ROLE OF CANAL AUTOMATION AND FARMER'S PARTICIPATION IN MANAGING WATER SCARCITY: A CASE STUDY FROM ORISSA, INDIA

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ABSTRACT

The Derjang irrigation project, initially planned and constructed to command 6000 ha, experienced serious shortage and inequity in water distribution (between 1967 to 1993). Distress of the system resulting from unauthorized tampering by the beneficiaries, to a large extent, led to significant deficiency in water conveyance. A complete rehabilitation of the distribution system with structured zones below which distribution is unregulated, and formation of Water Users associations (WUAs) has resulted in increased crop production and farm income. The hydrological data from 1967 to 1980 indicated an additional yield of 1000 ha-m annually which led to creation of increased live storage by installation of gates on open crested spillway. This has led to a Stage II extension for creating an additional potential of 1800 ha. With a healthy system and WUAs functional, it has been possible to irrigate an additional 1400 ha in 1998. But a major concern continues to be the abstraction of 10 to 15% over the authorized withdrawal, where mechanically operated shutters are provided. To obviate such a contingency, canal automation in a pilot scheme for the entire command is being formulated and will be implemented in a 2-year time frame. This scheme would be a training ground for 250,000 ha of command area being rehabilitated in Orissa through a World Bank assisted Water Resources Consolidation Project (WRCP). Preliminary assessment shows that a good system with automation and farmers participation can irrigate an additional command area of 10% with minimal investment.

INTRODUCTION

The Derjang irrigation project, in the State of Orissa, was constructed in 1967 to provide irrigation water to a drought prone command area of 6600 ha in which monsoon crops are grown over an area of 5951 ha. A reservoir, formed by an

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earthen dam, was built across the river Ningra, intercepting a drainage area of 399 sq km, and has a live storage capacity of 4640 ha-m.

The average monsoon rainfall over the basin is 1000 mm, but varies in a range of 700 to 1400 mm with considerable erraticity in the months of July, September and October (Table 1).

Table 1. Typical distribution of rainfall

Month	Rainfall Variability, mm		Average Rainfall, mm	Useful Rainfall, mm
	minimum	maximum		
June	100	250	130	30-100
July	200	400	300	100-300
August	250	400	350	120-300
September	75	250	150	50-130
October	50	150	70	0-50

As the predominant crop grown in the monsoon is rice (long duration), which needs at least 150 mm of effective rainfall in July for transplantation and 150 mm in September and October for flowering and maturity, scarcity is invariably experienced in drought years (total monsoon rainfall less than 800 mm) which have a recurrence interval of 1 in 3 years. The problem of equitable distribution of water particularly to meet the crop water need in the tail area (30 % of the command area) gets affected with the head of the command area (70%) utilizing 90 to 95% of the available water. Identification and delineation of the most needy areas in the command is not addressed by any well-defined mechanism. Consequently the water requirement for the crops at different stages of crop growth in the command, in space and time, is neither realistically assessed nor effectively met. The cropping pattern at the project design stage was based on the soil characteristics (Table 2).

The scarcity has become obvious due to the increased coverage of heavy duty crops (rice) in both cropping seasons of Kharif and Rabi. It is pertinent to mention that due to occurrence of two to three cyclonic storms per year (with a precipitation of 200 to 250 mm in a 3 day period), non-rice crops even on highlands suffer from impeded drainage and consequently provide poor remunerative yield leading to diversification to rice.

Table 2. Cropping Pattern at Project Formulation Stage

Cropping Period: Kharif (June to October)		
Rice Groundnut Sugarcane Others	64% 13% 3% 18%	Out of a total of 31%, almost 25% is currently covered with medium and long duration rice
Cropping Period: Rabi (November-May)		
Pulses Rice Others	18% 5% 5%	Rice coverage has gone up to 25% to 30% and overall Rabi coverage is 40%

WATER DISTRIBUTION NETWORK

A 13.2 km long main canal (Angul main canal) with a design capacity of 6.8 m^3/s at the head feeds the command area principally through five laterals (total withdrawal of 4 m^3/s) and a branch canal (Balaram Prasad branch) at the tail that draws 2.02 m^3/s (Figure 1). This tail branch feeds a major lateral canal, the Barasinga distributary which draws 0.72 m^3/s from the branch canal.

