



Modernization Strategy for Irrigation Management

MASSCOTE APPLICATIONS

in

UPPER KRISHNA PROJECT -KJBNL

KARNATAKA - INDIA



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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

NRLW	Water 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
ICA	Irrigated Command Area
IBC	Indi Branch Canal
ILIS	Indi Lift irrigation System
ITRC	Irrigation Training and Research Centre (California Polytechnic University)
JBC	Jewargi Branch Canal
KJBNL	Krishna Bhagya Jala Nigam Limited
LMA	Local Management Agency
LSM	Local System management
MAF	Million Acre Feet
MASSCOTE	MApping Systems and Services for Canal Operation Techniques
MASSLIS	MApping System and Service for Lift Irrigation System
MASMUS	MApping System and Service for Multiple Uses
MBC	Mudbal Branch Canal
M&E	Monitoring and Evaluation
MUS	Multiple Uses of Water Services
NCA	Net Command Area (irrigable)
NLBC	Naryanpur Left Bank Canal
NRBC	Naryanpur Right Bank Canal
O&M	Operations and Maintenance
OFWM	On-Farm Water Management
RAP	Rapid Appraisal Procedure
SBC	Shahapur Branch Canal
WUA	Water Users Association

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SUMMARY

The MASSCOTE application presented in this document has been initialized through a training workshop in Karnataka, for engineers and managers from the KJBNL, focussing on Upper Krishna Project from 31st January to 10th February 2009. The contributions of participants made during the working group sessions at this workshop were largely included in this report under the supervision of the supporting FAO team comprised of Daniel Renault (NRLW-HQ), PS Rao (FAO Delhi) as well as resource staff from KNNL Mrs Shukumar, Mahesh, Murley, Kulkarny, Mohanar, and Mr. Murley from KBJNL.

The Upper Krishna Irrigation Systems is a set of systems using water from the Naryanpur reservoir located in the downstream part of the Upper Krishna. A total of 8 systems are fed by the reservoir, totalling a net command area of 513 000 ha for a GCA of 601 000 hectares.

The irrigation systems are new and are operational from the year 2003. Some projects are incomplete till date and their development still is pending. Two of them are using energy to lift water at headworks, and several of them are significantly dealing with multiple uses of water.

The MASSCOTE approach used in this workshop and afterwards is a methodology developed by FAO, for auditing performance and planning improvements of large open channel irrigation systems. The basic MASSCOTE methodology has been applied to 8 systems; some specific modules have been additionally applied to deal with lift irrigation systems and multiple uses of water.

Key outputs of MASSCOTE application in Upper Krishna irrigation scheme

1. New infrastructure but already deteriorated canal lining.

The Upper Krishna Irrigation systems is a gigantic water infrastructure, which if well managed will serve generations to come, avoid food shortage and generate good incomes for rural population.

The main irrigation structures like cross-regulators and offtakes are recent and in good condition. Main and secondary canals are lined, some reaches are already showing significant deteriorations of the lining, increasing water seepages and consequently reducing the capacity to supply water to the tail-enders.

The lack of water level control structures below the main canal creates huge problem of distribution.

2. Good external performance

Considering the whole set of irrigation systems, agriculture and water management are doing well in terms of external performance or agriculture productivity. Estimated indicators are respectively 1200 \$/ha and 0.184 \$/m³ of water and ranks medium-high in the range of indicators reported from similar systems analysed by FAO worldwide.

3. Irrigation inefficiencies

Probably the major problem is the inequity in the distribution of water with too much water flowing in the upstream distys and water deficit in the tail-ender distys. There are

obvious indications on the ground that tailenders are suffering or not even getting water at all.

4. Operational mode: lack of water level control

Water level is not controlled at all along the infrastructure. Cross-regulators along the main canal are left fully open (not used for control but just for safety purposes). Along the secondary and tertiary there are no Cross-regulators and that absence lead to a significant decrease of water level in the downstream parts of the canals. Farmers tend to compensate that effect by creating cross-bunding with stones and various materials. This issue should be taken seriously by managers and find more permanent solutions.

With low water level in canals, sensitivity of offtakes are tremendously increased and sometimes capacity to withdraw the design discharge is dramatically reduced. High inequity in the distribution is a result of that effect.

The lack of gates at the offtakes below the disty heads makes the designed rotation impossible.

5. Lack of measurements and inaccuracy of information

Measurements, assessment and monitoring are generally extremely poor. Some subsystems are equipped here and there with flumes, gauges but overall there is no systematic and rigorous approach of measurement of flows along the infrastructure and no automatic information system. Clearly this is an area where high improvements of the performance can be generated without investing much. This should be the top priority of the managers.

6. Need to focus on Management

As the scheme is still under development, construction focus is still high among the engineers of KBJNL and the required management shift from construction phase to water management has not yet happened.

High distortion Official/Reality at management and user levels is found. Management is still somehow based on the “official pattern” which is far away from the reality: i) rotation is not followed leading to shortage of water at tail ii) In some subsystems probably 50 % or more of rice cultivation which consume more water than any other crops iii) Multiple Uses of Water is significant in the CA: Hydro, Domestic to towns, domestic to villages /to people, Environment, Fishing iv) numerous illegal pumps are installed along the canals.

Management capacity should be raised with the objective of implementing a service oriented approach tackling the reality of the practices and uses, the constraints and the opportunities.

7. Drainage Management

Drainage management is not yet performed. For at least three important reasons this need to be changed:

- Good water management requires that the outflows are measured and possibly reduced to minimize water losses.
- The need to reduce water losses is even more important for the lift irrigation systems where any drop of water require energy to be lifted. Water losses mean energy losses.
- Spreading water all over is good for easy access to water services during the dry period of the year, but it also generates shallow water stagnation in non drained shallow buckets with adverse effects such as invasive vegetation. Specific interventions need to be implemented in these not well drained buckets to avoid shallow water stagnation.

8. Cost of management - operation and maintenance

The estimated total cost per ha is 2131 INRs out of which 700 INRs are for electricity bill. The energy spending for lift systems are respectively 0.32 INRs/m³ for ILIS and 0.37 INRs for the two stages of RLIS.

9. Institution

As the systems have been recently developed, involvement of all users and stakeholders remains low and it should be increased in water management. The modality for partitioning the CA into effective management units should be investigated thoroughly on the basis of the MASSCOTE analysis.

10. Immediate plan for improvement (one year)

The immediate follow up of the MASSCOTE workshop was discussed and agreed upon by participants. The main elements are as follows:

- Actual assessment of CCA
- Spatial units for management (KBJNL, WUFs, WUAs)
- Assessment of WUA's ability in Integrated Management (Progressive transfer/non-homogeneous)
- Re-location of office management (with shift from construction to management focus)
- Design of capacity development programme (Staff / Users)
- Need of separate security force for Law and order ???
- Assessment of silt in MC, disty and laterals
- Assessment of gates on disty
- Policy decision regarding modernization/repairs of laterals and FICs (as they are handed over to the WUAs)
- Calibration of rated section - MC and Disty
- Installation of FLUMES - project to be developed
- Drainage
- Escapes (assessment of leakage)
- Repairs to arrest leakages in escapes and UTs
- Multiple uses
- Database management
- Telemetry and sensors
- Water balance at local level
- Outsourcing of RS and GIS activity in investment phase and training the staff to operate the system.

Introduction and Background

The MASSCOTE application presented in this document has been initialized through a training workshop in Karnataka for engineers and managers from the KJBNL focussing on Upper Krishna Project from 31st January to 10th February 2009. The contributions of participants made during the work group sessions at this workshop have been largely included in this report under the supervision of the supporting FAO team composed of Daniel Renault (NRLW-HQ) and PS Rao (FAO Delhi) as well as resource staff from KNNL Mrs Shukumar, Mahesh, Murley, Kulkarny and Mohanar and Mr. Murley from KBJNL.

This document presents the status of the MASSCOTE application development immediately after the workshop. It has several purposes:

- suggest some specific strategies to managers of the UKP systems on how they should conceptualise the modernization of irrigation management;
- 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 within the KJBNL one of the three Nigams of Karnataka
- validate a specific module of MASSCOTE MASSLIS which is dedicated to lift irrigation system.
- introduce a new module on multiple use of water.



Figure 1. Location of the Upper Krishna Naryanpur projects in Karnataka

Brief introduction to the Upper Krishna Project Systems

The Upper Krishna irrigation systems is a set of systems using water from the Naryanpur reservoir located at downstream part of the Upper Krishna. A total of 8 systems have been built since year 2003 which are fed by the Naryanpur reservoir, totalling a net command area of 513 000 ha for a GCA of 601 000 hectares. The subsystems are listed in table below:

Table 1. Upper Krishna Irrigation Systems

Name of subsystem	ICA hectares
Naryanpur Right Bank Canal NRBC	84000
Rampur Lift irrigation System RLIS	20235
Naryanpur Left Bank Canal NLBC	47223
Indi Lift irrigation System ILIS	63076
Indi Branch Canal IBC	131260
Shahpur Branch Canal SBC	122120
Mudbal Branch Canal MBC	51000
Jewargi Branch Canal JBC	57098

The 8 systems have been investigated using the MASSCOTE methodology with two variant MASSLIS for the lift irrigation systems RLIS & ILIS and MASSMUS for the multiple use of water in SBC.

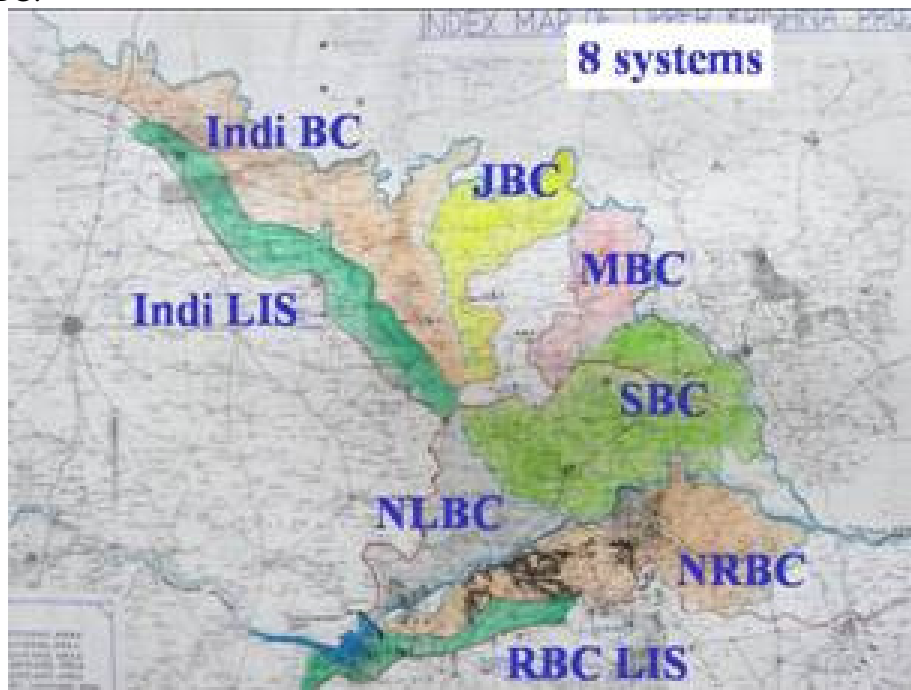


Figure 2. Layout of the 8 irrigation systems of the UK Naryanpur complex.

1. PRESENTATION of the MASSCOTE APPROACH

The generic 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 management and the development of a project for modernization of Canal Operation.

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

- service to users
- cost of producing the services
- performance Monitoring & Evaluation
- 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.

A specific module of MASSCOTE for Lift Irrigation System developed in 2008 called MASSLIS [Mapping System and Services for Lift Irrigation System] has been used in some subsystems of the Upper Krishna Project.

Another specific module called MASSMUS [Mapping System and Services for Multiple Uses of Water Services] which focuses on multiple uses of water in the command area has been recently developed by FAO and for the first time tested on the ground on this project.

1.1. Presentation of the methodology

The first 6 steps of MASSCOTE (Table 1) are conducted for the entire command area. The objective of step 7 is to identify 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 of the outputs are carried out at the main system level through steps 10 and 11. Thus, the methodology uses a back-and-forth or up-and-down approach for the different nested levels of management.

Table 2. 10 STEPS of MASSCOTE

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

PART I MASSCOTE in Upper Krishna Irrigation Systems

- The MASSCOTE analysis has been conducted for the 8 subsystems comprising the Upper Krishna Irrigation Systems (UKIS).
- In Part I the findings for the entire command area are synthesised aggregating all 8 subsystems.
- In Part II are reported special MASSCOTE applications for two Lift systems and one for Multiple Uses as well as field visit reports produced by participants during the workshop.
- Photographs of the infrastructure features are presented only in part II as part of the field report for each subsystems.

Step 1. Rapid Appraisal Procedure

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

Step 1.1 RAP Methodology for Canal System

The RAP is a quick and focused examination of irrigation systems and projects that can give a reasonably accurate and pragmatic description of the status of irrigation performance and 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 at an entire irrigation project level, is to perform a rapid appraisal (RAP) of the system as it is being operated.

The RAP can be described as follows:

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

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

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

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

Performance indicators

The external indicators compare input and output of an irrigation system to describe overall performance. These indicators are expressions of various forms of efficiency, for example water use efficiency, crop yield, and budget. But they do not provide any detail on what internal processes lead to these outputs and what should be done to improve the performance. They, however, could be used for comparing the performance of different irrigation projects,

nationally or internationally. Once these external indicators are computed, they are used as a benchmark for monitoring the impacts of modernization on improvements in overall performance.

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

Participants at the workshop were divided into 7 groups:

- Group 1: RLIS and NRBC
- Group 2: IBC 0 to 80 KMs
- Group 3: NLBC 77 KMs
- Group 4: SBC 76 KMs
- Group 5: JBC 78 KMs and MBC 51 KMs
- Group 6: IBC 80 to 172 KMs
- Group 7: ILIS 0 to 97 KMs

They spent 3 days on the field and gave ratings to all internal indicators. During a plenary session ratings were reviewed and finalized.

Common findings reported from the field visit

1. Gigantic water infrastructure that should be well managed to serve generations to come, avoid food shortage and generate good incomes for rural population.
2. Management shift from construction phase to water management has not yet happened.
3. High distortion Official/Reality at management and users levels
4. Measurements, assessment and monitoring extremely poor
5. Multiple Uses of Water is significant in the CA: Hydro – Domestic to towns – domestic to villages /to people – Environment – Fishing.
6. Involvement of all users and stakeholders should be increased in water management.
7. Spreading water all over is good for easy access to water services, but it also generates shallow water stagnation in non drained shallow buckets with invasive vegetation.
8. Drainage flow important (Nala): Water losses!
9. Water Services should thus include drainage.
10. In some subsystems probably 50 % rice cultivation
11. Water distribution not controlled
12. Rotation not followed leading to shortage of water at tail.
13. Lack of gates below disty heads making rotation impossible

14. Low flow spreading all around low efficiency of transport
15. Seepage losses due to canal lining deteriorated
16. Too much water flows in upstream distys.
17. Inequity Tail-enders deficit within Disty

Some findings are specific to some system; they are reported in table 3.

Table 3 Specific issues reported per subsystem

Subsystem	Specific issue reported
RLIS	BFV required to throttle the discharge Capacitor to improve PF
NRBC	Transitions between cutting and banking reaches of canal needs stabilization Sensitive off-takes (designed for Scheme-A+B requirement) needs immediate attention
IBC	Slippage of CC lining to be rectified in many reaches
NLBC	Vulnerable reaches in banking in km.61 to 63 needs special attention for stabilization. Aqueducts needs restoration
SBC	Excess withdrawal and specific geology lead to drainage problem in initial reaches
JBC	Deteriorated lining in initial 20 km stretch to be rectified
MBC	Substantial leakage in head regulator (diversion). Need proper structure to automate operation to avoid vandalism. Restoration of aqueduct in km.40
ILIS	Bank slides in intake channel is a serious problem

External performance indicators

The productivity of land for the entire area is estimated to reach 1206 \$/ha. It ranks upper medium when compared to other systems studied by FAO in ASIA and elsewhere as seen in figure 3. It also ranks medium when compared to similar systems of Karnataka: one could expect higher values as found in Bhadra or Ghataprabha but the slight gap is probably due to the recent development of the project. Some areas of the project have been irrigated for decades but others are really new for irrigation and some are still under development.

In terms of productivity of irrigation water, performance is significantly higher (it ranks 5th out of 28 systems studied and first for South Asia) and reach 0.18 \$ per m³ of water. One reason is that pumped water is probably more used as a supplementary irrigation rather than full fledged irrigation supply thus leading to higher value per irrigation volume unit.

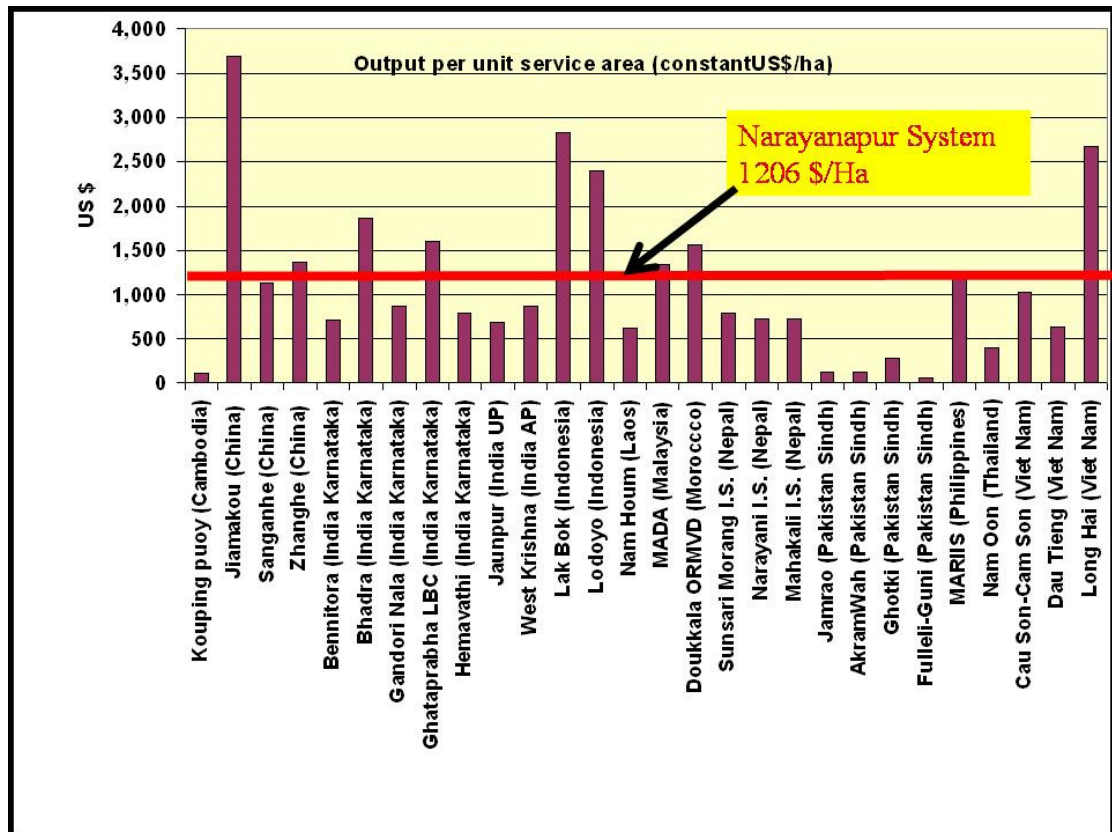


Figure3. Output per unit area in Upper Krishna systems compare to other systems

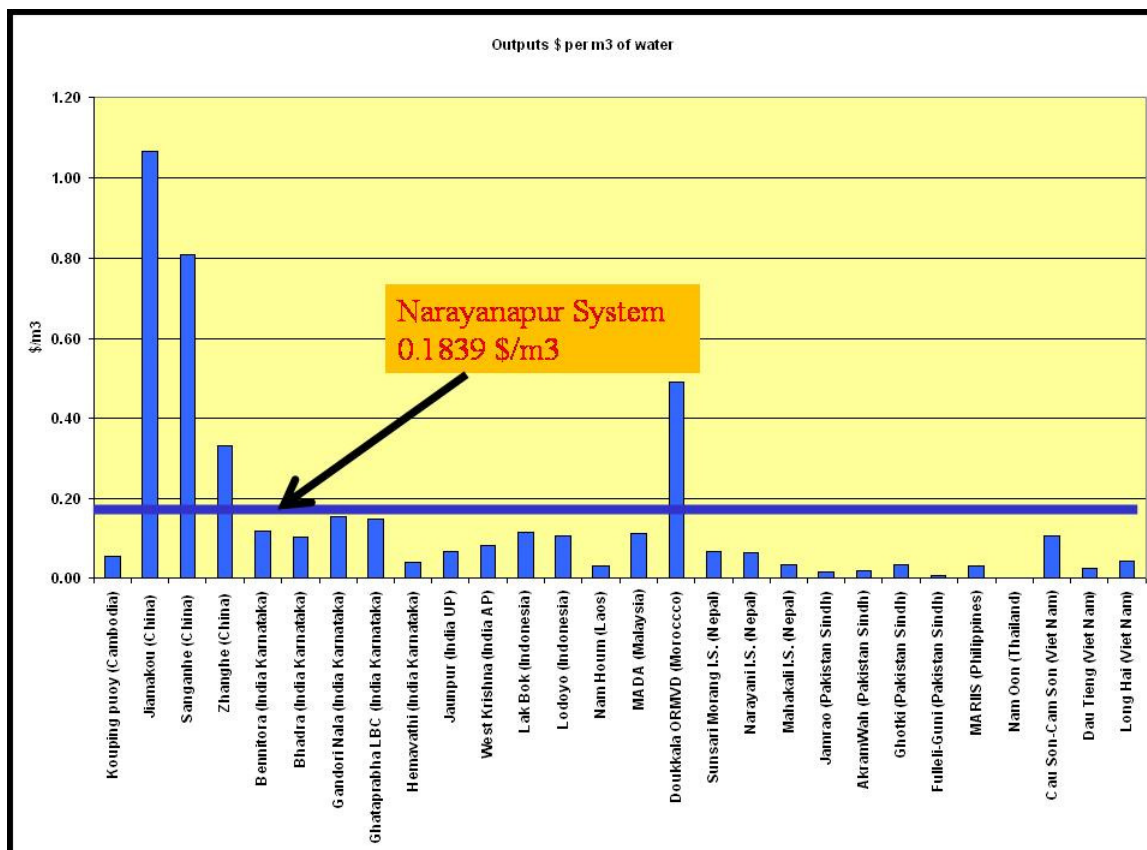


Figure4. Output per unit of water in Upper Krishna systems compare to other systems

Internal performance indicators

For the reporting of internal indicators, subsystems have been divided into 4 groups which are:

- **NRBC**
- **NLBC**
- **Branches = SBC, JBC, MBC & IBC**
- **Lifts = RLIS & ILC**

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).

