A MASSCOTE Case Study in

KARNATAKA - INDIA

GHATAPRABHA LEFT BANK CANAL-KNNL

Modernization Strategy for Irrigation Management

WORKING DOCUMENT [14/03/08].
CURRENCY EQUIVALENTS

Currency Unit = Indian Rupee (Rs)
US$1.0 = Rs 45.34

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

AGLW Agriculture Water Resources Development and Management Service of the Land and Water Development Division of FAO
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
GLBC Ghataprabha Left Bank Canal
ITRC Irrigation Training and Research Centre (California Polytechnic University)
KNNL
LSM Local System management
MAF Million Acre Feet
MASSCOTE Mapping Systems and Services for Canal Operation Techniques
M&E Monitoring and Evaluation
NCA Net Command Area (irrigable)
O&M Operations and Maintenance
OFWM On-Farm Water Management
RAP Rapid Appraisal Procedure
WUA Water Users Association
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Introduction and Background

The Masscote application presented here has been initialized through a training workshop in Karnataka for engineers and managers from the KNNL focussing on Ghataprabha Left Bank Canal [GBLC] from 6 to 20 October 2006. The contributions of the working group sessions at this workshop (RAP–MASSCOTE) have been largely included in this report. The MASSCOTE exercise has been further proceed by a team of KNNL, comprising officers from KNNL HQ as well as some officers from the Ghataprabha project itself together with the supporting FAO team composed of Daniel Renault (NRLW-HQ), PS Rao (FAO Delhi) and Thierry Facon (NRLW Bangkok) and at a later stage with inputs from Mr. S. Sijapati consultant (Nepal).

This document presents the status of the Masscote application development one year after the workshop. It has several purposes:

- suggest some specific strategies to managers of the Ghataprabha system on how they should conceptualise the modernization of irrigation management in GLBC;
- lay the foundations of a stepwise modernization plan, with the initial step for the next Kharif season starting January 2008.
- produce food for thought for decision-makers in Karnataka before engaging in investment plans, particularly on how to ensure that diagnosis and solutions are investigated properly in modernization projects;
- introduce the MASSCOTE and RAP exercises to a large audience through real-case application.
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 (Table 1) are conducted for the entire command area with the goal of identifying homogeneous managerial units for which specific options for canal operation are further sought by running the various steps of MASSCOTE for each unit taken separately. Then, aggregation and consolidation is carried out at the main system level. Thus, the methodology uses a back-and-forth or up-and-down approach for the different nested levels of management.
## 10 STEPS of MASSCOTE

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

![Plate 1. Location and lay-out of the Ghataprabha Left Bank Canal Irrigation Project](image)

**Project Description**

The Ghataprabha Left Bank Canal Irrigation Project is located in the North West of Karnataka, bordered by the two rivers Krishna and Ghataprabha. The layout map of the project is shown in Plates 1 and 2. The gross command area is over 180,000 ha with an irrigated area of approximately 160,000 ha.

The entire project which comprises also a right bank canal not included in the study, is bounded by the Krishna river in the North, Maharastra state to the West, the confluence of Krishna river & Malaprabha river in the East & the water divide are the basin boundary between Ghataprabha & Malaprabha rivers in the South. The area is bounded by North Latitudes 15°45’ & 16° 40’, East longitudes 74° 15’ & 76° 00’. The area is well connected by road & rail to other parts of the state. The Pune–Bangalore National Highway & the Banagalore Miraj line passes through the area. The interior part of the command area is well connected to both district headquarters at Belgaum & Bagalkot by weather roads.

The existing canal command is served by Ghataprabha Left Bank Canal (GLBC) & six Branch canals. There are 90 distributaries, major & Minor. The canal system was completed in 1974-75. The net command area is 1,61,871 Ha. The canal system provides irrigation to parts of 4 Taluks in Belgaum & 3 Taluks of Bagalkot districts. The Right Bank canal will irrigate 1,55,559 Ha covering parts of 6 taluks in Belgaum & 4 taluks in Bagalkot districts.
THE GHATAPRABHA PROJECT CATCHMENT AREA:

The Ghataprabha river

The river Ghataprabha has its source in the main hill range of Sahyadri near Chowkul, a village situated about 50 Kms of West of Belgaum town. The river in its uppermost reach flows almost in an easterly direction for a distance of 60 Kms upto Daddi & then in a North-Eastern direction up to the existing pick-up weir at Dhupdal. Another major river viz. the Tamraparni joins the Ghataprabha river little upstream of Daddi. The entire valley of the Ghataprabha including that of Tamraparni, consists of hilly terrain having large patches of forest growth at higher levels & cultivated land at lower levels. The total length of Ghataprabha river up to the confluence with the Krishna river is about 260 Kms.

The Hidkal Dam site is situated about 25 Kms below Daddi & is 20 Kms upstream of Dhupdal. The Ghataprabha valley upstream of Hadalga & more or less the entire valley of Tamraparni are situated in the Deccan trap Zone & are covered by an over burden of laterite & reddish lateritic soils over laying the original trap rock. At many places large exposure of the parent trap rock also seen. Below Hadalga up to Gokak, the valley is covered by sandstones (quartzite) belonging to the Kaladagi series, a very ancient rock formation of sedimentary origin. The rainfall in this region is confined to monsoon season from June to October the precipitation usually being most intensive during July & August. The climate is mostly temperate. Temperatures vary from a minimum of 7 degree in winter to about 41 degree Celsius in summer.

The total catchment area at Hidkal dam site is 10311.55 sq km. The catchment area is situated in a extremely hilly country & is mostly covered by forests & shrubs growth. Cultivation is confined to the narrow flat banks of the river & its tributary nallas. This area receives very good rainfall varying from about 6260 mm (250 inches) to about 1117.60 mm (44 inches). This portion of catchment, therefore, contributes more
or less to the entire run-off of the Ghataprabha river. The catchment below receives much less rainfall overlaying to about 626 mm (25 inches) & the runoff is comparatively small.

**The Hiryanakeshi river**
A major tributary of Ghataprabha river viz, the Hiryanakeshi river joins the Ghataprabha river 3 Kms downstream of Hidkal Dam. This river is a major contributor of GLBC during Kharif, the catchment area up to the entry point of GLBC (Dhupdal weir) is 2797 Sq km (1080 Sq miles). The Dhupdal weir is situated about 20 km s downstream of Hidkal Dam Site.

**GROUND WATER POTENTIAL OF THE COMMAND AREA :**

Geologically the entire command area of both Ghataprabha Left Bank Canal & Ghataprabha Right Bank Canal consists mainly of Deccan Traps (covering more than 95 % ) & the rest by quartzite’s of Kaladagi Age.

Deccan traps are the intrusive ignitious rocks & when fresh serves as poor receptacles because of their massive & impervious nature. Accumulation of ground water is confined only to the weathered & the joints present in the rocks. Bore hole beds present between two successive floors are better aquifers & hold dependable source of ground water of their pervious nature. Depth of weathering in traps range from 3 to 10 m thickness & of hole bed varies from 1 to 2 m. Zeolite traps found at few places have indicated dependable source of ground water.

Similarly quartzite’s are also poor aquifers when fresh but the joints if present will serves as conduits & some quantity of ground water will be recharged & held in the weathered zone & fractured planes. Groundwater occurs under water table conditions & the depth of water table ranges from 3 to 12 m. Ground water recharge take place through precipitation of rain water & morphological features of ground surface. In irrigated tracks, the major contribution to ground water will be by the canal water & irrigation return waters. A preliminary estimate of groundwater potential as per the Project report indicates the following details:

1) Groundwater recharge from precipitation over gross command: 4.31 TMC
2) Groundwater recharge from Irrigation supplies from canal & wells: 13.64 TMC

Total : 17.95 TMC

that is a total of 508 MCM (million cubic meters).

