



MASSCOTE
Gulbarga December 2006

Modernization Strategy for Irrigation Management

KARNATAKA - INDIA

GANDORINALA & BENNITHORA PROJECTS

WORKING DOCUMENT



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) (m ³ /s)	=	28.5 litre per second (l/s) = 0.0285 cubic meter per second	
TMC	=	Thousand Million Cubic Feet	= 28.3 Million Cubic Meters
MCM	=	Million Cubic Meter	

ABBREVIATIONS AND ACRONYMS

AGLW	Agriculture Water Resources Development and Management Service of the Land and Water Development Division of FAO
CA	Command Area
CCA	Culturable Command Area
CR	Cross regulator
DO	Direct outlet
FAO	Food and Agriculture Organization
FO	Farmer Organization
GB	Gondorinala-Bennithora
GCA	Gross Command Area
ITRC	Irrigation Training and Research Centre (California Polytechnic University)
KNNL	
LMA	Local Management Agency
MAF	Million Acre Feet
MASSCOTE	
M&E	Monitoring and Evaluation
NCA	Net Command Area (irrigable)
O&M	Operations and Maintenance
OFWM	On-Farm Water Management
RAP	Rapid Appraisal Procedure
WUA	Water Users Association

Introduction and Background.....	5
1. THE MASSCOTE APPROACH	6
Presentation of the methodology.....	6
2. The Gandorinala and Bennithora Projects	8
Bennithora irrigation project	8
Gandorinala irrigation project	11
3. MASSCOTE in Gandorinala and Bennithora Projects	13
Step 1. RAPID DIAGNOSIS: RAP	13
RAP Methodology	13
RAP in Gandorinala and Bennithora.....	15
External indicators	15
Internal Performance Indicators	15
Expected features about the Service	16
General Project Conditions	18
INTERNAL INDICATORS.....	20
MAIN FEATURES FOR GB MANAGEMENT.....	20
1. No water level control.....	20
2. Rapid Degradation of the canal lining	21
3. Expansion of irrigated area likely to happen.....	22
4. Likely changes in cropping pattern towards high demanding crops.....	22
CAPACITY Gandorinala	24
CAPACITY Bennithora	24
The critical issue of damped material on canal banks.....	25
The critical issue of canal seepage.....	25
SENSITIVITY of the irrigation structures.....	26
STEP 3: THE PERTURBATIONS	27
Step 4 MAPPING WATER NETWORKS & WATER BALANCE/ACCOUNTING.....	28
NETWORKS.....	28
WATER ACCOUNTING:	28
SUB-MANAGEMENT UNIT	29
INFLOWS	29
RAINFALL	29
STREAM FLOW FROM OUTSIDE THE COMMAND.....	29
CANAL WATER APPLICATION.....	29
Ground water.....	30
OUTFLOWS	30
EVAPOTRANSPIRATION: anticipating the acreage of the irrigation and the future Cropping Pattern!	30
DRAINAGE FLOWS:	30
Water recycling facility.....	31
Water Balance: a first proxy	31
Step 6 SERVICE to USERS.....	32
The various uses/users.....	32
Service to farmers	33
Step 5 MAPPING THE COST of OPERATION.....	34
Cost of Operation and Maintenance.....	34
Step 7 PARTITIONING IN MANAGEMENT UNITS.....	35
Management levels.....	35
Step 8 MAPPING THE DEMAND FOR CANAL OPERATION	35

Step 9 CANAL OPERATION IMPROVEMENTS.....	35
Step 10 AGGREGATING AND CONSOLIDATING MANAGEMENT	37
Step 11 PLAN FOR MODERNIZATION	37
Annexure-I/I.....	38
SALIENT FEATURES	38
Annexure-II.....	42
SALIENT FEATURES OF GANDORINALA IRRIGATION PROJECT	42
Design Flood	43
Length of spillway.....	43
Spillway.....	43
PRIVATE HOLDINGS.....	43

DRAFT

Introduction and Background

A FAO mission¹ visited Karnataka State from 9 to 16 December 2006 as part of a collaborative program between the Government of Karnataka and FAO, and more specifically a joint program between FAO and KNNL targeting the re-engineering/modernization of irrigation management under the control of KNNL corporate.

This mission is the second MASSCOTE exercise organised by FAO for KNNL, after the Gathaprabha project carried out in October 2006. A set of 3 is planned as part of the FAO-KNNL collaborative activities aiming at developing a modernization strategy for KNNL.

The mission organized a training workshop on modernization of irrigation management for 25 participants with a focus on Gandorinala and Bennithora projects, field visits and working group sessions together with short lecturing have been carried out from 10 to 15 December.

The application presented here has been developed through a training workshop in Karnataka with engineers and managers from the KNNL. The contributions of the working group sessions at this workshop (RAP-MASSCOTE) have been largely included in this report. The MASSCOTE exercise must be further carried out to its completion by a team of KNNL, comprising officers from KNNL HQ as well as some officers from the Gandorinala and Bennithora projects.

The conclusions and proposals in this document are the outcomes of the workshops as they were drafted during the workshop.

It is important to note:

- **that the workshop was especially short (6 days) compare to a normal duration of 10 days.**
- **that the GB systems are recent and just about to start to irrigate therefore the MASSCOTE evaluation cannot cover all aspects but still it has brought some very valuable points and suggestions for the immediate irrigation seasons.**

Further investigations have been made after the workshop by the local KNNL team, but the outputs have not been incorporated yet in the report.

The report has several purposes:

- 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;
- suggest some specific strategies to managers of the Gandorinala and Bennithora projects on how they should start the management and operation of these new irrigation systems introducing modern concepts and techniques ;
- lay the foundations of a progressive modernization plan, with some initial steps taken for the monitoring of the next Kharif season starting June 2007 and the objective to prepare by the end of December a PLAN for an effective Service Oriented Management in these two projects.

¹ The FAO mission consisted of D. Renault, (Senior Irrigation Management Officer, AGLW FAO HQ Rome), and P.S. Rao (Senior Officer of India FAO Bureau Delhi).

1. THE MASSCOTE APPROACH

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

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

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

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

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

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

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

Presentation of the methodology

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

10 STEPS of MASSCOTE

MAPPING....	1. PHASE A BASELINE INFORMATION
1. THE PERFORMANCE RAPID APPRAISAL PROCESS (RAP)	Initial rapid system diagnosis and performance assessment through the RAP: the primary objective of the RAP is to allow qualified personnel to systematically and quickly determine key indicators of the system in order to identify and prioritize modernization improvements. The second objective is to start mobilizing the energy of the actors (managers and users) for modernization. The third objective is to generate a baseline assessment, against which progress can be measured.
2 THE CAPACITY AND SENSITIVITY of the SYSTEM	The assessment of the physical capacity of irrigation structures to perform their function of conveyance, control, measurement, etc. Assessing the sensitivity of irrigation structures (oftakes and cross-regulators), identification of singular points. Mapping the sensitivity of the system.
3 THE PERTURBATIONS	Perturbations analysis: causes, magnitudes, frequency and options for coping with
4 THE NETWORKS & WATER BALANCES	This entails assessing the hierarchical structure and the main features of the irrigation and drainage networks, on the basis of which partition of the system into subsystems will be made. Water accounting should be undertaken, considering both surface water and groundwater, and mapping the opportunities and constraints related to them.
5 THE COST of O&M	Mapping the costs associated with current operational techniques and resulting services, disaggregating the different cost elements; cost analysis of options for various level of services with current techniques and with improved techniques.
	2. PHASE B IMPROVING CANAL OPERATION MATURING SERVICE ORIENTED MANAGEMENT
6 THE SERVICE to USERS	Mapping and economic analysis of the potential range of services to be provided to users at various levels of the systems. The services should be based on a compromise between the water management strategies, the agriculture objectives and the willingness to pay by users.
7 PARTITIONING INTO MANAGEMENT SUB-UNITS	The irrigation system management should be partitioned into few level of management and the command area should be divided and subunits (subsystems and/or subcommand areas) that are held homogeneous and/or separate from one another by a singular point or a particular borderline.
8 ASSESSING THE DEMAND FOR OPERATION	Assessing the resources, opportunity and demand for improved canal operation at the different levels of management and within the local management units.
9 IDENTIFYING CANAL OPERATION IMPROVEMENTS	Identifying improvement options (service and economic feasibility) for each management unit for (i) water management, (ii) water control, and (iii) canal operation)
10 INTEGRATING AND CONSOLIDATING MANAGEMENT	Integration of the preferred options at the system level, and functional cohesiveness check. Consolidation and design of an overall information management system for supporting operation
A PLAN FOR MODERNIZATION AND M&E	Finalizing a modernization strategy and progressive capacity development Select/choose/decide/phasing the options for improvements Plan for M&E of the project inputs and outcomes.

2. The Gandorinala and Bennithora Projects

The two projects are contiguous and located in the North East of the State.

