MASSCOTE
December 2007

Modernization Strategy for Irrigation Management

UTTAR PRADESH- INDIA

JAUNPUR BRANCH SYSTEM

CURRENCY EQUIVALENTS

Currency Unit = Indian Rupee (Rs)
US$1.0 = 39.46 INR

MEASURES AND EQUIVALENTS

1 meter	=	3.28 feet
1 ha	=	2.47 acres
1 km	=	0.620 miles
1 cubic meter (m^3)	=	35.310 cubic feet
1 million acre foot (MAF)	=	1.234 Billion cubic meter (Bm^3)
1 cubic feet per second (cusec)	=	28.5 litre per second (l/s) = 0.0285 cubic meter per second (m^3/s)
TMC	=	Thousand Million Cubic Feet = 28.3 Million Cubic Meters
MCM	=	Million Cubic Meter

ABBREVIATIONS AND ACRONYMS

CA	Command Area
CCA	Culturable Command Area
CR	Cross regulator
DO	Direct outlet
FAO	Food and Agriculture Organization
FO	Farmer Organization
GCA	Gross Command Area
GOUP-ID	Government of Uttar Pradesh Irrigation Department
HJBC	Hyderagrad Jaunpur Branch Canal
ITRC	Irrigation Training and Research Centre (California Polytechnic University)
JBC	Jaunpur Branch Canal
LMA	Local Management Agency
MAF	Million Acre Feet
MASSCOTE	MApping System and Service for Canal Operation TEchnique
M&E	Monitoring and Evaluation
NCA	Net Command Area (irrigable)
NRLW	Land and Water Division of FAO Natural Resources Department
O&M	Operations and Maintenance
OFWM	On-Farm Water Management
PACT	Project Activity Coordination Team
RAP	Rapid Appraisal Procedure
UP-WSRP	Uttar Pradesh Water Sector Restructuring Project
WUA	Water Users Association

Executive summary

A Masscote training workshop was organised in Sultanpur Uttar Pradesh from 7th to 19 December 2007 for 30 engineers and managers as part of a collaborative program between the Government of Uttar Pradesh and FAO aiming at developing the capacity in modernization of irrigation management.

The Rapid Appraisal of Performance was carried out on Hydergarh and Jaunpur Distributaries by 5 groups coached by FAO staff and other resources persons from Karnataka. It appears that productivity of land (770 $/ha) and water (0.077$/m3) are significantly low compare to similar systems in the region. The internal indicators of Jaunpur Branch Canal (JBC) systems are also quite low. For instance service to farm units ranks 1.2 on a range [0-4].

The absence of water control (level and discharge) below distributary headworks. High density of illegal direct outlets along the main canal generating water logging in upstream reaches.The system looses progressively control generating acute problems of sensitivity and deficit at tail-end. It is noted the inaccurate or improper measuring structures at all levels.

The system takes advantage of being a genuine conjunctive use system however remarkably diversification and agriculture efficiency are inversely proportional to canal water supply: the less canal water you get the more diversified and efficient you are.

The capacity of the infrastructure for transport is facing some limitation due to heavy siltation. This has generated here and there an encroached free board in the upstream of the canal reaches. Siltation is obviously a serious constraint for maintenance and operation of JBC. Discharge measurements along the main canal are made at each jurisdiction change, however there is no periodic calibration thus the accuracy of data is not warranted.

Water level control along the main canal is fairly good, whereas along the secondary canal almost no cross regulators. The result is a progressive lost of water level control as the discharge is progressively reduced.

Sensitivity of offtaking structures is low along the main canal with two exceptions i.e. upstream the Hydergar Cross Regulator and one distributary downstream. Offtaking nodes along distributaries and tertiary canals are highly sensitive: a small change of the flowing upstream conditions result in a high variation of offtaking discharge. Some offtakes are obviously hyper-proportional.

One of the major sources of perturbation is the inaccuracy of the operation process itself which tend to rapidly increase the fluctuations downward (mainly deficit, exceptionally surplus during Kharif). Excess and illegal water withdrawal is also a major source of perturbations which leads to both water logging upstream and water deficit downstream.

Water is abundant in the GCA, total inputs of 7063 MCM is made of 55% Rainfall and 45 % canal water. The water consumed through evapotranspiration of irrigated crops represents 27% of this input (1880 MCM), while the remaining is shared by non crop vegetation, seepage, deep percolation and drainage.

A vision of the irrigation system was crafted by participants, it is as follows:

"A strong Service Oriented Management with Integrated Multiple Use Water Resources Management practices, balancing surface and groundwater potential, supporting a productive agriculture system and sustaining the eco-system"

Modernization strategy and plans were also discussed and although a consistent modernization project was out of reach for this short exercise, some ideas discussed by participants might be worth considering.

The water management strategy should reformulate the concept of equity with regards to all sources of water and not restricted to canal water only. A drainage strategy should be proposed to avoid water logging. Water accounting should be promoted at various scales.

The previous concept of "pushing water" should leave the way to a concept of serving user groups with more flexibility, an increase reliability, to cope with the demand from users dictated by local water conditions and/or by their willingness to pay for a good service should be as far as possible taken on board. The service to agriculture should be defined for sub command areas and for individual farmers, looking at allocation, scheduling and water deliveries. The definition and the spatial variation of the service should be based on objectives criteria related to the various sources of water supply.

Canal services must be designed considering other sources rainfall, runoff during Kharif as well as recycling facilities and in some location access to groundwater.

Control exercised along the network of canals on the flows are by far too low to avoid chaos prevailing, water scarcity and water logging. The modernization project should aim at:

- regaining the water level control along the main canal diminishing the tolerance on water depth variation to 10 cm
- install effective control structure along the distributaries
- equip all withdrawing structures with appropriate gates.

Some of the measures that should be considered:

1. Introduction of SCADA for real time information monitoring
2. Recycling water through shallow wells in the area close to the canals.
3. Installation of measurement devices at all levels
4. Automation of the Cross-regulators
5. Remodelling the canal to increase the conveyance capacity
6. Optimised the cost of operation
7. Water balance studies at local levels.

Introduction and Background

A FAO mission[1] visited Uttar Pradesh India to carry out a MASSCOTE training workshop in Sultanpur Uttar Pradesh from 7th to 19 December 2007 as part of a collaborative program between the Government of Uttar Pradesh and FAO.

This mission is the first MASSCOTE exercise organised by FAO for GOUP, another 2 other studies are planned as part of the FAO-GOUP collaborative activities aiming at developing the capacity in modernization of irrigation management.

The mission organized a training workshop on modernization of irrigation management for 30 participants with a focus on Jaunpur Branch Canal System, field visits and working group sessions together with short lecturing have been carried out from 7th till the 19th December 2007.

The application presented here has been developed through a training workshop in Uttar Pradesh with engineers and managers from the GOUP-ID. The conclusions and proposals are still under a process of refinement and validation by the UP-ID and FAO, what is proposed here is reflecting the outcomes of the working group sessions at this 2 weeks workshop on the first 8 steps of MASSCOTE. Further investigations should be carried out to complete the approach.

This MASSCOTE draft report serves several purposes:

- produce food for thought for decision-makers of GOUP before engaging in investment plans, particularly on how to ensure that diagnosis and solutions are investigated properly in modernization projects;
- suggest some specific strategies to managers of Jaunpur Branch Canal System on how they should make the best use of the modernization investment made recently.
- lay the foundations of follow up interventions on modernization of irrigation management in other sections of the CA.

FAO involvement in irrigation management modernization

Since the mid 90s FAO has contributed a lot to the promotion of modernization in irrigation management particularly in Asia through the Bangkok regional Office and FAO HQ. To name a few activities, in 1996 and 1998 FAO organized key International workshops on Modernization, respectively in Bangkok and in Aurangabad (India).

For FAO modernization means not only modern techniques but institutional reform and implementation of service oriented management. FAO 1997 Definition of Modernization: *A process of technical and managerial upgrading (as opposed to mere rehabilitation) of irrigation schemes with the objective to improve resource utilization (labor, water, economics, environmental) and water delivery service to farms.*

[1] The FAO mission consisted of D. Renault, (Senior Irrigation Management Officer, NRLW FAO HQ Rome), and P.S. Rao (Senior Officer of India FAO Bureau Delhi), together with two resource persons from KNNL Karnataka Mrs Shiva Kumar and Mahesh, assited by Mrs N.V.Muralidhar, R.R.Kulkarni and Manohar V. Rotte.

During the last decade FAO activities on modernization has led to progressively produce key tools and methodologies to assess and benchmark the performance or irrigation system, and to develop consistent strategy for modernizing the management and the operation of the irrigation systems. The latest developed tool is MASSCOTE for Mapping System and Service for Canal Operation Technique, which complements previous and has been largely field tested in Karnataka State in 2006 and 2007.

In support to country members FAO advises developing strategy on management modernization with a multifold and multiscale dimension:

- the irrigation **project dimension** is obviously the major entry point to come up with realistic and practical solutions, through working on projects we are able to come up with practical solutions and at the same time we raise the capacity of engineers in handling modernization
- **a national or state strategy for modernization** is then the next logical step, on the basis of few representative projects, together with an approach of typology of irrigation systems, this allow building up the technical capacity as well as organizing the capacity development at national level aiming at capitalising knowledge.
- today the concept of **Integrated Water Resource Management** (IWRM) must be taken on board in the process of irrigation management as irrigation systems are often the unique permanent water source within the command areas.
- lastly the **professionalizing of irrigation management** which is instrumental to achieve high efficiency in irrigation management, needs to be sought for at 3 levels: project level through **good governance and technical capacity at WUAs,** and the national and public level in which Public bodies such as the Department of Irrigation have to undertake a complete **re-engineering** and renewal of their mandate and modus operandi, **the private sector** (civil society and private firms) which is called to play an increasing role in technical support of irrigation management through the design of modernization projects and or through the capacity developments.

1. THE MASSCOTE APPROACH

The methodology used in the study is called Mapping System and Services for Canal Operation Techniques (MASSCOTE). It has been developed by the Land and Water Division (NRLW) of FAO on the basis of 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.

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

- service to users
- cost of producing the services
- performance 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 is required in order to determine a consistent plan. Some steps need to be rediscussed and refined several times before achieving a satisfactory level of consistency.

Presentation of the methodology

The first steps of MASSCOTE 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.

MAPPING....	*1. PHASE A BASELINE INFORMATION*
1. THE PERFORMANCE RAPID APPRAISAL PROCESS (RAP)	Initial rapid system diagnosis and performance assessment through the RAP: the primary objective of the RAP is to allow qualified personnel to systematically and quickly determine 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 AND SENSITIVITY of the SYSTEM	The assessment of the physical capacity of irrigation structures to perform their function of conveyance, control, measurement, etc. Assessing the sensitivity of irrigation structures (offtakes 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 with
4 THE NETWORKS & WATER BALANCES	This entails assessing the hierarchical structure and the main features of the irrigation and drainage networks, on the basis of which partition of the system into subsystems will be made. Water accounting should be undertaken, considering both surface water and groundwater, and mapping the opportunities and constraints related to them.
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 level of services with current techniques and with improved techniques.
	2. PHASE B IMPROVING CANAL OPERATION MATURING SERVICE ORIENTED MANAGEMENT
6 THE SERVICE to USERS	Mapping and economic analysis of the potential range of services to be provided to users at various levels of the systems. The services should be based on a compromise between the water management strategies, the agriculture objectives and the willingness to pay by users.
7 PARTITIONING INTO MANAGEMENT SUB-UNITS	The irrigation system management should be partitioned into few level of management and the command area should be divided and subunits (subsystems and/or subcommand areas) that are held homogeneous and/or separate from one another by a singular point or a particular borderline.
8 ASSESSING THE DEMAND FOR OPERATION	Assessing the resources, opportunity and demand for improved canal operation at the different levels of management and within the local management units.
9 IDENTIFYING CANAL OPERATION IMPROVEMENTS	Identifying improvement options (service and economic feasibility) for each management unit for (i) water management, (ii) water control, and (iii) canal operation)
10 INTEGRATING AND CONSOLIDATING MANAGEMENT	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
A PLAN FOR MODERNIZATION AND M&E	Finalizing a modernization strategy and progressive capacity development Select/choose/decide/phasing the options for improvements Plan for M&E of the project inputs and outcomes.

Table 1. The 10 Steps of MASSCOTE

2. The Jaunpur Branch Canal System

The project is located in the South-Eastern part of the State. The Jaunpur Branch Canal (275,000 ha) is part of the large Sarda Sahayak Project which covers about 1 million hectare of CA.

