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Impact Assessment of Rehabilitation and Irrigation Management Transfer in the Minor Irrigation Systems of Orissa, India

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Authors

CONTENTS

Page No.

1. INTRODUCTION 1

1.1 Genesis of Minor Irrigation Development 2

1.2 Irrigation Management Transfer (IMT) Process 3

1.3 European Commission Aided Rehabilitation of Minor Irrigation Systems in Orissa 3

1.4 Context of Present Study 4

2. METHODOLOGY 5

2.1 Selection of the Study MIPs 5

2.2 Features of Selected MIPs 5

2.3 Impact Assessment Indicators 8

2.3.1 Hydrological impact 8

2.3.2 Agricultural impact 9

2.3.3 Socio-economic impact 9

2.3.4 Institutional impact 9

2.4 Selection and Interviewing of Farmers 10

3. FINDINGS 11

3.1 Impact on Irrigation Hydrology 11

3.1.1 Scenario at Koska MIP 11

3.1.2 Scenario at Devijhar MIP 14

3.1.3 Scenario at Analaberini MIP 15

3.1.4 Comparative Scenario among the Selected MIPs 17

3.2 Agricultural Impact 19

3.2.1 Cultivated area 19

3.2.2 Cropping intensity 21

3.2.3 Irrigated area 22

3.2.4 Irrigation intensity 24

3.2.5 Cropping pattern 27

3.2.6 Crop productivity 30

3.3 Socio-economic Impact 32

3.3.1 Educational level of the respondents 32

3.3.2 Age distribution of respondent farmers across the systems 32

3.3.3 Caste composition of the respondents across the systems 34

3.3.4 Size class wise distribution of respondents 35

3.3.5 Occupational distribution of households 36

3.3.6 Income 36

3.3.7 Migration 39

3.3.8 Consumption Pattern 40

3.3.9 Household liability 42

3.3.10 Employment pattern 43

3.4 Institutional Impact 44

3.4.1 Nature and functioning of WUAs 44

3.4.2 Attitude of the farmers towards WUA 46

3.4.3 Extent of WUA member-farmers' participation in irrigation management 48

3.4.4 Group effectiveness of WUAs 50

3.5 Mechanism of operation and maintenance of the system 54

4. SCOPE FOR FURTHER IMPROVEMENT 55

4.1 Creation of a Better Hydrological Regime in the Command 55

4.2 Improved Crop Planning and Productivity 56

4.3 Improvement in Socio-Economic Condition 56

4.4 Improvement in Institutional Performance 57

1. INTRODUCTION

India has a total water resources of 400 M ha m which is about 4.2% of world's fresh water resources with 16% of world's population, 15% of world's livestock and 2.4% of world's geographical area. More than 90% of the annual runoff in the peninsular rivers and more than 80% runoff of the Himalayan rivers occur during the months of June to September. This uneven distribution and disposal of precious water resource calls for the need to capture and store it in various types of storages to fulfill the requirement of the country with a population over one billion.

Agriculture is the main occupation of rural population of India. It contributes nearly 17% of the National Gross Domestic Product and sustains livelihood of about two-thirds of population. With the growing demand to increase agricultural production, the irrigation system and its management play a crucial role as a productive as well as protective input to agricultural system. The irrigation potential of the country has been increased from 22.6 million ha in the year 1950-51 to around 100 million ha by the year 1999-2000. Correspondingly, the food production of the country increased from 50.8 million tons in the year 1950-51 to over 205 million tones by the year 1999-2000. Further, about 60% of the country's food production is contributed from the irrigated agriculture. According to Planning commission sources investment in agriculture generates three times more employment as compared to equivalent investment in industrial sector. Therefore, the basic thrust should be focused to rapid growth, efficient management and sustainability of irrigated agriculture.

The ultimate irrigation potential of the country is estimated at 140 million ha, out of which the share of minor irrigation (MI) is 58.58% i.e. 81.54 million ha. Similarly, in the state of Orissa, it has been estimated that out of the total cultivable area of 65.59 lakh ha, 59.00 lakh ha (39.49 from major and medium, 9.70 from minor flow, 8.87 from minor lift and 0.94 lakh ha from other sources) can be brought under irrigation through different sources. The irrigation potential by the end of year 2003-04 is estimated as 26.51 lakh ha (12.35 from major and medium, 4.97 from minor flow, 3.84 from minor lift and 5.35 lakh ha from other sources). Thus, about 1/3 rd of the irrigated area in the state gets irrigation water from minor irrigation projects (MIPs). Minor irrigation schemes are environmental friendly and provide employment opportunities for the rural population. However, flat water pricing system coupled with unscientific irrigation water use by farmers has lead low marginal and average return. The water tax which is collected from the system is not enough to even meet the routine operation and maintenance of the system. The challenges of food security in minor irrigation sector calls for modernization and improvement of existing minor irrigation schemes besides taking up large numbers of new schemes.

Serious attempts are being made in different parts of the world for developing mechanisms for sustainable user managed distribution systems in irrigation projects.

The process was initiated in India during 1987 with adoption of National Water Policy and in Orissa during 1995 through Orissa Water Resources Consolidation Project (OWRCP). While OWRCP concentrated on Participatory irrigation Management (PIM) in Major and Medium Irrigation Projects with World bank funding, an innovative Irrigation Management Transfer (IMT) approach was initiated in some of the selected derelict Minor Irrigation Projects with financial and technical support from European Commission.

1.1 Genesis of Minor Irrigation Development

Minor irrigation development in India is as old as civilization itself. The system of water harvesting through ponds, *khuls*, *sagars* were considered mundane duties of a benevolent king in Indian tradition. However, with the decline of age old practice of community management of common property resources like tanks and *sagars*, the importance of these structures got dwindled in public mind albeit increase of necessities of these system in the current period. During British period some efforts were made to harness surface water through anicuts in some of the rivers and barrages. In the late twenties, the importance of major irrigation project was realized due to recurrent droughts and floods, which slowed down the private initiative in irrigation development as public investment crowded out it. In south India, the age-old tradition of tank irrigation also dwindled due to negligence of the system by the government and public as focus shifted to major irrigation projects. The small irrigation systems were dominant sources of irrigation till 1920s then covering about 59% of net irrigated area. After 1960s there was a major shift to minor irrigation again and the contribution of minor irrigation become more than 60% to overall irrigation potential created in the country. Many studies found that the degree of utilized potential was much higher under minor irrigation system in comparison to major irrigation projects in the country.

Over emphasis on major canal system in pre- and post independence period inhibited private initiative for exploitation of rainwater and ground water, which are traditional minor irrigation sources in Orissa. The old system of tank irrigation in western Orissa also became extinct due to different institutional factors. The traditional *Munda*, *Kata* and *Sagar* system in western Orissa got extinct and the recurrent droughts in these areas are a consequence of that. Minor irrigations are broadly categorized as flow irrigation and lift irrigation system. Presently, in Orissa, contribution of minor irrigation is around 1/3rd of total irrigation potential created over the years.

The development of minor irrigation in Orissa in plan periods has been not steady. Under minor irrigation, growth of irrigation through wells increased in all the plan periods. The growth rate of canal irrigated area from 1950 to 1995-96 was 5.4% and that of tanks 2.28%, wells 6.65% with total growth rate of irrigated area during the same period was 1.44% only. Paddy occupied major area under irrigation from different sources. However, there is a steady decline of paddy crop under irrigated area albeit at a slower pace.

In Orissa around 558508 ha of net irrigated area covered under minor irrigation schemes ending June 2003. There are around 3696 number of minor irrigation projects in the state out of which around 2200 are classified as fully operational, 740 as partially derelict and 582 as completely derelict. About 174 schemes are under construction. The area of these defunct and partially defunct schemes is about 159032 ha, which is about 28% of the net cultivated area of all MI schemes. The defunct schemes are damaged to different extent and have almost seized to serve as irrigation sources due to siltation, non maintenance, damages and reduction of contributing catchments area because of increased human activities. In recent years, it has been realized in the states like Orissa, Andhra Pradesh, Tamil Nadu and Karnataka that the tanks irrigation systems cater the need of a larger percentage of population in the rural areas; therefore, attention has been given to rehabilitation and rejuvenation of Minor irrigation systems.

1.2 Irrigation Management Transfer (IMT) Process

As the debate gained momentum over non-performance of publicly supplied irrigation system in early nineties, the participatory irrigation management was advocated as a panacea for sustainability. Irrigation being a common pool resource, the involvement of stakeholders in the management of it has gained prominence over the years. The transition period has marked confusion and opposition from the opinion makers and sometimes the farmers themselves are not able to reconcile with the shift from state dependency to self-control on irrigation management. Over the years excessive state control has dominated private endeavor to improve the system.

On the concept of peoples management of developmental infrastructures that requires local solution to local problems affecting them, the National Water Policy of Government of India of 1987 and the National Water Policy of 2002 as well as Orissa State Water Policy of 2002 stressed on farmers participation in irrigation management. In Orissa after rehabilitation, the irrigation system has been rapidly shifting over to Farmer's organizations under Water User's Association (WUA) umbrella in each project. The philosophy of participatory irrigation management has been put into practice under turned over minor irrigation projects in Orissa. The modus operandi of *Pani Panchayat* or WUA is through financial and institutional reforms. The community under defined unit of area of the system will have the control over supply and influence the demand for water through participatory crop planning.

1.3 European Commission Aided Rehabilitation of Minor Irrigation Systems in Orissa

The country having an extensive government controlled irrigation system faces the difficulty of managing irrigation in existing command areas resulting into low irrigation efficiency. It is gradually perceived that the capacity to cater to adequate operation and maintenance need involvement of farmers especially at the lowest level of distribution system. This requires organised farmers group activity to manage the systems at these levels. Hence, Participatory Irrigation Management (PIM) and Irrigation Management Transfer (IMT) concepts have been evolved. In this context Government of Orissa, with support from European Commission (EC) through Union Ministry of Water Resources, has implemented "Minor Irrigation in Orissa" project as a pilot project in some selected minor irrigation schemes.

An autonomous Project Management Unit (PMU) born under the Department of Water Resources of Government of Orissa with the aid of European Commission in the year 1996 has implemented the project. PMU was entrusted with the works to rehabilitate selected Minor Irrigation Projects with severe to moderate dereliction with people's participation and transfer the system to Water User Associations (WUAs) after rehabilitation. One of the multifaceted strategies being adopted by PMU is Irrigation Management Transfer in the commands of MI projects rehabilitated under the programme. The PMU carried out rehabilitation programme of 49 MIPs covering command area of 9312 ha in different phases spanning over in 7 districts of Orissa namely Angul, Cuttack, Dhenkanal, Ganjam, Kandhamal, Khurda and Nayagarh.

The wider objectives of the project is to rehabilitate derelict minor irrigation schemes and establish a viable model for user run management to improve small farm productivity and increase job opportunities. It is intended that these actions will lead to better living conditions for both male and female members of the families of small farmers and the landless.

The specific objectives of the project are to :

i. Develop farmer based water user groups and associations (WUAs) capable of managing maintenance, including collection of water taxes to fund the maintenance work and managing water distributions;
ii. Rehabilitate selected derelict / partially derelict minor irrigation schemes;
iii. Improve both efficiency and equity of water distribution;
iv. Convert Government MI operation and maintenance resources into a service / security support system; and
v. Reduce the dependence of seasonal migration as the main source of cash income and employment during the dry season.

1.4 Context of Present Study

The challenge before PMU was to formulate a strategy that will (a) operate and maintain the irrigation systems, sustain the hydraulic performance of the canal network and stabilize the agro economic gains achieved through rehabilitation of MI projects with people's participation (b) sustain the institutional mechanism for management of turned over MI projects and carry out operation and maintenance (O&M) work by the WUA without external support i.e. to make the WUAs self sufficient to look after O&M work of the MIPs.

As a consolidation exercise and to assess the impact of rehabilitation and turn over of MIPs, PMU entrusted the study of “Hydrological, agricultural, socio-economic and institutional Impact Assessment of Turned over MI Projects” to Water Technology Centre for Eastern Region, Bhubaneswar. Subsequently, WTCER after successful completion of the consultancy project took up an in house research project during 2005 after diagnosing the possible gaps from the impact assessment study and scopes for further improvement of the system. The findings of the consultancy project which form a reference database for interventions in minor irrigation systems of the region are described in the subsequent sections with comparative pictures across the studied systems.

2. METHODOLOGY

2.1 Selection of the Study MIPs

To select the study MIPs, a reconnaissance survey was under taken in 5 turned over MI projects (Gosinga Nala, Koska, Ghagara, Kakudi Khola and Darpa Narayana Pur) of Nayagarh district, 3 turned over MI projects (Devijhar, Mohan Sagar and Kenduaghai) of Ganjam district and 2 turned over MI projects (Ramei and Analaberini) of Dhenkanal district. Based on the experience gained during the survey and considering the pros and cons of several factors related to water availability, cropping pattern, command area size, organizational pattern & functioning of water users association and hardware of the irrigation system, 1 turned over MI projects each in Nayagarh, Ganjam and Dhenkanal district (i.e., Koska MIP in Nayagarh district; Devijhar MIP in Ganjam district and Analaberini MIP in Dhenkanal district) were selected for the study.

2.2 Features of Selected MIPs

Koska MI project is located in 20^0 17’ 30" N latitude and 85^0 06’ 00" E longitudes (Plate 1). It is the biggest among the three MIPs chosen with command area of about 840 ha spreading over 21 villages. The live and dead storage of the reservoir is 360.95 and 23.54 ha m respectively. The length of the dam is 899.16 m with maximum height of 14.02 m. There are three canals off taking from the reservoir i.e, Right Main Canal (3.61 km length with 9 outlets), Left Main Canal (3.39 km length with 11 outlets) and Diversion Weir Canal (4.20 km length with 12 outlets). The catchment area of the reservoir is about 35.6 square km area. Right Main canal has one branch canal (Plate 2) namely Madhupur (1.36 km length with 4 outlets); Left Main Canal has two branch canals namely Kandhapathar (1.65 km length with 5 outlets) and Pankal (1.10 km length with 6 outlets); and Diversion weir canal has three branch canals namely Singhibadi (1.14 km with 5 outlets), Kubharapada (0.73 km with 4 outlets) and Sardhapur (0.334 km length). Further, Singhibadi branch canal has a Singhibadi sub minor which is 0.89 km in length and has 6 outlets. There are about 72 on-farm chak demarcated in this command. This project is one of the eight MI schemes selected initially under phase 1 in 1998 and it was turned over on 10th July 2004. During the survey, it is observed that about 30% of the total ayacut was under *rabi* (2004-05) crop coverage, comprising of primarily sunflower, pointed gourd, ground nut and sugarcane cultivation. It was observed that the reservoir had water to meet the water requirement of *rabi* crop coverage and is connected with a perennial stream. This project has five WUAs and an Apex body. Thus, to have a clear picture about the impact of rehabilitation and IMT, this project was selected in spite of its remoteness.

Devijhar MI project of Ganjam district is located 19^0 43’ 00" N latitude and 85^0 07’ 00" E longitudes. This MIP has unique topography and reservoir site. The length of the earth fill dam is 204.86 m with maximum height of 16.2 m (Plate 3). The reservoir has a live and dead storage of 85.41 and 2.59 ha m respectively. The catchment area of the reservoir is 9.3 square km. There is only one main canal off taking from the reservoir whose design discharge at the sluice is 0.545 cumec (Plate 4). It is 5.30 km long having 24 outlets. There is one branch canal which off takes from the main canal having design discharge of 0.204 cumec. The length of the branch canal is 3.507 km with 17 outlets. This project is one of the twelve MI schemes selected under phase 2 (Tranch 1) in 2001 and turned over on 5th July 2004. It covers an ayacut area of about 500 ha and may be

Plate 1 : Koska MIP reservoir embankment and main canal system

Plate 2 : Flow measuring flume in theKoska MIP canal system

Plate 3 : Reservoir and embankment of Devijhar MIP.

Plate 4 : Main canal of Devijhar MIP.

categorized as a medium size MI schemes among the turned over projects. Further, excellent groundnut cultivation covering about 1/5th of the total ayacut was noticed during *rabi* season (2004-05). This project has one of the biggest WUA comprising of 934 members representing from 10 villages. Unlike other WUAs, Village Water Users Group (VWUG) committees prevail here and one member of VWUG represents in management committee of WUA.

Some of the salient features of the above selected MI projects are presented in Table 1

Table1. Brief account of WUAs under 3 selected minor irrigation systems

Name of MI system	Name of WUA	Canals and Minors under WUA	Ayacut (ha)	No. of member farmers	Total no. of villages
Koska MIS Dist. Nayagarh	WUA 1 (*Maa Pitabali* WUA)	LBC: 0-1350 m, and Kandhapathar minor : 0-1650 m	137	170	21
Turned over on	WUA 2 (*Nakodein* WUA)	LBC: 1350-3390 m, and Pankal minor: 0-1104 m	138	128	
10/07/04	WUA 3 (*Maa Bhuinani* WUA)	Diversion canal: 0-1785 m, Singibadi minor: 0-1180 m, and Singibadi sub-minor : 0-334 m	232	275	
	WUA 4 (*Jana Kalyan* WUA)	Diversion canal : 1785-4200 m, Kumbhapada minor: 0-730 m, and Shradhapur minor : 0-334 m	198	245	
	WUA 5 (*Maa Sindurai* WUA)	RBC: 0-3610 m, and Madhupur minor: 0-1360 m	135	161	
	Total		**840**	**979**	
Devijhar MIS Dist. Ganjam Turned over on 05/07/04	Baba Sidheswar WUA	Main canal: 5300 m (24 outlets from main canal) Branch canal: 3507 m (17 outlets from branch canal	499	934	10
Analabereni MIS Dist. Dhenkanal Turned over on11/03/05	Maa Brahmanidevi WUA	Main canal: 824 m	89	140	2

Analaberini MI project in Dhenkanal district is located at 28^0 50' 00" N latitude and 85^0 35' 00" E longitude. The reservoir has 25.27 and 3.04 ha m of live and dead storage respectively. The earth fill dam has a length of 365.76 m with maximum height of 8.83 m. There is only one canal off takes from the reservoir which has a design discharge of 0.097 cumec, length of 0.824 km and 5 outlets. The command area of the MIP is about 89 ha. Out of eleven MI schemes selected under Phase 2 (Tranch 4) in 2003 this projects was handed over to WUA on 11th March 2005. Considering this project as one of the small category projects among the turned over MI schemes was selected for the study. This system has one WUA with 140 members from two villages.

