Climate Change Innovation Programme

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ACTION ON CLIMATE TODAY

Water Use Report

SEP 2017

Prioritizing water use mechanisms for sustainable usage of water and Development of Integrated District Irrigation and Agriculture Plan

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Contents

List of Tables

List of Figures

Abbreviations and Acronyms

ACT	Action on Climate Today
ADB	Asian Development Bank
AE	Assistant Engineer
ATMA	Agriculture Technology Management Agency
BCM	Billion Cubic per Meter
BKKY	Biju Krushak Kalyan Yojana
CAD	Command Area Development
CADA	Command Area Development Authority
CCA	Culturable Command Area
CS	Cross Section
CWC	Central Water Commission
DAO	District Agriculture Officer
DDA	Deputy Director of Agriculture
DDH	Deputy Director of Horticulture
DIAP	District Irrigation and Agricultural Plan
DFID	Department for International Development
DLIC	District Level Implementation Committee
DoWR	Department of Water Resources
DRDA	District Rural Development Agency
DS	Design Statement
DTW	Deep Tube Well
EAP	Externally Aided Project
EE	Executive Engineer
ET	Evaporation Transpiration
FGD	Focused Group Discussion
GIA	Gross Irrigated Area
GoI	Government of India
GP	Gram Panchayat
GSDP	Gross State Domestic Product
GWS	Ground Water Scheme
IPC	Irrigation Potential Created
IPCC	Inter-governmental Panel on Climate Change
IPU	Irrigation Potential Utilized
Kc	Crop Coefficient
KFW	Kreditanstalt fur Wiederaufbau
LS	Long Section
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MIP	Minor Irrigation Project
MOWR	Ministry of Water Resources
NABARD	National Bank for Agriculture and Rural Development
NAC	Notified Area Council
NAPCC	National Action Plan on Climate Change
NIR	Net Irrigation Requirement
NWM	National Water Mission
OAIC	Odisha Agro Industry Corporation
OFD	On-Farm Development
OIIAWMP	Odisha Integrated Irrigated Water Management Project
OLIC	Odisha Lift Irrigation Corporation
PMKSY	Pradhan Mantri Krishi Sinchai Yojana
PP	Pani Panchayat
PS	Panchayat Samiti
RI	Revenue Inspector
RIDF	Rural Infrastructural Development Fund
RKVY	Rashtriya Krishi Vikash Yojana
RLS	River Lift Scheme
SPAP	State Specific Action Plan
SHG	Self Help Groups
TW	Tube Well
UIP	Ultimate Irrigation Potential
WP	Water Productivity

Glossary of Terms

Aquifer	An aquifer is an underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials (gravel, sand, or silt) from which groundwater can be extracted using a water well
Ayacut	The area served by an irrigation project such as a canal, dam or a tank which is used in the Indian subcontinent.
Beat	Beat is the lowest unit of an irrigation system under an irrigation section. Before introduction of Participatory Irrigation Management and formation of WUAs (Pani Panchayat), one field functionary was taking care of canal operation at beat level called patrol.
Bore Wells	A deep well / tube-well; over 50 feet (about 15m) depth. Although the construction technology is similar to a machine drilled shallow well, the type of pump is different since water has to be pumped from a deeper level
Capital Account	The Capital Account is the account of expenditure of a capital nature, such as the construction of buildings, irrigation projects, electricity projects etc. Such expenditure is ordinarily met from sources other than current revenues, e.g. borrowings, accumulated balances, receipts of a capital nature intended to be applied as a set-off to capital expenditure.
Chak	Odiya term meaning command area of an outlet.
Community Tube Well	A tube well is a type of water well in which a long 100-200 millimetres (3.9-7.9 inch) wide stainless steel tube or pipe is bored into an underground aquifer. The lower end is fitted with a strainer, and a pump lifts water for irrigation. The required depth of the well depends on the depth of the water table. It is a common tube well which is used by the community.
Conveyance Efficiency	Ratio of the volume of irrigation water delivered by a distribution system to the water introduced into the system.
Crop Coefficient	Crop coefficients are properties of plants used in predicting evapotranspiration (ET). The most basic crop coefficient, Kc, is simply the ratio of ET observed for the crop studied over that observed for the well calibrated reference crop under the same conditions.
Cross-Regulator	It is a hydraulic structure constructed in an irrigation canal. Cross regulator has gates which are closed to maintain required head upstream in the canal for delivery of required discharge in distributary, minor and sub-minor canals as well as outlets.
Culturable Command Area (CCA)	The area which can be irrigated from a scheme and is fit for cultivation.
Debt Account	The Debt Account is the account of Debt (Loans, Treasury Bills and Ways and Means Advances) incurred and discharged and of loans and advances made by the State Government to Local Funds, private parties and others and recovered from them.
Efficiency	Efficiency is defined as the ability to produce something with a minimum amount of effort.
Evapotranspiration	The process by which water is transferred from the land to the atmosphere by evaporation from the soil and other surfaces and by transpiration from plants.
Gross Irrigated Area	The area irrigated under various crops during a year, counting the area irrigated under more than one crop during the same year as many times as the number of crops grown and irrigated.
Irrigation Efficiency	It is the ratio of the amount of water consumed by the crop to the amount of water supplied through irrigation (surface, sprinkler or drip irrigation)
Irrigation Potential Created	The total gross area proposed to be irrigated under different crops during a year by a scheme. The area proposed to be irrigated under more than one crop during the same year is counted as many times as the number of crops grown and irrigated.

