IMPROVING WATER PRODUCTIVITY IN A CANAL COMMAND THROUGH CONSERVATION OF SURFACE AND GROUND WATER USING TANKS AND WELLS

K.G. Mandal, R.K. Mohanty, M. Raychaudhuri
Senior Scientists
Ashwani Kumar
Director
J. Padhi, P. Majhi
Res Assoc. Directorate
S. Ghosh
Sceintist (SS)
Water Management (ICAR), Bhubaneswar

ABSTRACT

The eastern part of India has one of the most favourable eco-system for agriculture, yet the agricultural production is much lower than its potential. Even though several factors are responsible for poor growth of agricultural productivity, lack of irrigation water availability and its reliability are the major constraints in realizing the production potential. The efficiency of the irrigation projects has been quite low. Therefore, attempts are made to study the technical, *operational, environmental and economic feasibility of a canal system, Kuanria Medium Irrigation project (KIP) in Nayagarh district of Odisha, augmented with rainwater harvesting and well systems for supplementing canal waters and crop diversification including fish, vegetables and pulses production. The project site covers two blocks viz. Daspalla and Nuagaon with geographical area of 571.57 and 385.24 sq. km, respectively. Kharif rice, brinjal and green gram are the most important crops occupying 90.4, 8.8 and 10.6% of the total command area, respectively. KIP irrigates 3780 ha benefiting about 37,000 people living in 67 villages under the command area. Amount of water released was highest in the month of Oct (354.3 and 314.2 ha m through LD and RD, respectively). During the period of Jul to Oct major amount of water was released from the Kuanria dam which is sufficient to irrigate 3780 ha of cultivable command area (CCA). Amount of released water was less during lean period (Dec-Jun) in comparison to monsoon period (Jul-Oct) as a result of which it is able to irrigate only 1908 ha of CCA. The current measured discharges in minors and sub minors of KIP were low in comparison to original design discharge because of changes in cross section due to erosion and soil deposition. As a result flow velocity and carrying capacity reduced. Even though water was supplied at higher water level than the designed, tail-end farmers did not receive adequate and timely supply of water. Multiple use of water is successful through fish culture and on dyke crop cultivation. Water productivity is increased by multiple use of water.*

INTRODUCTION

India has one of the largest and most ambitious irrigation programme in the world and created an irrigation potential of about 91 M ha against the ultimate irrigation potential of 139.5 M ha. However, the overall project efficiency from the head works to the farmers' fields has been quite low. As the cost of creating additional irrigation potential in terms of financial, human and environmental aspects has increased tremendously, there is growing realization to enhance efficiency of the existing canal irrigation projects to increase the irrigated area without developing additional resource. To fully exploit the irrigation potential created, it is necessary to improve the water availability and reliability of the system during lean season and increase agricultural production by bringing more areas under irrigation and increasing cropping intensity.

Baseline survey conducted in selected projects in Mahanadi canal command area revealed that 30 to 60% of the total canal command farmers do not get adequate and timely water supplies. Similar type of situation exists in many irrigation schemes in eastern India. In Orissa, majority of the canal command farmers do not get adequate and timely supply of irrigation. Tail end farmers always get less water and some time they do not get any water. Farmers keep their fields fallow after kharif season because water availability is very unreliable and undependable. To ensure water availability and dependability to all the farmers, it is necessary to develop and create a dependable and reliable water supply system in the canal command through conjunctive use of rain water, canal water and ground water.

In India, tank irrigation is an age-old practice, irrigating about 4 million ha [1]. Most of them are independent source of water supply. Many of these tanks located in the commands could be made adjunct to the existing canal system. For effective and efficient use of water, it is essential that every farm entity to have a service reservoir so that the farmer can use his allocation at his convenience, both in time and size of stream/ canal [2]. This study will also examine technical, economic and other feasibility of a canal irrigation system supplemented by water availability through rainwater harvesting and shallow wells, and crop diversification including fish, vegetables and flower production in canal command.