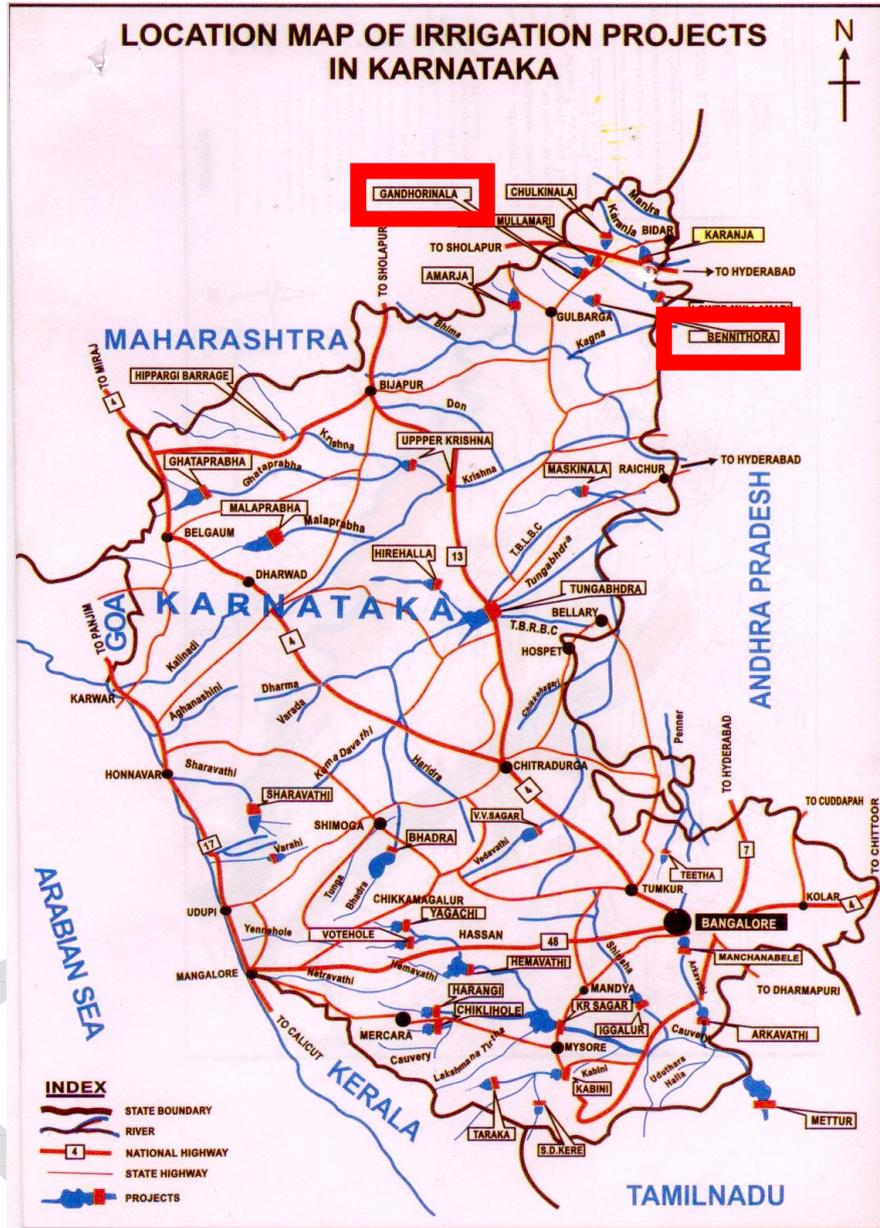


Plate 1. Karnataka map with the location of the projects (top-right).

Bennithora irrigation project

Project Description

Bennithora Irrigation Project is located near Herur(K) in Chittapur Taluk of Gulbarga District in Karnataka State across Bennithora river a tributary of river Kagna in Bhima sub-basin of Krishna Basin. The river Bennithora originates near Malegaon village in Osmanabad

district of Maharashtra. After flowing for a length of 45 Km, in Maharashtra and 91 Km in Karnataka it joins the river Kagna.

The project was cleared by the Planning Commission in 1993 for Rs. 73.25 Crores as per 1990-91 price level and administratively approved and technically sanctioned vide G.O. for Rs. 82.50 Crores by the Government of Karnataka. The latest estimated cost of the project is Rs. 315.05 Crores at 2005-06 level of prices.

The work on the project started during 1973 as famine relief work. The project will irrigate a Cultivable Command Area (CCA) of 20,234 hectare (ha) through its left and right bank canals in Chittapur and Sedam taluks of Gulbarga District.

The project envisages construction of:

- i) Earthen Dam,
- ii) Ogee Spillway with 7 nos. radial crest gates,
- iii) Two canals on both right and left banks to irrigate a CCA of 20,234 ha with an annual irrigation of 21,854 ha.
- iv) Rehabilitation of 11 villages affected.

The salient features of the project is given in **Annexure-I**. The location map of the project in Karnataka is given at **Plate I** and the index map is at **Plate-2**.

The project was proposed to be completed by March 1999 with NABARD assistance of Rs. 50.00 Crores. Now the project is handed over to KNNL, Bangalore and is programmed to be completed by March 2007.

The allotment of water by the Krishna Water Disputes Tribunal (KWDT) award for the project is 5.75 TMC and the total utilization proposed for the project is 5.74 TMC (162.44 MCM).

Organisational set up for the construction phase:

The Superintending Engineer, KNNL Irrigation Project Construction Circle, Gulbarga under the Chief Engineer, KNNL, Irrigation Project Zone, Gulbarga is looking after the project work with the help of two Divisions, one at Gulbarga (Threes sub-divisions) and another at Hebbal, (three Sub-Divisions).

Estimated Cost:

The original estimate cost of the project was Rs. 8.31 Crores at 1972-73 level of rates. The approved cost of the project by Planning Commission, Government of India is Rs. 72.25 Crore at 1990-91 level of rates. The latest estimated cost of the project is Rs. 315.05 Crores at 2005-06 schedule of Rates and is submitted to Government for sanction. Reasons for the sudden escalation in cost are stated to be due to enhanced charges for land acquisition and other material costs.

An expenditure of Rs. 280.00 croes has been incurred upto end of October 2006. On the basis of estiamted cost of Rs. 315.05 Crores, the cost of balance works as on 1-11-2006 works out to Rs. 35.05 Crores.

The KNNL authority approved AWP of Rs. 78.45 crores for 2006-07 for balance works.

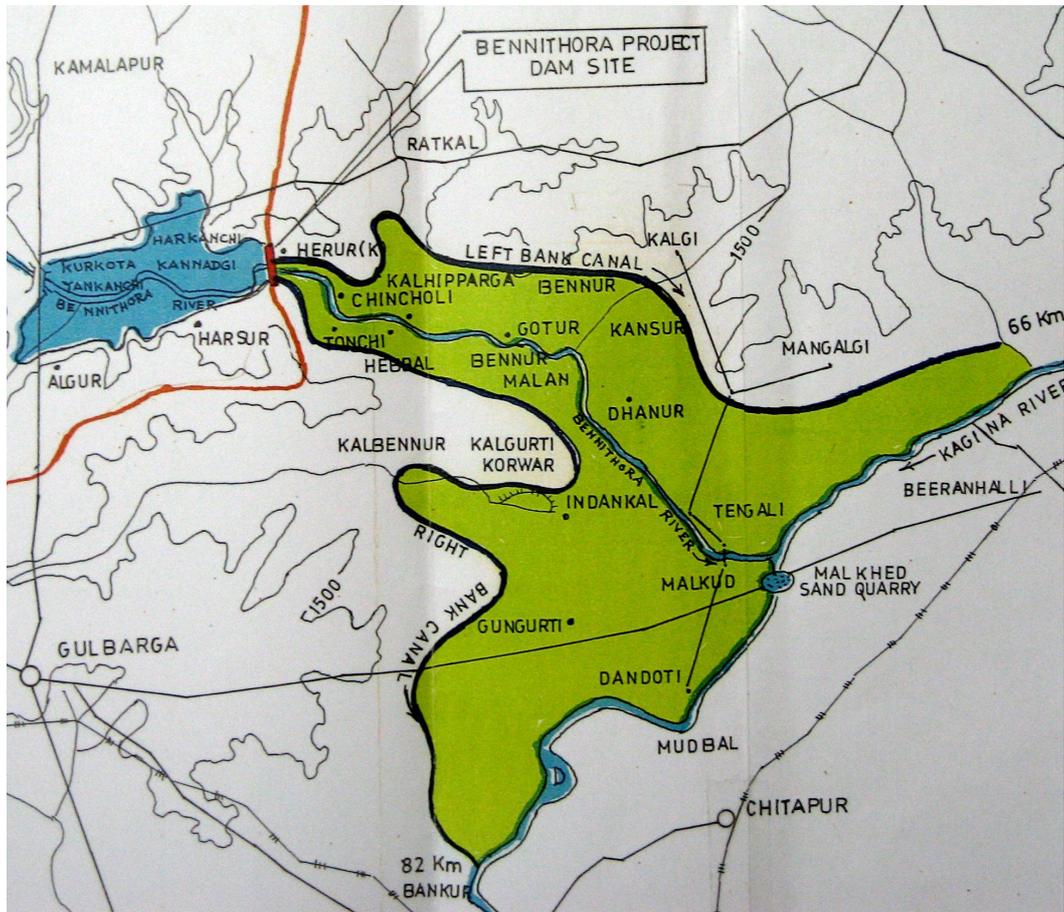


Plate 2. Index map of the Bennithara Irrigation Project

Physical programme and progress of different components of the project:

Dam works: The earthen dam on right and left bank is completed up to TBL i.e. Rs. 441.71M. The concrete spillway including road bridge is completed. The work of radial crest gates is entrusted to M/s Tungabhadra Steel Project, TB Dam. The works of fabrication and erection and fixing rubber seals are completed and water is stored in the Bennithora Dam since 2001.