The project also provides drinking water supply to the district headquarters town of Angul (population 1,00,000) and for industries by allocating 500 ha-m of the live storage for these purposes.

The undulating command area has good slope of 1 in 1000 for 70 % of the area, but is flat (1 in 4000) for 15 to 20% of the command where rice is necessarily grown in the Kharif and Rabi seasons. The soils are of silty clay type and have an infiltration capacity of 20 to 40 mm per day. The overall assessment of supplementation by irrigation for the entire command area based upon consumptive use study is 600 mm for the principal cropping season, June to October. Depending upon the quantity of surplus water available at the end of the monsoon (31 October), the cropping pattern and coverage for the Rabi crops (November to May) are decided.

MANAGEMENT PROBLEMS EXPERIENCED

Starting in 1967 when the system became operational, inequity in distribution became evident because of the following factors:

(a) Actual seepage loss over the 13.2 km long main canal and 76 km of medium and minor channels was 20 to 50% more than the assumed value of 2 m^3/s for one million sq km of wetted area. The overall conveyance efficiency was in the range of 60-65% (not exceeding 70% for well maintained channels) against the value of 75% assumed in the design.

(b) The design assumption for conveyance capacity for main/laterals was somewhat deficient. The channel could not carry more than 90 to 95% of their capacity under design conditions.

(c) Normally canal capacities were decided for the worst meteorological conditions to meet full crop water need. This necessarily meant that conveyance capacity was actually in excess in good years but needed careful regulation in average/bad years so that the release from the reservoir in any 10 day spell (normally releases are decided based on 1-day rainfall data) does not exceed the overall crop demand for the entire command.

(d) At the design stage, the laterals were planned to draw their authorized discharge when the parent channel is running at half supply (40 to 70 % of design capacity) when there is overall reduced crop water need. The individual outlets for laterals were therefore so positioned that they draw full supply when the parent channel is conveying partial discharge. With the regulating shutters operated manually becoming worn (sometimes non-functional), over-withdrawal occurred in all the off-taking channels in the head and middle reaches.

(e) An appropriate water management technique for varying crops over the command has neither been formulated nor practiced effectively. Consequently, undependable and inequitable distribution resulted in over-withdrawal in the head reach (over 40% of the command) and the middle and tail reaches getting as low as 50% of the authorized discharge intermittently, particularly during drought spells. Over-withdrawal in the head reach resulted in breaches, overtopping and damage to structures (outflanking), whereas the short supply down below made the farmers obstruct flow, cut canal banks, and operate and damage the structures in the tail reach in particular. The system, in summary, went into distress progressively and the conveyance capability of the system was significantly reduced.

(f) By 1985, within two decades, the project was incapable to irrigate even 5000 ha. Consequently, over the entire command, the productivity was skewed and the overall production/farm income was considerably lower than envisaged.

INTERVENTION CALLED FOR

Immediate need was felt for (a) rehabilitation of the system, (b) adoption of an appropriate cropping system with farmer's participation, and (c) flexible, but firm water management practice linked with crop water demand from hydro-meteorological considerations.

The OWRCP, financed by the World Bank (apprised and negotiated between 1992 to 1995 with a credit of $291 million) that followed the Bank-assisted National Water Management Project (NWMP) in India, addressed the issues comprehensively by including Derjang project for rehabilitation and improved water management and agricultural practices. Almost $1 million (forty million Rupees) has been spent on the System Improvement and Farmers Turnover (SIFT) activities for this project between 1993 through 1999.