Irrigation Potential Utilized	The gross area actually irrigated during reference year out of the gross proposed area to be irrigated by the scheme during the year.
Kharif	It is a local term used in Odisha for the cropping season in the monsoon period.
Major Irrigation Scheme	A scheme having CCA more than 10,000 hectares is major irrigation scheme.
Medium Irrigation Scheme	A scheme having CCA more than 2,000 hectares and up to 10,000 hectares individually is a medium irrigation scheme.
Minor Irrigation (M.I.) Scheme	A scheme having CCA up to 2,000 hectares individually is classified as minor irrigation scheme.
Net Irrigation Potential	The net irrigated area is the area irrigated during the year counting the area only once, even if two or more crops are irrigated in different seasons on the same piece of land.
Operational Plan	It means a schedule of irrigation deliveries with details of the mode and duration of supplies drawn up for regulation of irrigation in the commanded area of an irrigation system.
Outlet	An opening constructed by the State Government in an irrigation work through which water is delivered into a water course or directly on to any land.
Pani Panchayat	It is local term meaning an association of water users registered and functioning under the relevant act of Government of Odisha responsible for operation and maintenance of canal system, preparation of cropping plan and distribution of irrigation water to all water users under the association. The act has defined Pani Panchayat as an institution at the primary level consisting of all the water users, as constituted within a specified hydraulic boundary of a major, medium, minor (flow and lift) - both surface and ground water and creek irrigation projects funded by government.
Rabi	It is a local term for the cropping season in winter and summer
Relative Humidity	The amount of water vapor present in air expressed as a percentage of the amount needed for saturation at the same temperature.
Revenue Account	The Revenue Account is the account of the current income and expenditure of the State. The income is derived mainly from taxes (including share of Union Taxes), duties, fees for services rendered, fines and penalties, revenue from Government estate such as forests, other miscellaneous items and grants-in-aid from the Union Government to the State.
Root Zone Depth	The soil depth from which a mature crop extracts most of the water needed for evapotranspiration. The crop root zone is equal to effective rooting depth and is expressed as a depth in inches or feet.
Shallow Tube Well	A shallow well / tube-well; below 50 feet depth. This technology is applicable in shallow water tables, hence often in soft soil/ sandy formations. Due to their shallowness, shallow wells are prone to pollution from seepage of polluted water and drying up during dry season. However, with proper siting, these problems can be eliminated. Actually, in some areas, shallow wells tap into fresh water than deep wells, while the opposite is also true.
Solar Radiation	Solar radiation is radiant energy emitted by the sun, particularly electromagnetic energy. About half of the radiation is in the visible short-wave part of the electromagnetic spectrum.
Ultimate Irrigation Potential	The Ultimate irrigation potential should indicate only figures of gross irrigation of new area whether in the new command area or in the existing command (by increasing the intensity of cropping).
Warabandi	It is a local term. "Warabandi" means a system of distribution of water allocation to water users by turn, according to an approved schedule indicating the day, duration and the time of supply.
Water Course	Any channel or pipe not maintained at the cost of the State Government which is supplied with water from an irrigation work and includes all subsidiary work connected with any such channel.
Water Productivity	It is generally defined as crop yield per cubic meter of water consumption.

Executive Summary

The UK Department for International Development (DFID) is currently implementing Action on Climate Today (ACT) programme. ACT works with selected Governments to help integrate climate change into their policies, plans and budgets. There is a need to increase resilience of human and physical systems to cope with climate change. The Department of Water Resources, Government of Odisha, realizes that climate change oriented planning for water management is need of the hour. The present project titled "Prioritizing water use mechanisms for sustainable usage of water and Development of Integrated District Irrigation and Agriculture Plan" looks into such alternate planning approaches for two pilot districts in Cuttack and Subarnapur. The project has been undertaken under technical assistance from the Climate Change Innovation Programme of MoEFCC, Govt. of India funded by the Department of International Development, UK. Department of Water Resources (DoWR), Government of Odisha is the nodal department for the project. DoWR is widely consulted at different levels for obtaining secondary data and for their co-operation to conduct field studies. It has an objective to realign the activities of irrigation and agriculture departments in Odisha and add capacity to have effective programmes and governance of irrigation schemes to build resilience in the event of water scarcity and adverse situations caused by climate change. Looking at the emerging water demand in different sectors including agriculture and persisting gaps in addressing it, the Water Resources Department of the Government of Odisha is keen to come up with an alternative planning process which takes into account the sustainable and equitable use of water resource integrated with the agriculture planning process and train its personnel for their changed or additional tasks to be assigned by the department.

Cuttack and Subarnapur district have been selected as representative pilot districts with former representing eastern coastal region and the latter representing western region. The general findings of the study, future strategies for improvement, development of methodologies for integrated planning are thus applicable to the entire state.

In Odisha, as in other states of India, there are two predominant cropping seasons namely Kharif and Rabi. The present study assesses the current water use for both these seasons. The crops are already affected due to frequent drought, heat waves and strong climatic variability. Under various climate projections, it is expected that the rainfall pattern in Odisha will become more erratic with slightly higher average rainfall but lesser number of rainfall days. This will create more frequent as well as more severe floods and droughts. Irrigation provides one important coping mechanism for these impacts. However, irrigation service delivery will need improvement to become a functional adaptation strategy for the state.

Assessment of current usage pattern of irrigation from both surface and ground water sources is very critical in formulating any strategy or plan for improvement in management of irrigation projects to support climate adaptation. This report projects the baseline scenario of water use in the two pilot districts in order to identify the gaps in irrigation potential created (IPC) and irrigation potential utilised (IPU) and the reasons thereof. This is only the first step of the project. This will be followed up by development of a water use strategy and command area perspective plan.

This project has been implemented with the cooperation of Department of Water Resources of Govt. of Odisha. Engineer-in-Chief (WR) of the department had nominated two nodal officers to facilitate and leverage the project activities in the pilot districts. Stakeholder consultation workshops were organised in both the study districts, where the engineers of irrigation department and officers of agriculture department were requested to provide data on hydraulic particulars, Culturable Command Area (CCA), Pani Panchayat, design discharge of canal sections in different category of irrigation projects viz. major, medium, minor, lift irrigation projects, etc.