2.3 Impact Assessment Indicators

2.3.1 Hydrological impact

The performance evaluation of irrigation system by conventional methods depends on the availability of reliable flow data over space and time. However, during the present study such quantitative data could not be monitored / observed due to paucity of water availability in the reservoir. Further, among different stakeholders in an irrigation system, farmers are the producers of agricultural outputs through the utilization of irrigation services provided to them. In spite of being the fundamental stakeholder, farmers often receive least attention for assessment of performance. It is important to consider irrigation as a service provided to farmers. Therefore, in the present study an alternative approach with due focus on farmers view points was followed for the irrigation hydrology impact assessment. A methodology based on farmer's assessment of the irrigation water supply was adopted where farmers' opinions were recorded on following 11 indicators.

- P_1 Adequacy / sufficiency of irrigation water to meet crop water requirement
- P_2 Point of delivery of water
- P_3 Stream size of water / outlet stream size
- P_4 Timing of irrigation water availability
- P_5 Equity in water distribution among the farmers per ha of cultivated land
- P_6 Sufficiency in duration of irrigation water supply
- P_7 Frequency of irrigation water supply
- P_8 Prior knowledge / awareness about water delivery schedules
- P_9 Management decisions depending on irrigation water supply
- P_{10} Certainty of irrigation water availability
- P_{11} Performance of the canal system to cater the irrigation demand

Selected farmer-respondents were asked to give their judgments with respect to each above-mentioned indicator for both wet and dry season on a 5-point continuum scale (very good to very bad). They were also asked to put forward their perception regarding importance of those factors during both the seasons separately on a 5-point continuum scale (0-1, very bad; 1-2, bad; 2-3, average; 3-4, good; and 4-5, very good). Mean and standard deviation were calculated to aggregate the responses of farmers across different WUAs and reaches (head, middle and tail) of the MI system. Subsequently, the overall hydrological impact or the overall irrigation performance of the system was also assessed taking the mean score of all the above mentioned eleven indicators.

2.3.2 Agricultural impact

Agricultural impact addresses the effectiveness of on-farm water management. This was realized by assessing and making a comparison between pre- and post-rehabilitation scenario of the command with respect to land utilization, cropping intensity, area under irrigation, irrigation intensity, cropping pattern and crops productivity. Responses were taken from the selected farmers with respect to above-mentioned indicators both for wet and dry season with the help of an interview schedule developed for this purpose. The data obtained from the questionnaire survey was corroborated with the FGD and key informant interviews.

2.3.3 Socio-economic impact

The socio-economic profile of the respondents representing from selected MIPs was analyzed on the basis of educational type, age distribution, caste composition, size class distribution, occupational pattern, income distribution, migration, consumption expenditure pattern, on-farm employment pattern, liability position and gender issues. Most of the variables were analyzed as the existing scenario during post-rehabilitation period while few of them viz. income, migration, consumption pattern and employment were compared against pre-project scenario. Tabular analysis for primary data with application of standard statistical methods was used.

2.3.4 Institutional impact

Institutional intervention has taken place through formation of water user association (WUA) and handing over the irrigation system from Government control to WUA for its operation, management and maintenance. The nature and functioning of the system, attitude of the farmers towards WUA, the extent of their participation and group effectiveness of WUA were studied through focus group discussion, key informant interviews and interview schedule survey of selected farmers under each system.

To analyze the attitude of farmers towards IMT a scale was developed that included 10 statements and response of each farmer was taken towards each statement on a 3-point continuum (2-agree, 1-undecided and 0-disagree for favourable statement and reverse for unfavourable statement). Therefore, maximum and minimum possible score of overall attitude was ranged from 20 to 0. Frequency, mean and standard deviation were calculated to aggregate the responses of farmers.

The extent of WUA member-farmers' participation in irrigation management was measured with the help of a Farmers' Participation Index (FPI).

$$FPI = \frac{\text{Mean participation score (P)}}{\text{Maximum participation score}} \times 100$$

Where, $P = \Sigma P_i / N$ and $P_i = \Sigma PP_j$

Where, PP_j = Total score of farmers' participation

i = 1, 2, ………, N

j = 1, 2, ………, K

N = total number of respondents

K = total number of statements (statements related to farmers' participation and score was assigned as 1 for 'yes' and 0 for 'no' response to each statement)

To understand the effectiveness of WUA a Group Dynamic Effective Index (GDEI) was used that included 10 different parameters with different weightage (%) as indicated in Fig. 1.

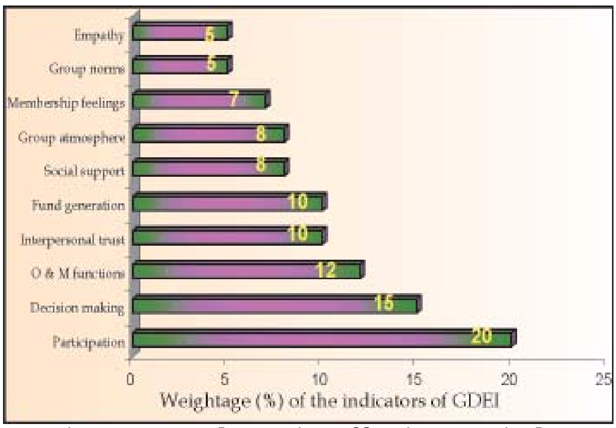


Fig. 1 Group dynamics effectiveness index (GDEI) with its indicators

Each indicator was assessed on the basis of 5-4 statements on which Farmers' responses were taken on 3-point continuum ranging from 0 to 2. Mean and standard deviation values of each indicator were calculated at first step and thereafter, overall group dynamic effectiveness was calculated on the basis of different weights of ten different indicators in GDEI.

2.4 Selection and Interviewing of Farmers

In the present study, a stratified probability proportionate random sampling method was used to select the farmers as respondents from the command area under WUA across head, middle and tail reach of the canal for the 3 selected minor irrigation systems. Koska MIP was having 5 WUAs with an Apex while Devijhar and Analabereni

MIP were having 1 WUA each. At Koska, the location of most of the ayacut of WUA 1 and WUA 3 falls under head reach and that of WUA 5 at tail reach of the system while ayacut of WUA 2 and WUA 4 comes under middle and tail reach of the system as evident from the Table 2.

It was decided to select about 10% of the total member-farmers as sample respondents in each of the selected irrigation systems. Accordingly, a total of 207 farmers were interviewed. Detail of sampling of the respondents is presented in the Table 2.

Table 2. Sampling plan for selection of farmers as respondents

Name of the selected system	Name of WUA	No. of farmers	No. of farmers at head reach	No. of farmers at middle reach	No. of farmers at tail reach
Koska MIP, Dist. Nayagarh	WUA 1 WUA 2 WUA 3 WUA 4 WUA 5 Total	17 12 25 24 18 96	WUA 1 and WUA 3 at head reach WUA 2 and WUA 4 at middle reach WUA 5 at tail reach		
Devijhar MIP, Dist. Ganjam	WUA 1	91	14	56	21
Analabereni MIP, Dist. Dhenkanal	WUA 1	20	6	13	1

3. FINDINGS

3.1 Impact on Irrigation Hydrology

The impact of rehabilitation and IMT is visible with a better water conservation in the reservoir specifically due to renovation of the sluice / head regulator and strengthening of the reservoir embankment. Presently sufficient amount of water in the reservoir is available to cater the supplemental irrigation requirement of *kharif* crop. There is a marked increase in area under *rabi* crop, utilizing the water in the reservoir after meeting *kharif* requirement. Farmers' perceptions on different hydrological indicators for the chosen MI systems and a comparison among them are presented below.

3.1.1 *Scenario at Koska MIP*

The mean values of indicators for different WUAs of Koska MIP for wet and dry seasons are presented in Table 3 and 4, respectively. As evident, the overall performance of the irrigation system in wet season (Table 3) looks better in comparison to dry season (Table 4). In wet season, all the indicators score are in the range of good to very good and in dry season they are in the range of average to good.

For the purpose of drawing some meaningful conclusion about the concern of farmers even after rehabilitation and IMT, two indicators with lowest scoring were considered in each WUA. In wet season (Table 3), among the indicators considered, equitable distribution of irrigation water among the farmers per ha of cultivated land (P_5) and knowledge/ awareness about water delivery schedule (P_8) in WUA1, WUA2 and WUA5; frequency of getting irrigation water (P_7) and point of delivery of water (P_2) in WUA3; timing of irrigation water availability (P_4) and knowledge/ awareness about water delivery schedule (P_8) in WUA 4 have scored lowest. Further, the mean scores

Table 3. Impact of rehabilitation and IMT on irrigation hydrology for wet seasonin Koska MIP

Hydro-logical indicator	WUA1		WUA2		WUA3		WUA4		WUA5	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
P_1	4.06	0.66	3.75	1.01	3.88	0.99	3.62	0.63	4.22	0.62
P_2	3.75	0.97	3.58	0.95	3.64	0.84	3.79	0.41	3.94	0.40
P_3	3.81	0.88	3.91	0.64	4.00	0.69	3.30	0.54	3.44	1.12
P_4	3.94	0.83	3.58	0.94	3.68	0.88	3.08	0.81	3.17	1.11
P_5	3.81	0.73	3.50	0.76	3.68	0.73	4.67	7.84	3.06	0.85
P_6	3.94	0.66	3.83	0.90	3.80	1.02	3.70	0.46	3.76	0.42
P_7	3.87	0.78	3.75	0.72	3.64	0.89	3.37	0.56	3.55	0.76
P_8	3.50	0.61	3.50	0.50	3.60	0.69	3.25	0.92	3.06	1.31
P_9	4.00	0.61	3.67	0.47	3.80	0.63	3.79	0.57	3.72	0.73
P_{10}	3.87	0.92	3.75	0.72	3.84	1.00	3.46	0.76	3.56	1.17
P_{11}	4.00	0.71	4.08	0.49	4.08	0.84	3.96	0.36	4.06	0.23

Table 4. Impact of rehabilitation and IMT on irrigation hydrology for dry season in Koska MIP

Hydro-logical indicator	WUA1		WUA2		WUA3		WUA4		WUA5	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
P_1	2.94	1.30	2.75	1.36	3.16	1.16	2.33	0.47	2.00	0.77
P_2	3.06	1.14	3.33	0.94	3.24	1.03	2.33	0.64	2.18	0.95
P_3	3.31	0.92	3.58	0.86	3.80	0.85	2.24	0.53	2.50	0.87
P_4	2.94	1.03	3.36	0.98	3.20	1.02	2.24	0.53	2.13	0.88
P_5	3.44	1.12	3.50	0.76	3.32	1.01	2.28	0.45	2.20	0.83
P_6	3.00	0.87	3.36	0.64	3.16	0.97	2.43	0.66	2.40	0.88
P_7	3.37	0.93	3.73	0.62	3.16	0.83	2.52	0.59	2.93	1.12
P_8	3.31	0.58	3.50	0.49	3.40	0.57	2.90	0.87	2.79	1.20
P_9	3.60	0.61	3.54	0.89	3.60	0.57	3.76	0.68	3.13	0.81
P_{10}	3.19	0.88	3.55	0.89	3.48	0.90	3.09	0.87	2.94	1.34
P_{11}	3.75	0.56	3.82	0.39	4.00	0.85	3.62	0.58	2.62	1.05

of the hydrological indicators for all the five WUAs reveals that, knowledge / awareness about water delivery schedule (P_8) is the concern of most of the farmers of Koska MIP followed by equitable distribution of irrigation water among the farmers per ha of cultivated land (P_5).

Similarly, in dry season (Table 4), among the indicators considered, adequacy of irrigation water amount to meet the crop water demand (P_1) and timing of irrigation water availability (P_4) in WUA1; adequacy of irrigation water amount to meet the crop water demand (P_1) and point of delivery of water in WUA2; adequacy of irrigation water amount to meet the crop water demand (P_1), duration of water supply in (P_6) and frequency of irrigation water supply (P_7) in WUA3; stream size of water (P_3) and timing of irrigation water availability (P_4) in WUA4; and adequacy of irrigation water amount to meet the crop water demand (P_1) and timing of irrigation water availability (P_4) in WUA5 have scored lowest showing the concern of the farmers. Considering all the above points, it is the adequacy of irrigation water amount to meet the crop water demand (P_1) which is the serious most hydrological problem during *rabi* followed by timing of irrigation water availability (P_4).

Thus, during *kharif* when there is better irrigation water availability, farmers are concerned more about the equitable distribution of the available water and the awareness about future delivery schedule. In *rabi*, their concern are all together different. They are more concern about the adequacy of water availability and timing of irrigation water supply due to insufficient irrigation water availability in the reservoir.

Fig.2 presents the overall hydrological impact of rehabilitation and IMT in different WUAs of Koska MIP in both the season. The mean score of wet season is higher than that of dry season. The mean score ranges between 3.59 to 3.87 (good) for *kharif* and 2.53 to 3.46 (average to good) for *rabi*.

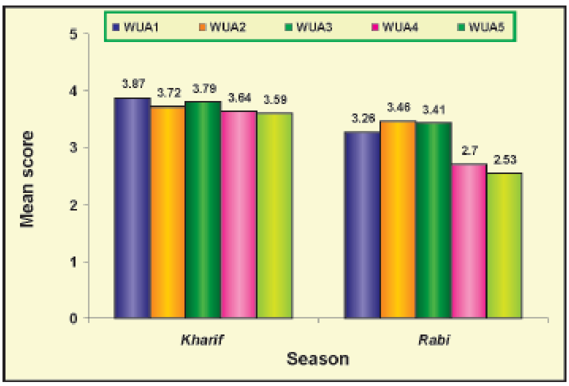


Fig. 2 Overall hydrological impact in different WUAs at Koska during *Kharif* and *Rabi*

Among the WUAs, the irrigation performance is found better in WUA1 & 3 (located in the head reach) which might be due to their locational advantage. The variation of overall hydrological impact over space during *kharif* is negligible. However, some spatial discrepancy is seen for WUA 4 and 5 during *rabi.* As command area of both of the WUAs are located in the middle and tail reaches, insufficient water availability due to excessive conveyance losses and inequitable distribution of water might be the reasons for this spatial discrepancy.

The overall impact of rehabilitation and IMT on irrigation hydrology is observed to be good in wet season and in the range of average to good in dry season for Koska MIP.

3.1.2 *Scenario at Devijhar MIP*

The mean values of hydrological indicators for head, middle and tail reach of Devijhar MIP during wet and dry seasons are presented in Table 5 and 6, respectively. As evident, the overall hydrological situation in wet season (Table 5) looks slightly better in comparison to dry season (Table 6). In both the seasons, the scoring of all the indicators is in the range of good to very good.

Table 5. Impact of rehabilitation and IMT on irrigation hydrology for wet season in Devijhar MIP

Hydrological indicator	Head		Middle		Tail	
	Mean	SD	Mean	SD	Mean	SD
P_1	4.84	0.38	4.12	0.72	3.52	0.68
P_2	4.31	0.75	3.82	0.72	3.38	0.92
P_3	4.08	0.64	3.81	0.62	3.43	0.81
P_4	4.54	0.78	3.64	0.73	3.33	0.92
P_5	4.31	0.85	3.64	0.75	3.33	0.66
P_6	4.75	0.45	3.58	0.63	3.43	0.60
P_7	4.63	0.50	3.94	0.61	3.86	0.85
P_8	4.61	0.65	4.14	0.67	3.52	0.98
P_9	3.85	0.69	3.44	0.60	3.38	0.74
P_{10}	4.46	0.66	3.96	0.86	4.14	0.85
P_{11}	4.46	0.52	3.88	0.68	3.81	0.87

Table 6. Impact of rehabilitation and IMT on irrigation hydrology for dry season in Devijhar MIP

Hydrological indicator	Head		Middle		Tail	
	Mean	SD	Mean	SD	Mean	SD
P_1	4.38	0.65	3.39	0.92	3.10	0.70
P_2	3.92	0.79	3.48	0.95	3.09	0.83
P_3	3.46	0.66	3.14	0.98	3.19	0.98
P_4	3.77	1.09	3.15	0.90	3.09	0.54
P_5	3.85	0.90	3.18	0.88	3.19	0.70
P_6	4.25	0.87	3.08	0.92	3.29	0.56
P_7	4.36	0.67	3.51	0.98	3.67	0.86
P_8	4.38	0.65	3.78	0.79	3.57	0.93
P_9	3.62	0.65	3.26	0.63	3.33	0.73
P_{10}	3.85	0.80	3.41	0.98	3.57	0.93
P_{11}	3.92	0.76	3.24	0.87	3.19	1.08

In the wet season (Table 5), among the indicators considered, stream size of water / outlet stream size (P_3) and management decisions on cultivation practices based on availability of irrigation water (P_9) in the head reach; duration of water supply (P_6) and management decisions on cultivation practices based on availability of irrigation water (P_9) in the middle reach; and timing of irrigation water availability (P_4) and equitable distribution of irrigation water among the farmers per ha of cultivated land (P_5) have scored the least. Thus, in *kharif*, management decisions on cultivation practices based on availability of irrigation water (P_9) is the concern of farmers of Devijhar MIP. Farmers have also shown their concern about the equitable distribution of water.