**RAINFALL IN THE COMMAND AREA**

Annual rainfall in the Command Area (CA) is a quite uniform between 550 and 500 mm, with a pocket below 500 mm on the North West of the CA (see Plate 3). The general gradient East-West which has a significant effect in the watershed from 500 mm up to 1200 mm at Belgaum does not seems to affect the CA.
EXTERNAL SOURCES OF WATER

The external sources of water to the CA are mainly from surface streams (small) and from the aquifers of the two major rivers Krishna and Ghataprabha bordering the command area.

One of the essential aspects in that regard is to estimate an accurate figure of the contribution of external sources in the overall balance. It is not easy because direct measurements are not possible and the estimation of the external sources comes as the closure of the water balance with high uncertainty.

Plate 3. Isohyets of rainfall in the GLBC command area

In the water balance section some estimations have been made showing that the external sources from groundwater might range annually from 154 to 732 MCM – respectively 7% and 26% of the total consumption - within the GCA, depending on the assumptions made for the calculation.

IRRIGATED AGRICULTURE

As per design the gross command area amounts to 181000 ha while the net irrigable area is 161,000 ha. In reality there is no updated survey on how much area is irrigated and by what source of water. There are many signs of encroachment of agriculture using water pumps on dry lands either outside the command area or inside the GCA. What is the importance of this physical expansion of the irrigated area is difficult to say.
The only source of data which is available is the Remote sensing GIS survey made in 2001, in which they say that the command area spans over 280,000 ha, that is hundred thousands more that the initial GCA.

A more recent analysis made as a follow up of the Masscote workshop shows that the total irrigated cropped area is about 220,000 ha.
Plate 4. Cropping pattern in GLBC command area from remote sensing survey
3. MASSCOTE in Ghatapraba Left Bank Canal Irrigation Project

**Step 1. RAPID DIAGNOSIS**

A RAP (Rapid Appraisal Procedure) was carried out as part of the first step of the exercise during the October 2006 workshop. 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](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. In general, these goals can only be achieved by paying attention to
internal details, or the internal indicators. The RAP addresses these specific internal details to
evaluate how to improve water control throughout the project, and how to improve the water
delivery service to the users.

**Looking at different management levels**

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. On large system the
partitioning into management units is fundamental to allow an effective service oriented
management from one level to the other down to the end-users.

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

**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.

**Key findings**
- GLBC is a very productive surface, conjunctive use and recirculation system dominated by sugarcane, with high economic outputs
- 60 to 70% farmers have pumps
- Inequity is not related only to canal water delivery but to economic or physical lack of access to groundwater

When compare to other systems in the world, GLBC rank high for the value per ha (1880 $/ha) or per m3 of canal water (0.23 $/m3) thanks to the conjunctive use and the cash crops grown in the area. Without these two features or if the farmers would have followed the official cropping pattern, then the value would have been very low as illustrated in the figure 1.

![No sugarcane and recycling](ch119)

**Figure 1. Economical Value of the agriculture production per ha**

**Internal Performance Indicators**

The Rapid Appraisal carried out in the Left Bank of the Ghataprabha Project focused on internal project operations and 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 internal indicators quantitatively assess the internal processes (inputs - resources used and the outputs - services to downstream users) of an irrigation project. Internal indicators are related to operational procedures, management and institutional set-up, hardware of the system, water delivery service etc. These indicators are necessary 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).

Participants were divided into 3 groups:
- Group A: UPSTREAM (km 0 to km 50)
- Group B: MIDSTREAM (km 50 to km 90)
- Group C: DOWNSTREAM (km 90 to end of system)

They spent 2.5 days on the field and gave ratings to all internal indicators. During a plenary session rating were reviewed and finalized.

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).

A discussion of the internal indicators for the GLBC compared to other international irrigation projects is included in Appendix 2. In general, the internal indicators for the GLBC were much lower than the other international irrigation projects evaluated by FAO during last decade.

Key findings
- Poor processes
- Poor service delivery
- Lack of control and poor measurement at all levels
- Severe budget constraints
- Failing PIM programme
- Operation issues
- High level of chaos (objectives, performance, cropping patterns, schedule) and anarchy

But:
- No major physical constraints
- Good assets, drainage
- Good communications and transportation

Main Canal of GLBC

Table 1 summarizes the internal performance indicators for the Main Canal of GLBC. It shows the relatively low values suggesting widespread problems of poor levels of
performance, particularly those that are associated with operations. Equity along the main canal is an issue as the tail-enders are receiving highly fluctuating and lower than expected supply.

**No water level control**

Most of the main canal cross regulators are left wide open with the gates out of the water. The only cross regulators operated are at 50 km and are used to partition the flow, between the main canal and the North Branch. Basically the water level is not controlled along the main canal. Variation of one foot of water level seems to be the norm. Thanks to the generally low sensitivity of the offtakes the water deliveries to the secondary level remains to a certain extent under control. But there is obviously an amplification of the perturbations as we go downward.

The concept of “no water level control” which might work well with insensitive offtakes and a strictly constant discharge in the main canal is increasingly distorted/degraded as we go down along the canal. The result is that the tail-enders are hit by large fluctuations of discharge as shown in MASSCOTE Step 4 on Perturbation (figure ).

Communications among the canal operators is present and could be easily improved. Certainly one of the main management problems is the partition of the main canal into 3 divisions.

**Table 1. Internal Performance Indicators for the Main canal of GLBC**

(Maximum possible value = 4.0, minimum possible value = 0.0)

<table>
<thead>
<tr>
<th>Internal Performance Indicator</th>
<th>Value (0-4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross regulator hardware</td>
<td>0.6</td>
</tr>
<tr>
<td>Headgates (distributaries/minors) from the Main Canal</td>
<td>2.9</td>
</tr>
<tr>
<td>Communications</td>
<td>2.0</td>
</tr>
<tr>
<td>General Conditions</td>
<td>1.8</td>
</tr>
<tr>
<td>Operations</td>
<td>1.7</td>
</tr>
<tr>
<td><strong>Actual Water Delivery Service by the Main Canals to the Secondary Canals (overall index)</strong></td>
<td><strong>1.7</strong></td>
</tr>
</tbody>
</table>

**Secondary Canals in GLBC**

The performance of the secondary canals (branch and main distributary) in the GLBC is summarized by the key internal indicators in Table 2. In general, the performance indicators for the second level canals were substantially worse than those for the main canal.

The secondary canals are not equipped with water level control structures whereas discharge changes a lot from one season to the other and probably during each season as well. During low flows in the canals the issue of water level is critical and operators are taking some temporary measures to raise the water level (blocks placed at bottom bed of the canal).

This lack of water control structures increases the chaos downward.
Table 2. Internal Performance Indicators for the Branch /Distributaries in the GLBC
(Maximum possible value = 4.0, minimum possible value = 0.0)

<table>
<thead>
<tr>
<th>Internal Performance Indicator</th>
<th>Value (0-4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross regulator hardware</td>
<td>0</td>
</tr>
<tr>
<td>Turnouts (watercourses) from the</td>
<td>1.9</td>
</tr>
<tr>
<td>Distributaries/Minors</td>
<td></td>
</tr>
<tr>
<td>Communications</td>
<td>2.1</td>
</tr>
<tr>
<td>General Conditions</td>
<td>1.5</td>
</tr>
<tr>
<td>Operations</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Tertiary Canals and final deliveries in GLBC

The internal indicators that characterize the actual water delivery service at the farm level are summarized in Table 3. The water delivery service being provided to the farmers is relatively low. This is a measure of the flexibility, reliability, equity, and measurement of the water supply to individual fields. The social order indicator reflects the degree to which irrigation deliveries are being taken either from unauthorized locations or in quantities greater than allowed. If one considers that many of the direct outlets, which divert up to 30-40% of the total irrigation supply, are not officially sanctioned or managed as part of the rest of the system, then the social order indicator should be much lower.