Irrigation potential created up to March 2016 was compiled for different categories of irrigation projects from the data received (Figure 1).

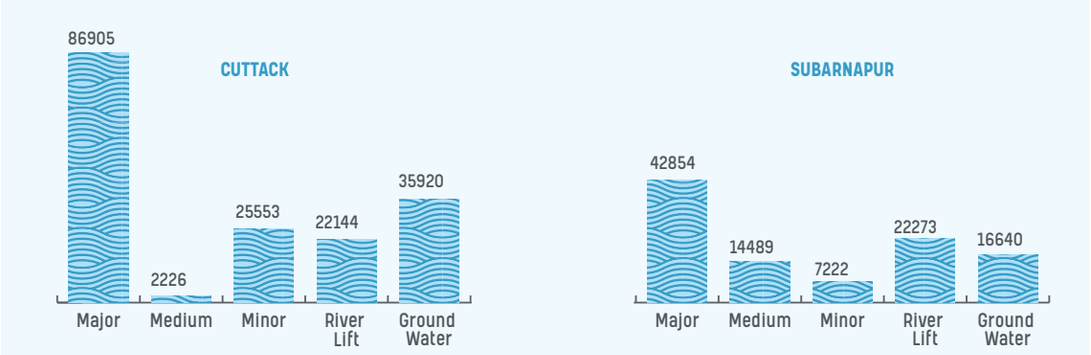
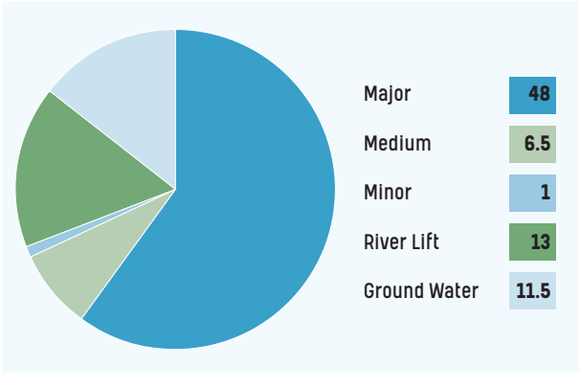


FIGURE 1 Irrigation potential created by different irrigation schemes

Field assessment was conducted in all categories of irrigation projects covering 9 out of 14 blocks in Cuttack district and all 6 blocks of Subarnapur district. Parameters related to current water usage pattern like conveyance efficiency, application efficiency, cropping pattern, crop productivity, water productivity, adequacy, dependability and equity in irrigation water distribution were determined by analysing data collected during field assessment.

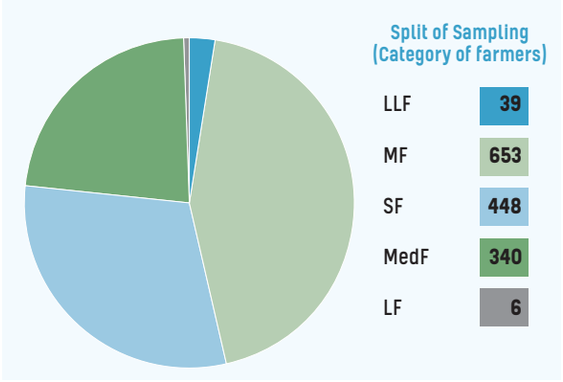
Entire command area of river lift and ground water schemes were covered under the study for verification of the irrigation infrastructure at the ground level. This included assessment of field channels, outlets, delivery tank and pipe line, pumping stations and electrical systems including transformers. In minor irrigation projects spill ways, head regulators, distributary canals were verified. For major and medium projects, the study assessed command areas in head, middle and tail reach of the distributary, and samples from minor and field channels.



The irrigation Potential created is from number of projects mentioned in Annexure I and the sampling for field assessment was decided based on the number of projects in different categories.

For the purpose of water use study in Cuttack and Subarnapur district, samples have been taken for making field assessment of actual utilization, lost ayacut and identifying issues related to irrigation man-

agement, conveyance efficiency, and application efficiency, cropping pattern, crop productivity, water productivity, adequacy, dependability and equity in irrigation water distribution. Extensive interactions were made with the water users, (i.e. farmers). A total of 711 persons were interviewed. Focus Group Discussion (FGD) were conducted for 276 farmers' groups covering both districts. Farmer-wise interview covered major, medium, minor, river lift, ground water projects. Total number of farmers interviewed could be split in Landless Farmers (LLF), Marginal Farmers (MF), Small Farmers (SF), Medium Farmers (MF) and Large Farmers (LF) as depicted in the adjacent graphics.



The gap between the irrigation potential created, as a percentage of the irrigation potential utilized for both districts is given below. Percentage gap between Irrigation Potential Created (IPC) and Irrigation Potential Utilised (IPU) are graphically represented here for Kharif and Rabi season and five categories of irrigation projects (Figure 2). Irrigation potential utilization is less than the potential created, and obviously this is a matter of concern. The lower utilization could be attributable to, *inter alia*, lack of effective and efficient management of irrigation projects, more release from Minor Irrigation (MI) tanks in Kharif season leading to less or no storage for irrigation in Rabi, absence of operation plan for reservoirs and canals, inadequate rotational water distribution system in field channels and minor canals, non-involvement of Pani Panchayat in water allocation and distribution.