DERJANG STAGE II PROJECT: EXPANSION OF THE COMMAND AREA

Interestingly, prior to formulating the NWMP proposal, it was revealed that the actual water yield of the basin based on reservoir operation studies (1965-1980) was higher by 15% over the design figure (1958). With increased availability of 1000 ha-m during the monsoon, two crucial decisions were taken: i) to install radial gates on the open crest of the spillway to store 1200 ha-m, augmenting the live storage to a total 4640 ha-m. This work was completed by 1984, and ii) the rehabilitation of the main canal in 1993-94 period indicated increased availability of water to the tail area, which dictated that the command area of 6000 ha can be extended in the tail by 1800 ha. In conjunction with the World Bank-assisted WRCP, the National Bank for Agricultural and Rural Development of India (NABARD) financed the extension project ($0.75 million or Rs 30 million) between 1996 through 1998.

STRATEGY AND ACTION PLAN FOR INTEGRATED DEVELOPMENT

System improvement under NWMP and WRCP enabled (a) restoration of the conveyance capacity of the entire network by desilting, raising of low banks, rehabilitation of damaged structures (1993-1995) which resulted in increased withdrawal of 50 to 60% in the laterals particularly in the lower reaches (Table 3), and (b) as experienced in two bad drought years of 1996 and 1998, the conveyance efficiency was close to 75% over the entire command, including the Stage II command area, where 1400 ha was the additional coverage in Kharif (June-October, 1996). The highest discharge drawn from the reservoir in September-October (1998) was 8 m^3/s for the overall covered area of 7400 ha (against the previous maximum of 4.8 m^3/s and 4500 ha up to 1993).

Table 3. Gain in Discharge and Area after Rehabilitation

Name of Lateral	Discharge, m^3/s			Command Area, Ha		
	Original Design	Pre-Rehab	Post-Rehab	Original Design	Pre-Rehab	Post-Rehab
Raniguda Dstributary @ head	0.64	0.38	0.60	548	366	530
Raniguda Distributary @ middle	0.34	0.21	0.30	310	219	300
Nuapada Distributary	0.51	0.30	0.50	431	258	400
Khalari Distributary @ head	0.84	0.55	0.80	631	425	600
Khalari Distributary @ middle	0.38	0.23	0.35	338	216	310
Balaram Prasad Branch	2.02	1.21	*3.50*	1847	1160	*3500*
Barasingha Distributary	0.72	0.41	*2.30*	695	404	*2400*
Angul Main Canal	6.80	4.80	*8.80*	5950	4500	*7500*

(Italic numbers–by resectioning and lining to feed Stage II area of 1800 ha)

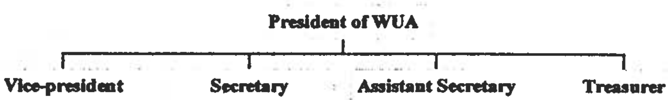
PARTICIPATORY IRRIGATION MANAGEMENT

With uncertainty and undependability of flow in the network, and low reservoir levels in drought years, it was obvious that farmers participation in the system management was crucial to conservation and optimal utilization in general and during droughts in particular. The key to participatory approach was to share the surplus and shortage over the entire command rather than over an individual channel. This necessarily meant that operation and management of minor channels over relatively small areas (say 300 to 400 Ha) involving farmers was an essential pre-requisite, by formation of Water Users Associations (WUAs). Again the key issue was to ensure availability and equitable distribution of water by relatively simple, robust and unregulated operation of all minor channels over the entire command area. In essence the Bank assisted NWMP and WRCP stipulated the re-organization of the distribution network into ***structured zones*** each serving up to a maximum of 2000 ha, below which all the off-taking channels will have no regulating shutters. At the head of the structured zone, the design flow would be maintained for a 3 day/7 day/10 day spell depending upon the crop need, with the entire zone receiving ON and OFF irrigation. Each turnout will be so designed and constructed that during the ON period, the farm area served will receive its authorized discharge and volume. The parent channels (main canal and major distributaries) will have regulators to supply the allocated quantity to the structured zones. Such dispensation would obviate the inequity significantly.