In the dry season (Table 6), among the indicators considered, stream size of water / outlet stream size (P_3) and management decisions on cultivation practices based on availability of irrigation water (P_9) in the head reach; stream size of water / outlet stream size (P_3) and duration of irrigation water supply (P_6) in the middle reach; point of delivery of water (P_2) and timing of irrigation water availability (P_4) in the tail reach have scored lowest. Thus, the stream size of water / outlet stream size (P_3) needs attention during *rabi*. Hence, study on unit command area of outlet is essential at Devijhar MIP.

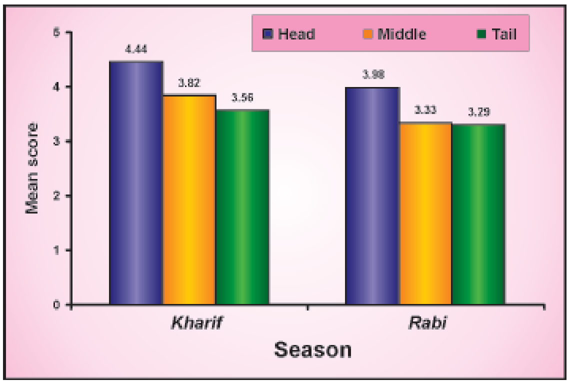


Fig. 3 Overall hydrological impact in head, middle and tail reach during both season at Devijhar MIP

Fig.3 presents the overall hydrological impact in the head, middle and tail reach of the Devijhar MIP in both the seasons. The overall impact is better in *kharif* than in *rabi*. During *kharif*, the impact difference is clearly seen among the reaches. Head reach has performed better over middle and tail reaches. The overall hydrological impact in the wet season ranges from 3.56 (good) to 4.44 (very good). However, in dry season it ranges from 3.29 to 3.98 (good). The focused group discussion (FGD) reveals that due to paucity of water in the reservoir during *rabi*, the crop cultivation (primarily groundnut cultivation) remains confined to head reach. This may be the reason for better scoring of hydrological impact in the head reach in *rabi*.

3.1.3 *Scenario at Analaberini MIP*

The mean values of indicators for head and middle reach of Analaberini MIP during wet and dry seasons are presented in Table 7 and 8, respectively. Like that of other MIPs, here also the overall hydrological impact in wet season (Table 7) looks better in comparison to dry season (Table 8).

In the wet season (Table 7), among the indicators considered, duration of water supply (P_6), frequency of irrigation water (P_7) and certainty of irrigation water availability (P_{10}) in the head reach; and frequency of irrigation water (P_7) and certainty of irrigation water availability (P_{10}) in the middle reach have scored the least. Thus, in *kharif*, certainty of irrigation water availability and frequency of irrigation are the prime concern of farmers of Analaberini MIP.

Table 7. Impact of rehabilitation and IMT on irrigation hydrology for wet season in Analaberini MIP

Hydrological indicator	Head		Middle	
	Mean	SD	Mean	SD
P_1	5.00	0.00	5.00	0.00
P_2	5.00	0.00	4.92	0.28
P_3	4.20	0.45	4.23	0.44
P_4	5.00	0.00	4.92	0.28
P_5	5.00	0.00	4.92	0.28
P_6	4.00	0.00	4.46	0.66
P_7	4.00	0.00	4.08	0.28
P_8	4.40	0.55	4.15	0.38
P_9	4.60	0.89	4.69	0.75
P_{10}	3.80	0.84	3.92	0.86
P_{11}	5.00	0.00	5.00	0.00

Table 8. Impact of rehabilitation and IMT on irrigation hydrology for dry season in Analaberini MIP

Hydrological indicator	Head	Middle		
	Mean	SD	Mean	SD
P_1	3.40	0.55	3.46	0.78
P_2	1.00	0.00	4.54	0.97
P_3	1.00	0.00	1.00	0.00
P_4	3.00	0.00	3.00	0.00
P_5	3.00	0.00	3.00	0.00
P_6				
P_7				
P_8	4.40	0.55	4.15	0.38
P_9	4.80	0.45	5.00	0.00
P_{10}	4.60	0.89	3.38	1.79
P_{11}	3.20	0.45	3.00	0.00

Similarly, in the dry season (Table 8), among the indicators considered, point of delivery of water (P_2) and stream size of water / outlet stream size (P_3) in the head reach; and stream size of water / outlet stream size (P_3) and timing of irrigation water availability

(P_4) in the middle reach have scored lowest. Therefore, it is the stream size of water / outlet stream size (P_3) which needs attention during *rabi*. Thus, in this command also the study on unit command area of outlet needs attention.

Fig. 4 presents the overall hydrological impact at Analaberini MIP in both the seasons. A distinct difference of impact is seen between the seasons, *kharif* remaining in the very good scoring (4.55 to 4.57) and *rabi* remaining in the good scoring (3.16 to 3.39). In this MIP, spatial discrepancy of hydrological impact is not observed. As this MIP is handed over to farmers few months before this study, there is a need to wait for some more time to assess its irrigation performance.

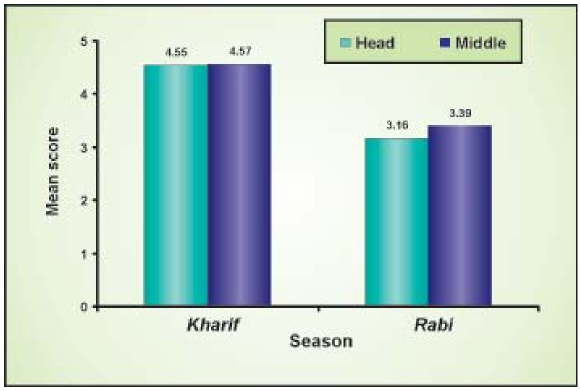


Fig. 4 Overall hydrological impact in both the season at Analaberini

3.1.4 ***Comparative Scenario among the Selected MIPs***

The mean values of the hydrological indicators for Koska, Devijhar and Analaberini MIPs for wet and dry season are presented in Table 9 and 10, respectively. As evident, the overall hydrological impact in wet season (Table 9) for all the MIPs looks better to that of dry season (Table 10).

In the wet season (Table 9), the overall impact on irrigation hydrology due to rehabilitation and IMT in all the three selected MIPs is in the range of good to very good. Among the indicators considered, equitable distribution of water among farmers per ha of cultivated land (P_5) and awareness about water supply schedules (P_8) in Koska MIP; equitable distribution of water among farmers per ha of cultivated land (P_5) and management decisions on cultivation practices based on irrigation water supply (P_9) in Devijhar MIP; frequency of irrigation water supply (P_7) and certainty of irrigation water availability (P_{10}) in Analaberini MIP have scored the least. Thus, during *kharif*, equitable distribution of irrigation water among the farmers per ha of cultivated land is the prime concern. Farmers are looking for equitable water distribution mechanism for implementation in the outlet (chak) command. Assured supply of irrigation water through a well defined delivery schedule and provision of field channels are essential for efficient use of irrigation water, planning of agricultural operation and investment on input use. These are some of the points which need attention to improve the hydraulic performance of the system further during *kharif* cultivation.

Similarly, in the *rabi* season (Table 10), the overall impact on irrigation hydrology due to rehabilitation and IMT in all the three selected MIPs is good. Among the hydrological indicators considered, adequacy of irrigation water availability (P_1) and timing of irrigation water supply (P_4) in Koska MIP; stream size of water/ outlet stream size (P_3) and timing of irrigation water supply (P_4) in Devijhar MIP; point of delivery of water (P_2) and stream size of water/ outlet stream size (P_3) in Analaberini MIP have scored the least. Thus, during *rabi*, stream size of water and timing of irrigation water supply are the two most important hydrological parameters for which farmers have sown their concern. Thus, there is a need to determine the optimum unit command area of outlet in each MIPs to make the delivery of water more efficient and effective.

Table 9. Impact of rehabilitation and IMT on irrigation hydrology for wet season in Koska, Devijhar and Analaberini MIPs

Hydrological indicator	Koska		Devijhar		Analaberini	
	Mean	SD	Mean	SD	Mean	SD
P1	3.89	0.83	4.09	0.77	5.00	0.00
P2	3.75	0.74	3.79	0.81	4.94	0.23
P3	3.68	0.85	3.76	0.69	4.22	0.42
P4	3.46	0.98	3.70	0.85	4.94	0.23
P5	3.41	0.88	3.67	0.79	4.94	0.23
P6	3.80	0.75	3.70	0.73	4.33	0.58
P7	3.61	0.78	4.01	0.70	4.06	0.23
P8	3.38	0.90	4.07	0.81	4.22	0.42
P9	3.80	.63	3.48	.65	4.67	0.74
P10	3.68	0.96	4.08	0.84	3.89	0.81
P11	4.03	0.59	3.94	0.73	5.00	0.00

Table 10. Impact of rehabilitation and IMT on irrigation hydrology for dry season in Koska, Devijhar and Analaberini MIPs

Hydrological indicator	Koska		Devijhar		Analaberini	
	Mean	SD	Mean	SD	Mean	SD
P1	2.66	1.13	3.47	0.92	3.44	0.68
P2	2.82	1.07	3.44	0.92	1.39	0.83
P3	3.09	1.03	3.20	0.93	1.00	0.00
P4	2.76	1.02	3.23	0.87	3.00	0.00
P5	2.93	1.04	3.29	0.86	3.00	0.00
P6	2.90	0.93	3.31	0.91		
P7	3.08	0.93	3.68	0.94		
P8	3.18	0.83	3.82	0.83	4.22	0.42
P9	3.55	0.73	3.33	0.66	4.94	0.24
P10	3.25	1.01	3.52	0.94	3.72	0.56
P11	3.60	0.89	3.33	0.93	3.05	0.23

Fig. 5 presents the mean score of hydrological impact for all three selected MIPs. In *kharif* the impact is best noticed in Analaberini followed by Devijhar and Koska MIP. However, during *rabi*, the hydrological impact is best observed in case of Devijhar MIP. During interaction with farmers and in course of focused group discussion, it is learnt that the farmers of Devijhar MIP are more aware of judicious use of water in growing crops with higher return than the Koska and Analaberini farmers. This is probably the reason for higher hydrological impact in *rabi* at Devijhar MIP. As the hydrological indicators impact was obtained in a 5 point continuum scale, in all the MIPs the overall hydrological impact mostly lie between the score 3 to 4 i.e. indicating the fact that the overall irrigation performance of the MI systems chosen is "Good".

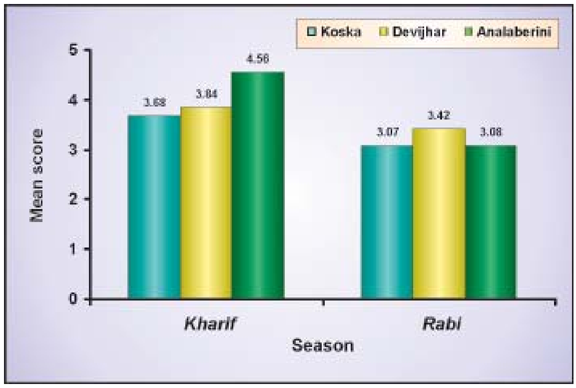


Fig. 5 Overall hydrological impact in both the season at selected MIPs

3.2 Agricultural Impact

Effectiveness of on-farm water management is generally reflected through agricultural output. To ascertain the agricultural impact due to rehabilitation and IMT, parameters such as cultivated area, cropping intensity, irrigated area, irrigation intensity, cropping pattern and productivity of various crops were used for pre and post rehabilitation period. Comparison was also made amongst the MIPs to comprehend the pros and cons of different systems.

3.2.1 Cultivated area

Tables 11, 12 and 13 present the cultivated area before and after the rehabilitation process of Koska, Devijhar and Analaberini MIPs respectively. Water being the prime input to agricultural production system, it is expected that with the rehabilitation of MIPs, the area under crop cultivation will increase. At Koska, about 22% increase in cultivated area is recorded during post rehabilitation period. Highest percent increase in cultivated area is recorded in WUA1 (79.41%) followed by WUA 3 (32.60%). This may be due to their proximity to the reservoir which has some direct relation with water availability. Due to the limited amount of water in the reservoir during *rabi*, the farmers of tail and middle reaches restrict themselves to go for crop cultivation in this season. That is why the percentage area increase in the head reach is considerably higher than the middle and tail reach. Devijhar MIP recorded an overall increase in cultivated area of 17.72% during post rehabilitation period. Its head reach recorded maximum increase (25.45%) followed by middle reach (18.18%) and tail reach (10.51%). Similarly, in case of Analaberini MIP, the overall increase in cultivated area is 9.6%. Head reach registered about 25.34% increase in cultivated area; however, no change is recorded for middle reach.

Table 11. Change in cultivated area in Koska MI project

Particular	Average land holding (acre)	Cultivated area (acre) / farmer						Change (%)
		Before rehabilitation			After rehabilitation			
		Kharif	*Rabi*	Total	*Kharif*	*Rabi*	Total	
WUA 1, n=17								
Mean SD	2.60 1.76	1.87 1.65	0.17 0.50	2.04	2.03 1.58	1.33 1.54	3.66	79.41
WUA 2, n=12								
Mean SD	3.52 3.16	2.50 2.58	1.20 1.49	3.70	2.65 2.46	1.73 1.51	4.38	18.38
WUA 3, n=25								
Mean SD	3.24 2.22	2.86 2.09	0.76 1.03	3.62	3.14 2.10	1.66 1.34	4.80	32.60
WUA 4, n=24								
Mean SD	4.29 2.26	3.44 1.79	0.72 1.03	4.16	3.46 1.79	0.83 1.16	4.29	3.12
WUA 5, n=18								
Mean SD	4.42 2.64	3.40 2.61	0.43 0.78	3.83	3.54 2.47	1.03 1.04	4.57	19.32
Koska MIP Overall (N=96)								
Mean SD	3.67 2.41	2.90 2.17	0.64 1.02	3.54	3.05 2.11	1.28 1.33	4.33	22.32

Table 12. Change in cultivated area in Devijhar MI project

Particular	Average land holding (acre)	Cultivated area (acre) / farmer						Change (%)
		Before rehabilitation			After rehabilitation			
		Kharif	*Rabi*	Total	*Kharif*	*Rabi*	Total	
Head reach, n=13								
Mean SD	3.85 1.52	3.77 1.64	1.81 1.52	5.58	3.85 1.52	3.15 1.46	7.00	25.45
Middle reach, n=57								
Mean SD	3.43 2.61	3.39 2.59	1.67 2.04	5.06	3.40 2.64	2.58 2.22	5.98	18.18
Tail reach, n=21								
Mean SD	3.33 2.51	2.98 2.86	1.87 2.24	4.85	3.24 2.61	2.12 2.46	5.36	10.51
Devijhar Overall (N=91)								
Mean SD	3.47 2.44	3.35 2.53	1.73 2.01	5.08	3.43 2.49	2.55 2.19	5.98	17.72

Table 13. Change in cultivated area in Analaberini MI project

Particular	Average land holding (acre)	Cultivated area (acre) / farmer						Change (%)
		Before rehabilitation			After rehabilitation			
		Kharif	*Rabi*	Total	*Kharif*	*Rabi*	Total	
Head reach, n=6								
Mean	3.00	2.55	1.08	3.63	2.63	1.92	4.55	25.34
SD	1.79	2.09	1.39		2.00	2.54		
Middle reach, n=14								
Mean	2.14	1.93	0.08	2.01	1.93	0.08	2.01	0.00
SD	0.63	0.70	0.16		0.70	0.13		
Analaberini Overall (N=20)								
Mean	2.40	2.12	0.38	2.50	2.14	0.60	2.74	9.60
SD	1.13	1.26	0.87		1.23	1.58		

3.2.2 Cropping intensity

Table 14 presents the cropping intensity before and after rehabilitation of the selected MIPs. Incase of Koska, there is an overall increase of 21.52% (96.46% to 117.98%) in cropping intensity after rehabilitation. However, the increase ranges from as low as

Table 14. Cropping intensity before and after the rehabilitation in the selected MIPs

Particular	Cropping intensity before rehabilitation (%)	Cropping intensity after rehabilitation (%)	Change (%)
Koska MIP (WUA 1, n=17)	78.46	129.23	50.77
Koska MIP (WUA 2, n=12)	105.11	124.43	19.32
Koska MIP (WUA 3, n=25)	111.72	148.15	36.43
Koska MIP (WUA 4, n=24)	96.97	100.00	3.03
Koska MIP (WUA 5, n=18)	86.65	103.39	16.74
Koska MIP Overall (N=96)	96.46	117.98	21.52
Devijhar (Head reach, n=13)	144.94	181.81	36.87
Devijhar (Middle reach, n=57)	147.52	174.34	26.82
Devijhar (Tail reach, n=21)	145.64	160.96	15.32
Devijhar MIP Overall (N=91)	146.38	172.33	25.95
Analaberini (Head reach, n=6)	121.00	151.67	30.67
Analaberini (Middle reach, n=14)	93.92	93.92	0.00
Analaberini MIP Overall (N=20)	104.17	114.17	10.00

3.03% in WUA4 to as high as 50.77% in WUA1. WUA1 and WUA3 which are located in the head reach recorded maximum increase in cropping intensity. At Devijhar, there is an overall increase of about 26% in cropping intensity. The head reach recorded an increase of 36.87% followed by middle reach with 26.82% and tail reach with 15.32%. In Analaberini, there is an overall increase of 10% in cropping intensity. In this case, there is an increase of 30.67% in the head reach while middle reach did not record any increase. Among the three MIPs, highest increase in cropping intensity is recorded at Devijhar and lowest at Analaberini. Head reach of all the MIPs recorded maximum increase in cropping intensity over middle and tail reaches due to its proximity to reservoir.