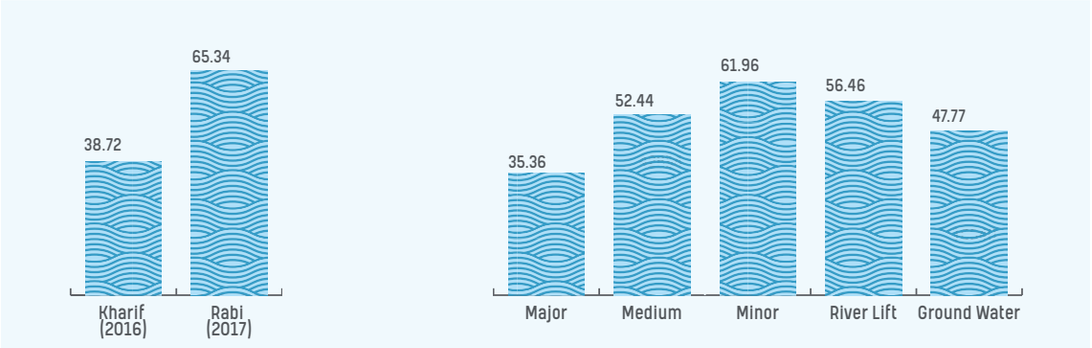
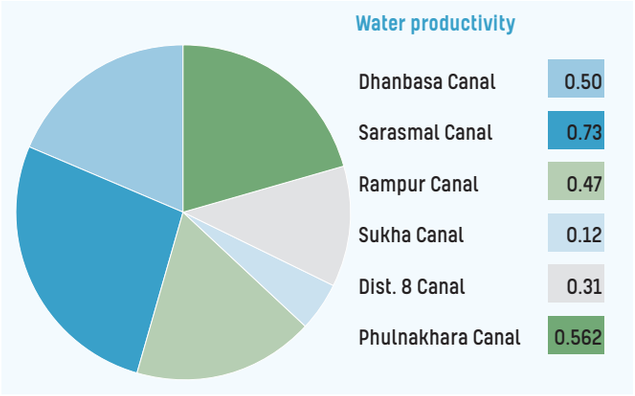


FIGURE 2 Gap between Irrigation potential created and irrigation potential utilised for different seasons and project categories

Cropping pattern during 2016-17 in the study areas of both districts was also assessed. Paddy is main crop during kharif season. Sugarcane is grown in a limited area. In rabi season, Green gram and groundnut is also grown in addition to paddy. Productivity of paddy (Kharif), paddy (Rabi), sugarcane, green gram and groundnut are computed from the sample. Yield for paddy is higher than the India average but lower than other Asian countries. Crop yield for sugarcane and groundnut is much lower than states such as Maharashtra (for sugarcane) and Punjab (for groundnut).

Crops	Yield (Qt/Ha) in Districts			
	Cuttack		Subarnapur	
Paddy	Rabi: 49.99	Kharif: 46.09	Rabi: 49.4	Kharif: 39.44
Greengram	Rabi: 3.95	Kharif: 2.98	Rabi: 3.48	Kharif: 3.2
Sugarcane	557.72		-	
Groundnut	-		9.88	

Overall irrigation efficiency on part of the Hirakud Major project was found to be only 42.16%[1] with average conveyance efficiency of canal system of 62.74% and average application efficiency of 67.20%. Causes for low irrigation efficiency are mainly field to field flooding irrigation, seepage and leakage in canals, lack of canal operational plan, non-existence of on-farm water distribution network, schedules for water distribution below and the non-involvement of water users' communities (Pani Panchayats). Remedial measures can be implemented with the existing financial provisions and capacity of the implementing agencies which will be described in the water use strategy report, the perspective command plan and District Irrigation and Agricultural Plan (DIAP). The National Water Mission (NWM) under implementation in India at present has a goal to increase efficiency by 20% in absolute terms. In the DIAP which is under preparation, approach for efficiency improvement will be highlighted. There is scope for increasing efficiency in the study districts.



Water productivity (WP) is computed for different irrigation systems for which canal release data are available. The adjacent pie chart represents the water productivity of different distributaries of both the districts. The average water productivity in both the districts is 0.450 kg/m^3 which is on the lower side as compared to global values of 0.15 kg/m^3 – 1.1 kg/m^3. Water productivity can be enhanced by minimising run-off from outlets by regulation of water in the outlets, improving on-field application efficiency and reduced wastage of water during canal operation.

Efforts were made to understand gender issues in water management and agriculture in irrigation projects villages. Women mostly participate in agricultural activities of the family as farm labour for transplanting, carrying of inputs (fertilizers, manure, seeds etc.), inter cultural operations, harvesting and transporting harvested produces. This is due to patriarchal pattern of society that is inherited over generations as a tradition. In discussions held at villages by the community, women are seldom invited. Women are not the mainstream of decision makers in the village set-up on matters related to water management and agriculture. Interaction with farm families lead to a conclusion that important decision with respect to farming sector is taken by men and women are consulted in only less than ten percent of the cases.

Financial and social inclusion[2] has been given a thrust by the Department of Water Resources particularly through ADB supported Odisha Integrated Irrigated Agriculture and Water Management Investment Programme (OIIAWMP). Under OIIAWMP project components, farmers groups are formed to take up livelihood activities at household level or village level. These kind of initiatives need to be promoted through agricultural and irrigation management programs as well. Gender equity is targeted by programmes aligned to support Pani Panchayat under OIIAWMP and Rastriya Krishi Vikash Yojana (RKVY). Implementation of such programmes was found to be inadequate to reduce gender inequality in irrigation sector. Gender budgeting in irrigation and agricultural sector, special incentives for women in terms of credit and subsidy to take lead role, etc. are envisaged to be integrated in the DIAP. Pani Panchayats should be motivated to ensure women are members of chak committees, works sub-committees, water management sub-committees, finance and resource sub-committees and executive committees. This policy can be incentivised by giving priority to those PPs who have women as decision makers and handle the affairs of Pani Panchayat. Government may move a step forward to make Pani Panchayat exclusively managed by women wherever possible. Such steps will trigger gender main-streaming and better role of women in agricultural and irrigation management.

