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Water Technology Centre for Eastern Region

(Indian Council of Agricultural Research)

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Preface

The coastal agro-ecosystem in India has immense potential for agriculture, horticulture, agro-forestry and fisheries. However, this ecology is prone to several natural calamities like cyclones and floods. The super-cyclone of 29th October, 1999 caused considerable loss not only to human being, agriculture and allied enterprises but also to basic natural resources like land and water in coastal Orissa, which is characterized by low and unstable yield and resource poor farmers. The repeated natural calamities have deteriorated the soil health, quality of the ground water as well as the water quality in the creeks and ponds. The land topography in the coastal area makes the region susceptible to water logging. The saucer shaped land, high rainfall and poor drainage conditions create severe water congestion consequently the area remains submerged for about one to two months under water depths which vary from 30 cm to 100 cm. Poor exploitation and management of water resources further aggravate the misery. Under such critical conditions WTCER played a pivotal role by developing and implementing a multi institutional and multi disciplinary research under National Agricultural Technology Project, entitled "Management of Coastal Agro-ecosystem affected by super cyclone in Orissa" to bring about a significant jump in agricultural productivity with a view to alleviate the perpetual poverty of the people of the coastal region. It was a multi-institutional project since the scientists of different disciplines of institutions like CRRI, WTCER. OUAT, CIFA, NRCWA and the regional centers of CTCRI, IIHR and NRCG joined hands in this effort for developing the area which comprised of 10 villages; 5 from Astarang block of Puri district and 5 from Ersama block of Jagatsinghpur district of Orissa. In this project WTCER has generated viable technology for micro water resource development like sub-surface water harvesting structure and very shallow tube well on participatory basis. Technology for participatory management of water resource utilization was also developed to increase water productivity and make the system sustainable. Unproductive waterlogged area was put under utilization through cultivation of water chestnut. Above-mentioned study has been presented in this bulletin, which may help in formulation of participatory water management strategies for similar areas in the region.

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AUTHORS

Executive Summary

Coastal belt of Orissa is characterized by traditional rice cultivation practices with low and unstable yield and resource. Poor farmers engaged in complex and diverse risk prone (CDR) agriculture. The super cyclone of October 1999 severely damaged the basic natural resources, viz., land, water and vegetation of this fragile agro-ecosystem and weakened farmers' economic capacity to invest in agriculture. In this context, during post cyclone period Water Technology Centre for Eastern Region (WTCER) took a leading role on participatory development and management of water resources in selected cyclone-affected area (Astarang and Ersama blocks of Puri and Jagatsinghpur district, respectively) under National Agricultural Technology Project (NATP) during the period 2001-2004. It has been strived to improve the fragile agricultural production system with rehabilitation of damaged water resources by providing prime mover and construction of new water resources to create irrigation facilities. Diagnostic survey of existing soil and water resources followed by creation and utilization of water resources and the formation of water user groups involving small and marginal farmers, including farm women, are the important components of this project. The impact evaluation in terms of utilities of water resources by the group of farmers and delineation of factors influencing the group effectiveness have also been addressed in this project.

Testing of soil samples revealed that majority of the soils were in the acidic range (pH of the soil samples varied from 3.56 to 6.70 in Ersama and 3.87 to 6.56 in Astarang) having varied level of salinity (EC of the soils ranged from 0.155 to 11.1 dS/m in Ersama and 0.045 to 15.4 dS/m in Astarang). Therefore, soil reclamation trials were conducted in selected places to demonstrate and train the farmers.

Diagnostic survey revealed that different types of water resources were available in both Ersama and Astarang blocks, but still farmers suffered from scarcity of water especially during *rabi* season. Moreover, lack of power/energy for lifting the water was found to be the major constraint in utilization of the existing water resources. In view of small and fragmented holdings, it was planned to have strategies to follow participatory approaches to provide power/ energy for lifting the water from existing water resources, to create new water resources through renovation and/or construction of tube-well and small subsurface water harvesting structures depending upon the suitability of the location and availability of good quality water. Accordingly, pump user groups (8 in Astarang and 11 in Ersama) were formed and one pump was distributed to each group. To combat water shortage during *rabi* season in Astarang and Ersama, several alternatives were planned. But seeing the ground condition of both the sites, it was planned to construct very shallow tube-well (VSTW) in Astarang and subsurface water harvesting structure (SSWHS) in Ersama. Ten shallow tube-wells were constructed for different group of farmers on participatory basis. Construction of tube-well at Ersama site was not feasible due to salinity in ground water, at lower depth (greater than 6 m). Therefore, small subsurface water harvesting structure was the best option available for poor farmers. In the first year, 7 such subsurface water harvesting structures were constructed on participatory basis by forming water user groups, where 40 per cent of the cost of construction/renovation expenses was borne by the farmers' group either by self-labour or by payment and 60 per cent of the cost was met from the project. In the second year another 14 farmers' groups came forward to participate in such intervention by paying 67% of the total cost and only one third of the cost was borne by the project.

Impact of pump used for irrigation both in Ersama and Astarang was realized during the year 2002 by increasing total cropping area under irrigation. The irrigated area increased to the maximum in case of rice followed by vegetables, groundnut and potato at both the places. The irrigation facilities through pump increased irrigated area of sunflower at Astarang considerably. It leads to crop diversification in place of predominant rice-fallow cropping pattern and enhanced cropping intensity. Tube-wells constructed at Astarang also facilitated the farmer to go for crop diversification in a big way. During *kharif* 2002, rainfall in the month of June and July was 25 per cent of the average monthly rainfall both at Ersama and Astarang. This destroyed the crop both at seedling as well as transplanting stage in other areas. But the groups who constructed / rehabilitated their water resources under this programme were able to save their crops. Participatory approach paid the dividend immediately. The farmers introduced cultivation of fish and aquatic crops like water chestnut in few tanks.

The group dynamics played pivotal role in the functioning of groups in an efficient manner. There were certain factors, which influenced on group functioning and group effectiveness. Participation received top most priority for the effective functioning of farmers' groups followed by decision-making, operation and maintenance of water resources, interpersonal trust and fund generation. The other factors identified were social support, group atmosphere, membership feelings, group norms and group leadership. An attempt was made to identify the socio-economic and personal factors, which influence farmers' participation. Correlation and multiple regression analyses were computed. Farmers' overall participation was considered as dependent variable while age, education, income, land holding, assets holding (tools, implements, equipments and other assets for agricultural operations) social participation and extension orientation of farmers were taken as independent variables. All independent variables barring age were significantly correlated with participation. Seven independent variables included in present study accounted for 76.8% variation in the farmers' participation ($R^2 = 0.768$). Land holding, income, social participation and extension orientation were found to have positive and significant relationship with participation. However, age, education and assets holding did not matter much in this regard.

For sustainability of a system, farmer's participation is essential. Farmer's paying capacity must be increased from the system to make it more sustainable. Mere distribution of seed, fertilizer, planting material does not help much and after the withdrawal of help the technology adoption reduce drastically. However, participation of farmer by paying 40% of the cost of water harvesting structures in 1st year and 67% of the cost in the 2nd year gave them the ownership feeling and they did not take it as donation from government. Since the system worked with cyclone ravaged poor people successfully this will also work in all coastal areas. This gives a new insight for development of small-scale water resources in coastal areas.