3.2.3 *Irrigated area*

Tables 15, 16 and 17 present the irrigated area during pre and post rehabilitation period of Koska, Devijhar and Analaberini MIPs, respectively. In case of Koska, there is about 107% increase in irrigated area after rehabilitation. Maximum increase in irrigated area is recorded in WUA 3 (196.03%) followed by WUA 5 (110.4%) and WUA 4 (95.83%). WUA 4 and 5 are located in the middle and tail reach of the command.

Table 15. Change in irrigated area in Koska MI project

Particular	Average land holding (acre)	Cultivated area (acre) / farmer						Change (%)
		Before rehabilitation			After rehabilitation			
		Kharif	*Rabi*	Total	*Kharif*	*Rabi*	Total	
Koska MIP (WUA 1, n=17)								
Mean SD	2.60 1.76	1.48 1.38	0.84 1.23	2.32	2.05 1.30	1.29 1.50	3.34	43.97
Koska MIP (WUA 2, n=12)								
Mean SD	3.52 3.16	1.39 1.42	0.42 0.90	1.81	1.68 1.81	1.65 1.85	3.33	83.97
Koska MIP (WUA 3, n=25)								
Mean SD	3.24 2.22	1.02 1.04	0.49 1.02	1.51	2.39 1.72	2.08 1.45	4.47	196.03
Koska MIP (WUA 4, n=24)								
Mean SD	4.29 2.26	1.62 1.58	0.54 1.56	2.16	3.34 2.03	0.89 1.20	4.23	95.83
Koska MIP (WUA 5, n=18)								
Mean SD	4.42 2.64	1.57 1.83	0.45 0.87	2.02	3.35 2.54	0.90 1.04	4.25	110.40
Koska MIP Overall (N=96)								
Mean SD	3.67 2.41	1.40 1.48	0.54 1.17	1.94	2.67 2.00	1.36 1.45	4.03	107.73

Table 16. Change in irrigated area in Devijhar MI project

Particular	Average land holding (acre)	Cultivated area (acre) / farmer						Change (%)
		Before rehabilitation			After rehabilitation			
		Kharif	*Rabi*	Total	*Kharif*	*Rabi*	Total	
Devijhar (Head reach, n=13)								
Mean SD	3.85 1.52	3.62 1.85	0.00 0.00	3.62	3.66 1.98	2.19 1.65	5.85	61.60
Devijhar (Middle reach, n=57)								
Mean SD	3.43 2.61	3.35 2.70	0.09 0.43	3.43	3.41 2.73	1.21 1.39	4.62	34.69
Devijhar (Tail reach, n=21)								
Mean SD	3.33 2.51	2.93 2.86	0.10 0.30	3.03	3.19 2.54	1.33 1.46	4.52	4.92
Devijhar Overall (N=91)								
Mean SD	3.47 2.44	3.29 2.62	0.08 0.37	3.37	3.39 2.57	1.38 1.47	4.77	41.54

Table 17. Change in irrigated area in Analaberini MI project

Particular	Average land holding (acre)	Cultivated area (acre) / farmer						Change (%)
		Before rehabilitation			After rehabilitation			
		Kharif	*Rabi*	Total	*Kharif*	*Rabi*	Total	
Analaberini (Head reach, n=6)								
Mean SD	3.00 1.79	2.38 2.06	0.83 1.44	3.21	2.47 1.98	1.83 2.02	4.30	33.96
Analaberini (Middle reach, n=14)								
Mean SD	2.14 0.63	1.11 0.55	0.04 0.13	1.15	1.25 0.75	0.04 0.13	1.29	12.17
Analaberini Overall (N=20)								
Mean SD	2.40 1.13	1.49 1.30	0.28 0.83	1.77	1.57 1.15	0.58 1.34	2.15	17.67

Thus, rehabilitation has ensured the water to reach the tail end of the canal due to which significant increase in percentage of irrigated area is recorded in middle and tail reaches. WUA 1 which is located in the head reach recorded least percentage increase in irrigated area (43.97%). This is because the command of WUA1 was receiving irrigation water even in pre rehabilitation period. Hence, rehabilitation has made a greater impact in increasing the percentage of irrigated area at middle and tail reaches of the Koska irrigation system.

The scenario is different in case of Devijhar and Analaberini MIPs. In case of Devijhar, there is an overall increase of 41.54% in the irrigated area in the post rehabilitation period in comparison to pre rehabilitation period. Maximum increase in irrigated area has been recorded in the head reach (61.6%). The least increase in irrigated area has been recorded in the tail reach (4.92%). Thus, the problem of spatial discrepancy in availability of irrigation water still prevails in Devijhar. In Focused Group Discussion, it is learnt that the canal network of Devijhar MIP is partially lined and due to highly permeable soil, irrigation water finds it difficult to reach the tail end. This may be one of the reasons for least increase in irrigated area in the tail reach. Similar finding is recorded for Analaberini MIP. Here, an overall increase of 17.67% in irrigated area during the post rehabilitation period is obtained. Head reach registered highest percentage increase in irrigated area (33.96%) followed by middle reach (12.17%).

Perusal of the data on cultivated area and irrigated area reveals that due to rehabilitation, the cultivated areas which were primarily depending on rainwater in pre-rehabilitation period, most of them have now turned to irrigated-cultivated areas.

3.2.4 *Irrigation intensity*

Table 18 presents the change in irrigation intensity due to rehabilitation of the system. There is an overall increase of about 57% in irrigation intensity at Koska. Among the WUAs, WUA 3 registered maximum increase of about 91.46%. Figs. 6 and 7 present the percentage of area irrigated during *kharif* and *rabi* respectively at Koska MIP during pre and post rehabilitation period. During *kharif*, there is marked increase in percentage of irrigated area in all WUAS except in WUA2. However, during *rabi*, only command areas of WUAs nearer to the reservoir i.e., WUA1, WUA2 and WUA3 have recorded considerable increase in irrigated area. Similarly, in case of Devijhar there is an overall increase in irrigation intensity by about 40%. The head reach registered maximum increase in irrigation intensity (58.16%). Figs. 8 and 9 present the percentage of irrigated area at Devijhar MIP during *kharif* and *rabi* season respectively. During *kharif* a negligible increase is noticed. However, a marked increase is recorded during *rabi*. Thus, for Devijhar MIP, the rehabilitation has significantly increased the irrigated area during *rabi*. Selection of suitable low water requiring crops for cultivation during *rabi* can increase the irrigated area as has been rightly done at Devijhar. Incase of Analaberini, the overall increase is about 15% and the increase in the head reach is about 36.22%. Figs. 10 and 11 present the percentage of area irrigated at Analaberini MIP during *kharif* and *rabi*, respectively. Like that of Devijhar, here also the increase in irrigated area is marginal during *kharif*. A marked increase in irrigated area is seen in the head reach during *rabi*.

Figs. 12 and 13 present the percentage of irrigated area for all three selected MIPs during *kharif* and *rabi* respectively. At Koska, the increase is significant both in *kharif* and *rabi*. However, in the remaining two MIPs i.e., in Devijhar and Analaberini the increase is significant only during *rabi*. Koska has been benefited the maximum in terms of increase in irrigation intensity (about 57%) due to rehabilitation followed by Devijhar (about 40%) and Analaberini (about 15%).

Table 18. Change in irrigation intensity due to rehabilitation in the selected MIPs

Particular	Percentage of area irrigated before rehabilitation			Percentage of area irrigated after rehabilitation			Percent increase in irrigation intensity
	Kharif	*Rabi*	Irrigation intensity (%)	*Kharif*	*Rabi*	Irrigation intensity (%)	
Koska MIP (WUA 1, n=17)	56.86	32.32	89.18	78.62	49.47	128.09	38.91
Koska MIP (WUA 2, n=12)	39.38	11.85	51.23	47.77	46.82	94.59	43.36
Koska MIP (WUA 3, n=25)	31.35	15.18	46.53	73.81	64.18	137.99	91.46
Koska MIP (WUA 4, n=24)	37.76	12.64	50.40	77.78	20.65	98.43	48.03
Koska MIP (WUA 5, n=18)	35.52	10.17	45.69	75.71	20.40	96.11	50.44
Koska MIP Overall (N=96)	38.13	14.71	52.84	72.75	37.06	109.81	56.97
Devijhar (Head reach, n=13)	94.00	0.00	94.00	95.16	57.00	152.16	58.16
Devijhar (Middle reach, n=57)	97.81	2.56	100.37	99.42	35.29	134.71	34.34
Devijhar (Tail reach, n=21)	87.86	2.86	90.72	95.71	40.00	135.71	44.99
Devijhar Overall (N=91)	94.96	2.22	97.18	97.92	39.78	137.70	40.52
Analaberini (Head reach, n=6)	79.44	27.78	107.22	82.33	61.11	143.44	36.22
Analaberini (Middle reach, n=14)	51.67	1.67	53.34	58.33	1.67	60.00	6.66
Analaberini Overall (N=20)	62.08	11.46	73.54	65.21	23.96	89.17	15.63

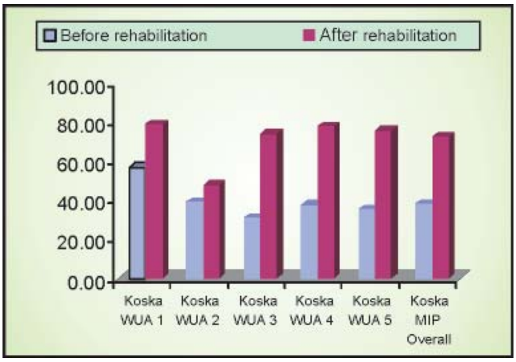


Fig.6 Irrigated area percentage during *kharif* in Koska before and after rehabilitation

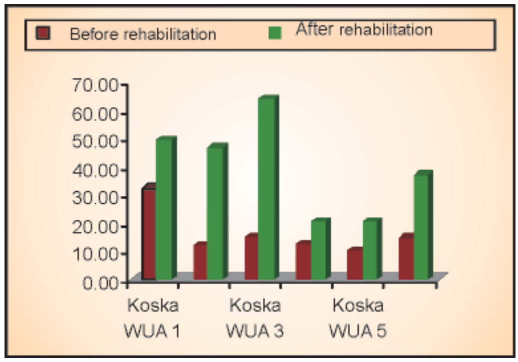


Fig. 7 Irrigated area percentage during *rabi* in Koska before and after rehabilitation

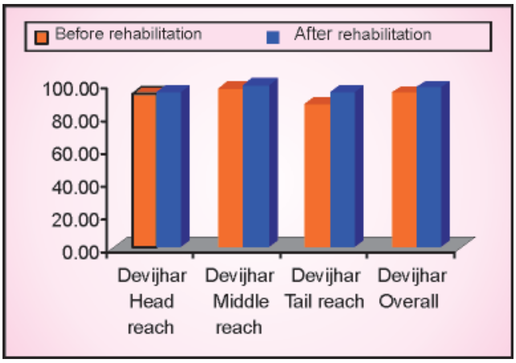


Fig. 8 Irrigated area percentage during *kharif* in Devijhar before and after rehabilitation

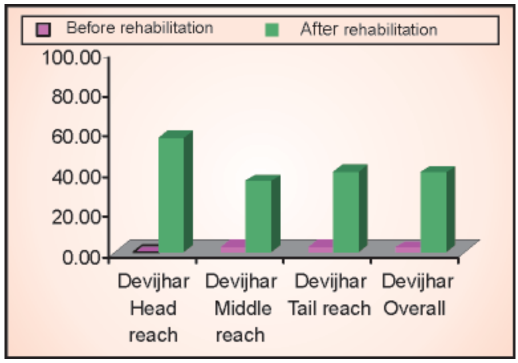


Fig. 9 Irrigated area percentage during *rabi* in Devijhar before and after rehabilitation

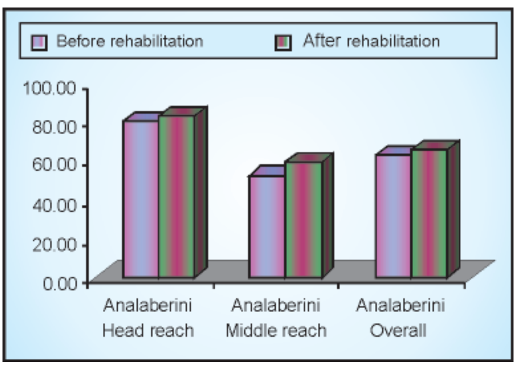


Fig. 10 Irrigated area percentage during *kharif* in Analaberini before and after rehabilitation

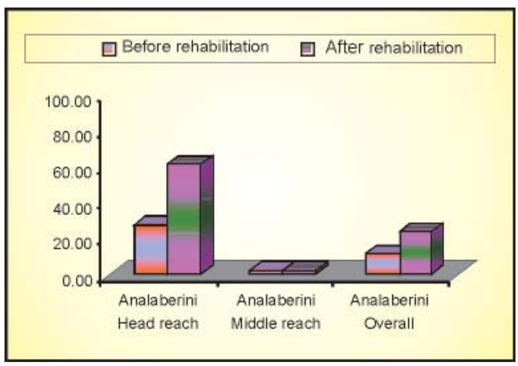


Fig. 11 Irrigated area percentage during *rabi* in Analaberini before and after rehabilitation

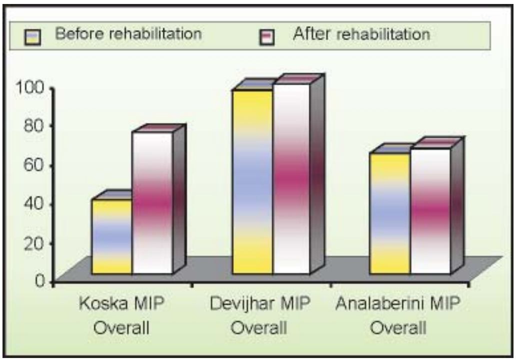


Fig. 12 Irrigated area percentage during *kharif* before and after rehabilitation of Koska, Devijhar and Analaberini MIP

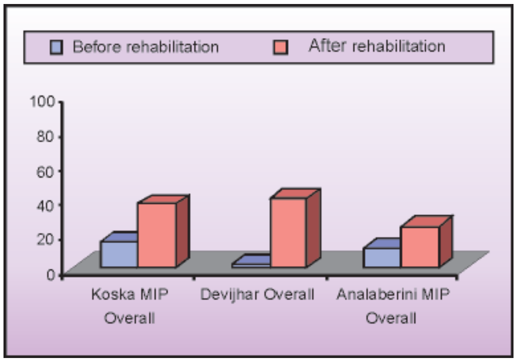


Fig. 13 Irrigated area percentage during *rabi* before and after rehabilitation of Koska, Devijhar and Analaberini MIP

3.2.5 Cropping pattern

Wet season scenario

The cropping pattern of Koska MIP before and after rehabilitation is presented in Table 19. During *kharif*, paddy is the predominant crop in all WUAs. After rehabilitation, there is a reduction in fallow area during *kharif*. Maximum reduction in fallow area has taken place in WUA3 command. Farmers in WUA 4 have taken up vegetable cultivation in a significant way there by increasing vegetable area from 1.24% to 11.88%. Similarly, a marked increase in sugarcane area (Nil to 13.98%) is also noticed in WUA1 after rehabilitation. Thus, after rehabilitation during *kharif* due to assured availability of irrigation water there is a crop diversification from paddy alone to paddy, sugarcane and vegetables. Figs. 14 and 15 present the cropping pattern of Koska MIP during pre and post rehabilitation period respectively during *kharif* season. The area under paddy increased from 78.43% to 80.10%. There is a decrease in fallow

Table 19. Cropping pattern during kharif season in the command of Koska MIP

Name of WUA cultivated	Period	% of area under different crops in command			
		Paddy	Vegetables	Sugarcane	Fallow
WUA 1	Before rehabilitation	69.61	1.16	0.00	29.23
	After rehabilitation	60.77	3.75	13.98	21.50
WUA 2	Before rehabilitation	70.07	0.95	0.00	28.98
	After rehabilitation	70.18	2.14	2.73	24.95
WUA 3	Before rehabilitation	88.27	0.00	0.00	11.73
	After rehabilitation	92.64	2.57	1.96	2.83
WUA 4	Before rehabilitation	78.95	1.24	0.00	19.81
	After rehabilitation	68.78	11.88	0.00	19.34
WUA 5	Before rehabilitation	76.79	0.15	0.00	23.06
	After rehabilitation	79.39	0.70	0.00	19.91

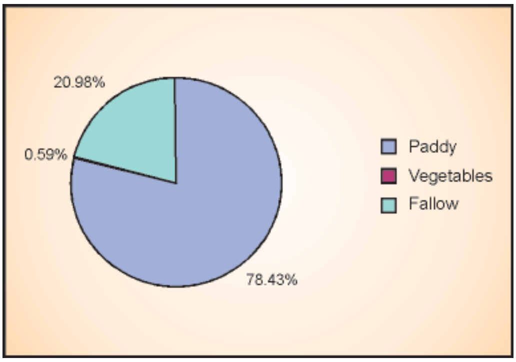


Fig. 14 Cropping pattern during *kharif* season in Koska MIP before rehabilitation

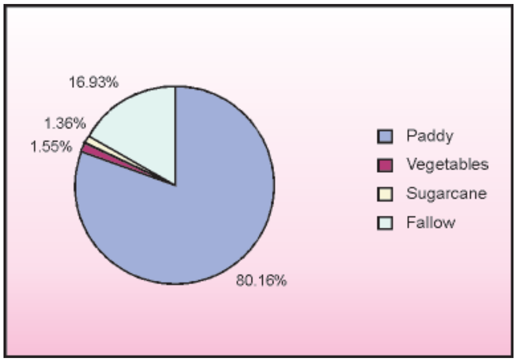


Fig.15 Cropping pattern during *kharif* season in Koska MIP after rehabilitation

area from 20.98% to 16.93%. The vegetable area enhanced from 0.59% to 1.55%. After rehabilitation, sugarcane is also grown in 1.36% area. In k*harif*, about 4% cultivated area has been additionally brought under cultivation after rehabilitation of the MIP.