Right Bank Canal:- The total length of RBC is 82 Km and is completed in all respects.

Left Bank Canal:- The total length of the LBC is 60 Km., and is completed in all respects.

Distributaries:- There are 30 distributaries (earlier 40 Nos, in which one is converted to DPO) under RBC out of which 38 are completed and remaining 01 is in progress. Out of 31 Nos. of distributaries under Left Bank Canal 23 are completed, and 8 are in progress.

Nota: most of the construction works of the canal network were made early 90s, while the dam was only completed in 2003 as a result water has not yet been released to the entire canal system. The first full irrigation season for the entire CA will be Kharif 2007.

Rainfall in the command area

Annual rainfall in the Command Area (CA) is between 1000 and 1500 mm. The general gradient East-West which has a significant effect in the watershed from 1000/

External sources of water

The external sources of water to the CA are mainly from surface streams (small) and

Irrigated agriculture

As per design the gross command area amounts to 24859 ha while the net irrigable area is 20234 ha. It is likely to see that not only the irrigable area will be used for irrigation but a significant part of the GCA plus some land outside the CA along the canal.

Gandorinala irrigation project

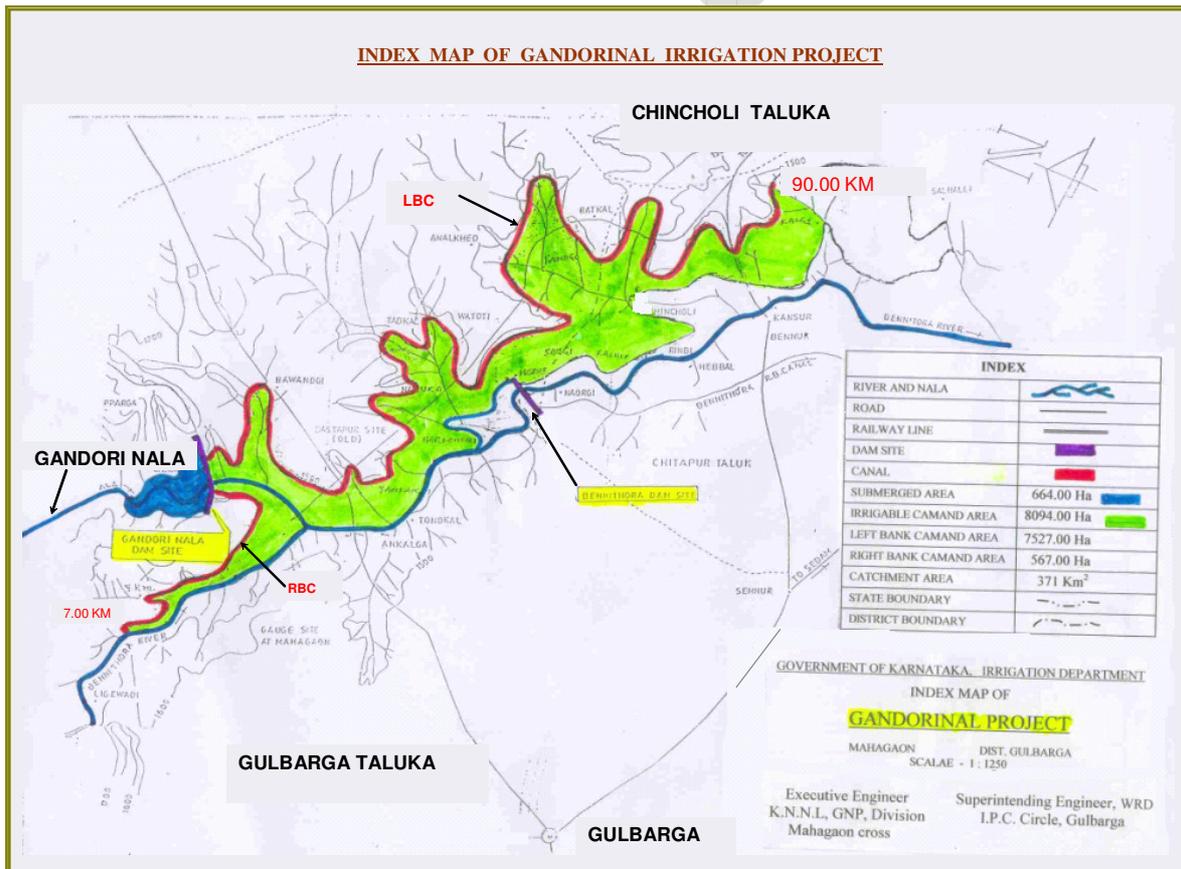


Plate 3 Index map of Gandorinala Project

Project Description

Organisational set up for the construction phase:

Rainfall in the command area

External sources of water

Irrigated agriculture

DRAFT

3. MASSCOTE in Gandorinala and Bennithora Projects

Warning: The MASSCOTE application in these two projects is peculiar in the sense that these two projects have not yet started irrigation. Therefore many steps of MASSCOTE cannot be related to existing practices but have to deal with planned management, current or planned organization set up, and likely changes in the farming systems following the introduction of irrigation. Despite that peculiarity the study shows that MASSCOTE can be meaningful in:

- **recommending key strategies to accompany in the more effective way the introduction of irrigation in these two systems.**
- **organizing the management and operation in an effective way.**
- **plan for M&E to allow quick adjustment with the development of the irrigation.**

Step 1. RAPID DIAGNOSIS: RAP

A RAP (Rapid Appraisal Procedure) was carried out as part of the first step (2.5 days) of the exercise during the December 2006 workshop. The following sections is the RAP executive summary.

RAP Methodology

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

The RAP can be described as follows:

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

Use of a systematic RAP for irrigation projects was introduced in a joint FAO/IPTRID/World Bank publication entitled *Water Reports 19 (FAO) – Modern Water Control and Management Practices in Irrigation – Impact on Performance* (Burt and Styles 1999). That publication

provides an explanation of the RAP approach and gives the results from RAPs the authors conducted at 16 international irrigation projects. Refer to Water Report 19 for further background to the RAP approach, available directly from FAO (<http://www.fao.org/icalog/inter-e.htm>).

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

A key component of the successful application of the RAP and MASSCOTE approaches is the knowledge and experience of qualified technical experts that can make proper design and modernization decisions. It is critical that MASSCOTE-RAPs are conducted by irrigation professionals with an extensive understanding of the issues related to modern water control. This technical capacity building will be addressed initially through training workshops that are going to be held by the FAO. In addition to making proper recommendations for modernization, evaluators using the RAP approach must have the ability to synthesize the technical details of a project with the concepts of water delivery service into a functional design that is easy-to-use and efficient.

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

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

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

Looking at different management levels

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

An important step of MASSCOTE is precisely to start from this diagnosis and re-organize the management of the system into units which are functional, responsible and responsive and consistent with the main features diagnosed in the gross command areas. Again in these

newly constructed projects diagnosis has been made on the Design, the Planned , the Stated by managers and NOT on practices which have not yet started.

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

RAP in Gandorinala and Bennithora

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

Participants were divided into 2 groups:

- Group A: Gandarinala
- Group B: Bennithora

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

External indicators

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

In the case of G&B projects external indicators will be focusing on the initial situation before irrigation starts, mainly looking at the productivity of rainfall water. It will be very useful as baseline information to monitor progressively the impact of the irrigation introduction, and the increase in water productivity.

Internal Performance Indicators

The internal indicators quantitatively assess the internal processes (inputs - resources used and the outputs - services to downstream users) of an irrigation project, in this case the planned

procedures. Internal indicators are related to operational procedures, management and institutional set-up, hardware of the system, water delivery service etc. These indicators are necessary in order to have comprehensive understanding of the processes that influence water delivery service and overall performance of a system. Thus they provide insight into what could or must be done to improve water delivery service and overall performance (the external indicators).

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

Expected features about the Service

Social Order

Social "Order" in the Canal System operated by paid employees	2.3	0.8
Degree to which deliveries are NOT taken when not allowed, or at flow rates greater than allowed	2	1
Noticeable non -existence of unauthorized turnouts from canals.	3	1
Lack of vandalism of structures.	3	0

Table 1. Anticipated Social Order with left Value for Ganda and right for Benni

The high difference between the two systems in terms of social order (table 1) is mostly related to the fact that Gandarinala has been very recently constructed whereas Bennithora has already suffered a lot of degradation since its construction 12 years back.