1. Introduction

The coastal agro-ecosystem of India forms a very valuable resource base, supporting the livelihood security of several millions of rural poor and also contributing to the national economy in a large measure. India has 8,129 km long coastline. Its peninsular region is bounded by the Arabian Sea on the west, the Bay of Bengal on the east and Indian Ocean at its south. The vast deltaic region on the east coast forms the rice-bowl of the country. Agriculture, agro-forestry and silviculture are the main agro-based activities. Sea level rise due to global warming has been predicted time and again. The implications of this phenomenon to coastal zone and island ecosystem can be imagined. Over and above this, natural calamities like cyclones, sea currents and tides are common features of these areas. Anthropogenic pressure and unfavourable environmental changes are also taking place (NATP 1998). The coastal regions, lagging significantly behind the inland areas in terms of productivity, has a still harder task ahead in lieu of several constraints limiting its productivity. Besides a number of soil, climate, and water-related factors limiting productivity of food grain crops, the entire shoreline is extremely fragile in nature. As a result, there is always an element of uncertainty to the lives and properties all along the shoreline, especially those in the lowlands. The areas are environmentally disadvantaged and are at a great risk to the ill effects of human activities and adversities of weather.

Coastal belt of Orissa is characterized by traditional rice cultivation practices with low and unstable yield and resource poor farmers engaged in complex diverse risk prone (CDR) agriculture. The super cyclone of October 1999 has severely damaged basic natural resources, land and water, of this fragile ecosystem. Swirling sea waves inundated the lands near the sea and deteriorated the soil health considerably. The qualities of the ground water as well as water in the creeks have been affected. The landform in the coastal area makes the region susceptible to waterlogging. The saucer shaped land forms, high rainfall and poor out fall conditions create severe water congestion condition and area remains submerged for about one to two months under water depths varying from 30 cm to 100 cm. But after December in *rabi* season, the land becomes dry but no crop can be taken up because of water scarcity. Although ground water is available within 50 cm, in most cases ground water below 5 meter is saline. Poor exploitation and management of water resources further aggravate the situation. Lowland rice fields in which nature of flash flood is stochastic suffer from poor yield (Sahoo and Verma, 2002). The low productivity in this eco system faces various constraints, namely;

1. Limited water during the seedling stage and excess water at later growth stage
2. Excess water at transplanting as well as later growth stages
3. Excess water during initial period and less water during later growth period
4. Stochastic nature of flash flood in lowland
5. Lack of irrigation in *rabi* season
6. Poor soil quality in terms of higher salinity and clay content
7. Saline groundwater making shallow tube-well infeasible

In view of above, it was felt essential to develop a sustainable water management strategy compatible to the socio-economic conditions and aspiration of the people. The water availability and efficient utilisation, storage and application at farm level are identified as the key performance indicators. It is not possible to manage all these indicators at farm level in waterlogged area unless some system is developed through co-operative basis. The real participation of the farmers paying their own share for development is likely to make the programme sustainable. The programme should be for the people, by the people and of the people (Bagdi *et. al*, 2002; Pande *et. al*, 2002). Concerted efforts by a group for achieving common goals and sharing benefits leads to the empowerment of CDR farmers through creating own assets and developing own irrigation system for cultivation (Khatik *et. al*, 1998).

In this context, Water Technology Centre for Eastern Region took a leading role in post cyclone period and present study was taken up in the waterlogged cyclone affected area funded by National Agricultural Technology Project with the objective of demonstrating a comprehensive policy of participatory development and management of water resources. The project has been strived to improve the fragile agricultural production system with rehabilitation of damaged water resources, providing prime mover and construction of new water resources to create irrigation facilities. Diagnostic survey of existing water resources followed by strategy formulation for creation and utilization of water resources and the formation of water user groups involving small and marginal farmers including farmwomen have been important components of this project. The impact evaluation in term of utilities of water resources by the group of farmers and delineation of factors influencing the group effectiveness has also been addressed in this study.

2. Location of the Study

The project has been implemented in 10 villages, 5 each from Astarang block ($19^0 58'$ N latitude $86^0 17'$ E longitude) of Puri district and Ersama block ($20^0 12'$ N latitude $86^0 24'$ E longitude) of Jagatsinghpur district in the State of Orissa. The study area in Astarang block comprised of a cluster of 5 villages viz. Hiradeipur (Kuanrpur + Patalada), Gudubani, Sundar, Manduki and Chakrpada. These villages are situated within the radius of 4 km and within 5 km away from seacoast. The villages are located at about 2-6 km away from the Astarang block, 12 km away from Kakatpur tahasil, 75 km away from Bhubaneswar and 115 km away from Cuttack district. The village Hiradeipur (Kuanrpur) comes under Astarang Gram Panchayat and Guduibani, Manduki and Chakrpada villages come under Patalada Gram Panchayat. The study area in Ersama block included 5 villages viz. Saraba, Badabellary, Sahadabedi, Ambiki and Kankan. These five villages are located in a cluster within the radious of 10 km and at a distance of 5 km from the seacoast. The distance from Cuttack and Bhubaneswar to this location is 90 km and 130 km, respectively. The village Saraba, Badabellary and Sahadabedi

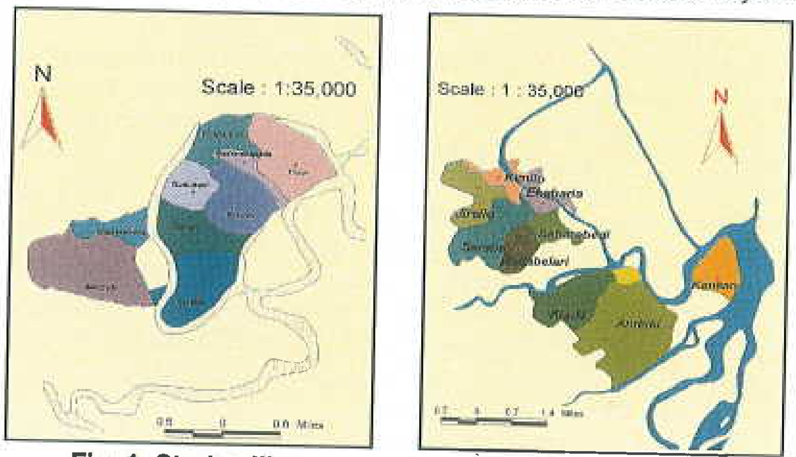


Fig. 1. Study villages of Astarang and Ersama block

come under Jirailo Gram Panchayat where as Ambiki and Kankan belong to Ambiki Gram Panchayat. All these 5 villages come under Erasama block (8 km away) and Kujanga Tahasil (25 km away) from Jagatsinghpur district. The peculiar feature of the area in Astarang site is that its location is at the mouth of river *Devi,* a gigantic branch of river Mahanadi. So whenever seawater rises due to heavy tide, the river water is not being discharged to sea and the adjoining area becomes saline and waterlogged. In case of Ersama, though there is no big rivers, but several creeks join to the sea. Hence during high tide seawater enters the hinterland thus making the land saline.

3. Diagnostic survey

3.1. Rainfall pattern

The average annual rainfall of Astarang block is 1653 mm and that of Ersama is 1356 mm. The annual rainfall during super cyclone year (1999) in Ersama was 2021 mm and in Astarang it was 1959 mm, i.e. 49% and 18% higher than average, respectively. Average monsoon rainfall (June to October) in Astarang is 1273 mm and in Ersama it is 1080 mm. The weekly rainfall, ponding water level and water table depth have been depitcted in Fig 2. From the figure it is clear that there is excess water from 32nd week (75 cm) to 49th week (5 cm). From January onwards, deficit starts. Water table is within 12 cm upto 2nd week (Jan 14) and then there is steep rise upto 16th week (end of April onwards) and again slowly comes near surface. This may be attributed to the reasons of heavy ground water withdrawal and one or two showers of rain after 16th week.