Table 3. Internal Performance Indicators for the Minors/laterals/Field channels in GLBC
(Maximum possible value = 4.0, minimum possible value = 0.0)

<table>
<thead>
<tr>
<th>Internal Performance Indicator</th>
<th>Value (0-4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross regulator hardware</td>
<td>0.1</td>
</tr>
<tr>
<td>Turnouts (watercourses) from the</td>
<td>1.8</td>
</tr>
<tr>
<td>Minors/Laterals</td>
<td></td>
</tr>
<tr>
<td>Communications</td>
<td>1.6</td>
</tr>
<tr>
<td>General Conditions</td>
<td>1.4</td>
</tr>
<tr>
<td>Operations</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Plate 4. Typical offtakes for which farmers have to raise water level by adding rocks at canal bed [Hangandi Minor].
Plate 5. Offtakes without gates Head of a Disty (Bellagelli)

Table 3. Final Delivery Point Internal Performance Indicators (0-4)
(Maximum possible value = 4.0, minimum possible value = 0.0)

<table>
<thead>
<tr>
<th>Actual Water Delivery Service to Individual Ownership Units (e.g., field or farm)</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.3</td>
<td>0.9</td>
<td>1.3</td>
</tr>
<tr>
<td>Measurement of volumes</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Flexibility</td>
<td>2.0</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Reliability</td>
<td>1.7</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Apparent equity.</td>
<td>3.5</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

The ratings for the internal indicators describing employees and farmer organizations show significant room for improvement. Employees, especially field operations staff, had little or no incentive to provide excellent service to farmers and were not empowered to make decisions on their own. The farmer organization indicator is low due to the fact that they had little ability to influence the real-time management of the system or to rely on outside help for enforcing rules and policies. Farmer organizations have been organized and trained as a part of previous reform efforts but have only minimal input into the day-to-day operation of the system.

Management and Water user societies
Small, few functions and impact, fewer resources
Things have not improved for farmers
Will not solve the O&M issue
Comedy of seasonal planning meetings of irrigation committee
Federation does not seem to provide service to its members and may close next year?
Table 4. Water User Association Internal Performance Indicators (0-4)
(Maximum possible value = 4.0, minimum possible value = 0.0)

<table>
<thead>
<tr>
<th>Water User Associations</th>
<th>0.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of all project users who have a functional, formal unit that participates in water distribution</td>
<td>0.0</td>
</tr>
<tr>
<td>Actual ability of the strong Water User Associations to influence real-time water deliveries to the WUA.</td>
<td>1.0</td>
</tr>
<tr>
<td>Ability of the WUA to rely on effective outside help for enforcement of its rules</td>
<td>1.5</td>
</tr>
<tr>
<td>Legal basis for the WUAs</td>
<td>1.7</td>
</tr>
<tr>
<td>Financial strength of WUAS</td>
<td>0.5</td>
</tr>
</tbody>
</table>

The key points from Tables 1 to 4 include:

- The level of service to individual field outlets is well below what is required to support modern on-farm water management and crop diversification.

- Flow measurement is not being done anywhere in the system. The actual operations are based on staff gauge readings (water levels) downstream of the regulation points. Operators and managers only have a vague idea about how much water (rate or volume) is being delivered at any particular point in the system.

- Communications between the field operators and division/sub-division offices is frequent and reliable. The operators are used to taking regular staff gauge readings, which can be used as the foundation for introducing real-time flow measurement when accurate flow measurement devices are installed.
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.

The following functions were considered by the participants as the important ones to be checked for capacity at different level of the GLBC system:

1. Carrying capacity of the system
2. Measurements at the border between management units.
3. Measurement skills
4. Functioning of CRs
5. Remote monitoring (including rainfall data in the command) along main canal
6. Escape capacity/Recycling and measurements
7. Buffer storage in / along and off the canal
8. Sensitivity of the cross-regulators and offtakes
9. Seepage accommodation
10. Special structures
11. Communication system (Road and telecommunication)
12. Regulating capacity of Dhupdal weir

A. Main system: Head works, Main Canal.

Carrying capacity of the main system
The carrying capacity along the main system is reduced in some places due to the collapse of the banks:

1) The UCR of masonry lining done for about 31.50 Km is very old and there is collapse of lining resulting in obstructing the flow of water which result in some reduction of
the carrying capacity. How much the capacity is reduced is a question that needs to be answered with reliable measurements.

2) Also, there has been a collapse of side of the canal in the reach Km. 84 to 89, during September 2006, which has provoked some reduction of the carrying capacity. This incident has been mentioned at several occasions as the main reason of the discharge cut-off at mid-September 2006. Again a thorough investigation needs to be made.

3) There is one siphon at Km. 92.70 in the main canal, through which the flow is not uniform and steady, because of the damage made to the siphon by illegal users, the carrying capacity has gone down and resulting in lesser discharge to the downstream of the canal.

**Measurements at the border between management units.**
Along the main canal reach, there are four measurement points at the border between management units (divisions) at km 0, 50, 70 and 109 Km. The measurement devices are maintained by the three management units (divisions). The SWF measuring devices have been provided at the above borders for proper monitoring of flow at border. The existing SWF have been constructed long back and are not periodically calibrated and maintained to keep a good accuracy of measurement. The gauge register have been maintained properly and gauge man taking reading at 2 hrs intervals. Some of the examined book records suggest though that in reality the measurement is probably not made every 2 hours but at a lower periodicity (say every 6 hours or so).

**Measurement skills**
According to the books the discharge is measured by gauge man at 2 hrs. interval. These measuring devices are functioning well but were calibrated long back. Gauge men are less educated but still the gauge registers are maintained well with few exceptions.

![Plate 8. Typical Cross-regulator along the main canal with fully and permanently opened gates](image)
Functioning of Cross Regulators
There are 11 cross regulators (CR) all along the main canal. Out of which only one cross regulator at 50<sup>th</sup> Km is being operated with great difficulty involving 2 to 3 persons to operate and time consuming to lift. But the structures of all cross regulators are in good condition. Typical variation of water level upstream the cross regulators between 50 and 90 km is about one foot but the branch canal and distributaries right behind these cross regulators are mostly of low sensitivity and not significantly affected by this variation (with few exception though). Hence the CRs are not being operated to maintain a precise water level control, they are kept almost open through out the cropping period, except the CR at 50<sup>th</sup> Km which is in fact used as a partition divider.

Remote monitoring (including rainfall data in the command) along main canal
During Kharif the main system is to some extent operated considering the rainfall pattern in the GCA either through direct measurements or by considering the demand from downstream group of users. Rain gauge stations are sporadic in the command. By knowing the rain fall data, the discharges in the head regulators are being monitored, water is being made available to the area of where rain fall has not occurred and where water is badly needed using the available water in the canal. This strategy is obviously important to reduce over irrigation in area susceptible to have water logging problems. However these areas are quite limited in the GLBC, drainage network is dense and efficient thanks to the topography.

An elaborate strategy of water management should be developed for each of local management areas with due consideration on rainfall but at the same time with the objective of trying to keep as much as possible the water into the systems, and in case of a significant reduction of use at field level trying to recharge groundwater. The strategy should be based on the fact that over irrigation might not be a problem but inversely beneficial for the water balance itself.

Escape capacity/Recycling and measurements
There are 7 escapes along the GLBC from KM 0 to 109 Km. There are no measurement devices in these escapes. Excess water coming in the main canal will go to the nalas through these escapes. Many of these escapes are purposely leaking, the low flow released being used by the downstream population for various purposes.

Buffer storage in/along and off the canal
At present there is no buffer storage along the GLBC from 0 to 109 Km. With proper operation procedures, the capacity of the canal itself to store water can be tapped but one has to realize that it has with limited effect, it is usually good to smooth down hourly variation of discharge, but no means sufficient for daily or weekly variations.

**Sensitivity of the structures**

Most of the off-takes are undershot, and thanks to the good topography conditions, served with a high head from the main canal which means that most offtakes are low sensitive (S< 0.5). However there are some offtakes that have been reported as highly sensitive (S>2). A thorough mapping of the sensitivity of the offtakes along the main canal should be undertaken.

The sensitivity of the 11 cross regulators on the main canal are very low because there is no substantiated head difference between upstream and downstream reaches and also because the flow is of overshot type as the gates are fully open.

