variation in demand. The system is not being operated according to the initial design as there are no proportional structures built, whereas the current operation is based on sharing the flow proportionally. Density of staff is far too high compared to similar systems investigated with the same FAO methodology.

### **5. Lack of measurements and inaccuracy of information**

The lack of measurement of discharges at key points, in particular at the intake of the main canal, main bifurcation points and the main drains is striking. This should be remedied in order to obtain accurate values of water balance (inaccuracies might be as high as 40 %). There is incomplete information on actual cropped area and actual cropping pattern. Deviations from the official cropping pattern imposed on farmers can be observed. No information on water level or head available across the cross regulator and offtakes is available.

### **6. Water Management**

Amount of water that is drained out of the command area or lost through deep percolation results in increased pumping costs for energy at lift station. Distributing the appropriate amounts of water and reducing water losses will reduce pumping and save water and cost.

## **7. Cost of management - operation and maintenance**

With a lift of 70 meters, the energy spent at the head station represents accounts to approximately 80 % of the overall operational and maintenance costs. The efficiency of the pumping station can be improved by replacing some parts of the pumping lines (30 years old) but basically significant improvements to reduce the cost should be made in the distribution itself. Saving water in the distribution network means high savings on electricity spending, e.g. 10 % of water savings equals to 25 Millions SP which is more than the budget staff allocated to the canal. Volumetric service and pricing should be promoted to favour a better control of water at all levels, including field application. At present the total cost of Management Operation Maintenance (MOM) per hectare amounts to 17850 SP, while irrigation fees are set at 3500 SP/ha and the MOM cost of the canal network without the lift station amounts to 2200 SP/ha.

## **8. Institution**

The institutional development of the water system should be designed and accompanied by the changes that already took place recently in terms of landholding transfers (state to private farmers). Establishment of Water User Association at an appropriate level should be considered. Information circulation among stakeholders should be improved.

## **9. Short term plan for improvement (one year)**

A plan of activities for the short term intervention has been discussed and proposed by participants:

- Evaluation of sensitivity along main, secondary and tertiary canals
- Identification of main critical key points and main physical problems to be fixed
- Identification of main key points to place measurement devices
- Calibration of existing measurement devices and upgrading
- Evaluating the level of efficiency at pumping plant based on accurate measurements
- Water balance at system level to be further investigated
- Start establishing water users association at the tertiary level canal
- Evaluating the average water use efficiency at field level based on measurements
- Monitoring plan for measuring the quantity and quality of drainage water.

## **10. Medium term plan for improvement (5 years)**

A plan of activities for the medium term intervention is also tentatively proposed by participants:

- Mapping demand of operation of the different project areas
- Redistribution of operational resources based on the demand for operation
- Establishment of WUAs at tertiary level canals (on-going process)
- Transfer of irrigation management to WUAs from the tertiary level canal downward
- Improvement of average efficiency of water use at field level
- Establishment of extension service activities to better orient and advise farmers
- Study for assessing the state of aquifer and groundwater resources in the CA and for evaluating the need of subsurface drainage systems
- Based on results from RAP and measurement campaign, increase the capacity of canal network at the secondary and tertiary level
- Definition of water delivery services
- Automation of structures, setting and installment of Telemetry for data collection and transfer.



## Introduction and Background

The MASSCOTE application presented here has been carried out as a part of FAO's activities on irrigation modernization in the Near East region. A regional training workshop on MASSCOTE was held at Aleppo, Syria from April 18<sup>th</sup> to April 30<sup>th</sup> 2009. A total of twenty Irrigation and Agriculture engineers from Egypt, Jordan, and Syria participated in the training workshop focusing on MASSCOTE application in Mounshaat-Al-Asad scheme in Aleppo Governorate.

The training workshop was organised to achieve the following objectives

- To launch FAO's regional initiative on modernization of irrigation management in the Near East;
- To introduce the MASSCOTE and RAP methodologies to participants from different countries in the region through real-case applications;
- To increase the capacity of the participants on usage of modern techniques and approaches of irrigation management and operation;
- To develop insights on the performance of management in Mounshaat-Al-Asad irrigation system and suggest some specific strategies to managers of the scheme on conceptualising the modernization of irrigation management;
- To produce food for thought for decision-makers in Syria before they engage in investment plans and on how to ensure these diagnoses and solutions are investigated properly in modernization projects;
- To validate a specific module of MASSCOTE- MASSLIS which is dedicated to lift irrigation system;
- To prepare follow up studies in Egypt and Jordan; and
- To produce some key recommendations for the concluding regional workshop.

This report/document presents the status of the MASSCOTE application development immediately after the workshop. The outcome of the working group sessions in this workshop (RAP-MASSCOTE) are included in this report.



# 1. THE MASSCOTE APPROACH

The generic methodology used in this study is called Mapping System and Services for Canal Operation Techniques (MASSCOTE). It is developed by the Land and Water Division (NRLW) of FAO based on its experience in modernizing irrigation management in Asia. MASSCOTE integrates/complements tools such as the rapid appraisal procedure (RAP) and Benchmarking to enable a complete sequence of diagnosis of external and internal performance indicators and the design of practical solutions for improved management and operation of the system.

MASSCOTE is a methodology aiming at the evaluation of current processes and performance of irrigation systems and the development of a project for modernization of Canal Operation.

Canal operation is a complex task involving key activities of irrigation management and numerous aspects which have to be combined in a consistent manner. These aspects are:

- service to users
- cost of producing the services
- performance Monitoring & Evaluation (M&E)
- Constraints and opportunities on Water resources
- Constraints and opportunities of the physical systems

MASSCOTE aims to organize project development into a stepwise revolving frame including:

- mapping the system characteristics, the water context and all factors affecting management;
- delimiting manageable subunits;
- defining the strategy for service and operation for each unit;
- aggregating and consolidating the canal operation strategy at the main system level.

MASSCOTE is an iterative process based on ten successive steps, but more than one round of application is required in order to determine a consistent plan. Some steps need to be re-discussed and refined several times before achieving a satisfactory level of consistency.

A specific module of MASSCOTE for lift system called MASSLIS [Mapping System and Services for Lift Irrigation System] has also been used to analyse the project.

## ***1.1. Presentation of the methodology***

The first steps of MASSCOTE (Table 1) are conducted for the entire command area with the goal of identifying homogeneous managerial units, for which specific options for canal operation are further sought by running the various steps of MASSCOTE for each unit taken separately. Then, aggregation and consolidation is carried out at the main system level. Thus, the methodology uses a back-and-forth or up-and-down approach for the different nested levels of management.

**Table 1. The Ten Steps of MASSCOTE**

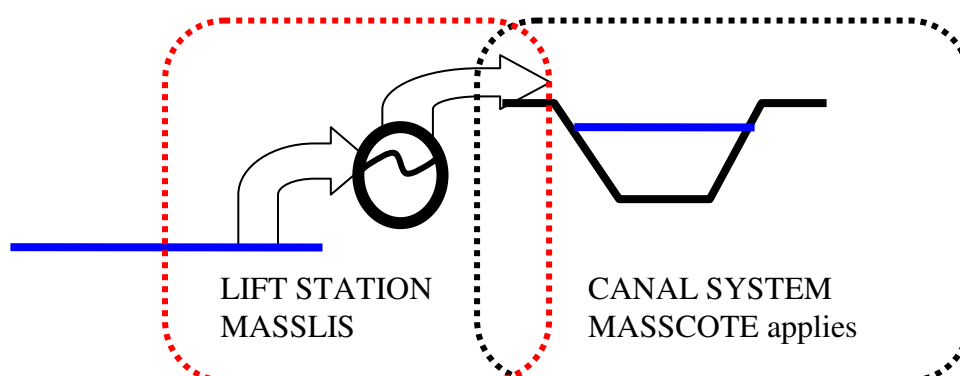
Mapping ....	Phase A – baseline information
1. The performance (RAP)	Initial rapid system diagnosis and performance assessment through the RAP. The primary objective of the RAP is to allow qualified personnel to determine systematically and quickly key indicators of the system in order to identify and prioritize modernization improvements. The second objective is to start mobilizing the energy of the actors (managers and users) for modernization. The third objective is to generate a baseline assessment, against which progress can be measured.
2. The capacity & sensitivity of the system	The assessment of the physical capacity of irrigation structures to perform their function of conveyance, control, measurement, etc. The assessment of the sensitivity of irrigation structures (oftakes and cross-regulators), identification of singular points. Mapping the sensitivity of the system.
3. The perturbations	Perturbations analysis: causes, magnitudes, frequency and options for coping.
4. The networks & water balances	This step consists of assessing the hierarchical structure and the main features of the irrigation and drainage networks, on the basis of which water balances at system and subsystem levels can be determined. Surface water and groundwater mapping of the opportunities and constraints.
5. The cost of O&M	Mapping the costs associated with current operational techniques and resulting services, disaggregating the different cost elements; cost analysis of options for various levels of services with current techniques and with improved techniques.
Mapping ....	Phase B – Vision of SOM & modernization of canal operation
6. The service to users	Mapping and economic analysis of the potential range of services to be provided to users.
7. The management units	The irrigation system and the service area should be divided into subunits (subsystems and/or unit areas for service) that are uniform and/or separate from one another with well-defined boundaries.
8. The demand for operation	Assessing the resources, opportunities and demand for improved canal operation. A spatial analysis of the entire service area, with preliminary identification of subsystem units (management, service, O&M, etc.).
9. The options for canal operation improvements / units	Identifying improvement options (service and economic feasibility) for each management unit for: (i) water management, (ii) water control, and (iii) canal operation.
10. The integration of SOM options	Integration of the preferred options at the system level, and functional cohesiveness check. Consolidation and design of an overall information management system for supporting operation.
11. A vision & a plan for modernization and M&E	Consolidating a vision for the Irrigation scheme. Finalizing a modernization strategy and progressive capacity development. Selecting/choosing/deciding/phasing the options for improvements. A plan for M&E of the project inputs and outcomes.

## 1.2. MASSLIS: Masscote approach for Lift Irrigation System

A Lift Irrigation System is a Canal System (or subsystem) fed by a lifting device. So, the main feature that differentiates a lift system from a canal gravity fed system is only the lifting station at head. MASSCOTE analysis should apply for the transport and distribution components as for a classical open channel system. Readers are advised to refer to the FAO Irrigation & Drainage Paper 63, which describes in detail the MASSCOTE methodology.

The lift station at the headworks adds some important points that need to be addressed properly. This section focuses on the peculiarities brought by the lift station in relation to various steps of MASSCOTE dealing with capacity, sensitivity, and perturbation and cost mainly.