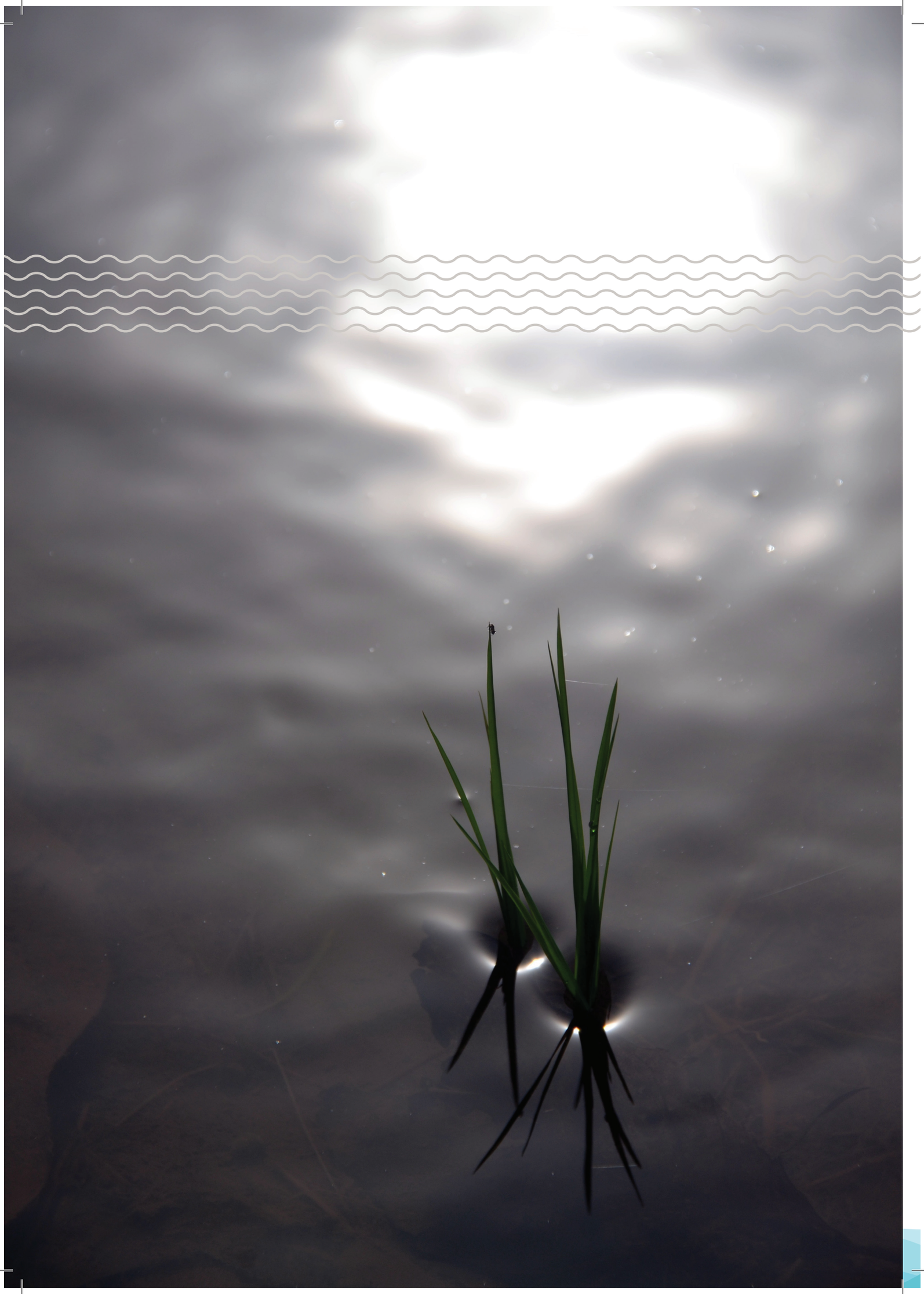
1 In Sanjay Sarovar irrigation project of Madhya Pradesh, the irrigation efficiency is planned to be 61% and in Dharoi Irrigation Project of Gujarat it is planned to be 56% as pilot projects.

2 Project report of OIIAWMP

From the water use study conducted and presented in this report, it can be concluded that there is gap between irrigation potential created (IPC) and irrigation potential utilised (IPU) during the year 2016-17. Reducing the gap between irrigation potential created and utilized will also increase the production of rice which is the main crop in the region. Five percent reduction in gap between IPC and IPU could lead to enhancement of 3981 MT and 2476 MT of paddy production in Kharif season which is 0.59% and 0.56% of the total production from IPC from all irrigation projects in Cuttack and Subarnapur district respectively.

There are several issues which lead to the gap in IPC and IPU. Planning of annual irrigation, taking all factors that may influence proper utilisation is not being considered at present by Agriculture and Irrigation officials. In the proposed DIAP framework, DSSAT and its crop simulation models are proposed to be used for applications like on-farm (micro) level and project (macro) level assessments of the impact of climate variability and climate change. Regular coordination between irrigation and agriculture department is lacking at present in the absence of proper governance framework that impacts growth in irrigated agriculture. Lack of planning in seasonal allocation of water results in overutilization of water in the kharif and water scarcity in rabi. Due to uncertainty in irrigation availability in rabi season, farmers also do not take risks in growing or investing in crops in rabi, resulting in lower utilization of water as well as lower productivity of crops. Farmers should also be encouraged to follow the planned cropping pattern to ensure equitable distribution of irrigation water. Emphasis should be placed on advanced intimation to the water users regarding water availability in the CCA. Rotation of water distributaries and minor canals with a well worked out canal operational plan will ensure such availability. Involvement of Pani Panchayat institutions needs to be further encouraged to receive allocated water and its distribution among its members. Integrated irrigation and agriculture planning at district level and its implementation through PMKSY mechanism is the need of the hour. Innovative changes in water governance that would be focussed on optimum and efficient water use, enabling Pani Panchayat institutions and striving for more crop per drop should be the future approach. Pilot projects can be launched by Odisha Government in either a few minor irrigation projects or one smaller medium project to showcase improved practices and develop a sustainable, efficient and productive model.