![Main canal level too low](image)

*Plate 10. An exceptional very sensitive offtake at Saidarpur intake: Overshot Flow is critical S= 7.5*

**Seepage accommodation**

**Seepage quantification:** Seepage on the main canal is mainly due to not having concrete lining for entire main canal. Out of 109 Km. of main canal 31.5 Km. is concrete lining, 28.5 Km is of masonry lining and 49 Km. is unlined. Quantum of seepage is not measured for entire main canal.

It has been reported that a measurement campaign was carried out few years back to estimate the value of seepage between 26km and 54 km and the then seepages was calculated from the difference of discharge at this 2 points which amounts to 200 cusecs. Given that the measured flows were in the vicinity of 2000 cusecs, the uncertainty surrounding each discharge measurements accumulates (probably +- 100 cusecs at best) and therefore the resulting difference between the two measurements is not known with a significant accuracy. It might be worthwhile to consider a more accurate method such as the ponding method.

**Seepage and water management:**
From a water management point of view the canal water losses through the seepage helps in recharging the ground water and as such is not real losses. This ground water is effectively being utilized by the ryots in cultivating the lands by pumping the water through bore wells and open wells. Thus conjunctive use of water is widely practiced in the CA. The seepage water which enters the drainage system is also being utilized by constructing series of Bhandars across the drainage system, thereby by utilizing the water effectively by the ryots. This seepage accommodation is certain for the upper reaches of the main canal down to km 109, however below that point along the Biligi Branch, there are sections of canals for which seepage losses are likely to be real losses (absence of shallow groundwater system). It is therefore recommended to accurately map the “seepage accommodation” along the main canal and branches.

Seepage and energy management:
Pumping from groundwater represents an additional cost of capital and for the maintenance as well as for the energy spent. It has been estimated that some 2600 Kwh are spent for one hectare sugarcane per year fed by shallow tubewells, the ratio is 0.086 Kwh per m3. As such seepage losses are recovered at a cost of 0.06 Kwh per m3. This dimension needs to be considered from the energy point of view as well as for the cost/savings for whoever pays for the energy (Sate budget or Farmers).

Special structures
There is one siphon at Km. 92.70 in the main canal, with some problems of capacity as mentioned previously.

Communication system (Road and tele-communication)
Road: As per the project planning service road all along the main canal from Km. 0 to 109 was provided with murrum i.e., rough road, due to years of usage and heavy rains, the road way is reduced from 4.5 mtr. to 3.50 meters in some reaches and corrugated the surface, which results in increase in travelling time and un-safe movement of vehicles of the management and as well as of the farmers.
Tele-communication : At present, there is lack of direct communication system to monitor the performance of canal network regarding conveying 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 more difficult during emergent alarming situation.

Human capacity building
In the irrigation networks of GLBC right from main canal to secondary and tertiary canals, the proposed gauging as well as release of required quantity of water from the off-take points of main canal to secondary canal and secondary canal to tertiary canal is to be maintained properly. To do so, the gauge records at the off-take point 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 off-take point.

Regulating capacity of Dhupdal weir
Plate 11. Dhupdal weir along the Ghataprabha river, controlling headworks of GLBC

The capacity of Dhupdal weir with F.R.L. of 2008 feet is about 0.3 TMC. The Dhupdal weir acts as a balancing reservoir as well as diversion river to divert the water of Hiranyakeshi and also the water released of Hidkal Dam into GLBC through Head regulator.

During monsoon most of the Hiranyakeshi river water is directed into GLBC i.e., about 2600 cusecs and the excess flow in the Hiranyakeshi will result in spillage of the weir.

During the non monsoon period, the water released from Hidkal is diverted into GLBC to an extent of 2600 cusecs and 284 cusecs of water is released downstream of weir through sluice gates to Gokal mills for power generation.

Some time, it so happen that there will be low flow in the Hiranyakeshi river, hence the water from Hidkal reservoir is got released for feeding GLBC (2600 cusecs) and to release of 284 cusecs downstream of the weir, during this process, sudden rainfall in the catchment of the Hiranyakeshi will result in spillage of the weir, resulting in wastage of stored water.

B. Secondary system: Branch canal and distributaries

Water level control
The secondary system of GLBC mainly consisting of 10 branch canals, which are the main influencing overall water management of canal system. Any excess withdrawals in any of these branches affect the flows in the corresponding canal system. The total length of this branch canal amounts to 250 Kms.

There are 21 Nos. of CR’s on those secondary canal system out of these only almost 8 to 10 CR’s are being functional and periodically operated in order to control water level in the secondary system whenever required. All other cross regulators have become non functional. Density of cross regulator on secondary system is one for 12 Kms.
Measurements
The measuring devices for secondary canal system have been provided for all main branch canal of GLBC, it is observed that measuring devices provided are SWF, the flow conditions are unsteady and there is lot of turbulences, wave action in upstream of measuring devices. The measuring chamber of these systems is interfering in the flow as these are provided within the canal section.

The surface condition of SWF has changed overtime and they are not giving true value as per calibrated chart. It is learnt they are all calibrated 20 years back. The location of SWF is close to off-takes causing unsteady flow.

Further, it is observed that there are no measurement devices to ascertain water level in the system @ upstream and downstream of cross regulators.

In order to have a scientific approach for proper reading, computing and calibrating the readings of the measuring devices, the operation staff such as gauge readers, inspector, supervisor (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 keeping of the details for better management of the system.

Telemetry
At present, the secondary canal networks are operated based on feed back from farmers, operation staff etc., regarding the excess water in the system due to rainfall in the command area and deficit system due to reduction of flow in the main canal. On the basis of this information, directions will be given to operators for controlling the system for situation on account of above reason, which is in consuming much time for better operation.

**Safety**

**Safety structure**: The secondary canal system of GLBC is equipped with safety structures like escapes sluices. For the safety of canal system, the escape sluice has to be operated to their design discharge during emergency situations.

It is observed that, these escapes can not be operated to the optimum discharge due to encroachment of the mother value of the nala downstream. If too much excess discharge is allowed in the nalas, they might cause either destructions to crops or take further deviation in path and there is possibility that the nala water may enter into inhabited area.

An updated assessment of the escapes downstream conditions is therefore essential to be carried out in view of safety measures as well as in view of releasing water when rainfall occurs and one still want to keep the water inside the CA.

**Buffer storage**

Some branch canals are chronically under water deficit (i.e. Biligi branch) and therefore storage capacity along the branch system should be sought for to attenuate the deficit.

**Sensitivity of the off-takes**

The secondary system of GLBC consists of a large network of approx. 250 Kms. serving more than 100 offtakes.

Field observations during October 2006, shows that contrary to the situation found along the main canal, the offtakes along the branch canals are much more sensitive. In particular along some of the branch canal where there is no water control, water head on offtakes are low and thus sensitivity to fluctuations very high. Situation might differ of course from one season to the other: Kharif to Rabi.

Each turnout along the branch canal 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 some currently sensitive offtakes will become insensitive once the water control has been properly achieved.

**Seepage accommodation**

There is obviously some similarity for seepage accommodation between branch canals and the main system. Some branch canals are located upstream of the CA and therefore it is always preferable to accommodate or store seepage from canal system and also farms / fields by constructing small Bhandaras, check dams pickups in canal network system. So that these storage may be made use of during the deficit period. Such storage will also help in recharging ground water table in surrounding areas during off season of irrigation system which helps in utilizing ground water either through the open wells or tube wells.

**Special structures**
It is observed that, there are no inlets and surplussing weirs on the secondary canal system. It is noticed that, there are no reaches where secondary canal system runs in deep cuts with possibility of rain water entering into canal system.

Many siphon structures in the secondary canal system are damaged and have become less functional with a lower discharge than designed because of clogging due improper maintenance. Therefore, providing suitable cross drainage works instead of siphon at these points may be thought after studying Hydraulic details at the site.

The partitioning of Khariff and Rabi
It is stated that by the project officers that, presently both Khariff and Rabi / two seasonal crop areas have been earmarked under same distributory. This is causing a great problem in proper water management both during Khariff and Rabi season because, the area identified either for Khariff or Rabi are drawing water during irrigation period for which they are not suppose to draw. This seasonal On-Off along the same canal is one of main draw back for today management of the irrigation system.