Main canal operation

Table 4 summarizes the internal performance indicators for the Main Canal. The situation of the main canal is diverse. The lifts systems ranked the lowest whereas NLBC the highest, with the main difference coming from the General conditions of the Main Canal [0.6 to 2.6].

Table 4. Upper Krishna systems Internal Performance Indicators for the Main canal
(Maximum possible value = 4.0, minimum possible value = 0.0)

MAIN CANAL	NRBC	NLBC	Branches	Lifts	Overall
Cross regulator hardware (Main Canal)	1.1	3.3	1.8	1.4	1.9
Turnouts from the Main Canal	2.1	3.3	2.8	2.0	2.55
Regulating Reservoirs in the Main Canal	0.0	0.0	0.0	0.0	0
Communications for the Main Canal	2.7	2.5	2.3	2.7	2.55
Existence and frequency of remote monitoring (either automatic or manual) at key <u>spill</u> points, including the end of the canal	0.0	0.0	0.0	0.0	0
General Conditions for the Main Canal	1.6	2.6	2.7	0.6	1.87
Operation of the Main Canal	1.8	2.2	2.0	1.3	1.82
Clarity and correctness of instructions to operators.	2.7	2.7	2.7	2.7	2.7
<i>Average of above indicators (except reservoir and spill indicators)</i>	2	2.7	2.3	1.7	

Table 5. Actual vs Stated performance

	Actual / Stated			
	NRBC	NLBC	Branches	Lifts
Water Delivery Service by Main Canal to the Second Level Canals	1.3 / 2.4	2.4 / 2.5	2.4 / 1.8	1.6 / 2.0
Flexibility	1.0 / 1.0	2.0 / 3.0	1.0 / 1.0	1.0 / 1.0
Reliability	1.0 / 3.0	2.0/ 3.0	3.0 / 3.0	3.0/ 3.0
Equity	2.0 / 3.0	3.0 / 2.0	3.0 / 1.0	1.0 / 2.0
Control of flow rates to the submain as stated	1.0 / 3.0	3.0 / 0	3.0 / 3.0	1.0 / 2.0
Average of the above indicators	1.25/ 2.5	2.5/ 2.1	2.5/ 2	1.5/ 2

Stated performance reflects how managers see their performance [ranking is made after office project interviews]. The stated performance indicators are different from one group to the other in Table 5 as managers are different.

What is remarkable and unusual is the fact that managers are not overestimating their performance. The average stated indicators are between 2 and 2.5 which means that managers are aware of the lack of good performance and they are not hiding the facts. Only in the case of NRBC can we notice a gap between the stated performance (average 2.5) and the actual (average 1.25). For others subsystems actual and stated are medium and reasonably close to each other.

Secondary Canals

The performance of the secondary canals (branch and main distributary) in UKIS is summarized by the key internal indicators in Table 6. In general, the performance indicators for the second level canals are substantially lower than those for the main canal (the average indicator reaches 1.7 instead of 2.2.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 6 UKIS Internal Performance Indicators for the Secondary canals
(Maximum possible value = 4.0, minimum possible value = 0.0)

Second Level Canals	NRBC	NLBC	Branches	Lifts	Overall
Second Level Canal hardware	0.5	1.0	2.4	1.0	1.2
Turnouts from the Second Level Canals	1.5	2.2	1.3	1.0	1.5
Regulating Reservoirs in the Second Level Canals	0.0	0.0	0.0	0.0	0.0
Communications for the Second Level Canals	2.0	2.8	0.4	2.7	2.0
Existence and frequency of remote monitoring (either automatic or manual) at key <u>spill</u> points, including the end of the canal	0.0	0.0	0.0	0.0	0.0
General Conditions	1.4	2.4	2.7	2.5	2.2
Operation of the Second Level Canals	1.8	1.6	1.8	1.2	1.6
<i>Average of above indicators (except reservoir and spill indicators)</i>	1.44	2	1.72	1.68	1.7

Table 7. Internal Performance Indicators for the Branch /Distributaries
(Maximum possible value = 4.0, minimum possible value = 0.0)

Internal Performance Indicator	Value (0-4)
Cross regulator hardware	<u>1.1</u>
Turnouts (watercourses) from the Distributaries/Minors	2.2
Communications	3.0
General Conditions	1.6
Operations	2.4

Tertiary Canals and final deliveries

The internal indicators that characterize the actual water delivery service at the farm level are summarized in **Table 8**. The water delivery service being provided to the farmers is relatively low (average below 1). This is a measure of the flexibility, reliability, equity, and measurement of the water supply to individual fields.

Inversely to what was stated for the main canal, here there is a significant gap between what managers think they are doing and what has been stated by participants (average stated = 1.79 actual assessed= 0.87).

Table 8. Internal Performance Indicators for the Minors/laterals/Field channels
(Maximum possible value = 4.0, minimum possible value = 0.0)

	Actual / Stated			
	NRBC	NLBC	Branches	Lifts
Water Delivery Service at the head of field channel	0.9 / 2.4	0.9 / 1.9	1.2 / 1.9	0.9 / 1.9
Number of fields downstream of this point	0.00 / 0.00	0.0 / 0.0	0.0 / 1.0	0.0 / 0.0
Measurement of volumes	0.0 / 2.0	0.0/ 0.0	0.0 / 0.0	0.0/ 1.0
Flexibility	1.0 / 2.0	0.0 / 2.0	2.0 / 2.0	1.0 / 2.0
Reliability	1.0 / 3.0	2.0 / 3.0	2.0 / 3.0	2.0/ 2.0
Apparent equity	2.0 / 3.0	2.0 / 3.0	1.0 / 3.0	1.0 / 3.0
Average of the above indicators	0.82/ 2.07	0.82/ 1.65	1.03/ 1.82	0.82/ 1.65

Table 9. Final Delivery Point Internal Performance Indicators (0-4)
(Maximum possible value = 4.0, minimum possible value = 0.0)

	NRBC	NLBC	Branches	Lifts	Overall
Actual Water Delivery Service to Individual Ownership Units (e.g., field or farm)	1.7	1.1	0.6	1.1	1.13
Measurement of volumes	0.0	0.0	0.0	0.0	0.00
Flexibility	2.0	0.0	0.0	2.0	1.00
Reliability	2.0	2.0	1.0	1.0	1.50
Apparent equity.	2.0	2.0	1.0	1.0	1.50

The social order indicator reflects the degree to which irrigation deliveries are being taken either from unauthorized locations or in quantities greater than allowed. The ranking for social order is very low (0.4 – 0.6) except for the branch canals which can be considered as medium (1.6).

Table 10. Social order
(Maximum possible value = 4.0, minimum possible value = 0.0)

Social "Order" in the Canal System operated by paid employees	NRBC	NLBC	Branches	Lifts
	0.6	0.6	1.6	0.4
Degree to which deliveries are NOT taken when not allowed, or at flow rates greater than allowed	1.0	1.0	1.0	1.0
Noticeable non -existence of unauthorized turnouts from canals.	1.0	1.0	2.0	0.0
Lack of vandalism of structures.	0.0	0.0	2.0	0.0

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.

Budget

The ranking for budget is almost zero as expressing a drastic lack of money for operation and maintenance and for modernization.

Management and Water user societies

The ranking for WUA in the rap comes to almost zero for the following reasons:

- 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?

Key findings of the field visit

- 1) No measurements
- 2) Improper flow control
- 3) Violation of rotation
- 4) CRs are not used for water level control
- 5) Vandalism of structures
- 6) Lack of training
- 7) Ineffective WUAs
- 8) Lack of communication
- 9) Lack of information system
- 10) Insufficient operators

Step 2. SYSTEM CAPACITY AND SENSITIVITY.

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

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

Step 2.1. The capacity along the canal

The assessment of the capacity of the Upper Krishna Irrigation Systems by participants has yielded to the following points or conclusions:

- Main Storage is sufficient but there is no online storage
- Conveyance system is OK.
- Some reduced capacity due to siltation.
- Some sections affected by seepage
- Diversion OK
- Distribution OK
- Control of water level deficient
- Measurements: Deficient rated section often no gauges low calibration
- Safety: not enough escapes
- Transmission OK
- SR along main canal is in good condition . 50 % is good.

In conclusion the main efforts to be made for capacity are for measurements, water level control and safety.

Step 2.2. The sensitivity along the canal

Low Sensitivity at Cross regulators

Cross regulators are installed along the main canal which follows the contour lines and as such there is limited drop (head) at each regulator thus the sensitivity of the CRs remains low everywhere.

Variable Sensitivity at offtakes

Sensitivity at offtakes varies with the location along the canal and the level of canals. By design sensitivity of most offtake is low (<1) when canals are run at FSD. However it is reported for many subsystems that tail end offtakes are facing harsh problems of sensitivity and supply limitations due to low discharge in canals.

One exception is ILIS which appears to be having high sensitive offtakes all over as reported in Table 11.

Table 11. Reports on sensitivity of offtakes along the UKIS

Subsystem	OFFTAKES - OUTLETS
RLIS	Medium sensitive Off takes are medium sensitive. [1.6 ; 1.34; 0.56]
NRBC	NRBC : Off takes are low sensitive. [0.15- 0.38]
IBC	Main canal offtake 0.8 (upstream) (0.3 downstream) Distry offtakes 0.8 1.7 Lateral offtakes Highly sensitive FIC outlets Highly sensitive
NLBC	Low sensitive
SBC	By design sensitivity of offtakes is low (<1) along main canal [average Head = 1.5] Only tail end offtakes are facing harsh problems of sensitivity and supply limitations due to low discharge in canals.
JBC	Along main canal low sensitive in the upstream reaches Sensitivity increases downward from 0.7 to 2.5
MBC	Along main canal low sensitive in the upstream reaches Sensitivity increases downward from 0.7 to 2.5
ILIS	Main canal initial off takes are high sensitive varying from 1.86 to 2.76. and tail end off takes are of very high sensitive above 3.5. Distributary off take sensitivity increases down the distributary at the tail end. Minor off takes are very sensitive. Tail end off takes are not properly fed due to insufficient head.

STEP 3: THE PERTURBATIONS

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

CAUSES:

- Unauthorized off-takes (siphons) and lifting of water from canal
- Temporarily constructed obstructions (Bunding - walls) to raise water level at offtake
- lack of proper gate to close offtake.
- Inaccuracy in management
- The operation of pumps is one of the main causes of perturbations. The pumps are designed to operate for 24 hours, whereas in reality they are working from 12 hours to 24 hours. When pumps are shut down, there is sudden lowering of water level in the canal. Power shutdown.
- Closure of pumping during rains results in perturbations.
- Rain water entering the main canal during rains .
- Unauthorised operation of gates by the farmers.
- Uncontrolled flows in distributors and minors.
- Siltation
- Blockage of outlets in the minors by the farmers.

MAGNITUDE:

It is significant in case of pump operation and illegal withdrawals from pump sets.

Location

Perturbations are seen all along the length of the canal, more towards downstream end.

Frequency

It is more prominent during Rabi season due to unauthorised withdrawal from pumps.

Options to cope with:

- By continuous pumping by all the pumps for 24 hours, the perturbations can be reduced.
- The CRs / weirs can be constructed and operated frequently to maintain the required depth of water.
- There are no regulating reservoirs (on-line storage) along the canal to store surplus water. The storage capacity of the main canal (tapping the free-board) should be considered.

Step 4 MAPPING WATER BALANCE

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

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

Water Balance: a first proxy for year 2006-2007

Irrigation supply from the main reservoir accounts for almost $\frac{3}{4}$ of the total (5260 MCM - 73%) water input in the area, and gross precipitation for $\frac{1}{4}$ (1956 MCM - 27%) as shown in Figure 5. the total input being 7216 MCM.

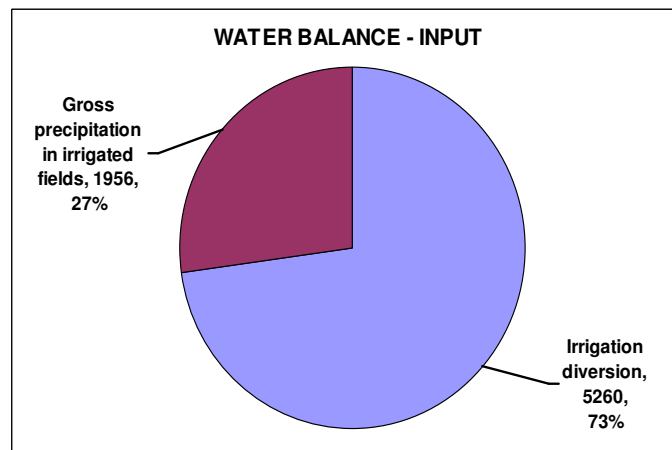


Figure 5. Water Input balance for UKIS (2006-2007)

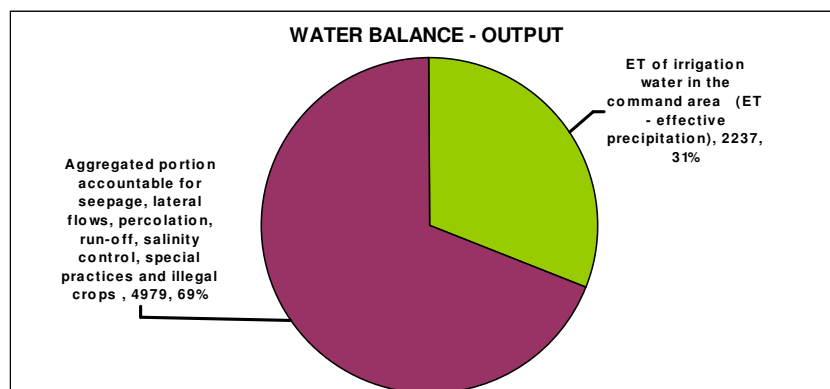


Figure 6. Water Output balance for UKIS(2006-2007)

The irrigation water needs are estimated by accounting the demand for evapotranspiration and deducting the effective precipitation. The climatic demand ETo amounts to 1753 mm per

year and the demand for evapotranspiration in the CA is estimated to be 3365 MCM for the year 2006-2007. With an effective precipitation taken as 1128 MCM the Net ET of Irrigation water amounts to 2237 MCM (fig.6), that is 31% of the total water inputs and 42 % of the irrigation water supply from the main reservoir.

The main conclusion from this water balance analysis is that some 69 % of the water entering the command area is not used by the planned irrigated crops and is either used by some unplanned uses of water or drained back to the Krishna river.

Table 12. Water balance OUTPUTS (2006-2007)

Sl. No.	Mode of output	Quantity in MCUM	Percentage
	ETa Evapotranspiration needs at field level	3365	-
	Effective precipitation	1128	-
1	ET of irrigation water in the command area (ET – effective precipitation)	2237	31%
2	Aggregated portion accountable for seepage, lateral flows, percolation, run-off, salinity control, special practices and illegal crops	4979	69%
	Total:	7216	100%

Step 5 MAPPING THE COST of OPERATION

Objective: *The objective is to gather as many elements of cost as possible which enter in to the operation of the system, in order to identify the areas where possible gains can be sought for with the current service and operational set up, and to know the cost of implementing improved service. This step thus focuses on mapping the cost for current operation techniques and services, disaggregating the elements entering into current cost and for various levels of services with current techniques and with improved techniques.*

Cost of Operation and Maintenance

The budget analysis is made for 3 different zones covering the area. The first share of the cost is maintenance and repair, each zone is spending between 60 to 67.5 Millions INRs (600 and 675 Lakh of INRs figure 10.). The second item very close to previous is Salary 34 to 65 Millions INRs. The other items are accounting for some 10 % total for travel office machinery and equipment.

The proportion of maintenance and salaries in the total varies significantly as can be seen in figures 7, 8 and 9; maintenance from 43 % to 63% and salaries from 31 % to 47%.

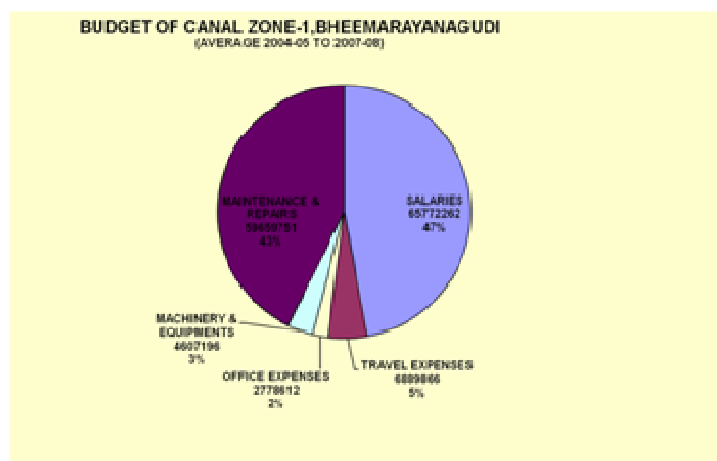


Figure 7. Breakdown of the budget for UKIS Zone 1.

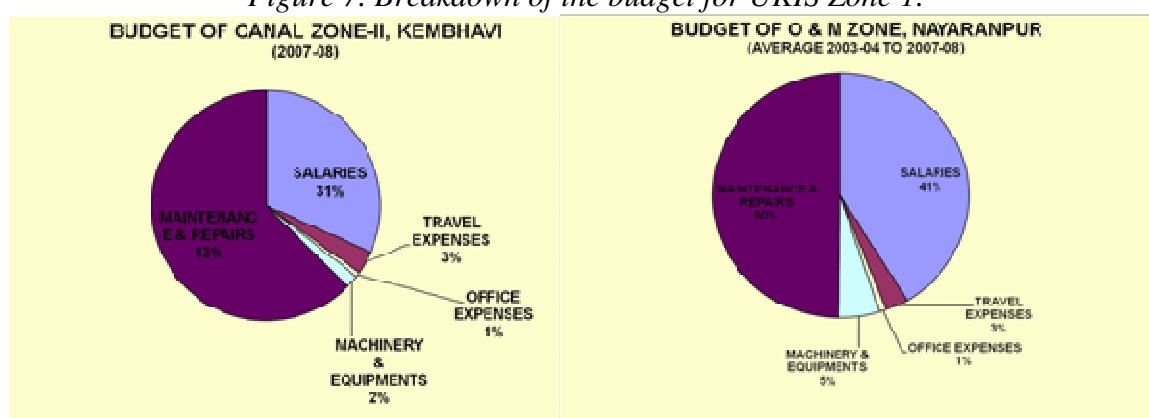


Figure 8. Budget for UKIS Zone 2.