Service to farmers

Actual (anticipated) Water Delivery Service to Individual Ownership Units (e.g., field or farm)	G	B
	1.4	0.9
Measurement of volumes	0.0	0.0
Flexibility	1.5	1.0
Reliability	1.5	1.0
Apparent equity.	1.5	1.0

Table2. Anticipated Service to farmers

As it is now the anticipated water delivery service to field or farm is expected to be low (1.1) due to expected poor service indicators and absence of measuring devices.

Service to field channels

	G	B
Water Delivery Service at the most downstream point in the system operated by a paid employee	1.6	2.1
Number of fields downstream of this point	0.0	0.0
Measurement of volumes	0.0	2.0
Flexibility	2	2.0
Reliability	2	2.0
Apparent equity.	3	3.0

Table3. Anticipated Service to field channels

Service to field channels is anticipated to be better than at farm level, although there are some doubts about the anticipated/expected service indicators on equity in particular.

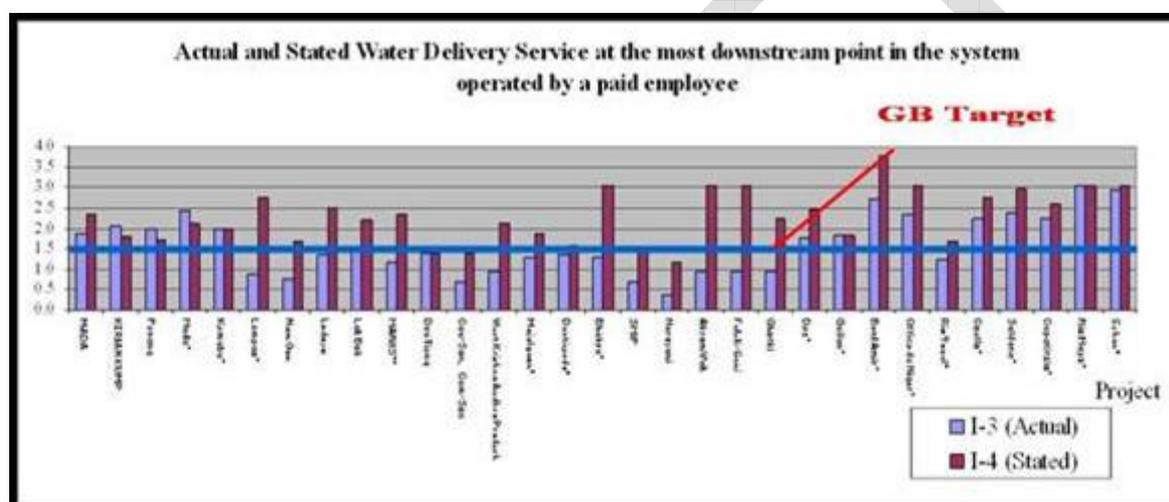


Plate 4. Targeted/Stated Water Delivery at the most downstream point in the system operated by a paid employee in GB compare to actual and stated in world wide systems.

Comparison with the ranking made in several other international systems shows that the target for G&B projects are below average stated value, but above average when it comes to actual. If managers will be able to deliver what they are targeting, then the performance will be fairly good comparing to other systems.

Service by main canal

	G	B
Actual (anticipated) Water Delivery Service by Main Canal to the Second Level Canals	1.6	1.4
Flexibility	0.0	1
Reliability	2	2
Equity	2	2
Control of flow rates to the submain as stated	2.	1

Table4. Anticipated Service from main to secondary canals

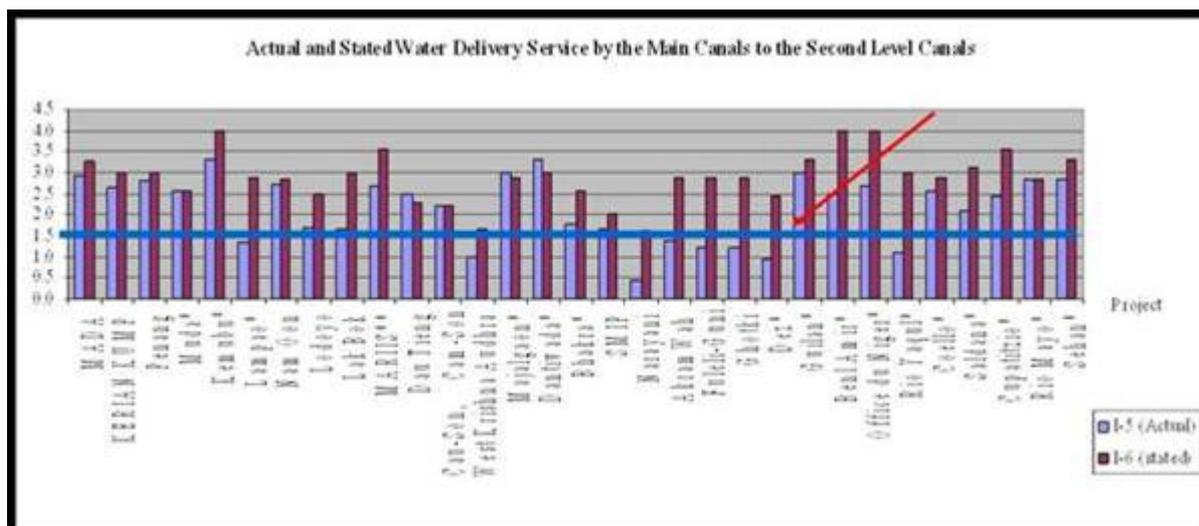


Plate 5. Targeted/Stated Water Delivery Service by the main canal to the Second level canals in GB compare to actual and stated in world wide systems.

General Project Conditions

Main canal

MAIN CANAL G/B	G/B
Cross regulator hardware (Main Canal)	0.8 / 2.6
Travel time of a flow rate change throughout this canal level	1.0/1.0
Turnouts from the Main Canal	2.7 / 2.0
Regulating Reservoirs in the Main Canal	0.0
Communications for the Main Canal	2.3 / 2.5
Existence and frequency of remote monitoring (either automatic or manual) at key spill points, including the end of the canal	0.0
General Conditions for the Main Canal	2.0 /1.4
Operation of the Main Canal	1.5 / 2.7
Clarity and correctness of instructions to operators.	1.3/1.3

Table5. Status of the infrastructure main canal

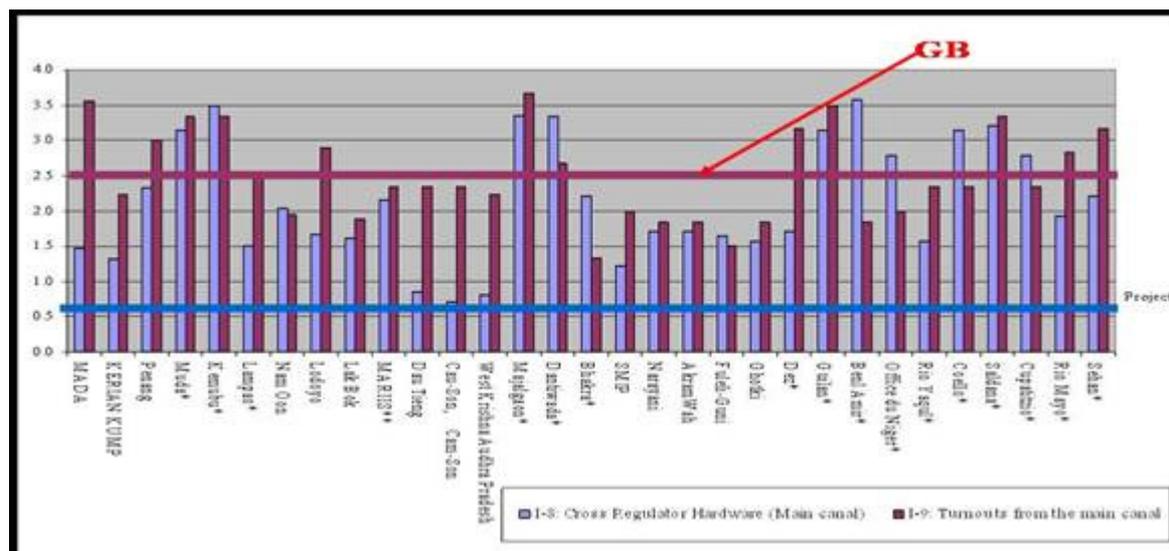


Plate 6. Irrigation structures in GB compare to actual and stated in world wide systems.