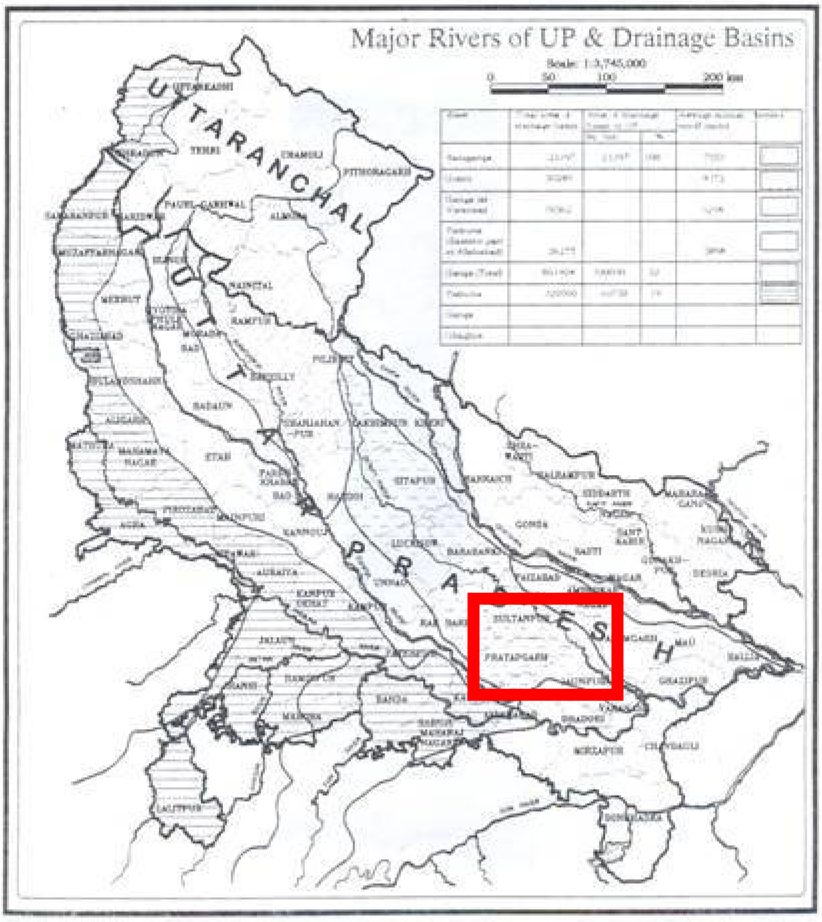

Figure 1. Uttar Pradesh map with the location of the Jaunpur Branch System.

Government of Uttar Pradesh has adopted a “State Water Policy” and an Action Plan to implement the same. To achieve the objectives of the “State Water Policy” the Government of Uttar Pradesh has received a credit equivalent to US$150 million towards the cost of “Uttar Pradesh Water Sector Restructuring Project”, through the Government of India. The UPWSRP envisages a comprehensive program of reforms in management of State Water resources in general and irrigation, drainage and ground water in particular.

Rehabilitation and modernization of irrigation system of Jaunpur Branch Canal command area covering about 275,000 ha of culturable command and associated drainage network in the Gomti Sai sub basin and the piloting of replicable management option for sustained irrigation and drainage operations is one of the main objective of the assignment.

The canal systems of the state are generally under-performing due to both non availability of full irrigation water supplies as well as management and operational problems. In order to provide reliable water delivery services and to upgrade / modernize the water use / management processes, a “Pilot Project Area” has been identified for the above assignment.

It includes rehabilitation and modernization of the irrigation and drainage system of the Jaunpur Branch Sub basin including Haidergarh branch of Sarda Sahayak Project.

The redesigning of irrigation and drainage system under "piloting reform options for irrigation and drainage operations" component of the project has been carried out by Tahal Consulting Engineers Ltd., Israel and implementation of the proposed solutions by this firm had started at the time of the Masscote workshop.

Uttar Pradesh Water Sector Restructuring Project [UP-WRSP]

The development objectives of the Uttar Pradesh Water Sector Restructuring Project are to: a) set up an enabling institutional and policy framework for water sector reform in the State for integrated water resources management; and b) initiate irrigation and drainage sub-sector reforms in the State to increase and sustain water agricultural productivity.

Formulated early 2002, the UP-WSRP started effectively in 2004. The investment plan amounts to 150 million $ and encompasses 5 main components:

Component A: Creation of Apex Water Institutions and Strengthening Socially and Environmentally Sustainable Multi-sectoral Water Resources Planning, Allocation and Management Capacity

Component B: Irrigation Department Reform, Capacity Building and Business Process Re-engineering

Component C: Piloting Reform Options in Water Resources Management

Component D: Piloting Reform Options in Irrigation and Drainage Operations (PROIDO)

Component F: Project Activities Coordination

The two major boosts of the program are components B (22 % of the budget) and D (58%).

Collaboration between GOUP and FAO are part of components B [Re-engineering of DOI] and D [PROIDO].

For component B on DOI reform, the objective of the collaboration program is to ensure that the lessons learned in UP would be of value elsewhere, this deals with the knowledge-based and normative mandate of FAO.

For component D on Piloting Reform Options Irrigation and Drainage Operations, the objective is to share mutual experience in carrying out some capacity development activities and to learn from the implementation of current modernization projects. **The focus of the collaborative work is on component D** and more particularly **on D1 and D3** (see appendix I) looking at:

- Modernization of the main system: flow control and regulation
- Feasibility of Service Oriented Management

JBC Project Description

Jaunpur branch takes off from the Haidergarh branch as its km 22.98. The Haidergarh branch, itself, which is serving as carrier for the Jaunpur branch system, takes off from the left bank of the main feeder canal at its km 171.5 (see Figure 2). The head discharge capacity of the Jaunpur branch is 123.2 cumec. The salient features of the canal systems of Jaunpur branch canal command are:

(i) Head discharge Capacity - 123.2 Cumec,
(ii) Length of Jaunpur branch – 119.45 km,
(iii) Gross Command Area – 5.54 lakh ha,
(iv) Culturable Command Area – 2.75 lakh ha,
(v) Distributary and minor canal system.

13 Distributary canals off take from the Jaunpur branch.

The Jaunpur branch canal covers a Culturable Command Area of 2,75,000 ha in districts Barabanki, Raebarely, Sultanpur, Pratapgarh and Jaunpur.

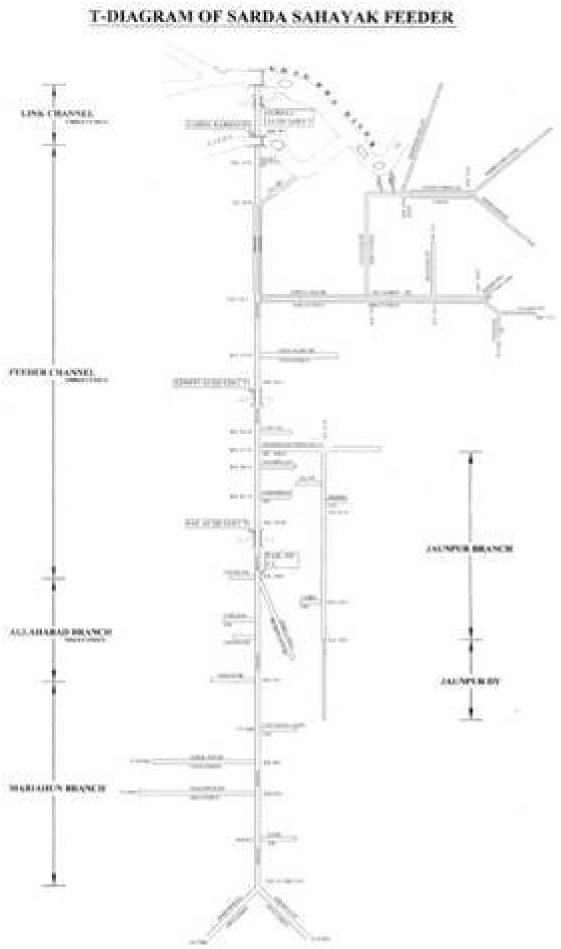

Figure 2 Layout of the Sarda Sahayak project

3. MASSCOTE in Jaunpur Branch Canal

Step 1. RAPID DIAGNOSIS: RAP

A RAP (Rapid Appraisal Procedure) was carried out as part of the first step of the exercise during the December 2007workshop. The following sections is the RAP executive summary.

RAP Methodology

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 provide a basis for making specific recommendations related to hardware and management practices. The first step in evaluating irrigation performance, whether at the farm level or an entire irrigation project, 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 that 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 held 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 efficient.

Key performance indicators from the RAP help to organize perceptions and facts, thereby facilitating the 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 labor, improved social harmony, and an improved environment by reducing a project's diversions or increasing the quality of its return flows. <u>In general, these goals can only be achieved by paying attention to internal details, or the internal indicators</u>. 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

When one analyzes a project by "levels" (office, main canal, second level canal, third level canal, distributaries, field), a huge project can be understood in simple terms. 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 precisely to start 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.

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.

RAP in JBC

A Rapid Appraisal Procedure was carried out in JBC system focussing on planned project operations and the current status of canal system infrastructure. The objective was to identify the key factors related to water control, measurement and communications in the system as well as to the social organisations. The completed results of the RAP including those for the main canal, secondary and tertiary canals, and final deliveries are contained in excel files attached to this report.

Participants were divided into 5 groups:

- **Group 1: 0 to 23 Hydergarh and 0 to 23 Jaunpur D. Dy of 70 km**
- **Group 2: 27 to 56 km of Jaunpur & 4 distributaries**
- **Group 3: 56 to 77 km of Jaunpur & 3 distributaries**
- **Group 4: 77 to 110 km of Jaunpur branch & dys**
- **Group 5: Tail end**

They spent 2 days on the field and gave ratings to all internal indicators. During a plenary session rating were reviewed and finalized.

Note:

1) The **RAP** carried out in JBC system refers exclusively to the **situation prevailing before the modernization proje**ct. Wherever works have already started (desiltation, water control, ...) they have not been accounted for and the ranking has been made strictly with reference to the situation before project started.

2) The RAP in JBC can therefore be used as a reference diagnosis to monitor the impact of the on going modernization project

External 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 a benchmark for monitoring the impacts of modernization on improvements in overall performance.

A first estimation of the external indicators has been carried out during the workshop. It has led to the estimated value per ha of 770 $ while productivity of water amounts to 0.077 $ m3. Both external indicators are low with respects to national and international standards, this is more the consequence of recorded low yields than a low productive cropping pattern.

Internal Performance Indicators

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

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). The complete set of internal indicators ranked by each group is given in appendix 2.

Features about the Service

Social Order

Social "Order" in the Canal System operated by paid employees	**1.3**
Degree to which deliveries are NOT taken when not allowed, or at flow rates greater than allowed	**1.8**
Noticeable non-existence of unauthorized turnouts from canals.	**1.2**
Lack of vandalism of structures.	**0.4**

Table 2. Social Order indicators

The social order in JBC is ranked low 1.3.

Service to farmers

Actual Water Delivery Service to Individual Ownership Units (e.g., field or farm)	**1.2**
Measurement of volumes	**0.2**
Flexibility	**1.2**
Reliability	**1.2**
Apparent equity.	**1.4**

Table3. Service to farmers

The service to farmers is ranked very low [1.2] significantly below average when compare to others system worldwide (Figure 3).

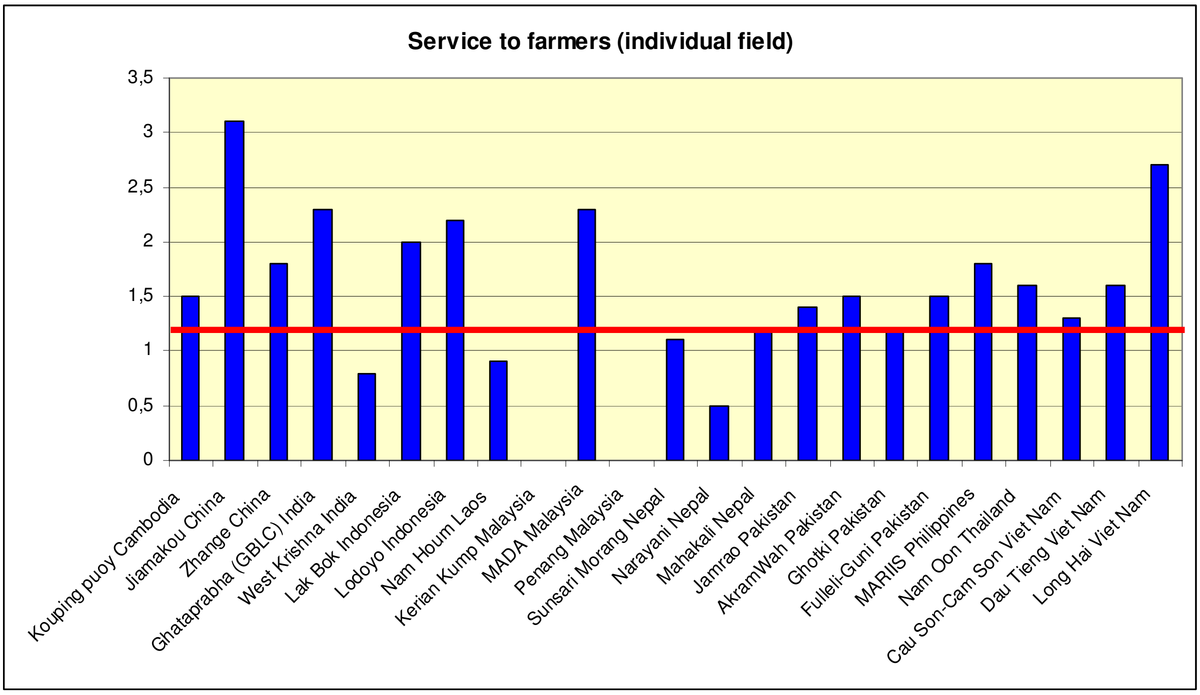

Figure 3. Service to farmers

Service by main canal

	Actual	Stated
Actual Water Delivery Service by Main Canal to the Second Level Canals	**1.9**	**3.3**
Flexibility	**1.4**	**1**
Reliability	**2.4**	**4**
Equity	**2.4**	**4**
Control of flow rates to the submain as stated	**1.6**	**4**

Table4. Service from main to secondary canals

There is a high gap between what the managers think they are doing in terms of delivery services and the actual estimated on the ground. The highest differences are obtained for reliability and control of flow rate.