Figs. 16 and 17 present the cropping pattern of Devijhar MIP during *kharif* before and after rehabilitation respectively. Before rehabilitation, about 94.77% of the command was covered under paddy, 1.84% under vegetables and 3.38% under fallow. After rehabilitation there is a major shift in the cropping pattern. Paddy being the predominate crop continue to get cultivated in major portion of the command. However, there is a decrease in paddy area. It has come down to 74.57%. Farmers have shown interest in growing vegetables as a result 23.93% area is grown with vegetables. About 0.29% area is covered under sugarcane and 1.21% area has still remained fallow. Thus, in *kharif* there is a shift from paddy to non paddy crops which might be the due to assured irrigation water availability and trainings received by the farmers from different agencies during the process of Irrigation Management Transfer.

At Analaberini MIP during *kharif* paddy continue to be the predominant crop. One or two farmers have started growing sugarcane recently.

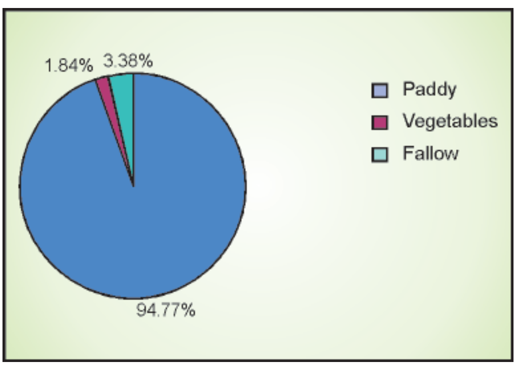


Fig. 16 Cropping pattern during *kharif* season in Devijhar MIP before rehabilitation

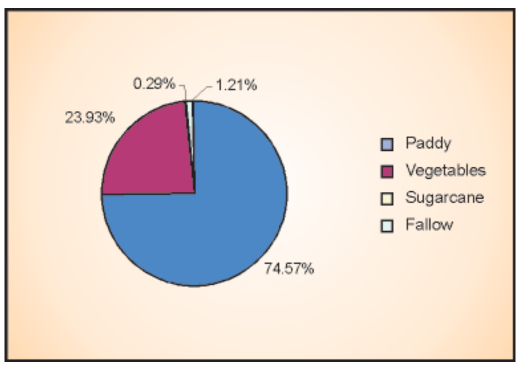


Fig. 17 Cropping pattern during *kharif* season in Devijhar MIP after rehabilitation

Dry season scenario

Table 20 presents the cropping pattern of Koska MIP before and after rehabilitation for *rabi* season. There is a reduction in fallow area. Farmers are largely growing pulses like Green gram, Horse gram, Black gram and Bengal gram. There is also increase in oilseed cultivation such as Sunflower.

Table 20. Cropping pattern during *rabi* season in the command of Koska MIP

Name of WUA	Period	% of area under different crops cultivated in command				
		Pulses	Oilseeds	Vegetables	Sugarcane	Fallow
WUA 1	Before rehabilitation	4.81	0.00	0.42	0.00	94.77
	After rehabilitation	25.38	2.43	9.36	13.98	48.85
WUA 2	Before rehabilitation	32.47	0.00	1.62	0.00	65.91
	After rehabilitation	41.21	3.89	1.31	2.73	50.86
WUA 3	Before rehabilitation	23.46	0.00	0.00	0.00	76.54
	After rehabilitation	42.15	2.18	4.95	1.96	48.76
WUA 4	Before rehabilitation	15.96	0.00	0.82	0.00	83.22
	After rehabilitation	18.40	0.00	0.95	0.00	80.65
WUA 5	Before rehabilitation	9.73	0.00	0.00	0.00	90.27
	After rehabilitation	22.32	0.78	0.20	0.00	76.70

There is an increase in vegetable cultivation. Pointed gourd is the prime vegetables grown in the command followed by Brinjal. Significant increase in vegetable cultivation is recorded in the command of WUA 1 and 3 that are located in head reach of the system. Similarly, sugarcane cultivation is adopted by farmers of WUA 1. Sugarcane being a high water requiring crop, its cultivation needs to be restricted if more area is to be brought under cultivation during *rabi* with the limited availability of water. At the same time Sugarcane is a cash crop which attracts the enterprising farmers to go for it. Figs. 18 and 19 present the percentage of area under different crops during *rabi* season before and after rehabilitation respectively. There is a reduction in fallow area from 82.58% to 65.12%. The area under pulses increased from 16.91% to 30.30%. Also crops like sunflower (oilseed) and sugarcane is successfully grown in the command in about 1 to 2% of the area. About 65% of the area still remains under fallow during *rabi* due to limited water availability.

Figs. 20 and 21 depict the cropping pattern of Devijhar MIP before and after rehabilitation during *rabi* respectively. The scenario looks better than Koska. There is a marked improvement in bringing additional area under cultivation. This has resulted in lowering the fallow area from 50.14% to 26.52%. Before rehabilitation pulses used

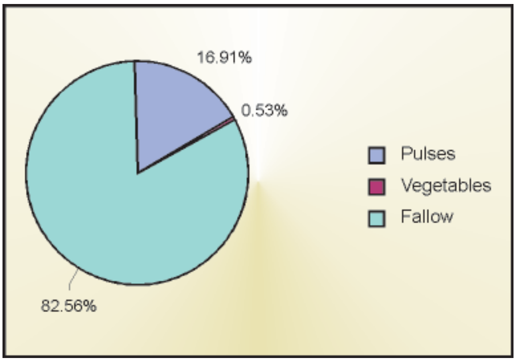


Fig. 18 Cropping pattern during *rabi* season in Koska MIP before rehabilitation

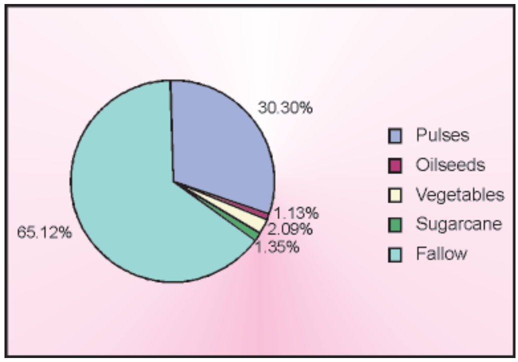


Fig. 19 Cropping pattern during *rabi* season in Koska MIP after rehabilitation

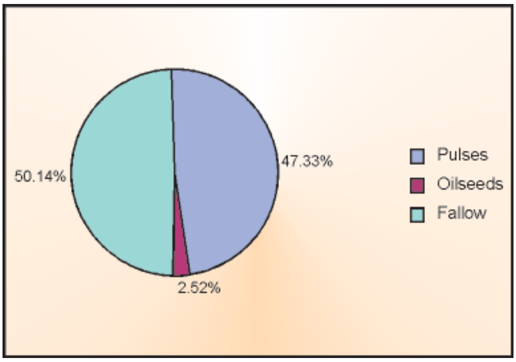


Fig. 20 Cropping pattern during *rabi* season in Devijhar MIP before rehabilitation

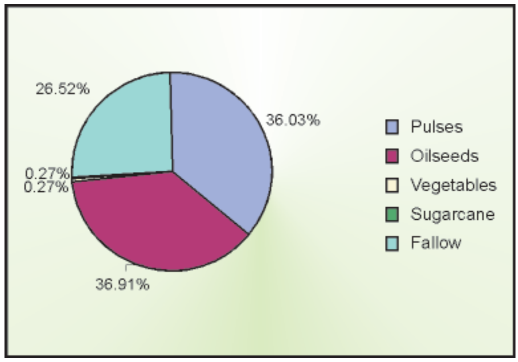


Fig. 21 Cropping pattern during *Rabi* season in Devijhar MIP after rehabilitation

to be the major crop of the command during *rabi*. After rehabilitation, the area under pulses is reduced from 47.33% to 36.03%. With the availability of irrigation water farmers have shown interest to go for cash crop like Groundnut because of which the area under oilseed is increased from 2.52% to 36.91%. This has increased the income of farmers and livelihood condition. Thus, the positive impact rehabilitation and IMT is clearly noticed in Devijhar MIP. There is a need to create more water resource to bring the remaining fallow area under cultivation. There is also a need to judiciously use the available irrigation water.

Since Analaberini MIP has been handed over to farmers few months before this study, its impact on *rabi* crop will be clear in coming *rabi* season.

3.2.6 *Crop productivity*

Crop productivity is one of the most important indicators of the agricultural impact assessment study. The productivity of paddy, pulses, oilseed, sugarcane and vegetables before and after rehabilitation for the MIPs selected are presented in Figs. 22 to 26, respectively. Incase of paddy (Fig. 22), yield improvement in Devijhar MIP is remarkable. On an average, the paddy yield has increased by 37.78%, 73.27% and 21.51% in Koska, Devijhar and Analaberini MIPs respectively due to rehabilitation and IMT. Further, at Devijhar the farmers have started growing high yielding paddy varieties. It is hoped that there will be increasing trend towards cultivation of high yielding paddy not only in Devijhar but also in other MIPs. Thus, in future years it is expected that the yield of paddy will continue to increase.

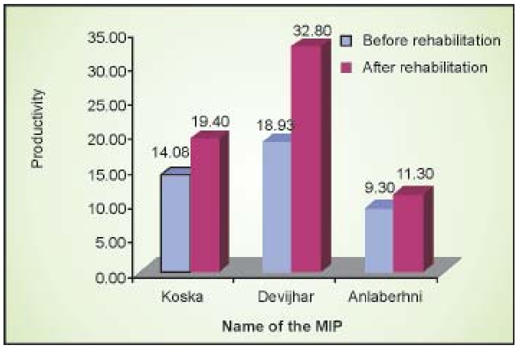


Fig. 22 Productivity of Paddy in the command of selected MIPs before and after rehabilitation

With regard to pulses (Fig. 23), the yield has increased considerably after rehabilitation. Koska registers yield increase of 57.14% and Devijhar 61.70%. Of course the area under pulses has dwindled in Devijhar as farmers have shown their interest towards Groundnut cultivation which fetches more income to them. Remarkable increase in yield is also noticed incase of oilseeds (Fig. 24). Sunflower and Groundnut are the main oilseed crops grown in Koska and Devijhar MIP respectively. In Devijhar, the increase in Groundnut yield is 187.95%. During FGD, farmers and the management committee members of WUA at Devijhar expressed their satisfaction over the extent of cultivation, yield and profit generated from Groundnut cultivation. Sugarcane, a perennial high water requiring crop is also cultivated in the head reach of Koska and Devijhar MIPs. This crop records yield increase of 40% and 44.15% in Koska and Devijhar MIPs respectively (Fig. 25). Vegetable cultivation has come up in a big way in both the MIPs. Pointed gourd and Brinjal are the two main vegetables grown in the command. The yield increase of vegetable (Fig. 26) is about 40% and 45.25% in Koska and Devijhar MIPs respectively. Thus, it may be concluded that rehabilitation and IMT has brought a remarkable increase in crop yield. Farmers of Devijhar have per-

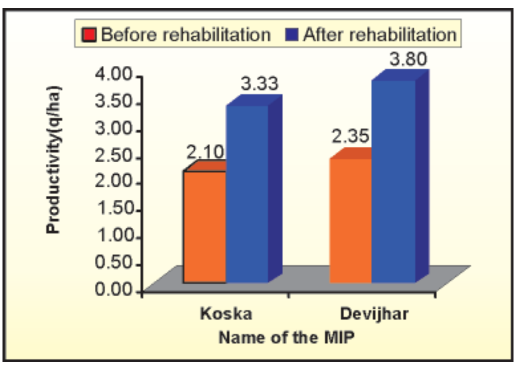


Fig. 23 Productivity of Pulses in the command of selected MIPs before and after rehabilitation

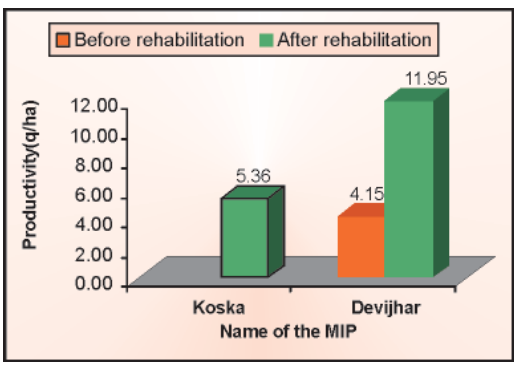


Fig. 24 Productivity of Oilseeds in the command of selected MIPs before and after rehabilitation

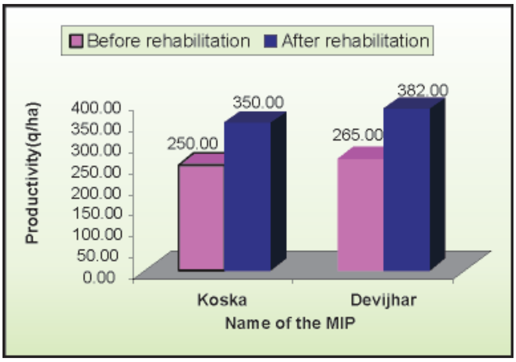


Fig. 25 Productivity of Sugarcane in the command of selected MIPs before and after rehabilitation

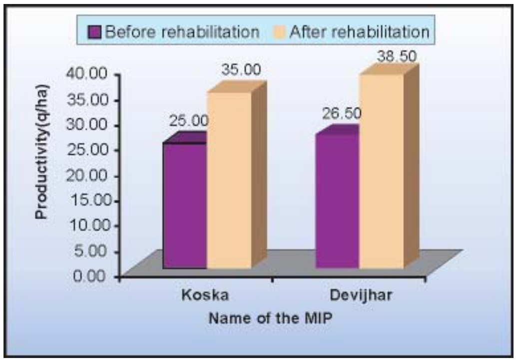


Fig. 26 Productivity of Vegetables in the command of selected MIPs before and after rehabilitation

formed better than that of Koska and Analaberini. As far as the productivity of various crops is concerned, Koska farmers have performed excellent.

3.3 Socio-economic Impact

The socio-economic profile of the respondents from selected MIPs was analyzed on the basis of literacy level, age group, caste composition, land holding size class distribution, occupational pattern, income distribution, migration, consumption expenditure pattern, on-farm employment pattern, liability position and gender issues.

3.3.1 *Educational level of the respondents*

Table 21 reveals that under all categories of farmers in Koska system, maximum households come under primary educated respondents where as for medium and large farmer category, the education level is high school. Only three respondents in Koska attained college education that came under large category of farmers. It indicates that majority of the farmers were primary educated in Koska system irrespective of size class wise holdings. Similar is the case for Analaberini, which indicates that more than 60% of farmer comes under primary educated category. However for Devijhar, most of the farmers are either illiterate or functionally literate which combined together come to more than 70% of the total respondents. The effect of literacy on management of WUA and crop production parameters may have a bearing in the long run when sustainability factor is taken into account.

3.3.2 *Age distribution of respondent farmers across the systems*

Table 22 reveals age composition of respondent farmers across the MI systems. It is reflected from the table that in Koska irrigation system, more than 50% of farmers under marginal and small category are of age between 18-50 years, which indicates that, the respondents are productive in managing the agricultural operations and can take risk. However the farmers having above 50 years of age is also around 50% which

Table 21. Distribution of households on education type

Name of MIP	Education level	Frequency of farmers			
		Marginal & Small (up to 2.5 acres)	Medium (2.5 to 5.0 acres)	Large (above 5.0 acres)	Total
Koska	Illiterate	1	1	0	2
	Functionally literate	5	0	0	5
	Primary	35	19	16	70
	High school	6	9	1	16
	College	0	0	3	3
	All	47	29	20	96
Analaberini	Illiterate	0	0	0	0
	Functionally literate	3	3	0	6
	Primary	9	3	1	13
	High school	1	0	0	1
	College	0	0	0	0
	All	13	6	1	20
Devijhar	Illiterate	17	11	5	33
	Functionally literate	14	11	8	33
	Primary	9	12	0	21
	High school	2	0	1	3
	College	1	0	0	1
	All	43	34	14	91

Table 22. Distribution of respondents in to age group

Name of MIP	Age	Frequency of farmers			
		Marginal & Small (up to 2.5 acres)	Medium (2.5 to 5.0 acres)	Large (above 5.0 acres)	Total
Koska	0-18	0	0	0	0
	18-50	24	18	9	51
	Above 50	23	11	11	45
	All	47	29	20	96
Analaberini	0-18	0	0	0	0
	18-50	7	3	1	11
	Above 50	6	3	0	9
	All	13	6	1	20
Devijhar	0-18	0	0	0	0
	18-50	26	23	5	54
	Above 50	17	11	9	37
	All	43	34	14	91

reflect ageing of the farming community under this category, indicating less risk bearing ability and may be less ability to try out with new cropping system. Under Analaberini system, the trend is also similar with respect to marginal and small as well as medium category of farmers where as for Devijhar the farmers having age group between 18 to 50 years is dominating among all size class of farmers indicating a healthy trend towards risk taking ability and possibility of crop diversification as well as effective WUA operation. It is inferred from the table that, for Devijhar system the functioning of WUA may be more vibrant due to relatively younger group dominance in the farming community who can assimilate new ideas and can be early adopters.