Secondary canals

Second Level Canals	
Cross regulator hardware (Second Level Canals)	0/0
Turnouts from the Second Level Canals	3/1.3
Regulating Reservoirs in the Second Level Canals	0/0
Communications for the Second Level Canals	2.3/1.5
Existence and frequency of remote monitoring (either automatic or manual) at key spill points, including the end of the canal	0/0
General Conditions	1.9/1.4
Operation of the Second Level Canals	1.5/1.9

Table6. Status of the Second level canals

Tertiary canals

Third Level Canals	
Cross regulator hardware (Third Level Canals)	0/0
Turnouts from the Third Level Canals	2.5/1.3
Regulating Reservoirs in the Third Level Canals	0/0
Communications for the Third Level Canals	2.2/1.5
General Conditions for the Third Level Canals	1.8/1.4
Operation of the Third Level Canals	1.6/1.6

Table7. Status of the tertiary canals

Employees

Employees	1.2/3.1
training	0/3
Availability of written performance rules	3/3
Power of employees to make decisions	0/3
Ability of the project to dismiss employees with cause.	1/3
Rewards for exemplary service	0/2
Relative salary of an operator compared to a day laborer	3/4
Mobility and Size of Operations Staff: Operation staff mobility and efficiency, based on the ratio of operating staff to the number of turnouts.	0/0

Table8. Status of the employees

INTERNAL INDICATORS

The key findings of the RAP/field survey are:

- A freshly constructed system (Gando)
- A canal of 12 years (Benni) finally put under water
- An agriculture system eager to start irrigating.
- Likely to see major changes in cropping pattern.
- Development of water recycling and conjunctive use more likely needed to cope with expected increasing of water demand
- System partially degraded (weathered)
- Planned service delivery on rotation-seasonal is likely to fail !!
- Lack of water level control and measurement at all levels
- Designed operation procedures need strengthening
- Risk of chaotic and non equitable distribution.

But:

- No major physical constraints
- Good assets, drainage
- No bad habits yet on both side, users and managers !!

MAIN FEATURES FOR GB MANAGEMENT

1. No water level control

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

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



Plate 7. Illustration of the water level control weaknesses: Left farmers have damped material in the main canal to get sufficient head to supply the near by offtake; right an offtake where level of supply is markedly too low.

2. Rapid Degradation of the canal lining



Plate 8 Degradation of the canal lining from freshly constructed (left-Gando) to 12 years old canal (right Benni)



Plate 9. Rapid physical degradation of recently constructed (Gondo)

3. Expansion of irrigated area likely to happen.



Plate 10 Pumping from the Bennithora canal for (left) uphill outside the CA and (right) inside the CA.

4. Likely changes in cropping pattern towards high demanding crops



Plate 11 Dry crop (left) in downstream Benni RBC and Sugarcane in upstream Benni reaches already watered.

Where water has been already flowing as in the Bennithora LBC, the shift towards cash crops has already started – sugarcane has been introduced - and it is expected to see a major shift from dry crops to high water demanding crops.

This shift is likely to create some tension on the water management and inequity in distribution. What is it possible in that regard given the available water resources? The response is not yet certain but only a high efficient management taking advantage of a high recycling is likely to respond to this largely increased demand as compare to the initial estimates of the project.

DRAFT

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.

After thorough discussion among the participants, the following functions were considered as the important ones to be checked for capacity at different level of the GLBC system:

CAPACITY Gandorinala

CAPACITY	
Storage:	No buffer storage, recycling facilities to be looked along streams by construction of small bandharas .
Conveyance :	Sections are sufficient to carry designed discharge, Free board is high 0.75 m. Excavated stuff dumped at the edge of the canal , RISK of slide & obstruction for flow.
Water Level Control	No level control devices, Only 3 CRs Escape along LB
Distribution :	Offtakes are designed to pass the required discharge with minimum head (40 % of main Discharge)
Measurements:	No measurement devices, required to be constructed
Safety:	Not enough escapes
Communication:	Sufficient by mobile phones
Transportation :	Transportation along the canal is difficult, excavated stuff dumped at the edge of the canal

CAPACITY Bennithora

CAPACITY	
Storage:	No buffer storage, recycling facilities to be looked along streams by construction of small bandharas .
Conveyance :	Sections are sufficient to carry designed discharge, Free board is high 0.75 m.
Water Level Control	No active level control devices, 7 CRs for escape along LB - Needs for new CR to be investigated.
Distribution :	Offtakes are designed to pass the required discharge with minimum head (40 % of main Discharge)
Measurements:	No measurement devices, required to be constructed
Safety:	Regular manual escapes provided
Communication:	Sufficient by mobile phones
Transportation :	Except in some reaches transportation is fine .

The critical issue of damped material on canal banks



Plate 12 Canal at high risk: Banks used as a dumping place creating dangers for the canal and obstruction for transportation



Plate 13 Example of a secondary canal completely clogged by fallen material from the bank.

The critical issue of canal seepage

Large sections of lined canals are so degraded that it is anticipated to see a significant losses of water through seepage. As measured by a world bank survey even if the cracked area represents only 1% of the total area then the seepage losses will be about 70 % of what will experienced an unlined canal [Ref].

In Bennithora mainly but also in some early constructed sections in Gandorinala it is anticipated that the cracks between the slabs are important and one should anticipated high water losses by seepage (see figures). This phenomenon should be monitor carefully with appropriate measurements of seepage per sections of canals in order to have a comprehensive strategy to counteract efficiently as managers have already started. Some sections of Bennythora canal have been relined with concrete lining.

Concrete lining is certainly better than slab lining however, it should be recommended to move further and include polyethylene lining which is obviously a longer lasting technique than any others.

SENSITIVITY of the irrigation structures

Offtakes

Offtakes along the main canal are “medium” sensitive, mostly between 1 and 1.5 except in the downstream reaches of the canals where sensitivity increases and even jumps above 2 as shown in Plate 9 below.

An offtake with a sensitivity indicator of 1, will see its discharge varying of 10% whenever the water level in the main canal is changed by 10 cm, respectively the discharge variation will be 20% for a sensitivity of 2 with the same water level change.

There is a High RISK of seeing a significant increase of sensitivity due to reduction of head exercised on the offtake which may result from:

- running the flow below FS level in the main canal (water level control is not ensured so far along the canal)
- construction of measurement devices if the design is such that they tap too much the available head.

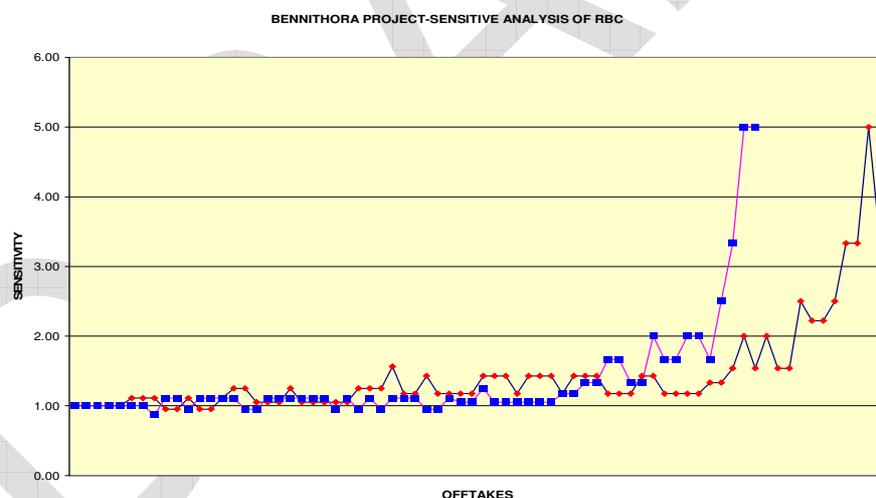


Plate 14 Offtakes sensitivity along the right and left bank canal in Bennithora

Cross-structures

By design the maximum head between upstream and downstream experienced at a cross regulator occurs when the discharge is minimum. In that case we have a controlled water level of (1.2 m) upstream the CR whereas and downstream the height is minimum (0.7 m). The difference is thus $1.2 - 0.7 = 0.5$ meter.

The sensitivity of the Cross Regulator is medium: $S \approx 0.5/0.5 \approx 1$ when we do not consider the submergence effect and $S = 1.4$ when due consideration to the submergence is incorporated.

A change of 5 % of the main canal discharge will be reflected by a change of 7 cm of the water level upstream the CR (respectively 14cm for 10% of discharge variation).



Figure 15. A typical cross structures (seen from downstream) used to close the canal and divert the water through the escape (on the left)

STEP 3: THE PERTURBATIONS

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

For each system the perturbation features are identified below:

Perturbation in G :

Unauthorised pumpsets on the canal

Slippage of excavated muck dumped along the canal sides (observed along the canal)

Runoff from Rainfall during Khariff season

ERRORS in supply/demand

Perturbation in B: Unauthorised lifting of gates;

Runoff from Rainfall during Khariff & Rabi season

Unexpected closure of gates after high rainfall.

As a general effect it is expected that perturbation will increase downward: as the canals are very long, density of structures high, the chances of experiencing perturbations in the downstream part of the canals are quite high.

Step 4 MAPPING WATER NETWORKS & WATER BALANCE/ACCOUNTING

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

NETWORKS

Certainly one of the main features pertaining to the two projects is that they are contiguous and one, Gandorinala, is fully drained into the other (except for the latest parts of the LBC).

This one of the reasons to consider the two projects grouped in one called the GB project. In the following we will consider the GB project (unless specify otherwise).