**MASSLIS = Special MASSCOTE for LIFT STATION + MASSCOTE for Canal**



*Figure 1 A Sketch of MASSCOTE & MASSLIS*

It is proposed to apply in this study a similar MASSCOTE analysis for the LIS, basically by introducing a specific module for the Lift station MASSLIS.

## 2. Mounshaat-Al-Asad irrigation scheme

Mounshaat Al Asad irrigation scheme has a gross command area of 21,000 ha out of which 16,832 is equipped with irrigation facilities. This is located in arid Aleppo district (figure 2), with average annual rainfall of about 250 mm. The scheme is more than thirty years old and has gone through several maintenance and repairs. A study of the scheme is being conducted for complete rehabilitation and modernization that is expected to result in expanding the irrigated area from 21,000 ha at present to 35,000 hectares.

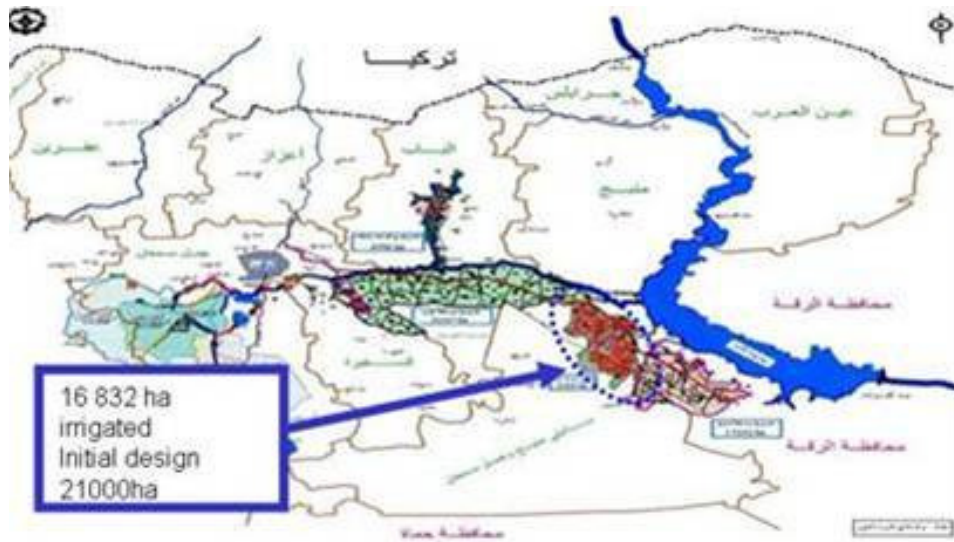


Figure 2. Location of Mounshaat-Al-Asad project in Aleppo Directorate

The main source of water is Al Asad lake (plate 1) that draws and stores water from the Euphrates River. The storage capacity of the lake is about 12 BCM. Water is lifted for about 69 meters (maximum 80) from the lake into the canal and then transported to the farms through a network of lined canals. About 1% of water pumped is for drinking purposes.

Water allocation to farmers is based on the following:

1. Agriculture plan decided at the central level in Damascus each year. Current plan is to have 65% of the total area cropped by wheat and 35% by cotton.
2. Mean monthly water requirements of the crops practiced (based on Blaney-Criddle formula used for designing the scheme).
3. Gross water requirements (considering irrigation efficiency of 55%) are supplied to farmers assuming that each irrigation applies  $700 \text{ m}^3/\text{ha}$  (70 mm).
4. Rotation based on above considerations. When precipitation occurs, the rotation is delayed according to the depth of precipitation.



Plate 1: Al-Asad lake on the Euphrates River

### ***Mounshaat-Al-Asad Project Description***

The pumping station of Mounshaat-Al-Asad irrigation scheme was designed by Russians in 1979 for irrigating 21,000 ha. The elevation head can vary between 65 - 85 meters depending on water level in the lake. With 6 main pumping units and 2 auxiliary pump sets, the total design capacity of the pumping plant is 35 m<sup>3</sup>/s.

There are two raising pipes of 2 x 2.4 m diameter each. Each raising pipe is 700 m long steel pipe and has an opening for servicing located at 150 m equal distance on the pipe. The pipes discharge into the main canal.

The canal network of Mounshaat-Al-Asad irrigation scheme (figure 3) is comprised of mainly lined Main canals (MC, MC1, and MC2); second level canals (MC11, X); third level canals (MC111); and elevated quaternary canals (flumes). The hardware of the canals, in general, is in good condition (plates 2 and 3) with some problems identified at the tertiary and quaternary canals. Some secondary and tertiary canals are equipped with the spills (plate 4), however the main canals do not seem to have escapes.

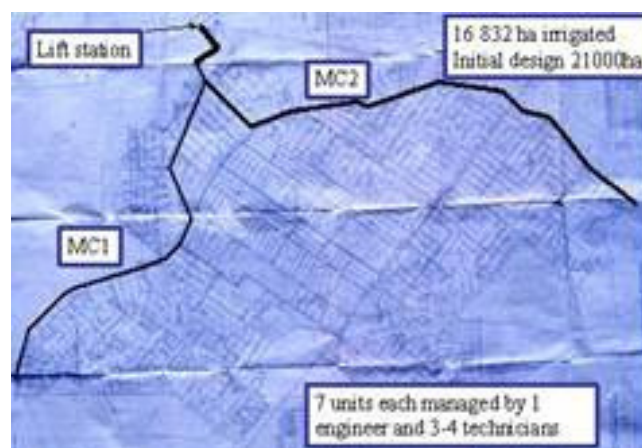


Figure 3. Lay-out of Mounshaat-Al-Asad lift irrigation scheme



Plate 2: Main canals: Rectangular section (left) and trapezoidal section (right)



Plate 3: Portable gate along quaternary canal



Plate 4: Spill along tertiary canal (lateral weir on the side of the offtake spilling in the quaternary channel).

Cross regulator infrastructure also is in good shape. Most of the gates of cross regulator on the main and the second level canals are motorised and can be operated easily. Head gates of the tertiary canals are often manually operated sluice gates, however there seems to be no problem with moving these gates as well (plate 5).



Plate 5: Gate operator moving the gate of a tertiary canal

Although the irrigation scheme was designed for upstream water level control, it is operated on the basis of proportional flow. The flow is partitioned according to the area at the main bifurcation points. There are no gauges or any other devices to monitor water level.

Command area is divided into seven units; water distribution is managed by 1 engineer and 3-4 technicians for each unit. Water distribution is organized in the following manner:

- An Engineer is in charge of main canal from pumping station down to the inlets of the 7 units
- Other engineers are in charge of water distribution in their respective units - from unit inlets down to inlets of secondary canals
- Technicians are in charge of operating down to inlets of tertiary canals, assisted by labourers who open and close gates, including those supplying tertiary canals. Each technician is in charge of an irrigated area of 500-700 ha.
- Farmers distribute water among them on a rotation basis, either directly or through a person designated by all the beneficiaries of a tertiary canal to supervise the rotation. The staff of the ministry intervenes at this level only in the case of conflict between beneficiaries.

Main crops grown include wheat, cotton, maize, and fodder crops. However, some farmers are now experimenting with more cash crops such as cumin. These farmers are also opting for pressurised farm-network, for which they dig wells in their farm to obtain flexibility and reliability of water supply which is required to grow water sensitive cash crops. This flexibility is not provided by the current irrigation system.

The government charges only a nominal fee for water services. The fee is based on the farm area (3500 SP/ha) rather than the amount of water used (it is assumed that all farms use more or less the same amount of water per hectare given the fact that they all grow the same crops and water is allocated by the public services rather than on the basis of demand by farmers).

### 3. MASSCOTE in Mounshaat-Al-Asad irrigation scheme

#### Step 1. RAPID DIAGNOSIS

A RAP (Rapid Appraisal Procedure) was carried out as part of the first step of the exercise during the workshop. The workshop participants were divided into 2 groups and each group spent one and a half day in the field and gave ratings to all internal indicators. During a plenary session these rating were reviewed and finalized.

The section wise RAP summary is detailed below.

##### ***Step 1.1 RAP Methodology for Canal System***

The RAP is a quick and focused examination of irrigation systems and projects that can give a reasonably accurate and pragmatic description of the status of irrigation performance and provides a basis for making specific recommendations related to hardware and management practices. The first step in evaluating irrigation performance at the farm level or at an entire irrigation project level, is to perform a rapid appraisal (RAP) of the system as it is being operated.

The RAP can be described as follows:

The Rapid Appraisal Process (RAP) for irrigation projects is a 1-2 week process of collection and analysis of data both in the office and in the field. The process examines external inputs such as water supplies, and outputs such as water destinations (ET, surface runoff, etc.). It provides a systematic examination of the hardware and processes used to convey and distribute water internally to all levels within the project (from the source to the fields). External indicators and internal indicators are developed to provide (i) a baseline of information for comparison against future performance after modernization, (ii) benchmarking for comparison against other irrigation projects, and (iii) a basis for making specific recommendations for modernization and improvement of water delivery service.

Use of a systematic RAP for irrigation projects was introduced in a joint FAO/IPTRID/World Bank publication entitled *Water Reports 19 (FAO) - Modern Water Control and Management Practices in Irrigation - Impact on Performance* (Burt and Styles 1999). That publication provides an explanation of the RAP approach and gives the results from RAPs the authors conducted at 16 international irrigation projects. Refer to Water Report 19 for further background to the RAP approach, available directly from FAO (<http://www.fao.org/icatalog/inter-e.htm>).

RAP is now fully integrated as the STEP 1 or the foundation of the new approach developed by FAO for modernization strategy and plans which is called MASSCOTE.

A key component of the successful application of the RAP and MASSCOTE approaches is the knowledge and experience of qualified technical experts who can make proper design and modernization decisions. It is critical that MASSCOTE-RAPs are conducted by irrigation professionals with an extensive understanding of the issues related to modern water control. This technical capacity building will be addressed initially through training

workshops that are going to be organized by the FAO. In addition to making proper recommendations for modernization, evaluators using the RAP approach must have the ability to synthesize the technical details of a project with the concepts of water delivery service into a functional design that is easy-to-use and is efficient.

Key performance indicators from RAP help to organize the perceptions and facts, thereby facilitating further development of a modernization plan through the different steps of MASSCOTE. From the RAP we have already some good indications on:

- Further investigations that should be carried out for the development of the modernization plan
- Specific actions that can be taken to improve project performance
- Specific weakness in project operation, management, resources, and hardware
- The potential for water conservation within a project

Broad goals of modernization are to achieve improved irrigation efficiency, better crop yields, less canal damage from uncontrolled water levels, more efficient labour, improved social harmony, and an improved environment by reducing a project's diversions or increasing the quality of its return flows. In general, these goals can only be achieved by paying attention to internal details or the internal indicators. The RAP addresses these specific internal details to evaluate how to improve water control throughout the project, and how to improve the water delivery service to the users.