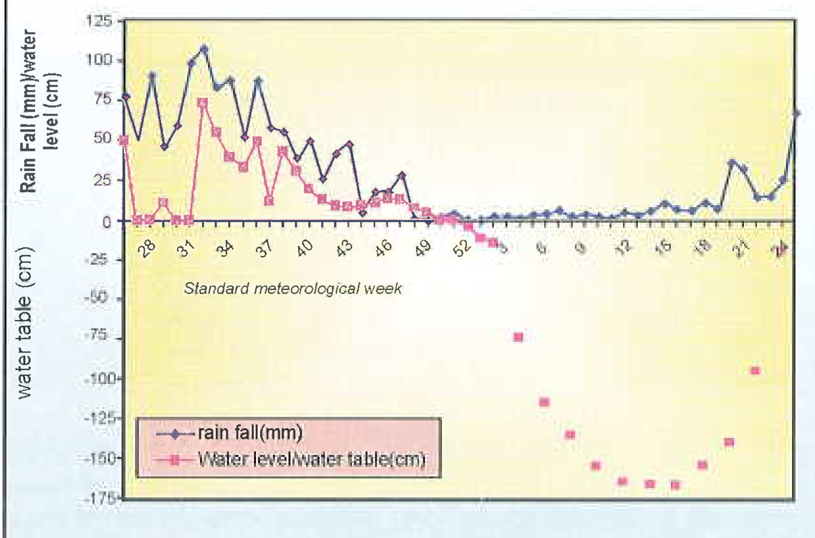


Fig.2 Hydrograph of weekly rainfall & water level

3.2. Demographic feature

The typology of households both in Astarang and Ersama is categorized into 6 types viz. Landless labourer, Landless sharecropper, Marginal (< 1ha), Small (1-2 ha), Medium (2-4 ha) and Large (> 4 ha). Both in Ersama and Astarang more than 12% of the total households were landless out of which about 6% were sharecroppers. Majority of the households (68-69%) belonged to marginal category. Small and medium categories included about 15% and 3% of the households, respectively. Only less than 1% of the households were having more than 4 ha of land who belonged to large category. In Ersama, majority of the households were Bengali who have migrated from East Bengal during partition. Their level of education ranged from illiterate to higher secondary and above. The dominant livelihood options were crop farming and fish farming.

3.3. Water Resource Survey

Diagnostic survey revealed that different types of water resources are found to be available in both Ersama and Astarang blocks (Table 1), but still farmers suffer from scarcity of water especially during *rabi* season.

Table - 1 : Existing water resources available at Ersama and Astarang block.

Sl. No	Type of water resources	Ersama		Astarang	
		Number	Area irrigated (ha)	Number	Area irrigated (ha)
1.	Tank	84	94.8*	27	37*
2.	Shallow Tube- well	2	-	41	34
3.	Creek	12	42.8*	1	-
	Total	98	137.6*	69	71

** Irrigated in Kharif season only*

Ersama site

Although plenty of water resources are available in Ersama block, still farmers suffer from scarcity of water during *rabi* season. The groundwater below 3 m to 5 m is saline in Ersama block. Rural water supply project has constructed 7 drinking tube-wells with a depth varying from 80 meter to 100 meter. There are about 84 tanks with capacity varying from $100m^3$ to $1000m^3$, 2 shallow tube-wells and 12 creeks in 10 villages of Ambiki Panchayat. The most important creek is *Hansua* river. About 42 ha area is irrigated by lift from this source. The creek in Kankan is mostly used for fish production and it supplies water to shrimp ponds. The creek at Baghadi (Chaulia) also serves similar purposes. Other creeks are mostly used for fish production and supplying water to shrimp ponds. It is evident from Table 1 that about 137.6 ha is under irrigation i.e. (11% of the total cultivable area). Most of the irrigation is being done by lifting of water through manual water lifting devices like *Tenda*. However the cyclone has affected this process very badly leading to a condition where sufficient manpower is not available to operate these water-lifting devices. The area under the command of tanks has been provided with water during *kharif* after cessation of the monsoon only. Water in most of the tanks becomes saline after kharif season due to its higher depth (more than 4 to 5 m).

Astarang site

Unlike Ersama, creeks are scantily available in Astarang block. However, the area is comparatively rich in good quality ground water that is available at shallow depth. The farmers have augmented the resource with low capacity ponds in backyards of their households to utilize surface water for kitchen garden. The summary of water resources at Astarang is presented in Table 1. It is evident that about 71 ha area is irrigated i.e. 37 ha by tank and 34 ha by shallow tube-wells. The command area under tank gets irrigation only in *kharif*. In case of shallow tube-well, after February, the water becomes saline due to higher depth (> 17 m). Many of the shallow tube-wells in this region have been defunct due to this reason.

3.4. Soil Survey

Ersama site

The pH of the soil samples varied from 3.56 to 6.70 with majority of the soils falling in the acidic range. EC of the soils ranges from 0.155 to 11.1 dS/m with majority of the soil from all villages having medium level of salinity. Water samples collected from shallow tube-wells, open well, drinking water wells and ponds from 6 villages from Ersama site are having pH in the range of 6.4 to 7.4 and EC in the range of 0.3 to 8.2 dS/M. Majority of the samples show presence of salt and are saline in nature. Regular use of this water for irrigation may cause soil salinisation and unfavorable soil physical condition.

Astarang Site

The pH of the soil samples ranges from 3.87 to 6.56, indicating majority of the soils in the acidic range. EC of the soils varied from 0.045 to 15.4 dS/m indicating varying levels of salinity. Soils from Timor and Patalda villages are found to be saline to highly saline in nature. EC and pH of 35 water samples taken from different villages of Astarang were also tested. The pH of the water samples varies from 5.67 to 7.02 and EC varies from 0.40 to 4.0 dS/m. Water samples collected from Timore and Patalda are saline in nature.

4. Strategy formulation and implementation for water resource management

Strategy formulation for utilization of existing water resources and creation of new water resources was carried out through group discussion, farmers' meeting and participatory need assessment. In view of small and fragmented holdings, utilisation of water resources on community basis was planned and accordingly water users groups (WUG) were formed for implementation of participatory work plan. It was planned to have strategies to follow participatory approach to provide power/energy for lifting the water from existing water resources, to create new water resources through construction of very shallow tube-well and small subsurface water harvesting structures depending upon the suitability of the location and availability of good quality water.