The authorities may have to re-look in fixing either Khariff or Rabi areas completely under one distributary to eliminate this problem.

Further, the areas to be limited for two seasonal crops may also be identified within initial reaches of main canal.

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

The inspection paths are damaged by way of encroachment or not in existence which leads to non approach of canal on inspection path side.

Further, generally it is noticed that, there are very few crossings on secondary system (and main canal). Existing crossing structures like, roads bridges, CTC’s are narrow and parapets of these were severely damaged causing dangerous condition to moving vehicles and men / animals.

It is noticed that, guard stone with chaining in embankment and deep cut reaches are not provided and even in other reaches guard stones rarely observed. Index boards are not provided at many places @ turnouts and regulator positions.

It was stated by field staff that present system of communication for obtaining information is through telephone located in a range of maximum 5 to 8 Kms resulting in possible delay in transferring information. However this problem should be solved as the mobile phone technology is widely spreading and covering even remote rural areas.

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

Operation
Seepage accommodation

Over irrigation is practice due to misconception. The excess water than the crop requirement gets deep into the underground and it is noticed that water table is high.

At the same time tail-enders of the FIC’s are often suffering of water shortages, most have introduce conjunctive use of groundwater and canal water. Due to adequate groundwater, the farmers who are affordable use the shallow aquifers through pumping to supplement the canal water and allow all-year round irrigation to grow sugarcane for instance.

The excess water entering the drainage system, is also being utilized by constructing series of Bhandaras across the drainage system and then pumping it. Thereby a good use of water is being practiced to some extent.

No water logging and salinity of any land was noticed.
**STEP 3: THE PERTURBATIONS**

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

**Water level perturbations along the main canal**

Perturbation along the main canal occurs mainly at start of the season and during and after the main intake closure as illustrated for Kharif 2006 at km 70 in figure below. The significant reduction of flows on the 15th of September was motivated by i) some rainfall in the GCA ii) the collapse of the Bank at km 84.

**Discharge perturbations**

Recorded for Kharif 2006 the variation of discharges along the man canal shows clearly the increasing presence of perturbation downward. The further down the longer it takes for the canal to stabilize at the beginning of the season or after the sudden closure and re-opening in September 2006. For instance stabilization occurs on the 8/7 at km 0; 24/7 at km 26; 3/8 at km 50 and one week after at km 70.

During September 2006 there was wide spread rainfall in the command area. The demand for water was reduced. Hence the head discharge was reduced to 1015 cusecs on 14-09-06 as demanded by the downstream Executive Engineer.

On September 20th slipping of the canal sides occurred in the deep cut portion which blocked the flow completely & caused obstruction to the flow & resulted in the heading up of water on the U/S banks. In order to avoid overtopping on the banks, the discharge in Km 70 was reduced. Since there was no demand for canal water from the farmers, combined requisition to reduce discharge at head was given.

From 22-09-06 the debris fallen was cleared by dumping to the sides & water was made clear temporarily & water was released to its full capacity. Gauge records can be referred for details.

The slippage in the canal is a recurring problem, which is being tackled by easening the side slopes of deep cut portion from $\frac{1}{4}:1$ to $\frac{1}{2}:1$. 
The perturbation increasing downward

During the Field survey many signals and indications has been reported about the tail-ender problems along the main system. This can be illustrated by the critical examinations of the records of discharge during 2006 Kharif.

The first graph below shows the deficit of the on-going discharge during the cut-off of the discharge in September. The reduction increases from less than 15% up to 36% at km 70.
The figure above shows the withdrawals along the main canal during Kharif 2006. Serie 1 is the withdrawal in 1000 cusecs from 0 to 26 km; serie 2 from 26 to 50; serie 3 from 50 to 70 km and serie 4 below 70 km.

What is remarkable is that the cut off generated upstream has affected the sections in very different manner. In fact the upstream sections (0-26 km) has received much more than their usual share (more than 800 cusecs compare to 600 as normal) while of course the last 2 sections are suffering most. Section 2 from 26-50 have seen a lot of variation but roughly the discharge did not deviate too much from average target.
Excess or illegal withdrawals
Fluctuations of the flow occurred along the main system due to illegal withdrawal of water and also in some cases, excess drawing of water through turnouts. This fluctuation is about 5% which will result shortage of water for irrigation of notified area.

Plate 15. Offtake protected against vandalism and illegal interventions. The spindle’s head being deep inside a concrete block.

Night & day irrigation
The canal capacity is fixed considering both day & night irrigation. But it is a general habit of the farmer to irrigate the land during the day time and very few farmers adopt the night irrigation. Then there will be fluctuation of water level in canal resulting in inadequate supply of water during day time.

Sudden gate closure (rainfall)
As results of unexpected rainfall in the command area, crops are no longer in need of irrigation water and farmers are tempted to close the gates turnouts to avoid flooding of the land and that interventions result in disturbance in the canal.

Linked to possible buffer storage management
The main perturbation for linked buffer linked buffer storage management is cost effectiveness. The huge expenses has to be incurred for construction of burm, if the storage is made in the canal and for nala training if the storage has been made off the canal, and also for construction of storage unit. The flow controlling devices and flow measuring devices has to be installed separately for the account purpose of buffer storage quantities. The trained staff to operate the devices related to buffer storage unit has to be deployed.

Slipping of canal sides
It is observed that slippage of canal sides is occurring regularly in the main canal from the Km. 84 to 89 resulting in obstruction of flow which will create perturbation in the canal.
**Tripping of the powerhouse**
The water to main canal is fed through a power house after generating power. Occasionally, the generators is to trip and the flow in the canal is suddenly stopped and the water to the main canal is fed through main head regulator gates. Due to this there will be time lag resulting in perturbation of flow in the main canal.

**Dhupal weir level**
The required discharge in the main canal depends on the drawing head and inflow of the water level in the Dhupal weir. The required discharge of 2600 cusecs can be received at the canal head only if the water level in weir is constantly maintained at RL 2008.

**Lack of control below the main canal**
The lack of proper control of flow in the main canal and even more so along the secondary canals is an important source of perturbations. This lack of control with most of the time a very low water level in the parent canal made the supply to offtakes very sensitive to any variation of water level. As farmers and operators are tempted to correct this lack of water depth by putting boulders in the canal, the results is a somehow chaotic variation of discharge at the influenced offtakes. Of course as mentioned previously the chaos is always increasing downward and the further we go down the more reaction of users and impacts on the tail-enders. It is snow ball effect that needs to be stopped by proper regain of water control.
**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 of irrigation water management as well as operation of the canal infrastructure. It is observed that no water accounting is being done for the GLBC project and it is strongly suggested to conduct water accounting studies for GLBC for evolving appropriate modernization strategies at various levels: local management areas as well as for the GLBC.

**GLBC Project**

**Physical boundaries of the project:** Owing to it is particular topography, almost the entire project area of GLBC is an independent watershed. However, on the western side, the watershed extends beyond GLBC project area, namely for GLBC upto Km 50 and for North branch canal. Similarly on the lower side of the project namely for Bilagi Branch canal and south branch canal, the watershed extends beyond the canals. Therefore the watershed in this portion should be correctly mapped with the command area for all the inflows into the command area for water accounting.

Similarly, since the GLBC canal is almost located along watershed ridge, there are no irrigation projects located on the upper side. Exception to this is on the western side of the project, namely for GLBC upto Km 50 and North branch canal, where the Chikkodi Branch canal system has been constructed as part of the Right Bank development project. Out flows from this Chikkodi Branch canal project are entering into GLBC project area and must be included in the water accounting of the GLBC.

**Drainage network and Measurement:** The GLBC project area is drained by Krishna river on northern side and Ghataprabha river on Southern side, through a network of drains. At present there are no measurements of the drains of the GLBC project area. As the assessment of out flows is essential for water accounting it is strongly suggested to construct measuring structures on the drains especially at the boundary of the project area and maintain records of flows.