Most of the necessary changes in the planning process do not involve huge capital outlay and are possible in near term with available finances and budgetary support. Most of these will be management-oriented interventions and will require a change in the functional approach of the departmental officers in both irrigation as well as agriculture departments. There will be a necessity to allocate resources in terms of time and capacity development by the departmental officers for new activities like preparation of database, operational plans, benchmarking and efficient water management practices.



SECTION 1

Foreword

The Water Sector is an important sector from climate change perspective for Odisha. There are some critical challenges facing water sector in this state. There is increasing competition and conflict among different water uses. The quality of service delivery in irrigation is very poor in Odisha affecting the performance of irrigated agriculture. The irrigation sector is also contributing to fiscal issues in the State due to less collection of water tax against annual targets. These problems may get aggravated by the impact of climate change on water resources in the state. Most of these issues are linked to the vagaries of monsoons, creating variability in river flows and increased frequency/intensity in extreme events of droughts, heat waves etc. Frequent droughts are also major concern in the State and the impact on farmers has been so severe that they are not able to uplift their economic conditions in spite of a number of irrigation schemes implemented by the state Government. Odisha is highly vulnerable to variations in rainfall and many parts of the state suffer from droughts and dry spells as well as hot weather conditions with water scarcity. People do not venture to grow crops in Rabi season if irrigation water availability is not assured.

State Government is making efforts for constructing large number of irrigation schemes and has taken initiatives for managing schemes through water user association (Pani Panchayats). There is a need to increase resilience of human and physical systems for coping with climate change that may be severely felt by 2050 as per IPCC reports. Climate change will bring higher temperatures and more weather variability. Specifically, in the case of Odisha, the rainfall pattern is likely to become more erratic with slightly increased average rainfall but lesser number of rainfall days. This increases surface run-off and reduces the amount of water that can be utilised for aquifer recharge, leading to increase frequency and severity of floods as well as droughts. Rural economy is vulnerable to change in climatic parameters. Less reliable water supplies will reduce agricultural production and energy generation. Climate change will impact irrigation water availability and its usage for agriculture. IPCCC 5th assessment report mentions that irrigation water requirement will increase in future.

83% of the farmers of Odisha are marginal farmers and there is a need to develop mechanisms for sustainable usage of irrigation water to cope up with climate change impacts. In the year 2015-16, the state faced severe drought. As per the crop cutting report (Memorandum of Odisha Govt. on drought, 2016), 235 blocks in 28 districts were affected due to drought. The total crop area affected was calcu-

lated as 21.6 lakh hectare out of which at least 15.36 lakh hectare has suffered losses to the tune of 33% or more crop loss in Kharif season. In the final memorandum, submitted by the Government of Odisha to the Central Government for the year 2015-16, cumulative loss of INR 2344.99 crore due to drought was highlighted. This indicates that Odisha has to take up some transformative steps in managing irrigation schemes and realign its programs, policies, plans and budgets and increase funding under Externally Aided Projects (EAP) with emphasis on climate change adaptation actions. Data published in the annual report (2015-16) of Department of Water Resources, Govt. of Odisha reveals that utilization of the irrigation potential created, varied between 67.27% to 70.35% during the 5-year period (2009-10 to 2013-14). The utilization is less and prevents the state from achieving its objectives of increased rural livelihood and agricultural production. Due to lack of efficiency in management of irrigation schemes, less inflow to Minor Irrigation (MI) tanks and reservoirs, there is a gap in designed ayacut created through different irrigation schemes and actual area being irrigated in different years.

In this background, there is an urgent need to realign the activities of irrigation and agriculture departments in Odisha and add capacity to have effective programmes and governance of irrigation schemes to build resilience in the event of water scarcity and adverse situations caused by climate change. Looking at the emerging water demand in different sectors including agriculture and persisting gaps in addressing it, the Department of Water Resources, Government of Odisha is keen to come up with an alternative planning process which takes into account the sustainable and equitable use of water resource integrated with the agriculture planning process and train its personnel for their changed or additional tasks to be assigned by the department.

The present project titled "Prioritizing water use mechanisms for sustainable usage of water and Development of Integrated District Irrigation and Agriculture Plan" looks into such alternate planning approaches for two pilot districts in Cuttack and Subarnapur. The project has been undertaken under technical assistance from the Climate Change Innovation Programme of MoEFCC, Govt. of India funded by the Department of International Development, UK. Department of Water Resources (DoWR), Government of Odisha is the nodal department for the project. DoWR is widely consulted at different levels for obtaining secondary data and for their co-operation to conduct field studies. CTRAN Consulting, Bhubaneswar is providing the implementation support for the project. The aim of this exercise is to develop "Integrated District Irrigation and Agriculture Plan" for the two districts and a model toolkit for imparting training.

Specific objectives of the assignment are;

1. Assessment of actual irrigation potential created and its utilization by irrigation sources;
2. Mapping key reasons of deviations in the current irrigation potentials by sources;
3. Understanding crop water management practices in irrigated conditions;
4. Prepare a new perspective planning with climate change scenarios;
5. Prepare a model toolkit for integrated planning;
6. Build capacity of the department to continue with the integrated planning in the other districts;

Present report titled as "Water Use Report" is first technical report of this project that covers methodology, sampling, parameters on current usage pattern like irrigation potential utilised, conveyance efficiency, application efficiency, cropping pattern and crop productivity, water productivity, equitability in water distribution, gender equity in irrigated agriculture, and issues related to irrigation management concerning all types of irrigation schemes. This will be followed up by a water use strategy and command area perspective plan.