4.1. Strategy for utilization of existing / created water resources

Earlier with available man power irrigation was practised through indigenous wooden lifting device called "Tenda". But the supercyclone left the farming community with little resource to repair or replace the existing system. Again availbility of man power to operate these systems was a major constraint. Hence, at the first stage it was decided to improve the utilization of existing water resources. It was found that lack of power/energy for lifting the water is the major constraint in utilization of the existing water resources. In view of this it was decided to provide 3.5 / 1.5 HP (petrol start, kerosene operated) pump sets to the group of farmers for irrigating crops. In view of small and fragmented holdings these pumping sets can be used effectively on community basis. Further it was not possible to provide on individual basis due to various socio economic reasons. Thus, 19 pump user groups were formed inclusive of few women self-help groups and one pumping set was given to each group. In all 11 and 8 pumping sets were given at Ersama and Astarang, villages respectively. It is often found that one of the major shortcomings of any operational research project is speedy withdrawal of technology and poor maintenance of resources created/supplied after completion of the project. This makes the project unviable. To avoid this and to make this programme sustainable, a participatory approach for utilization, operation and maintenance has been followed. It was decided that the pump user group would collect a nominal rent as a part of group's fund generation process. The decision on quantum of rate was left to the user group and it varied from Rs. 10/- to Rs. 25/- per hour of operation of pump in their field. The money so collected was deposited in groups' account. The memorandum of understanding (m.o.u) stated clearly that the amount so deposited totally belonged to the group to meet operation and maintenance expenditure as well as to make group's savings for purchase of a new pump. Because the pump provided earlier was to be taken back from the site once group mobilised required the amount to purchase new pump and the same process would be replicated with new groups. It leads the system self-paying and sustainable.

4.2. Strategy for development of new water resources

To combat water shortage during *rabi* season for Astarang and Ersama, several alternatives were planned. After initial investigation of ground water tables of both the sites, it was decided to construct and renovate small subsurface water harvesting structures in Ersama and very shallow tube-wells in Astarang.

Astranga site

Strategy for creating micro water resource development was to construct very shallow tube-wells with depths varying from 8m to 17m depending on the site condition. There was advantage of small diameter shallow tube-wells over large diameter tube-wells in coastal area, because increase of diameter of tube-well by two times increased discharge only upto 10% and higher discharge resulted in ingress of sea water from unconfined aquifer zone. The cost of deep tube-well was much high, with a possibility of sometimes getting bad quality water aquifer zones. This type of water resource added extra benefit in terms of less water losses because it was constructed nearer to the cropped land. Under such condition water conveyance efficiency is very high. Four shallow tube-wells were constructed for different group of farmers on participatory basis in the first year. The cost of one tube-well was Rs. 2476/- only. The tube-wells were of 7.5 cm diameter and dug up to 13 m depth. In order to make the programme sustainable, the group was mobilized to purchase a kerosene operated pump (2 HP) to be fitted to shallow tube-well. Agreement was made with the group to share the water among all the group members and to non-members on payment so that the maintenance could be done with the fund generation by the group. In the second year, four more water user groups came forward to construct shallow tube-wells on the same condition. In the third year with 50% of the project support, two groups constructed similar shallow tube-wells (project support was Rs. 1250 only).

Ersama site

Construction of tube-well at this site was not feasible due to high salinity in groundwater. Construction of creeks and large water harvesting structures in coastal area needs proper planning and financial support from other agencies. Success of big ponds needs integrated farming system in which fish, poultry and horticultural crops on the pond bund should be added in a big way. Again this technology requires big land size and resource rich farmer. But in cyclone affected coastal area, resource poor farmers are not able to add all these components. Under such condition construction of small subsurface water harvesting structures on participatory basis was the best option available for poor farmers. Keeping this in mind Water Technology Centre for Eastern Region, Bhubaneswar developed a design for sub-surface water harvesting structures (excavated tank). In this system small sub-surface water harvesting structures (excavated tank) were constructed with an inlet to a depth of 3-4 m or less to harvest surface water in rainy season and to harvest sub-surface seepage water in *rabi* season after each pumping session. This structure provided water for raising paddy nursery in June and irrigated additional area during *rabi* as well as summer. It was also used for aquaculture and aquatic crops. This system proved very effective in providing assured irrigation. As the resource of the farmers of the region was poor, they could not construct it on their own nor govt. could fully subsidize the programme. Hence a participatory approach with involvement of the farmers group was considered to be successful to bring about sustainable water resource development.

Use of Participatory approach system

This system can be installed at any place that is nearer to the creek and where a sand zone is underneath within 10m below ground level. This zone is locally called Bellary in the state of Orissa. In Paradip and Ersama zone, this type of land is available in a vast stretch of area within 5-10 km from sea. There should be arable land and habitation near the zone for taking up farming in both *kharif* and *rabi*. Seepage rate should be more than 10 mm per day. There should be clayey zone below the surface upto first 3-4 m. The design of the sub-surface water harvesting structure depends upon expected rate of seepage. If the rate of seepage is more, then the area of tank is reduced and vice versa. The recuperation rate by pumping at different site in 556 m^3 to 899 m^3 tanks varies from 1.58 m^3/hr to 4.07 m^3/hr in sandy zone and from 1.01m^3/hr to 3.4 m^3/hr in clayey zone. Capacity of structure may vary from 200 m^3 to 1500m^3. The depth of structure may also vary from 2-4 m.

To make the project more sustainable, a participatory approach was developed and followed. After selection of a site, irrigation user group was formed around the site. Each group member was advised to pay a small percentage of the cost of the project either through labour or by cash or kind. In the first year it was decided for the irrigation user group to pay 40% of the cost of the project. Initially no farmer came forward. But seeing the successes of Madhab Mandal (group leader) with this participatory approach, 6 such farmer's groups were formed in different cyclone hit villages of Ambiki Panchayat. At the site, layout of the structure was marked in two parts (60% & 40%) and the group was asked to complete 40% work first. For example for a 30m x 20m x 2m structure layout was given for 30m x 8m x 2m for the farmer group to complete and then project functionary came forward to complete the remaining 30m x 12m x 2m earth work through the same user group by providing the wages. By this the group felt their ownership in the project. For any subsequent repair and maintenance they took care of the entire expense. In the second year, after seeing the success of the project, the subsidy was reduced from 60% to 33%. Still 13 user groups were formed in 7 different villages. The procedure of construction remained the same.

5. Impact of water resources creation and utilization

5.1. Utility of pumps

The impact of pump used for irrigation both at Astarang and Ersama was realized during last two years (2002-2004) by increasing total cropped area under irrigation. At Astarang irrigated area has been increased from 5.6 ha to 92.3 ha in the first year and 180.1 ha in the second year. At Ersama, cropped area of both paddy and non-paddy was increased from 13.4 ha to 93.1 ha in the first year and 243.8 ha in the second year. The irrigated area increased to the maximum in case of rice followed by vegetables, groundnut and potato at both the places. The irrigation facilities through pump increased irrigated area of sunflower at Astarang. It leads to crop diversification in place of predominant rice-fallow cropping pattern and enhanced cropping intensity.

A brief account of all the pump water user groups at Astarang and Ersama is presented in Table 2 and 3, respectively. It is noticed that some groups have functioned well, utilizing pump to irrigate different crops and making regular saving in group's account through collection of pump operation charges from the users. In contrast, few groups could not generate funds consistently that resulted in relatively less saving in their group's account.