A necessary adjunct to this proposition was the formulation and operation of Water User's Associations that would fully operate and distribute water, do routine maintenance, leaving the operation and maintenance of main channels up to the structured zones to the Water Resources Department. With success stories of WUAs in developing and developed countries (Philippines, Mexico, Turkey, Italy, Japan and the USA), it was decided to cover the Stage I command area of 5951 ha. Annex I and II describe the philosophy of Participatory Irrigation Management (PIM) concept, and the structure of WUAs in Derjang Project. Four more WUAS have also been formed informally for the Stage II command since 1998. The WUAs were actively involved during system rehabilitation and decided that intervention was needed primarily for better water management by modifications from regulated conditions to unregulated turnouts at suitable locations and of suitable size.

An Apex Committee regulated a few (6 to 8) WUAs by periodic review meetings with Water Resources and Agriculture Departments officials. A typical setup is shown below.

APEX COMMITTEE



To promote and accelerate formation of WUAs (between August 1996 to January 1997) a Non-Governmental Organization (NGO), the Youth Service Center of Angul, was selected. The NGO deployed Social Organizers in the locality for motivation of farmers. The NGO selected was earlier involved for four years in the locality to implement literacy and health programs. The benefit that accrued from system rehabilitation and constitution of WUAs can be typically described for WUA No.7 with a command area of 473 ha.

(i) *Benefit in Kharif Cropping Season*

Shorter duration rice was slowly adopted (June 15 to October 15th) to replace long and medium duration rice (June 15th to November 15th). Water shortage due to uncertain monsoon was not to affect the crop yield. Long duration (400 ha) and medium duration (53 ha) was replaced by short duration (200 ha) and medium duration (100 ha) and long duration (150 ha). Fertilizer input increased from 20 kg/ha to 35 kg/ha (1997), which along with better water availability resulted in almost 40% increase in crop yield from 880 metric tons to 1150 metric tons from the pre-rehabilitation to the post-rehabilitation stage with WUAs.

(ii) *Canal Automation*

The decision to extend the system at the tail-end was taken in 1994 primarily because the entire distribution network was rehabilitated under World Bank assisted NWMP (1993 to 1995) and WRCP (1995 to 1999), which inter-alia provided for constitution of Water Users Associations (WUAs) over the original command area of 5951 ha. As of 1999, thirteen (13) WUAs have been constituted and are functioning satisfactorily. There has been improvement in the farm yield and farm income in this project area.

With cross-regulators and head regulators having regulated gates feeding structured zones, abstraction from the parent canal was higher (10 to 30%) in the head reach. For example, the main canal of 13.2 km feeds the initial 3800 ha until branching out to Balaram Prasad Branch which is now required to command an area of 3700 ha including the Stage II. With a drought situation that prevailed in 1998, the main canal was drawing a maximum of 8 m^3/s for the overall command of 7400 ha as against the design capacity of 8.8 m^3/s. The head- reach with a command area of 3800 ha consumed 4.7 m^3/s leaving only 3.3 m^3/s for the tail 3600 ha (actually irrigated). It was estimated that the seepage loss in the head command was 0.85 m^3/s, and 0.6 m^3/s in the tail. Thus the overall duty at the head of field application was 987 ha per 1 m^3/s and 1270 ha per m^3/s for the head and tail command areas, respectively. Because the tail area was more compact (with 50% less channels than the head), seepage loss was less and with active support of WUAs and strict monitoring the tail area was by and large satisfactorily irrigated. Only 1 cumec was provided to the tail-end of the system- 1800 ha of area under Stage-II Santri distributary- by difficult and time consuming manual operation as against the demanded requirement of approximately 2 cumec.