**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.
Monitoring ground water levels: Monitoring ground water levels in the project area is essential to map the ground water movement, assess water movements, changes in ground water regime etc. It is informed that CADA Belgaum is monitoring the ground water levels of the project. Since 1962, thoroughly 72 numbers of observation wells. It is suggested to use this network as the basis for water management after having verify the number and location of these observation wells, considering the spatial variation of occurrence of ground water in the project area and also utilize the data collected from these observation wells appropriately in water accounting. Further additional points of observations might also be required.

Cropping Patterns: Data on actual crops grows in the project area, both in extent and type is essential for the estimation of evapo-transpiration, another major out flow from the project in the water accounting. Such data collected while conducting joint measurement of crops for the purpose of raising water charge demand can be utilized. However it is reported that there are discrepancies in, both in extent and type of crops as per actuals and as reported. Therefore, it is suggested to initiate steps to correctly assess and report the actual cropping while taking joint measurements. Also the possibility of utilizing satellite imageries for assessment of actual cropping is to be explored.

SUB-MANAGEMENT UNIT
It is important to consider a sub-management unit in the command area for water balance to know the various flows that are taking place within the system which will help the management to take decisions for efficient use of water. A unit could be defined by the boundary between two secondary level canals or by two drains with one secondary level canal. In the first option, the surplus flows and seepage from one side of each secondary canal enters the drain and the drainage measurement will reflect the quantum of water from the area bound by the secondary canals. Only one drainage measurement is necessary to know the outflow. However, this measurement will reflect the outflows of one side of each secondary canal. Another option could be to consider the area bound by two drains with one second level canal. Here, two drainage measurements are necessary, but the drainage measurements reflect the outflows from the neighbouring secondary canals also. In the first option, the quantum of drainage flows reflects the areas of less number of societies and consequently less area than in the second option. If the area is more the management will have more difficulty in taking decisions to correct the system.

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 about 1.8 lakh hectares under GLBC). There are 19 raingauge stations in and around the entire command of Ghataprabha Project and the data available has been studied and found that the percentage errors computed to be less than 10% and are within acceptable limits and can be considered to be representative of the study area. The density is adequate. The quantum of rainfall occurring on a sub-management unit / command of GLBC can be estimated based on the data of rainfall over the year.
STREAM FLOW FROM OUTSIDE THE COMMAND

The stream flow due to rainfall from outside the command enters into the command and flow through the drains. 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 GLBC runs as a contour canal and also as a ridge canal. There are several streams entering the command under contour canal. From the stream flow measurements, the quantum of water entering into the system can be assessed. In the case of Chikkodi Branch Canal which runs on the upstream of North Branch canal, the surplus flows from the command of Chikkodi branch canal entering into the command of GLBC form a part of the inflow. The mapping of the watershed to the command area will give an indication of the size of the stream and where the inflows need to be measured.

CANAL WATER APPLICATION

The discharges in the canal system are known. The quantity of water entering into the system can be assessed. The Canal runs for about 9 months of the year irrigating Kharif, Rabi and Two-seasonal crops. As per the Ghataprabha Project report, a cropping pattern of 40% Kharif (Jowar, Maize, Ground nut, bajra), 40% Rabi (Jowar, wheat, sunflower, maize, pulses) and 20% two-seasonal (10% cotton, 10% sugarcane) is planned with a total irrigation intensity of 100%. A better knowledge of the actual cropping pattern will have a significant bearing on the schedules of watering and the water requirement calculations.

LIFTING OF WATER FROM THE RIVERS:

This also becomes a constituent of inflow where water is lifted from the river near Hipparagi and Alamatti. The assessment of quantum of water lifted and used in the tail end command will be an inflow into the system.
Ground water
In the command of GLBC, 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, but this need not be accounted as it would amount to double accounting of water. The water entering into the system through canals and stream flows is already accounted. This same water enters as seepage and recharges the ground water.
In the zone without aquifers like the area under Bilgi Branch, 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.

OUTFLOWS

EVAPOTRANSPIRATION:
The Evapotranspiration is the largest and most important component of water balance. This is estimated as the product of cropped area irrigated and evapotranspiration (Etc) for each crop. Etc is the product of ET0 which is the reference Evapotranspiration based on climatological data and Kc, the crop coefficient, which is specific to each crop. Thus, the quantity of water consumed as Evapotranspiration from the crops in the command can be worked out. 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. If there is any limitation in the optimum use of water for any cropped area and shortage of water, a stress coefficient ranging from 0 to 1 will have to be considered to arrive at the right amount of Evapotranspiration.

From the field observation it is obvious that the intensity of irrigation is much more than the designed value of 100%. The extent of sugarcane area is almost about 50% (or even more). Other high water consuming cash crops like banana, turmeric etc are also grown. 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. In a sub-management unit, the flow leaving the unit needs to be measured. The mapping of structures such as Bandharas, barrages and tanks will help the management to know where the surplus flows and seepage water is being recirculated and also to plan new structures for optimum use of water.

The spills which occur at the end of the canal, main canal and secondary canals due to any reason 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 agrochemical loads

**CONSUMPTION BY TREES AND VEGETATION**

Here, the difference between the GCA and the NCA is about 20,000 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. Without irrigation the rainfall (500 mm) would have only allow a complete different set of vegetation types much more drought resistant. Trees as coconuts are taking advantage of lateral flows others are thriving on deep rooting system. Whatever the non crop vegetation also consume water. The area especially in the upper and middle reaches has abundant trees and vegetation. An estimate of such consumption needs to be accounted in the outflows. This is the reason why in the following first proxy of the water balance the entire GCA is considered.

**Infiltration / Ground water**

In the zone without aquifers like the area under Bilgi Branch, 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 recycling facility**

*Figure 20. Left: Bandara along a drainage fed by surplus of surface canal water and purposely made deliveries through escapes - Right: a Tank for storage and recharge*

**Water Balance: a first proxy**

A rough annual water balance in GLBC is given in the graph below. This balance considered the following components:

- Canal water for Rabi and Kharif: measured; averaged 2000-2005 = 1170 MCM
Rainfall over the GCA [181,000ha] measured; averaged 30 years 550 mm = 996 MCM
the aerial outflows from Evapotranspiration all over the GCA at ETo 1600 mm = 2900 MCM.

The resulting estimated deficit to cover crops needs when rainfall and surface water are accounted for is the net input from externals sources, i.e. mainly groundwater. In this estimation the contribution from external sources of groundwater is about 732 MCM.

Comments:
1) Rainfall is taken as 100 % because in one way there is no drop of rainfall getting out of the system. Every drop will be i) used directly through evapotranspiration, or ii) recharge groundwater (and reuse) or iii) contribute to the increase the surface streams which are captured by dams along the two major rivers.
2) Canal water is considered same as 100% input: direct use, recharge or runoff recycled.
3) The Deficit is thus the net external source brought by groundwater laterals flows from the rivers.
4) To be conservative the demand for Evapotranspiration has been taken on the high side: considering the entire GCA and not the NCA, and considering ETo as if all crops were having permanently a Kc (crop coefficient) factor of 1.
5) If we restrict the demand to the NCA then the value of the deficit drops down to 412 MCM.
6) If we further considered an average coefficient of 0.9 instead of 1, then the deficit is reduced to 154 MCM that is 7 % of the total.

Figure 21. Proxy of water balance for the entire GCA made during the workshop.
### WATER BALANCE OF GHATAPRABHA LEFT BANK CANAL PROJECT AREA FOR THE YEAR 2004 - 05

<table>
<thead>
<tr>
<th>S.No</th>
<th>INFLOWS into the Command area</th>
<th>Volume (MCM)</th>
<th>S.No</th>
<th>OUTFLOWS from the Command area</th>
<th>Volume (MCM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Canal Water</td>
<td>1322.70</td>
<td>1</td>
<td>Crop Evapotranspiration in Command area</td>
<td>1316.22</td>
</tr>
<tr>
<td>2</td>
<td>Rainfall</td>
<td>754.56</td>
<td>2</td>
<td>Outflows into Rivers &amp; Groundwater</td>
<td>1649.97</td>
</tr>
<tr>
<td>3</td>
<td>Water Lifted From Rivers</td>
<td>413.10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Runoff entering from outside the Command Area</td>
<td>451.61</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Regenerated flow from Chikkodi Branch Canal command</td>
<td>24.23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>TOTAL</strong></td>
<td><strong>2966.20</strong></td>
<td></td>
<td><strong>TOTAL</strong></td>
<td><strong>2966.20</strong></td>
</tr>
</tbody>
</table>
**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 Operation and Maintenance of GLBC**

205 Millions Rs is the total budget for GLBC that includes investment expenditure in infrastructure (repairs and cc lining).