SECTION 2:

Project Area

2.1 Introduction

The project is being undertaken in Odisha, a State on the eastern coast of India. It has a geographical area of 155,707 km^2 of which 61,650 km^2 is cultivable land. It is assessed that an Ultimate Irrigation Potential (UIP) 49,900km^2 (4.99 million hectares) can be brought under irrigation through major, medium and minor (flow & lift) irrigation projects. The state has increased the irrigation potential (net) from 0.183 million hectares in 1951 to 3.622 million hectares by March 2016. Estimated ultimate potential through major and medium irrigation projects is 3.1300 million hectares.

There are 11 river basins in Odisha in addition to some areas that directly drain into the sea (Fig.1). Mahanadi river basin is the largest basin in the state; it covers 42.15% of the geographical area of the state.

2.2 Governance

Administratively the state is divided into 30 districts, 58 subdivisions, 171 Tahsils, 314 blocks, 6,234 Gram Panchayats and 51,061 villages. The institutions that have a strong association with management and development of water resources include the State Planning Board, the State Water Board, Department of Water Resources, Department of Agriculture, Department of Revenue, Department related to Fisheries, and the Department of Rural Development. The State Water Plan, which was prepared in 2004, needs to be revisited to factor in the recent policy changes made by the DoWR and other suggestions which is likely to be brought out from the present study. Local Governance Institutions and farmers organisations like Pani Panchayats also have significant roles in management of water resources. MGNREGA[3] resourc-

3 **MGNREGA: Mahatma Gandhi National Rural Employment Guarantee Act**
This scheme promises unskilled manual work for 100 days, to adult person of all rural households. It is a right based employment guarantee programme, with a demand driven approach. It is the world's largest social welfare programme. The scheme has arguably, managed to lift several lakhs of villagers out of rural poverty.

es are required to be accessed for maintenance of canal systems. PMKSY[4] resources with four components like Accelerated Irrigation Benefits Programme (AIBP), *Har Khet ko Pani,* Per drop more crop, PMKSY (Watershed Development Component) also need to be utilised. Convergence is to be planned among the relevant institutions and all agriculture, irrigation and allied activities to be integrated in planning process.

FIGURE 3: River Basin Map of Odisha, Source: Orissa State Water Plan - 2004, DoWR

2.3 Pilot Districts

Cuttack and Subarnapur are taken up as pilot districts for detailed field level assessment and formulation of district level integrated plan. Cuttack district represents the districts in the eastern part of the state and Subarnapur district represents the western part of the state. Both the districts are located in Mahanadi river basin which is the major river basin of the state. Total numbers of irrigation projects in two pilot districts are 5295 comprising of 1760 projects in Cuttack district and 3535 projects in Subarnapur district (See annexure for details).

2.3.1 Cuttack District: Overview

Cuttack district is situated in the mid-eastern part of Odisha. It is a coastal district extending over an area of 3932 km^2, it occupies 2.52% of the State's area. The district has three sub-divisions, which are further sub-divided in 14 blocks. 1740 km^2 of the district is Net Sown Area and 777.6 km^2 is forest area.

The district has a population of 1,936,310 as per 2011 Census with population density of 667 per square kilometre area. Cuttack district experiences a tropical wet and dry climate. The summer season is from March to June when the climate is hot and humid. The temperature around this season is 35°C to 40°C. Thunderstorms are common at the height of the summer. The monsoon months are from July to October

4 **PMKSY: Pradhan Mantri Krishi Sinchayi Yojana**
The major objective of the PMKSY is to achieve convergence of investments in irrigation at the field level, expand cultivable area under assured irrigation (Har Khet ko Pani), improve on-farm water use efficiency to reduce wastage of water, enhance the adoption of precision-irrigation and other water saving technologies (More crop per drop), enhance recharge of aquifers and introduce sustainable water conservation practices by exploring the feasibility of reusing treated municipal based water for peri-urban agriculture and attract greater private investment in precision irrigation system. The scheme also aims at bringing concerned Ministries/Departments/Agencies/Research and Financial Institutions engaged in creation/use/recycling/potential recycling of water, brought under a common platform, so that a comprehensive and holistic view of the entire "water cycle" is taken into account and proper water budgeting is done for all sectors namely, household, agriculture and industries.

when the district receives most of its rainfall from the South West Monsoon. The annual rainfall is around 144 cm. Temperatures are considerably lower during the rainy season, averaging around 30 °C. The winter season from November to February is characterised by mild temperatures and occasional showers. The winter months feature chilly northerly winds which bring down the temperature to around 15°C, though the bright sunshine helps maintain the pleasant weather. Temperatures may exceed 45 °C at the height of summer and may fall below 10 °C in winter.

The Mahanadi River supplies water to the existing canals of the Mahanadi Division at Cuttack. To supply water to the canals of this system, three anicuts have been constructed. One of them is at Naraj (1,169 meters) at the head of the Kathajori River, which serves as feeder anicut by diverting the water from the Mahanadi. The other two are at Jobra (1,936 meters) on the Mahanadi and at Choudwar over Birupa (604 meters). The barrages help to make a ponding of water at the apex of the delta to provide irrigation. The major source of irrigation is the canal system of major project which provides irrigation of 64575 ha during Kharif and 35576 ha during Rabi (Figure 4) in normal years through Mahanadi South division, Mahanadi North Division, Prachi Division to 8 out of 14 blocks namely Cuttack Sadar, Baranga, Kantapada, Niali, T. Choudwar, Salipur, N.Koili, and Mahanga. Irrigation potential created in the district is 152939 ha. (100326 ha. during Kharif and 52613 ha. during Rabi) which is graphically presented below in Figure 5. Irrigation Potential created in the district from all projects is 53.32% of 188150 ha of net sown area in Kharif and it is 27.96% in Rabi.