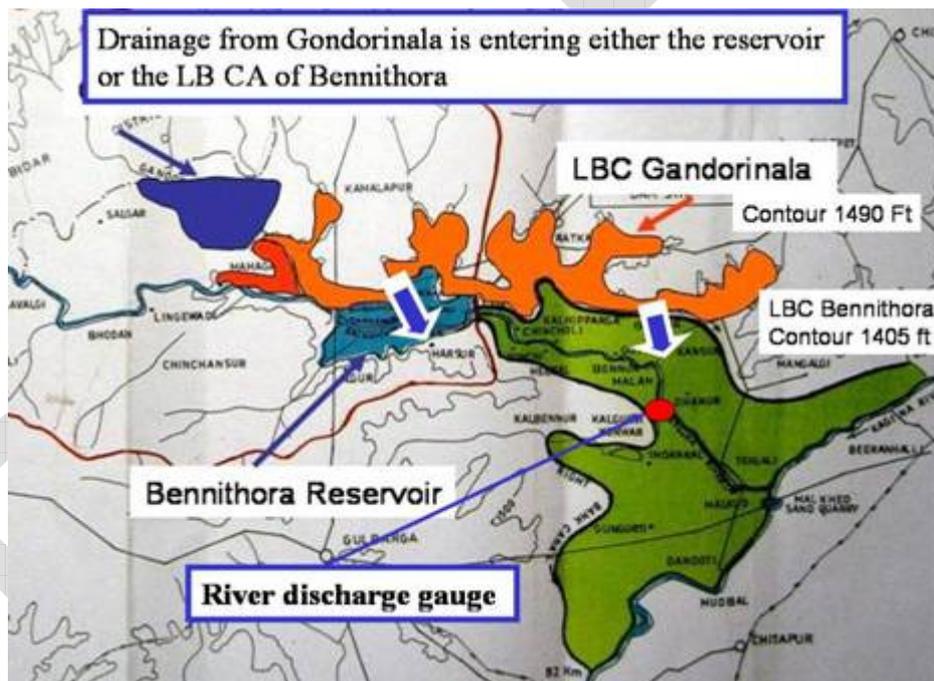


Plate 16 Map showing the drained water from Gondorinala entering the reservoir or the CA of Bennithora.

WATER ACCOUNTING:

Water accounting is a fundamental of irrigation water management as well as operation of the canal infrastructure. It is observed that no water accounting has yet being properly done for the two projects.

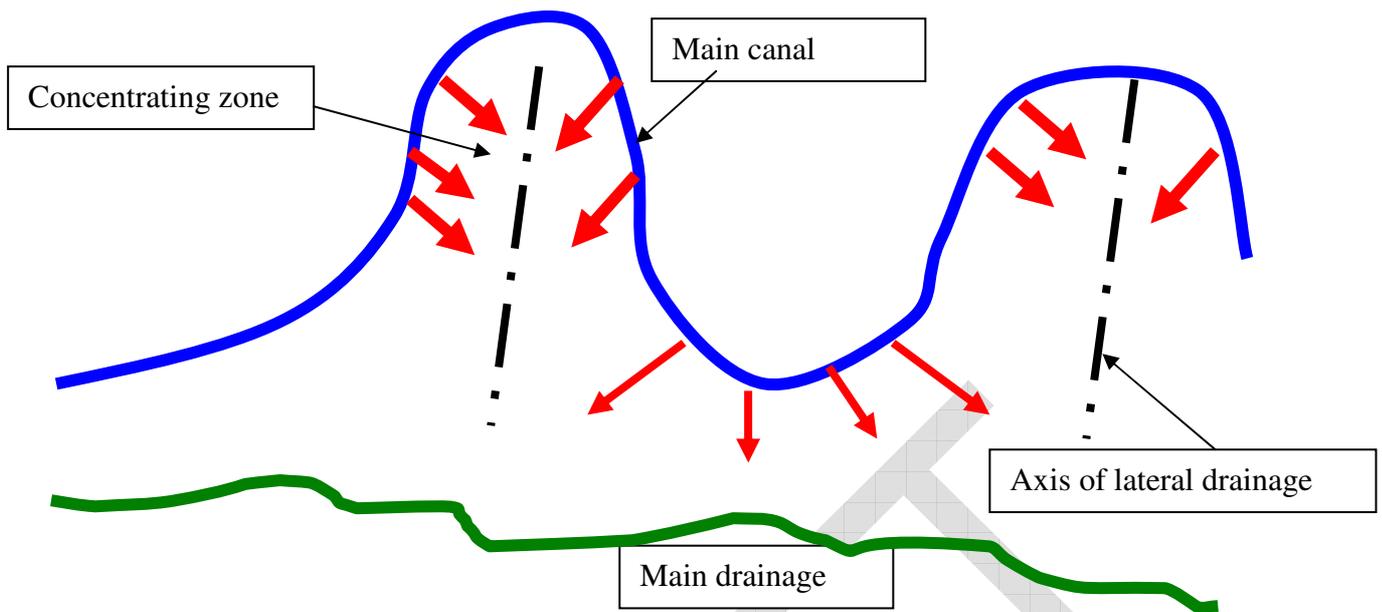


Plate 17 Typical sequence of alternance of concentrating and deflecting zones for the drainage

Physical boundaries of the project:

Drainage network and Measurement:

Spill Measurement:

Monitoring ground water levels :

Cropping Patterns :

SUB-MANAGEMENT UNIT

INFLOWS

RAINFALL

STREAM FLOW FROM OUTSIDE THE COMMAND

CANAL WATER APPLICATION

Ground water



Plate18 Example of canal crossing a valley (aqueduct) which exhibits a shallow groundwater.

Groundwater is not spread out all over but significant presence of small aquifers are present along the main drainage axis as shown in picture above.

OUTFLOWS

EVAPOTRANSPIRATION: anticipating the acreage of the irrigation and the future Cropping Pattern!

The Evapotranspiration is the largest and most important component of water balance. This is estimated as the product of cropped area irrigated and evapotranspiration (Etc) for each crop. Etc is the product of ET_0 which is the reference Evapotranspiration based on climatological data and K_c , the crop coefficient, which is specific to each crop. Thus, the quantity of water consumed as Evapotranspiration from the crops in the command can be worked out.

Here, it is important to correctly anticipate the type of crops that will be grown in the future and the likely acreage covered. It is likely that area and crops grown will go beyond what has been authorized (expansion of the irrigated area and high water demanding crops).

Water balance at the initial stages of the irrigation process is therefore critical to provides all users with correct figures on what should be allowed and what should not because of lack of water.

DRAINAGE FLOWS:

The surplus water after application to the fields and also to some extent the seepage water enters into the drainage in the command area. Also, the storm water during rains both from

outside the command and inside enters the drainage of the system. This is an important component of outflows that need to be measured. The data of drainage flows at key points in the system is necessary to estimate the flows. In a sub-management unit, the flow leaving the unit needs to be measured. The mapping of structures such as Bandharas, barrages and tanks will help the management to know where the surplus flows and seepage water is being recirculated and also to plan new structures for optimum use of water.

The spills which occur at the end of the canal, main canal and secondary canals due to any reason need to be measured. Though, they don't form a component of the outflows as the flows through the drains are already taken. The periodic feedback of spill measurements will help the management both at WUA level and the project level to know what is happening in the system and take appropriate decisions.

Also, the monitoring of quality of water is important which will have a check on agro chemical loads

Water recycling facility

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

Water Balance: a first proxy

A very rough estimate of the water balance for Gandorinala leads to :

Irrigation gross supply 45 MCM
Rainfall gross supply to the CA 58 MCM

Considering irrigation efficiency at 50%, and useful rainfall at 50%, it amounts to a NET input for crops of 52 MCM.

Crop water requirements computed for the official cropping pattern amounts to 43 MCM.

Possible conclusions for Gando:

1. Water availability is more than sufficient to sustain the official pattern (52 vs 43)
2. BUT it is likely that farmers deviate from the official pattern and go for cash crops - water demanding crops, such as sugarcane, bananas as well as increase the cropping intensity.
3. Considering a fraction of the rainfall recharge groundwater, irrigation losses are either recharging groundwater or entering a drainage. THEN another 28 MCM might be recoverable by adequate pumping and recycling which would place the overall availability to about 80 MCM.

4. It should then be possible to increase significantly the cropping intensity (double?).

Bennithora

- The estimated annual quantum of water available is 120 MCum (Excluding Reservoir Losses of 40 MCum)
- Crop water requirement is 45 MCum for Khariff (60%) and 75MCum for Rabi(48%) 120 Mcum.
- The effective rainfall contribution considered is 44 MCum during Khariff and minimal during Rabi (50% useful rain)
- Irrigation efficiency (65 %) conveyance and field => 78 MCum.
- The Qty of water available 122 Mcum is enough to sustain the planned cropping pattern.
- A rough estimate of 12 MCum is made for ground water recharge after irrigation.
- Due to availability of ground water, it is possible to increase the intensity of irrigation by 10% or sustain water demanding cash crops like sugarcane, banana etc.

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.*

Service for Canal Water = by design limited to dry crops BUT risk is high to move towards cash crops and high demand for water!!!

The various uses/users

RABI Service = Options for flexibility for WS to manage their allocated volume in the Dam. Kharif Service = Full supply is planned in Gando, 60% for Benni.