## Looking at different management levels

A huge project can be understood in simple terms if it is analyzed level wise (office, main canal, second level canal, third level canal, distributaries, field). The operators of the main canal only have one objective - everything they do should be done to provide good water delivery service to their customers, the distributary/minor canals (and perhaps a few direct outlets from the main canal). This "service concept" must be understood and accepted by everyone, from the chief engineer to the lowest gate operator. Once it is accepted, then the system management becomes very simple. Personnel on each level are only responsible for that level's performance.

An important step of MASSCOTE is to start precisely from this diagnosis and re-organize the management of the system into units which are functional, responsible and responsive and consistent with the main features diagnosed in the gross command areas. On a large system the partitioning into management units is fundamental to allow an effective service oriented management from one level to the other, down to the end-users.

Main canal operators do not need to understand the details of that day's flow rate requirements for all the individual fields. Of course, in order to subscribe to the service concept, operators generally need to know that their ultimate customer is the farmer. But the details of day-to-day flow rates do not need to be known at all levels. Rather, the main canal operators have one task to accomplish, to deliver flow rates at specific turnouts (offtakes) with a high degree of service.

## Performance indicators

The external indicators compare input and output of an irrigation system to describe overall performance. These indicators are expressions of various forms of efficiency, for

example water use efficiency, crop yield, and budget. But they do not provide any detail on what internal processes lead to these outputs and what should be done to improve the performance. They, however, could be used for comparing the performance of different irrigation projects, nationally or internationally. Once these external indicators are computed, they are used as benchmarks for monitoring the impacts of modernization on improvements in overall performance.

The internal indicators quantitatively assess the internal processes (inputs - resources used and the outputs - services to downstream users) of an irrigation project. Internal indicators are related to operational procedures, management and institutional set-up, hardware of the system, water delivery service etc. These indicators are necessary to have a comprehensive understanding of the processes that influence water delivery service and overall performance of a system. Thus they provide insight into what could be done to improve water delivery service and overall performance (the external indicators).

### External performance indicators in the Mounshaat-Al-Asad system

The productivity of land (3562 US\$/ha) is quite high when compared to other systems studied by FAO elsewhere as seen in figure 4 (ranked 2<sup>nd</sup> out of 28 systems). On the other hand, performance in terms of productivity of irrigation water is average/medium (see figure 5 - ranked 8<sup>th</sup> out of 28 systems). Reasons for high productivity of land are related to 1) high yield of the crops - average yields of the major crops are 5 tons/ha for wheat and maize; and 3.5 tons/ha for cotton ; 2) High value fodder crops, such as Berseem, are grown on 38% of the command area 3) high support prices set by the Government for major crops grown in the area, namely, wheat, maize, and cotton.

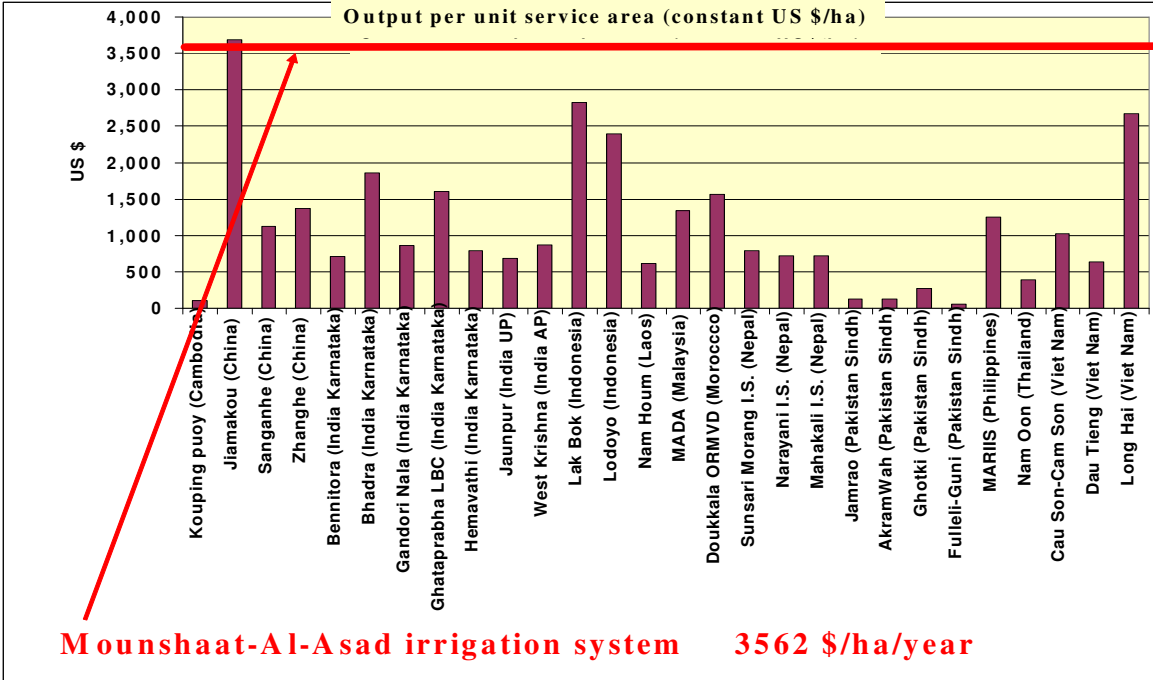


Figure 4: Output per unit area in Mounshaat-Al-Asad compare to other systems

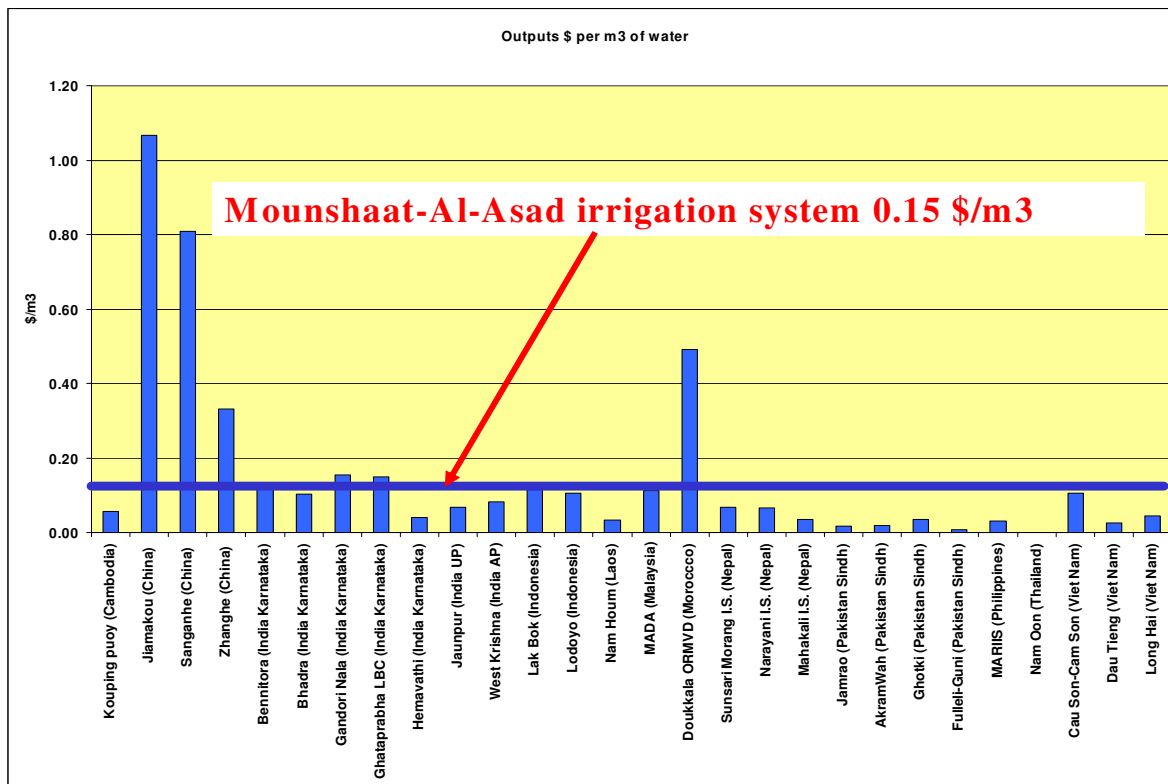


Figure 5: Output per unit of water in Mounshaat-Al-Asad compare to other systems

## Internal performance indicators in the Mounshaat-Al-Asad system

The values of the primary internal indicators reflect an evaluation of the key factors related to water control and service throughout the command area. The internal indicators and their sub-indicators at each level of the system are assigned values from 0 to 4 (0 indicating least desirable and 4 indicating most desirable).

Table 2 summarizes the internal performance indicators for the Main Canal of Mounshaat-Al-Asad. It shows relatively high values for offtakes, communication and general condition of the canal, and low values for cross regulator hardware and operation. The low value of cross regulator hardware is mainly due to the sub-indicator characterising water level fluctuations. Otherwise, CRs are physically in good condition, they are well maintained and easy to operate (motorised). However operation of CR of the main canal is very poor. In fact CRs are not operated to control water level and the instructions for CR operation given to the gate operator by the managers/engineers are incorrect.

### No water level control

Although the irrigation scheme was designed for upstream water level control, it is operated on the basis of proportional flow. The flow is partitioned according to the area at the main bifurcation points. There is no gauge or any other device to monitor water level and the water level is not controlled along the main canal. Variation of 30 cm of water level is common; however it can not be verified as there are no gauges. The offtakes along the main canal seem to be less sensitive hence the water deliveries to the secondary level remain to a certain extent under control. But there is obviously an amplification of the perturbations as we go downstream.

Communications among the canal operators is overall good; however there are differences between the day and the night time communication.

**Table 2. Mounshaat-Al-Asad Internal Performance Indicators for the Main canal**  
(Maximum possible value = 4.0, minimum possible value = 0.0)

Internal Performance Indicator	Value (0-4)
Cross regulator hardware	1.6
Headgates (distributaries) from the Main Canal	3.0
Communications	3.2
General Conditions	3.4
Operations	1.6
<b>Actual Water Delivery Service by the Main Canals to the Secondary Canals (overall index)</b>	<b><u>2.6</u></b>

### Second Level Canals

The performance of the second level canals in Mounshaat-Al-Asad irrigation scheme is summarized by the key internal indicators in Table 3. In general, the performance indicators for the second level canals are in the same order of magnitude as for the main canal.