DESCRIPTION OF STUDY SITE

This study is being carried out in Kuanria Medium Irrigation Project (KIP) at Daspalla, Nayagarh district of Odisha (Fig. 1). It is located at 20°21′0″ N latitude and 84°51′0″ E longitude at an elevation of 122 m above mean sea level. The geographical area of Daspalla block is 571.57 km^2. This study site comes under Agro-Eco Sub-Region 12.2 (AESR 12.2) and Agro-Climatic Zone 7 (ACZ 7) according to NBSS&LUP (ICAR) and Planning Commission, Govt. of India classification, respectively [3]. The dominant soils of this region are clay and sandy clay to sandy clay loam. Soil was slightly acidic to neutral (pH 6.0-7.4) in upper soil layers and alkaline (pH 7.0-9.0) at 60-120 cm soil depths. Bulk density of the soil varied between 1.46 to 1.50 Mg m^{-3}.

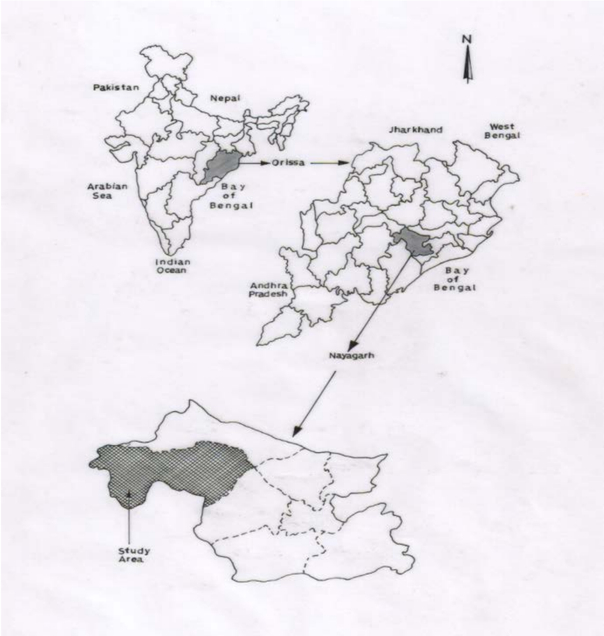


Fig. 1. The study area i.e., Daspalla region of Nayagarh district in Orissa.