Figure 9. Budget for O&M Zone Nayanpur

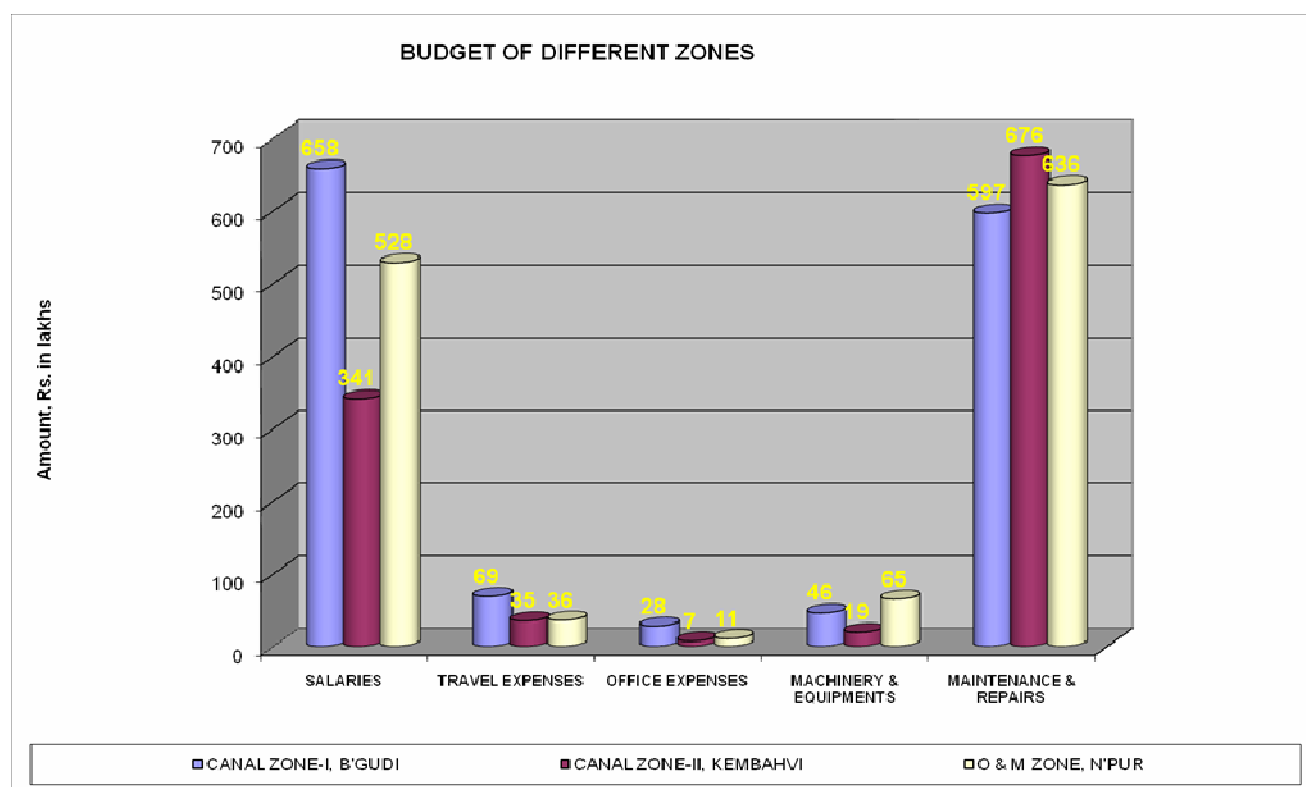


Figure 10. Breakdown of the budget for UKIS Zones.

In tables 13a and 13b breakdown of cost per hectare is calculated respectively for the gravity systems and for the lift systems. Not surprisingly the difference is huge from 652 Rs per ha to 1698 Rs per ha but energy spending explains only half of it (558 Rs out of 1046 Rs). The remaining gap is generated by higher cost in administration and maintenance.

Table 13 a . Cost per hectare for Gravity canals.

Components	Cost per Ha. in Rs.
Operation & Machinery equipments	52
Administration charges	294
Maintenance of canal net work	306
Total	652

Table 13 b . Cost per hectare for Lift Systems

Components	Cost per Ha. in Rs.
Energy charges	558
Operation & Maintenance of pumps	41
Administration charges	538
Maintenance of canal net work	560
Total	1698

Step 6 SERVICE to USERS

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

The analysis of service to users is central in the MASSCOTE development process. However a single one go is not sufficient to characterise all aspects and options of the water services. Several applications 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 UKIS.

- The first part of the section deals with the “multiple uses of water” which has been mentioned in several subsystems of UKIS.
- The second part addresses the service to farmers looking at existing situation and developing the perspectives which ultimately lead to propose a “Vision of the irrigate agriculture and water management”.

Generalities on Multiple Uses of Water

Beyond water for crops, irrigation projects are seen within the larger context of basin water management with regards to both the qualitative and quantitative aspects of water. Moreover, also within a canal system, “irrigation water” may be used for many other purposes by farmers and other inhabitants of the area. Furthermore, the demands on the operator also include issues in the sphere of mitigation of possible negative side-effects of irrigation, e.g. salinization, waterlogging and the spread of vector-borne diseases. All these issues place more or less stringent requirements on the chosen mode of operation.

Within a canal system, there are several services and/or externalities that managers have to deal with:

- domestic water supply to villages;
- groundwater recharge;
- streams and waterbodies for fishing activities;
- water supply for livestock;
- environmental needs/impacts (groundwater recharge, waterlogging, salinity, and drainage and return flow from the CA to natural streams);
- recreational needs;
- health and sanitation.

Energy production is sometimes another important use of water stored in multiple-use reservoirs. The routing and scheduling of water demands for generating energy is most often at the main inflow point to the project. However, in some cases, it may be within the system itself.

Multiple uses, functions, roles and purposes

When we talk about MUS, uses such as domestic water supply, irrigation supply and hydropower generation are the ones that immediately come to mind, albeit sometimes at different scales. The concept of MUS may go beyond these very tangible uses, to embrace also other functions, roles and purposes such as flood protection associated with irrigated paddy cultivation, or with multi purpose reservoir.

Some functions are rooted in the social and cultural aspects of water management; others are related to the hydrological processes, specific agriculture practices such as terraces in paddy cultivation, others to the biological and ecological processes.

Table 14. Classification of uses and functions

Uses	Functions and Roles
Domestic water	Flood protection
Sanitation and wastewater management	Groundwater recharge
Irrigation	Support to fishing
Water for cattle	Tourism
Transportation	Support to natural ecosystems (biodiversity)
Hydropower	Social functions linked to the infrastructure and management
Environmental flows	Recreation
Flood protection	Soil conservation
	Habitat improvements (raw materials for construction, shade, cooling effect,...)

Table 15. Typology of MUSF systems

TYPE		Shared system	Typical situation
MPR(1)	A reservoir with separate system-networks for each use of water. Usually Large infrastructure	Reservoir	Multipurpose reservoir
MPN	A distribution system-network designed for serving multiple uses	Network	Multipurpose network
MU +	Single Use distribution network yielding opportunities and externalities for other uses.	Water resource & Network	Domestic + Irrigation +
MU Seq	Sequential system: drops cascading from one compartment to the other <u>Successive non consumptive uses of water</u>	Water cycle/pathway	A surface groundwater hydrosystem supporting irrigation and domestic
MF	Multi dimension/functions/services Several functions/roles associated to some uses of water and/or resulting of the circulation of water and/or the set of practices associated with water management	Eco-system	Paddy Field system Wetlands

MUS in management: elements for quantifying the size of each service

First set of elements that one needs to have in mind is related to the importance of a specific use, which can be described as:

- Quantum or Share of Water Use (or Magnitude of the use) considering both water quantity and water quality
- Share of the total benefits that are generated by this use.

Another critical issue is how do stakeholders value the various uses. This question goes beyond the strict approach of benefits to include the preference of users among alternatives. Approaching the values of water uses is important but requires more in depth survey, user interviews to understand on what ground comparison among uses should be made, decision should be taken and conflict resolution proposed

The second set of elements relate to the inclusion of the use into the management set up. The following elements are crucial:

- Stakeholder/Actor representing the use
- Definition of the specific corresponding service
- Share of MOM cost coverage to sustain the water services.

In short 3 elements are critical for quantifying the size of a use: Water, Benefit and Cost. (figure 5).

Mapping the Gross Command Area, Land Uses and activities

The delineation of the gross command area of an irrigation system is critical in the sense that it gives the upper limits within which water drops circulate. Also external watersheds contributing to the runoff into the GCA need to be delineated to account for precipitation contributions.

One of the first elements to seize MUS in a Gross Command Area is to map down the main land uses which are contributing in various way to the evaporation and runoff. Through the land use we have a good sense of the evaporative areas in the GCA.

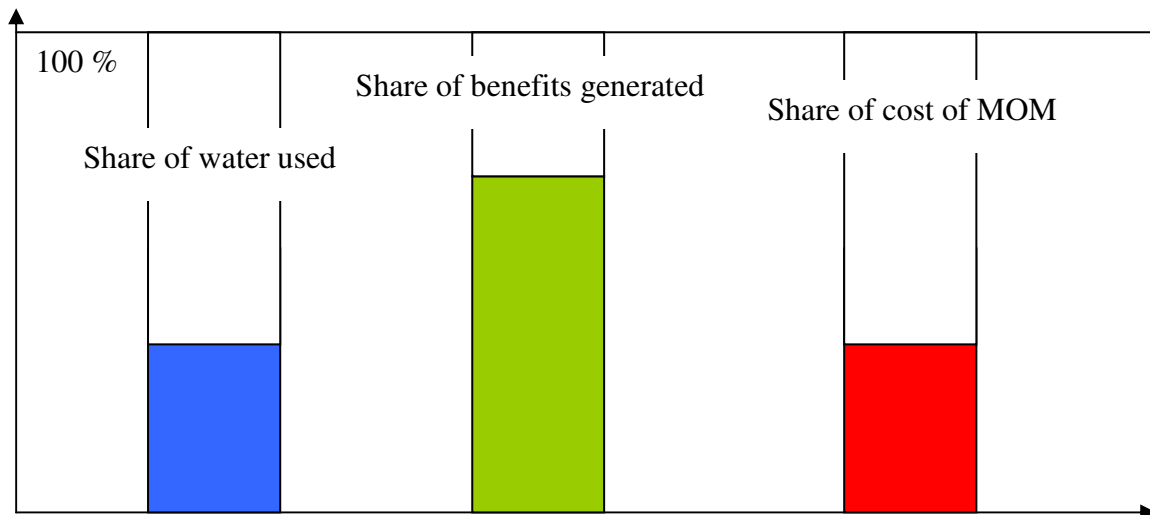


Figure 11. The 3 main dimensions of a Water Use in a MUSF irrigation system.

Activities that are localized (not associated to a large area) need also to be identified on the GCA map.

It is also important to have an idea of the population distribution and the size of the various economical activities:

- Farming: number of farmers, Gross product
- Fishery: number of fishermen, Gross product
- Employment: number per type, Gross product

Households (rural and urban). For each use of water, one needs to identify the type of Users, Users group, Actors such as the regulatory authority for this use, and stakeholders.

MAPPING WATER USES & SERVICES in UKIS

The first stage is to identify and estimate the importance of the various water uses met in the command area. For several subsystems visited, reports mentioned the existence of significant Multiple Uses and Functions of Water Services (MUSF) in the CA. This is particularly the case for Shahapur Branch Canal for which a specific MASSCOTE module has been applied (see part II MASSMUS in Shahapur). MUSF is also mentioned as significant feature of water use in RLIS, NRBC and IBC. All in all we can consider that all subsystems are to a certain extent concerned by MUSF, for at least two other uses which are water for people and water for animals.

In Shahapur the system for which MUSF has been systematically analysed, one can find 8 significant water uses/services beyond irrigation:

1. Domestic water supply to individuals
2. Domestic water supply to villages
3. Domestic water to cities
4. Water for cattle
5. Hydro power generation

6. Environment and Ecosystems.
7. Drainage.
8. Flood protection.

Main users of the system are obviously farmers doing irrigated agriculture. The project has been designed as an irrigation project only; however wherever possible water is being used for other uses and functions.

In the following section a description of each water use is provided then followed by a definition of the service and some recommendations on how to improve it.

Domestic water supply to individuals: access to water

Many people depend on the irrigation canal for domestic water: for bathing, washing and even for cooking. This use is widespread in the command area; all groups have witnessed people using the canal for their domestic needs. There is no data available as to how many people are benefiting from the canal water for their domestic use. For the MASSMUS analysis in the RAP sheet we have considered that 30 % of the fraction of people who are not living in cities are dependant on canal water for their domestic needs. This guess leads to some 78 000 people depending on canal water for their domestic water.

The service for that use is characterized by water availability in the canal network; quantity is less an issue but canal water access is central to define the service with following characteristics:

- physical access to water and safety
- Availability of water (irrigation timing)

The examples shown in Plate 1 below reflect perfectly what is it “Servicing individuals” along a canal and what is lack of service. People along the main canal shown in left picture are facing very dangerous conditions in accessing water at that location. There is no structure to access safely the water and fatal accident is happening. Inversely on the right picture we can see on the same command area a safe access to water with a specific structure built along a secondary canal to ease and safeguard the access.

This type of domestic water service by canal water to individuals is very sensitive to the closure. During the off period of the canal when irrigation stops, people might suffer from lack of access, which reflect in people going long distance for fetching water and a much lower quality of water as mentioned by the women interviewed (plate 1). Therefore the 3 months of the off-period in UKIS is very difficult for people without access to other sources of water (tanks or shallow wells).

Improving the domestic services to individuals might consider several options:

1. Create regular safe access along canals with specific structures.
2. Ensure alternative sources of water or enough local storage for the off period.
3. Consider issuing water periodically to refill canals.



Plate 1. Domestic water for individuals SBC with no safety (left) and a much safer access with stairs (right).

Domestic water supply to villages

The service of domestic water to villages results from tank supply or groundwater recharge. In the example shown in plate 2 the Shetykara tank/village one can find both with the tank used for washing and the near by well used for cooking and drinking.



Plate 2. Direct domestic water use in Tank Shetykara (left) and a well recharged by the tank near by (right).

Consistent with the previous guess for individuals we have considered that 70 % of the fraction of people who are not living in cities are dependant on water served by tanks and shallow groundwater recharge/refilled by irrigation water. This guess leads to some 182 000 people use these services.

With this service (tank-groundwater) the canal off period is less a problem. If the storage capacity in surface and in the groundwater system is enough to cope with losses and uses during the closure then users won't face any restriction in terms of quantity. Water quality in tanks might deteriorate when surface supply is off, this must be monitored.

Domestic water to cities

The water service to cities corresponds to a specific delivery at one point of delivery (Reservoir or Pump station). In SBC raw water supply is provided by gravity to the Shahapur city in a buffer reservoir upstream the city (see plate 3.). According to the water supply company, approximately 30 % of the 45000 city inhabitants are fed by 116 tubewells and 70 % by irrigation water after treatment.

The volume of the Shahapur reservoir corresponds to a consumption of 2.5 months, therefore there is often a gap at the end of the off period of the irrigation canal (3 months). The volume of water supply per capita at the reservoir is estimated to be at 230 liters/day/capita. This of course includes the losses in the treatment and distribution and is far above the actual consumption per capita. In that case it seems that improving the efficiency in the water process and distribution would solve the problem of making ends meet.



Plate 3. Domestic water supply to Shahapur city: Outlet of the irrigation canal into the buffer reservoir.

Another example of domestic water to cities is reported for Sindagi (plate 4.).



Plate 4. One example of Domestic water supply to a city (SINDAGI –Pumphouse)

Water for animals

Cattle in the area is of great importance for farmers and people. We count approximately 3 people and 3 animals (medium to big) per hectare of land. For Shahapur sub-systems the number of animals and water consumption are reported in table 16. In terms of quantity of water use the animals represent a neglectable share of water use, for instance in SBC 1.5 Million vs 1200 Million of m³.

Table 16. Accounting for animals and their water consumption in SBC

Animals Water consumption	type of animal	liters/head/day	m ³ /head/annual	Number of heads	Volume consumed Million m ³
Big size	Cattle Buffaloes	20	7.3	145460	1.06
Medium	Goats-Sheeps-pigs	7	2.555	167460	0.423
small	Poultry	0.15	0.05475	118677	0.0065



Plate 5. Cattle and goats/sheeps along UKIS canals.

It is possible to improve the services to animals by creating ramps to provide a safe access to the canal water as shown in plate 6 for systems in Bhadra Karnataka and in Uttar Pradesh.



Plate 6 Examples of ramp easing water access for animals (Bhadra –left; Main Ganga UP right) .

HYDRO-POWER GENERATION & INDUSTRY

There are many power plants in the CA managed by private companies.

In Shahapur subsystem a total of 5 power plants are installed, representing 6.6 MWatts. The annual production is of 20 Million KWh which at a selling price of 2.9 INRs/KWh represents monetary outcomes of 58 millions INRs.

The power plant shown in plate 7 above has the following characteristics:

Head = 6.5 meters

Capacity 1.3 MW

Discharge = 782 cusecs = 22.3 m³/s

Turbine type Kaplan

In Shahapur command area no significant industry using water is reported.



Plate 7. Power plants (left) on SBC (right) on NRBC.

In BC there is thermal station at Raivhur with an estimated consumption of 0.98 TMC.

Environmental services



Plate 8. Lake as a bird sanctuary downstream of the CA in SBC.

Irrigation supplies many internal water bodies which will run dry during the long months of the dry season. Some of this water bodies have a specific function with regard to natural wildlife such as the bird sanctuary found downstream of SBC (plate 8).

Water flows from irrigation has also a general greenery effect in the command area.

DRAINAGE SERVICES

The drainage approach has been carried out only for SBC during the workshop. The conclusions are reported here below, but they maybe specific to the geomorphology of the SBC subsystem. Therefore one of the recommendations is to carry out a drainage survey for all subsystems in UKIS.

The critical issue of water stagnation, vegetation proliferation and drainage in SBC

Geomorphology of the Shahapur subsystem is characterized by a waterproof substratum made of granite. Drainage is constrained by natural rock weir downstream of many flat areas. The low drainage capacity of this flat areas leads to water stagnation when water is abundant, and it has been always so during monsoon time.

The recent introduction of irrigation supply has though created abundance of water almost throughout the year and there are now many places where this phenomenon has created permanent water stagnation on surface, small ponds. One of the negative impacts of that situation is an invasion of undesirable vegetal species and jungle (plate 9).



Plate 9 Example of topo sequence of flat land surrounded by granite boulders in SBC.

Drainage should be considered as part of the water management in order to prevent externalities of irrigation as water stagnation.



Plate 10 Downstream a village: water stagnation in a topographic depression with invasion of vegetation

Shallow surface water stagnation is not desirable because it leads to proliferation of aquatic vegetation, also create conditions for mosquito's breeding, therefore the alternatives for managers are:

- Create a tank with a raised water level to prevent vegetation development (many tanks exist in the area)
- Drastically reducing the drainage water by acting on irrigation water supply.
- Channel the drainage flow through or around the depression to avoid wide stagnation.

The critical issue of water management and drainage in SBC

Surface water leaving the command area is not measured and is not accounted for, while the field visits made downstream Shahapur BC show that significant flows are leaving the CA (see plate below). In one case measurement weir is there but not used and in another case specific measurement devices should be installed.



Plate 11 Downstream of Shahapur BC, weir with possibility of monitoring the flow (left) – bridge which should be equipped with measurement device (right)

Losses or water for other uses?