**Table 3. Internal Performance Indicators for the Second level canals in Monshaat-Al-Asad irrigation scheme**  
(Maximum possible value = 4.0, minimum possible value = 0.0)

Internal Performance Indicator	Value (0-4)
Cross regulator hardware	2.0
Turnouts (tertiary canals)	3.3
Communications	3.2
General Conditions	3.1
Operations	1.9

The secondary canals are maintained very well, but lack of water level control is resulting in chaos in the system. Water level fluctuations are amplified towards the tail end of the canal. During the low flows in the secondary canals, some offtakes, in the tail sections can not be supplied with stable target flowrates. However, as the water level is not controlled by the gate operators, farmers take some measures to raise the water level by placing the blocks in the canal (plate 6).

### Tertiary Canals and final deliveries

The internal indicators that characterize the actual water delivery service at the tertiary canal, quaternary canal (final delivery) and the farm levels are summarized in **Table 4**, **Table 5** and **Table 6**. The water delivery service being provided to the farmers is relatively low. This is a measure of the flexibility, reliability, equity, and measurement of the water supply to individual fields.



Plate 6: MC2 - C25 (left) Concrete blocks to raise water level at offtake while downstream X-Reg (right) is not used to control water level as it should be.

**Table 4. Internal Performance Indicators for tertiary canals in Mounshaat-Al-Asad irrigation scheme** (Maximum possible value = 4.0, minimum possible value = 0.0)

Internal Performance Indicator	Value (0-4)
Cross regulator hardware	2.4
Turnouts from the third level canal	2.7
Communications	3.2
General Conditions	3.0
Operations	2.2

**Table 5. Internal Performance Indicators at the final delivery (quaternary canals - the most downstream point in the system operated by a paid employee) in Mounshaat-Al-Asad irrigation scheme** (Maximum possible value = 4.0, minimum possible value = 0.0)

Internal Performance Indicator	Value (0-4)
<b>Actual Water Delivery Service at the most downstream point operated by the paid employee</b>	<b>1.2</b>
Number of fields downstream of this point	2.0
Measurement of volumes	1.0
Flexibility	1.0
Reliability	1.5
Apparent equity.	1.0

Table 7 presents internal indicators for social order, which reflects the degree to which irrigation deliveries are being taken either from unauthorized locations or in quantities greater than allowed. This indicator is also quite low for Mounshaat-Al-Asad irrigation scheme because of over tapping of water by the farmers either through illegal offtakes (plate 7) or longer than allowed irrigation time. The structures however are not vandalised.

**Table 6. Water delivery service to individual ownership units in Monshaat-Al-Asad irrigation scheme Water Delivery Internal Performance Indicators (0-4)**  
(Maximum possible value = 4.0, minimum possible value = 0.0)

<b>Actual Water Delivery Service to Individual Ownership Units (e.g., field or farm)</b>	<b>1.3</b>
Measurement of volumes	0
Flexibility	1
Reliability	1
Apparent equity.	2



Plate 7: Illegal offtakes from quaternary canals

**Table 7: Social order indicators**

<b>Social Order Indicator</b>	<b>1.3</b>
Degree to which deliveries are NOT taken when not allowed, or at flow rates greater than allowed	0
Noticeable non-existence of unauthorized turnouts from canals.	2.0
Lack of vandalism of structures.	3.0

The social order indicator reflects the degree to which irrigation deliveries are being taken either from unauthorized locations or in quantities greater than allowed. It can be considered that many of the direct outlets which divert up to 30-40% of the total irrigation supply, if not are officially sanctioned or managed as part of the rest of the system, then the social order indicator should be much lower.

The ratings for the internal indicators describing employees (RAP indicator = 1.2) and water users association (RAP indicator = 0) show significant room for improvement. Employees, especially field operations staff, had little or no incentive to provide excellent service to farmers and were not empowered to make decisions on their own. The water users association indicator is 0 because there are none in Mounshaat-Al-Asad irrigation scheme.

The key points from **Tables 2 to 7** include:

- The level of service to individual field outlets is well below what is required to support modern on-farm water management and crop diversification.
- Flow measurement is not being done anywhere in the system. The actual operations are based on partitioning of the flow based on the gate openings, without any real assessment of discharge or water level. Operators and managers only have a vague idea about how much water (rate or volume) is being delivered at any particular point in the system.
- Communications between the field operators and division/sub-division offices is frequent and reliable.
- Capacity of operators for real-time flow measurement and accurate flow measurement is currently low and should be raised before introducing new efficient devices.

### **Key findings of the field visit**

1. Infrastructure is in a very good condition and is well maintained, particularly at main and second level canals.
2. Water is abundant but the energy cost is high.
3. Partition of flow is done but not well specified.
4. No Measurements (no gauges), no assessment and no monitoring of flows and services.
5. Water level control is not done although it is needed downstream of the MC.
6. Water distribution to farmers is based on rotation but rules are not very clear.
7. High drainage resulting from surface irrigation and over irrigation
8. Farmers are recycling drainage water (also for nutrients).
9. Dominantly cultivated crop is Wheat.
10. Multiple Uses of Water: Potable water from main station, industrial uses inside the scheme (sugar factory, etc.), some villages are supplied with raw domestic water.

### ***Step 1.2 RAP for the Lift Station***

As part of the study in **Mounshaat -Al-Asad** system a rough assessment of the lift station has been carried out using a similar methodology as the RAP.

However not all the required information was available to perform a complete analysis of the lift station. In particular the pump's characteristics were not provided and therefore the efficiency analysis of the lift station was limited to an overall estimation based on the electricity bill.



Plate 8. The lift raising pipes at Mounshaat-Al-Asad system (lake in the background)

The main features of the lift station are as follows:

**Table 8: Main features of the lift station**

<i>inlet</i>	<i>Outlet</i>	<i>Raising main length</i>	<i>Elevation min. at inlet</i>	<i>Elevation at MC entrance</i>
Lake	Horizontal submerged at head on Main canal	2 pipes of 2400mm (steel) 700 meters	302 (with an annual variation of 2 meters)	370
		Total design capacity 35 m <sup>3</sup> /s	Elevation head: 65 - 67 meters under normal variation of the lake - [ up to maximum 85 meters by design]	

Russian design in 1979 for the irrigation of 21,000 ha

Purpose: Irrigation, potable water, industrial uses inside the scheme (sugar factory, etc.) and raw water supply to villages.

Pumping units are:

6 main units x 7.5 m<sup>3</sup>/s each Inflow diameter: 160 cm Speed: 375 RPM

Power: 11 KV transformed into 7500 KW (pumping station has an autonomous electrical supply line)

3 auxiliary units x 1.5 m<sup>3</sup>/s Inflow diameter: 60 cm each Speed: 1000 RPM

Power: 11 KV transformed into 1600 KW

2 transformers x 40 MW (1 operating and 1 spare)

2 electrical lines x 230 KV

Electricity price: 2.7 S.L/KW (fixed by government)

**Pumping station operation:**

Maximum: 3 main - 2 auxiliary during peak water demand (July-August)

Minimum: 1 + 0 to 1 + 2

Maximum operation capacity: 25 m<sup>3</sup>/s ( vs. design capacity of 35 m<sup>3</sup>/s)

Pumping Station Closure/Maintenance: 15 October to 1 December, except one auxiliary unit to supply drinking water

**Characteristics** (according to engineer in charge of the pumping station)

Engine designed to operate under optimum capacity, otherwise it automatically shuts off.  
Stainless steel shaft with no friction losses

Pump station has been built 30 years back, managers mentioned that pumps efficiency checks have been performed in 1987, 1998 and 2003, leading to the same constant ratio of Kwh/m<sup>3</sup> but the figures given are too low. These efficiency studies should be double-checked.

### **Nominal discharge vs actual**

The estimation of the volume of water pumped at the lift station is based on the running of the different units operated, assuming that the pumps are functioning at Best Efficiency Point (BEP) and that the nominal discharge is the same as at construction stage. Using the pumps formulas to estimate the volume pumped assumes that the pumps efficiencies have not decreased over time.

Water meters (ultra-sonic sensors) are installed in the system but are not used. Provision for discharge measurement was made at entrance of the main canal (N.B. visit revealed that the system used for this measurement is not reliable, not well calibrated and is not actually used).

It is normal that performance of the pumps decrease over time and more likely the actual discharge of pumps could be lower than respectively 7.5 m<sup>3</sup>/s and 1.5 m<sup>3</sup>/s. It is therefore quite important to perform a discharge measurement campaign on the pumps to come out with more accurate figures on actual discharges.

### **Water at inlet**

The pump station has been designed for a variation of water between 287 and 302 meters elevation, however managers signalled that in practice the lake variation is very low only 2 meters during a year. Therefore the average static head elevation is about 69 meters (plus or minus 1 meter).

## **Step 2. SYSTEM CAPACITY AND SENSITIVITY.**

**Objective:** *Assessing the physical capacity of irrigation structures to perform their function of transport, control, measurement, etc.*

*Assessing the sensitivity of Irrigation Structures (offtakes and regulators), identification of singular points. Mapping the sensitivity.*

### **Step 2.1. The capacity along the canal**

Assessment of the capacity of the **Monshaat-Al-Asad** system by the workshop participants was made considering the various functions of a canal network: storage, conveyance, diversion, distribution, control, measurement and safety. Capacity is generally good along the canal except for measurement which is currently a major weakness.

The following statements considering the various functions performed by a canal were made by participants:

#### **Storage - Reservoir**

No problem at the main storage

Main canal - some storage capacity in the canal itself but no buffer reservoir

### Conveyance

MC and SC good, no seepage

TC - Fair - leakage; spills

### Diversions

MC - no problem good

SC - some problem of diversion

### Distribution

MC and SC good

### Control structures

MC - good

SC - fair - some problems

TC - problems - poor

### Measurement

Poor at all levels

### Safety

Main canal - No structures

Good at the secondary canal

Enough free-board

Spills at the secondary canal

some problem at TC level

### Transmission

Mobile phone but no automatic not at night

Good at the main and secondary canal

Fair TC

## ***Step 2.2 The lift station capacity***

The capacity of a lifting structure is defined in terms of discharge (Q) at the outlet of the station or the entrance of the main canal. This capacity depends on the internal characteristics of the station (power & efficiency/losses) and the water level conditions of the supply and of the restitution. These two levels determine head at the lift station.

For a lift station the discharge lifted [Q] into the system at a given elevation will then depends on:

- the water levels (head conditions) at lift station
- the power and energy input
- the head losses within the station (inlet and outlet pipes ; pumps)
- the energy efficiency of the pumps.

### **Setting point vs Best Efficiency Point (BEP)**

Pumps are designed for a BEP for which efficiency is maximum. However inlet water level may vary during the season.