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

- Farmers/crops
- Recharge to groundwater
- Ecosystem (wetlands, rivers)
- Domestic water
- Fishyculture in the reservoir

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

Allocation principle:

- Based on cropped area (not cropping pattern)

- Possible adjustment for areas with low access to groundwater or to recycling facilities (+10%)

Scheduling principle: Gandorinala

- Strict rotational plan on 3 times 3 days per block.
- Possible flexibility PER BLOCK (3 blocks per canal) in scheduling the water for RABI season with the same time frame on discharge adjustment. Bennitora: Water to be let out for entire length with variation in discharge and no rotation (Staggering of base period and supplemented with buffer storage)

Service for Canal Water = Target + Allowed variations in flow rate from targets.

At WUCS outlet: A target of +/- 5% has been proposed by the workshop participants. For the medium sensitive offtakes of the upper reaches, this quality of service can be achieved with a control of water level of +/- 5 cm [$S=1$ then $Tol(H) = 0.05/1$] of the water profile along the main canal. This is a very strict target which can be achieved only with high quality operational procedures.

For high sensitive offtakes as for the downstream reaches of Bennithora the $Tol(H)$ would decrease to about 2 cm which is NOT feasible !!!

In the downstream part of the system one should set the service to +/- 10%.

The Service Oriented Management strategy maps out the VISION underlining the future of the system!

- An economically sustainable and equitable water delivery system which supports growth of agriculture wealth by increasing recycling and conjunctive use.
- Farmers are main users/payers (volumetric) and stakeholders of this development (decision).
- M & E of performance of the main agency is carried out and managers are rewarded accordingly.

Service to farmers

Step 5 MAPPING THE COST of OPERATION

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

Cost of Operation and Maintenance

2.3 Crores (23 Millions Rs) is the budget that has been estimated for the management and operation of the GB project. That does not include the maintenance.

COST ANALYSIS IN %

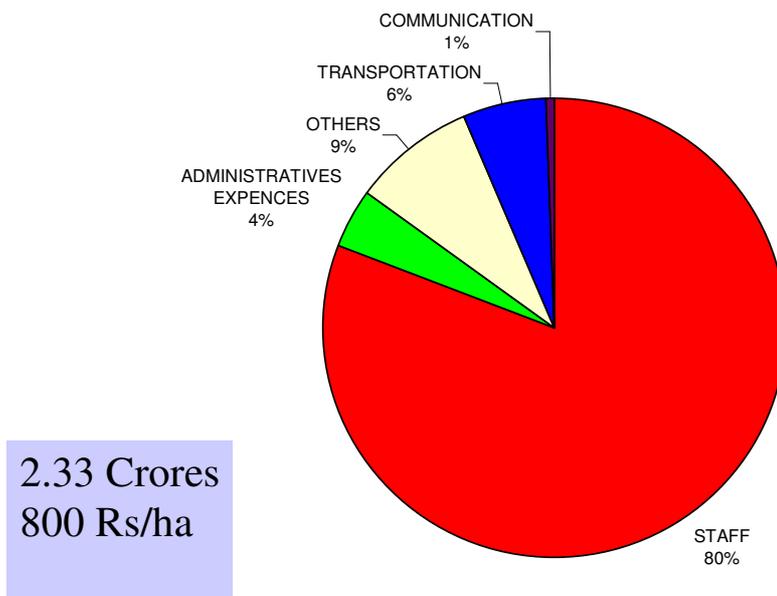


Plate 19 showing the breakdown of the budget for GLBC

Staff

Willingness to pay for good service

Step 7 PARTITIONING IN MANAGEMENT UNITS

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

Management levels

Step 8 MAPPING THE DEMAND FOR CANAL OPERATION

*Objective: Assessing Means, opportunity & demand for Canal Operation
A spatial analysis of the entire command areas, with preliminary identification of Sub-Command Areas (Management, service,..)*

Step 9 CANAL OPERATION IMPROVEMENTS

**Water level control (adding regulators)
Installation of measurement devices
Volume control to deal with inaccuracies, perturbations and to serve properly tail-enders.**

Storage: Sites for Off line buffer storage and recycling facilities to be identified. Conveyance: Excavated stuff dumped at the edge of the canal to be removed rapidly. Water Level Control Existing CR and new water level control structures to be investigated.

Measurements: Measurement devices to be constructed at each outlet to WCS.

Safety: Not enough escapes

Transportation: Transportation along the canal is difficult, excavated stuff dumped at the edge of the canal

- **Manual SCADA [Supervisory Control and Data Acquisition]**
- **Safety: Not enough escapes**

Adapting existing CR as Mixed Regulator with the construction of a Weir to control the water level.

Advantage: no need to have a permanent operator



Plate 20 Examples of long crest weirs installed at CR to control water level without the need of permanent staff (Left Gondo Right Benni).

DRAFT

Step 10 AGGREGATING AND CONSOLIDATING MANAGEMENT

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

This step not needed

Only one main unit of management and 3 separate branches.

Step 11 PLAN FOR MODERNIZATION

Irrigation is about to start in the CAs.

Practices have not yet been established

Parameters of efficiency not calibrated

Water networks and Water balance likely to be highly changed by irrigation

Ideas for modern management from Masscote needs to be further confronted to practices

High need to build up the information and knowledge on issues, constraints and opportunities

BEFORE proposing a relevant PLAN.

Short term interventions 2007:

Physical:

Gauging for temporary measurement at selected points along the main canal.

Installation of flumes at Outlets.

Careful Monitoring of the irrigation campaigns:

Canal Operation practices inputs and outputs

Parameters of efficiency

Water networks and Water balance

Identifications:

Opportunities of conjunctive use and recycling, of buffer storage

Survey the today users demand and estimate their future

This monitoring/investigation required the intervention of a special team well equipped and not busy with operation and management problems.

Early 2008:

Design and Elaboration with users of an updated Service Oriented Management strategy and operation plan for GB.

Design the physical intervention required

Annexure-I/I**BENNITHORA IRRIGATION PROJECT.****SALIENT FEATURES**

- I. General
- | | |
|--------------------|---|
| 1. Name of project | :: Bennithora Irrigation Project. |
| 2. Name of River | :: Bennithora River. |
| 3. Location | :: Across Bennithora River near Herur, Khurj Village, Chittapur Taluka, Gulbarga District.
(a) Latitude 17 ⁰ -27'
(b) Longitude 77 ⁰ -01' |
| 4. Purpose | :: Irrigation |
| 5. Means of access | :: Site is 38.40 Km (24 miles) from Gulbarga on Gulbarga – Chincholi Road upto Watwati and thereby approach road of 3 Km. |
- II. Geophysical Features:
- | | |
|--|--|
| 1. Catchment area | |
| (a) Karnataka | :: 1266.51 Sq. km (489 Sq. miles). |
| (b) In Maharashtra | :: 937.58 Sq.Km (362 Sq. miles). |
| Total | :: 2204.09 Sq. Km. (851 sq. miles). |
| 2. Nature of catchment | :: Upper reaches consist of hilly terrain with forest growth and the lower reach is moderately flat catchment. |
| 3. Climate | :: Moderate and tending to be hot. |
| 4. Temperature condition | :: Minimum - 10 ⁰ C
Maximum - 45 ⁰ C |
| 5. Mean annual precipitation weighted rainfall | :: 62.92 Cm (24.77 inches). |
| 6. 75% dependable yield at the dam site. | :: 172.45 M. Cum (6090.93 Mcft). |
- III Technical Details:
- A. Reservoir:
- | | |
|---------------------------------------|----------------------------------|
| 1. Gross storage capacity | :: 149.98 M.cum (5296.75 Mcft.) |
| 2. Dead storage capacity | :: 9.28 M.Cum (327.77 Mcft) |
| 3. Live storage capacity | :: 140.70 M.cum (4968.98 Mcft). |
| 4. Lower River Bed level | :: 418.00 M.cum(1371.37 ft) |
| 5. Dead storage level | :: 428.22 M (1404.90 ft) |
| 6. Full supply level (FRL) | :: 438.89 M (1439.91 ft) |
| 7. Maximum Water level | :: 440.56 M (1445.39 ft) |
| 8. T.B.L. | :: 441.71 M(1449.16 ft) |
| 9. Deck slab level (Spillway portion) | :: 443.10 M(1453.72 ft). |