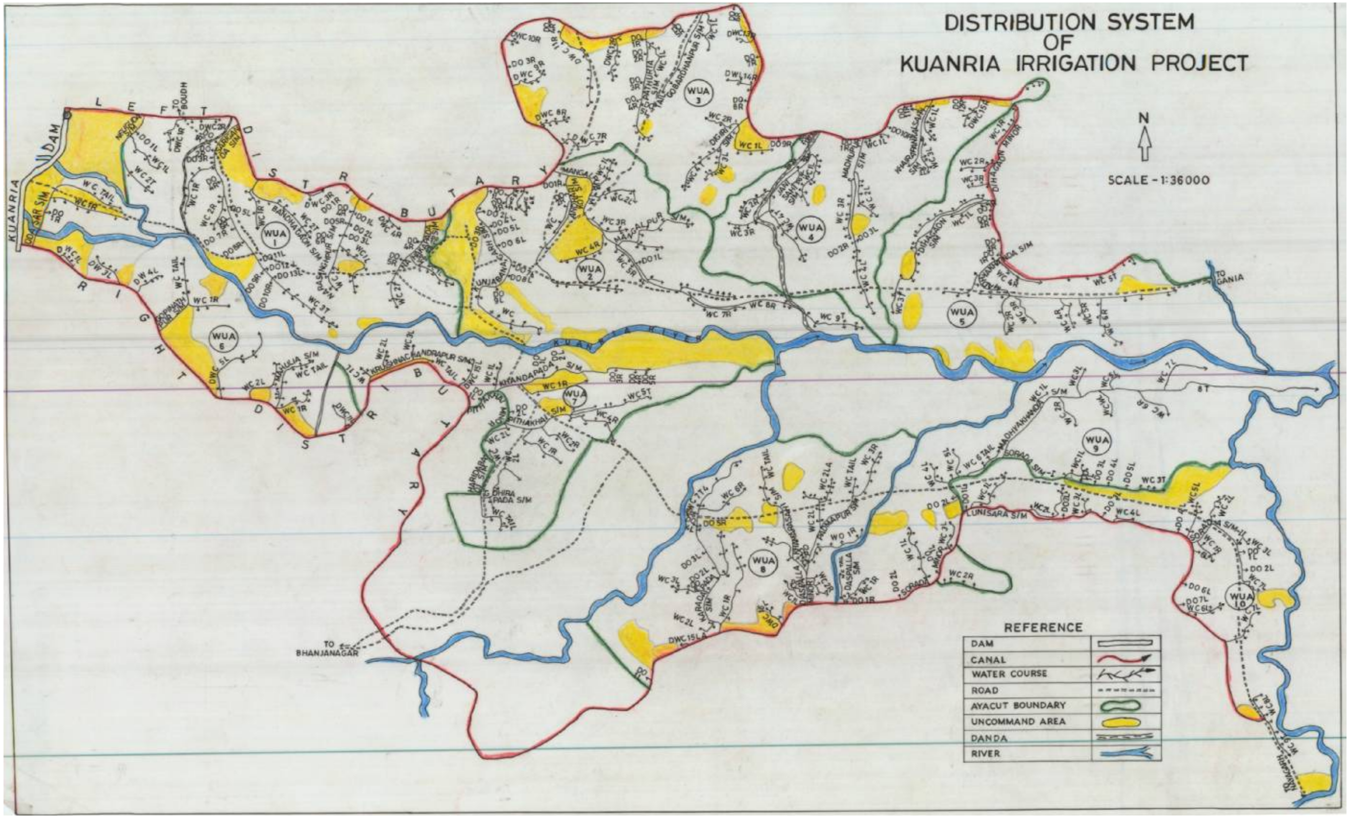
KUANRIA MEDIUM IRRIGATION PROJECT

Kuanria Irrigation Project (KIP) is located near village Odasara in the western side of Daspalla Tahasil in Nayagarh district of Orissa, at the latitude $20^{\circ}20^{'}$N and longitude $84^{\circ}28^{'}$E (Fig. 2). KIP is a medium irrigation project. Intercepting river ‘Kuanria’, a right tributary of river Mahanadi and a nallah named ‘Khalakhala’ by an earth dam form the reservoir of KIP. The catchment area of the reservoir is 124 sq km.

Kuanria medium irrigation project irrigates 3780 ha of land benefiting about 37,000 people living in 67 villages under the command area. The top bank level of the dam (TBL) with 5.0 m top width is 138.0 m, maximum water level (MWL) or flood reservoir level (FRL) of the reservoir is 135.7 m and the dead storage level is 130.3 m. The project has two number of head regulators such as right and left distributaries. Right and left distributaries runs for a length of about 18.2 and 16.5 km having design discharges of 2.00 and 1.98 m^3sec^{-1} respectively.

The gross storage capacity of the reservoir is 2200 ha m with a live storage of 1750 ha m. The GCA is 4800 ha and CCA is 3780 ha. The CCA of right distributary is 1868.13 ha and that of left distributary is 1911.87 ha. Discharge rate for all minors and sub-minors of right and left distributary were measured. The water released data through left and right distributary of Kuanria Dam was also collected. There are 10 water users’ association (WUA) distributed over the entire area of the Kuanria Medium Irrigation Project (KIP). WUA 1 and 6 are situated towards head end, WUA 2, 3, 7 and 8 are in the mid end and similarly WUA 4, 5, 9 and 10 are situated at tail end under KIP.

Rainfall data for 16 years (1995-2010) have been collected from meteorological observatory of Kuanria dam, Daspalla, Nayagarh. The monthly effective rainfall was calculated following USDA Soil Conservation Service method. This method is being widely used in India for calculation of monthly effective rainfall at different locations [4, 5]. Onset and withdrawal of rainy season was computed from weekly rainfall data by forward and backward accumulation methods [6]. In this study, weekly rainfall values have been computed from daily values and were used for initial, conditional and consecutive dry and wet spell analysis based on Markov chain probability model [7].