Table - 2: A brief account of Pump Water User Groups formed at Astarang site under NATP(Coastal) during 2001-04

Name of pump water user group and location	Name of Group leader	No. of members	Type of pump (HP)	Area irrigated before providing pump (ha)	Area irrigated after providing of pump (ha)		Balance amount* in group A/C (Rs)
					1st year	*2nd year*	
Mahila Mandals Gudhani	Sushila Nayak	30	3.5	0.6	4.4	12.7	950
Water User Group Temora	Nathu Mallick	12	3.5	1.2	6.8	17.2	3270
Water User Group Sundar	Laxmidhar Swain	21	3.5	1.2	8.9	25.4	1513
Water User Group Adikandapursasan	Saroj Kumar Kar	12	2.0	0.2	17.2	25.7	1013
Karanjai Swayam Sahayak Jala Bebyahar Gosthi Sundar	Rebalata Senapati	25	2.0	0.9	21.4	31.2	1100
Water User Group Patalda	Sibram Mallick	15	2.0	0.3	14.2	21.2	1913
Water User Group Baridhi	Dharanidhar Nayak	20	2.0	0.7	12.3	19.5	2712
Jagannath Mahila Mandal Baridhi	Susila Mahapatra	18	2.0	0.5	7.1	27.2	1410
	Total	153		5.6	92.3	180.1	

Table - 3 : A brief account of Pump Water User Groups formed at Ersama site under NATP(Coastal) during 2001-04

Name of pump water user group and location	Name of Group leader	No. of members	Type of pump (HP)	Area irrigated before providing pump (ha)	Area irrigated after providing pump (ha)		Balance amount* in group A/C (Rs)
					1st year	*2nd year*	
Group-I	Mrinal Kanti Nanda	12	3.5	2.2	6.93	15.41	918
Group- II	Sunil Samal	14	3.5	0	5.87	12.46	1000
Group-III	Brundaban Mandal	15	3.5	0	7.25	14.35	1000
Group-IV	Subal Dalai	15	3.5	1.3	8.71	21.20	500
Group-V	Kelu charan Sahoo	14	3.5	0.6	9.21	27.12	2500
Group-VI	Pabitra Swain	11	2	3.1	15.21	28.34	500
Group-VII	Puspak Nayak	8	3.5	1.3	7.81	15.41	500
Group-VIII	Gulam Mustafa	13	2	1.6	7.8	25.1	1000
Group-IX	Bhanu Mandal	7	2	0	2.5	17.8	400
Group-X	Madhab Mandal	6	3.5	1.2	7.9	26.2	1300
Group-XI	Bikas Maiti	9	2.0	0.8	3.2	10.2	1000
	Total	157		13.4	93.1	243.8	

** Balance amount remained in group's account till June 2004 after meeting expenditure towards repair and maintenance of pump (repair/change of damaged washer, ring, etc. parts ; oil change.*

5.2. Performance and economics of the sub-surface water harvesting systems

A properly designed and constructed sub-surface water harvesting structure based on the above principle will mitigate the early drought in *kharif* season and provide irrigation during *rabi* and summer. The evaluation of such system has shown its effectiveness in dealing with early drought in *kharif* 2001 in saving an area of 8.8 ha. The details of benefit in kharif 2002 and benefit cost ratio are given in Table 4 and 5, respectively.

Table -4 : Name of the farmer and Capacity of Tank.

Name and address of farmer	40% of total cost (Rs)	60% of total cost (Rs)	Total cost (Rs)	Capacity (m^3)	Area saved (*kharif* 2002) (ha)	No. of farmers in the group
Madhav Mandal Chaulia (Baghadi), Ambiki, Ersama,	7093.00	10640.00	17733.00	1287.4	2.4	11
Puspak Nayak Ambiki, Ersama,	5044.00	9066.00	15110.00	899.0	2.2	10
Subal Behera, Kiyada(Nagari), Ersama,	5458.00	8188.00	13646.00	1011.5	2.2	10
Sunil Samal, Chaulia, Ambiki, Ersama,	7541.00	11313.00	16255.00	1571.0	2.6	17
Sabyasachi Jena, Kiyada(Nagari), Ambiki, Ersama,	6080.00	9120.00	15200.00	1152.3	2.4	11
Babaji Pradhan, Ambiki, Ersama,	2996.00	4494.00	7490.00	556.2	1.9	6
Srikanta Rana, Ambiki, Ersama,	2964.00	4445.00	7409.00	779.0	3.1	6

The irrigation rotation schedule was developed for the group for *kharif* (for paddy nursery in case of drought) and for *rabi* vegetables and pulses. Area irrigated during *rabi* was 27.9 ha for 71 farmers. The total income from the paddy and *rabi* crop for each SSWHS was determined after crop harvest. The total amount of fish captured from each SSWHS was determined and the income from fish varied from Rs. 3000/- to Rs. 17,600/-. Fish crop income ratio varied from 1:1.85 to 1:3.16 in different SSWHS (except in one SSWHS due to low yield of fish). Income from fish per cubic meter of capacity of SSWHS varied from Rs. 2.96/- to Rs. 12.23/-. Generally as the capacity increases fish income increases with little variation. But total income from SSWHS varied from Rs. 12.93/m^3 capacity to Rs. 47.20/m^3 capacity in the first year itself. Low income from crop was sustained by high income from fish as the SSWHS was being fed continuously by sub-surface seepage water in coastal waterlogged area. The total income from SSWHS with respect to cost of construction varied from 0.98 to 3.43 in the first year itself. The investment on small sub-surface water harvesting structure was found to be Rs. 3328/- ha out of which farmer's group payment was Rs. 1331/-. In the second year 13 irrigation user groups were formed when the farmers participation was upto 67% of the project cost. The performance index is given in Table 6.

The B: C ratio varied from 0.93 to 2.18 with an average B: C ratio of 1.55 in the first year of the construction itself. Cost of structure varied from Rs. 12.66/m^3 to Rs. 18.10/m^3 with an average of Rs. 14.18/m^3. Water productivity varied from Rs. 15.84/m^3 to Rs. 80.43/m^3 with an average of Rs. 36.20/m^3 by taking into consideration total income from all the structures. If only the benefit was considered then water productivity ranged from Rs. 9.00/m^3 to Rs. 53.70/

Table - 5 : Economics of Sub-surface water harvesting structure (2002-2003 & 2004)

Name of farmer	Capacity (m^3)	Total Cost (Rs)	*Kharif* income (Rs)		*Rabi* income (Rs)		Fish income (Rs)		Total income (Rs)		Total Expend. (Rs)		Benefit (Rs)		B.C ratio		Crop intensity (%)	
			1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
Madhab Mandal	1287.4	17733	9000	7500	37250	45666	14600	7500	60850	60666	20050	20110	40800	40556	2.3	1.85	177	245
Sunil Samal	1571	16255	8000	7000	24650	30780	17600	10000	50250	47780	16570	15875	33680	31905	2.07	1.82	182	215
Puspak Nayak	899	15110	5000	6000	21300	8500	11000	7500	37300	22000	12130	10317	25170	11683	1.66	0.98	192	150
Subal Behera	1011.5	13646	9000	5700	19650	12850	3000	3500	31650	22050	10650	7217	21000	14833	1.53	1.72	132	186
Srikanta Rana	779	7409	2500	4000	11770	8800	4950	5000	18220	17800	6735	6375	11485	11425	1.55	1.60	190	155
Babaji Pradhan	556	7490	3000	5000	8900	11600	4300	5200	16200	21800	5315	10025	10885	11725	1.45	1.09	185	173
Sabyasa chi Jena	1152	15200	5000	4000	6100	10900	3800	9400	14900	24300	4675	9132	10225	15168	0.67	1.42	175	234

m^3 with an average of Rs. 23.26/m^3. Pumping test determined the replenishment rate of the sub-surface water harvesting structures as 1.67 m^3/hr to 4.92 m^3/hr in sandy zone and 1.34 m^3/hr to 4.2 m^3/hr in clay zone. The participatory approach of implementing the above technology thus improved the financial status of several people and to some extent increased the employment opportunity.

During *kharif* 2002, rainfall was 25 per cent of the average rainfall up to June and July both at Ersama and Asratrang. Below average rainfall destroyed the crop both at the seedling and transplanting stages in other areas. But the groups who had rehabilitated their water resources under this program were able to save their crops. Participatory approach paid the dividend immediately.