Even after the almost complete rehabilitation (between 1993 and 1998) and formation of WUAs (1996 to 1998), the need for additional operational/structural improvements for ensuring/restricting the supply to each structured zone to the authorized quantity was felt. The lesson learned is that canal automation has to be introduced to obtain equity, particularly with the extension of the command area. A comprehensive scheme for remote operation of the entire system by a centralized control center at the reservoir, getting feedback in real-time from the regulators for the laterals and ensuring a proportional withdrawal is being formulated with the technical guidance provided by Colorado State University. The Department of Civil Engineering at Colorado State University, through the 2nd author, is a constituent of an International Lead Consultant Body for the Orissa WRCP. The automation scheme would essentially consist of:

- Developing an operational plan for the system
- Developing an outlet scheduling algorithm
- Developing a feedback control algorithm
- Software Integration
- Installing data acquisition/communication system
- Flow measurement at cross-regulators and head regulators for structured zones.

The hardware components of the scheme would be:

- Construction of additional cross-regulators and minimum rehabilitation of structures to enable installation of remote control operation of gates.
- Installation of equipment for data acquisition, transmission and operation of regulating structures.

The automation scheme is likely to cost $500,000 (Rs 2 million) to improve irrigation efficiency by at least 10 to 15% and primarily to assure the beneficiaries of the earnestness of the Department of Water Resources to maintain equity. In addition, this pilot scheme is undertaken to act as a demonstration and training site for the engineers of the Department.

SUMMARY AND CONCLUSIONS

The Derjang medium irrigation project was initially planned and constructed to command 6000 ha experienced serious shortage and inequity in water distribution (between 1967 to 1993). Distress of the system resulting by unauthorized tampering by the beneficiaries to a large extent led to significant deficiency in conveyance. With World Bank assistance, a complete rehabilitation of the distribution system with structured zones below which distribution is unregulated, and formation of WUAS that resulted in Participatory Irrigation Management, have already been done and have resulted in significant increase in production and farm income. The farm income has gone up substantially by adoption of cash crops in the winter and has shown 250% increase over half the command (from Rs 4000 in 1992 to Rs 10000 in 1998). The hydrological data from 1967 to 1980 indicated additional yield of 1000 ha-m annually which led to creation of increased live storage by installation of gates on open crested spillway. This has led to a Stage II extension for creating an additional potential of 1800 ha. With a healthy system and WUAs functional, it has been possible to irrigate an additional 1400 ha in 1998. But a major concern continues to be the abstraction of 10 to 15% over the authorized withdrawal, where mechanically operated shutters are provided. To obviate such a contingency, canal automation in a pilot scheme for the entire command is being formulated and will be implemented in a 2-year time frame. This scheme would be a training ground for 250,000 ha of command area being rehabilitated in Orissa through the World Bank assisted WRCP. Preliminary assessment shows that a good system with automation and farmers participation can irrigate an additional command area of 10% with minimal investment.

ANNEX-I. WHY IRRIGATION MANAGEMENT TRANSFER TO FARMERS

- Make farmers conscious of the price and utility of water. A government managed system delivers water on-demand irrespective of the merit of the demand, such as crop water need related to the growth stage; more important whether irrigation can be damaging to the crop yield. This is particularly true under Indian conditions where small holdings of 200 or more farmers receive water concurrently over a small command of 200 - 300 Ha. The possibility of different variety of crops grown all over the command in a staggered manner between holdings exists.

- Farmers pay for the water delivered quantitatively and hence economic water use.

- Distribution network at a minor level is usually in poor condition when the government (under Indian condition) maintains the entire system. The water inequity is significant from the head to the tail in a minor channel, which is primarily due to loss of conveyance capacity (even minor channels/water courses become non-existent after 10/20 years of use). Farmers through WUA will have to ensure minor preventive maintenance for ensuring equity.

- Infrastructural improvement done such as provision of unregulated turnouts prior to transfer ensures equitable distribution provided the Association is totally responsible for operation/water management.

- Appropriate cropping practice/diversification becomes possible to generate optimal farm income.

- The Farmers Association necessarily gets better access to government aided technology demonstration/extension programs as well as access to credit for better seed, fertilizer, pesticide and storage cum marketing facility. Use of farm equipment to cut down labor time and cost can be significant with associations trying to cover large compact farm areas.