DISTRIBUTION SYSTEM
OF
KUANRIA IRRIGATION PROJECT
N
SCALE - 1:36000
REFERENCE
DAM
CANAL
WATER COURSE
ROAD
AYACUT BOUNDARY
UNCOMMAND AREA
DANDA
RIVER
LEFT DISTRIBUTARY
RIGHT DISTRIBUTARY
KUANRIA DAM
KUANRIA RIVER
TO BHANJANAGAR
TO GANIA
WUA 1
WUA 2
WUA 3
WUA 4
WUA 5
WUA 6
WUA 7
WUA 8
WUA 9
WUA 10

RESULTS AND DISCUSSION

Texture for all the soil layers was clay at the tail end of the canal system where water availability through canal supply is relatively less than the mid or head reaches. The soil organic carbon content decreased as soil depth increased for the tail end site. Bulk density of soil varied between 1.41 to 1.47 Mg m^{-3} and EC varied between 0.01 to 0.11 dS m^{-1}. Reverse was the trend for mid-reach soils. The soils in the mid reach are predominantly sandy clay loam up to 45 cm soil depth and sandy clay in the 45-120 cm soil depths due to higher proportion of sand and clay contents. Soil pH in mid reach soils are mostly neutral. Saturated hydraulic conductivity (K_s) in mid-reach soils is higher than the tail-end soils, but available water content (AWC) in mid reach soils are lower than tail-end soils. Due to higher K_s and lower AWC values in mid reach soils, there will a requirement of frequent irrigation and effective soil water conservation measures for successful cultivation of crops. In case of tail end soils, the interval of irrigation will be more due to higher AWC values. The careful management of water should be the basis for improving water and crop productivity.

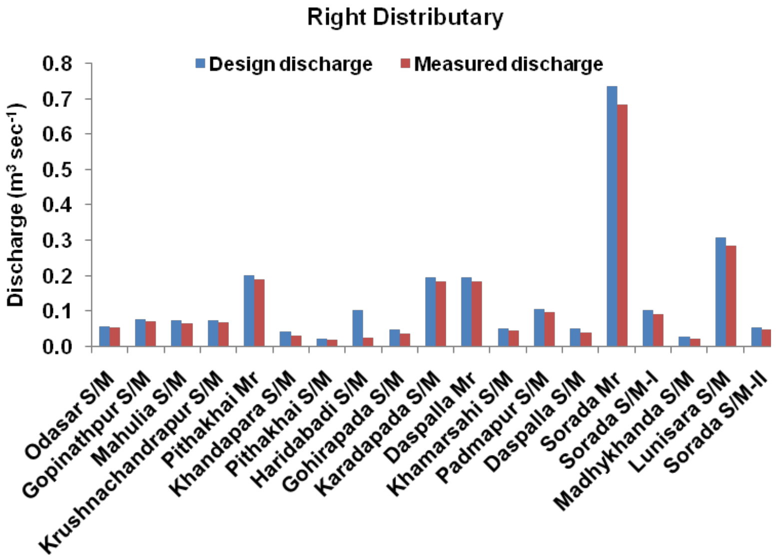


Fig. 3. Comparison of design and measured discharge rates of minors and sub-minors in right distributary

It is observed that, the carrying capacities (i.e. measured discharge) in all the minors and sub minors of right and left distributaries have reduced in comparison to the original design discharge (Fig. 3 and 4). It is found that the cross section of the minors and sub-minors are changed due to soil erosion and high amount of soil is also deposited on the bed. For this reason velocity of flow is reduced and ultimately the carrying capacity is reduced.

Amount of water released was highest in the month of October (i.e. 354.3 and 314.2 ha m for LD and RD, respectively) was highest. During the period of July to October major amount of water was released from the Kuanria dam which is sufficient to irrigate 3780 ha of cultivable command area along with average annual rainfall of 1509 mm. Amount of released water was less during lean period (Dec-June) in comparison to monsoon period (July-Oct).