The case of **Mounshaat-Al-Asad**, the static head of the lift varies as follows:

- H1 minimum = 287 m
- H1 average = 301 m

- H1 maximum = 302 m

With a restitution level at 370 m, the lift head usually varies between 68 m and 70 m. Head losses generated in the raising main pipe should be added to this to determine the dynamic head. They have been estimated at 1.4 m for 12.5 m<sup>3</sup>/s discharge for the on line losses and 0.6 for singular losses at converging, bending and outlet at canal head, that is a total of 2 meters.

### Capacity of estimating volume input at head of systems

Managers tend to record number of hours run by each pumps and estimate the volume input by multiplying this amount by the nominal discharge of the pump. The analysis above leads to the following conclusions as far as the capacity of assessing the volume is concerned:

- Using pumping hours is absolutely insufficient to give accurate discharge and volume.
- One should associate water levels and accurate assessment of head losses in the pipe.
- the BEST option should be to have a measurement point upstream of the main canal.

### ***Step 2. 3. The structures sensitivity along the canal***

The sensitivity of irrigation structures characterize the way they react when flow changes occur. Indicators of sensitivity are linearly related to available head through the structure and therefore studying sensitivity means assess the head at each structure. No good information on head at structures was available during the workshop, and so the assessment is just a preliminary one that needs to be consolidated by a survey.

Rapid assessment made during the field visit seems to indicate that sensitivity is low for cross-regulators (head between upstream and downstream of the structures is low), whereas for offtakes the sensitivity is low at head reaches but high to very high downstream of the main and secondary canals as water level drops as a result of no water level control.

Therefore a sensitivity survey of the regulators and offtakes should be carried out along MC SC and TC.

## **STEP 3: THE PERTURBATIONS**

Perturbations analysis: causes, magnitudes, frequency and options for coping with.

The perturbations are unexpected flow changes or deviation from expected flows that may occur along a canal network having various origins, magnitude, frequency etc. Mapping perturbation then means identifying the perturbations and their characteristics.

Two main sources of perturbations in **Mounshaat-Al-Asad** have been identified and discussed by participants and are described in table 9.

## Step 4 MAPPING WATER & ENERGY BALANCE

**Objective:** *The objective here is to map the nature and structure of all the streams and flows that are affected and are influenced by the command area. It includes assessing the hierarchical structure and the main features of the Irrigation and drainage networks, natural surface streams and groundwater, and the mapping of the opportunities and constraints including drainage and recycling facilities.*

*An additional specific objective for the lift systems is to map down the balance of energy at the lift stations.*

**Table 9. Analysis of perturbations**

	<u>Causes</u>	<u>Magnitude</u>	<u>Location</u>	<u>Frequency</u>	<u>Options for coping</u>
<b>Lack of control, operation and measurements</b>	No measurement devices Lack of operation focus Lack of clarity on the concept and application of rotation	Small to medium (but probably high downstream of canals)	Downstream of main and secondary canals.  Along quaternary canals	Daily during the peak demand.	Fix the causes
<b>Illegal withdrawals (overtapping, illicit withdrawals)</b>	Deviation of official cropping pattern due to attractive price for other crops. Lack of adherence of cropping pattern to the agricultural plan. Lack of communication and collaboration between ministries agric. & irrigation. Water charging based on area not appropriate.	Medium	Whole project area	Throughout the year	<u>Options for coping</u> Increase the supervision Monitor irrigation practices of farmers Formation/creation of WUA (water users associations)

### **STEP 4.1. WATER ACCOUNTING:**

A preliminary attempt was made to assess the water balance of the Command Area (CA). This must be considered as tentative and should be revised after a comprehensive measurement campaign aiming at estimating accurately the inflows and outflows of the CA. There are in particular large uncertainties on the inflow from the lake and the outflow in the drainage.

This preliminary water balance is based on the followings:

1. average irrigation supply for the year 2007-2008; and
2. all other data from 2008.

The information used in the analysis was provided by the managers of the irrigation scheme and included the following items:

- annual irrigation water supply for the year 2007 (299 MCM) and 2008 (392 MCM)
- rainfall (251 mm)
- reference evapotranspiration (ET<sub>o</sub>) using Blaney and Criddle method (1724 mm)
- percentage of command area grown under different crops

### 1) Water accounting using average values

Annual irrigation gross supply per hectare is very high (20 000 m<sup>3</sup>/ha) and irrigation efficiency appears to be low (40%) when calculated using the average irrigation water needs after deducting the contribution of rainfall, effective rainfall is estimated to reach some 32 MCM.

**Table 10: Elements of the water balance for the year 2007-2008**

Water balance calculations considering only irrigation supply and crop water requirement	
Irrigation Input (MCM - average 2007-2008)	350
Irrigated area (hectare)	16,832
Annual supply volume average 2007-2008 (m <sup>3</sup> /ha)	20,000
Crops water needs (ET) (MCM)	155
Effective rainfall (MCM)	32
Overall efficiency (water required/water supplied) = (155-32)/350	40 %

### 2) Water accounting for the year 2008

Water accounting was carried out using the information for the year 2008, after considering the rainfall and the leaching requirement (11% of net irrigation rate) following the information provided in the report on rehabilitation of the irrigation schemes. Following figures provide information and contribution of inflows and outflows of Mounshaat-Al-Asad irrigation scheme. The information on drainage outflows is estimated by subtracting all the other outflows from the inflows and is used as a closure term.

Rainfall contributes to approx 10 % of the total gross inflow to the CA (42 MCM out of a total of 434 MCM) and 90 % is contributed by irrigation water from the lake.

#### Lack of drainage monitoring

Real, measured values of amount of water drained out of the command area were not available, however field observations suggested that a significant amount of water is drained out of the command area through surface drainage network - probably several m<sup>3</sup>/s (see plate 9). With respect to quality and particularly salinity problems, managers said they are monitoring the quality of drainage water. No data is available to confirm the risk of salinity problems in using drainage water and many farmers located downstream of the canal network are actually using drainage water to complement water supply as well as to use nutrients in drainage water. The absence of data does not allow concluding on that issue.

#### Diagnosis and uncertainties on WB

1. Annual supply calculated from the running hours of the pumps is certainly overestimated. It would be normally expected that the performance of the pumps declined since the construction phase (30 years). If we then consider a reduction of efficiency close to 15 % then the average annual volume for 2007-2008 should be taken as close to 300 MCM instead of 350 MCM.

2. Reference ETo is known with high accuracy, the value considered by project managers 1724 mm is very close to the value estimated by FAO Aquastat Climatic data which is 1704 mm.
3. Drainage flow is not measured therefore we cannot count of this flows to double check and close the balance.

**Note:** Regardless of the possible effects of the already signalled uncertainties on the terms of the water balance, the diagnosis will remain that efficiency is low. This was already evident from the benchmarking of the external indicators:

- Very high productivity amounting to 3562 \$/hectare when measured using output per unit area indicates clearly that the system is one of the best out of 29 systems analysed.
- Medium productivity of 0.15 \$ /m<sup>3</sup> when measured using output per unit of water.

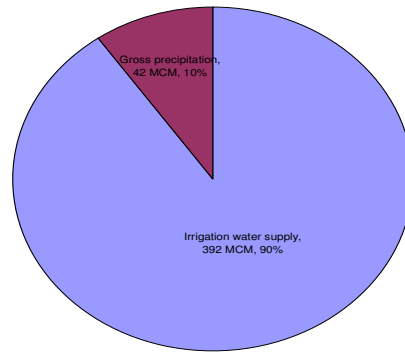
The gap between the ranking of these two indicators is clearly an indication that compared to other systems, the Mounshaat-Al-Asad system is not efficient in terms of water productivity.



Plate 9 Main drainage downstream of Mounshaat-Al-Asad irrigation scheme

Both the analyses showed that irrigation water supplied by the system is a lot more than what is required by the crops as well as for leaching purposes. Huge savings can be made at the pump station by diminishing the volume of water lifted, after raising efficiency at field and irrigation system levels. However, more accurate measurements of the inflows and outflows, are needed at the key locations in order to obtain more reliable values of efficiencies based on which concrete actions can be taken to improve the situation.

Inflow into Mounshaat Al-Asad irrigation scheme in the year 2008



Outflows from Mounshaat Al-Asad irrigation scheme in 2008

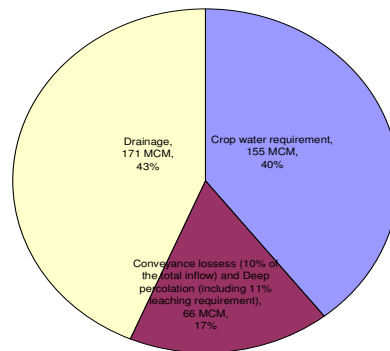


Figure 6: Inflows and outflows in the command area of Mounshaat-Al-Asad irrigation scheme for the year 2008

## Step 4.2 MAPPING the ENERGY

Accounting for energy is a critical step for lift irrigation system as energy is usually the major cost of operation.

### Energy input by the lift station

The energy input into the water stream at a lift station in terms of quantum of water elevated is given by the following equation:

$$Energy(KWh) = \frac{Volume(m^3) \times Headstatic(actual)(m)}{367} \quad (1)$$

Head static (actual) is the difference of water elevation between canal inlet ( $H_1$ ) and outlet ( $H_3$ ) (see figure 7).

Head static for Mounshaat-Al-Asad pumping station is 69 meters. Thus the energy input is equal to:

$$Energy\ input\ per\ m^3 = 1 \times 69/367 = 0.19\ Kwh/m^3$$

## Energy required by the lift station

The energy required at a lift station depends on the total head, the volume pumped (V) and the efficiency of the system [ $\eta$ ].

$$Energy(KWh) = \frac{Volume(m^3) \times Head_{total}(m)}{367} \times \left[ \frac{1}{Efficiency} \right] \quad (2)$$

Total head is the head static of the pump [ $H_2 - H_1$ ] plus head losses in the inlet and outlet pipes.