In addition to the building of skills and capacity of the farmers in operation and maintenance of the shallow tube-well and portable 3.5 HP kerosene pumps and shallow sub surface water harvesting structures / tanks, the farmers of WUGs were trained on judicious use of water for improved agricultural production. The major impact was realized in terms of educating and sensitizing the farmers towards economic use of water resources for cultivation of less water intensive and more profitable crops like potato, oilseeds and vegetables; leading to positive change in the socio-economic status of the farmers with improved financial status.

Table - 6 : Performance indices of sub-surface water harvesting structure constructed (2003-04)

Name of the farmer	Capacity (m^3)	Total Cost (Rs)	Irrigated Area (ha)	*Kharif* income (Rs)	*Rabi* income (Rs)	Fish income (Rs)	Total income (Rs)	Total Expend. (Rs)	Benefit (Rs)	B.C ratio	Crop intensity (%)
Sukumar Samal	1038.0	14944	1.924	9984	30287	8500	48771	16234	32537	1.83	192
Aurobindo Samantaray	969.0	12868	1.6	9000	27750	6500	43250	14142	29108	1.88	200
Bikash Ch. Maiti	1310.0	19078	1.64	11500	30750	10500	41250	14037	27213	1.70	184
Brundaban Mandal	478.0	6803	2.16	6500	26950	5000	38450	12980	25670	1.88	270
Hemanta Pradhan	1034.0	13512	1.716	11000	20700	3500	35200	12735	22465	1.59	214
Chitaranjan Manna	1389.0	17386	1.244	9000	16160	9000	34160	10130	24030	2.02	178
Nibas Ch. Phandkar	1194.0	17828	1.216	8000	14950	10000	32950	14550	18400	1.12	152
Jhadeswar Parida	516.0	6533	1.712	11000	16300	5000	32300	9715	22585	2.18	194
Jogendra Swain	811	12829	0.984	8000	9400	4000	21400	8795	12605	1.25	123
Ballav Mallick	590	7631	0.564	4000	7600	4000	15600	6215	9385	1.34	141
Prahlakar Akhal	498	9016	0.584	6000	4650	2000	12650	6130	6520	0.93	122
Chittaranjan Midya	265	3693	0.288	2500	2450	1500	6450	2500	3950	1.38	120
Sarbeswar Swain	253	3563	0.346	2500	810	200	4010	1732	2278	1.09	108

5.3. Utility of shallow tube-wells

The utility of very shallow tube wells constructed at Astarang site is presented in Table 7. It is evident that Benefit cost ratio varied from 0.74 to 1.42 with an average of 1.04. The ratio was low as in some tube wells the data was for two years and in some cases it was for one year only. Similarly cropping intensity varied from 107 to 154% with an average of 132.7 percent. Water productivity was found to be very high in Ersama in sub surface water harvesting structure due to fish compent. However, in Astarang it was low as water was used for crop only. It varied from Rs. 4.03/m^3 to Rs. 5.55/m^3 with an average of Rs. 4.84/m^3 with an assumption that tube well was working for 50% of days during *rabi* and summer with 8 hours of pumping per session.

Table - 7: A brief account of very shallow tube-wells created at Astarang site under NATP (coastal) during 2001-04

Sl. No.	Name of the tube well water user group with no. of participants	Area irrigated (ha)			Income (Rs.)				Cost of production (Rs.)	Benefit (Rs.)	B:C Ratio	Cropping intensity	Water productivity (Rs./m^3) (rabi + summer)
		Kharif	Rabi	Summer	Kharif	Rabi	Summer	Total income (Rs.)					
1	Chakradhapur (6)	3.0	1.0	0.5	42,000	60,000	20,000	1,22,000	50150	71850	1.42	150	5.24
2	Adikandapur Sasan-I (8)	2.0	1.0	0.3	27,500	56,175	10,350	94,025	41050	52,975	1.28	110	4.35
3	Adikandapur Sasan-II (16)	2.0	1.2	0.7	31,500	61,200	22,375	1,15,075	56321	58,754	1.04	130	5.47
4	Mandaki (8)	1.8	0.8	0.6	23,475	46,310	21,371	91,156	52135	39,021	0.74	107	4.43
5	Patalda-I(7)	2.5	1.0	0.6	35,130	52,375	21,375	1,08,880	54370	54,510	0.99	137	4.83
6	Patalda-II(8)	3.0	0.9	0.7	40,050	54,010	22,110	1,16,170	57890	58,280	1.002	154	4.98
7	Baridi-I(8)	2.8	0.7	0.5	35,728	42,130	19,371	97,229	47316	49,913	1.04	133	4.03
8	Baridi-II(8)	2.4	1.0	0.6	34,130	56,130	20,380	1,10,640	55376	55,264	0.99	133	5.01
9	Hiradeipur (6)	2.6	0.8	0.8	35,314	46,375	23,109	1,04,798	54375	50,423	0.92	140	4.55
10	Timore (7)	2.0	1.1	0.9	31,781	60,430	24,340	1,16,551	58375	58,176	0.99	133	5.55

Table - 8 : Detail of land development and its performance at Ersama during 2002-2003

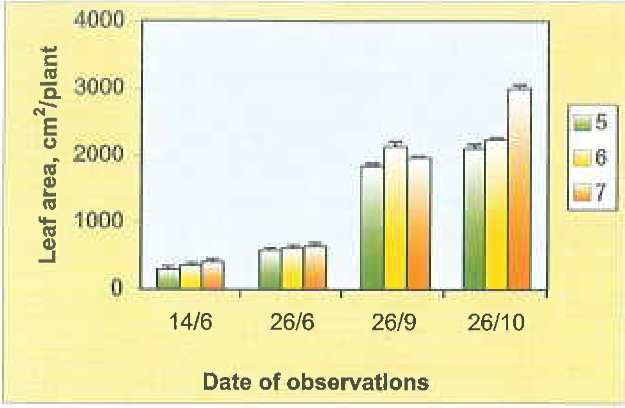
Name of the farmer and location	Terrace no.	Total cost (Rs.)	Project share (Rs.)	Area developed (m^2)	Income (Rs.)				Cost of production (Rs.)	Benefit (Rs.)	B.C. Ratio	Cropping intensity (%)
					Kharif	Rabi	Summer	Total				
Bhanu Mandal, Haltapal	I	3374	1113	116	232.00	900.00	393	1525	545	980	1.11	300
	II	1889	624	196	392.00	1520.00	664	2576	920	1656	1.49	300
	III	2519	832	260	1800.00	1630.00	130	3560	1221	2339	1.58	225

5.4. Land modification and its utilization

The super cyclone destroyed several houses and high tidal water rendered the houses into earth dunes. Applying the same participatory, technique, land modification work was carried out with two third cost being shared by the farmers. Performance of the system is presented in Table 8. From the table it is clear that in the first year itself B.C ratio was found to be 1.11, 1.49 and 1.58 in the three terraces respectively. Cropping intensity in the first two terraces was 300% whereas in third terrace it was 225%. In the third terrace in summer only one fourth of the area was cultivated due to shortage of water.