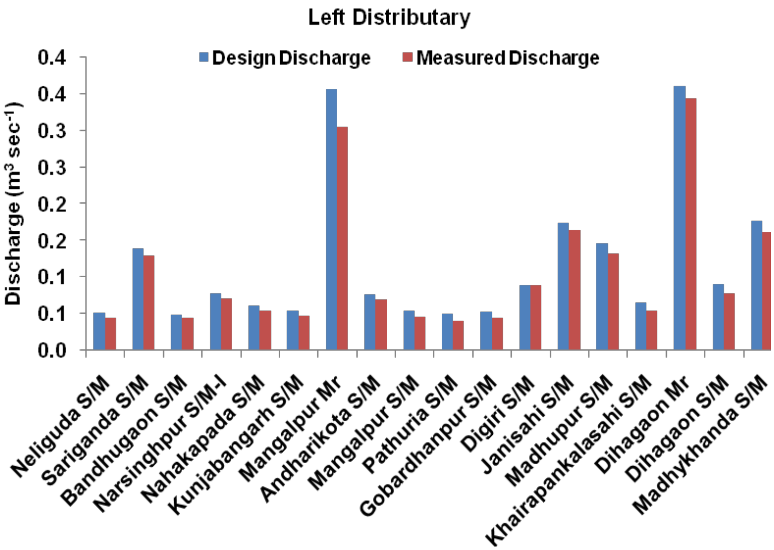


Fig. 4. Comparison of design and measured discharge rates of minors and sub-minors in left distributary

Total annual rainfall of Daspalla block was ranged between 993.5 mm and 1901.8 mm with an average annual rainfall of 1509.2 mm and the coefficient of variation (C_v) of 14.8%. Total annual effective rainfall (ER) is 858.2 mm which is 56.9 percent of the total annual rainfall. Therefore 651 mm of rainfall water lost in the form of surface runoff, deep percolation and evaporation. The normal southwest monsoon, which delivers about 75.7% of annual rainfall, extends from June to September. This is also the main season (rainy season) for cultivation of rainfed crops. As 1133.3 mm of rainfall is spread over a few rainy days with fewer rain events of high intensity, surface runoff can cause temporary water stagnation in agricultural fields. Winter season contributes only 3.1% of the total annual rainfall. 10.8 and 10.4% of the total annual rainfall occurred during pre and post-monsoon season respectively.

In this region, most of the farmers' keep their fields fallow after harvesting of rainy season rice because only 162.6 mm of rainfall took place during post-monsoon season which is not sufficient to grow another crop in post monsoon season. Rainfall is quite less during winter and pre-monson season (i.e. 5 months). Therefore, for effective and efficient use of water, it is essential that every farm entity to have a service reservoir so that the farmer can use his allocation at his convenience [2].

Fig. 5. Development of water harvesting structures under KIP

Based on experiences from watershed management research and large-scale development efforts, practical harvesting of runoff is possible only when the harvestable amount is more than 50 mm or greater than 10% of the seasonal rainfall [8]. In this study area, as runoff amount was more than 10% of the seasonal rainfall, therefore practical harvesting of runoff is possible. Therefore it is essential to construct water harvesting structures (WHS) for conservation of rainfall and runoff water to ensure water availability and dependability to all the farmers. In order to conserve the rainfall, seepage and excess canal water ponds (i.e. WHS) are constructed within the Kuanria irrigation command area (Fig. 5). We have also released fishes such as rohu, catla and mrigal in those constructed ponds. In 2011, this region received less amount of monsoon rainfall. Therefore, farmers have irrigated few times the surrounding fields by utilising the stored water within the ponds. The harvested water in the WHSs during monsoon season can be used as multisource water for irrigation, domestic use, fish rearing and duckery, growing papaya, banana etc along the banks and thus serve as an for integrated faming system. This stored water can be used as supplemental or life saving irrigation to post monsoon crops. Crop selection can be made based on the availability of stored water in the reservoirs.