10. Maximum length of water spread	:	17.6 Km (11 miles).
	:	
11. Maximum width of water spread	:	9.00 Km (5.6 miles).
	:	
B. Utilisation:		
1. For irrigation	:	120.10 M Cum (4242 Mcft).
	:	
2. Reservoir losses	:	41.00 M.Cum (1448 Mcft)
	:	
3. Drinking water allocation	:	1.35 M.Cum (48 Mcft).
	:	
4. Total utilisation	:	162.45 M.cum (5738 Mcft).
	:	
IV Storage:-		
1. Type of dam	:	Central concrete spillway with earthen dam on flanks of zonal type on either side.
2. Length of the dam spillway portion	:	133.00 (436.35 ft).
	:	
3. Earthen dam left flank and right flank	:	2207.00 M(7240.73 ft)
	:	
4. Maximum height of dam above lowest foundation level of spillway	:	31.39 M (102.98 ft).
	:	
5. Maximum height of dam above deepest nala bed level	:	23.71 M (77.77 ft)
	:	
6. Top maximum width of dam foundation level overflow section	:	33.621 M (110.30 ft)
	:	
7. Top width of earthen dam	:	
(a) Top width of earthen dam	:	4 M (13.12 ft).
	:	
(b) Top width of spillway portion	:	8M (16.25 ft).
	:	
8. Type of spillway	:	Ogee shape with 150 grade concrete with 1 M thick cover and M-100 grade.
	:	
9. Foundation treatment	:	Consolidation grouting.
	:	
10. Deepest foundation level	:	410.60m (1347.10 ft)
	:	
11. Crest level of spillway	:	427.39 M (1402.18 ft)
	:	
12. Probable max. flood discharge	:	12.160 Cumecs (4,30,000 cusecs).
	:	
13. Overhall length of spillway	:	133 M (436.35 ft).
	:	
14. Discharging length of spillway	:	105M (344.48 ft).
	:	
15. Drainage gallery	:	1.6 x 4.20 M (5.25 ft x 13.78 ft).
	:	
16. Max. flood lift	:	11.5M (37.73 ft).
	:	

- 17. Max. discharging capacity : 3,10,800 cusecs of routed discharge for a
: PMF of 4.30 lakh cusecs when six vents
are open.
- 18. Energy dissipating arrangement : Horizontal type sliding basin with chute
: blocks, baffle blocks and sills.
- V. Bridge over spillway :
:
:
1. Type of bridge : RCC
:
2. Clear span between piers : 15 M (49.21 ft).
:
3. No. of spans : 7 Nos.
:
4. No. of pier : 6 Nos.
:
5. Width of pier : 3.5 M (11.48 ft).
:
6. Spillway profile : W.E.S. Profile.
:
7. Crest gates : Radial gates 15M x 11.5 M
: (49.12 ft x 37.73 ft).

VI Details of submergence:

- 1. Area of submergence at FRL : 3054 ha (7546 acres).
:
2. Area of submergence for which
land compensation is to be paid : 2359 ha (5829 acres).
:
3. Villages submerged : Four villages fully submerged and five
: villages partly submerged.
- 4. Houses affected : 1911
:
5. Population affected : 10776
:
:
10. Deepest foundation level

Salient features of the canals:

	Details	Left Bank Canal	Right Bank Canal.
A.	Irrigation sluice vent	One vent of 2m x 1.40m (6.56 ft x 4.59 ft).	2 vents of 2m x 1.40m (6.56 ft x 4.59 ft).
	1. Sill level of the sluice	428.22 M (1404.90 ft)	428.22M (1404.90 ft)
	2. Length of main canal	66 Km (41.25 M)	82 Km (51.25M).
	3. Capacity at head	3.45 cumecs (121.84 Cusecs)	6.197 cumecs(218.76 Cusecs).
	4. Bed width at head	2.44M (8.01 ft)	5.19 M(17.03 ft).
	5. Full supply depth at head	1.234 M (4.05 ft)	1.22 M (4.00 ft).
	6. Bed slope	1 in 5000	1 in 5000
	7. Side slope (Cutting)	1½ :1	1½ :1
	8. Side slope (banking)	2:1	2:1
	9. Value of 'N' for lined canals	0.018	0.018

10. Velocity head	0.663 m/s	0.724 m/s
11. Irrigable area	6799 ha (16,800 acres)	13435 ha(33,200 acres)
12. Gross command	9712 ha (24,000 acres)	15147 ha(37,130 acres)
B Details of corrupting pattern and cropped area under this project is as following.		
Kharriff		
1. Tur	2428 Ha	6000 acres.
2. Pulses	6880 ha	17000 acres.
3. Groundnut	1619 ha	4000 acres.
4. Maize	405 ha.	1000 acres.
5. Ly. Jowar	809 ha	2000 acres.
Total	12,141 ha	30,000 acres.
Rabi		
1. Groundnut	1012 ha	2500 acres.
2. Sunflower	7892 ha	19500 acres.
3. Bengal gram	809 ha	2000 acres.
Total	9713 ha	24000 acres
Grand Total	21,854 ha.	54000 acres.
Financial forecasts		
1. Cost of the Project	::	Rs. 315.05 Crores.
2. Cost per acre irrigated	::	Rs. 63011
3. Allocation as per KWDT award	::	5.75 TMC
4. Utilisation	::	5.75 TMC

Annexure-II**SALIENT FEATURES OF GANDORINALA IRRIGATION PROJECT****GENERAL :**

- | | | | |
|----|---------------------|---|---|
| 1. | Name of the Project | : | Gandorinala Project |
| 2. | Name of the River | : | Gandorinala |
| 3. | Location of Dam | : | Near Belkota about 8 Km. from Mahagaon Cross Gulbarga Dist. |
| | Latitude | : | 17° 35' N |
| | Longitude | : | 76° 56' E |
| 4. | Purpose | : | Irrigation |
| 5. | Mean of access | : | Dam site is approachable from Mahagaon |

GEOLOGICAL FEATURES :

- | | | | |
|----|---------------------------|---|---|
| 1. | Catchment area | : | Total catchment area is 371.00 sq. Kms of which intercepted catchment area is 1530 sq.km. |
| 2. | Nature of Catchment | : | The catchment is partially hilly and partially plain is considered as good catchment. |
| 3. | Climate | : | Moderate tending to hot |
| 4. | Mean and Annual rainfall | : | 777.20 mm |
| 5. | Average yield at dam site | : | About 55.87 M.Cm |
| 6. | Silt charge per year | : | 0.043 M Cum /year |
| 7. | Geological features | : | Hard trap with stones of vesicular trap |

TECHNICAL DETAILS :**Reservoir**

- | | | | |
|----|-------------------------|---|-------------|
| 1. | Gross storage capacity | : | 53.45 Cum |
| 2. | Dead storage capacity | : | 4.18 M. Cum |
| 3. | Live Storage Capacity | : | 49.45 M.Cum |
| 4. | Average River Bed Level | : | RL 451.00 |
| 5. | Lowest Foundation Level | : | Rs. 445.00 |
| 6. | Dead Storage Level | : | RL 454.13 |
| 7. | Full Reservoir Level | : | RL 467.00 |
| 8. | Maximum Reservoir Level | : | RL 467.00 |
| 9. | Top of Dam | : | RL 470.00 |

Non Overflow Section :

- | | | |
|------------------|---|---|
| Upstream side | : | Vertical from 458.00 to 459.50 and 1:10 from 459.50 to 461.00 |
| Down stream side | : | WES Profile x 1.78 = 7.492 Y |

Types of Dam : Composite Dam :

1. Earthen Embankment on left Flank at : Ch. 0 to 1270 Mtr.
 2. Concrete Dam on Right Flank at : Ch. 1270 to 1370.00 mtr.
- Foundation :
- Treatment : Curtain grouting with cement in key trench and consolidation grouting in spillway portion

Design Flood

Intensity : 2223 Cumecs or 78500 cusecs

Length of spillway

Dam : 100m

Discharge length of : 93.50m

Spillway

Maximum flood lift : 6m

Maximum discharges : 2223 cumecs or 78500 cusecs

Capacity through the spillway

Energy dissipation : Bucket type stilling of basin 30mtr. Width

Spillway crest : WES Profile

Crest Gates : Radial Gates of 8 Nos. of 9.5m x 6m

IRRIGATION SLUICE:

1. Left flank : 2 Nos. of 1.60x1.40m
2. Right flank : 1 No. of 1.00 x 1.00

DESIGN ASSUMPTIONS :

- Weight of M10 – grade
1. Concrete 2400 Kg/cm³
 2. Uplift pressure : 100% at heel & Tail water depth at the toe
- Details of submergence : 664 hectares

PRIVATE HOLDINGS

Dry lands : 664 hectares

Gardens : --

Waste : --

House affected : 746

Population affected : 1824

CANALS :

1. **Right Bank Flow Canal** :
 - i. Length : 7.00 Km.

- ii. Capacity at head : 0.505 cumecs
- iii. F.S.D. : 0.60 mtr.
- iv. Bed Fall : 1 In 3000
- v. Bed width : 1.00 Mtr.
- vi. Side slope : 1.5:1
- vii. Value of N manning's formulae : 0.018

2. Left Bank Flow Canal

- i. Length : 94 Km.
- ii. Capacity at head : 4.72 cumecs
- iii. F.S.D. : 1.30 mtr.
- iv. Bed fall : 1 in 5000
- v. Bed width : 3.40 mtr.
- vi. Side slope : 1.5:1
- vii. Value of N Manning's formulae : 0.018

3. Irrigation Details

- i. Cultivable command area : 8094 hectares

	Left Bank	Right Bank
Flow Canal	7527 Hectares	567 hectares

Crop pattern :

- Kharrif dry 100% : 8094 hectares
- Rabi dry 39% : 3561 hectares

Abstract :

- 1. Ayacut : 8094 hectares
- 2. utilisation : 1970.99 M.Cft.
- 3. Cost of project (Revised) : Rs. 13295.00 Lakhs
- 4. cost per acre : Rs. 66,475.00