There are many places along the canal those can be considered as leakages, from water gates at escape or in the banks of the canal. In plate 12 examples of such water losses are given. However it remains to be seen whether these losses are real losses or whether the flow that escape from the canal is de facto used by people living along the drainage. This situation is very common in fact in Karnataka, and many managers are not willing to repair leakages knowing that users may suffer downstream and may try to deteriorate the gate or the canal. These leakages are thus purposely tolerated for crop or to satisfy other uses (domestic, cattle, etc..). [Example of this is the escape at the Y Junction upstream JBC, MBC and SBC].



Plate 12. Example of leakages at an escape along SBC (left) on an aqueduct KM 40 OF MBC (right) which are more likely used downstream.

Flood protection

The positive effects of the main reservoir on the flood regimes downstream of the dam are incontestable. That does not concern all the areas of UKIS but only the ones close to the Krishna River. No precise data was made available during the workshop on the positive effect of the reservoir in diminishing the extension and gravity of floods in the Krishna river valley downstream of the reservoir.

Seizing the various water uses

As said earlier the share of water consumption is the first indicator to look at when addressing MUSF. Figure 12 displays the results of the water use share according to the identified uses of water. The amount of water uses in SBC is estimated to reach 1200 MCM out of that field consumption (crops+fallow period) accounts for 1010 MCM (84 %), perennial natural vegetation for 114 MCM (9,5 %), environmental flows for 57 MCM (5%). Minor use

quantity wise are fisheries 11 MCM (1 %), domestic water 6 MCM (0.5%) and animals 1.5 MCM (0.12 %).

In terms of share of the total estimated benefits, crops are bringing some 69%, animals are contributing to 23 % and domestic water to 6%. Electricity produced is only 1 % of the value. Benefits from perennial vegetation have been estimated also at 1 % of the total.

Nota: Environmental flows and fisheries have not been quantified in terms of benefits due to lack of data.

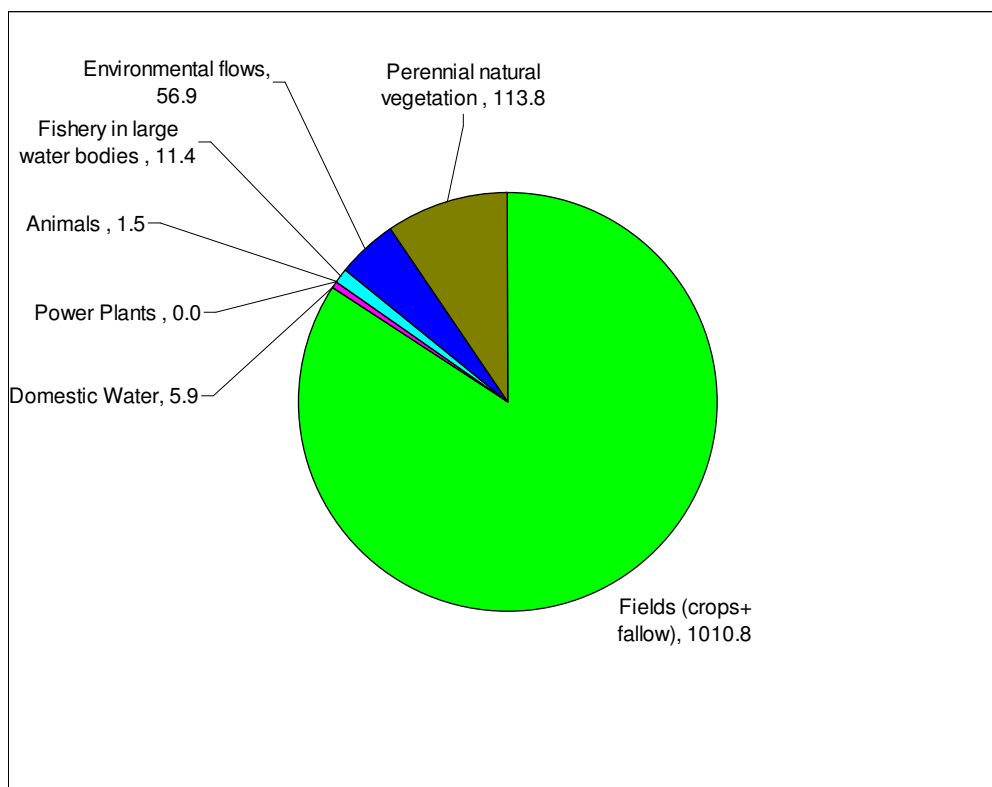


Figure 12. Water use per services in MCM for the Shahapur Branch Canal

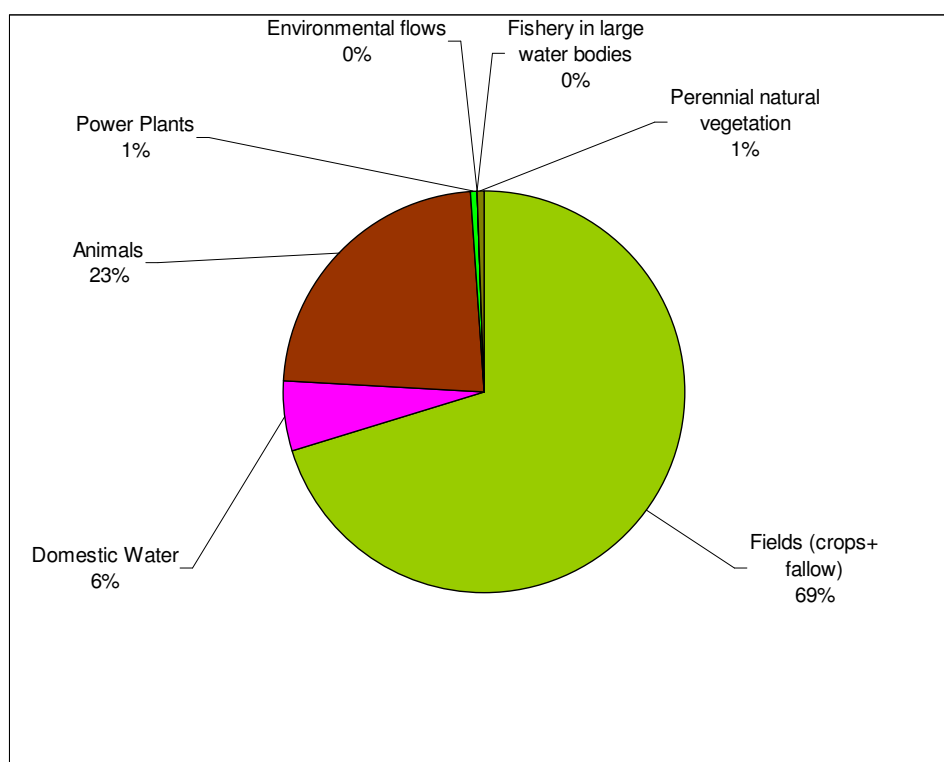


Figure 13. Share of estimated benefits per use

SERVICES to agriculture

Services to agriculture was discussed during the workshop, no final conclusion was reached. Here are some of the points put forward by participants.

1. There should be high production per Ha of land with less consumption of water through the use of advanced farming machineries.
2. The cropping pattern should not be divided on the basis of availability of water but should be on the basis of Geography or Topography of land.
3. There should be an integration of department like revenue, Agriculture, Irrigation , WUA's and they should come to an agreement that any violation of cropping pattern should be dealt by all departments
4. We feel some industries should be there in command area so that more employment can be achieved.
5. After ten years, when more sophisticated system is implemented, then part of the work force in agriculture can be used for industrial growth.
6. At "Narayanapur" reservoir, navigation activity, mineral water purifying plant can be started.

7. By making the system automatic, human errors can be minimized by having only one control point at Narayanapur.
8. There should be a survey of number of open wells, bore wells, tanks, canal water etc., pertaining to each farmer should be known so that any violation of cropping system can be dealt by different departments.
9. Our KBJNL should work on the principles/ Techniques of Mumbai electrical train operation by centralizing the unit.

Vision of the scheme

While discussing services at length, a vision of the Upper Krishna Irrigation Systems was progressively crafted. Below are the two versions:

“ A very efficient environmentally sustainable agriculture oriented towards high value production and value addition. An overall reliable cost effective water management targeting equity in water access, multiple uses throughout the command areas with high capacity professionals. Farmers active and responsible in water resource management progressively taking over management and cost recovery with other stakeholders. ”

“Agriculture business system with multiple use of water”

Step 7 PARTITIONING IN MANAGEMENT UNITS

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

Due to shortage of time this step was not addressed by participants except for one group. The preliminary results are presented below.

Rational of partitioning Management:

- 500 Ha or Lateral level WUCS (depending upon size of the system)
- 1000Ha or Disty level LMU
- Each subsystem level Federation
- System level- PRESIDENT of federation

INDI LIS

The sub command area ILIS has been investigated further as far as management partitioning is concerned. The proposed partitioning of management for INDI LIS is as follows:

- One division + 3 sub divisions

- WUCS- 500Ha each
- LMAs- 5000Ha (3-4 LMAs/ Subdivision)
- Federation- 10 LMAs (Division)
- Main canal maintained by KBJNL
- WUCS look after maintenance of Dy & below in coming years.

Plate 13 illustrates the proposal.

Table 17. Proposal for management units changes on UKIS

<u>EXISTING UNIT</u>	<u>PROPOSED UNITS</u>
Sub-division : 52	Sub-division : 40 AEE-1, AE/JE – 2 +2, FDC/SDC – 2+2 Comp Operator-1, Work Inspector – 5, Sawadi-20
Divisions : 12	Divisions : 10
Circle : 4	Circle : 3
Zone : 3	Zone : 1

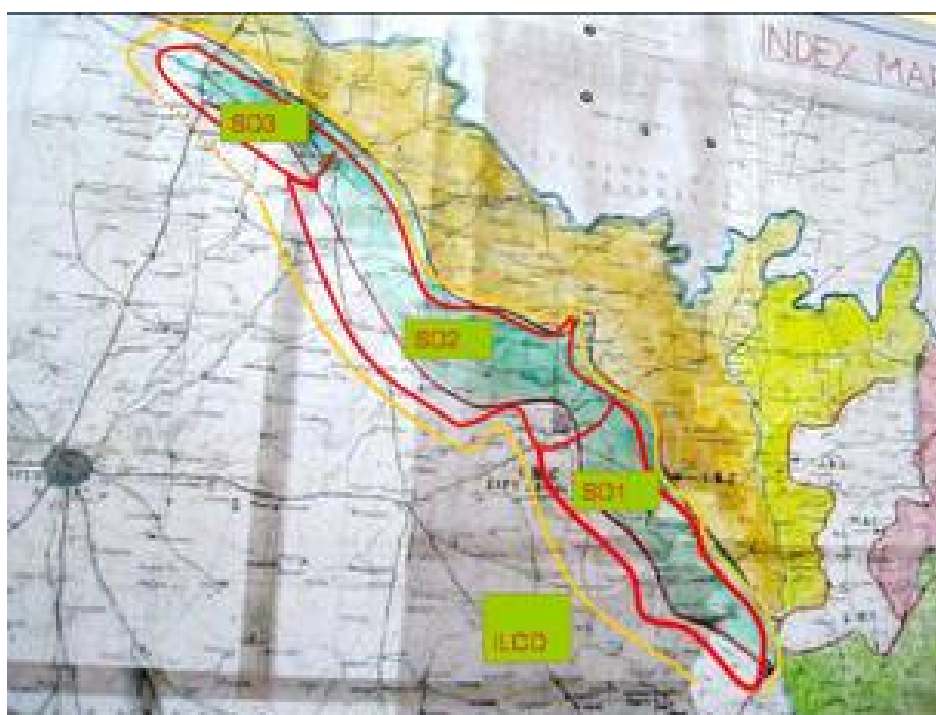


Plate 13. Management partitioning for ILIS

Step 8 MAPPING THE DEMAND FOR OPERATION

Objective: Assessing Means, opportunity & demand for Canal Operation

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

Water management strategy:

Kharif:

- Main canal: Continuous flow, tolerance: $\pm 5\%$, flow varied during rain fall
- Distributary: Within the Disty Rotation to 3rd level canal, tolerance: $\pm 10\%$
- In lift schemes main canal should be used for storing water as buffer storage (online) to combat voltage fluctuation and also, preferably within CA buffer storage during rains for optimum utilization of water and as a energy saving technique.

Rabi:

- Main canal: Continuous flow, tolerance: $\pm 5\%$
- Distributary: Within the Disty Rotation to 3rd level canal, tolerance: $\pm 10\%$
- Ensure better service to areas without ground water potential.
- Recycling facilities to be made use of by the users.
- Conjunctive use to be encouraged.

Operation strategy:

- Rotation with flexibility: kharif: flexibility in main canal (discharge varies due to rains)
- Duration : 10 days
- •Kharif : Flow controlled by CRs and surplus; Stored in buffer storages / canal
- Rabi: Flexibility in main canal limited to availability
- Information system: Manual SCADA, digitization of data
- Operation rules at various levels: Kharif-TOL 10 cm TOL (H) cm Rabi - TOL 5 cm
- Main canal : Khariff: 120 days, Rabi: 90 days
- CR operated to maintain Water level at FSD.
- New structures to be added: CRs (mixed) and escapes, duck bill weirs in Dy

Service strategy:

1) Allocation of water to farmers:

- Allocation on volumetric basis to WUAs
- Allocation varies for kharif because of contribution of rain fall
- Allocation for rabi is fixed
- Deficit to be shared equally

2) Schedule of watering: Rotation among distributaries for both kharif and rabi

3) Deliveries: tolerance of 1 day for rabi and 3 days for kharif

4) Specific rules for services to downstream users:

- Water to be fed from tail end to upwards at the beginning of seasons
- Within the distributary, rotational delivery starts from tail end
- It is the responsibility of tail enders not to waste water

Step 9 OPERATION IMPROVEMENTS: CANAL & LS

WATER DISTRIBUTION:

- Assessment of water level control and sensitivity of MC and Disty, reduction of high sensitive structures
- Allocation based on availability
- Assessment and repairs to CC lining, removal of silt in MC/Disty
- Assess off-take gates on Disty !!!

DRAINAGE:

- Mapping of drainage system (bandharas, re-cycling, well)
- Interlinking ponds
- Monitoring of water quality
- Outflow of the Catchment Area

MEASUREMENTS:

- Phase-1: MC- rated gauge
 Disty - rated gauge
 Lateral - rated gauge
- Phase-2: Accuracy!
- Automatic data recorder and communication
- Separate monitoring unit for KBJNL
- Database system for KBJNL

INFORMATION SYSTEM:

- Information - Remote Sensing - GIS

Step 10 AGGREGATING AND CONSOLIDATING MANAGEMENT

Step 10 was not addressed during the workshop, instead an immediate plan for investigation and preliminary measures was discussed and is reported below. The immediate follow up of the MASSCOTE workshop are as follows:

- Actual assessment of CCA
- Spatial units for management (KBJNL, WUFs, WUAs)
- Assessment of WUA's ability in Integrated Management (Progressive transfer/non-homogeneous)
- Re-location of office management (with shift from construction to management focus)
- Design of capacity development programme (Staff / Users)
- Need of separate security force for Law and order
- Assessment of silt in MC, disty and laterals
- Assessment of gates on disty
- Policy decision regarding modernization/repairs of laterals and FICs (as they are handed over to the WUAs)
- Calibration of rated section - MC and Disty
- Installation of FLUMES – project to be developed
- Drainage
- Escapes (assessment of leakage)
- Repairs to arrest leakages in escapes and UTs

- Multiple uses
- Database management
- Telemetry and sensors
- Water balance at local level
- Outsourcing of RS and GIS activity in investment phase and training staff to operate the system

end of Part I

PART II

SPECIAL APPLICATIONS & FIELD VISIT REPORTS

MASSLIS MASSCOTE approach for Lift Irrigation System

Two systems in Naryanpur are fed with lift stations. For these subsystems MASSLIS has been carried out using a similar methodology as the RAP. The information gathered and analysis made about the lift stations is presented in the various steps of MASSLIS in the following sections.

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

The lift station at the headworks adds though some important points for management and operation that need to be addressed properly. Here in this section we are focusing on the peculiarities brought by the lift station in relation with various steps of MASSCOTE dealing with capacity, sensitivity, perturbation and cost mainly.

MASSLIS = Special MASSCOTE for LIFT STATION + MASSCOTE for Canal

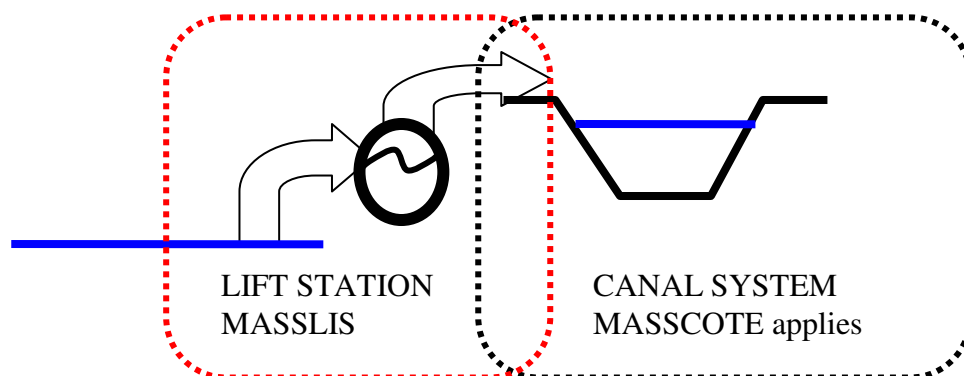


Figure 1. Sketch of MASSCOTE & MASSLIS

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

II. 1. MASSLIS Application RAMPUR LIFT SYSTEM - RLIS

Nota: This section reports some of the detailed steps made for RLIS by the working group 1. Some steps are not addressed here as they were discussed and developed for the entire UK complex and are reported in the main document.



Plate 1. Main pipeline and delivery chamber of one lift system in Rampur

The Rampur LIS is made of two pump stations separated by a canal of 14 km.

Visits

1. Narayanpur left bank power house
2. Narayanpur dam and HR of LBC and RBC
3. Rampur LIS (jackwell 1 and 2,
4. lead-off canal (14 Kms),
5. East Branch canal (20 Kms),
6. west Dy (26.14 km)
7. Lead-off canal-Dy3
8. East Br. Canal Dy3 and lateral no4
9. West dy –lateral No 7

Key findings

1. RLIS is in operation since 2003-04. The systems are freshly constructed.
2. The canal system is partially degraded. Degradation is mainly due to
 - Inadequate maintenance
 - Vandalism by the ryots
 - Accumulation of silt and growth of jungle along the canal system
 - Erosion of banks and failure of lining in some reaches of canal.
 - Rampant lifting of water by the farmers from the canals, more in main canal
 - Inadequate maintenance staff
 - Poor operation techniques (e.g.no discharge measurement devices anywhere)
3. No measuring devices anywhere in the canal, resulting in high degree of inaccuracy

4. In RLIS, there are gates to laterals, whereas, there are no gates for laterals in NRBC. Flow is proportional in the laterals in NRBC. Branch Dys in NRBC are also ungated.
5. RLIS- There are no CRs for level control
6. Due to ungated system of distribution, lot of water wastage is seen due to tendency of farmers not resorting to night irrigation. Night irrigation is not practiced. Lot of flow is seen in drains. No drainage measurements. Drains are choked with weed growth and encroachment by the farmers.
7. No WUAs yet formed. Proposed to be formed and the process is on.
8. Allocation of water is 5.6 TMC for RLIS.
9. Cropping pattern- Designed for semidry crops (100% intensity of irrigation. khariff 60%, Rabi 40%), But paddy cultivation is seen , more in areas where assured water supply is there (head reaches of main canal and Dys and laterals). Paddy is grown in RLIS also. Extent of paddy is about 10-20%. Other crops grown are ground nut, sunflower, jowar, wheat, cotton, pulses, millets and garden crops). The area of unauthorised irrigation is not accounted. Actual cropped area is more than official figures. Cultivation of more water demanding crops (paddy) can be anticipated.
10. Sensitivity :RLIS-offtakes –Low to medium(<1, 1-2)
11. Main Canals- there are no capacity problems. Silted up to some extent. Dys and laterals are also silted up.
12. Perturbations-
13. RLIS- Huge perturbations are seen when the pumps (one or more) trip, sometimes discharges becoming too low. Unauthorised withdrawal, drains entering in to canal, illegal withdrawals, and closure during rains cause perturbations.
14. Communication –Roads are good along main canal and distributaries. No all weather roads. There is good road network in the command area.