Overall quality of canal Operation declines downward

Main Canal	Secondary Canal	tertiary canal
2.1	1.9	1.6

Table 5. Aggregated Indicator of operation per level

The quality of operation is assessed through averaging indicators on CR, turnouts, communication general conditions and operation. The resulting indicator shows declines from 2.1 for the main canal to 1.6 for tertiary canals.

WUA

Water User Associations	**1.4**
Percentage of all project users who have a functional, formal unit that participates in water distribution	**1**
Actual ability of the strong Water User Associations to influence real-time water deliveries to the WUA.	**2.4**
Ability of the WUA to rely on effective outside help for enforcement of its rules	**1.2**
Legal basis for the WUAs	**2**
Financial strength of WUAS	**1**

Table 6. Water Association assessment

The ranking for WUA is low.

Main features of JBC reported from field visit

Beyond the indicators of RAP the main features reported by the groups are as follows:

1. It is a genuine conjunctive use system.
2. Diversification and agriculture efficiency are inversely proportional to canal water supply: the less canal water you get the more diversified and efficient you are.
3. The absence of water control (level or discharge) below distributary headworks.
4. The inaccurate or improper measuring structures at all levels.
5. Highly sensitive offtakes along distributories and minors leading to chaos in the water distribution.
6. Limited conveyance Capacity: encroached free board upstream of the canal reaches.
7. Siltation is a serious constraint for maintenance and operation.
8. High density of illegal direct outlets along the main canal.
9. Water logging in upstream reaches. Off-take gates to minors are inexistent or damaged.
10. Escapes are insufficient and uneasy to operate

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 Capacity

The capacity issues have been scrutinized by participants. The following functions were considered as the important ones to be checked for capacity at different levels of the Jaunpur Branch Canal system:

1. Regulating capacity of the head regulator.
2. Conveyance and Carrying capacity of the system (reduced flow is suspected as a result of high siltation)
3. Measurements at the border between management units.
4. Measurement skills
5. Functioning of CRs
6. Remote monitoring (including rainfall data in the command) along main canal
7. Escape capacity and measurements
8. Seepage measurements.
9. Special structures
10. Communication system (Road and telecommunication / wireless)

Theses functions are analysed below considering successively various levels of the system.

Regulating capacity at head

The entire irrigation system is a run-off the river type and neither head nor intermediate reservoirs can help management in smoothing the fluctuations between demand and supply. Normally these fluctuations depend largely on the flexibility allowed to the users. At present flexibility of the service is low and experienced fluctuations (see STEP 3) are mainly generated by uncontrolled outlets along the main canal. In the future the fluctuations will thus depend on how far the uncontrolled outlets have been reincorporated in the management and how flexible the future service will be.

Once the needs for regulating fluctuations have been properly investigated, the capacity to accommodate some flexibility in the running discharge should be explored in two ways: online buffer storage or using volume control along the main canal.

A. Main system: Head works, Branch Canal.

Carrying capacity of the main system
The carrying capacity along the main system is reduced due to severe siltation (plate 1) which is a result of the heavy sediment load from the river. The silt is inherent in the system. Another aggravating factor is the flat topography, canal slope is too low to allow high velocity particularly at the tail reaches causing siltation. The vegetation and weed growth and scour of the sides (plate

2) add to the problem of reduction in capacity of the canal apart from the irregular section of the canal causing change in the characteristics of the canal such as roughness coefficient and shape of the canal section. How much the capacity is reduced is a question that needs to be answered with reliable measurements. Clearly an accurate estimation campaign of where and to what extent the capacity is reduced must be carried out before qualifying these problems as serious needing strong immediate interventions.

Plate 1. Jaunpur Branch Canal km.74
Heavy Siltation

Plate 2. Jaunpur Branch Canal km.72
Slipping of canal side

Measurements at the border between management units.

Along the main canal, there are twelve measurement points (12) upstream of cross regulators (near major offtakes) which are also locations of change of jurisdiction of management units (7 Divisions).
Rated section and staff gauges are used for flow measurements. However, no periodic calibration is carried out to keep a good accuracy of measurement and some gauges are in poor condition (see Plate 3.) . The gauge registers have been maintained properly and gauge man taking reading at 12 hrs intervals.

Measurement skills

The measurement skills are inadequate. The gauges are not calibrated periodically; the methodology of recording discharges is approximate and vague as the canal characteristics would have changed appreciably since the previous calibration. The gauge readers are not educated, but still the gauge registers are maintained well.

Plate 3. Gauge for discharge measurement on Jaunpur Branch canal

Plate 4. Typical Cross-regulator along the main canal (CR at 35.52 KM of JB Canal)

Functioning of Cross Regulators

There are 12 cross regulators (CR) along the Jaunpur Branch canal. All the CRs are operating and functioning moderately well. They are in fairly good condition and well maintained. The operation is manual requiring 2-3 operators even sometimes 4 as shown on plate 5 and cumbersome and time consuming to operate.

Typical variation of water level upstream of the cross regulators (Kms 22 to 120) is between 20-30 cm. The cross regulators are really used here for water level control i.e upstream control. With this typical variation of water level (tolerance on control), the major distributaries which are having low sensitive offtakes at head are not affected much. Only direct minors which are having medium to high sensitivity are experiencing significant variation of discharge as a result of water level fluctuations.

Plate 5. A difficult to operate cross-regulator along JBC: 4 people required for gate setting.

Remote monitoring including rainfall data in the command

During rainfall in khariff, since the source of water is directly from the river (run-of-the river scheme), generally, the weekly roaster is mainly based on crop water requirement and cropped area. However, when there is extensive rainfall in the command area, there will be reduction in discharge to avoid inundation / water logging, especially, in Sultanpur District where the drainage network is very poor and susceptible to water logging. The appropriate strategy for management of the surplus canal water entering into command area during rainfall would be by diverting the flows to the areas of less rainfall, ground water recharge, fish ponds and irrigation tanks for optimizing the utilization.

Escape capacity and measurements

There are four escapes along the Hydergarh Jaunpur Branch canal from Km 0 to 143. There are no measurement devices in these escapes. Excess water coming into the branch canal is meant to go to the nalas (drainage streams) through these escapes. However, in reality, the escapes are not functioning properly because of choking of drains, poor maintenance and flat topography making evacuation of surplus flows extremely difficult. In case of emergencies, the number of escapes is found to be insufficient in the canal. The escapes are seldom operated.

Seepage quantification

The issue of seepage quantification is critical with regards to several aspects of water management and system operation:

- **Water logging** is high in the upstream reaches of JBC: it is critical to understand the partition of excess water between seepage and over irrigation at field level.
- **Loss of canal discharge** reducing availability of flow to tail end
- **Cost and energy input**: even though one can consider that water balance is not negatively affected by seepage losses, this water is usually recovered at a financial cost/energy input. Clearly reducing seepage can reduce energy spending and cost of pumping in the command area.

Seepage on the branch canal is the result of unlined canal for entire reach. In Jaunpur branch sub-basin, unbalanced use of surface water / ground water is noticed. The undesirable seepage from the canal system is adding to substantial recharge of ground water which is best exploited only by the tail end farmers. Quantum of seepage is not measured for entire branch canal. The seepage depends on numerous parameters: soil characteristics (permeability); geometry and hydraulics of the canal, climatic conditions, sediment deposition and velocity of flow and groundwater table. Some studies taken up by the project authorities reveal that the estimated seepage loss is of the order of 13.94 cumecs in entire length of Hydergarh and Jaunpur canal for a peak discharge of 165.5 cumecs, which is about 9 %.

Special structures: Siphons

There are 20 drainage siphons along JB canal. The cross drainage works are of siphon type only, invariably with some problems of capacity due to absence of defined nala course. This is also causing water logging in the vicinity of the siphon when leaks occurred.

Communication system (Road and tele-communication / wireless)

The service road along most of the Hydergarh Branch and Jaunpur Branch on either side is motorable. Due to unauthorized offtakes and also raincuts, the sides are eroded causing hardship for communication and increased travel time and unsafe for movement of vehicles. The service roads also provide connectivity to the villages serving as means of communication for passenger movement and transportation of agriculture produce and they are helpful in regular transport of villagers.

Tele-communication / wireless : At present, there is lack of (official) direct communication system to monitor canal operation and specifically the information of gauge level and demand of water between field level staff and the controlling level staff. Normally, field level staffs have to travel 5 to 8 Kilometres for conveying periodical information and it will be very difficult during emergent and alarming situation. Unofficially the mobile phone technology has changed the situation, as almost every staff of irrigation has his own private mobile phone, and this is used for communication.

Human capacity building

In the irrigation networks of Hydergarh and JBC, right from branch canal to secondary and tertiary canals, there is a need to increase the information about the flows and the status of the main structures. To do so, the gauge records at the off-take points should be maintained and gate operators should be trained to understand the calibration of gauging as well as, the calibration of opening of gates of off-take points and also regular maintenance of measuring units and the gates of the offtake point.

B. Secondary system: distributaries

Water level control
The secondary system of Hydergarh and JBC mainly consists of 10 No. of major distributaries. There are a large number of direct minors (51 Nos.) offtaking from the branch canal. The total length of this distributary system amounts to 465 Kms.

CRs are far insufficient to perform the required water level control. The existing CRs are functional and periodically operated in order to control water level in the secondary system whenever required. Density of cross regulator on secondary system is too low.

Measurements
There are no measuring devices at headwork of ditributaries. Only staff gauges are provided at the offtakes. No periodic calibration is done. Further, it is observed that there are no measurement devices to ascertain water level upstream of the few existing cross regulators.

In order to have a rigorous approach for proper reading, computing and calibrating the readings of the measuring devices, the operation staff such as gauge readers, inspectors, supervisors (A.E. / J.E.) are to be trained for systematic observation of reading, recording and computation. Also, periodical calibration should be done for measuring devices. The process will help in up keep of the details for better management of the system.

Telemetry
At present, the secondary canal networks are operated based on a distribution plan with some downstream adjustments from operating staff. There is some time lag in the data transmission which is responsible for important delays in responding to water demand adjustment. There is no communication of real time rainfall data, discharges at key locations and downstream demand for adjustment to the central office. The consequence is that both excess water in the system due to rainfall in the command area and deficit due to reduction of flow in the main canal, are not properly managed.

Safety
Safety structure: The secondary canal system is not equipped with safety structures like escapes.

Sensitivity of the off-takes
The secondary system consists of a large network of approx. 825 Kms. serving about 500 offtakes.
Field observations during December 2007, show that contrary to the situation found along the Branch canal, the offtakes along the distributaries are much more sensitive. In the absence of offtake gates, the sensitivity tends be very high (4 and above). An example is shown on Plate 6, the discharge withdrawn at this point is likely to highly fluctuate when water level in the distributary fluctuates.

Plate 6. Golahi Minor Offtek on Nagapur Dy.@   KM 32.02

Each turnout along the distributary should be studied case by case for its sensitivity, with reference to the existing situation as well as a future situation where the water level control along these canals has been fully restored. It might happen that discharge fluctuations at sensitive offtakes will become acceptable once the water level control in the distributary has been properly achieved.

Seepage:
There is obviously some similarity of seepage causing water logging between the branch canals and the distributaries.

Communication system (Road and telecommunication)
It is noticed generally that the secondary canal service roads are not in motorable condition, which is one of the main reasons causing delay in mobilization of men and machinery during maintenance as well as at times of emergency.

C. Tertiary system: Minors and Quaternary system: Field Channel

Operation
The offtakes on minors (kulabas) are ungated and the absence of water level control structures along minors result in chaotic management. The farmers put up temporary earthen bunds to divert the flows and get their share of

Plate 7 .Tail end of Shivgadh minor of Jaunpur   Dy .Lack of control structure

Seepage
Due probably to the unreliable services of canal water, farmers upstream are usually practicing over irrigation whenever they get access to water. The excess of water (more than the crop

requirement) gets deep into the underground and it is noticed that water table is high. Inversely he tail-enders of the FICs are suffering from shortages of water and are practicing conjunctive use of ground water.

SENSITIVITY of the irrigation structures

Variable sensitivity along main canal

The sensitivity of irrigation structures along the main canal is quite variable as one can see in figure 4.

The sensitivity of the cross regulators is low to medium, there is no substantial head difference between upstream and downstream of the CR. For cross regulators sensitivity expresses the ratio of the variation of water level and the variation of the main discharge. For instance the CR referred 13 has a sensitivity indicator of 0.6 i.e. for a variation of 5 % of the discharge in the main canal, water level will vary at the CR of 0.03 meter (3 cm) which is very low.

The sensitivity of major distributary offtakes ranges from low to very high (see figure 4). Out of 14, 3 are low sensitive (S indicator <0.5), while 7 are medium (S indicator between 0.5 and 1.5) and 4 high to very high (S indicator greater than 1.5).