3.3.3 *Caste composition of the respondents across the systems*

The caste composition of the respondents is reflected in the Table 23. A cursory view of the caste composition of the respondents reflects that Other Backward Castes (OBC), majority of which belong to traditional cultivator class in Orissa, is predominant in all the system except in Analaberini. The traditional cultivator class in Orissa is more enterprising and hard working in the field of agriculture. The marginal and small farm size class has maximum households under OBC category except Analaberini where general caste is predominant. For Koska and Devijhar, the OBC category of farmers is predominant (more than 70%) in all the size class of farmers. In terms of cultivation practices, enterprising and risk taking, it may be a good composition to have traditional farming communities in predominance. The homogeneity in caste and social background may contribute to strengthening of WUA sustainability in the long run. So more the social homogeneity, the more is the likelihood of sustainability of WUAs.

Table 23. Caste composition of respondents

Name of MIP	Age	Frequency of farmers			
		Marginal & Small (up to 2.5 acres)	Medium (2.5 to 5.0 acres)	Large (above 5.0 acres)	Total
Koska	SC/ST	4	1	4	9
	OBC	41	28	12	81
	General	2	0	4	6
	All	47	29	20	96
Analaberini	SC/ST	4	3	0	7
	OBC	0	0	0	0
	General	9	3	1	13
	All	13	6	1	20
Devijhar	SC/ST	4	5	0	9
	OBC	31	25	13	69
	General	8	4	1	13
	All	43	34	14	91

3.3.4 *Size class wise distribution of respondents*

Table 24 reveals the size class wise distribution of the sampled farming communities across the MI systems. The size class wise distribution of land holding indicates the land owning pattern and equity of land distribution across the size classes. The table reveals that the marginal and small size class of farmers under Koska irrigation system which constitute 49% of the total respondents under the system are having 21.5% of total operational holding and medium farmers who constitute 30.20 percent of total respondents possess 32.32% of operational holding as against 46.18% of holding by large farmers who constitute only 20.83% of the respondents. A perusal from table for Koska reveals that land distribution is not equitable under the system and there is little scope for the farmers to diversify or try out with new crops, as the traditional paddy cultivation has to continue to assure household cereal security from small piece of land. The average holding of the farmers in the marginal and small category under Koska system was calculated to be 1.61 acre in comparison to average holdings for medium and large holding of 3.92 acre and 8.13 acre respectively. It indicates large inequality in the operational holding across the size class of farmers, which may jeopardize the institutional mechanism in the long run if sufficient attention is not given to the interest of the marginal and small farmers.

For Analaberini, the average size of holding for marginal and small groups was calculated to be 1.61 acres as against 3.16 and 6.00 acres for medium and large farmers respectively. The total operational area under the different size class indicates that marginal and

Table 24. Size Class wise distribution of households

Name of MIP	Farm Size	No. of farmers	% of total sample	Total land holding (acres)	Average holding (acres)	% of total holding
Koska	Marginal and small	47	48.95	75.69	1.61	21.5
	Medium	29	30.20	113.8	3.92	32.32
	Large	20	20.83	162.6	8.13	46.18
	All	96	100	352.09	3.67	100
Analaberini	Marginal and small	13	65	23	1.76	47.92
	Medium	6	30	19	3.16	39.58
	Large	1	05	6	6.00	12.5
	All	20	100	48	2.40	100
Devijhar	Marginal and small	43	47.25	63	0.63	20.06
	Medium	34	37.37	139.5	4.10	44.35
	Large	14	15.38	112	8.00	35.59
	All	91	100	314.5	3.47	100

small holdings that constitute 65% of the respondents possess around 48% of operational area as against 40% and 12.5% of area possessed by medium and large categories of farmers who constitute 30% and 5% of total holdings respectively. The inequity in operational area also holds true in Analaberini case, which is a matter of concern.

For Devijhar system, the perusal of table reveals that around 47% of the respondents who belong to marginal and small holding category possess only 20% of operational area where as the medium and large farmers who constitute 37% and 15% of respondents possess 44% and 36% of operational area respectively indicating strong inequity in the distribution of operational holdings. The inequalities in land distribution may come on the way of smooth operation of institutional mechanism for equitable distribution of water in a MI system. It may also weaken the democratic rights of the WUA members as the economically weaker section may get marginalized under the pressure of large holdings that may manage to control the WUA through more economic power.

3.3.5 *Occupational distribution of households*

The occupational distribution of sampled households (Table 25) indicates that more than 95% across the size class of farmers under all the system depend on agriculture as the main source of income. For Koska, 1.04% of respondents reported Dairy and Business as main occupation where as for Analaberini and Devijhar around 1.9% respondents reported for Dairy and Service as main occupation and 5% respondents under Analaberini reported Business as main occupation. The trend in occupational pattern for all the system indicate that agriculture being main stay of the population, there is likelihood that the farmers would take genuine interest in managing the system under WUA umbrella. There would be real interest of the farmers to increase agricultural income through commercialization and diversification if their skill is upgraded under assured water availability scenario. The change in occupation pattern may have taken place after availability of assured irrigation for sampled farmers. For Koska system as revealed from the analysis of migration pattern, migratory farmers have adopted agriculture as main occupation after rehabilitation. Random sample survey of a bench mark study under Devijhar system indicates that around 45% of respondent farmers reported agriculture as the main occupation in the year 1999 in comparison of 95% during the study. This is a distinct improvement of rehabilitation of the MI system over pre rehabilitation scenario.

3.3.6 *Income*

Perusal of Tables 26 to 28 and Figs. 27 to 29 reveals that the income change after rehabilitation has been substantial for all the systems of MI under study. The percent change in income (71%) for WUA 3 at Koska has been maximum in comparison to other WUAs after rehabilitation and turnover of the system. The WUA 3 under Koska

Table 25. Occupation wise distributions of sampled households

Name of MIP	Education level	Frequency of farmers				
		Marginal & Small (up to 2.5 acres)	Medium (2.5 to 5.0 acres)	Large (above 5.0 acres)	Total	%Total
Koska	Agriculture	46	27	20	93	96.87
	Dairy	1	0	0	1	1.04
	Fishery	0	0	0	0	0.00
	Service	0	1	0	1	0.00
	Business	0	1	0	1	1.04
	Other	0	0	0	0	0.00
	All	47	29	20	96	100.00
Analaberini	Agriculture	13	5	1	19	95.00
	Dairy	0	0	0	0	0.00
	Fishery	0	0	0	0	0.00
	Service	0	0	0	0	0.00
	Business	0	1	0	1	5.00
	Other	0	0	0	0	0.00
	All	13	6	1	20	100.00
Devijhar	Agriculture	42	33	13	88	96.70
	Dairy	0	1	0	1	1.09
	Fishery	0	0	0	0	0.00
	Service	0	0	1	1	1.09
	Business	0	0	0	0	0.00
	Other	1	0	0	1	1.09
	All	43	34	14	91	100.00

Table 26. Average income of farmers at Koska before and after rehabilitation

Particular	Period	Income (Rs.)
WUA 1 at Koska	Before rehabilitation	2301.69
	After rehabilitation	3915.25
WUA 2 at Koska	Before rehabilitation	2792.82
	After rehabilitation	3834.25
WUA 3 at Koska	Before rehabilitation	2593.69
	After rehabilitation	4441.02
WUA 4 at Koska	Before rehabilitation	4206.50
	After rehabilitation	7175.83
WUA 5 at koska	Before rehabilitation	4221.30
	After rehabilitation	4955.41
Koska overall	Before rehabilitation	3436.81
	After rehabilitation	5367.24

system is situated in the head end of the main canal. Adequacy and reliability of irrigation supply might have contributed to better agricultural input management. Within the WUAs the least income change (17%) was noticed for WUA 5 under Koska system. The WUA 5 under Koska system is situated at the tail end of the canal and reliability as well as adequacy factor is weak under present scenario.

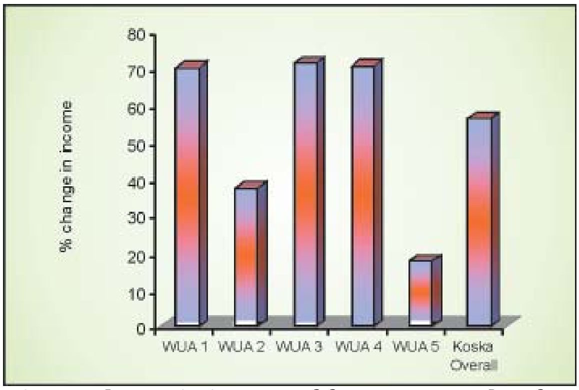


Fig. 27 Change in income of farmers at Koska after rehabilitation

Table 27. Average income of farmers at Analaberini before and after rehabilitation

Particular	Period	Income (Rs.)
Analaberini Head	Before rehabilitation	5667
	After rehabilitation	7528
Analaberini Middle	Before rehabilitation	2966
	After rehabilitation	3641
Analaberini Overall	Before rehabilitation	4020.83
	After rehabilitation	5147.92

It is revealing from Table 27 and Fig. 28 that the income change after rehabilitation of Analaberini MI system was calculated to be the least (28.3%). The fact that the system was recently rehabilitated and turned over and weak institutional build up might have contributed to non-realisation of irrigation potential after rehabilitation. A focused Group Discussion (FGD) revealed that the farmers were not aware about the pricing modalities of canal water and skill build up of farmers was not adequate. However more hydrological investigation is required to study the canal water supply and crop water demand under the system.

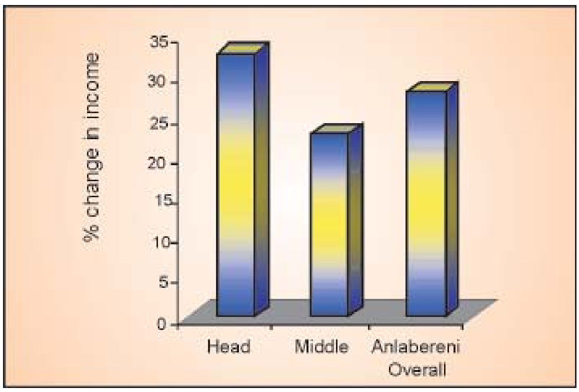


Fig. 28 Change in income of farmers

Evidently from Table 28 and Fig. 29, the change in income (80%) of farmers at Devijhar system has been highest in comparison to other system due to large-scale groundnut cultivation in the command during *rabi*. Devijhar head reach change in income comes next to the tail reach change percentage. It is startling that the tail farmers are benefited

Table 28. Average income of farmers at Devijhar before and after rehabilitation

Particular	Period	Income (Rs.)
Devijhar Head	Before rehabilitation	4163
	After rehabilitation	8432
Devijhar Middle	Before rehabilitation	4895
	After rehabilitation	8096
Devijhar Tail	Before rehabilitation	3571
	After rehabilitation	7698
Devijhar Overall	Before rehabilitation	4490.77
	After rehabilitation	8061.82

maximum due to rehabilitation in Devijhar system. The tail end farmers under Devijhar system were getting low income before the intervention indicating lower base income in comparison to other reaches of the system. Before rehabilitation it is observed that the tail reach income was abysmally low due to non-availability of assured irrigation water. The increase in income after rehabilitation was remarkable. The crop diversification and cultivation of groundnut as well as scientific water management by the farmers might have contributed to the substantial increase in income in the above cases. So the rehabilitation of the systems has positively impacted the farm business income of farmers. Overall Devijhar performed better in terms of income impact followed by Koska (56.17%) and Analaberini (28.13%).

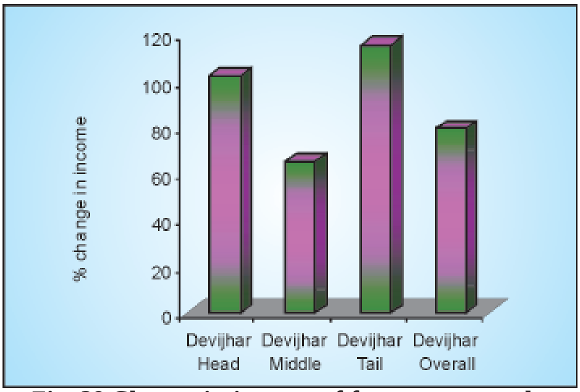


Fig. 29 Change in income of farmers across the system at Devijhar after rehabilitation

3.3.7 *Migration*

The rehabilitation impact on migration is reflected in Table 29. It is inferred from the table that under Koska system, 13 and 16 farmers were migrating under WUA1 and WUA 3, respectively. Under WUA 2 only 2 farmers were migrating. The number of days of migration was 130 days for WUA 3 and 73 days for WUA 1 and 45 days for WUA 2. The type of job engaged at the migration point were mostly unskilled and semiskilled ones. The daily wage rate varied from as low as Rs. 38 to as high as Rs. 60. The analysis of post rehabilitation scenario in Koska reveals that the impact on migration has been significant. The seasonal migration has stopped totally. The availability of alternative income source through improved agriculture has stopped migration in the area. In Analaberini, the migration was not much even before

Table 29. Effect of rehabilitation and IMT on migration

Particular	Period	No. of persons	No. of days	Type of Job	Wage rate (Rs/day)	Monthly income (Rs)
WUA 1 at Koska	Before rehabilitation	13	73	Labour, Driving	49	1414
	After rehabilitation	-	-	-	-	-
WUA 2	Before rehabilitation	2	45	Labour	38	1500
at Koska	After rehabilitation	-	-	-	-	-
WUA 3	Before rehabilitation	16	130	Labour, spinning	60	1800
at Koska	After rehabilitation	-	-	-	-	-
WUA 4	Before rehabilitation	-	-	-	-	-
at Koska	After rehabilitation	-	-	-	-	-
WUA 5	Before rehabilitation	1	15	Labour, spinning	55	1000
at Koska	After rehabilitation	-	-	-	-	
Koska	Before rehabilitation	39	86	Labour, Spinning, Driving	52	1603
overall	After rehabilitation	-	-	-	-	-
Analaberini	Before rehabilitation	6	60	Labour	42	
	After rehabilitation			-	-	-
Devijhar	Before rehabilitation	154	214	Labour, Spinning, Mason	80.75	4222
	After rehabilitation	139	209	-	-	-

rehabilitation. Only six respondents reported migrating for a duration of 60 days in a year. After rehabilitation, the migration reduced to zero indicating a very positive impact of the rehabilitation. For Devijhar system the data on migration reveals that even after rehabilitation 154 numbers of people migrated from the 91 respondent families with an average of 1.69 per family. The post rehabilitation impact on migration was not much substantial as the figure came down to 139 from 154. There was semiskilled migration in the area after rehabilitation, which is a healthy trend as the monthly mean income is stated to be around Rs. 4220, which looks to be a modest one in comparison to low-level agricultural income. The duration of migration is also more for Devijhar system indicating more meaningful employment at the destination source.

3.3.8 Consumption Pattern

The analysis of impact of rehabilitation on monthly consumption pattern of major food and other items indicates that there has been little effect of system improvement on overall consumption pattern (Table 30). However, as the increase in income of the beneficiaries is yet to be sustained, the overall income impact may take some time to manifest.

Table 30. Monthly household expenditure pattern on major items of consumption across the systems

Particular	Period	Cereals		Pulses		Oil		Vegetables		Milk		Festivals	Others	Total	%
Koska		Qnty. (Kg.)	Value (Rs.)	Qnty. (Kg.)	Value (Rs.)	Qnty. (Kg.)	Value (Rs.)	Qnty. (Kg.)	Value (Rs.)	Qnty. (Kg.)	Value (Rs.)				Change
WUA 1 at Koska	B	92	924	4	99	2	97	36	346	11	109	2	0	1577	
	A	81	807	3	89	4	157	26	112	7	74	10	3	1252	-20.60
WUA 2 at Koska	B	59	589	4	104	2	74	27	266	4	44	10	0	1087	
	A	61	610	5	124	2	118	29	132	3	29	15	3	1031	-5.15
WUA 3 at Koska	B	75	754	3	82	1	70	19	197	6	64	18	7	1192	
	A	82	820	3	99	2	85	21	85	8	82	21	9	1201	0.75
WUA 4 at Koska	B	101	1085	7	187	3	127					52	38	1489	
	A	104	1035	7	190	3	135			4	42	40	57	1499	0.67
WUA 5 at Koska	B	158	1653	10	263	3	161					20	21	2118	
	A	153	1528	10	263	3	146	3	17			13	39	2006	-5.28
Koska overall	B	98	1015	6	148	2	107	15	146	4	41	23	15	1495	
	A	98	978	6	154	3	126	14	62	5	49	22	25	1414	-5.41
Analaberini	B	102	939	5	131	2	92	36	360	3	33			1555	
	A	102	1018	5	129	2	108	37	356	4	36			1647	5.91
Devijhar	B	82	847	17	370	3	132	54	534	6	60	256	378	2577	
	A	87	872	15	364	3	143	57	563	7	70	273	399	2684	4.15

B and A stand for before and after rehabilitation

In Koska, WUA 1, WUA 2 and WUA 5 experienced negative expenditure on major food items. The respondents mostly replied for the purchased items only. The home production items sometimes do not get reported in rural areas. The vegetable is mostly home produced which gets under reported during questionnaire survey. There has been marginal increase on food items in other MI systems. The inflationary impact on food prices has also negated the quantification of the items of consumption. So definite conclusion cannot be reached with regard to impact of rehabilitation on pattern of consumption expenditure across the MI system. The monthly per capita consumption expenditure in Koska, Analaberini and Devijhar comes to Rs. 282.80, Rs. 329.40 and Rs. 536.80 respectively, which is much better than the all Orissa average food item expenditure of Rs. 239.25 during 2000-2001.