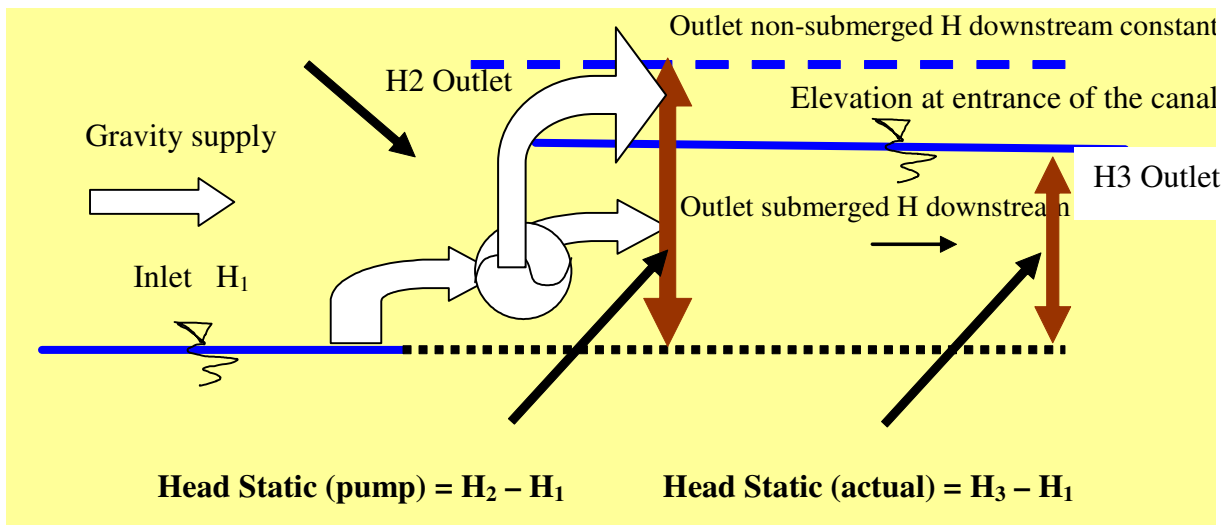


Figure 7. Sketch of a lift station head variables.

### Head data at the lift station

H<sub>1</sub> minimum = 287 m  
H<sub>1</sub> average = 301 m  
H<sub>1</sub> maximum = 302 m

The outlet is submerged therefore the elevation to consider is H<sub>3</sub>.

H<sub>3</sub> restituted at present = 370 m

### Energy balance for average running conditions

Characteristics curves of the pumps have not been accessible during the study therefore the efficiency analysis could not be performed.

### From energy analysis

From the electricity bills for 2007 and 2008 we have calculated an estimate of the ratio of energy spent per m<sup>3</sup>. Estimates come to 0.234 KWh/m<sup>3</sup> (in 2008) and 0.254 KWh/m<sup>3</sup> (in 2007). They are based on a volume calculated with the nominal pump discharge, so the actual values should be more than that as the real pumped volume should be less.

Table 11. Energy ratio per m3

	2007	2008
Volume MCM	293.6	392.4
MKWh	74.6	92.0
KWh/m3	0.254	0.234

These estimates compared to previous estimation of input (0.19 KWh) would indicate an efficiency of 74 - 80 %. Actually the expected values for efficiency after 30 years of running should be less than what is estimated. But without accurate measurements of the flow at the main station we cannot pursue the analysis. Once accurate calibration of the pumps discharge will be available, this performance analysis will be recalculated.

## Step 5 MAPPING THE COST of OPERATION

**Objective:** *The objective is to gather as many elements of costs as possible which go into the operation of the system to identify the possible gains with the current operational set up and service, and to know the cost of improved service implementation. This step thus focuses on mapping the cost for current operation techniques and services, disaggregating the elements going into the cost, cost options for various level of services with current techniques and with improved techniques.*

### Cost of Operation and Maintenance

Total O&M budget for Mounshaat-Al-Asad irrigation scheme in 2008 was about SP 300 million, as shown in figure below, out of which 88% is spent on the pumping station. The single major expenditure of the O&M budget is for electricity cost for lifting water from the lake into the canal network. This cost can be reduced by improving water use efficiency at the field level. A 10% reduction of pumped water will reduce the energy cost by 25 Millions SR.

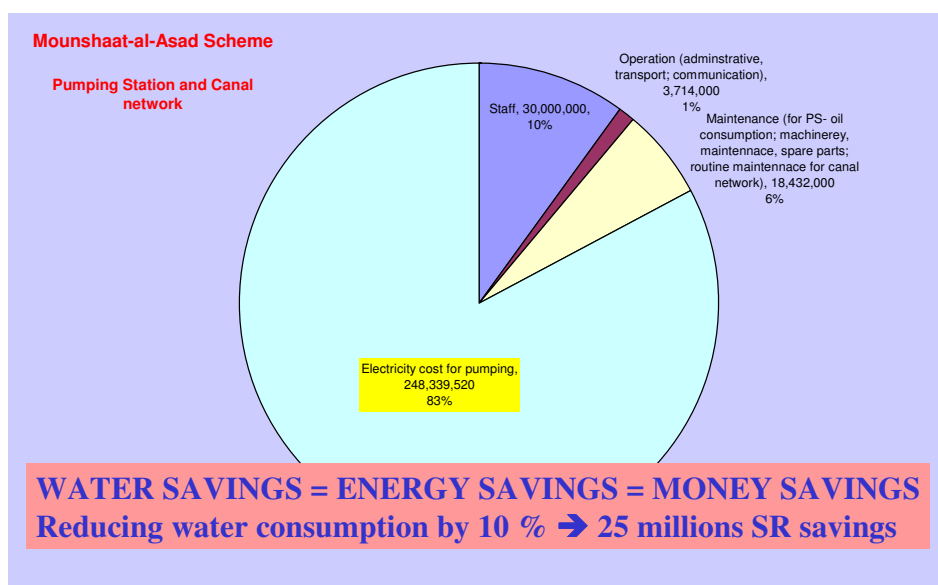


Figure 8. Budget breakdown for Mounshaat-Al-Asad irrigation scheme

Figure 9 presents budget breakdown for canal network only. The highest budget allocation is for operation and maintenance staff. However, in total the amount of money spent on maintenance is higher than the amount of money spent on operation, which is usually uncommon in large scale irrigation systems.

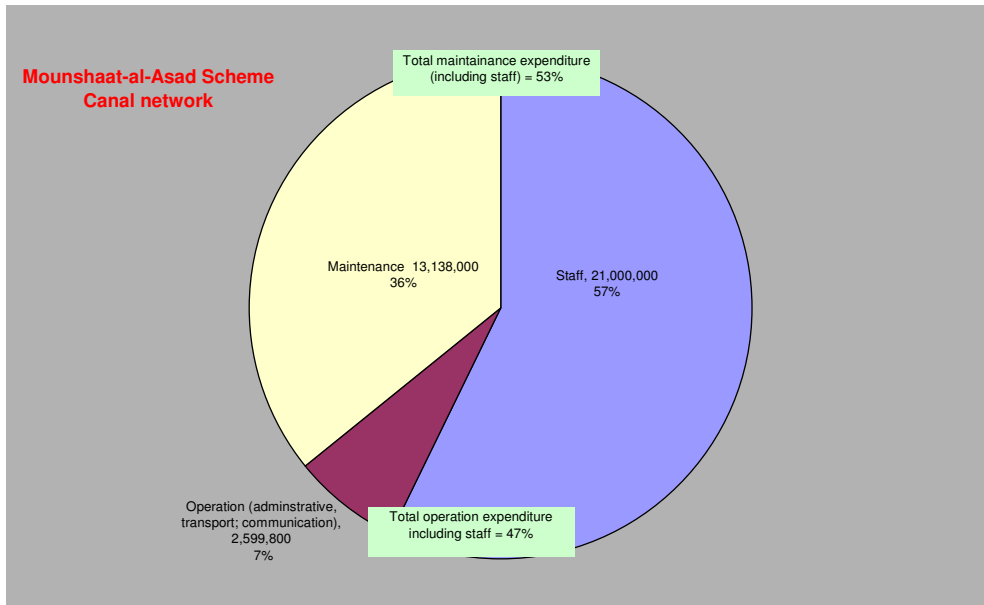


Figure 9. Budget breakdown for Mounshaat-Al-Asad irrigation scheme

Currently, the major part (80%) of the budget is allocated by the Government with minimum contribution from the farmers, which is only 20% of the total expenditure (see figure 10 and table 12). However, farmers who have their private wells spend about 3 times more in order to acquire good (flexible and reliable) water delivery service. This shows that farmers are willing to pay a higher price than existing water charges if water delivery service from the canal network improves.

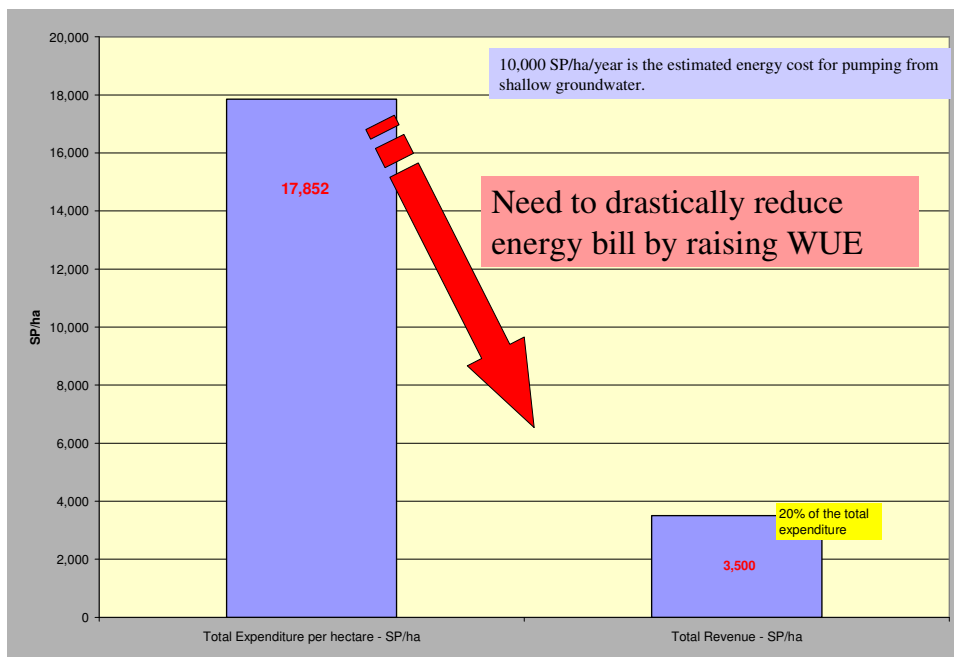


Figure 10: Cost and irrigation fees

Table 12: Cost breakdown

Components	Cost per Ha. In SP.	
	Pumping station	Canal network
Energy charges per ha.	14,754	
Staff	535	1,248
Operation	66	154
Maintenance	315	781
<b>Total</b>	<b>15,669</b>	<b>2,183</b>

## Step 6 SERVICE to USERS

**Objective:** Mapping existing and possible options for services to Users with consideration to Farmers and Crops as well as to Other Users of water.

The analysis of the “service to users” is at the heart of the MASSCOTE development process. A single one go is not sufficient to characterise all aspects and options of the water services. Several back and forth are required to converge towards a “service” that is desirable, possible to implement and at an agreed upon cost with the users, consistent with the management constraints and set up.