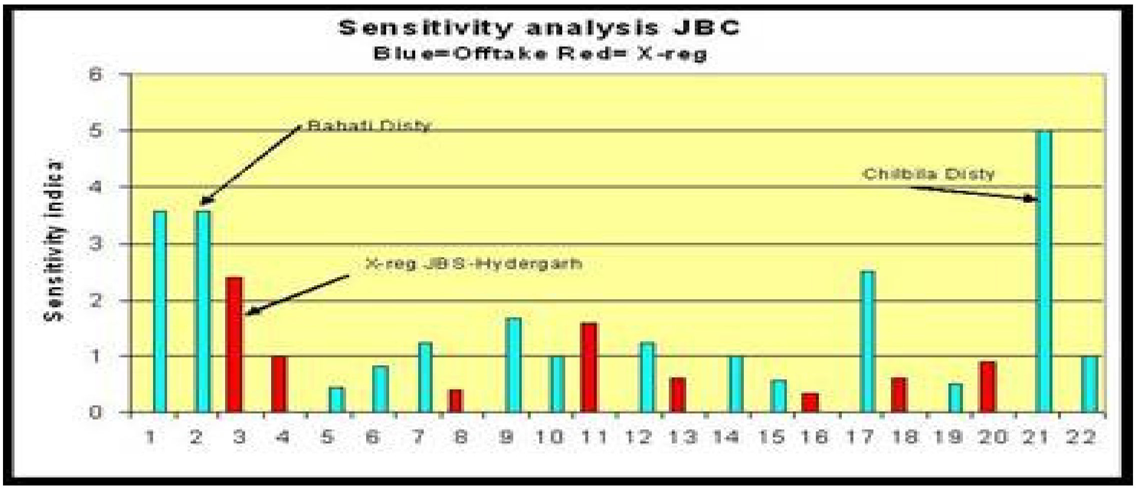

Figure 4. Sensitivity of CR and Offtakes along JBC

Table 7 examines the sensitivity indicators estimated at the offtaking structure along the canal and the resulting variation of discharge for two level of water control: when water level is controlled at 20 cm and when it is controlled at 10 cm.

From this table it is clear that the current control exercised along the main canal which has been reported as characterized by a variation of 20cm of water level, is insufficient to keep a steady discharge at the offtakes. Only 3 offtakes are below 15% of discharge variation. An increased control of water depth at 10cm would put most of the offtakes lower than 12.5 % variation of discharge. Still offtakes 1, 2, 17 and 21 needs some more specific interventions, basically to reinstall a slide gate in order to allow enough head between the main canal and the distributary to reduce the sensitivity.

Offtaking Structure Ranking as on fig. 4	1	2	5	6	7	9	10	12	14	15	17	19	21	22
Sensitivity indicator	3.5	3.5	0.45	0.85	1.2	1.67	1	1.25	1	0.56	2.5	0.5	5	1
Discharge variation in the distributary for a ΔH of 20 cm (percentage)	70	70	9	17	25	33	20	25	20	11	50	10	100	20
and for ΔH of 10 cm (%)	35	35	5	8	12.5	16	10	12.5	10	5	25	5	50	10

Table 7 offtake sensitivity along JBC and resulting discharge variation for a typical variation of head

Very high Sensitivity along distributary canals and minors

There is no water control structure along the secondary canals [distributory and minors] therefore water level is dictated by on going discharge. The sensitivity indicator for water level in a non regulated section of a canal is given by following equation:

$$S=[H/(1.7)]$$

H being the water depth at the considered point.

For a water depth of 0.85 meter S is equal to 0.5, this means that a variation of the discharge of 20% will be reflected by a variation of water depth of 0.1 meter (10 cm).
Sensitivity of the structure offtaking from the distributary and minor is extremely high (5 or more). Canals are not water depth regulated and offtake are ungated. Management of flows is impossible and chaos prevails!

Plate 8. Low sensitive CR 44.26 KM: Overshot [gates opened, head on crest = 1meter S= 0.50]

Plate 9. Typical offtake along a minor serving a field channel highly sensitive to variation of water level S=6 Detailed calculations are given in table 8.

Variable	Minor	Field channel
Water depth H	H=0.75	H=0.25
Sensitivity for water depth in the minor	S= ΔH/[ΔQ/Q]	
Sensitivity for water withdrawal of the field channel		S= [Δq/q]/(ΔH)
Exponent "α" of the discharge head relationship	1.66	1.66
Estimator of sensitivity	S= H/ α S=0.75/1.66 = 0.45	S= α / H S=1.66/0.25 = 6.64
Assuming an INPUT variation of discharge of	10%	
Resulting water depth change	ΔH = S . [ΔQ/Q] ΔH = 0.45. 0.1=0.045 4.5 cm	
Resulting variation of discharge at the field channel		[Δq/q]= S ΔH [Δq/q]= 6.64x0.045=0.3 30%
Conclusion		**Offtake highly sensitive** and **hyperproportional** For a discharge change of 10% in the parent canal, the change in the field channel is 30%.

Table 8 Sensitivity assessment for the offtake shown in plate 9.

STEP 3: THE PERTURBATIONS

Objective: *Identifying and characterizing positive and negative perturbations, their dimensions, origin, frequency and timing, location, size and amplitude and options for coping with.*

Water level perturbations along the Branch Canal

One source of perturbations is related to inaccuracies of the process, which leads to increasing fluctuations downstream of the network. The absence of proper measuring devices, water control devices and data acquisition lead to following complexities in canal operation:

- Inaccurate discharge measurements and uncertainty of off-take and regulator operations.
- Inaccuracy of data for assessing water demand (due to self-imposed cropping pattern) and variation of flows in the river main source of water for the CA (run-of- the river)
- Imprecision in anticipating the impact of downward propagation of waves caused by operation itself.
- Inaccurate gate setting of off-takes and cross regulators.

Plate 10. Jaunpur Branch Canal km.72

Discharge perturbations

As the system is "run-of- the river system", it is subjected to greater variability in inflow causing perturbations as reported in Figure 5. The inaccurate measurement, the lack of real-time data, further add to increased perturbation in the downstream of Jaunpur Branch Canal.

Excess and illegal withdrawals

Fluctuations of the flow occurring along the Branch canal is due to illegal off-takes. But along the secondary and tertiary canals, it is not only due to illegal withdrawals (Plate 11)but also with temporary earthen bunds (Plate 12) to raise water level in the absence of proper water control device causing extremely high perturbations for downstream users. Even the legal drawal from the branch canal for religious ceremony at Allahabad (confluence of Ganga-Yamuna rivers) and for drinking water supply to Lucknow city during summer also cause perturbations.

Self-imposed cropping pattern

The absence of real-time data regarding the type of crops sown, calendar and estimation of water requirement per crop, results in high fuzziness in assessing water demand. This leads to frequent adjustment of the flows to respond to downstream demand causing variation in discharge and thereby perturbation.

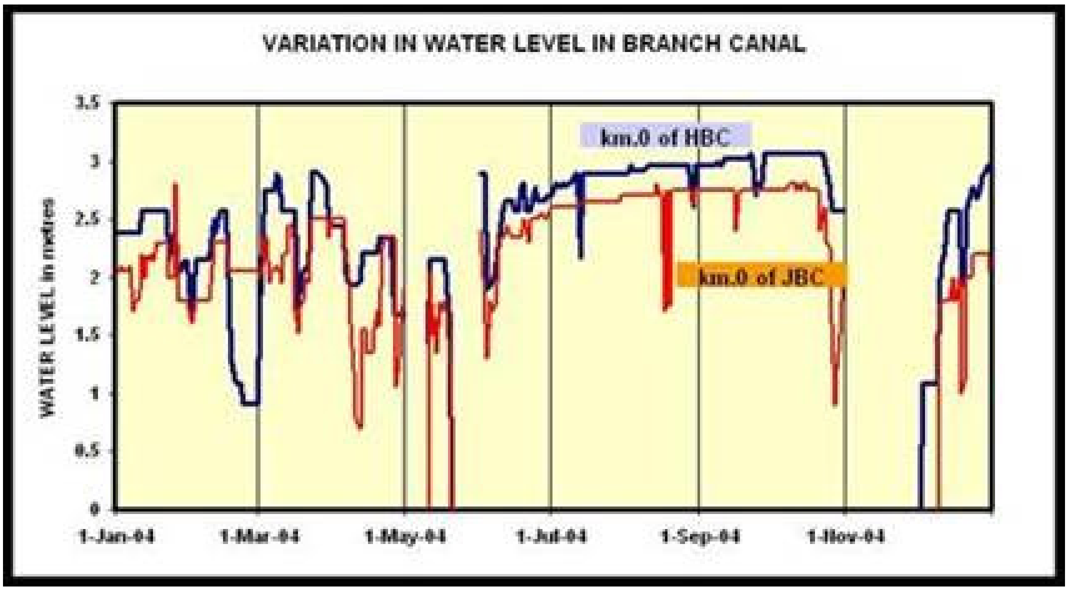

Figure 5. Water levels records at heads of JBC and HBC

Plate 11 . Jais Dy Illegal offtake.

Plate 12. Trilokpur Minor on Jaunpur Dy.

Sudden gate closure (during rainfall)

During rainy season where showers occurred in the command area, farmers are tempted to close the gate turn-outs to avoid flooding of their lands while crops no longer need irrigation water. Such interventions lead to high perturbations and risks for the canal.

Night and day irrigation

The canal capacity is fixed considering both day and night irrigation. But, it is a general habit of the farmers to irrigate the lands during the day time and very few farmers practice irrigation at night. This results in hourly fluctuations of the water demand which is not incorporated into the management and the flow regulation along the canal and this is causing additional perturbations.

Lack of flow control below Branch Canal

The lack of control in Branch Canal due to:

- Inaccurate measurement,
- Illicit operation at minors and below by WUAs and this phenomenon increases downward since farmers try to compensate by propagating the deficit downstream.
- Direct off-takes from Branch canal which have no proper diversion mechanism, generating variations in discharge.

Options to cope with perturbations

- One of the options to absorb the positive perturbations in the branch canal itself is by raising the canal banks and storing the water temporarily. This would require careful monitoring of the water levels by the operators.
- Another option would be to divide the flow proportionately in to the offtakes.
- The timely and synchronised operation of series of CRs with real time data of water levels and by reducing the operation time of the CRs by mechanizing the operation.

Step 4 MAPPING WATER NETWORKS & WATER BALANCE/ACCOUNTING

Objective: *The objective here is to map the nature and structure of all the streams and flows that 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.*

WATER ACCOUNTING:

Water accounting is a fundamental exercise of irrigation water management as well as operation of the canal infrastructure. It is observed that no water accounting is being done for the HJBC project and it is strongly suggested to conduct water accounting studies for HJBC for evolving appropriate strategies at various levels for water management as well as for modernization planning.

HJBC Project

Physical boundaries of the project:
HJBC canal system is part of the irrigation facilities of SARDA SAHAYAK CANAL system. The project is located in the area bounded by Gomti river in north east and in the South east by Sai river (Fig.6). Hence the spatial limits for the Water balance will be by delineation of hydraulic boundaries between the above two river basins. Therefore the watershed in this portion should be correctly mapped with the command area for all inflows in to the command area for water accounting. The two rivers join in the downstream part of the GCA.

The HJBC offtakes from SARDA SAHAYAK FEEDAR CANAL at Km 171.50 of SSFC. Hence by limiting the hydraulic boundaries between HJBC head works and the two river basins the water balance is accounted for.

Water balance at different scales: GCA and Sub- Units

Water balance is important for the entire gross command area. It is also important for any sub-management unit that may be decided as part of the improvement program considering the situation of each sub-unit is different with regards to water inflows and outflows. Therefore the water balance exercise that we discussed here for the entire command area must be then duplicated at lower scale level to allow future managers to base their practice on a sound assessment of the water flows within their sub-command areas.

DRAINAGE NETWORK AND MEASUREMENT:
The HJBC Project area is drained by Gomti river in north-eastern side and Sai river in south-eastern side through network of drains. At present there is no measurement on the outflows of drains in the system. It is strongly suggested to construct measuring structures on the drains, especially at the eastern boundary of the project and maintain record of flows.

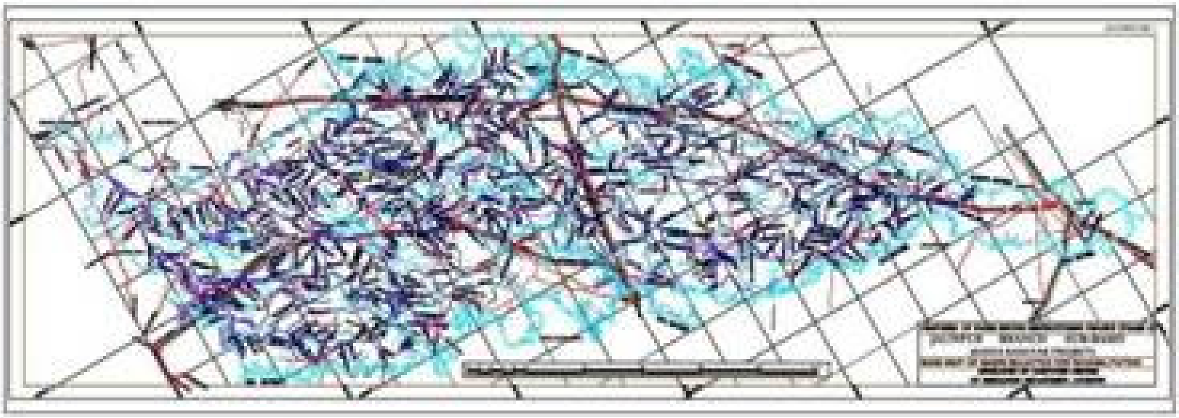

Figure 6 Map of the GCA with the two rivers bounding the system.

Spill Measurement: Measurement of the canal spills is not required for the water accounting of the entire project, since these out flows are accounted finally as outflows from drains. However, measurement of canal spills might be required for water accounting of sub-management units, namely distributory block etc. and also to monitor the situation at the tail-end of the secondary canals. In fact at the tail-end of a canal one should monitor not only the spill flows (surplus of water) but also the deficit if any.