Weekly rainfall data of 16 years (1995-2010) indicated that the monsoon starts effectively from 23rd SMW (4-10th June) and remains active up to 43rd SMW (22-28th October). The range of probability of occurrence of dry week from 1st to 22nd SMW is between 56-100%. The probability of occurrence of dry week preceded by another dry week (P_{DD}) and that of dry week preceded by another wet week (P_{DW}) vary from 54-100% and 28-100% respectively during 1st-22nd SMW periods. However from 23rd to 40th SMW the probability of both P_D and P_{DD} are low. The probability that these weeks (23rd-40th SMW) remain wet (P_W) varies between 62-100%. The conditional probability of wet week preceded by another wet week (P_{WW}) varies between 30-100%. The chances of occurrence of dry spells are again high from 42nd SMW to the end of the year.

Since the probability of occurrence of wet week is more than 30% during 19th–21st SMW (7-27th May) and average weekly rainfall ranges from 24.1 to 40.7 mm, this pre- monsoon rain can be utilized for summer ploughing and initial seed bed preparations. Therefore sowing operations can be done during 22nd SMW (28th May–3rd June) because of the probability of wet week is more than 31% and average weekly rainfall is more than 15 mm. Sowing operations performed on 22nd SMW favours good germination of seeds and also helps in avoiding moisture stress for germination period during 24–26th SMW. Instead of growing rice, short duration crops of groundnut, pigeon pea, maize, sorghum, green gram, soybean, sunflower, field bean, cowpea and other low water required crops which have high return value can be grown during monsoon season.

Since, post monsoon rainfall is uncertain and erratic than southwest monsoon, growing of high value post monsoon crops without supplementary irrigation would be very risky. The significant contribution of weekly rainfall (>46 mm) during 36–40th SMW and high consecutive wet week probability during 36–40th SMW, there is an potential for harvesting excess runoff water for future supplemental irrigations and also drives attention towards soil erosion measures to be taken up for soil erosion control. Similarly, high consecutive dry week probabilities after 44th SMW, hints for need of supplementary irrigations and moisture conservation practices to be taken up.

We have also done survey of existing socio economic status of farmers under KIP by using a pre tested questionnaire, which covers eight gram panchayat and 30 villages. Main occupation is agriculture for all the farmers. 84.4, 9.4, 4.7 and 1.6 percent of total farmers adopting agriculture, business, diary and fishery respectively as their secondary occupation. Average annual income of the farmer is Rs. 31,484/- with maximum and minimum income of Rs. 90,000 and 5,000 respectively. Average farm size of the farmer was 3.6 acre. 76.6 percent of total farmers belong to medium household and remaining farmers belong to small (i.e. 14.1%), large (i.e. 6.3%) and very large (i.e. 3.1%) household.

SUMMARY AND CONCLUSION

Long term analysis of rainfall data at Daspalla region revealed that 651 mm of rainfall water was lost due to runoff, deep percolation and evaporation. This estimated water loss indicates a large potential to improve crop water use efficiency by mitigating dry spells. This can be achieved through water harvesting structures, where local runoff flow is harvested and stored in reservoirs and used for supplementary irrigation during dry spells. The harvested water can also be used for growing of on-dyke crops, fish culture and duckery and life saving irrigation in dry period. The carrying capacities of all minors and sub minors of right and left distributaries have reduced in comparison to the original design discharge due to soil erosion and deposition of soils. Therefore water is supplied from KIP through left and right distributaries at higher water level than designed. Saturated hydraulic conductivity (Ks) in mid-reach soils is higher than the tail-end soils, but available water content (AWC) in mid reach soils are lower. Main occupation is agriculture for all the farmers. Of course, business, diary and fishery are the secondary occupation for a few farmers.

There is a potential for improving water productivity through conservation of excess canal water in water storage structures like tanks and open wells. The rain water as well as runoff will also be collected in the water storage tanks and wells in the command area. The storage water will be utilized for providing irrigation to post-monsoon crops. There is a tremendous potential for growing on-dyke cultivation of horticultural crops for enhancing water productivity and farm income.