Multiple use of water is largely practised in RLIS.

1. Irrigation,
2. Drinking water supply (Muddebihal, Nalatwad, Hungund, Ilkal & Kushtagi –from Naraynpur reservoir) and Lingsugur from NRBC. Water supply to some villages from NRBC under execution. (0.18 TMC)
3. Industry-Raivhur thermal station (0.98 TMC)
4. Hydro-power-
 - Near NLBC Left bank HR , 2 *5.8=11.6 MW generation unit.
 - Near Km 55 of NRBC (head 33 m), 2*6=12 MW generation unit.
5. Flood control- Reservoir is used for flood control with controlled releases during floods (Aug-Sept)
- 6.. Other uses (animals, birds, washing purposes, recreation etc.)
7. Environmental (Greenery in the command area due to trees (Jalli flora mainly), regenerated water (return flow) helping to maintain aquatic life in the river and streams)

Step 1.2 RAP for the Rampur Lift Irrigation Systems

For the lift system a special module of RAP-MASSCOTE is applied. It is called MASSLIS and is based on a similar methodology as the RAP. The information gathered and analysis made about the lift stations is presented in the various steps of MASSLIS in the following sections.

The RLIS is made of two stages separated by a canal of 14 km long.

Stage 1 Reservoir Pumping station

The first lifts of RLIS offtake from the right bank of the main reservoir and lift the water for about 11 meters.

Table 1. Characteristics of Stage 1 lift

	Inlet	Outlet	Raising main	Head at inlet	Head at MC entrance
RBLIS 1	Reservoir	SS Siphon Submerged	850 m length 2.6 m diameter	492.25 maximum 487.75 minimum	502.1 m



Plate 2. Stage 1 Lift Intake of main reservoir (left) and Delivery chamber (right)

The outlet configuration is **Siphon Submerged**, and as such the static head is defined by the FSD in the canal that is $h_3 = 500,00 + 2.1$ m.

Stage 2 Pumping station

The second lift of RLIS is located at km 14 of the main canal, it lifts the flow for about 26 meters.

The outlet configuration in the delivery chamber is **Non Submerged Siphon**, thus the static head of the lift is defined by pipe end elevation which is $h_2 = 526.3$ m.

Table 2. Characteristics of Stage 2 lift

	Inlet	Outlet	Raising main	Head at inlet	Head at MC entrance
RBLIS 2	Main Canal	Non Submerged Siphon	1100 m length 2.2 m diameter	499.71 max 497.91 min	525.35

Lift station appraisal

- Generally functioning very well.
- Log books maintained.
- Some loss of static head is seen in delivery chamber 1 and 2
- Frequent power failure is seen. Efficiency of system is affected by losses (static head losses and losses in raising main due to higher capacity of raising main. Raising main designed for expansion phase also). Efficiency is affected due to non-operation in BEP range.



Plate 3. Stage 2 LIFT: Intake of from main canal (left) and Delivery chamber (right).

Step 2. SYSTEM CAPACITY AND SENSITIVITY.

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

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

Step 2.1. The capacity along the canal

STORAGE: The lift operates between levels 487.7 m and 492.25 m which are minimum and maximum water levels. Generally, from July to April the storage in the dam is adequate for operation of the lift.

CONVEYANCE

Pump house 1 : Pumps installed are 2+1, each capable of discharging 5 cumecs capacity. The discharge from 1st Jackwell is 10 cumecs. The raising main is of 2 rows of dia 2.6 m steel pipes for 850 m. Raising main is designed to carry 15 cumecs, taking into consideration expansion phase.

Lead-off canal (14 Kms) is designed for 14 cumecs.

Pump house 2 : Pumps installed are 2+1, each discharging 4.75 cumecs, totalling to 9.5 cumecs. Raising main is 2.2 m dia, 1.1 km long 2 rows steel pipe. It is designed to carry 14.25 cumecs, considering expansion phase.

Canal system : There are no conveyance problems. Canal system is capable of conveying water to the entire command area of 20235 ha.

DIVERSION: Flow diversion takes place in Km 4 of East Branch Canal, called as Y-Junction. There are no problems of diversion.

DISTRIBUTION: Distribution of water is through gated off takes . The gates require to be attended for proper upkeep.

CONTROL : There is no water level control in the main canal or in distributaries. Butterfly valve is provided in the raising main for controlling discharge. However, this is sparingly used. Used only when there is an emergency like overtopping of canal banks.No CRs are provided. Due to frequent tripping of pumps, daily water level fluctuations in the main canal is common. One option to maintain water level would be to have weirs across canal to maintain water level. However, there is risk of upstream people getting more water at the cost of downstream people.

MEASUREMENT : There are no measuring devices anywhere. Presently, discharge based on number of working pumps is taken into account. The variation in discharge due to variation in head is not considered.

- Need to fix flow meters to measure discharge of each pump.
- There is a need to measure the discharge at critical points (near pump house and main canal) and for Distributary off takes.

SAFETY : There are 2 escapes, one in lead-off canal and one in East Branch Canal, which are sufficient.

TRANSMISSION : Transmission of data / instructions is done through mobile phones from office to field.

- Centralised (@ pump station1) monitoring of flow data of various points of canal and pump house 1 & 2 could be considered. This could either be done by manual or automatic transmission.

Step 2.2. SENSITIVITY

RLIS

1. Along West Dy. Off takes are medium sensitive.

Dy3 Sensitivity = $0.6/0.3= 1.6$

2. Along East Branch Canal Off takes are low to medium sensitive.

Off take D-3 @ Ch.4.26 Km

Sensitivity= $0.5 /0.37 =1.34$

3. D-3 of Lead off canal @ 6.3 Km

Sensitivity = $0.5/0.9=0.56$

Step 2.3 The lift station capacity

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

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

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

Setting point vs Best Operating point

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

RLIS 1

The case of RLIS 1, the static head of the lift varies between 8 and 12.55 meters. Head losses generated in the raising main pipe is estimated to be about 0.45 meter. Thus we obtained the following table of the running conditions:

Table 3 Head characteristics of Stage 1 lift

	Dynamic head	Discharge m ³ /s	Efficiency
Min	8.35	6.19	0.80
Max	12.9	5.75	0.87

The BEP of the pump is obtained for bowl head of 19 and is 91.0 and yield a discharge of 5.0 m³/s. It can be seen from table above that the average running conditions of the pumps are deviating significantly from BEP and that has two effects:

- Average discharge capacity is significantly increased from 5.0 to more than 5.7 m³/s
- Average running efficiency of the pump is below optimum: average 85.6 % instead of 91 %.

For the computation of minor head losses along the main pipeline it has been considered: an inlet – a valve – a 90° bend - 2 30° bends and an outlet.

RLIS 2

The case of RLIS 2, the static head of the lift varies between 24.2 and 26 meters. Head losses generated in the raising main pipe is estimated to be about 0.7 meter. The variation of head is very limited and the pump is run close to BEP, thus the efficiency of the pumping remains close to maximum at 89 %.

Thus we obtained the following table of the running conditions:

Table 4 Head characteristics of Stage 2 lift

	Dynamic head	Discharge m ³ /s	Efficiency
Min	24.2	5.23	0.885
Max	25.9.	5.08	0.895

STEP 3: THE PERTURBATIONS

Perturbations analysis: causes, magnitudes, frequency and options to cope with.

Causes

- The operation of pumps is one of the main causes of perturbations. The pumps are designed to operate for 24 hours, whereas in reality they are working from 12 hours to 24 hours. When pumps are shut down, there is sudden lowering of water level in the canal.
- Illegal withdrawals from the lead off canal and from the main canal by pumping by farmers.
- The temporary obstructions at off takes.
- Closure of pumping during rains results in perturbations.
- Rain water entering the main canal during unprecedented rains .
- Unauthorised operation of gates by the farmers.

Magnitudes

- It is significant in case of pump operation and illegal withdrawals from pump sets.

Location

- Perturbations is seen all along the length of the canal, more towards downstream end .

Frequency

- It is more prominent during Rabi season due to unauthorised withdrawal from pumps.

Options to cope with

- Continuous pumping by all the pumps for 24 hours, the perturbations can be reduced.
- The CRs / weirs can be constructed and operated frequently to maintain the required depth of water.
- There are no regulating reservoirs (on-line storage) along the canal to store surplus water, which may be considered.

Step 4.2 MAPPING the ENERGY at RLIS

Energy produced by the lift station

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

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

head static (actual) is the difference of water elevation between canal inlet (H_1) and outlet (H_3).

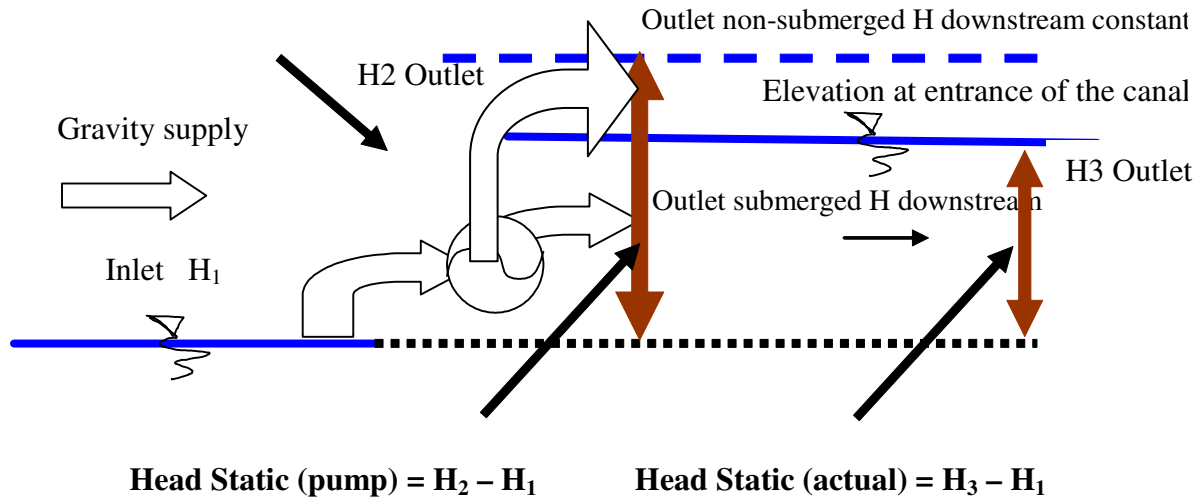


Figure 2. Sketching out the water head at a Lift station

Energy required by the lift station

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

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

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

Head data at the STAGE 1 lift station

H_1 minimum = 487.75 m

H_1 average = 488.25 m

H_1 maximum = 492.27 m

H_3 restituted at present = 502.1 m

Efficiency from head analysis Stage 1

Given the head losses in the pipe, the efficiency for head lifted is equal to $12.03/12.5 = 96\%$. At the functioning head the pump efficiency is 86% lower than BEP because BEP is obtained for a head of 19 meters. Together with the motor efficiency of 95% the overall efficiency is then estimated to be 78%.

Table 5 Stage 1 Lift efficiency analysis

Static head	12.03		Head total	12.5
Head losses along the raising pipe		0.47	Head input	12.5
Losses at outlet <i>Delta H</i>		0		0.96
Efficiency pump		86		
Efficiency motor		95	Overall Efficiency	0.78

Efficiency from head analysis STAGE 2 lift station

H1 minimum= 497.91m

H1 average = 498.81 m

H1 maximum = 499.71 m

H3 restituted at present = 523.90 m

H2 = 525.90

Energy balance for average running conditions**Table 6 Stage 2 Lift efficiency analysis**

Static head	23.99		Head total	25.99
Head losses along the raising pipe		0.80	Head input	26.79
Losses at outlet <i>Delta H</i>		2		0.90
Efficiency pump		89		
Efficiency motor		97	Overall Efficiency	0.78

Given the head losses in the pipe and at the delivery chamber, the efficiency for head lifted is equal to $23.99/26.79 = 96\%$. At the functioning head the pump efficiency is 89% close to BEP. Together with the motor efficiency of 97% the overall efficiency is then estimated to be 77%.

Step 5 MAPPING THE COST of OPERATION

see the main report for more details on cost of operation

Cost of pumping in RLIS

Another important component of the cost for irrigation supply to agriculture is that of pumping systems.

The spending of energy can be calculated for 1 m3 of water as follows :

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

Table 7a. Energy spent and cost at RLIS stations

	KWh/m3	Cost IRs /m3
RLIS 1	Energy /m3= $1 * 12.5/367/0.817 = 0.042$ KWh/m3	0.125
RLIS 2	Energy /m3= $1 * 26/367/0.86 = 0.082$ KWh/m3	0.246

Table 7b. Breakdown of expenses for RLIS

I.	Administrative charges	AMOUNT, Rs. in lakhs
1	SALARIES	212
2	TRAVEL EXPENSES	19
3	OFFICE EXPENSES	6
II.	Operation & Maintenance of LIS, machinery & equipments	
4	MACHINERY & EQUIPMENTS	18
5	LIS	129
III.	Operation & Maintenance of canal network	
6	MAINTENANCE & REPAIRS	248
	TOTAL	633

NOTE: STEPS 6 to 10 on SERVICE - PARTITIONING - DEMAND - IMPROVEMENTS & CONSOLIDATION are reported for the entire UKIS in the main report.

II.2. MASSLIS application INDI LIFT SYSTEM - ILIS

Nota: This section reports some of the detailed steps made for ILIS by the working group 1. Some steps are not addressed as they were discussed and developed for the entire UK complex.

The Indi LIS is fed by Naryanpur Left Bank Canal at Ch 73.47 km.

Pump station

Intake	: Open channel of length 1.050km from main NLBC
Jack well	: Rectangular size
Pump	: VT axial flow pump 2100KW, 5+1
Raising main	: 53m of 1.8m dia of MS IS2062
Delivery chamber	: Rectangular size 39 X 21.15 X 4.6 m
Inlet elevation	: 469.50
Outlet restitution el.	: 503.31

CANAL DETAILS

LENGTH	: 97.30 km
ICA	: 41900 ha Scheme – A
	: 20642 ha Scheme – B not developed pending interstate allocation of water
	total : 62542 ha
NO. OF DISTRYS	: 47 NO.
OFFTAKE DETAILS:-	
DISCHARGE	: 35.22 CUMECS.
F S D	: 3.30 MTRS.
BED WIDTH	: 6.50 MTRS.
BED FALL	: 1 IN 7500
UTILISATION	: 11.90 TMC

DETAILS OF LONGEST DISTRIBUTORY UNDER ILC

LONGEST DISTR	: NO.28 DY.
LENGTH OF DISTR NO.28	: 19.737 KM.
ICA OF THE DISTR 28	: 2216 HA.
DISCHARGE OF THE DISTR 28	: 1.279 CUMECS.

Key findings from field visit made (3-2-09 to 5-2-09)

Jack well : having a constant head of 33.25 m, since inlet and outlet elevation doesn't change much, as they are controlled canal wherein variation remains small compared to static head.

MAIN CANAL

- It is a contour canal with CC lining siltation is likely due to canal bank sliding during rainy season.
- Water logging in embankment reaches due to improper sealing of expansion joints in CC lining.
- No measuring device installed in any of the canal network.
- Cross regulators (CR) are not properly operated for water level control.



Plate 4. Jackwell at ILIS



Plate 5. Raising pipes and delivery chambers at ILIS

CANAL OPERATION

- Upstream control.
- Up to final deliveries network is maintained by the department.
- Scheduling of flows is rotational (10 days) and from distributaries to the final deliveries is proportional.
- CRs are not used for water level control in the main canal.
- No CRs in distributaries and minors.
- Unauthorized command areas on either side of the canal are significantly well irrigated by unauthorized well installed syphon pipes and pumps; probably more than 600 off takes in 97kms. (estimated 25% of the inflow discharge)

- Ground water table is quite high and its depth is of the order of 15 ft from surface in the initial reach of the canal.

CANAL MAINTENANCE

- Main canal in deep cut reaches silted up to the tune of 1 to 1.5m.
- Service road is fairly motorable, needs clearance of thick jungle on either sides.
- Off take gates damaged in many places, needs repair.
- Distributaries and laterals are badly silted up. No off take gates and many unauthorized off takes in distributaries 11 to 21, complete reengineering is required.
- Sufficient maintenance grant is required to keep the canal operation healthy.
- Laterals are tampered in many places to tap water by the farmers making impossible to feed official FICs properly.



Plate 6. Lack of water level control compensated by temporary weirs made of rocks



Plate 7. Examples of illegal pumping along ILIS

TRANSPORTATION

- Roads exist on only one side of the canal.
- Service roads are good on main canal but needs jungle clearance on either side of the canal.
- Along the distributaries service roads are motorable. They are encroached by the farmers in some reaches.

PERFORMANCE for EQUITY

- Head reaches get sufficient water.
- Tail ends get insufficient water during low discharge in canal.
- Unauthorized lifts, off takes are getting better service than the command area stake holders.

PERFORMANCE for RELIABILITY

- Good reliability in the initial reaches of the network but the tail end reaches are deprived off sufficient water supply.

Step 2. SYSTEM CAPACITY AND SENSITIVITY.

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

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

Step 2.1. The capacity along the canal

CANAL SYSTEM

- Main canal is capable of carrying the desired discharge.
- In deep cut canal sections, de-siltation is badly required.
- Capacity of 2nd and 3rd level canal is insufficient due to siltation and also exaggerated due to over drawl.
- Generally there is no free board, encroached 2 to 3 times of free board due to over drawl.
- Uncontrolled flows in distributaries, minors and FICS as there are no control gates.

MEASUREMENT

- No measuring device in any canal.
- Flumes installed in one or two distributaries, are not properly calibrated.

SAFETY

- 7 escapes are provided for safety of the canal.
- Escape gates to be reengineered to avoid substantial leakage.

SENSITIVITY

- Main canal initial off takes are high sensitive varying from 1.86 to 2.76. and tail end off takes are of very high sensitive above 3.5.
- Tail end off takes are not properly fed due to insufficient head.
- Distributary off take sensitivity increases downward the tail end.
- Minor off takes are very sensitive.
- Some minor off takes need to be reengineered.

Step 2.2 The lift station capacity

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

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

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

Setting point vs Best Operating point

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

The case of ILIS, the variation of static head at the lift station is limited because it is fed by a canal:

- H1 minimum= 469.5 m
- H1 average = 470.5 m
- H1 maximum = 471.6 m

With a restitution level at 503.31 m, the lift head is set to 32.8 ± 1 m.

Raising main pipe

For a horizontal length of 53m, the actual pipe length from the jack well inlet to the chamber is 81 meters. Major head losses along the raising pipe are computed considering that length. They are low given the short distance about 0.15 m.

Minor head losses should be added considering the following features, one 90 d* bend, a butterfly valve, 2 60 d* bends and one 90 d* bend. They amount to about 0.33 m.

Thus we obtained the following table of the running conditions:

Table 8 Running conditions of the Lift Station

	Dynamic head	Discharge m ³ /s	Efficiency
Min	32	5.348	0.922
Max	34	4.953	0.929
Average	33	5.165	0.927

The BEP of the pump is obtained for bowl head of 33.89 and is equal to 0.92. The motor efficiency is specified by manufacturer at 0.974. It can be seen from table above that the average running conditions of the pumps are close to BEP, thus the efficiency of the lift station is maximum at 89.7%.

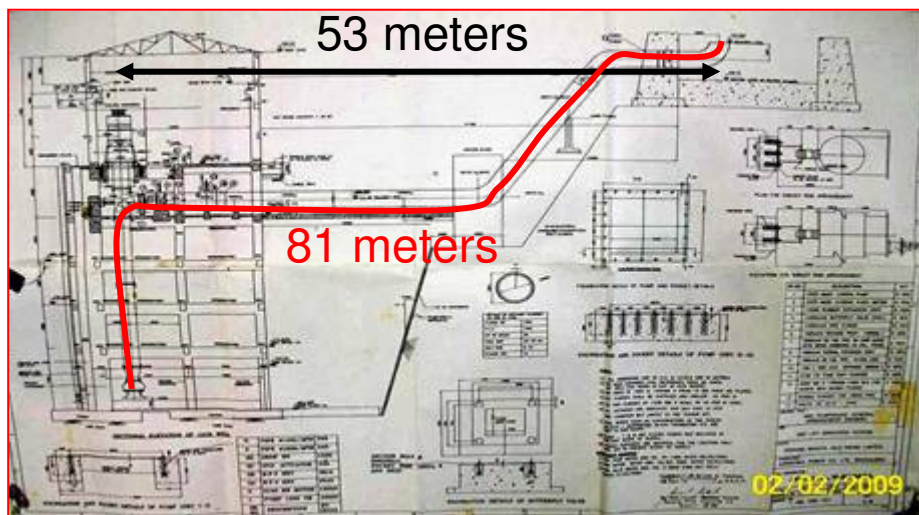


Plate 8 Design drawings of the ILIS pumping station

Capacity of estimating volume input at head of systems

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

- Using pumping hours is reasonable to give accurate discharge and volume within a certain limit depending on the head. Discharge varies at 4 % about average value (see table 1).
- One should consider associate water levels and accurate assessment of head losses in the pipe.
- the BEST option should be to have a measurement point upstream of the main canal.