5.5. Water chestnut cultivation in sub-surface water harvesting structures

As a part of crop diversification program in waterlogged areas, attempts were made to popularize water chestnut cultivation in super-cyclone-hit coastal waterlogged area of Ersama in Jagatsinghpur districts. Planting was done at seven water bodies in farmers field. The crop was planted during mid June in 2002 ensuring full water in the water bodies. Both green varieties "haldipada green" and "haldipada red" were planted in each pond in 1:1 ratio. The vine of three seedlings at a time was tied loosely together and the knot was gently buried in to mud bottom of the pond with the help of toe. The planting was done at a spacing of 1.5m X 1.5 m. The compost was applied @ 8 t/ha before planting. The N:P:K fertilizer @ 40:60:40 were applied in three splits. The one third of N as urea and K as muriate of Potash with full P as single super phosphate were applied as basal dose. The rest 2/3 N and K were applied in two splits at two and four months after planting. To minimise the infestation of singhara beetle (*Calerucella birmanica*) Sevin @ of 1.5 kg/ha was applied three times from the third month onwards as and when infestation appeared. Out of seven places, cultivation was successful at three places. In four places salinity level was relatively high (3-8.8 ppt) for which crops did not grow well. The dissolved oxygen content, pH and temperature did not vary significantly at



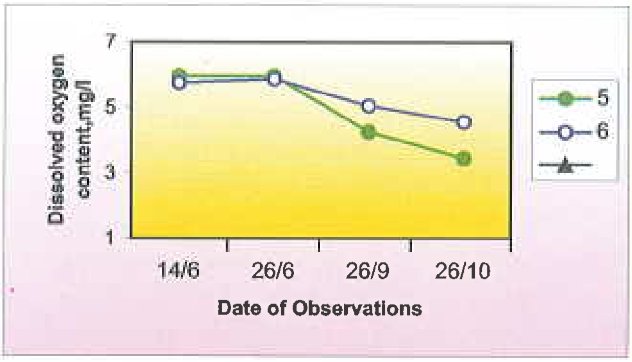


Table - 9 : Performance of water chestnut is sub-surface water harvesting structures at Ersama.

A. Variable cost of production		Ersama (200m²)
(i) Pond preparation (Rs)		150.00
(ii) Seeding cost (Rs)		50.00
(iii) Labour	Planting (1 man days) @ Rs.40/-	40.00
	(b) Weeding (1 man days)	40.00
	(c) Harvesting (5 man days)	200.00
(iv) Fertilizer (N :P: K) 40:40:60 Urea 1.75 kg SSP 5 kg MOP 2 kg		35.00
(v) Insecticide(Rs)		50.00
(vi) Miscellaneous(Rs)		---
B. Fixed cost (Rs) Land rent		40.00
Total cost A+B (Rs)		605.00
Income from Yield of chestnut (approx) @ Rs. 5.00/kg		200 kg Rs.1000.00
Net profit		Rs. 395.00

different places initially during monsoon. After recession of monsoon salinity increased appreciably in one place for which the crop growth was poor. At the start of the experiment the leaf area increased slowly as the branching of the plants were limited till second month of the crop (Fig. 3). Increased leaf area over surface of water significantly decreased dissolved oxygen concentration at later stage of crop growth (Fig. 4). The total productivity of nuts in three water bodies were 7.32, 7.56 and 8.87t/ha with net profit ranging from Rs.19,800 to 20,200 per ha. Performance of water chestnut in sub-surface water harvesting structures at Ersama is presented in Table 9.

6. Effectiveness of group dynamics

The group dynamics plays pivotal role in the functioning of groups in an efficient manner. There are certain factors, which influence on group functioning and group effectiveness (Samra *et al*, 1996). The "Group Dynamics Effectiveness" (GDE) has been operationally defined as the sum total of forces among the members of group based on certain sub-dimensions/factors. It could be assessed with respect to it's different parameters *viz.* participation, decision making procedures, operation, maintenance & management functions, interpersonal trust, fund generation, social support, group atmosphere, membership feelings, group norms, empathy, etc. The factors affecting group dynamics effectiveness of WUGs were delineated. A schedule was developed for this purpose including probable factors, which may influence the group activities. Responses were taken from users of WUGs on a 5 point continuum i.e. highly disagree (1) to highly agree (5) with respect to each factor for its influence on group effectiveness. Further, respondents were asked to put relative weightage to 10 mostly agreed factors in such a manner that sum of weightage for all those 10 factors would be 100. Mean values for these factors were calculated. Further probing with respect to the most important factor was carried out through group discussion method by exploring of different issues under that factor

Table - 10 : Factors of group dynamics effectiveness of WUGs.

Factors	Mean of evaluatory score	Standard deviation	Weightage (%)
Participation	4.85	0.52	20
Decision making	4.60	0.48	15
Operation and Maintenance	4.32	0.63	12
Interpersonal trust	4.30	0.55	10
Fund generation	4.25	0.82	10
Social support	3.74	0.85	8
Group atmosphere	3.65	0.73	8
Membership feelings	3.50	0.58	7
Group norms	3.25	0.67	5
Leadership	3.15	0.88	5

A perusal of Table 10 indicates that the factor of participation has received top most priority for the effective functioning of WUGs followed by decision-making, operation and maintenance of water resources, interpersonal trust and fund generation. The other factors identified were social support, group atmosphere, membership feelings, group norms and group leadership.

7. Farmers' participation

People's participation in any development programme is vital for its success. It has been observed that any development programme taken up without involvement of local people ends up with no takers after the executing agency withdraws. Participation is a group dynamic process in which all members of a group contribute to the attainment of group objectives, share the benefits, exchange information of common interest and follow the norms, regulations and other functions. There are certain factors, which influence on group functioning and group effectiveness. Participation has received top most priority for the effective functioning of farmers' groups. A study was carried out to assess the level of farmers' participation in water resource creation, maintenance and utilization and to find out interrelationship of socio-economic and personal traits with farmers' participation

This study focused on farmers' participation in creation, maintenance and utilization of seven subsurface water harvesting structures, which were constructed in first year (2001-02) of project by forming seven farmers' groups. Therefore, 45 farmers of seven groups were selected randomly and their responses were recorded with help of developed schedule. The schedule included statements related to farmers' participation and score was assigned as 1 for 'yes' and 0 for 'no' response to each statement and farmers' participation index (FPI) was calculated as under:

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

Where,

$P = S\,P_i / N$ and $P_i = S\,PP_j$

Where,

PP_j = Total score of farmers' participation

$i = 1, 2, \ldots\ldots\ldots, N$

$j = 1, 2, \ldots\ldots\ldots, K$

N = total number of respondents and K = total number of statements

Interrelationship between socio-economic and personal traits (independent variables) with peoples' participation (dependent variable) was worked out by correlation as well as multiple regression analyses.

Farmers' participation was studied separately for the stages of water resource creation, utilization and maintenance. It is evident from Table 11 that most of the farmers considered water resource creation beneficial and felt its need, therefore, formed users group and contributed share of cost/labour towards construction of water resource. The mean participation score with respect to different issues at creation stage varied from 0.24 to 0.98. Value of FPI in creation stage was found to be 61.94.

Table 12 elucidates farmers' participation in utilization of created water resource. FPI value in this stage is 45.83. Farmers' participation in water resource maintenance is presented in Table 13. Farmers of water users group take care of maintenance of water resource and raise group fund to meet this expenditure. Farmers appreciate the technical guidance, advice and support from project implementing agency in maintaining the created water resources and sustainable utilization. Mean participation score varied from 0.11 to 1.00 with FPI value of 58.61.

Table - 11 : Farmer's particupation in water resources creation (N=45).