![Chart showing the Budget breakup](image)

*Figure 22. showing the breakdown of the budget for GLBC*

**Cost of pumping in GLBC**

Another important component of the cost for irrigation supply to agriculture is that of pumping systems. A survey of the electricity consumption for agriculture in the Gross Command Area (220,000ha) shows that for the year 2006-2007 the consumption amounts to 114 millions KWh.....................
Step 6 SERVICE to USERS

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

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

What is thus presented in this section is not the definitive response for services but the state of the thinking at a given point of time for GLBC.

The various uses/users

The first stage was to clarify the uses and users, it maps out as follows:

1. Farmers
2. Water Societies
3. Domestic water supply
4. Hydro power generation
5. Environment and Ecosystems - Vegetation & trees

The main users of the system are obviously the farmers. The project has been designed as an irrigation project only, however wherever possible water is being used to produce electricity also.

Recently during 2001-02 the WUCS’s have been formed to take up the maintenance at lateral levels & also to release water to farmers within their jurisdiction. The average area of the WUCS is around 500 Ha. The dept is supposed to sell water on volumetric basis to WUCS at a rate Rs 12 / TCM & the associations are inturn responsible for supplying water to individual farms. However the RAP study has revealed that there is no proper mechanism to measure the water supplied to the WUCS & in turn to the farmers by WUCS. The WUCs are supposed to raise the demand & collect not less than the water rate fixed by the Govt. The associations are supposed to retain 20% of amount collected towards administrative charges & also Rs 40 / Ha towards the maintenance of the system. The remaining amount should be deposited to the KNNL.

In GLBC as of now 60% area has been covered by WUA’s. A federation has also been formed at the project level. However it is found that the WUA are not functioning well as per RAP studies & it is felt that especially at the tail end WUA have no realistic rights in Irrigation management & most of the WUA are financially weak. They cannot afford to have technical personnel expertise on their own for proper maintenance & management of the water system. The fluctuations in water level at the point of change in management are very high.

Due to the high sensitivity of the structures & as there are no level control mechanism in the system, has resulted in inequitable distribution of water both within the area & outside the areas.
The services provided by GLBC

1. Providing reliable and equitable service to farms
2. Providing domestic water supply to towns (bulk water emergency supply from dam during summer)
3. Providing hydropower and industrial inline turbining GLBC (by-product)
4. Providing industrial hydropower (river)
5. No direct environmental services as such but M&E of water quality in relation to irrigation management.

Service to farmers

As the main service provided by GLBC, service to farmers retained most of the attention during the MASSCOTE development.

1. A first and primary decision was made on the principle of service to farmers as follows:

**Canal water service to complement rainfall and groundwater to match crop needs.**

This decision implies among many other things that the quantum of canal water will be different according to the status of the various sources of water for each area.

2. Second decision was that canal service will be ensured only during a period of 8-9 months: for areas without groundwater, we need to assure a minimum Kharif + Rabi but it is felt impossible to provide them year-round irrigation.

3. Third decision is related to the different water management strategies for Rabi and for Kharif

The conditions of the supply are different during the two seasons therefore the service will differ also. For Kharif season, the surface supply is from the river only and the water management strategy is to let enter the GCA as much as water possible. It then implies:

- to run the canal full whenever the supplies conditions by the upstream river allow to do so
- when the supply exceeds the downstream demand thanks to precipitation, the management will maintain the surplus in the system and channel it towards areas where storage facilities are available and where groundwater recharge is possible.

Thus little flexibility is left to users during Kharif as the objective is to divert and use or store in the CA as much as water possible.

For Rabi season the situation is much different as water is mostly supplied by the Hikdhal reservoir. It is suggested that some flexibility should be left to Local Agencies/Water Societies/Farmers in managing their allocation throughout the season. Therefore on the basis of an initial water delivery schedule decided before the start of season, users should be allowed to manage their allocation by slightly changes the schedule of deliveries. How much flexibility can be offered to Local MA remains to be carefully studied considering the physical constraints of the system.
In particular the main system capacity is limited at the entrance and does not allow accommodating high peaks beyond the maximum discharge (2600 cusecs). So to a certain extent the accumulated delayed deliveries may create a high peak demand during the last month and may have to be accommodated by prolonging the season (addition deliveries in March).

On the other hand the crop needs are not varying much. If we take ETo as an indicator of the demand - it is possible to do so because mostly semi-permanent crops are cultivated (Kc factor does not vary too much and is close to 1) – then one can see that the monthly demand does not vary much about average during Rabi: Only ± 8%.

![Water demand Schedule for RABI (based on ETo)](image)

*Figure 23  Variation of ETo During Rabi from October till March.*

**Some key points about the current services:**

- Supply of water for semi-dry crops with provision for 10% sugarcane is envisaged in the Project report
- Allocated discharge of 2000 cusecs at head
- Actual study reveals more than 50% sugarcane cropping
- Officially the management is not considering the ground realities
- Actual discharge released at the head is 2600 cusecs. In reality in a way the management has accepted the existence of sugarcane by release of more water.
- Master plan committee has allocated additional 8 TMC for stabilizing the existing cropping pattern.

- In some of the distributaries the command at the head reach is classified as Khariff & command at the tail is classified as Rabi. This results in inequitable distribution of water within the command of the distributary.

- In view of the above observations & RAP studies, the total command area under GLBC may be classified into 3 distinct categories as far as the water services are concerned:
  - Upper Reach – Achkut from Km 0 to 50 – negligible suffering
  - Middle reach – Achkut from Km 50 to 109 – manageable suffering
  - Tail reach – Achkut Beyond Km 109 – severe suffering

In order to improve the services to the farmers & WUCS the management may think of taking any or all the following steps.

- There is a urgent need for the management to look into ground realities & assess the water requirement for the existing cropping pattern, availability of water resources & sufficiency of the canal network to meet the demand. Depending on availability & needs suitable measures for Conjunctive use of water should be explored.

- The availability of ground water may not be uniform with respect to depth & yield in the entire project area (as reported during visit to Bilgi Branch & South Branch). The priority of the management should be to provide more surface water to places with low ground water with efficiency & reliability.

- The average time required to reach from the head to tail of main canal & from head of branch at tail end of main canal to its tail end is about 7 days. Further any changes in the discharges will also take equal amount of time. This has made the water management at the tail end very difficult. Hence the management has explore possibilities of buffer storage at least the tail end to mitigate the problems of the tail-enders.

- Suitable provision for buffer storage in/along the canal may be thought of.

- At times of excess discharges in the canals, the spill points should be connected to tanks wherein water can be used.

- In view of change in cropping pattern the re-classification of distributary into Khariff, Rabi & two seasonal are required.

- The practice of dividing single distributary into both Khariff & Rabi should be avoided as far as possible.

- As the branch canals & distributaries are overdesigned, suitable level control structures such as weirs & cross regulators should be incorporated.
All the branch canals & distributaries should be lined, inorder to reduce the seepage losses, also to reduce time lag. The excess canal capacity may be used as buffer storage.

Necessary measuring devices need to be provided at all major regulating points in the system, so as to ensure equity.

**Multiple uses of water:**

The service to other uses of water through recharge of drainage streams, tanks etc., should be maintained and monitored properly.