Monitoring ground water levels: Monitoring ground water levels in the project area is essential to map the ground water table, assess water movements, changes in ground water regime etc. It is informed by the Project authorities that SECON Surveys has revealed the fact that the project area has 4648 nos. of tube wells and 15832 nos. of shallow bore wells. Further, it is also appraised that the concentration of tube wells and shallow bore wells is dense in the tail reaches and scarce in the head reaches. It is therefore suggested to use this network as basis for water management.

Cropping Patterns : Data on actual crops grown in the project area, both in extent and type is essential for estimation of evapotranspiration, this is a major outflow from the project in the water accounting. The data compiled by the Project authorities is reported to be based on NIC information towards crops grown block-wise is taken for water accounting. However the possibility of utilizing the satellite imageries for assessment of actual cropping is to be explored as a step towards more accurate assessment of cropping details.

INFLOWS

RAINFALL

It is one of the important constituents of inflows. Here, the density of the rain gauge stations and also the area it represents in the command area is an important factor to be considered. If the density is low, the spatial distribution of the rainfall in the command will not be truly reflected as there is wide variation in rainfall distribution, especially if the command is very big (GCA of **5.42 Lakhs hectares** under HJBC). There are 9 rain gauge stations in and around the entire command of Hydergarh-Jaunpur Branch Canal. The quantum of rainfall occurring on a sub-management unit / command of HJBC can be estimated based on the data of rainfall over the year. The rainfall data of water year 2004-05 as furnished by Project authorities is taken into consideration for accounting water balance.

STREAM FLOW FROM OUTSIDE THE COMMAND

The stream flow due to the runoff from outside the command enters into the command and flow through the drains to river, part of the stream flow enters the ground water and helps in recharge of the ground water and the rest flows out of the system. The HJBC almost runs in a ridge.

CANAL WATER APPLICATION

The discharges in the canal system are known. The quantity of water entering into the system can be assessed. It is informed that canal runs for about 9 months of the year (i.e., with two months and one month closures respectively during Kharif and Rabi) irrigating Kharif, Rabi and Zaid crops. As per the information compiled by the Project authorities based on statistical data of NIC indicates an actual cropping pattern of 89% Kharif (rice, jawar, bajra, maize, urd, arhar and other crops), 98% Rabi (wheat , gram, pea, oil seeds, potato and other crops) and 1% Zaid (cereals, pulses and sugarcane). The intensity of irrigation works out to 188% during 2004-05.

Ground water

In the command of HJBC, there are two zones, one is a zone with aquifers and another zone without aquifers. In the zone with aquifers, lot of pumping of ground water to supplement the crop water requirement takes place. This contribution from groundwater needs to be considered but not as an external source of water as it is generated by percolation from rainfall and irrigation. The issue here is to avoid double accounting of water as the water entering into the system through canals and stream flows is already accounted for. This same water enters as seepage and recharges the ground water.

OUTFLOWS

EVAPOTRANSPIRATION:

The Evapotranspiraton from irrigated fields is estimated as the product of cropped area irrigated and evapotranspiration (Etc) for each crop. Etc is the product of ETo which is the reference Evapotranspiration based on climatological data and Kc, the crop coefficient, which is specific to each crop and each stage. Thus, the quantity of water consumed as Evapotranspiration from the crops in the command can be worked out considering that crops are all the time well fed and not water stressed. Here, it is important to correctly assess the type of crops grown and the correct acreage. The area and crops grown by unauthorized irrigation within the command is to be considered also.

From the field observation it is obvious that the intensity of irrigation is much more than the designed value of 100 % [see above estimation for 2004-2005 of 180 %]. It is important to know the actual cropping pattern adopted by the farmers and the actual area irrigated. The actual cropping pattern adopted will have a significant bearing on the water requirement calculations.

DRAINAGE FLOWS:

The surplus water after application to the fields and also to some extent the seepage water enters into the drainage in the command area. Also, the storm water during rains both from outside the command and inside enters the drainage of the system. This is an important component of outflows that need to be measured. The data of drainage flows at key points in the system is necessary to estimate the flows.
The spills which occur at the end of the canal, main canal and secondary canals need to be measured. Though, they don't form a component of the outflows as the flows through the drains are already taken. The periodic feedback of spill measurements will help the management both at WUA level and the project level to know what is happening in the system and take appropriate decisions. Also, the monitoring of quality of water is important which will have a check on agro chemical loads.

CONSUMPTION BY TREES AND VEGETATION

Here, the difference between the GCA and the ICA is about 262000 Ha. In the project there are evidences that trees and natural vegetation are taking advantage of the water flows resulting from irrigating the farm fields. The rainfall in the command area is 1000 mm per year but concentrated during 4 months (about 900 mm in June-July-August-September), while the remaining 8 months get only 100 mm. Without irrigation the vegetation in the CA would have been completely different with much more drought resistant perennial crops. Trees as coconuts are taking advantage of lateral flows, others are thriving on deep rooting system. Non crop vegetation consumes water and an estimate such consumption needs to be accounted in the outflows.

Infiltration / Ground water

In the zone, where ground water pumping is not possible, there is a need to consider infiltration that takes place which is lost from the system. This can be worked out by soil moisture studies. Here, it will become a component of outflow.

Water resources

For farmers in the command area there are 3 major sources of water resources: canal surface water, groundwater and direct rainfall. Where these 3 sources of water can be combined, basically in the irrigation gross command area, the water supply to agriculture is not limited. According to consultant studies water supply should be enough to cover the needs of at least 2 crops per year.

As common in the region surface water infrastructure has been designed to cover about 1/3 of a full crop coverage needs. Rainfall is about 1000 mm and concentrated in just a few months. Shallow groundwater of good quality is available in most places, although sodic problems occurs in some areas particularly in the eastern part of the CA [this problem has ignited a project for reclamation and protection against (WB) which is still active].

However no matter what groundwater is abundantly used for irrigation, the net groundwater contribution is held low, as most groundwater supply is generated by rainfall and irrigation. It is even possible that the net contribution of groundwater is negative meanings that the CA recharges the groundwater system, but there is no evidence of that.

Water Balance: a first proxy

A rough annual water balance for the Gross Command Area in Hyd-JBC is given below in table 9 and Figure 7.

	MCM	
Canal water for Kharif	**1362**	**16%**
Canal water for Rabi	**1134**	**13%**
Canal water for Zaid	**694**	**8%**
Rainfall over the GCA	**5566**	**64%**
TOTAL	**8756**	

Table 9 Water inputs partition for 2004-2005.

Comments:

1) Rainfall is taken as 100 %: each drop will i) be used directly through evapotranspiration, or ii) recharge groundwater (and reuse) or iii) contribute to the increase the surface streams which are captured by drains along the two major rivers.
2) Canal water is considered same as 100% input for direct use.
3) Groundwater net contribution is assumed as low.

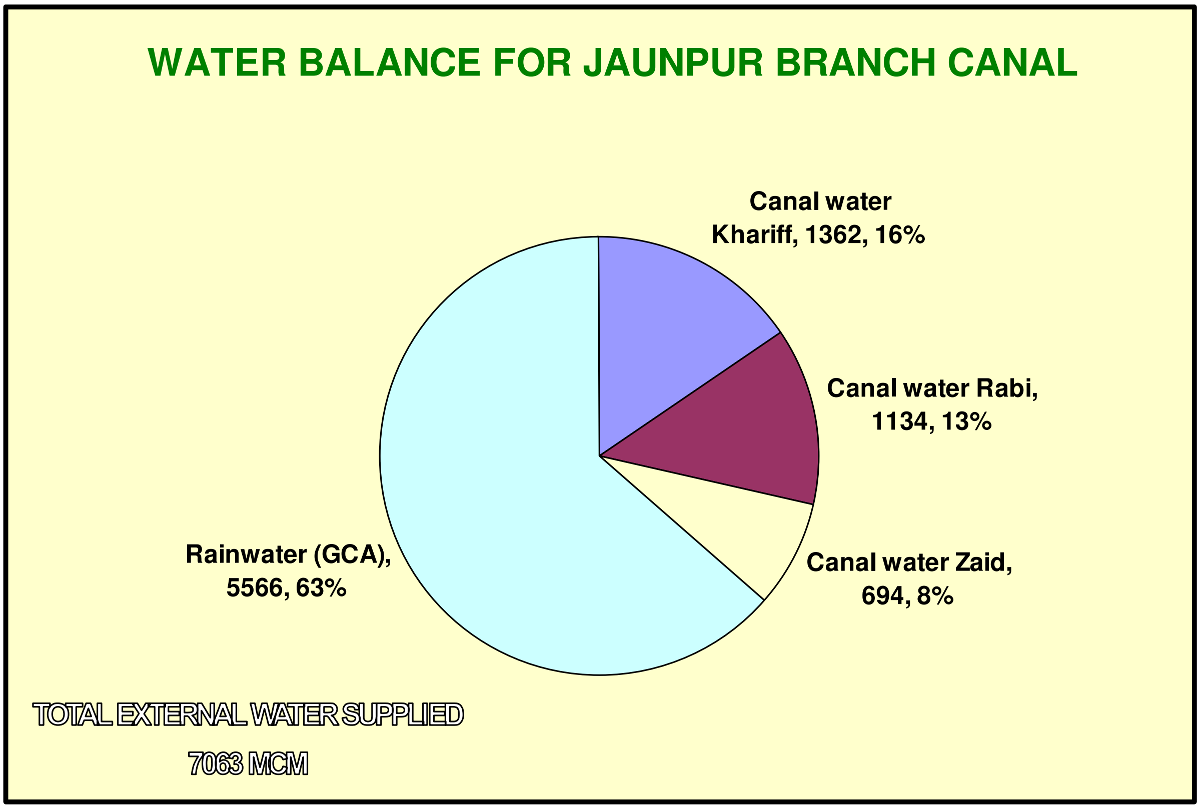

Figure 7. Inputs in the Water balance in HJBC

A similar water balance **at field level** accounting for 100 % rainfall and an estimated canal water supply at field level considering a transport efficiency of 46 % gives very similar results as the previous for the percentage: total is 4240 MCM, with rainfall 2772 (65 %) and canal water 1467 (45%).

OUTPUTS OF THE WATER BALANCE

Outputs	Value in MCM	Percentage at field level %	Percentage at GCA %
Evaporation including all irrigation requirements within CCA	1880 (*)	44	21
Water not consumed at field, leaving as drainage and percolation.	2360 (**)	56	27
Aggregated portion accountable towards: 1) Net requirements for vegetation outside CCA but within GCA including ET 2) Seepage, lateral flows accountable and Run-off drained out of the system within (GCA-CCA) area	4516 (**)	-	52
Total	**8756**	**100**	

Table 9 Outputs of the water balance

(*) This value is directly calculated.

(**) This value is deducted from the closure of the water balance.

Water resources studies have been carried out within the WSRP: at basin and sub-basin level (SMEC contract) and command area down to the minor level (Tahal contract). According to Tahal study the situation of the minors varies significantly for water resources, supply from canal water is not evenly distributed and depth to groundwater variable from 3 to 8 meters. The latter is having an influence more on the cost of pumping than on the availability.

Beyond the variety of situations within the CA, a common feature is that water is abundant enough to cover the needs of at least 2 crops a year. So the real issue is not adequacy of water but the cost in accessing that water and the reliability/flexibility of the delivery services.

Available studies show that the level of groundwater throughout the CA is related to the canal water system and management. High recharge of groundwater occurs as a result of losses through canal seepages and at the head end of the minor which is often over irrigated. Inversely at the tail-end of minors water is much lower due to less water surface supply and better drainage conditions (Figure 8).

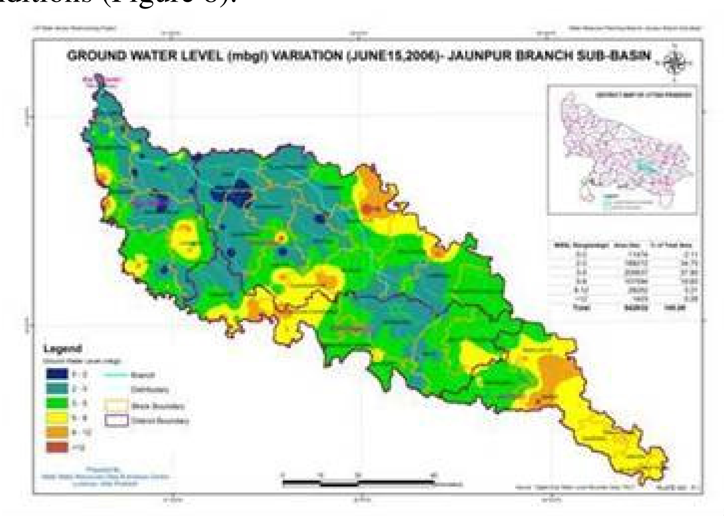

Figure 8. Groundwater level in the CGA

Step 5 MAPPING THE COST of OPERATION

Objective: *the objective is to gather as much as possible elements of costs entering into the operation of the system in order to identify where possible gains should be sought for with the current service and operational set up, and what would the cost of implementing improved service. This step thus focus on mapping the cost for current operation techniques and services, disaggregating the elements entering into the cost, costing options for various level of services with current techniques and with improved techniques.*

Cost of Management Operation and Maintenance

A budget analysis was carried out during the workshop see figure 11, and show the followings:

- 16 Crores/year 4.0 M $
- Operation accounts for 50% of the spending while maintenance is low at 17%
- The spending is obviously too low as compare with needs: 14.60 $/ha for the entire CA

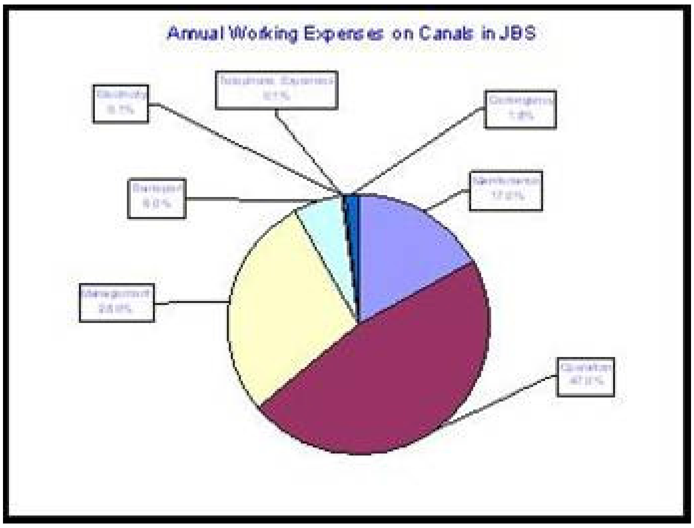

Figure 9. Breakdown of the budget for MOM in HJBC

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.*

Users

There are mainly 4 categories of uses in the GCA:

- irrigation (farmers)
- domestic supply (drinking)
- raw water to tanks (animals)
- fisheries.