Sl. No.	Issues at the stage of water resources creation	No. of farmers with positive response	Mean participation score	Standard Deviation
1.	Considering water resource creation beneficial	44	0.98	0.15
2.	Participating in planning and designing of water resource	13	0.29	0.46
3.	Desiring (felt need) creation of water resource to utilize water for cultivation	40	0.89	0.32
4.	Contributing some share of cost of construction	17	0.38	0.49
5.	Contributing labour (self/hired) towards construction of water resource	16	0.36	0.48
6.	Forming users group before creation of water resource	39	0.87	0.34
7.	Agreeing to share water among members of the group	11	0.24	0.43
8.	Motivating for crop diversification with increased production and income with help of created water resource	43	0.96	0.21
				FPI value = 61.94

Table - 12 : Farmer's participation in water resource utilisation (N=45).

Sl. No.	Issues at the stage of water resources utilisation	No. of farmers with positive response	Mean participation score	Standard Deviation
1.	All farmers in water user group involve in deciding internal water distributions to their fields from created water resources	44	0.96	0.21
2.	Participating in collection of water rates	34	0.76	0.43
3.	Farmers' group maintain the collected fund	14	0.31	0.47
4.	Farmers follow water sharing process for irrigating crops when required	21	0.47	0.50
5.	Selecting specific crop pattern to be adopted by all member farmers	0	0.00	0.00
6.	Adopting different practices for multiple use of water (cultivation of crops, aquatic plants - water chest nut, fishery, duckery, etc)	8	0.18	0.39
7.	Holding group meeting periodically to decide on different issues of water utilisation	45	1.00	0.00
				FPI value = 45.83

Table - 13 : Farmer's participation in water resource maintenance (N=45).

Sl. No.	Issues at the stage of water resources maintenance	No. of farmers with positive response	Mean participation score	Standard Deviation
1.	Farmers of water users group take care of maintenance of water resource	43	0.96	0.21
2.	Financial support to manage and maintain the water resources	5	0.11	0.32
3.	Farmers raise their own fund / income	42	0.93	0.25
4.	Contributing own labour for repair and maintenance of own water resource	10	0.22	0.42
5.	Contributing own money for repair and maintenance of own water resource	8	0.18	0.39
6.	Farmers get trainings in water management, deficient water use, and participatory water management	14	0.31	0.47
7.	Project implementing institute/ department officials act as a facilitator and supportive to farmers' participation in water management	44	0.98	0.15
8.	Farmers' group receive technical guidance, advice and support to properly maintain the created water resources and sustainable utilisation	45	1.00	0.00
				FPI value = 58.61

The participation level of most of the farmers was medium, however, about 20% farmers ensured high level of participation (Table 14). FPI was highest at creation stage followed by maintenance and utilization stage with an overall FPI value 55.46. The relatively low value at utilization stage may be attributed to non-selection of specific cropping pattern by group members as well as most of the members were not interested for water sharing and adoption of different practices for multiple water use to avoid any possible conflict or dispute.

Table - 14 : Level of farmers' participation in water reources creation, utilization and maintenace.

Sl. No.	Participation level	Number of respondents	Percentage	Mean	Standard Deviation	FPI value
A. Water resource creation						
1.	Low level	5	11.11	4.96	1.65	61.94
2.	Medium level	32	71.11			
3.	High level	8	17.78			
B. Water resource utilisation						
1.	Low level	4	8.89	3.67	1.04	45.83
2.	Medium level	32	71.11			
3.	High level	9	20.00			
C. Water resource maintenance						
1.	Low level	5	11.11	4.69	1.28	58.61
2.	Medium level	30	66.67			
3.	High level	10	22.22			
						Overall FPI value = 55.46

An attempt was made to identify the socio-economic and personal factors, which influence farmers' participation in development and management of water resources. Correlation and multiple regression analyses were computed. Farmers' overall participation was considered as dependent variable while age, education, income, land holding, assets (tools, implements, equipments and other assets for agricultural operations) social participation and extension orientation were taken as independent variables. All independent variables barring age were significantly correlated with participation (Table 15). The values in Table 16 reveal that seven independent variables included in present study account to 76.8% variation in the farmers' participation (R^2 = 0.768). Land holding, income, social participation and extension orientation were having positive and significant relationship with participation. The respondent's age, education and assets holding did not matter much in this regard.

Table - 15 : Correlation of socio-economic and personal variable with farmers' participation.

Sl. No.	Socio-economic and personal variables	Correlation coefficient
1.	Age	-0.177
2.	Education	0.670**
3.	Assets holding	0.491**
4.	Land holding	0.662**
5.	Income	0.701**
6.	Social participation	0.671**
7.	Extension orientation	0.688**

Table - 16 : Factors affecting farmers' participation in context of water resources development and management.

Factors	Regression coefficient	t-value
Age	0.003	0.122
Education	0.058	0.216
Assets holding	0.017	0.142
Land holding	0.704	2.523*
Income	0.657	2.259*
Social participation	1.231	2.230*
Extension orientation	0.825	2.898**
		F value = 17.589** R^2 = 0.768

Farmers' participation are ensured because of following facts:

- Desire of farmers to use pump for existing water resources utilization
- Formation of water users group for utilization of pump to lift irrigation water
- Agreement to share pump among all members of the group
- Collection of pump operation charges by the users' group and maintaining the collected fund in group's account for future expenditure and savings to purchase group's own new pump
- Holding group meeting periodically to decide on different issues of pump utilisation
- Responsibility of operation and maintenance of pump being taken care of by water user's group
- Project implementing officials acting as facilitator and supportive to farmers' participation, monitoring periodically and providing motivational and technical training
- Creation of more water resources to avail this facility by new users groups and dissemination of this technology in the belt

8. Conclusion

The experiences of the present study show that farmers' participation is essential to make any program sustainable. The strategy formulated and implemented for participatory development and management of water resources has successfully worked with the cyclone ravaged, resource-poor farmers. Participation of the farmers by paying a portion of the cost of water resources developed has provided them a kind of ownership rights. The groups of farmers cultivated different crops by irrigating them from the water resources created by them. The irrigated area increased about five times resulting into increased cropping intensity. The positive impact was realized through the increase of the productivity and income. It gives a new insight for further research and extension work to empower the socially and economically poor, small and marginal farmers to create their own assets by forming groups and to enhance the productivity of the complex, diverse risk prone farming system. It is also inferred that location specific micro water resource development is the real answer for increasing irrigated area and productivity in coastal waterlogged area. Integrated farming system approach for each micro water resource (SSWHS) proved to be more economical. It is very easy to manage and operate the system. Another benefit is the enhanced productivity on sustainable basis from each micro water resource. Sustainability of a system depends on farmer's participations. The farmers paying capacity must be increased from the system to make it more sustainable.

Mere distribution of seed, fertilizer and planting material will not help the farmer unit and unless they have their own share in the whole production system. After the withdrawal of help the technology will vanish. Participation of farmers by paying 40% of the cost of water resources gives them the ownership rights and they do not think this, as one of the government donations or work. That is why in the second year more number of farmers came forward (15 nos) and even ready to pay upto 67% of the cost of the sub surface water harvesting structure. Similar is the case of construction of very shallow tube well at Astarang. Since the system worked with the cyclone ravaged poor people successfully, this is expected to other eco systems work in finally it gives a new insight for further research and extension work in the field of agriculture in general and small-scale water resource development and management in particular.

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ONE DAY FARMERS TRAINING
AT WTCER

MULTIPLE USE OF WATER
IN SSWHS