3.3.9 *Household liability*

The liability position under different study systems is depicted in the Table 31. From the table it is evident that most of the farmers have gone for institutional borrowing from the sources like Cooperative Societies, Commercial Banks and Government sources. Under Koska system, most of the farmers have hand loans from relatives and friends. Some farmers have loans from Moneylenders also. Under Devijhar system, farmers have availed loans from all the institutional sources comprising of Government, Banks and Cooperatives. All size class of farmers also takes hand loans under Devijhar system. With respect to total amount borrowed, for Koska System, Cooperatives have played a major role followed by Commercial Banks and Govt. source respectively. The average loan position under all system of study is maximum for large farmers followed by medium farmers and small and marginal farmers. The loan position of marginal and small farmers is the least of all size class of farmers under Analaberini

Table 31. Household liability positions across the systems

Particular	Amount Borrowed (Rs.)						Amount Repaid (Rs.)				
	Size class	Govt.	Bank	Co-operative	Money lender	Hand loan	Govt.	Bank	Co-operative	Money lender	Hand loan
Koska	Marginal & small	0	957	319	0	213	0	63	204	0	0
	Medium	1276	1138	1414	0	1724	0	2	0	0	0
	Large	0	4300	6750	100	1750	0	0	0	0	0
	Total	385	1708	1990	21	990	0	31	100	0	0
Analaberini	M&S	0	462	6692	0	0	0	438	0	0	0
	Medium	0	11667	13667	0	0	0	2500	2500	0	0
	Large	0	0	25000	0	0	0	0	0	0	0
	Total	0	3800	9700	0	0	0	1035	750	0	0
Devijhar	M&S	419	953	4209	0	2698	116	465	419	0	1116
	Medium	1030	588	7647	0	1423	353	0	471	0	147
	Large	0	1429	8286	0	2143	0	0	0	0	0
	Total	582	890	6121	0	2136	187	220	374	0	582

system. The average amount borrowed by all farmers is maximum from Cooperative system followed by Banks and Government source.

3.3.10 Employment pattern

Table 32 and Figs. 30 to 32 depict the employment pattern in farm sector before and after rehabilitation in different MI system under study. The perusal of Table 32 and Fig. 30 reveals that under Koska system, maximum change in hired labour (60.60%) has come under marginal and small farmer category indicating the increase in on-farm employment, which resulted in total stoppage of migratory labour from the area after rehabilitation. There has also been a substantial increase in family labour in all categories of farmers except large farmers which infact went down after rehabilitation. It might have been due to renting out the lands or farm mechanization. But there has been a change of 38% in the hired labour indicating overall increase in on-farm employment. The Koska system has experienced increase in on-farm employment varying between 13% to as high as 60.60% for different size class of farmers.

Table 32. Change in Employment Scenario across the systems

Particular	Period	Man-days employment per acre					
		Small and Marginal Farmer		Medium Farmer		Large Farmer	
		Family Labour	Hired Labour	Family Labour	Hired Labour	Family Labour	Hired Labour
Koska	BR	2.54	14.95	1.46	17.29	1.18	14.56
	AR	2.99	24.01	1.66	23.51	0.94	20.08
Analaberini	BR	1.33	3.97	0.72	2.42	0.72	2.42
	AR	1.22	4.25	0.72	2.43	0.72	2.43
Devijhar	BR	22.56	6.52	25.64	13.03	25.64	13.03
	AR	40.26	14.64	34.72	18.41	34.72	18.41

BR and AR stand for before and after rehabilitation

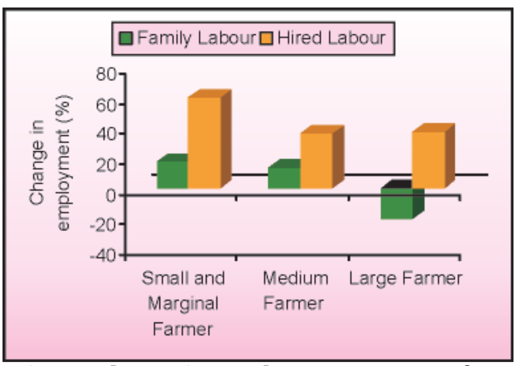


Fig. 30 Change in employment pattern after rehabilitation in Koska MIP

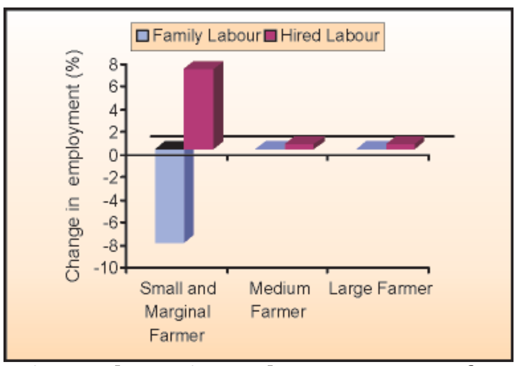


Fig. 31 Change in employment pattern after rehabilitation in Analaberini MIP

For Analaberini system, there has been no or little change in the on-farm employment scenario after rehabilitation as is evident from the Table 32 and Fig. 31. The reason being, the farmers are yet to internalize the impact as the system was handed over only four months before the study was undertaken. The farmers are yet to take up *rabi* crop after rehabilitation which may enhance the on-farm employment of hired and family labour in future.

Devijhar system has experienced maximum change in on-farm employment after rehabilitation (Table 32 and Fig. 32). Maximum change of 124% in hired labour has been observed for marginal and small farmers . The trend is healthy one and may create economic employment for the migratory labourers in long run. Crop diversification and increase in cropping intensity may have contributed to increase in on-farm employment for the small and marginal farmers. The picture is also equally encouraging for other size class of farmers under the MI system. There has been significant increase in employment of family labour for all size class of farmers in Devijhar system, which varies between 35% to as high as 78% for large and marginal and small size class of farmers. The increase in on-farm employment has been quite significant for all the system of rehabilitated MI projects under study other than Analaberini, which is yet to take up crop after rehabilitation. Maximum on-farm employment creation has been experienced by marginal and small category followed by medium category and the large category of farmers for all the system.

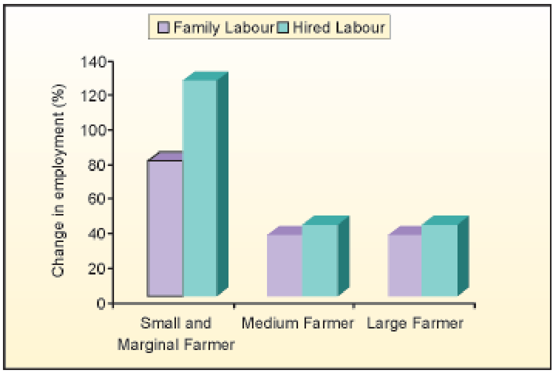


Fig. 32 Change in employment pattern after rehabilitation in Devijhar MIP

3.4 Institutional Impact

Institutional intervention has taken place through formation of water user association (WUA) and handing over the irrigation system to it for operation and management. The nature and functioning of the system, attitude of the farmers towards WUA, the extent of their participation and group effectiveness of WUA were studied through focus group discussion, key informant interviews and interview schedule survey of selected farmers under each system.

3.4.1 *Nature and functioning of WUAs*

The nature and functioning of the WUAs under the Koska, Devijhar and Analabereni MIPs was found to be contrasting. A total of five WUAs have been functioning with an APEX under the Koska MIP covering 21 villages while only one WUA has been functioning at Devijhar covering 10 villages and one WUA at Analabereni covering 1 village and 1 hamlet. Total numbers of members in WUAs at Koska ranged from 128 to 275 for different WUAs while the WUA at Devijhar and Analabereni have 934 and 140 members, respectively. APEX at Koska is a body of 11 persons (2 members from each WUA barring WUA 4 from where 3 members as selected by general body of WUAs). The village committee or village water user groups function at Devijhar and one member of each village committee represents in WUA management committee.

The objectives fulfilled at all the places through IMT are

- Created awareness amongst farmers in the commands towards the benefits of formation of WUA
- Inculcated a feeling of unity and brotherhood among fellow farmers
- The farmers feel the renovated irrigation system as their own rather than that of Government
- Built confidence amongst farmers regarding better returns once equitable, timely irrigation supplies are assured.
- Convinced farmers for going for cash crops under crop diversification programme to get better returns on their investments
- Arranged trainings at State, District, Block and *Panchayat* levels to develop capacities, knowledge and skills of the farmers

There are specific prescribed functions for the WUA; however, still there is a gap between prescribed and performed functions. The WUAs selected for present study have been primarily taking up following major activities:

- Preparing and maintaining an inventory of the irrigation system, member-farmers, natural resources (common land, water bodies, etc) within the WUA's area of operation
- Operation and maintenance of irrigation system in its jurisdiction
- Ensuring construction, maintenance and repair of all the watercourses, field channels, field drainage in the said area
- Preparing cropping programme in its area
- Collection of water rates
- Establishing its own operation and maintenance fund (O & M fund) to meet the operation and maintenance expenditure
- Accounting and record maintenance

3.4.2 *Attitude of the farmers towards WUA*

The attitude of farmers towards irrigation management transfer (IMT) was studied through the following statements using the methodology stated earlier:

- WUA has made significant improvement in the farming condition of farmers
- WUA promotes mutual co-operation among farmers
- WUA does solve water related problems of farmers
- WUA fails to maintain economy and equitability in distribution of water among the farmers
- Irrigation system performs excellently since the responsibility of operation and maintenance shifted to farmers group / WUA
- WUA also ensure regular maintenance of all the watercourses and other structures in its jurisdiction
- WUA establishes financial self-sufficiency
- WUA does not have any impact in increasing the income of member farmers
- WUA intends for judicious management of water and in reality nothing is done so far
- Formation of WUA has increased conflicts in village

It is found from the responses of member-farmers of WUA 1 and WUA 2 at Koska that more than 80% of respondents showed favourable attitude towards WUA as it has made significant improvement in the farming condition of farmers, promoted mutual co-operation among farmers, ensured better performance of irrigation system with regular maintenance of it. The member-farmers also agreed to the fact that irrigation management and transfer to WUA have also made a positive impact in increasing their income. Although 80 % of the member-farmers of WUA 3 were convinced about the significant improvement in the farming condition of farmers due to irrigation management transfer to WUA but quite a good number of respondents (>20%) were having a kind of doubtful opinion for many of the issues. However, majority of the respondents expressed their opinion positively leading to a favourable attitude towards WUA. It is interesting to note that in case of WUA 4 at Koska, only about 25% of the selected member-farmers opined that the WUA promotes mutual co-operation among farmers and about 30% of them felt that the WUA has increased conflicts in the villages. Although all the respondents agreed with the assured maintenance of the system by WUA in its jurisdiction but they did not agree with WUA's financial self-sufficiency. Most of them expressed that WUA has made significant improvement in the farming condition and income of the farmers and solved water related problems of them. Like the member-farmers of WUA 4 the most of the selected member-farmers of WUA 5 also were not agreed that WUA establishes financial self-sufficiency and mutual co-operation among farmers. Inspite of their favorable perception with WUA in improving farming condition majority did not perceive many of the other issues favourably; in fact, many of the respondents were found to be undecided of their opinion for few issues.

The contrasting attitude of member-farmers of WUAs under Koska MI system may be influenced by spatial differences in their area of operation, group size and group dynamic effectiveness.

It is heartening to find that all the selected member-farmers of WUA under Devijhar MI project showed positive attitude being agreed most of the issues. However, almost all of them were undecided about WUA's role in judicious management of water and few of them were not fully convinced that WUA establishes financial self-sufficiency. This kind of non-convincing attitude may be due to the experience of the farmers during last year (2004-05) while many farmers have cultivated groundnut crop during dry season and faced dearth of irrigation water during later crop growth period. It gives a feed back to make proper crop planning depending on area, crop water requirement and availability of water in reservoir for providing irrigation.

It is a kind of contrasting attitude of the selected member-farmers under Analaberini MI system as all most all of them agreed with most of the issues that WUA has improved farming condition, promoted mutual co-operation, solved water related problems, increased irrigation performance, ensured regular maintenance of system, established financial self-sufficiency and reduced conflicts in village. However, it is surprising to note that they were not convinced that WUA has made an impact in judicious water management and increased income of farmers. This contrasting attitude may be due to the fact that farmers grow crops as per their will rather than a selected cropping pattern by WUA.

Linguistic expression of the farmers on 10 different issues was quantified on 3-point continuum (2-agree, 1-undecided and 0-disagree for favourable statement and reverse score for unfavourable statement). To understand the overall level of attitude of member-farmers in different WUIAs, the aggregate of farmers' responses was derived through calculation of mean value and variations in their opinions were realized through standard deviation values. An analysis of the attitude of the farmers of selected 3 MI systems is presented in the Table 33.

It reveals that member-farmers of WUA at Devijhar showed more favourable attitude as compared to WUAs at Koska and WUA at Analabereni. WUA 1 and 2 at Koska were found to be perceived relatively better by the selected farmers; however, the difference in the farmer' perceptions seemed to be very high in case of WUA 2 followed by WUA 3 at Koska. Perceived attitude level of member-farmers was lowest in case of WUA 5 at Koska. Member-farmers of both Koska and Analabereni WUAs varied in their attitude as evident from relative higher standard deviation values and that was

Table 33. Perceived attitude level of member-farmers in different selected WUAs

Name of WUA	Overall mean score	Standard deviation
WUA 1 at Koska (n=17)	17.41	2.92
WUA 2 at Koska (n=12)	17.00	5.69
WUA 3 at Koska (n=25)	16.44	4.39
WUA 4 at Koska (n=24)	14.00	1.14
WUA 5 at Koska (n=18)	13.11	2.17
Overall at Koska including all WUAs (N= 96)	15.45	3.74
WUA at Devijhar (N=91)	18.67	0.93
WUA at Analabereni (N=20)	15.00	3.70

Maximum and minimum possible mean attitude score is 20 and 0, respectively

strikingly low at Devijhar with standard deviation value of 0.93. The reasons for favourable attitude of the farmers at Devijhar may be attributed to the fact that all the villages have village water user groups and one of the members also represents in the management committee (MC) of WUA. This kind of arrangement may have served a better purpose or need of the farmers of all villages without any bias toward any specific village/villages.

3.4.3 *Extent of WUA member-farmers' participation in irrigation management*

The responses of selected member-farmers were recorded with help of developed schedule that included statements on following different issues related to farmers' participation:

- Farmers involve in internal water distributions
- Farmers fix water rates for different crops
- Farmers participate in the collection of water rates
- Farmers follow water sharing for irrigating crops
- Farmers select specific crop pattern to be adopted by all member farmers
- Farmers take care of maintenance of outlets, channels and distribution systems
- Farmers aware about law /rule /act, which support farmers' participation in irrigation management
- Farmers raise their own fund other than water rates
- Farmers have got mobilized for participatory irrigation management through training
- Farmers understand problems related to irrigation service controlled by outsiders, therefore, adopt participatory methods to solve such problems

- All member-farmers participate in periodical meetings of WUA
- Farmers' group / WUA arrange financial support for participatory agricultural activities time to time

Extent of farmers' participation was studied using farmers participation index (FPI) as stated under methodology section.

Extent of farmers' participation in WUA 1 at Koska is found quite high in most of the activities barring selection of cropping pattern and water sharing. It is an unhealthy sign that member-farmers are not very much aware about the rules / acts that support farmers participation and it may be attributed to the fact that only MC members play active role in management of the group and related legal activities. The extent of member-farmers participation in the activities of WUA 2 at Koska is perceived as very high as in case of WUA 1; however, here also the members are not aware of rules / acts etc. that facilitates farmers' participation in irrigation management. The extent of farmers' participation in WUA 3 at Koska is reasonably high for most of the activities but about 30% of the respondent-farmers have not responded positively with respect to participation in water allocation, water sharing for irrigation, adoption of selected cropping pattern and mobilization for participatory irrigation management through training. The selected member-farmers of WUA 4 at Koska have perceived the extent of participation in some of the activities poorly such as participation in WUA meetings and trainings, arrangement of financial support for agricultural activities, fixing of water rates and internal water distributions. It is quite common that absence of member-farmers in the meetings would automatically eliminate their views in water rate fixation, water distribution and other such issues decided by WUA. It is observed that perception of selected member-farmers of WUA 5 at Koska regarding the participation of farmers in many of the activities very low. Member-farmers only fully participate in collection of water rates and maintenance works of the system. The reluctance of the member-farmers of WUA 5 in participation of WUA activities may be due to their dissatisfaction with the irrigation service being located at tail reach of the system and facing large amount of difficulties as compared to others who are located in head and middle reach of the canal.

It is interesting to note that member-farmers of WUA at Devijhar did not participate in fund generation activity other than water tax collection and they are also not involved in deciding cropping pattern and training for mobilization of the farmers towards participatory irrigation management. In earlier section of attitude analysis it is found that farmers were undecided in their responses towards WUA's role in judicious management of water and financial self-sufficiency. It is worth concluding here that lack of participation as revealed above has influenced their attitude.

Most of the respondent-farmers of WUA at Analaberini have put forward their positive response towards participation in all the activities barring non-participation of all members in the WUA meetings. It may give an impression that either member-farmers are not communicated well for the meetings or decisions are mostly taken by the MC and followed by members.

A comparative scenario with respect to farmers' overall participation in irrigation management is presented in Table 34. It is revealing that overall farmers' participation in WUA's irrigation management activities is highest in Analabereni followed by Koska and Devijhar with FPI values of 90.83, 69.33 and 65.92, respectively. However, difference of opinions of the farmers was highest in case of WUA at Koska followed by Analabereni and that was quite low at Devijhar as evident from the standard deviation values. It is in contrast to the attitudinal level of member-farmers towards WUA of selected 3 systems. The reasons for better participation of member-farmers in WUA activities at Analaberini followed by Koska may be due to smaller size of the WUAs, where numbers of member-farmers are about 100 to 300 while WUA at Devijhar consists of 934 members. Out of 5 WUAs at Koska, member-farmers' extent of participation in irrigation management was lowest in WUA 5 followed by WUA 4 and highest in WUA 2 followed by WUA 1. It is again interesting to note that the WUA 2 is the smallest among the 5 WUAs at Koska with 128 members. However, WUA 5 is also relatively smaller in size (161 members) but its ayacut comes under tail reach of the system. Therefore, spatial differences in functioning area or location of WUA may have an influence on the variation in farmers' participation in different activities.