Irrigation

With the context of abundance and the possibility of combining 3 sources of water, farmers are confronted to several options for water services as shown in table below.

	Rainfall	Canal water	Groundwater
Characteristics	One season only Erratic Variable for adequacy	all seasons (except long closures) low adequacy (1/3) Equity is low No flexibility Often unreliable	all times adequate, reliable flexible
Cost	nil	600 Rs year as the nominal fixed fees per ha. BUT this figure should be significantly increased to cover the real cost.	3000 to 6000 Rs per crop season (very rough proxy)
Kharif	Abundant but possible dry spell	Maximum flow	Groundwater recharge
Rabi	non available	Reduced flow from the river	Low water table

Table 10. Service and costs

Comments: *The cost of irrigating with groundwater should obviously be better documented. A rough figure is that the energy cost (diesel) amounts to about 2 Rs per m3, to this one must add the investment and the maintenance of the pump.*

Conveyance : SERVICE

It is pertinent to look at the crop management practices in the command area and the variation in upper and tail reaches in order to have an idea of the strain put on the conveyance system. It is observed that :

- Crop management Practices are better in tail end areas. The areas closer to the canal are not properly adopting the crop management practices.

- Wheat and rice is mainly seen in the areas near the canal.
- Diversification of crops in the distant areas from the canals. They have developed need based crops due to uncertainty of water supply from the canals. They have developed their own sources.
- Conjunctive use: farmers having large land holdings are using ground water effectively. Small farmers mainly depend on canal water.
- Yield: The yield in fields where own arrangement of water is made are higher than where only canal water is available. But lower yield does not necessary means water stressed areas. In fact these areas are well fed sometimes too much fed generated water logging.
- Crop rotation is not adopted in reaches closer to canal areas.

The vision

During the workshop, discussion on water services and in particular on what should be the services to users in the future has led to a VISION for the irrigation system! It conditions to a large extent the further steps of development service and modernization plans, this VISION discussed during the workshop is as follows:

"A strong Service Oriented Management with Integrated Multiple Use Water Resources Management practices, balancing surface and groundwater potential, supporting a productive agriculture system and sustaining the eco-system"

Step 7 PARTITIONING IN MANAGEMENT UNITS

Through this step the issue of management unit is addressed. The central idea is that large irrigation system management should be partitioned into few level of management and the command area should be divided and subunits (subsystems and/or subcommand areas) that are held homogeneous and/or separate from one another by a singular point or a particular borderline.

Institutional development

The command area of the JBC is about 300,000 ha, therefore it is crucial to partition the system into manageable units. The on going modernization project has made a lot of efforts in developing WUAs at minor level while embarking on an ambitious re-engineering process of the UP-ID. Successes in these endeavours are still obviously much variable, but one cannot expect fast results when it comes to creating from zero the capacity of local institutions (WUAs) in being a strong and dedicated partner of the management. Overall it is a process that should requires several 3 times as much as the normal duration of a project funded by the WB.

As it stands now the ID will remain a mighty single service provider to numerous (often weak) WUAs. The associations are too small to being able to recruit a professional and therefore the critical interface as it stands now will be between WUAs (with no technician) and the lower level of the UP-ID.

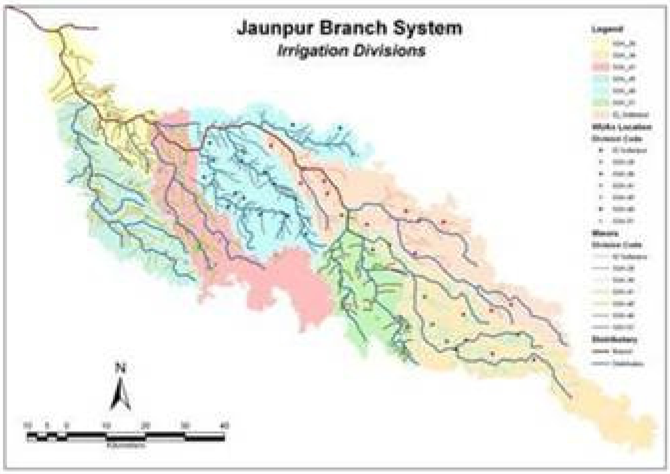

Figure 10 WU As mapping

Weakness of current setting: the lack of intermediate level

The weak point of this set up is that the Officers at the lower level of ID will be more interested to please their hierarchy than the users they are serving. Thinking otherwise is simply unrealistic. The current rotation of staff within the UP-ID is also another important problem particularly when it comes to the interface with users. Lastly the reform implementation will also be at least for a certain period of time, a source of worry and deviation of the focus for local UP-ID staff.

The existing current set up will thus face difficulties in being able to support sufficiently the introduction of new techniques for canal operation and the full development of local competence (WUA), to value the improvement of canal water availability from the rehabilitated/modernized main system, and to be responsive to and accountable in front of, local user groups.

There is in the current set up the risk of seeing the project achievements so far, being slowly negated by loosing momentum in the development of local competency, by not being able to improve in a significant way the services to users and not offering enough flexibility to them through possible arrangements about the service.

Urgent need of Federation of Associations

It is critical to develop an intermediate level of competence (technician) responsible in front of the associations and interfacing with the main service provider (ID). To achieve that it is advisable to create rapidly Federation of WUAs, grouping near-by WUAs leading to a size that allows the federation to have enough financial resources and means for operating the system and organising the development of the association.

The mission of the FWUAs will be many folds: organize effective operation and maintenance interface with UP-ID on the whole range of issues of management and develop the capacity of WUA members. To carry out these tasks a technician should be recruited by the federation on a long term basis (5 years) and trained appropriately by PACT.

Depending on the average number of WUAs grouped in a federation, we can anticipate between 50 and 100 FWUAs in the Jaunpur Branch CA. The former corresponds to 8 WUAs per federation and the latter to 4.

A grouping by distributory is certainly a solution that needs to be considered for its advantages of simplicity and clarity. This solution will be suitable for some disty, however for many others this will probably lead to too large command area or too long disty. Having a federation for each disty and sub-disty would mean about 25 FWUAs for the command area, the average size of which being more than 10,000 ha grouping about 25 WUAs each. Some disty are more than 70 km long and therefore poses serious problems for transportation, for operation and checking as well as for the organisation of meetings among the WUA members.

For the sake of social cohesion as well as for these practical reasons of transport it would be better in many cases to split the disty into two or more Federations.

There are hardware implications to support such a partition: it is crucial that along the distributory at the interface between two federations a measurement structure being installed. This equipment should be including during the modernization of the project and built if there is an agreement on how the grouping of WUAs should be made or planned for a later construction if there is no certainty as to where they should be built.

Transitory recommendation

The principle of having a strong local intermediate support during the transition phase can be implemented by UP-ID without waiting for a formal decision and all the necessary legal and institution steps that needs to be done towards the creation of FWUA. Rapid training and redeploying local ID staff according to a preliminary WUAs grouping and with a renewed

TOR for the staff can be done for the coming irrigation campaigns. This could be an intermediate satisfactory solution.

The advantage of this informal rapid solution is that by the time PACT takes a decision on this issue and, if positive, finalises the creation of Federation with legal and official status, PACT would have gained experience on the practicalities of this solution and on the best options for the grouping.

Step 8 MAPPING THE DEMAND FOR CANAL 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,..)

The mapping of the demand for operation is based on 3 main criteria: service, perturbations and sensitivity. Conceptually the demand can be seized through the following formula:

DEMAND for Operation = SERVICE x PERTURBATION x SENSITIVITY

The higher the service the higher the demand; the greater the perturbations, the higher the demand; the higher the structures sensitivity the higher the demand for operation.

The demand expresses the requirements to achieve a given targets with due consideration on the constraints it also reflects **the efforts needed to operate the system** to perform as targeted. In some areas little efforts are sufficient whereas in other more efforts are needed to achieve the same objective.

Main criteria for partitioning the CA for canal operation demand

The level of service
The demand for operation will depend on the definition of service agreed upon at main system level as well as at sub-unit levels.

The perturbations
The main perturbation along the main canal is related to the runoff during Kharif, as this affects the entire system with a quite similar intensity, a priori there is no differentiation of the demand with respect to this criteria.

Along the secondary system the intensity of perturbation is related to the number of upstream nodes (partition of flows) given the lack of control which characterizes the secondary network. This is why the length of the secondary networks should be taken as criteria of differentiation of the demand for operation.

Length of secondary canals
As seen in the initials steps (RAP) problem of distribution are plaguing the secondary system and below. Therefore the longer the secondary canal is the more effort is required to properly manage the water flows and ensure in particular that the tail–enders are receiving a fair share.

Recycling
Recycling is important in some sub command areas, whereas inexistent elsewhere. This criteria is therefore a critical one in allocating efforts for operating the secondary system. Wherever drainage is recycled, fewer efforts are needed for operation and where there are no recycling facilities high efforts to control water deliveries on the upstream side.

Step 9 CANAL OPERATION IMPROVEMENTS

Objective: Identifying improvement options (service and economic feasibility) for each management unit for (i) water management, (ii) water control, and (iii) canal operation)

Water management strategy

It is not clear as to whether some general principles by which the different sources of water should be combined and managed to better serve the users in an equitable, reliable and flexible manner have been clearly set.

At the moment the designed objective of water management is to provide canal water to all users at a maximum rate of 0.3 l/s/ha corresponding to the traditional concept of the Gangetic irrigation system. The concept of equity is based on a fair share of canal water deliveries. There are clear indications though that these achievements in terms of equity are low in both along the main system and along the minors.

Drainage management

The issue of drainage is also central in the command area. Various patches of water logged area can be seen in the CA. Studies made by consultants shows that water logging is to a large extent due to the raising of water table as a consequence of over-irrigation and canal seepages in the head-end of canals and minors.

A strategy of drainage for the whole command area should be designed within the project considering the natural drainage conditions within the landscape, as well as the improvements one can expect by improving water management and more specifically decreasing over irrigation in some key places.

Water resource monitoring: water balance on sub-units

The on going modernization project [UP-WSRP] is making valuable efforts to generate a network of measurement points for the 3 resources contributing to water supply to crops: canal water, rainfall and groundwater. The project has proceeded to the installation of a network of 500 measurements points for groundwater monitoring, for rainfall together with an improvement of the measurement made on the surface supply.

The initial phase of installation of the monitoring network has been achieved in 2005, and it is about time now **to consolidate** or **further strengthen the operation of the network**. The efforts that have been put into the installation and the initial stage of data collection should be refocused now on the production of **water balance studies at various scales of the GCA**, to help developing an effective and sustainable water management.

According to Tahal hydrogeology study, water conditions are significantly variable, then one should contemplates to revise the equity concept by ensuring that the areas that are in less favourable conditions for groundwater access, received more canal water. In other words the equity should be set on the "**access to any source of water**" and not limited to canal water.

What strategy?

Water management strategy within the command needs some further clarification in terms of management options for canal and groundwater. Simply replicating what was there before to spread water and fight against famines, does not seems to correspond to the today demand for water services in support of crop diversification.

On water management issues, the policy of developing conjunctive use, and improved surface water management to avoid water logging should be spelled out more clearly and with indications on how this should be put into practices. For instance how to favour groundwater pumping in head-ends of minors to reduce waterlogging?

The previous concept of "pushing water" should leave the way to a concept of serving user groups with more flexibility, an increase reliability, to cope with the demand from users dictated by local water conditions and/or by their willingness to pay for a good service should be as far as possible taken on board.

Irrigation modernization strategy within UP-WSRP

The strategy for modernization within the UP-WSRP is quite comprehensive and consistent, in the sense that it develops in several complementary direction: water sector management, irrigation management, institutional development re-engineering of UP-ID development of WUAs.

However during the MASSCOTE exercise two problems have been identified as far as the modernization project is concerned:

- water management strategy is unclear at least in the documents of the project, as discussed previously in this section,
- new concepts of operation, discharge and water level control techniques, introduction of new type of structures are not known or mastered by local irrigation staff.

The appropriation of the modernization management strategy by irrigation staff should be increased through appropriate trainings.

A spatially variable service to agriculture/farmers

The service to agriculture should be defined for sub command areas and for individual farmers, looking at allocation, scheduling and water deliveries. The definition and the spatial variation of the service should be based on objectives criteria related to the various sources of water supply.