**Service to environment**

**Step 7 PARTITIONING IN MANAGEMENT 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.

**Management levels**

Management units at present: 3 divisions and 250 wucs. We need to divide into smaller management units than 3. Now the set up is as follows:

<table>
<thead>
<tr>
<th>Existing management set-up</th>
<th>Proposed management set-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dam Management</td>
<td>Dam Management KNNL</td>
</tr>
<tr>
<td>GLBC Management</td>
<td>GLBC Management Agency KNNL</td>
</tr>
<tr>
<td>3 Divisions of 50000 ha</td>
<td></td>
</tr>
<tr>
<td>3 or 4 subdivisions: 10000 ha</td>
<td>Local Management Agencies</td>
</tr>
<tr>
<td>Sectors of 5000 ha</td>
<td>[stakeholders management] serving Water Societies where there are active or directly Field group at field channel.</td>
</tr>
<tr>
<td>Distributory sub-committees</td>
<td></td>
</tr>
<tr>
<td>WCs (500 ha)</td>
<td>Water Societies serving farmer groups</td>
</tr>
<tr>
<td>Field channel groups.</td>
<td>Farmer groups</td>
</tr>
</tbody>
</table>

At present, KNNL delivers water to Water Societies on volumetric basis and WUCS deliver water to farmers.

The main recommendations on management set up were:
1. main canal & branches down to the delivery point to next level units water supply on volumetric basis to next level
2. next level: 5 to 10000 ha federation of wucs, which can recruit technicians, and provide water delivery service on volumetric basis to WUCS
3. who distribute water to Field channels
4. farmer operation of FCs

WUCS:

Concern: we don’t want to upset existing WUCS if possible and of not required.
- On areas where they are not functioning or not existing, we can consider new options.
- On areas where they exist and are more or less functional, we may encourage WUCS to merge or regroup, but it is their decision.

Issue:
- ensuring equity within these units
- measuring & controlling at service interfaces
- management and operation within sub-units

Service by 1st level [Main System Agency]: not only delivery, but also looks at water balance, spills, and interacts with sub-unit, and builds their capacity.

In parallel with the management and operation set-up, the institutional organization needs also to take care of policy, tariff, etc... for the entire scheme, therefore it is suggested to have a higher level federation as now: representation, policies, building lower levels etc.

Main System Agency: Main level/corporate role

- Overall water management and development in the area
- Service to Local Management Agencies (Sub-GCA).
- Provide services to low level management in dealing with conjunctive use and IWRM

Modernization of management should be:
- Service Orientation Management
- Improve Main System Operation for water delivery (cost and effectiveness)
- Introduce volumetric management
- Moving towards a responsive management

Local System management: Second level/professional unit

Role: Operate the subsystem to serve WC, Disty or FG.
- Develop professional skills at lower management
- Develop sound governance for IWRM at lower level.

End-users groups: Third level/professional societies:
- With a minimum skills to ensure the last distribution level
- Stakeholders of the 2nd level association
The preliminary partitioning during the workshop was considering 11 LSM, the study done after the workshop ended up with 10 LSM and clear cut borders as shown in figure above.

**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,..)*

There are clear indications that the demand for canal operation is high for the 2 subsystem below km 109 that is Bilgi and South branches. But this step should be investigated further once LSMs are decided, and service and constraints for each documented.

Other than that there is no major variation of the demand as the main characteristics are quite similar.

**Step 9 CANAL OPERATION IMPROVEMENTS**

This step cannot be addressed at this stage when the previous one and particularly on partitioning have not received clear responses.

The proposed development of modernization encompasses at least two phases, with the first being done in 2008. Phase 2 is not yet clearly defined but basically will be the extensions and strengthening of Phase 1 depending on initial results.

**Phase 1 for 2008**
Creation of 2 LSMs: Jamkhandi Branch LSM - North Branch LSM.

The following tasks have been carried out:

**KNNL-LSM**
Establishment of a clear repartition of responsibility between KNNL – LSM - WUCS and farmers.
Definition of the legal status of LSMs. It is recommended to use existing legal framework such as a Federation.
Carrying out a MASSCOTE exercise for the two LSMs: leading to a more specific modernization plan for these irrigation systems.
Establishing solid foundations for generating a budget for irrigation management operation and maintenance at LSM level.

**MSM**
Implementation of a manual SCADA for main canal till delivery points to future LSMs. This would mean:
- establishment of calibrated measuring points (Checking the design, calibration campaign,..)
- design and implementation of an information system in KNNL with interconnection between the 3 offices.
- design of database management and user interface (including reporting, dashboard, performance evaluation,..).
- preliminary test of manual scada (using mobile phone)
- technical and cost study of a buffer storage in the downstream part of the canal

**SERVICES, Management and Operation**
- Establishment and validation of rules for decision making on water allocation, water scheduling and deliveries services for Kharif and more importantly for Rabi. With a clear partition of the decision at KNLL, LSM, WUCS and farmers.
- Future of the rotation of canals Kharif/Rabi.
- Practical procedures to ensure a good circulation of information KNNL-LSM both ways.
- Specification of Services from KNNL to LSMs (targets, default, compensation, etc...)
- Specification for the remuneration of services, fees collection, etc... in accordance with the state (to be renewed) policy.

**Policy level**
- Remuneration of water services.
- LSM budget generation/constitution.
- Rules for decision and financing on the modernization works (participation of the LSM budget to the works).
**Important Note:** After thorough discussion, there was an agreement among managers and FAO experts at the wrap up meeting that despite being a good idea for improving the management, the creation of LSMs is doomed to failure without having find a realistic solution on how the money would flow from users to the service providers, and how would the budget of LSM being managed.

So the main recommendation from FAO is to not move massively into this direction (LSM) without having first sorted out the issue of money for services the scope of which goes beyond the project and should be addressed at state level.

This caution approach goes along with some preliminary actions to be carried out in the system such as a having Masscote on the command areas of the 2 LSM proposed in phase 1. The concern here is to not create expectations that could not be met and avoid future disappointments similar to what has happened with creation of Water societies.

Restructure the management in 3 levels (instead of 4/5).

Main system/GCA: KNNL Single Management Unit 161000 ha
Local Management Unit: Professional unit of about 10000 ha grouping 10 to 20 Water Societies
Water Societies: 500 ha possibly re-grouped at Disty level

Main system/GCA a Single Management Unit and
Local management units (Sub-GCA) served by the former.

Main level/corporate role:
- Service to Local management units (Sub-GCA).
- Overall water management and development in the area
- Provide services to low level management in dealing with conjunctive use and IWRM

Modernization:
- Service Orientation Management
- Improve Main System Operation for water delivery (cost and effectiveness)
- Introduce volumetric management
- Moving towards a responsive management through “payment for service” for each use

Second level/professional unit

Role: Operate the subsystem to serve WS or Disty
- Develop professional skills at lower management
- Develop a sound governance for IWRM at lower level.

Third level/professional societies:
- With a minimum skills to ensure the last distribution level
- Stakeholders of the 2nd level association

The main is SCADA

Masscote Study at LSM level.
Step 10 AGGREGATING AND CONSOLIDATING MANAGEMENT

This step of aggregating the solutions cannot be addressed at this stage when the previous ones have not yet been addressed. In particular it is critical that a Masscote study is made for each LSM in order to provide the demand for improved MOM from the users. Only once this is done that we can then talk of aggregation.
Appendix 1. GLBC Compared to other systems for Selected Internal Indicators

[From FAO Water Report 19 and other RAPs carried out by FAO]

This appendix provides a comparative assessment with the 16 international irrigation projects that were evaluated as part of the FAO Water Report 19, Modern Water Control and Management Practices in Irrigation- Impact on Performance, plus some more system that have experienced RAP since 2000. A total of 31 systems are in the base.

The internal indicators results are compared to the values from the GLBC RAP for discussion purposes. This section includes graphs of selected internal indicators to illustrate key modernization concepts shown in Figures A-1 to A-5. The results of the GLBC RAP have been added to the graphs of the internal indicators from the report in order to provide a relative comparison with the other projects.

Actual service indicators are shown in BLUE and stated service indicators are shown in PINK.

Figure A-1. Comparison of stated vs. actual water delivery service to individual fields
Figure A-2. Comparison of stated vs. actual service by main canals to sub-main canals.

Figure A-3 is service from the main canal to secondary canals.
Figure A-4 is a Management and social index.