Table 34. Extent of farmers' participation in irrigation management

Name of WUA	Overall mean score	Standard deviation	FPI value
WUA 1 at Koska (n=17)	10.00	1.41	83.33
WUA 2 at Koska (n=12)	11.00	0.00	91.67
WUA 3 at Koska (n=25)	9.76	2.33	81.33
WUA 4 at Koska (n=24)	7.50	0.76	62.50
WUA 5 at Koska (n=18)	6.86	1.86	57.17
Overall at Koska including all WUAs (N= 96)	8.32	2.42	69.33
WUA at Devijhar (N=91)	7.91	0.28	65.92
WUA at Analabereni (N=20)	10.90	0.45	90.83

Maximum and minimum possible mean overall participation score is 12 and 0, respectively

3.4.4 *Group effectiveness of WUAs*

To understand the effectiveness of WUA a Group Dynamic Effective Index (GDEI) was used that included 10 different parameters, which are participation (P), decision-making procedures (D), operation, maintenance & management functions (O), interpersonal trust (T), fund generation (F), social support (S), group atmosphere (A), membership feelings (M), group norms (N) and empathy (E). Each indicator was assessed on the basis of 5-4 statements on which Farmers' responses were taken on 3-

point continuum ranging from 0 to 2. Mean and standard deviation values of each indicator were calculated at first step and thereafter, overall group dynamic effectiveness was calculated on the basis of different weights of ten different indicators in GDEI. Overall GDE was calculated as follows:

GDE=0.20*P+0.15*D+0.12*O+0.10*T+0.10*F+0.08*S+0.08*A+0.07*M+0.05*N+0.05*E

Levels of parameters of group dynamic effectiveness in different WUAs are presented in the Table 35. It is evident that parameters like participation, group atmosphere and membership feeling were perceived relatively high by the member-farmers of WUAs at all the 3 places. Lower value for the parameter empathy indicates the lack of understanding of each others situation among the members of the WUAs at all 3 places..

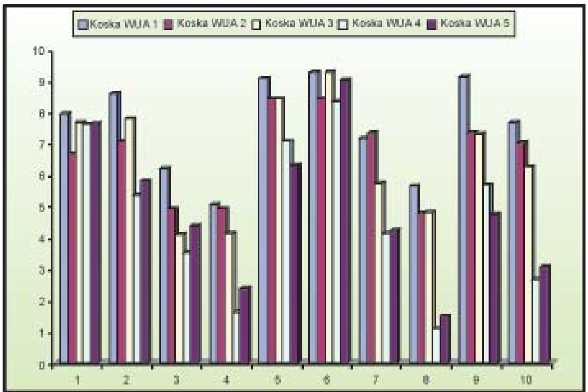
Table 35. Group dynamics effectiveness index of WUAs in 3 selected MI systems

Parameters of GDEI	Overall at Koska including all 5 WUAs (N= 96)		WUA at Devijhar (N=91)		WUA at Analabereni (N=20)	
	Mean	SD	Mean	SD	Mean	SD
Participation	8.05	1.93	7.99	0.10	8.10	1.02
Decision making	6.86	2.09	5.37	1.55	7.10	2.13
O & M functions	4.47	2.03	6.84	0.58	5.20	1.64
Fund generation	3.44	1.90	6.93	0.74	7.10	1.74
Group atmosphere	7.80	1.83	9.20	1.29	7.60	1.79
Membership feeling	8.89	1.39	7.88	0.47	8.45	2.01
Norms	5.51	2.16	6.45	0.85	7.60	1.79
Empathy	3.40	2.58	3.32	0.73	2.05	0.69
Interpersonal trust	6.74	2.71	6.02	0.30	5.85	1.46
Social support	5.09	2.83	6.01	0.10	4.00	1.12
Overall GDE	6.28	1.30	6.82	0.26	6.57	1.26

Maximum and minimum possible mean score is 10 and 0, respectively

At Koska farmers perceived fund generation activities and O&M functions at a lower level (below average with mean score < 5.0) along with the empathy as compared to other parameters in GDEI. Social support was perceived as below average at Analabereni. Member-farmers of WUA at Devijhar perceived most of the parameters relatively high barring empathy leading to highest GDE value (6.82) followed by Analabereni (GDE value 6.57) and Koska(GDE value 6.28). It is interesting to note that inspite of largeness of the WUA at Devijhar member-farmers perceived most of the parameters favourably. Prevalence of village water user groups at each village and their representation in the MC of WUA may have cater the need of the farmers better thereby influenced the perceptions of the respondent-farmers at Devijhar. It is also evident from the standard deviation values that the variation in the responses of farmers were less in case of Devijhar as compared to other two systems.

In case of three parameters viz. participation, decision making and membership feeling, farmers of WUA at Analabereni and Koska opined better than that of Devijhar. This fact may be attributed to the smaller size of WUAs at both Koska and Analabereni as compared to WUA at Devijhar comprising of 934 members.



1. Participation 2. Decision making procedure 3. Operation, maintenance and managt functions 4. Fund generation 5. Group atmosphere 6. Membership feeling 7. Norms 8. Empathy

Fig. 33 Level of parameters of group dynamics effectiveness in 5 WUAs at Kosk

The level of parameters of group dynamics effectiveness is varied in 5 WUAs at Koska as evident from the Fig. 33.

It is evident that most of the parameters were perceived higher in case of WUA 1 as compared to other WUAs. It is found to be almost similar kind of perception for many of the parameters in case of both WUA 2 and WUA 3. The perceptions of the member-farmers of both WUA 4 and WUA 5 were strikingly low for many of the parameters of GDEI. This kind of variation in the perception of member-farmers of different WUAs may be spatial difference of the location of the WUAs in the system.

The overall group dynamics effectiveness of 5 WUAs at Koska is presented through radar diagram (Fig. 34) on a scale ranging from 0.00 to 10.00 which is categorized as low (0.00-3.33), medium (3.34-6.66) and high (6.67-10.00). It is noticed that, overall group dynamics effectiveness in a decreasing order was WUA 1, WUA 3, WUA 3, WUA 4 and WUA 5. It is evident from the graph that GDE score for most of the farmers in case of WUA 1 is at higher level while it is lowered in case of WUA 5 and WUA 4 with a similar kind of spreading of the values in the graphs. The trend is quite similar in case of WUA 2 and WUA 3; however, variation in the GDE scores of farmers of WUA 2 is seemed to be very high.

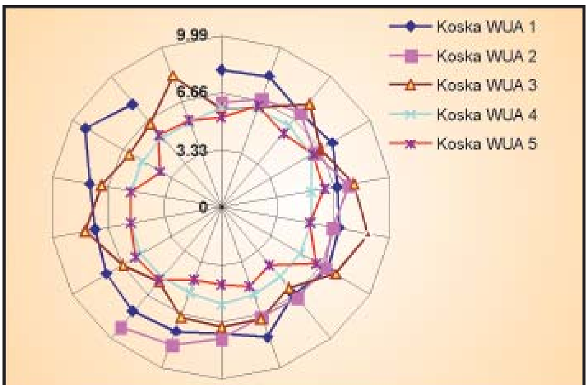


Fig. 34 Radar diagram showing overall group dynamic effectiveness of 5 WUAs at Koska

The value of overall group dynamic effectiveness (GDE) of the 5 WUAs at Koska and WUA at Devijhar and Analabereni is given in Table 36.

Table 36. Overall group dynamic effectiveness of selected WUA

Name of WUA	Mean score	Standard deviation
WUA 1 at Koska (n=17)	7.58	0.61
WUA 2 at Koska (n=12)	6.63	2.27
WUA 3 at Koska (n=25)	6.66	0.99
WUA 4 at Koska (n=24)	5.50	0.28
WUA 5 at Koska (n=18)	5.34	0.68
Overall at Koska including all WUAs (N= 96)	6.28	1.30
WUA at Devijhar (N=91)	6.82	0.26
WUA at Analabereni (N=20)	6.57	1.26

It can be noticed that the overall group effectiveness is highest in case of WUA at Devijhar followed by Analabereni and Koska. But, WUA1 at Koska found to be best with GDE value 7. 58. Group effectiveness of WUA 5 at Koska was lowest with the value of 5.34. The variation in farmers' responses are highest in case of WUA 2 at Koska while it is lowest in case of WUA at Devijhar. The location of land of most of the farmers of WUA 1 and WUA 3 is at head reach and that of WUA 5 at tail reach of the system while ayacut of WUA 2 and WUA 4 comes under middle and tail reach of the system. Therefore, difference in the overall group effectiveness of different WUAs at Koska may be due to spatial difference of those WUAs in the system.

During the discussion with officials, MC members of WUA and farmers, it was agreed by the majority that success and achievement of WUA depend on the extent to which nature and functioning of the programme / project address the problems and needs of the farmers in irrigation management, the extent to which the farmers have been organized in group with participation and empowerment culture for group action, the extent to which the improvements can be made in the strategies for effective group mobilization and sustainability.

It can be generalized that decision-making, fund generation, empathy and social support are the parameters those need attention to improve the overall group dynamics effectiveness of selected water user groups in present study. It is the fact that the small and marginal farmers are unaware of the WUAs in many cases and there is considerable gap in awareness between small and large farmers within the same WUA. Small farmers use more water because they cultivate paddy more often than the large farmers. They face more problems in accessing water as their lands are concentrated in the tail ends unlike those of large farmers. It leads to the dissatisfaction of the small and marginal farmers towards decision-making process. The gap in the need and awareness of the farmers depending on their socio-economic condition also results into poor empathy despite being the members of same group (WUA). Admittedly, the government water rates are abysmally low; therefore, collection of water rates by the WUA generally suffer from the earlier mindset of farmers in many cases. Water entitlements in canal irrigation are singular, that is only refer to agricultural production and they are exclusive, that is only landholders in the command area can enjoy them. However, water as a common resource has other functions like domestic and industrial use. The concept of WUA does not consider the needs of the landless that may hamper the issue of social support.

It is interesting to note that the farmers' groups / WUAs under minor irrigation projects seemed to be more effective as compared to the major irrigation projects. The reasons for this kind of differential group performances may be attributed to the fact that in case of minor irrigation, irrigation management transfer to the farmers' group has inculcated a sense of ownership, access and control of the system to manage water distribution as well as financial independency of the group through collection of water rates to fund the maintenance work thereby taking up the responsibility of operation and management of the irrigation system. It is worth mentioning that a paradigm shift from participatory irrigation management to participatory irrigation governance giving the irrigators (farmers) real decision-making power in managing the irrigation system as a whole system has made positive impact.

3.5 Mechanism of operation and maintenance of the system

There is a paradigm shift in operation and maintenance of the system after rehabilitation and IMT. The delivery is no more a supply driven, rather demand driven. The operation of head regulator and allocation of water to particular outlet / group of outlets is decided by the Management Committee (MC) of Water User Association (WUA) upon receipt of the demand from the farmers through outlet committee (*Chak* Committee). Presently during *rabi* the farmers of tail reach are unable to take up crops due to shortage of water. Farmers are encouraged to go for light duty cash crops. It is experienced during the study that lack of proper crop planning based on the water availability in the reservoir has resulted sometimes in shortage of irrigation water towards later part of crop growth. Therefore, crop planning in consultation with the line department should be done taking into account the water availability in the reservoir in the beginning of the season. Further, provision of field channels and a distribution mechanism below the outlet will improve the equitable and efficient delivery of irrigation water. To meet the seasonal maintenance expenditure of the canal system the WUA generates fund through water taxes and takes up the maintenance work periodically. Rapid siltation of reservoir as expressed by WUA members is a serious concern for which separate funding and maintenance mechanism needs to be chalked out.

4. SCOPE FOR FURTHER IMPROVEMENT

4.1 Creation of a Better Hydrological Regime in the Command

- Hydrological impact assessment reveals that during dry season irrigation water availability is limited in all the MIPs. Due to this, few selected pockets of the command of Devijhar and Koska MIP have been brought under cultivation during *rabi*. It is also realized that there is ample scope of capturing rainwater in the command itself to augment irrigation water availability. Thus, the scope for creation of secondary / auxilliary reservoirs in the command may be explored. In addition to storing the canal water during excess supply period, these reservoirs can also harvest rainwater during monsoon season. Further, there is a need to increase the productivity of the stored water through multiple use management by way of fish culture and duckery in the reservoir, horticulture in the reservoir's embankment etc. Besides increasing the cropping intensity and irrigation intensity, this will enhance the water productivity. The capacity, number and location of these secondary reservoirs need to be determined taking into account the soil type, cropping pattern, climatic condition and water availability in the main reservoir at different probability levels. One of the possible locations of these reservoirs can be just at the down stream of each outlet i.e., at the beginning point of field water courses. The institutional mechanism for operation and maintenance of the proposed secondary reservoirs need to be developed and tested.

- There is a need for judicious use of available irrigation water. As far as possible the conveyance system needs to be seepage proof. Lining of the entire canal network seems to be one of the possible ways to achieve this objective. This will bring additional area under cultivation during dry season. Lining of the entire canal network will bring down the periodic maintenance cost; however, the fund requirement for repair and maintenance of these lined canals when get damaged will be substantial. An exercise is required to know the benefits accrued and cost required for complete lining of the conveyance system.

- A mechanism for equitable distribution of irrigation water in the outlet command is essential. A rotational water supply system with suitable modification may be tried initially in couple of turned over MI schemes with necessary capacity building measures of stakeholders. To achieve this, construction of field channels is essential in all the outlets commands. The farmers need to be educated about the advantages of irrigating their fields through field channels. Field to field irrigation should be discouraged. This will result in saving of considerable amount irrigation water.

- The feasibility of utilizing groundwater resource through dug wells particularly in the tail reach of the canal system may be explored to save the crops at critical growth stages and dry spells. If found feasible, this intervention may be extensively applied to bring more area under cultivation in the tail reach.

- It is also observed from the impact assessment study that during dry season, in addition to limited irrigation water availability farmers have also shown concern about the stream size or the outlet size. Thus, there is a need to determine the unit command area of each MI system. Unit command area in turn will decide the optimum stream size of each outlet so that there efficient application of irrigation water without much wastage.

4.2 Improved Crop Planning and Productivity

- Appropriate crop planning taking into account the water availability in the reservoir should be carried out at the beginning of each cropping season. Services of line departments may be utilized to assist WUA in this exercise. High water requiring crops such as Sugarcane etc. should be discouraged and may be taken up only in pockets where there is plenty of water available. By and large heavy duty crops may be discouraged to bring more area under low water requiring crops. This will improve equitable distribution of water among the farmers and generate more employment.
- The right to fish farming in the reservoir may be given to WUA / Apex body so that the generated income may be utilized for maintenance of reservoir and head regulators / sluices.
- The income generation activities like growing of horticultural crops on the canal embankments, rearing of fish in community water bodies and selling of agricultural inputs, hiring out of agricultural machineries, etc may be explored and introduced.

4.3 Improvement in Socio-Economic Condition

The sustainability of any natural resource use implies whether the present level of its usage will continue to be available in future without deterioration in its quantity, quality and without affecting the ecosystem. Here, the primary factor of sustainability is availability of irrigation water during the hour of need. Adequate and equitable irrigation water supply over space and time creates a condition for better input utilization by all size class of farmers, ensures better crop productivity and production and increase in farm income. The increase in income would push the consumption expenditure on food and non-food items. The overall economic condition will be boosted under improved irrigation scenario. To sustain the gains of rehabilitation and IMT, the following policy shifts with respect to socio economic scenario may be adopted by the irrigation planners.

- Equitable distribution of operational holding and discouraging absentee land lords which comes on the way of on-farm capital investment there by reducing irrigated area yields.
- Improving input supply system at the farmer's doorstep through single window system.
- Linking production to efficient market system and strengthening market intelligence system in the irrigated area.
- Strengthening backward and forward linkages of the rehabilitation gains with institutional support mechanism.
- Steps should be taken to strengthen informal organizations at the village level to promote community participation.
- Strengthening community to review the working of WUAs under each rehabilitated system through continuous skill upgradation trainings.
- Property rights need to be clarified under changed scenario to avoid conflict within the community and WUA
- Effective delivery mechanism and conflict resolution mechanism within the WUA system.

4.4 Improvement in Institutional Performance

Strategy for mobilization of effective WUA should consider 3 distinct phases viz. group formation (0-4 months), group stabilization (4-15 months) and group-independency (15-36 months). In most of the cases, project personnel are concerned on the first two stages and the last stage remains largely unaddressed leading to the unsustainability of the group. While helping to build the farmers' groups their prolonged integrity and functionality should be always kept in mind. All the efforts and resources invested in forming groups will be meaningless if they do not sustain themselves for long. In fact it should become a part of the tradition of the village over time, as is the case with the already existing traditional village organizations.

Following steps may be taken into account for making the WUA independent and self-sustaining

A. Ensuring independent group / organization

- Developing action plans for performance enhancement of irrigation system as well as farming system of irrigated agriculture.
- Planning and execution of action plans as per schedule of different units.

- Selection of master farmers in respect of irrigation management, technical, production, credit and marketing to establish separate unit under each master farmer's committee.
- Skill development of selected master farmers through training in respective areas and equipping them to give training to improve knowledge, attitude and skill of other farmers.
- Development of new set of master farmers after a year paving the way for leadership development among the group members in due course.
- Organization of periodical meetings of group members for farmer to farmer technology transfer – farmer led extension.
- Reducing and facilitating role of group promoters / project personnel for the refinement, improvement and problem solving with respect to various activities through master farmers.

B. Sustainability of group

- Assuring active participation of members in every activity of group.
- Follow-up actions in post operational / post-project stage.
- Setting of appropriate mechanisms to resolve conflicts and problems within the group.
- Establishing networking of farmers' organizations / groups.