Canal services must be designed considering other sources rainfall, runoff during Kharif as well as recycling facilities and in some location access to groundwater.

Regaining control of level and discharge

The RAP-MASSCOTE has clearly pointed out that the control exercised along the network of canals on the flows are by far too low to avoid chaos prevailing. This situation leads to various problems (water scarcity and water logging). The modernization project should aim at:

- regaining the water level control along the main canal diminishing the tolerance on water depth variation to 10 cm
- install effective control structure along the distributaries
- equip all withdrawing structures with appropriate gates.

Some solutions to consider

Solutions for improvements were briefly discussed during the workshop they are listed below, however time constraint did not allow enough time to explore the potentials advantage and the constraints associated to. Therefore one has to consider the following list as options that need to be investigated.

Introduction of SCADA for real time information monitoring

A real time information system should be put in place to allow making quick decision on the basis of a reliable in time assessment of the situation.

Recycling water through shallow wells in the area close to the canals.

This is an option that attempt to reduce water logging upstream of the command area, it has to go with a better control of water deliveries in the same areas.

Installation of measurement devices at all levels

Automation of the Cross-regulators

To regain control of water level along all canals many more cross regulators have to be installed, it is recommended to use automatic structure whenever possible to reduce the staff requirements for operation.

Remodelling the canal to increase the conveyance capacity

Transport capacity is reduced by high sediment deposit, therefore a modernization program needs to include the restoration of the transport capacity.

Optimised the cost of operation

Operation should be scrutinized in view of being

Water balance studies at local levels.

Water balance for each sub-canals and further each federation of associations will have to be carried out in order to develop for each management unit an appropriate water management strategy.

Step 10 AGGREGATING AND CONSOLIDATING MANAGEMENT

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

This step was not addressed during the workshop as the previous one and particularly on partitioning have not been sufficiently investigated and agreed upon.

Step 11 PLAN FOR MODERNIZATION

Finalizing a modernization strategy and progressive capacity development
Select/choose/decide/phasing the options for improvements
Plan for M&E of the project inputs and outcomes.

This step was not addressed during the workshop as the previous one and particularly on partitioning have not been sufficiently investigated and agreed upon.

Appendix I SALIENT FEATURES OF Modernization of JBS

Project Description Summary
Extracts from the PAD

Project components
The water sector reform would be initiated through Component A. Irrigation and Drainage sub-sector reforms would be initiated through Component B. Reform options for integrated water resources management would be piloted at the sub-basin level through Component C and the reform measures for sustainable and efficient operation and management of irrigation and drainage infrastructure would be piloted at an appropriate scale in selected commands and associated drainage boundaries through Component D.

Component A: Creation of Apex Water Institutions and Strengthening Socially and Environmentally Sustainable Multi-sectoral Water Resources Planning, Allocation and Management Capacity
This component would support the setting up and operationalizing State Apex water institutions proposed in the State Water Policy. These include:
* State Water Resources Agency (SWaRA): This institution would develop environmentally and socially sustainable inter-sectoral water allocation and optimal water resources management inr a basin context throughout the State. it would also serve as the technical secretariat for the State Water Board.
* State Water Resources Data and Analysis Center (SWaRDAC): This institution would collate, verify, analyze and disseminate information on all aspects of integrated water resources management and assistance in basin planning.
* State Water Tariff Regulatorv Commission (SWaTReC): This is envisaged as the central agency to review and monitor water sector costs and revenues, and to rationalize and set user fees to enable the sector institutions to be financially self-sustaining.
* Ghagra-Gomti Basin Development and Management Entity (GGBDME): This would be set up as a multi-sectoral and representative body that would help refine and implement environmentally and socially-sustainable water resources development and management plans for the GGB.
The project will enhance the capacity of these institutions through provision of computer hardware, software and connectivity, consultants' services, office building (2000 sq.m) and equipment, incremental staff and operating costs and extensive training.

Component B: Irrigation Department Reform, Capacity Building and Business Process Re-engineering
This component would initiate measures required to rationalize and streamline the manner in which irrigation and drainage investments are planned, implemented, managed, operated and monitored. This involves the following activities:
* Institutional Reform: This envisages the execution of a program to reduce UPID establishment costs through a phased Voluntary Retirement Scheme (VRS) and other approaches, undertaking staff awareness, consultation, training and re-training campaigns, and establishment of a Reforms Task Force (RTF) to monitor implementation of the reform program and oversee further institutional studies.
* UPID Capacity-building: This includes modernization of the technical, administrative and managerial capacity of UPID, which would be carried out through the provision of technical

advisory services, training and study tours in order to equip it with the technical, managerial, social, environmental, economic and information management skills necessary for modem irrigation management in partnership with the farmer clients.
* Business Process Re-Engineering: This activity involves the setting up of an extensive management information system and supporting administrative and water resources databases and associated analytical and commuimcation facilities to modernize and streamline UPID business processes auif provide the tools necessary for modern technical, financial, operational and managerial capacity, strengthening inter-agency coordination and public-private partnerships and piloting participatory irrigation management approaches.

Component C: **Piloting Reform Options in Water Resources Management**
This component seeks to operationalize the concept of integrated water resources management in a basin framework with decentralized basin development and management institutions. Given the large number of large river basins in UP, it would be appropriate to begin in selected sub-basins supported by demonstration pilots. This would involve the following activities:
* Creation and Strengthening of Jaunpur Branch Sub-basin Development and Management Board (JBSDMB) and the Imamgani Branch Sub-basin Development and Management Board (IBSDMB) through support for infrastructure, technical advisory services and operating costs. These Boards are expected to be focal points for shared vision water resources planning and management in the selected sub-basins.
* Decision Support Systems development through information systems and modeling for socially and environmentally sustainable optimal water resources management in the JBS and IBS.
* Rainwater Harvesting through improvement of community-managed village ponds through technical advisory services and conservation and management of other water bodies in the JBS and IBS through small works and technical assistance for sustainable community-based management.
* Piloting Canal-based Small Hydro Development in the IBS located at Km. 6.5 on the Imamganj Branch Canal accompanied by appropriate institutional development for participatory management of the scheme.

Component D: Piloting Reform Options in Irrigation and Drainage Operations(PROIDO)
This component would operationalize the concepts and provide the necessary investments for (i) reliable delivery of water measured and supplied on an appropriate volumetric basis in the irrigation systems to improve system performance, cost-recovery and accountability of the service provider; (ii) effective drainage network operation and management and conjunctive use to assist in effective water management (iii) an outcome-oriented approach with integrated sustainable agricultural intensification and diversification and private sector participation to complement effective water management; and (iv) unbundled operational management of the irrigation and drainage systems, including participatory user management and private sector participation. Given the current state of irrigation and drainage infrastructure in the State and the magnitude of tasks and finances required to achieve the above throughout the State, these far-reaching reforms would be initiated at an appropriate scale to build confidence and generate lessons in mainstreaming these reforms.
The PROIDO component would therefore involve the following activities:
* Rehabilitation and modernization of the irrigation and drainage systems based on community priorities in about 300,000 ha covering the physical irrigation delivery systems and drainage infrastructure in the Jaunpur Branch Command of the JBS and the Bahraich

Distributary Command of the IBS (including electronic and other measuring devices) to enable reliable systems operation and supply of water on a volumetric basis. This would include the development of an appropriate knowledge-base (including detailed topographic and asset surveys and GIS development), detailed consultation and environmrnetal and social assessmients prior to civil works, baseline development~ and awareness-building and training activities. The community involvement would be facilitated by formation and operationalization of Water User Associations (WUAs), and extensive consultations and joint walkthroughs.

* Agricultural intensification and diversification through support for extension, study tours and other training, and on-farm trials for agriculture and horticulture and, promotion of environmentally-sustainable techniques (including integrated pest management and organic farming), improvements in livestock management and knowledge dissemination through village kiosks. This activity would be coordinated by the Bank-financed Uttar Pradesh Diversified Agriculture Support Project (UPDASP) and would involve other line departments, NGOs and the private sector.
* Piloting replicable management options for irrigation and drainage systems operations and agricultural diversification. This would involve (i) progressive transfer of management responsibilities to WUAs at the minor-level; (ii) testing management paradigms at the distributary-level by leasing to a private sector operator or to a financially-decentralized UPID entity; and (iii) induction of specialized crop zone management by private sector.

The lessons learned from the implementation of this component would help shape the rehabilitation and management structures to be adopted in future investments.

Component E: Feasibility Studies and Preparation Activities for the Next **Phase**
This would include initiating topographic surveys and environmental, social and other assessments and preparation of feasibility studies for activities to be undertaken in the second project in the UP Water Sector Reform Program. Lessons learned during early implementation of the project would be reflected in this preparatory work.

Component F: Project Activities Coordination
The project activities would be coordinated by a multi-disciplinary Project Activities Core Team (PACT).
This component is designed to assist the PACT with its role in facilitating and guiding the implementation and monitoring of all project activities, ensuring synergy and coordination amongst activities and agencies implementing these activities, preparing consolidated reports and facilitating training.

<u>**Brief description of Component D: PROIDO *[from the PAD]***</u>

Component D: Piloting Reform Options in Irrigation and Drainage Operations(PROIDO)
This component would operationalize the concepts and provide the necessary investments for (i) reliable delivery of water measured and supplied on an appropriate volumetric basis in the irrigation systems to improve system performance, cost-recovery and accountability of the service provider; (ii) effective drainage network operation and management and conjunctive use to assist in effective water management (iii) an outcome-oriented approach with integrated sustainable agricultural intensification and diversification and private sector participation to complement effective water management; and (iv) unbundled operational

management of the irrigation and drainage systems, including participatory user management and private sector participation. Given the current state of irrigation and drainage infrastructure in the State and the magnitude of tasks and finances required to achieve the above throughout the State, these far-reaching reforms would be initiated at an appropriate scale to build confidence and generate lessons in mainstreaming these reforms.

The PROIDO component would therefore involve the following activities:

D1 * Rehabilitation and modernization of the irrigation and drainage systems based on community priorities in about 300,000 ha covering the physical irrigation delivery systems and drainage infrastructure in the Jaunpur Branch Command of the JBS and the Bahraich Distributary Command of the IBS (including electronic and other measuring devices) to enable reliable systems operation and supply of water on a volumetric basis. This would include the development of an appropriate knowledge-base (including detailed topographic and asset surveys and GIS development), detailed consultation and environmental and social assessments prior to civil works, baseline development~ and awareness-building and training activities. The community involvement would be facilitated by formation and operationalization of Water User Associations (WUAs), and extensive consultations and joint walkthroughs.

D2 * Agricultural intensification and diversification through support for extension, study tours and other training, and on-farm trials for agriculture and horticulture and, promotion of environmentally-sustainable techniques (including integrated pest management and organic farming), improvements in livestock management and knowledge dissemination through village kiosks. This activity would be coordinated by the Bank-financed Uttar Pradesh Diversified Agriculture Support Project (UPDASP) and would involve other line departments, NGOs and the private sector.

D3 * Piloting replicable management options for irrigation and drainage systems operations and agricultural diversification. This would involve (i) progressive transfer of management responsibilities to WUAs at the minor-level; (ii) testing management paradigms at the distributary-level by leasing to a private sector operator or to a financially-decentralized UPID entity; and (iii) induction of specialized crop zone management by private sector.
The lessons learned from the implementation of this component would help shape the rehabilitation and management structures to be adopted in future investments.

Appendix II RAP Internal Indicators

SERVICE and SOCIAL ORDER		Team I	Team II	Team III	Team IV	All Final
Actual Water Delivery Service to Individual Ownership Units (e.g., field or farm)		0.9	1.3	0.9	1.0	1.1
	Measurement of volumes	0.0	0.0	0.0	0.0	0.0
	Flexibility	1.0	1.0	1.0	1.5	1.0
	Reliability	1.0	1.0	1.0	1.0	1.0
	Apparent equity.	1.0	2.0	1.0	1.0	1.0
Stated Water Delivery Service to Individual Ownership Units (e.g., field or farm)		2.2	2.2	2.2	2.2	2.2
	Measurement of volumes	0.0	0.0	0.0	0.0	
	Flexibility	2.0	2.0	2.0	2.0	
	Reliability	2.0	2.0	2.0	2.0	
	Apparent equity.	3.0	3.0	3.0	3.0	
Actual Water Delivery Service at the most downstream point in the system operated by a paid employee		0.7	0.9	0.7	0.4	0.7 to 0.4
	Number of fields downstream of this point	0.0	0.0	0.0	0.0	0.0
	Measurement of volumes	0.0	0.0	0.0	0.0	0.0
	Flexibility	1.0	0.0	1.0	0.5	0.4
	Reliability	1.0	2.0	1.0	0.0	1.0
	Apparent equity.	1.0	2.0	1.0	1.0	1.0
Stated Water Delivery Service at the most downstream point in the system operated by a paid employee		1.6	1.6	1.6	1.6	1.6
	Number of fields downstream of this point	0.0	0.0	0.0	0.0	0.0
	Measurement of volumes	0.0	0.0	0.0	0.0	0.0
	Flexibility	2.0	2.0	2.0	2.0	2.0
	Reliability	2.0	2.0	2.0	2.0	2.0
	Apparent equity.	3.0	3.0	3.0	3.0	3.0
Actual Water Delivery Service by the Main Canals to the Second Level Canals		1.8	2.2	1.3	1.2	2.2 to 1.2
	Flexibility	1.0	1.0	1.0	1.0	1.0
	Reliability	2.0	3.0	1.5	1.5	2.0
	Equity	2.0	3.0	1.0	1.5	2.0
	Control of flow rates to the submain as stated	2.0	2.0	1.5	1.0	1.5
Stated Water Delivery Service by the Main Canals to the Second Level Canals		1.8	1.8	1.8	1.8	1.8
	Flexibility	1.0	1.0	1.0	1.0	1.0
	Reliability	3.0	3.0	3.0	3.0	3.0
	Equity	4.0	4.0	4.0	4.0	4.0
	Control of flow rates to the submain as stated	0.0	0.0	0.0	0.0	0.0