- A downstream benefit is that, in addition to farm income, incremental family income is generated through a community approach covering dairy, poultry, piggery, horticulture, pisciculture and even commercial activities like weaving, painting, handicraft, etc. In addition community facilities related to health, education and rural connectivity can be better realized.

- A sense of belonging of the irrigation system prevails and grievance redressal is much faster.

- Worldwide experience shows management transfer to farmers to be cost effective and a sustaining development process.

Specific functions assigned to the Water Users Associations and objectives to form the Associations are:

a) to demonstrate and make the farmers conscious of the need of equitable distribution to ensure increased agricultural production
b) to increase consciousness for ensuring economy in water use
c) to develop and adopt appropriate cropping pattern
d) to advise the DOWR on minor level improvements
e) to operate and maintain the distributary/minor canals and structures that will be improved under WRCP
f) to collect irrigation fees on behalf of the DOWR
g) to ensure equitable water distribution among the WUA members; and
g) through the apex council, to advise the DOWR on main system operations as these affect operations within the WUA's management perview.

ANNEX II. DERJANG IRRIGATION PROJECT PROFILE OF WATER USERS ASSOCIATIONS

WUA No.	Ayacut Area (Ha)	Total Number of Farmers	Villages Involved
1	339	420	4
2	271	457	5
3	324	383	3
4	480	410	4
5	558	425	5
6	212	270	2
7	473	575	6
8	720	475	5
9	46	502	11
10	635	619	11
11	630	620	5
12	176	400	3
13	598	505	6
Total	5951	6060	70

All WUAs were registered during August 1996 to January 1997. Average land holding = 5951 / 6060 ~ 1.00 Ha / Family

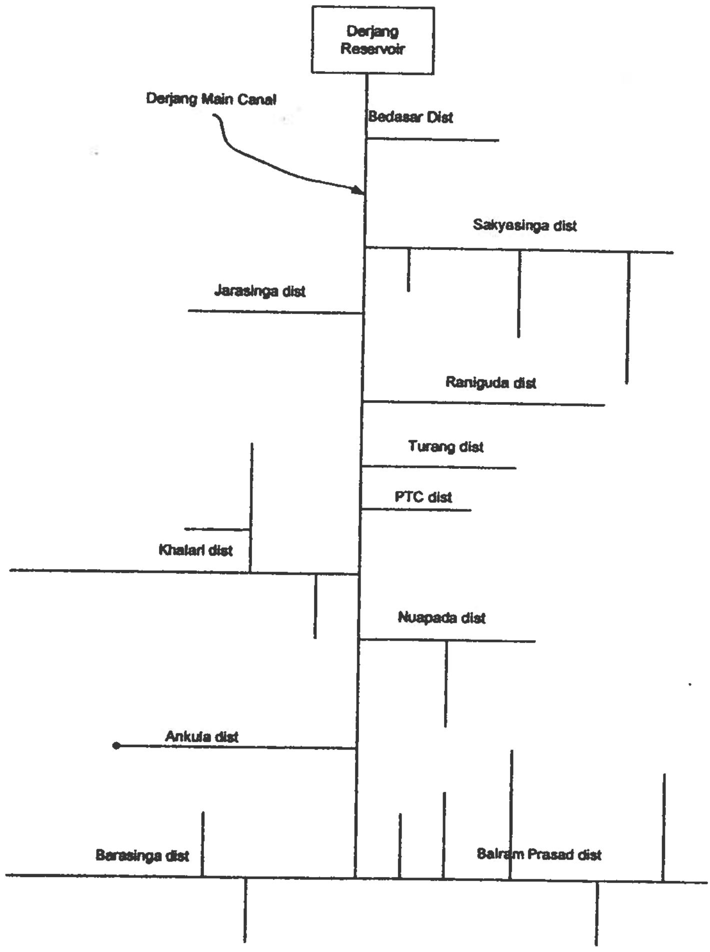


Figure 1. Index Map of the Derjang Irrigation Scheme