STEP 3: THE PERTURBATIONS

Perturbations analysis: causes, magnitudes, frequency and options to cope with.

PERTURBATIONS

- Unauthorized pumping and off takes are substantially throughout the length of main canal, distributaries and laterals.
- Uncontrolled flows in distributors and minors.
- Siltation
- Power shutdown.
- Bunding by the farmers near off takes.
- Blockage of outlets in the minors by the formers.

Step 4 MAPPING WATER & ENERGY BALANCE

NOTE: See the WB for the entire area

Step 4.2 MAPPING the ENERGY at ILIS

Energy produced by the lift station

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

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

head static (actual) is the difference of water elevation between canal inlet (H_1) and outlet (H_3) [See Sketch of heads in figure 2 previous section].

Energy required by the lift station

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

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

Efficiency being that of the pump set (motor+pump).

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

Head data at the lift station

Inlet elevation as follows

- H_1 minimum = 469.5 m
- H_1 average = 470.5 m
- H_1 maximum = 471.6 m

Outlet elevation

H_3 restituted at present (entrance of the canal) = 503 m

H_2 outlet (top edge of the vertical pipe in the chamber) = 503.80 m

H_2 considering the flow about the edge of the pipe = 505 m

Efficiency from head analysis

Given the losses of elevation at outlet and head losses in the pipe, the efficiency for head is estimated to reach 94%. Together with the pump efficiency of 92.7 % and motor efficiency of 97.4% the overall efficiency is estimated at 85%.

Table 9a. Stage 1 Lift efficiency analysis

Static head	34.5		Head total spent	35
Head losses along the raising pipe		0.5	Head input into the flow	32.5
Losses at outlet <i>Delta H</i>		2		0.94
Efficiency pump		92.7		0.87
Efficiency motor		97.4	Overall Efficiency	0.85

Step 5 MAPPING THE COST of OPERATION

Note: See the main report for more details on cost of operation

Cost of pumping in ILIS

Another important component of the cost for irrigation supply to agriculture is that of pumping systems.

The spending of energy can be calculated for one cubic meter of water as follows :

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

$$Energy /m^3 = 1 * 35/367/0.90 = 0.106 KWh/m^3$$

At usual price of electricity (INR3/KWh) that would cost: 0.318 INRs/m³

Table 9b. Breakdown of expenses for ILIS

I.	Administrative charges	AMOUNT, INRs. in lakhs
1	SALARIES	188
2	TRAVEL EXPENSES	17
3	OFFICE EXPENSES	6
II.	Operation & Maintenance of LIS, machinery & equipments	
4	MACHINERY & EQUIPMENTS	16
5	LIS	336
III.	Operation & Maintenance of canal networks	
6	MAINTENANCE & REPAIRS	219
	TOTAL	782

NOTE: STEPS 6 to 10 on SERVICE - PARTITIONING - DEMAND - IMPROVEMENTS & CONSOLIDATION are reported for the entire UKIS in the main report.

III. MASSMUS application in Shahapur Right Branch Canal

This section on Shahapur RBC starts with the filed visit report from the Group-4 participants and then move into the MASSMUS analysis of this sub-system.

III.1. FIELD VISIT REPORT on SHAHAPUR BRANCH CANAL.

The group 4 was assigned with the work of Rapid Appraisal Program (RAP) for the Shahapur Branch Canal (SBC), and the field visit is done between 3-02-2009 to 5-02-2009 for collecting the data and flow characteristics of the branch canal and it's distributory network system.

During the course of visit of the SBC the group has consulted the project officer/ Manager, i.e., the Chief Engineer who is in charge of the maintenance of the Shahapur Branch Canal (SBC) canal and collected the data for filling the project office questionnaires.

The SBC takes off at Chainage 76.14 Km. of Naryanpur Left Bank Canal (NLBC), the following are the salient features of SBC:

- | | |
|-----------------------------|--|
| 1)Length | : 76.00 Kms. |
| 2)Discharge | : 104.00 Cumecs. 3673.00 Cusecs. |
| 3) Bed width | : 9.68 Mts. (in cutting) : 6.10 Mts. (in embankment) |
| 4) F.S.D | : 4.60 Mts. |
| 5) Side slopes | :1:1 (in cutting), 2:1 (in embankment) |
| 6) Bed fall | :1 in 6400 |
| 7)No.of Distry's | : 38 Nos. |
| 8)Total length of Distry's | : 382.00 Kms. |
| 9)Total ICA | : 1,11,767.00 Ha. |

The Head regulator of SBC consists of two Radial gates, which are controlled by electrically as well as manually.



Plate 9. D/S of the SBC Head Regulator View showing the Radial gate

The alignment of canal is a contour canal from 0.00 to 29.00 Kms and the canal runs on ridge portion. The conveyance capacity of the canal is adequate for irrigating the contemplated command area and irrigates lands of Shahapur and Surpur Talukas to an extent of 1,11,767 Ha. There is also a proposal of Mallabad Lift Irrigation Scheme-1 (LIS) at 6.50 Km of SBC, which draws 600 cusecs of water to irrigate an area of 10,000 Ha. The Mudbal Branch canal (MBC) off takes at 28.63 Km of SBC (Y-junction) which has the capacity of 1200 Cusecs, length of 50.00 Kms and irrigating 50,000 Ha. of land in Shahapur and Jewargi talukas.



Plate 10 Y- Junction structure comprising MBC, SBC and Escape.

The SBC is serving water for five Hydro electric power generation stations, those are constructed along the main canal and one station is constructed on the Distributary No.9 where total electric power generated is of 7.6 MW.



Plate 11. Power generation station on SBC

There is also a proposal to construct two power stations on the Distributory No.6 and 7.

The water is flowing in main canal to its full supply depth; however there are some reaches where the designed section and bed slope is not attained. There is accumulation of silt in the bed to a depth of 0.7mts to 0.8mts in the initial reaches and at the time of construction of canal during 1987, many cross walls were constructed to head up the water to be utilized by the near by farmers. These walls exist even now and due to this water is heading up and freeboard is submerged and also exact discharge going in the branch canal can not be assessed. The tail end of the canal about 10 km is not getting the sufficient water to irrigate the lands especially during the end of Rabi season.

DISTRIBUTION: **DISTRIBUTORY AND LATERALS**

The SBC has a total 38 number of distributories, having the total length of 382 kms, and irrigating an area of 1,11,767.00 Ha of Shahapur and Surpur taluka. Among them Dy-6 and Dy-9 are having maximum length of 36.00 km each, serving 18,377 Ha and 15,530 Ha respectively, and Dy-5 and Dy-7 are having the length of 28.50 km each, serving 8,440 Ha and 8,082 Ha respectively.

The water then flows through the Laterals and finally through FIC's to irrigate the fields. The total length of the laterals is about 1200 Kms. The water is flowing to it's full supply depth, in Distributories and laterals of the initial reaches. However there are some reaches in major distributories where the designed section and bed slope is not attained, also there is accumulation of silt in the bed to a depth of 0.5 mts and there are many obstructions made to head up the water by farmers, due to this water is heading up and freeboard is submerged. Hence accurate discharge going in the distributory can not be assessed. The tail end of the distributories and laterals are not getting the required amount of discharge which is causing the growth of vegetation and weeds in the canal bed itself. Almost all of the tail end distributories are not getting sufficient water to irrigate the lands especially during the end of Rabi season.



Plate 12 Distributory No.6



Plate 13 Distributory No.9



Plate 14 Lateral with damaged lining, weed and jungle growth

There is a growth of jungle (jail flora) along the Inspection path and Service roads of distributory and laterals, which is causing the hindrance in regular inspection of the canals and maintenance.



Plate 15 Illegal water is heading up by farmers

FIELD IRRIGATION CHANNELS

The field irrigation channels (FIC's) are constructed with the slab lining, many of them are removed by the rice cultivators and levelled the land following the plot to plot irrigation i.e., applying water on plot which is on higher elevation. After collecting the water up to 5 to 10 cm height the water spills over to the next plot which is at lower level than the earlier one. And at many places the slabs were missing.



Plate 16 FIC'S without water (left) FIC'S without slab lining (right)

FLOW CONTROL

The flow is regulated in SBC through radial gated head regulator having undershot flow characteristics and low sensitivity. This is operated by both electrically and manually and is in good condition. The distributories, laterals and direct pipe outlets are fitted with vertical sliding gates.



Plate 17 Vertical sliding gate for Dy.No.-9

About 60% to 75% of the distributory gates are well maintained and are in operating condition and almost many of the gates of laterals and direct pipe out lets are damaged and can not be operated for regulating the water.



Plate 18 Damaged gate for lateral



Plate 19 Damaged gate for D.P.O

SENSITIVITY

Sensitivity is defined as the ratio of change in output to change in input.

$$S = \frac{\text{Variation in out put}}{\text{Variation in in put}}$$

For the SBC all the gates are of sliding vertical gate with undershot flow. Hence the sensitivity:

$$S = (\alpha / \text{Difference head at inlet and outlet})$$

The value of $\alpha = 0.5$ for the undershot type of flow

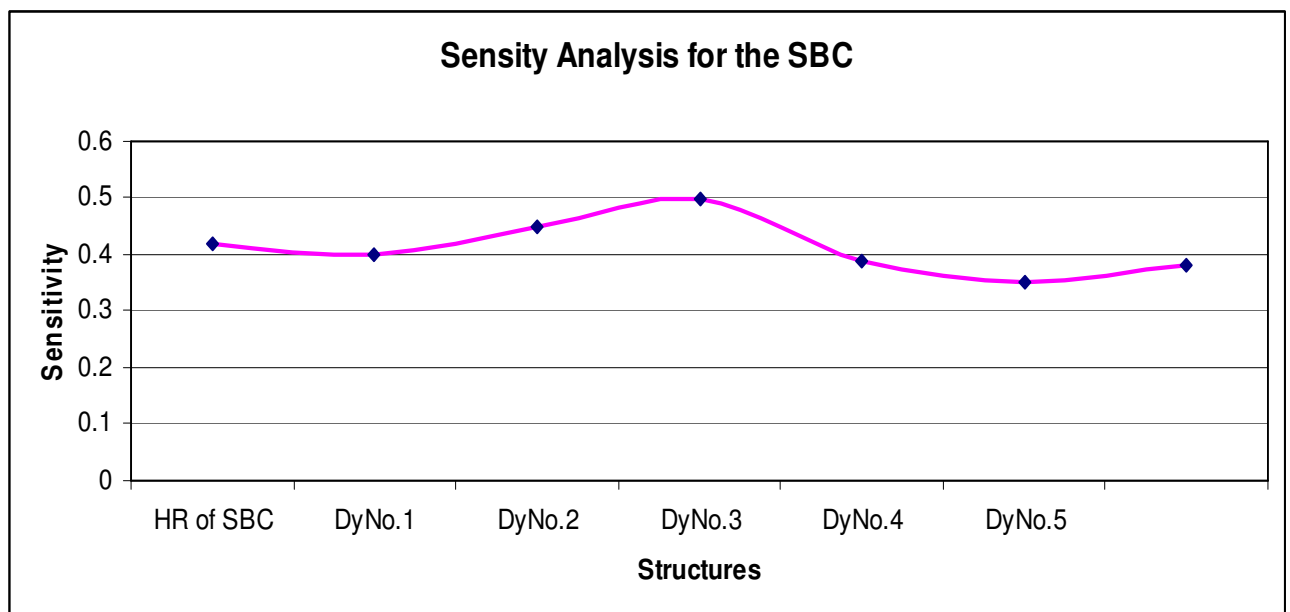


Figure 5. Sensitivity indicators at Disty headworks along SBC

FLOW MEASUREMENT

There are no proper flow measuring devices in the network of the canal. Presently the measurement is being done by reading the gauge painted on slant length of canal lining of the branch canal and distributories. Many distributories do not even have the painted gauge and only two distributories have the gauge well for reading the depth of flow. There is an ambiguity between up stream controlling authority and down stream officers regarding flow measurement due to accumulation of silt in canal bed.

The gauge is painted just D/s of the canal, distributory head works, and U/s of piers of the bridge and cross regulator, as at this location the flow is turbulent which results in variation in flow level, hence these are the unsuitable locations to measure the flow. The measuring structures like flumes and other devices are required to install at steady flow reaches.



Plate 20 Gauge painted on SBC



Plate 21 Gauge painted on Dy.No.-6



Plate 22 Gauge aside well on Dy.No.-6

COMMUNICATIONS AND TRANSPORTATION

In the earlier days the communications were done through wireless, nowadays, the mobile phones are being used for communications. The project vehicles are being used for inspection, operating the gates and attending the maintenance works of the canal.



Plate 23. Head regulator operation control room

The Service roads (SR) and Inspection paths (IP) are in good condition and are used for vehicular transport. Only few SR of the distributories are used for vehicular transport and some others can be accessed by Motor cycles only. However the rest of the roads are not accessible because of growth of jail flora (jungle).

SAFETY

There are totally two Cross Regulator Cum Escapes which are provided in SBC, one at the Y- junction of MBC and SBC and another one at 13.70 KM. In case of emergency the escapes are operated to release the excess water to avoid the breaches and damages to the canal, and second one can be used for the maintaining head at its upstream side.



Plate 24 Cross Regulator Cum Escape Km 13.70 of SBC Plate 25 Cross Regulator Cum Escape Km.- 7.5 of Dy.-6

As per design norms 6 numbers of CR cum Escape are provided along the SBC and are functioning properly, and the unintended leakages are observed in the escapes.

PERTURBATION

Perturbations are observed in the canal and distributaries which have negative impact on the canal performance. Mainly the water is drawn from the canal by using the electric pumps, diesel pumps and by syphonic action. Because of improper maintenance of escapes, the water is leaking in to the natural drainages, and because of improper irrigation practices by farmers of paddy fields much of the water is flowing in to the natural drains and considerable amount of the valuable water is wasting.



Plate 26 Illegal pumping



Plate 27 Water leaks



Plate 28 Illegal siphon



Plate 29 Drainage outlet before the river

CROP PATTERN

The command area of SBC have the mixed cropping pattern, in initial reaches of the canal network system the percentage of the paddy fields is more compared to the other type of crops because of the availability of more water. In tail end reaches the pattern is vice versa.



Plate 30. Set of shots on crops and farmers

The following pie chart shows the percentage of the different type of crops grown in SBC command area for the year 2007-2008.

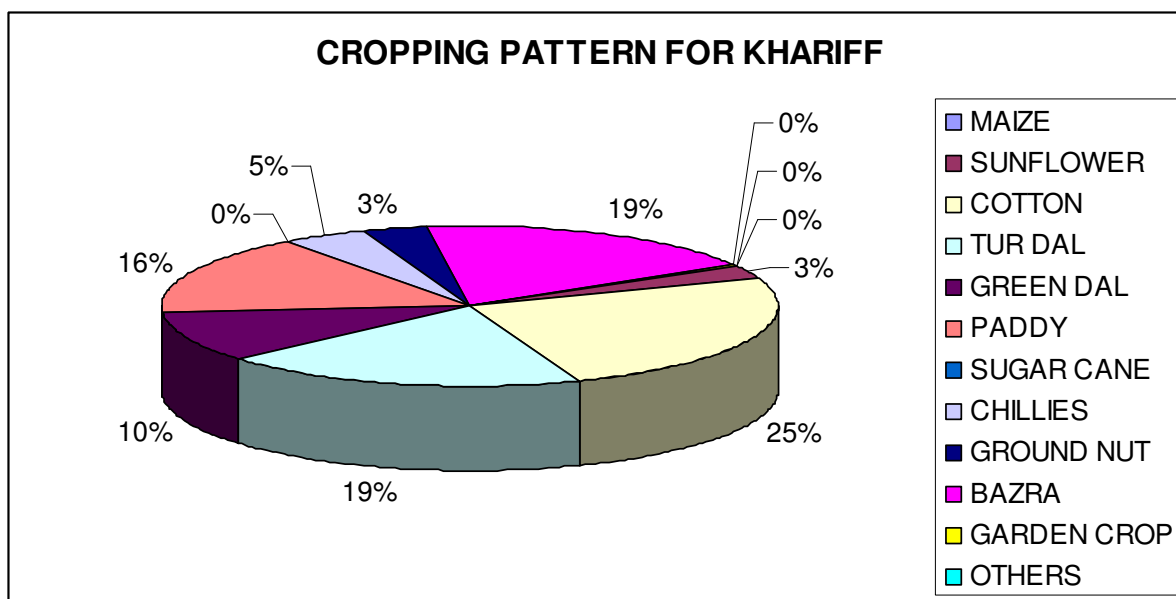


Figure 6 Cropping pattern for kharif

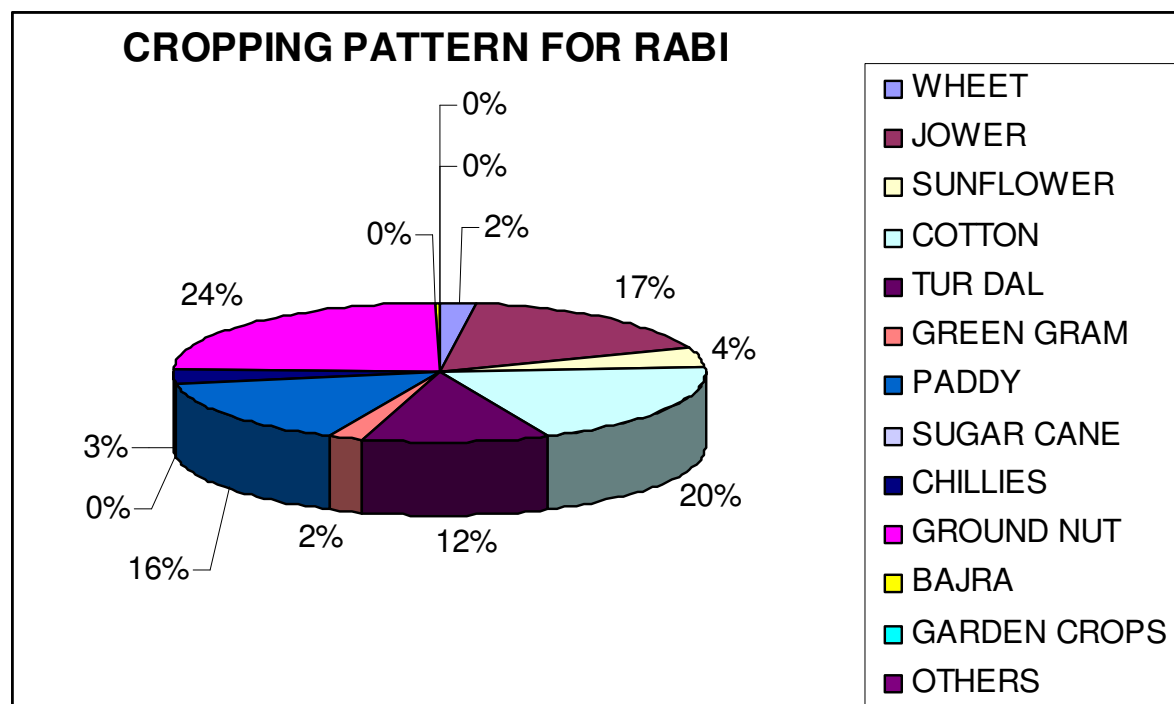


Figure 7. Cropping pattern for Rabi

MULTIPLE USES

The SBC is being utilized for the multiple services like Domestic water supply for the 75 % of the population of Shahapur taluka, with a per capita rate of 90 litres/day. Similarly the KBJNL Bheemarayangudi camp is also drawing water for the domestic purpose for a population of 6000 at a per capita rate of 45 litres/day, to cope up with the shortages of present water supply.