### The users in Mounshaat-Al-Asad system

- Farmers are the main users of water (99%) and dominant cultivation is wheat.
- Some farmers are recycling drainage water to complement water supply and also to benefit from nutrients.
- Multiple Uses of Water: Potable water from main station, industrial uses inside the scheme (sugar factory, etc.), some villages are supplied with raw domestic water.

From data records during the off period we estimated domestic water to be around 5 millions m3 per year that is about 1.5 % of the total pumped.

The irrigation services last throughout the year except one and a half month (15 October - 1<sup>st</sup> December) for maintenance. During that period though, supply for domestic use is maintained through a special pipe.

### The current service to farmers: proportional rotational adjusted service.

The actual service provided to farmers is based on rotation along quaternary canals. The water demand is estimated from the cropping pattern and climatic conditions, and flow is pumped accordingly. Once in the canal, the flow is more or less shared proportionally at the nodes of the system. Adjustments to the proportional sharing are made time to time basis requested by users.

Water demand (Climatic) → pattern of inflow at main station → proportional sharing along MC SC and TC → rotation at quaternary with upward adjustments (increasing or decreasing demand)

It is noteworthy to state that this currently practiced proportional distribution mode is not the one for which the canal network has been designed. All structures are gated and there is no proportional divider.

## **Services and Visions**

From the analysis of current practices of services and the issues related to efficiency and performance at canal system and field level, participants at the workshop formulated new concepts of services to farmers. This was done in parallel with discussing a vision for the Mounshaat-Al-Asad system. Some more detailed elements of the visions and services are presented in appendix 1 where scenarios are examined according to a grid of elements. Two different visions were considered by participants:

### **Vision G1 INTENSITY**

**An agriculture system moving towards intensification and diversification, increased participation of users in management and cost sharing**

### **Vision G2 CONSERVATION**

**An agriculture system responding to state food security strategy and water use efficiency with wheat and low consuming crops, improved management with Water Users Association and volumetric water charging**

## **Furthering services and visions**

Due to time constraints the process of discussing vision and services was not completed during the workshop. This step therefore requires further investigation and discussion in the coming months at both field level and system levels. Elements to consider for the revised concept of services to farmers are:

- improved adequacy to farm gate (measurement) and possibility of volumetric monitoring
- the issue of night irrigation
- surface irrigation modernization techniques (distribution pipes, land levelling, automation at field level)
- introduction of downstream control to better match the downstream demand
- use of canal inline storage to cope with flow variations.

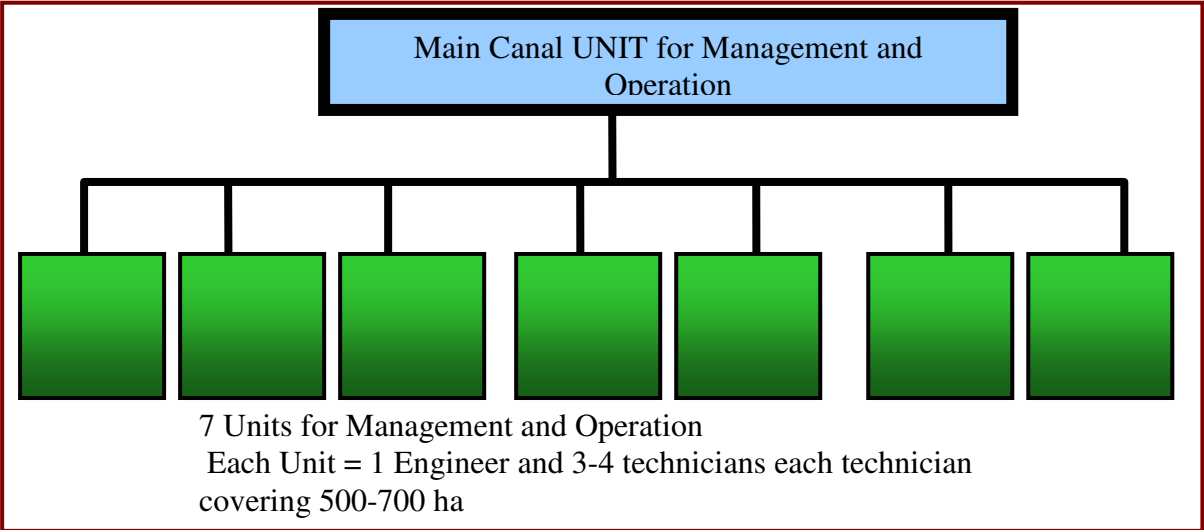
# Step 7 ORGANIZING MANAGEMENT UNITS

**Objective:** *The irrigation system management should be partitioned into few levels of management and the command area should be divided in subunits (subsystems and/or subcommand areas) held homogeneous and/or separate from one another by a singular point or a particular borderline.*

Discussions on management during the workshop were fruitful although not conclusive. This aspect of the planning requires the determination of Vision and Services for the Mounshaat-Al-Asad system and in depth analysis of the managerial and social contexts before making any sound recommendation.

The management organisation has been discussed in terms of layers (How many, which type, etc...), in terms of size of units (per area, per canal etc..) and in terms of staff density.

At present the management is organised through 7 units served by one main unit as shown in figure 11.



*Figure 11. Current management organisation*

The proposal from the participants to regroup the top management into one single unit instead of three separate units, reached a rapid consensus.

### The issue of over staffing

When compared with other projects it is evident that the Mounshaat-Al-Asad system is largely overstaffed. The density of professionals (permanent and temporary recruits) is much higher than that found in other systems studied by FAO which can be seen in table 13. The average command area per professional amounts to 100 ha (3 times lower than that found in Doukkala Morocco and 5 times less than in Jamiakou China ).

This very high density of staff cannot be justified by a very high demanding operational mode. Actually this is the contrary as the actual operation mode in the system is more or less proportional which is the lowest demanding mode. Therefore it can be firmly concluded that the system is by far overstaffed for the current operational mode and the

performance achieved in water management. This should be taken seriously into consideration in the modernization project with several objectives in mind:

- achieving higher performance in providing reliable and equitable services to farmers taking advantage of a high density of staff
- reducing cost of operation by reducing professional staff.

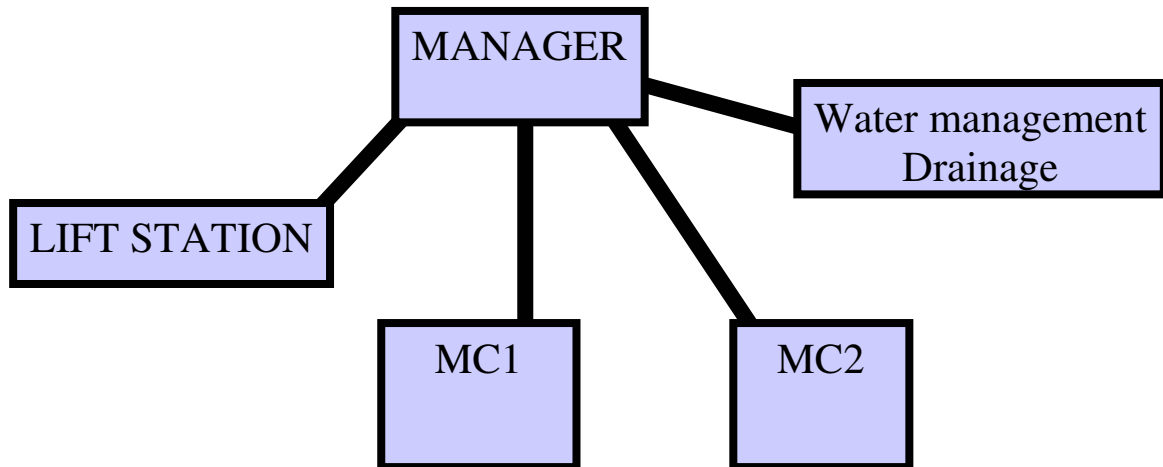


Figure 12. Proposed new management structure

Table 13. Professional staff and command area

Project	CA	Professional Staff	CA per staff (ha)
Gathapraba India	162000 ha	93	1750
Jiamakou China	17000 ha	37	460
Doukkala Morocco	96000 ha	300	320
Mounshaat-Al-Asad Syria	16800 ha	167	100

## Step 8 MAPPING THE DEMAND FOR OPERATION

**Objective:** *Assessing Means, opportunity & demand for Canal Operation*

*A spatial analysis of the entire command areas, with preliminary identification of Sub-Command Areas (Management, service,..)*

Given the small size of the system, the climatic and soil conditions which are even with a uniform cropping pattern projects little variation in the command area. Therefore the mapping of the demand should consider only two elements:

- Tail enders are noticeably suffering therefore downstream sections require more attention.
- More investigation below Main Canal is needed for staff allocation to perform a cost effective service provision.

## Step 9 OPERATION IMPROVEMENTS: CANAL & LS

Overall improvements in terms of water delivery service require shifting from rigid supply based water delivery scheduling to arranged water delivery at the farm gate. In order to achieve this, improvements in operation, institutions, budget and water charging, and monitoring and evaluation are needed. These are presented in the table 14 below:

**Table 14: Concepts considered for introducing Service Oriented Management.**

Water Delivery Service - Arranged water delivery at the farm level			
Operation	Money	WUA	Monitoring and Evaluation
<ul style="list-style-type: none"> <li>• Need to be improved to achieve the proposed water delivery service</li> <li>• Water level needs to be control for better discharge</li> </ul>	<ul style="list-style-type: none"> <li>• Volumetric pricing</li> <li>• Tariff adjustments based on reduced cost of pumping and increased service charges.</li> <li>• Billing and collection mechanisms for volumetric pricing need to be checked out</li> <li>• Give incentives to farmers - Ag. extension for improved irrigation at the farm level</li> </ul>	<ul style="list-style-type: none"> <li>• TC and area based (not less than 500 ha) - responsible for distribution and link with the agency</li> <li>• Federation of the WUA</li> </ul>	<ul style="list-style-type: none"> <li>• Measurement at the key points</li> <li>• PS-MC-SC-TC</li> </ul>

More detailed plan for immediate and medium term improvements was discussed during the workshop which is briefly presented below:

### Short term plan for improvement (one year)

- Evaluation of sensitivity along main, secondary and tertiary canals
- Identification of main critical key points and main physical problems to be fixed
- Identification of main key points to place measurement devices
- Calibration of existing measurement devices and upgrading
- Evaluating the level of efficiency at pumping plant based on accurate measurements
- Water balance at system level to be further investigated
- Start establishing water users association at the tertiary level canal
- Evaluating the average efficiency of water use at field level based on measurements
- Monitoring plan for measuring the quantity and quality of drainage water