Social "Order" in the Canal System operated by paid employees		**0.0**	**1.3**	**0.5**	**0.0**	**0.5**
	Degree to which deliveries are **NOT** taken when not allowed, or at flow rates greater than allowed	0.0	2.0	1.0	0.0	1.0
	Noticeable **non**-existence of unauthorized turnouts from canals.	0.0	0.0	0.0	0.0	0.0
	Lack of vandalism of structures.	0.0	1.0	0.0	0.0	0.3
MAIN CANAL						
Cross regulator hardware (Main Canal)		**0.0**	**0.6**	**1.0**	**0.9**	**0 to 1**
	Ease of cross regulator operation under the current target operation. This does not mean that the current targets are being met; rather this rating indicates how easy or difficult it would be to move the cross regulators to meet the targets.	0.0	0.0	2.0	2.5	
	Level of maintenance of the cross regulators.	0.0	0.0	3.0	2.0	
	Lack of water level fluctuation	0.0	0.0	0.0	0.0	
	Travel time of a flow rate change throughout this canal level	0.0	2.0	1.0	1.0	
Turnouts from the Main Canal		**1.7**	**2.8**	**2.0**	**2.0**	**2.4 to 2.0**
	Ease of turnout operation under the current target operation. This does not mean that the current targets are being met; rather this rating indicates how easy or difficult it would be to move the turnouts and measure flows to meet the targets.	2.0	2.8	2.0	1.5	
	Level of maintenance	1.0	2.5	2.0	1.5	
	Flow rate capacities	2.0	3.0	2.0	3.0	
Regulating Reservoirs in the Main Canal		**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	Suitability of the number of location(s)	0.0	0.0	0.0	0.0	
	Effectiveness of operation	0.0	0.0	0.0	0.0	
	Suitability of the storage/buffer capacities	0.0	0.0	0.0	0.0	
	Maintenance	0.0	0.0	0.0	0.0	
Communications for the Main Canal		**2.2**	**2.5**	**2.4**	**2.8**	**2.5**
	Frequency of communications with the next higher level? (hr)	2.0	2.0	3.0	3.0	
	Frequency of communications by operators or supervisors with their customers	3.0	3.0	3.0	4.0	
	Dependability of voice communications by phone or radio.	2.0	3.0	2.0	3.0	
	Frequency of visits by upper level supervisors to the field.	4.0	4.0	4.0	4.0	
	Existence and frequency of remote monitoring (either automatic or manual) at key **spill** points, including the end of the canal	0.0	1.0	0.0	0.0	
	Availability of roads along the canal	2.0	2.0	2.0	2.0	
General Conditions for the Main Canal		**1.4**	**1.5**	**1.6**	**1.9**	**1.5 to**

						1.9
	General level of maintenance of the canal floor and canal banks	0.0	1.0	0.0	1.5	
	General lack of <u>undesired</u> seepage (note: if deliberate conjunctive use is practiced, some seepage may be desired).	2.0	2.5	4.0	3.0	
	Availability of proper equipment and staff to adequately maintain this canal	1.0	1.0	1.0	1.0	
	Travel time from the maintenance yard to the most distant point along this canal (for crews and maintenance equipment)	3.0	2.0	2.0	3.0	
Operation of the Main Canal		1.6	1.9	1.6	0.6	1.8 to 0.6
	How frequently does the headworks respond to realistic real time feedback from the operators/observers of this canal level? This question deals with a mismatch of orders, and problems associated with wedge storage variations and wave travel times.	1.3	1.3	1.3	0.0	
	Existence and effectiveness of water ordering/delivery procedures to match actual demands. This is different than the previous question, because the previous question dealt with problems that occur AFTER a change has been made.	1.3	1.3	1.3	0.0	
	Clarity and correctness of instructions to operators.	2.7	2.7	2.7	2.0	
	How frequently is the whole length of this canal checked for problems and reported to the office? This means one or more persons physically drive all the sections of the canal.	1.3	2.7	1.3	1.0	
Second Level Canals						
Cross regulator hardware (Second Level Canals)		1.3	2.0	1.9	0.9	2.0 to 1.0
	Ease of cross regulator operation under the current target operation. This does not mean that the current targets are being met; rather this rating indicates how easy or difficult it would be to move the cross regulators to meet the targets.	0.0	3.0	2.5	0.0	
	Level of maintenance of the cross regulators.	0.0	3.0	2.0	0.0	
	Lack of water level fluctuation	1.0	0.0	1.0	0.0	
	Travel time of a flow rate change throughout this canal level	3.0	4.0	3.0	3.0	
Turnouts from the Second Level Canals		2.0	2.3	1.3	1.0	2.2 to 1.0
	Ease of turnout operation under the current target operation. This does not mean that the current targets are being met; rather this rating indicates how easy or difficult it would be to move the turnouts and measure flows to meet the targets.	2.0	3.0	1.0	1.0	
	Level of maintenance	2.0	2.0	1.0	0.0	

	Flow rate capacities	2.0	2.0	2.0	2.0	
Regulating Reservoirs in the Second Level Canals		**0.0**	**2.3**	**2.7**	**0.0**	**2.5 to 0.0**
	Suitability of the number of location(s)	0.0	3.0	4.0	0.0	
	Effectiveness of operation	0.0	2.0	2.0	0.0	
	Suitability of the storage/buffer capacities	0.0	2.0	2.0	0.0	
	Maintenance	0.0	2.0	2.0	0.0	
Communications for the Second Level Canals		**1.8**	**1.7**	**2.1**	**1.8**	**1.9**
	Frequency of communications with the next higher level? (hr)	2.0	1.0	2.0	1.0	
	Frequency of communications by operators or supervisors with their customers	3.0	1.0	4.0	2.0	
	Dependability of voice communications by phone or radio.	1.0	2.5	2.0	2.0	
	Frequency of visits by upper level supervisors to the field.	3.0	3.0	3.0	4.0	
	Existence and frequency of remote monitoring (either automatic or manual) at key **spill** points, including the end of the canal	0.0	0.0	0.0	0.0	
	Availability of roads along the canal	2.0	2.0	1.0	2.0	
General Conditions for the Second Level Canals		**1.3**	**1.8**	**1.4**	**1.5**	**1.8 to 1.4**
	General level of maintenance of the canal floor and canal banks	0.0	2.0	2.0	1.5	
	General lack of undesired seepage (note: if deliberate conjunctive use is practiced, some seepage may be desired).	1.5	3.0	4.0	2.0	
	Availability of proper equipment and staff to adequately maintain this canal	1.0	1.0	0.0	1.0	
	Travel time from the maintenance yard to the most distant point along this canal (for crews and maintenance equipment)	3.0	2.0	1.0	2.0	
Operation of the Second Level Canals		**1.9**	**2.6**	**2.4**	**1.7**	**2.6 to 1.7**
	How frequently does the headworks respond to realistic real time feedback from the operators/observers of this canal level? This question deals with a mismatch of orders, and problems associated with wedge storage variations and wave travel times.	1.3	2.7	2.7	2.0	
	Existence and effectiveness of water ordering/delivery procedures to match actual demands. This is different than the previous question, because the previous question dealt with problems that occur AFTER a change has been made.	1.3	2.0	2.7	1.0	
	Clarity and correctness of instructions to operators.	2.7	2.7	2.7	2.0	
	How frequently is the whole length of this canal checked for problems and reported to the office? This means one or more persons physically drive all the sections of the canal.	2.7	2.7	1.3	1.3	

Third Level Canals						
Cross regulator hardware (Third Level Canals)		**0.3**	**1.1**	**1.1**	**1.1**	**0.3 to 1.1**
	Ease of cross regulator operation under the current target operation. This does not mean that the current targets are being met; rather this rating indicates how easy or difficult it would be to move the cross regulators to meet the targets.	0.0	0.0	0.0	0.0	
	Level of maintenance of the cross regulators.	0.0	0.0	0.0	0.0	
	Lack of water level fluctuation	0.0	0.0	0.0	0.0	
	Travel time of a flow rate change throughout this canal level	1.0	4.0	4.0	4.0	
Turnouts from the Third Level Canals		**1.3**	**1.3**	**1.3**	**0.8**	**1.3 to 0.8**
	Ease of turnout operation under the current target operation. This does not mean that the current targets are being met; rather this rating indicates how easy or difficult it would be to move the turnouts and measure flows to meet the targets.	0.0	1.0	1.0	0.5	
	Level of maintenance	0.0	1.0	1.0	0.0	
	Flow rate capacities	4.0	2.0	2.0	2.0	
Regulating Reservoirs in the Third Level Canals		**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	Suitability of the number of location(s)	0.0	0.0	0.0	0.0	
	Effectiveness of operation	0.0	0.0	0.0	0.0	
	Suitability of the storage/buffer capacities	0.0	0.0	0.0	0.0	
	Maintenance	0.0	0.0	0.0	0.0	
Communications for the Third Level Canals		**1.6**	**1.5**	**1.9**	**1.6**	**1.6 to 1.9**
	Frequency of communications with the next higher level? (hr)	2.0	1.0	2.0	1.0	
	Frequency of communications by operators or supervisors with their customers	3.0	2.0	4.0	2.0	
	Dependability of voice communications by phone or radio.	0.0	2.0	2.0	2.0	
	Frequency of visits by upper level supervisors to the field.	4.0	3.0	3.0	4.0	
	Existence and frequency of remote monitoring (either automatic or manual) at key **spill** points, including the end of the canal	0.0	0.0	0.0	0.0	
	Availability of roads along the canal	2.0	1.0	0.0	1.0	
General Conditions for the Third Level Canals		**1.0**	**1.0**	**1.8**	**1.3**	**1.0 to 1.6**
	General level of maintenance of the canal floor and canal banks	1.0	0.0	1.0	0.5	

	General lack of undesired seepage (note: if deliberate conjunctive use is practiced, some seepage may be desired).	2.0	2.0	4.0	2.0	
	Availability of proper equipment and staff to adequately maintain this canal	0.0	1.0	1.0	1.0	
	Travel time from the maintenance yard to the most distant point along this canal (for crews and maintenance equipment)	2.0	1.0	2.0	2.0	
Operation of the Third Level Canals		**0.8**	**1.9**	**2.4**	**1.7**	**1.0 to 2.4**
	How frequently does the headworks respond to realistic real time feedback from the operators/observers of this canal level? This question deals with a mismatch of orders, and problems associated with wedge storage variations and wave travel times.	0.0	2.7	4.0	2.7	
	Existence and effectiveness of water ordering/delivery procedures to match actual demands. This is different than the previous question, because the previous question dealt with problems that occur AFTER a change has been made.	1.3	0.0	1.3	0.0	
	Clarity and correctness of instructions to operators.	1.3	2.7	1.3	2.0	
	How frequently is the whole length of this canal checked for problems and reported to the office? This means one or more persons physically drive all the sections of the canal.	1.3	1.3	1.3	1.3	
Budgets, Employees, WUAs						
Budgets		**1.6**	**1.6**	**1.6**	**1.6**	**1.6**
	What percentage of the total project (including WUA) Operation and Maintenance (O&M) is collected as in-kind services, and/or water fees from water users?	0.0	0.0	0.0	0.0	
	Adequacy of the actual dollars and in-kind services that is available (from all sources) to sustain adequate Operation and Maintenance (O&M) with the present mode of operation.	2.0	2.0	2.0	2.0	
	Adequacy of spending on modernization of the water delivery operation/structures (as contrasted to rehabilitation or regular operation)	4.0	4.0	4.0	4.0	
Employees		**0.9**	**0.9**	**0.9**	**1.1**	**1.0**
	Frequency and adequacy of training of operators and middle managers (not secretaries and drivers). This should include employees at all levels of the distribution system, not only those who work in the office.	1.0	0.0	1.0	1.0	1.0
	Availability of written performance rules	1.0	1.0	1.0	1.0	1.0
	Power of employees to make decisions	1.0	2.0	1.0	1.0	1.0
	Ability of the project to dismiss employees with cause.	2.0	1.0	2.0	2.0	2.0
	Rewards for emplemary service	0.0	1.0	0.0	0.0	0.0
	Relative salary of an operator compared to a day laborer	0.0	0.0	0.0	1.0	0.0

Water User Associations		**0.5**	**0.2**	**0.0**	**0.5**	**0.0**
	Percentage of all project users who have a functional, formal unit that participates in water distribution	0.0	0.0	0.0	0.0	0.0
	Actual ability of the strong Water User Associations to influence real-time water deliveries to the WUA.	0.0	0.0	0.0	0.0	0.0
	Ability of the WUA to rely on effective outside help for enforcement of its rules	1.0	0.0	0.0	1.0	1.0
	Legal basis for the WUAs	2.0	1.0	0.0	2.0	1.0
	Financial strength of WUAS	0.0	0.0	0.0	0.0	0.0
Mobility and Size of Operations Staff	Operation staff mobility and efficiency, based on the ratio of operating staff to the number of turnouts.	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Computers for billing and record management	The extent to which computers are used for billing and record management	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Computers for canal control	The extent to which computers (either central or on-site) are used for canal control	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**