Plate 31 Domestic water Reservoir fed by irrigation pipe.

Water storage tank for supplying water to shahapur town

The surplus water of distributory and laterals of D-6 and D-9, flows in to the natural streams and nalas and contribute to the water for Shattikera tank which is used for fishery and minor irrigation purpose. The water table level at this region has considerably increased and the open wells are serving with sufficient water.



Plate 32 Shettikera MI Tank



Plate 33 Open well in Shettikera

The canal water was being used also for drinking, for animals, for bathing and washing the cloths along the canals the villages that are situated nearby.

As explained earlier the SBC is also serving for the Hydro electric power generation for 6 stations.

DRAINAGE

In the initial reaches of the SBC canal network the surplus water was flowing from the paddy fields and tail ends of the distributory and laterals, because of improper irrigation practices and water management causing serious water logging, salinity problems and growth of the swamps and weeds increases which indirectly causes the growth of mosquitoes and unhealthy conditions.



Plate 34 MUS in SBC



Plate 35 Cattle accessing water



Plate 36 Drainage and vegetation



Plate 37 Drainage and vegetation

WATER USER SOCIETY

A total of 500 Water Users Co-Operative Society (WUS) are formed in the SBC command area among which only 5% of them are functioning to a little extent. A meeting was conducted with the members of Ganganal village WUS and the problems faced by the society members as well as the departmental people were discussed. The farmers were educated about the use of the water without wasting the water by letting the same to the drainage.

The necessity of further formation of the WUS to the entire achnut area is suggested for smooth water management and good revenue collection for the Nigam.



Plate 38 Meeting with office bearers of Ganganal WUS

III. 3. MASSMUS in Shahapur.

STEP 1 SPECIFIC Rapid Appraisal Procedure (RAP) for MUS

The first step in MASSMUS is identifying the uses and functions that are significant as service provided or as a practice.

Table 12. Mapping the MUSF met in Shahapur: Significant use/functions signalled bold underlined

Uses	Functions and Roles
<u>Domestic water</u> Sanitation and wastewater management	<u>Flood protection</u> Groundwater recharge
<u>Irrigation</u>	Support to fishing
<u>Water for cattle</u>	<u>Tourism</u>
Transportation	<u>Support to natural ecosystems (biodiversity)</u> Social functions linked to the infrastructure and management
<u>Hydropower</u>	<u>Recreation</u> Soil conservation
<u>Environmental flows</u>	Habitat improvements (raw materials for construction, shade, cooling effect,...)
<u>Flood protection</u>	

Also to identify the type of MUS system as presented in Table 11, the Shahapur system is a Multipurpose Reservoir (MPR) and a Multi Irrigation plus (MI+).

As presented earlier RAP is a systematic set of procedures for diagnosing the bottlenecks and the performance and service levels within an irrigation system. It aims at providing qualified personnel with a clear picture of where conditions must be improved and assists in prioritizing the steps for improvement. Furthermore, it also provides key internal and external indicators that can be used as benchmarks in order to compare improvements in performance once modernization plans are implemented.

The details of the methodology and description of RAP worksheets are given in Appendix 1. Readers are also invited to refer to MASSCOTE document for that purpose.

Specific Worksheet: MUS

In the RAP-MUS excel file, the worksheet 7.a. focuses on MUS, where key information or indicators for MUS had to be inserted. The main elements to be filled in for each use are mentioned in table 13 below.

External indicators: ASSESSING the various VALUES of MUS

In worksheet 1 the tables at bottom are summarizing the values recorded for MUS as part of water uses and as share of the total generated value.

In the basic RAP for irrigation canal, the gross value of the agriculture production is the criteria used for calculation of Monetary Product per ha (\$/ha) and per m3 of water (\$/m3). It is thus suggested to take whenever it is possible the same value – Gross production value - for other uses in order to allow comparison among the various uses. However for some uses or function of water the gross value does not make sense and some other criteria have to be considered.

Table 13. Elements to be filled for each specific Use of Water (Worksheet 7.a).

Bulk water to cities
Means of delivery/provision
Characteristic of the service: definition
Service achievement
Use of water: Consumptive vs non-consumptive - (fraction recycled)
Use vs other uses: How would you characterize the coexistence of this use with others
In case of conflict for water or in the system operation explain in few words in the cell below
Users and Governance
Service remuneration and associated taxes
Remuneration of the service by users/organisations directly to the Water Management Entity
Fee associated to the service paid by user/organisations to the State
Water use tax paid by user/organisations directly to a Water Basin Authority.
Value associated to or generated by the service

Table14. Ranking of integration of MUSin management & operation

Indicator value	Management attitude	Manager attitude [as stated]	Local level operators and local practices [as seen on the field]
0	Ignoring or denying MUS and/or its magnitude	"There is only one single use for irrigation"	
1	Blind eye on MUS practice by users	Manager is aware of some MUS related practices but do not consider them as part of his job.	No intervention to reduce direct pumping from canals No particular concerns about groundwater pumping No intervention to prevent use of canal as a waste disposal.
2	Positive marginal practices to support MUS		Local operators accommodate in their day to day practices the other uses of water. e.g. letting unfixed leakages to drainage when water is used by downstream people/villages. letting unauthorized gate flowing into near by small tanks or drainage.
3	Integration of other services concerns into the operation	Manager knows and organise the management to serve other uses or to ensure that operation for irrigation do not penalised the other uses.	Bulk water deliveries to villages tanks Main canal filled with water after irrigation season to provide water to people in the GCA. Local reservoirs managed to account for other uses. Minimizing period of canal maintenance.
4	Integration of Multiple Uses Services into the management and governance.	MUSF is fully integrated in the Management Operation and Maintenance. Governance is made on the basis of multiple services with multiple users/stakeholders.	Each service well defined. Users well identified, they pay for the services, they have a say on decisions on the system management.

Internal indicators: how MUS is integrated by management

In worksheet 5 “Project Office question” a special section (line 89 and below) has been introduced to assess the way managers are seeing MUS. This is described in table 14 column 3 from the left. Column 4 introduces the ranking once local practices are considered.

The Shahapur system has been ranked 3 for MUS integration (table 14).

STEP 2. CAPACITY & SENSITIVITY for MUS

Capacity of the infrastructure

In MASSCOTE approach, capacity and functionality of canal system is assessed for each physical structure with respect to four main features:

- **functionality**: whether the infrastructure/structure is functional or not;
- **capacity**: if functional, what the actual flow capacity of the structure is with regard to its function (possibly compare with design and/or ideal target);
- **ease of operation**: how easy the structure is to operate;
- **interference**: whether the structure has adverse impact on the behaviour of other structures (perturbations to other hydraulic structures).

Capacity and Sensitivity for Multiple Services

For MUS the capacity at stake is the one dealing with all types of service. Capacity must be seen as a **physical capacity** as well as **time capacity**. For instance, irrigation canal systems are regularly (annually) off for repair and maintenance or because the irrigation season is over, this results in having services to other uses reduced, if not simply cut during these periods. Thus the capacity issue for MUSF is also a calendar issue throughout the year.

The requirement to maintain the capacity for other uses may then drastically reduce the period of closure of the canal and thus the time allocated for repairs and maintenance. This is for instance practiced in the Indus River basin irrigation systems, in order to not let the areas without water supply for a too long period of time. Considerations on population health are dominant here but this is often conflicting with the requirement for repairs and maintenance works.

Capacity in assessing physically the water is sometime critical and an issue of safety. Easy access is quite often provided along secondary and tertiary through construction of stairs but along the main canal the situation is different and it can be very dangerous. Women are at risk when washing their clothes just standing along the slope with no safety protection as shown in Plate 39 left.



Plate 39 Left Lack of provision for accessing the SBC main canal; Right access provided along secondary equipped with stairs.

Table 10. Example of capacity and sensitivity for multiples Uses

SERVICES	Characteristics required for the service	CAPACITY	SENSITIVITY
Domestic Water	<ul style="list-style-type: none"> • Highly reliable controlled flow • High quality of water 	reduced during canal closure	High sensitive to deficit and pollution
Water to cattle	<ul style="list-style-type: none"> • access to canal water • supply to water ponds 	reduced during canal closure	
Groundwater recharge	<ul style="list-style-type: none"> • canal seepage • Field losses • specific recharge facilities 	Reduced by canal lining	Low sensitive
Homestead garden	<ul style="list-style-type: none"> • groundwater pumping • high water table to feed root system 	Groundwater recharge and percolation from adjacent fields	Low sensitive
Environment	<ul style="list-style-type: none"> • Environmental flows 	Availability of water	Water scarcity Pollution
Fishery	Presence of water	Minimum water flows or volume in water bodies at season's end.	sensitive to long term quality

STEP 3 PERTURBATIONS for MUS

In general terms and having MUSF in mind, a perturbation is defined as:

An unplanned variation of the influencing conditions that may lead to a significant change of the intermediate or ultimate delivered services.

The nature of perturbation is a function of the service specificities. It is also quite different in terms of duration: for a delivery point in irrigation, fluctuations lasting less than one hour can have serious impacts of the service delivered, whereas for groundwater recharge, only long duration of shortage can yield a noticeable change in the aquifer.

Mapping and managing perturbations

To be able to incorporate perturbation in management and operation of the system, mapping perturbations is essential. It means identifying and characterizing their dimensions as well as the option to cope with (see Table 12):

- origin;
- frequency and timing;
- location;
- sign and amplitude;
- options for coping.

Managing perturbations has two basic objectives:

- ensure passing variable flows without adversely affecting on line services;
- ensure that the perturbation is managed properly, by coping with service perturbation, e.g. compensating for a deficit of water if the perturbation is negative, or by storing the surplus if it is positive.

To achieve these objectives, there are two options:

- Set up an infrastructure in such a way that perturbations are dealt with automatically, e.g. the surplus is diverted automatically towards areas that can store or value the water.
- Detect the perturbations and have a proper set of procedures for the operators to react.

For analysis, the perturbation domain is divided into two components: (i) generation; and (ii) propagation. These can also be termed “active” and “reactive” processes.

The active and reactive processes can be analysed in three constituent parts:

- the causes of perturbations, such as return flows, illicit operation of structures, and drift in the setting of regulators;
- the frequency of occurrence;
- the magnitude of perturbations experienced.

STEP 4. WATER ACCOUNTING for MUS

Water accounting, also called water balance, refers to the accounting of the influxes and outfluxes of water in a given space and time. Water accounting is an important part of the MASSCOTE process and the foundations for a modernization project. MUS do not bring any specific demand for water balance but it reinforces heavily the need to measure each and every use of water in the gross command area.

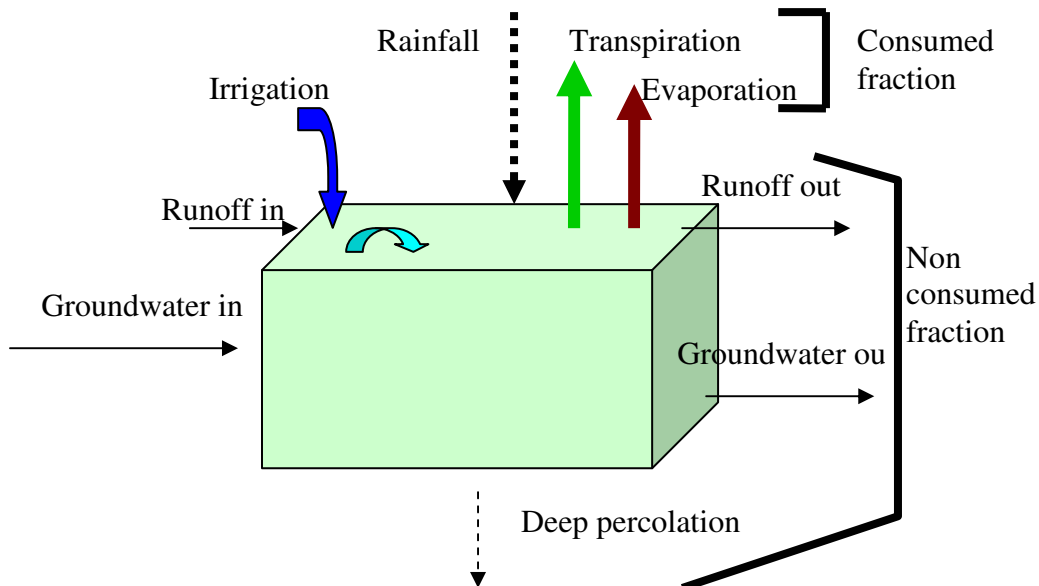


Figure 8 Sketch out of water balance of an irrigation system.

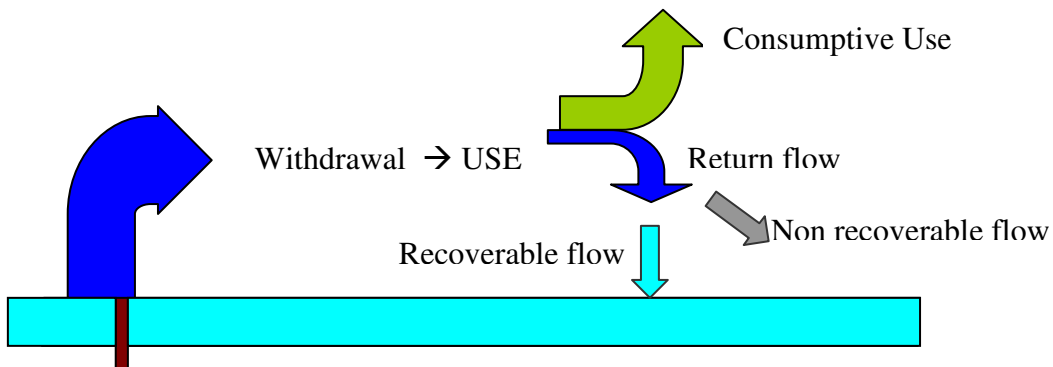


Figure 9. Sketch out of water partitioning: consumptive use and return flow.

Water in & Water out

Water accounting must consider all water (surface water and groundwater streams, conjunctive use, storage and recharge, etc.) that enters and leaves a defined area in a particular span of time.

As “water in” we have to account for precipitation in the CA, the GCA, Runoff from adjacent watershed, groundwater net contribution and of course irrigation water. As “water out” we have to account for Evapotranspiration (ETP) which is often the main component, the runoff out and the groundwater lateral out.

Water use

Using water might have several meanings which essentially are related to one of the following characteristics:

- Quantity: water use can consume water
- Quality: water use can reduce water quality
- Energy: hydropower water use consumes the elevation (energy) of water to produce electricity.

Furthermore there are several ways of qualifying water use using the following criteria as illustrated in table 12: water uses can be depletive or non depletive, consumptive and non consumptive, processed or non processed, but all have to be somehow evaluated to develop a comprehensive MUSF approach.

Table 13. Characterisation of water use

Characteristic of the Use	Definition	Example of such use
Consumptive	Water leave the system (hydrological cycle) and return to atmosphere	Irrigated crops Homestead garden Perennial natural vegetation
Non-consumptive	Water is not consumed. Water maybe diverted and used but is returned after use.	Hydro-power Domestic water (recycled) Animals
Depletive	Water is depleted from the natural resources	Diversion schemes Groundwater Pumping
Non depletive	Water is used on its site without any diversion	Recreational use in aquasystems Landscape tourism
Process	Water is needed by the productive process.	Crop growth hydro-power
Non process	Water consumed is not part of the process, but rather a side effect	Fisheries and evaporation from water bodies Tourism, recreational value
Beneficial	Positive externalities	Groundwater recharge
Non beneficial	No added value. Negative externalities	Pollution from agriculture areas.

Nota: the qualification of the water use as in table 13 is not always clear cut.

Consumptive use means water leaves the hydrological cycle. We found in this category all uses associated to evapotranspiration process: it is either the result of a direct process consumption such as evapotranspiration for crops or for perennial vegetation in the GCA or an indirect consumption (they are not necessary for the process) such evaporation from water bodies for fisheries, environment, recreational and tourism.

Non consumptive uses are the ones which return large part if not all of the fraction they have taken.

Note that evapotranspiration is not the only consumptive use, the fraction of water sunk into deep groundwater aquifers or water which becomes unusable after too much degradation falls

in this category. However they are more seldom and this is why here we have restricted this category to ETP.

Depletive Uses: Evapotranspiration

The consumptive use of water is mainly due to evapo-transpiration, water returning back to the atmosphere. The rate of evapotranspiration is highly related to the nature of land use and its water status (well fed or dry).

From Uses to Beneficiaries

Identifying beneficiaries and benefits of water uses are important to appreciate the importance of each use within the GCA. For instance one step is to say that for example 8 % of total water is evaporated from the water bodies within the GCA, the second step must identify who are the beneficiaries sharing the values/benefits associated to this use. A similar reasoning must be made for the natural ecosystems.

Uses and beneficiaries sometimes coincide, e.g. for crop production and farmers, in that case the measure of water outputs is affected to one single use. Coincidence between one use and one beneficiary is not always met, e.g. water bodies evaporate water but this use can be related/associated to many beneficiaries (fisheries, tourism and recreation, environment and wildlife, transport,...). This latter point is addressed below.

Partitioning benefits of water bodies

Some consumptive uses are unambiguously associated to one single use like crop production, or homestead garden, natural vegetation, although they might yield to several beneficial outputs.

Some consumption corresponds to several uses or function of water and it is not straightforward to partition the consumption according to these various associated uses. This is in particular the case of water bodies such reservoirs, lakes, tanks etc... They may serve several purposes: storage of water for the dry season, fisheries, recreational activities, tourism, wild life, flood protection, etc... There are no simple rules to partition the water evapotranspired from a reservoir. Criteria that can be used to weigh the consumption are:

- numbers of beneficiaries, households, jobs
- monetary value generated per use
- Environmental values.

Impact of water quality

The return of water into the system after some use can be done with deteriorated quality (pollutant, thermal change, ...) and that has to be considered when water accounting is processed as a whole.

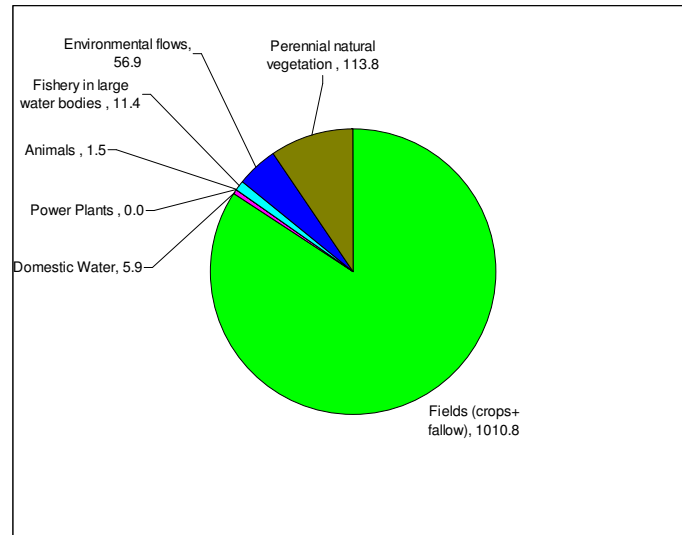


Figure 10. Use of Water in Shahapur system (in MCM).

STEP 5. Accounting Values of water uses

This step is added specifically to address MUSF system. The values associated to the water uses must be characterized in such a way that it can then be used for comparison among uses, for decision making about water allocation as well as for estimating the possible contribution for cost coverage.