### Medium term plan for improvement (5 years)

- Mapping demand of operation of the different project areas
- Redistribution of operational resources based on the demand for operation
- Establishment of WUAs at tertiary level canals (on-going process)
- Transfer of irrigation management to WUAs from the tertiary level canal downward
- Improvement of average efficiency of water use at field level

- Establishment of extension service activities to better orient and advise farmers (WUAs would become core entities to obtain such extension services and spread good practices among farmers)
- Study for assessing the state of aquifer and groundwater resources in the CA and for evaluating the need of subsurface drainage systems
- Based on results from RAP and measurement campaign, increase the capacity of canal network at the secondary and tertiary level
- Definition of water delivery services
- Automation of structures setting and installment of Telemetry for data collection and transfer

## **Step 10 AGGREGATING AND CONSOLIDATING MANAGEMENT**

Immediate follow up of the MASSCOTE workshop are as follows:

- Carry out MASSCOTE steps with accurate information available
- Sensitivity analysis to be carried out
- Water balance to be further investigated
- Flow measurements to be carried out on key locations - particularly head of the main canal; selected canals and main drain
- Actual cropping pattern to be assessed

## Annexe 1. Elements of Scenario intensity

	Elements	SCENARIO INTENSITY
1	Agriculture system: vision of the agriculture in the CA	An agriculture system moving towards intensification and diversification as the land is owned by the farmers. Even there will be a agricultural plan and farmers will try to cultivate more crops in the year (which is not against the year)
2	Types and rules/flexibility for cropping irrigated pattern	Fixed for the strategic crops with some flexibility for other crops and intensification
3	Types of water users (farmers - others)	Almost all water users are farmers. Establishing WUA at different levels will help a lot in water management
4	Allocation of water to farmers : rules, management under severe deficit, (wet/dry year)	Currently, water allocation is not limited except the limitation of maximum canal capacity. However, with some water threats and expected high consumption, it will be a problem in water allocation and this should be faced by irrigation improvement.
5	Systems: Major decisions for expansion and changes for Operation and Maintenance	Water threats and high consumption will require better operation and maintenance. This could limit the ability for expansion. This should be covered by increasing the share of the farmers to the cost
6	Water Service: flexibility, Reliability, equity, cost.	With the expected water threats and water consumption, different services issues will be negatively affected and the cost should be increased to maintain the current service level.
7	Techniques at field level	Imposing some cost sharing might encourage farmers to implement modern irrigation techniques especially if the sharing is related to the consumption
8	Alternative water resource (Groundwater, river)	An intensive study should be conducted about the aquifer in the CA and the water quality of the drainage and ground water in order to decide the ability to use them.
9	Budget and finance (water fees : tariff, recovery , financial balance)	The budget of the project should increase to face the required improvement. This increase will be covered by the government and the users.
10	Role of the main agency and of other bodies	Main agency (state) will operate the main and secondary canals. WUAs distribute the water between farmers
11	Organization of the main agency	The main agency should be State agency.
12	Groups of water users : Importance, role, budgets	WUAs coordinate with the main agency in water distribution. It is established election. The law should impose a minimum budget fed by users.
13	Irrigation Water Productivity	Water threats and high consumption will enforce the agency and the farmers to introduce better water management and agriculture science to increase productivity in the future
14	RISKS associated to the scenario	This scenario anticipated water shortage in future. Risks of this scenario are: 1) Agencies do not feel the threat and not ready to work on it on an immediate basis. 2) Leaving the farmers without involving them in the irrigation management
15	OPPORTUNITIES associated	The intensification will help farmers economically and they will go for more cash crops Introducing WUAs will help the agency in the operation and it will save the budget This scenario will encourage the state and the farmers to improve irrigation

## Annexe 2. Elements of Scenario Conservation

	Elements	SCENARIO CONSERVATION
1	Agriculture system: vision of the agriculture in the CA	Less intensive agriculture responding to the strategy of food security by the government and with improved water management at farm level resulting from establishment of WUAs, enforcing measurement and volumetric water charging This will result in improved water productivity, less energy cost for pumping and better water distribution throughout the CA
2	Types and rules/flexibility for cropping irrigated cropping pattern	Consistent with the agricultural plan, set every 5-10 years but with some room for flexibility to farmers decisions (representatives from farmers unions sitting at board of agricultural plan)
3	Types of water users (farmers - others)	WUAs from tertiary canals downward
4	Allocation of water to farmers : rules, management under severe deficit, (wet/dry year)	Sharing the deficit among all farmers at CA
5	Systems: Major decisions for expansion and changes for Operation and Maintenance	Smaller units and higher number of operators in order to implement a better management and structure control
6	Water Service: flexibility, Reliability, equity, cost.	More accurate measurement and control will allow higher flexibility of delivery along the season as well better reliability and equity. All the above will contribute reducing the energy cost, but somehow the cost of operation will relatively increase
7	Techniques at field level	Improved surface irrigation methods
8	Alternative water resource (Groundwater, river)	NO Drainage recycling and re-use
9	Budget and finance (water fees : tariff, recovery , financial balance)	Higher water tariffs and also differentiated tariffs according to the levels of service provided
10	Role of the main agency and of other bodies	Main agency controls and operates the main and secondary canals, whereas from the tertiary canals onward the WUAs carry out the control and operation
11	Organization of the main agency	State agency controlled by the Government
12	Groups of water users : Importance, role, budgets	WUAs will manage water from tertiary canals downward. WUAs will basically pay for the provision of water service to the state agency and will be responsible for water distribution among farmers, collecting water fees from farmers on a no-profit basis. WUAs should also be in charge of extension service activities to farmers
13	Irrigation Water Productivity	Productivity of irrigation water will be relevantly increased at farm level up to + 20 %
14	RISKS associated to the scenario	Increased state budget contribution to sustain wheat price and inputs. More inconsistency of agriculture plan with respect to what really farmers grow.
15	OPPORTUNITIES associated	Farmers own responsibility in water use. Safe in case of food crisis The improved organization of water delivery services will enable maintaining a food-security oriented agriculture set-up but will also allow for extension of irrigated areas where more market-oriented agriculture will be possible, once the food security level has been fulfilled.

## Annexe 3. Workshop program

<b>DAY 1 Saturday 18<sup>th</sup> October</b>	Lecture
17:00 19:00 Opening Ceremony Keynote addresses by Officials Introduction and Overview of Workshop Purposes	
<b>DAY 2 Sunday 19<sup>th</sup> October</b>	Lecture
8:30 <b>MASSCOTE</b> Introduction to FAO tools for developing Modernization plans. Vocabulary for irrigation system operation technique and principles of Service Oriented Management	
10:30 <b>IRRIGATION STRUCTURES</b> - Hydraulic principles- control levels and flows - Basic Structures: orifice and overflows, free flow -submerged <b>SYSTEM OPERATION TECHNIQUES</b> Operation organisation: from structures to systems	
13:30 <i>Lunch</i>	
15:00 <b>CANAL CONTROL TECHNIQUES</b> : Upstream control - Downstream Control – Procedures for scheduled and unscheduled operation	
15:40 <b>PUMPING PLANTS</b>	
<b>DAY 3 Monday 20<sup>th</sup> October</b>	
8:30 <b>PERFORMANCE in Canal Operation and Management</b>	
10:00 <i>Coffee-break</i>	
10:30 <b>MEASUREMENTS</b>	
12:00 <b>MASSLIS</b>	
13:00 <i>Lunch</i>	
14:45 Presentation on MASSCOTE STEP 1 ( <b>The Rapid Appraisal Procedure RAP</b> ): Presentation and preparation of the interview	
15:45 Presentation about the Project	
17:00 RAP Project Office Interviews with Management Staff	
<b>DAY 4 Tuesday 21<sup>th</sup> October</b>	
7:00 <b>FIELD VISIT</b> : Groups and visit to the <b>Headworks, Main Canal secondary and tertiary canals</b> <ul style="list-style-type: none"> <li>• Travel down the main canal, second level canal and third level canal stopping at cross regulators, and Interview main canal operators</li> <li>• Interviews with operations staff and tour of control structures</li> <li>• Interview with farmers</li> </ul>	
<b>DAY 5 Wednesday 22<sup>th</sup> April</b> <b>FIELD VISIT</b>	Resource persons
07:00 14:00 <b>FIELD VISIT</b> (2)	
15:00 Group sessions for filling the RAP sheets	
<b>DAY 6 Thursday 23<sup>th</sup> April</b>	
8:30 Group sessions for filling the RAP sheets	
14:30 RAP indicators aggregation and finalisation in plenary	

**Friday 24<sup>th</sup> April Day OFF**

<b>DAY 7 Saturday 25<sup>th</sup> April</b>	
8:30 Presentation MASSCOTE Steps 2 ( <b>Capacity and sensitivity</b> ) and 3 ( <b>Perturbations</b> )	
9:30 Working groups on Steps 2 (Capacity and sensitivity) and 3 (Perturbations)	
12:30 Reports on Steps 2	
<i>13:00 Lunch</i>	
14:30 Report on Step 3	
15:45 Presentation on analysis of pumping station capacity and energy consumption	
<b>DAY 8 Sunday 26<sup>th</sup> April</b>	
<b>08:30</b> Presentation MASSCOTE Step 4 ( <b>Water Balance</b> )	
09:00 Working group session on Step 4	
10:00 Coffee	
11:00 Working group session on Step 4	
11:30 Presentation on Step 6 ( <b>Service and Vision</b> ) development for water management strategy, service to users, management set-up, operators and objective of management, on water scheduling and targets for canal operation	
12:00 Group work on step 6	
<b>13:00 Lunch</b>	
14:30 Working session on step 6 – special working group session on step 5	
15:45 Report on Step 6 and finalization of the vision	

<b>DAY 9 Monday 27<sup>th</sup> April</b>	
8:30 Presentation Step 5 ( <b>Cost</b> )	
9:00 Presentation of the cost analysis	
9:30 Discussion on Vision	
9:45 Group work on vision	
<b>10:30</b> Coffee	
<b>11:00</b> Presentation Steps 7, 8 and 9 Management Units – Canal Operation demand and improvement strategies	
Group presentation on Steps 7,8,9	
<b>13:00 Lunch</b>	
14:30 Group work on Step 9	
16:30 Preparation for presentation	

<b>DAY 10 Tuesday 28<sup>th</sup> April</b>	
08:00 Preparation of the presentation	
10:30 Coffee Break	
10:30 Presentation of MASSCOTE-RAP outcomes and closing ceremony	
<b>13:00 Lunch</b>	
<b>14h30 16h00 Special meeting to organize the follow up next steps – MASSCOTE application in other countries and completion in Syria</b>	

## Annexe 4. List of workshop participants

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