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BRIEF PROFILE OF THE AUTHORS

Dr. K.G. Mandal graduated in Agriculture from Visva-Bharati University in 1991. He obtained Ph.D. in Agronomy from BCKV, West Bengal in 1998 and joined ICAR under Agricultural Research Service as Scientist at IISS, Bhopal and stayed there up to 2007. While his service at Bhopal, he did his PDF in Agronomy at CAU, Beijing, China for one year. Presently he is working as Senior Scientist at Directorate of Water Management (ICAR), Bhubaneswar since 2007. He has commendable contribution in research, development and extension in the fields of water management agronomy, water-nutrient interaction and participatory water management in canal commands.

Dr. Ashwani Kumar graduated in Agricultural Engineering from Allahabad University in 1972 and obtained Ph.D. from Indian Agricultural Research Institute in 1983. Joined Agricultural Research Service in 1977 and did outstanding contribution in micro-irrigation, plasticulture, hydrology, remote sensing, crop-weather interaction, crop diversification, contingency planning, climate change mitigations. Out of 34 years of experience, 17 years was in administration, research management, planning and human resources development. Presently he is Director, Directorate of Water Management, Bhubaneswar and also coordinating All India Coordinated Research Projects on Water Management and Ground Water Utilization to generate location specific and cost effective technologies.

Dr. Jyotiprakash Padhi graduated in Agricultural Engineering from Orissa University of Agriculture and Technology in 2002. He did M.Tech. from IIT, Kharagpur in Soil and Water Conservation Engineering in 2005 and obtained Ph.D. in 2010 from University of Southern Queensland, Australia. He has around 6 years of research experience in the field of soil and water engineering. Presently, he is working as a Research Associate for the MoWR, GOI sponsored R&D scheme at Directorate of Water Management (ICAR), Bhubaneswar since July 2010. He has research interests and experience in irrigation, precision agriculture, crop water management and surface and groundwater hydrology.

Dr. Souvik Ghosh graduated in Agriculture from Visva-Bharati University in 1995. He obtained Ph.D. in Agricultural Extension from Indian Agricultural Research Institute in 2000 and joined Agricultural Research Service as Scientist. He is presently working as Scientist-SS. His contributions include integrated assessment of water management technologies; adoption dynamics model; methodology for evaluation of irrigation system from farmers' perspectives; study of water user group dynamics; assessment of irrigation-agriculture-living-poverty links; irrigation institutional analyses, etc. He mobilized farmers' groups to adopt the on-farm water management innovations in the commands of major, medium and minor irrigation projects for improved irrigation and agricultural performance.

Dr. Rajeeb K. Mohanty post graduated in Fisheries Management from Central Institute of Fisheries Education (ICAR), Mumbai in 1992. He obtained a Ph.D. in Aquaculture at the Sambalpur University in 2000 and D.Sc. in 2009. In 1997, he joined ICAR as Scientist (Fish & Fisheries Science). From 2006, he has been Senior Scientist at Directorate of Water Management (ICAR), where he has worked on water budgeting, aquaculture water productivity, water quality and production aspects of freshwater high-value aquaculture.

Mr. Pradeepta Kumar Majhi graduated in Agriculture from Chandra Sekhar Azad University of Agriculture and Technology, Kanpur in 1999 and post graduated in Agricultural Chemistry, Soil Science and Biochemistry from OUAT, Bhubaneswar in 2002. He has 10 years of experience in the field of research and development. Presently, he is working as a Research Associate for the AICRP on long term fertilizer experiment at OUAT, Bhubaneswar since August 2011. He has research interests and experience in soil microbial activities, soil nutrient and crop water management.

Dr. Mausumi Raychaudhuri graduated in 1986 and a Ph.D. in Soil Science and Agricultural Chemistry from University of Calcutta. From 1990 to 1992 she worked for Soil and Land Use Survey of India, Ministry of Agriculture, GOI and expertise on GIS and remote sensing. She joined ICAR in 1992 as Scientist. Since 2001 she is working as Senior Scientist and presently working at Directorate of Water Management (ICAR), Bhubaneswar since 2008. She has expertise in GIS and remote sensing, management of acid soils in north-eastern India, use of poor quality water, soil and land quality, decision support system.