- Value per Uses and per benefits:
 - gross product supported from this water service
 - employees
 - households
 - values: monetary and non monetary (social, culture, etc..)
 - health
 - environmental values
- Theory of Valuation
- Value with respect to all water

Value with respect to irrigation water (with & without irrigation analysis)

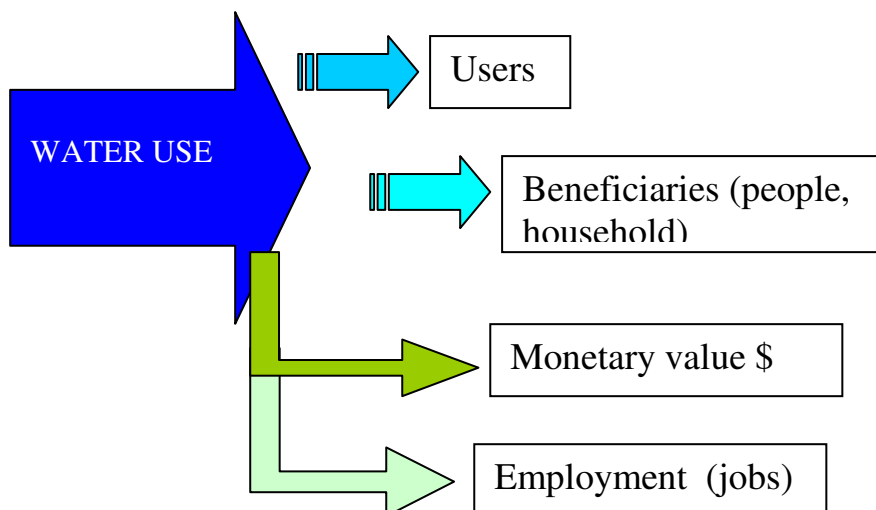


Figure 11. Accounting water use, beneficiaries and values

Table 14. Water Uses and Values estimator

Use/function	VALUE estimator
Delivery to farms	Crop yields \$/ha irrigated - \$/m3
Domestic water	Cost paid by service users Estimated cost of an alternative solution Number of capita served
Drinking water for cattle	Value of annual animal products Number of households
Homestead garden	Value generated by the garden
Support/recharge to natural surface streams (surface and groundwater) & environment	
Industry and Hydropower	Economical value generated, employment
Tourism, fishing, recreation, wild animals & natural parks	Economical value generated, employment
Control of vector-born diseases in waterbodies	
Flood control	Population and assets protected
Control of drainage return flow	
Transport	Quantum transported Economical value, employment

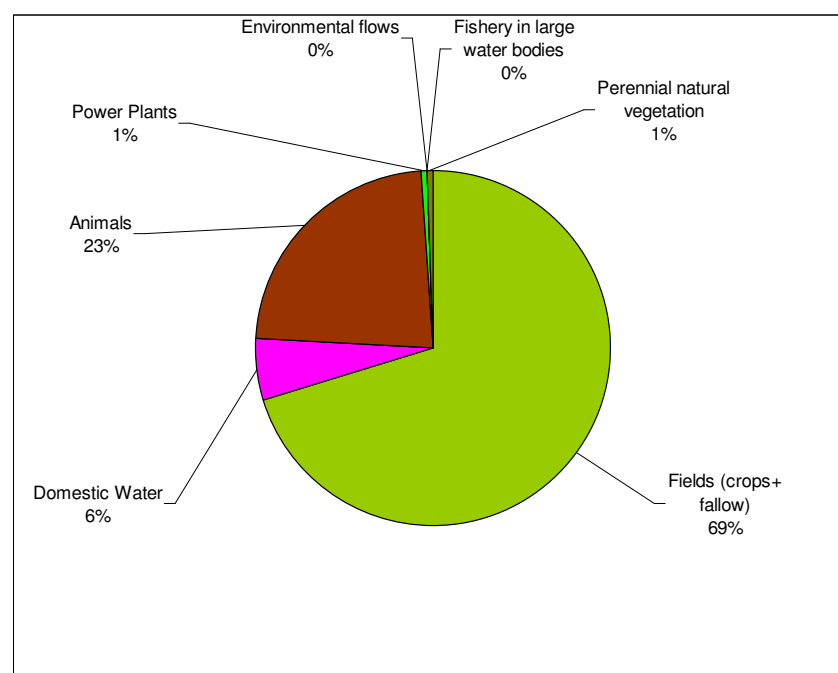


Figure 12. Share of Monetary Value per use in Shahapur system .

IV. NARYANPUR RIGHT BANK CANAL

Nota: This section reports some of the detailed steps made for NRBC by the working group 1. Some steps are not addressed as they were discussed and developed for the entire UK complex.

NRBC

Length: 95 kms.

ICA: 84000 ha. Total developed 55841.44 ha

No. of distrys: 22

Branch canals: nil.

Offtake details:-

Discharge: 101 c/s

FSD: 5.49 meters.

Bedwidth; 6.00mtr

Bed fall: 1 in 6400

Utilisation: 23.33tmc

Key findings from field visits made (3-2-09 to 5-2-09)

1. Narayanpur left bank power house
2. Narayanpur dam and HR of LBC and RBC
3. NRBC (km 0 to 95), Dys 5, 7(a), 9 and lateral No 3 and Dy 16
4. Hydel scheme near Km 55 of NRBC (Somanmaradi Hydro-electric Project)

- RLIS and NRBC are in operation since 2003-04. The systems are freshly constructed. RLIS is fairly new compared to NRBC. Though NRBC was constructed in the late nineties, water is released only in 2003-04. The delay is due to bottlenecks along the canal, which took some time to complete.

- Both the systems are partially degraded. Degradation is mainly due to
 - Inadequate maintenance
 - Vandalism by the ryots
 - Accumulation of silt and growth of jungle along the canal system
 - Erosion of banks and failure of lining in some reaches of canal.
 - Rampant lifting of water by the farmers from the canals, more in main canal
 - Inadequate maintenance staff
 - Poor operation techniques (e.g.no discharge measurement devices anywhere)
- No measuring devices anywhere in the canal, resulting in high degree of inaccuracy
- There are no gates for laterals in NRBC. Flow is proportional in the laterals in NRBC. Branch Dys in NRBC are also ungated.
- NRBC, there are 5 CRs along main canal (Ch 17.36 Km, 39.1 Km, 55 Km, 72 Km, 95 Km). In addition, there are 8 cross walls (weirs) constructed to raise water level behind to feed the offtakes whose bed levels are higher than CBL of main canal. They are used for level control. The CRs are also operated.

- Due to ungated system of distribution, lot of wastage of water is seen due to tendency of farmers not resorting to night irrigation. Night irrigation is not practiced. Lot of flow is seen in drains. No drainage measurements. Drains are choked with weed growth and encroachment by the farmers.
- Multiple use of water is practised.
 - Irrigation,
 - Drinking water supply (Muddebihal, Nalatwad, Hungund,
 - Ilkal & Kushtagi –from Naraynpur reservoir) and Lingsugur from NRBC. Water supply to some villages from NRBC under execution. (0.18 TMC)
 - Industry-Raivhur thermal station (0.98 TMC)
 - Hydro-power-
 - Near NLBC Left bank HR , $2 \times 5.8 = 11.6$ MW generation unit.
 - Near Km 55 of NRBC (head 33 m), $2 \times 6 = 12$ MW generation unit.
 - Flood control- Reservoir is used for flood control with controlled releases during floods (Aug-Sept)
 - Other uses (animals, birds, washing purposes, recreation etc.)
 - Environmental (Greenery in the command area due to trees (Jalli flora mainly), regenerated water (return flow) helping to maintain aquatic life in the river and streams)
- No WUAs yet formed. Proposed to be formed and the process is on.
- Allocation of water is 22.6 TMC for NRBC and 5.6 TMC for RLIS.
- Cropping pattern- Designed for semidry crops (100% intensity of irrigation. khariff 60%, Rabi 40%), But paddy cultivation is seen , more in areas where assured water supply is there (head reaches of main canal and Dys and laterals). Paddy is grown in RLIS also. Extent of paddy is about 10-20%. Other crops grown are ground nut, sunflower, jowar, wheat, cotton, pulses, millets and garden crops). The area of unauthorised irrigation is not accounted. Actual cropped area is more than official figures. Cultivation of more water demanding crops (paddy) can be anticipated.
- Sensitivity : NRBC offtakes-Low (<1)
NRBC CRs -Low (<1)
- Main Canals- there are no capacity problems. Silted up to some extent. Dys and laterals are also silted up. Silt is more pronounced in deep cut reaches of NRBC.
- Perturbations-
 - NRBC- Illegal withdrawal, pumping by farmers, reduction in discharge during rains, when hydel scheme trips, some time is taken (30 min) to divert the flow to main canal results in perturbations in main canal downstream below Km 55. Rain water enters main canal through inlets causing perturbations.
- Communication –Roads are good along main canal and distributaries. No all weather roads. There is good road network in the command area.



Plate 40 Ungated distribution along secondary and laterals



Plate 41 Cross regulator and main offtake along NRBC



Plate 42 Importance of drainage flows

Step 2. SYSTEM CAPACITY AND SENSITIVITY.

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

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

Step 2.1. The capacity along the NRBC canal

STORAGE : The storage in Narayanpur dam , which is a balancing reservoir is sufficient to supply water for Khariff and Rabi covering an area of 84000 ha.

CONVEYANCE : NRBC is a gravity canal, 95 Kms long with 18 Dys . Conveyance along ,main canal is good. There are no problems along main canal as far as conveyance is concerned. However, when design discharge of 3500 cusecs is allowed when expansion of area takes place in Phase-II, the Main canal will pose problems, because of

- Siltation, growth of weeds causing reduction in discharge
- Damaged lining portions in banking reaches are vulnerable to breach

DIVERSION : The diversion capacity is sufficient.

DISTRIBUTION : The distribution is by a system of distributaries, laterals and FICs. The lateral gates are ungated, resulting in uncontrolled supply of water. There is a need to install gates for branch Dys and laterals.

CONTROL : There are 5 CRs along main canal. They can be used for water level control.

MEASUREMENT : There are no measurement devices anywhere. There is a need to measure the discharge at all levels of canal system.

SAFETY : There are 5 escapes along the main canal, which is sufficient.

TRANSMISSION : Communication is being done through mobile phones. Centralised data acquisition could be thought of for improved water management.

Step 2.2. The Sensitivity along the NRBC canal

NRBC : Off takes are low sensitive as illustrated for some distributaries below

1. Dy-3 @ Km 10.84 $S=0.5/2.2 = 0.22$
2. Dy-4 @ Km 17.45 $S= 0.5/2.7 =0.18$
3. Dy-7 A @ 35.9 Km $S= 0.5/3.25 =0.15$
4. Dy-12@ Km 69.47 $S=0.5/1.3 =0.38$
5. Dy-17 @ Km 94.53 $S=0.5/1.4 =0.35$
6. Dy-18 @ Km 94.88 $S= 0.5/1.85 = 0.27$

CRs are low to medium sensitive

1.CR @ Ch 17.36 Km

$S=0.5/0.5=1$

2. CR @ 71.015 Km

$S=0.6/0.5 =1.2$

STEP 3: THE PERTURBATIONS

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

Causes

- The operation of pumps is one of the main causes of perturbations. The pumps are designed to operate for 24 hours, whereas in reality they are working from 12 hours to 24 hours. When pumps are shut down, there is sudden lowering of water level in the canal.
- Illegal withdrawals from the lead off canal and from the main canal by pumping by farmers.
- The temporary obstructions at off takes.
- Closure of pumping during rains results in perturbations.
- Rain water entering the main canal during unprecedented rains.
- Unauthorised operation of gates by the farmers.

Magnitudes

- It is significant in case of pump operation and illegal withdrawals from pump sets.

Location

- Perturbations are seen all along the length of the canal, more towards downstream end.

Frequency

- It is more prominent during Rabi season due to unauthorised withdrawal from pumps.

Options to cope with

- Continuous pumping by all the pumps for 24 hours, the perturbations can be reduced.
- The CRs / weirs can be constructed and operated frequently to maintain the required depth of water.
- There are no regulating reservoirs (on-line storage) along the canal to store surplus water, which may be considered.

V. JEVARGI BRANCH CANAL AND MUDBAL BRANCH CANAL

Nota: This section reports some of the detailed steps made for JBC and MBC by the working group 5. Some steps are not addressed as they were discussed and developed for the entire UK complex.

Jevargi Branch Canal

length 86.31 km, command area : 57,100 ha

Mudabal Branch Canal

length 50.01 km, command area : 51,000 ha



Plate 43 Trijunction of IBC, Escape & JBC

Head regulator of JBC

No of gates: 02

Type: radial gates

Discharge: 36.32 cum

ICA: 57,000 ha

Operation : electrical / manual

Measurement: gauges on upstream and downstream

Head regulator of MBC

Due to leakages of around more than 250 cusecs at head regulator of MBC, the initial distributaries of MBC are being fed with water for 3-4 days after closure and no water at the tail end distributary D-26 at km.50.80

It is represented that D-26 at the tail end of MBC having designed discharge of 177 cusecs, is not even receiving 20-25 cusecs, which could not be seen due to rotation closure period in the reach from 31-01-2009 to 10-02-2009.



Plate 44 cross regulator at 9.250 km

Main Canal

No of CRs : 7, One each per 12 km

Type : radial

Measurement: No gauges

Flow control :Only head regulator is being operated for flow changes.

Intermediate CRs are kept open and not used in adjusting the flow

Changes except CR at dy-12, which is used for rotation

Each cross regulator is provided with escape

Sensitivity at head regulator is 0.5, which is low

All other cross regulators being fully open, sensitivity is high

Offtakes of main canal are less sensitive in upstream reaches and sensitivity increases at tail reaches. The sensitivity variation ranges from 0.7 to 2.5

Bottom width: 7.9 m; FSD: 3.0 m

Free board: 1.0 m

Slope: 1:6400

100% cc lining

Lining degraded/ damaged at many reaches

Silt level is around 5% to 10%

Capacity is enough to carry required discharges

Illicit withdrawals by way of lifting water through pumps and syphonic actions by pipes

Cross bunds are constructed as permanent structures

All along the main canal subsequent to the individual offtake of distributory for raising the head in the main canal to draw extra water to the distributory is the prime reason for tail end problems

No optimum utilisation of water due to uncontrolled flows through offtakes without any measurements.

Diversification of crops in initial reaches and unutilized excess water from fields is left to nalas.

At certain places of the main canal through excavated drains rain water entry is given to main canal and this act as positive perturbation.

Service roads need improvement, since present accessibility is rough on one side and no access on the other side.

Secondary canals

Scheduling of operation in secondary canal is on 10 days rotation basis

Distributory offtakes are less sensitive

Cross bunding in the main canal is leading for capacity problems in the secondary canals

No gauges for measurements

Illicit operations through pumping also prevails in the secondary canals

Cross bunding problems in the mbc is leading for no water at the tail end distributory, such as dy-26.

Laterals

Laterals and FIC's are ungated

In the initial 75% of the reaches the laterals and fic's are well fed, but tale end laterals and fic's are finding shortage of water

Communication is through cell phones and is effective

Accessibility of offtakes of distributories and laterals is average on one side (sr) and no access on the other(ip)



Plate 45. Scouring of canal lining in JBC DY-12



Plate 46. Damaged cc-lining in MBC main canal



Plate 47 Illegal pumping



Plate 48. Cross bunding along main canal subsequent to distributaries



Plate 49. Rain Water drained to main canal

V. NARYANPUR LEFT BANK CANAL

Nota: This section reports some of the detailed steps made for NLBC by the working group 3. Some steps are not addressed as they were discussed and developed for the entire UK complex.

View of NLBC Upstream

- Length of canal = 77.52 km
- Discharge of canal = 10000 cusecs
- Bed width of canal = 16.45 m
- FSD = 6.1 M
- FB = 1.0 M
- CBL = 481.584
- Bed fall = 1:7400
- Total command area = 53000 ha
- No of dys = 25 no.
- No of cr with escape = 5 no.



Plate 50. Inlet

- Most of FIC's are controlled by stones
- No proper control ,overflow over the flumes



Plate 51. Field channel inlet (deteriorated)



Plate 52. D3A of NLBC



Plate 53 Multiple Uses of Water



Plate 54 Cattle access to canal water

- Cross regulators (CR) are not operated for water level control.
- No proper measuring device installed in any of the canal network.

- All the distributaries are flowing encroaching the free board, even then tail end is suffering
- Violation of cropping pattern is observed all along the command of NLBC by the farmers as well as WUA's.
- 50% WUA's are functioning and are active
- Upstream control.
- Up to final deliveries network is maintained by the department.
- Scheduling of flows is rotational (10 days)
- from distributaries to the final deliveries is proportional.
- CRs are not used for water level control in the main canal.
- No CRs in distributaries and minors.
- Uncommand area on either side of the canal are irrigated by unauthorized pumps
- Ground water table is quite high and its depth is of the order of 15 ft from surface in the initial reach of the canal.
- Service roads for distributaries are fairly motorable, needs clearance of thick jungle on either side.
- Off take gates damaged in many places, needs repair.
- Distributaries and laterals are silted up. No off take gates and many unauthorized off takes in distributaries 1 to 25, complete reengineering is required.
- Sufficient maintenance grant is required to keep the canal network operation healthy.
- Laterals are with many unauthorized outlets making it impossible to feed notified area.
- 5 escapes are provided for safety of the canal. Between the reach of 0 to 77 Km
- Escape gates to be reengineered to avoid substantial leakage.

Table 15. Evaluation of sensitivity indicators at offtakes

Sl No	Offtake	Delta H	Delta Q	sensitivity
1	D 1 A	3.6	0.5	0.138
2	D 2 A	2.05	0.5	0.24
3	D 3 A	1.66	0.5	0.30

Table 16. Evaluation of sensitivity indicators at CR

Sl No	CR	Delta H	Delta Q	sensitivity
1	CH 51.89	0.12	0.5	0.24

V.I. INDI BRANCH CANAL Upstream 0 - 80 km

Nota: This section reports some of the detailed steps made for IBC by the working group 2 & 6. Some steps are not addressed as they were discussed and developed for the entire UK complex.

MEASUREMENT

- Gauges on rated section on main canal sides and distributaries
- Few flumes are installed on distributary and laterals



Plate 55 Gauge upstream the canal



Plate 56 Painted gauge on a bridge



Plate 57 Measurements flumes

- Lifting of water through pumps and siphon action from main canal, distributary and escape channels
- Rain water enters the canal in deep cut reaches
- Tailing-off of Indi Lift Canal enters IBC
- Temporary bunds constructed across distributaries and laterals
- Number of pipes are inserted into canal sides to draw water to the adjacent fields
- 3 pumps/km on main canal - drawing about 70 cusecs (average)
- 2 pumps/km on distributaries canal (average) - drawing about 20 cusecs (average)
- Temporary bunds almost near all distributary off-takes
- Illicit withdrawal by pumps, siphon action



Plate 58 Illegal pumping



Plate 59 Illegal cross regulators

- Using CR for water level control and construction of weirs to maintain head
- Providing canal berm in deep cut reaches
- Providing catch water drains along the canal
- Managing the water distribution to avoid unauthorized off-takes
- Leveling the lands to allow the water to reach tail end FICs
- Educating the farmers towards optimum use of canal water

V.II. INDI BRANCH CANAL Downstream 80 - 172 km

Nota: This section reports some of the detailed steps made for IBC downstream by the working group 6. Some steps are not addressed as they were discussed and developed for the entire UK complex.

Group -6 Indi branch canal 80 to 172 km

Main canal : total length 92 km

Distributaries and Laterals

Number of offtakes- 32 nos

Total contemplated ICA of 63,000ha.

This canal is having discharge of 40.485 cumecs.

- 1) To have equity among all the offtakes the main canal should be free from perturbation. The offtakes should have less sensitivities. To regulate the quantity of water flowing into the distributaries controlling structures such as cross regulators and measurements flumes, gauges are to be established. Recording of gauge reading at each offtake point should be recorded. Equity should be maintained among all the offtake points. All water users associations should be trained to adopt warabandi system to fully utilize quantum of water supplied to them. Water users associations should form their federations to plan the efficient use of supplied water and also to collect the revenues.
- 2) Drainage monitoring: as far as possible cropping pattern shall be followed. However drainage inevitable due to violation of the cropping pattern, drainage shall be monitored by construction of necessary checked dams and bandharas. Study of quantity of drainage water both quantitatively and qualitatively shall be made and program to reduce the seepage water should be chalked out. For example in indi branch canal area are utilized drainage water from canal network system is utilized by constructing bandharas and open wells under SCP and TSP works.
- 3) Measurements: for main canals at all regulators, gauge reading may be marked on upstream/downstream and wherever necessary measurement units like flumes may be constructed and at distributaries level to measure the quantum of water measuring devices like flumes may be constructed. The quantum of water used by water user associations may be checked and recorded by the department and WUAs.
- 4) A buffer storage point (i.e at ramanahalli tank) and telemetry station may be installed and managed.
- 5) Information systems: currently the wireless system that is installed on Irrigation Officer's vehicle is used as a information system. At all headworks and offtakes remote sensing and GIS may be installed.

end of part II