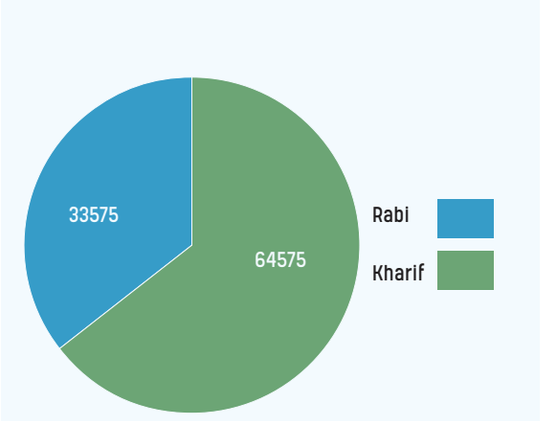


FIGURE 4: Irrigation Potential in Cuttack District from Major Projects

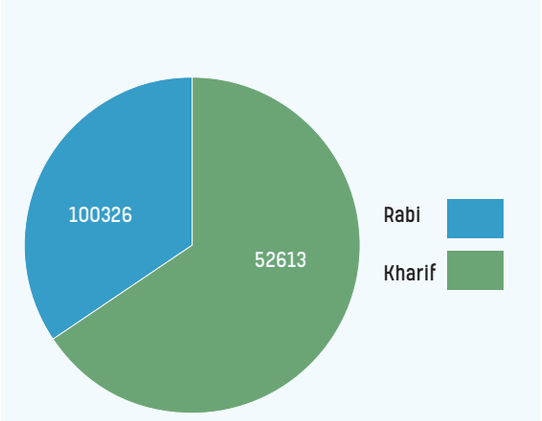


FIGURE 5: Irrigation Potential in Cuttack District from all types of projects

The volumetric estimation of designed irrigation supply is 2.14 BCM (1.62 BCM in Kharif and 0.52 BCM in Rabi). Cereals like paddy, maize, pulses such as arhar, green gram, black gram and others, oilseeds such as groundnut, sesamum, sunflower, mustard and other crops are grown in the district. Sugarcane is the major cash crop grown in irrigated areas.

2.3.2 Subarnapur District: Overview

The district Subarnapur has a total geographical area of 2344 km^2, with two Sub-division and six administrative blocks. The gross cropped area for the district is 2300 km^2. The Net Sown Area is 1210 km^2. Out of this 1090 km^2 of the area is sown more than once. There are wastelands of about 470 km^2, and around 250 km^2 of land is under other uses.

Subarnapur district has 62 rainy days in a year. The summer season extends from March till middle of June where the maximum temperature varies from 34.3°C to 47.7°C. The month of May is the hottest while December is the coldest month of the year, when the temperature drops down to 6°C. It is observed that about 90% of the total annual rainfall takes place due to South West monsoon between the middle of June and mid-October. The northeast monsoon gives erratic & insufficient rainfall. The normal annual rainfall is 1443.5 mm (source: Ground water information booklet of Subarnapur district,

Orissa, CGWB). The rainfall is highly erratic both in space and time. There is a large spatial variation as observed from the rainfall data of various blocks. Wind is generally light to moderate, but it increases during summer. During summer wind direction is variable and in rainy season wind from southwest direction is very common.

The district comes under Mahanadi river basin. The river Mahanadi, Tel and their tributaries constitute the main drainage system in the district. The tributaries are ephemeral in nature. The river Mahanadi flows as almost north south course as it enters the district, which changes to south east as it nears Sonepur and finally takes an easterly course after confluence of river Tel with it at Sonepur. River Tel flows in a north easterly course through the border of the district in the south-western part before its confluence with Mahanadi. Ong is another important tributary of the river Mahanadi which flows in a south easterly course in the western part of the district and joins Mahanadi a few kilometres north of Sonepur town. The drainage is effluent in nature.

The district gets irrigation from major, medium, minor & lift irrigation projects and also from ground water source. The major source of flow irrigation projects is surface water, which mainly depends on rainfall; hence actual area-getting irrigation in different crop seasons in different year varies. The irrigation potential created from all sources aggregates to 1025 km^2 in the district. The volumetric estimation of canal irrigation of Subarnapur district comes to 2.01 BCM[5] (1.38 BCM in Kharif and 0.63 BCM in Rabi).

5 District Irrigation Plan, Subarnapur

SECTION 3

Approach & Methodology

The approach and methodology adopted for conducting field study for preparing the water use report is briefly described here under.

3.1 Stakeholder Consultation

For involvement of the stakeholders, district level consultation workshops were organised at Cuttack on 28 Dec 2016 and at Subarnapur on 13 Jan 2017. During the workshop, concerned irrigation divisions were requested to provide secondary data concerning schemes in operation under their respective jurisdictions. District level agriculture department officials were also requested to furnish relevant information and data. State level officials of DoWR and Agriculture Directorate have also been consulted at different stages of the study.

3.2 Study Framework

Two different frameworks for irrigation and agriculture aspects have been developed. Formats for secondary data sets on different types of irrigation schemes were developed and furnished to the nodal officers nominated by the Department of Water Resources for obtaining the same from respective divisions. Study framework was shared and discussed in detail with the district level officials in the workshops.

For soliciting pertinent information from farmers and Pani Panchayats (WUA), stakeholder interaction formats for individual farmer and Pani Panchayat (Focus Group Discussion) have been developed. Required information and data have been captured accordingly for analysis.

3.3 Sample Coverage

Samples of minor, river lift and ground water irrigation schemes were selected by systematic sampling. In canals of major and medium schemes, distributaries and minor canals were selected belonging to head, middle and tail reaches. Similarly, checks in head, middle and tail reaches were taken as samples for field study and obtaining information from farmers by filling up of stakeholder interaction formats. The summary of samples taken in major, medium, minor, river lift and ground water along with percentage of Culturable Command Area (CCA) of sample schemes to the total CCA of Cuttack and Subarnapur district for each type of scheme is presented in Table 1 and Table 2 respectively. Details of samples are elaborated in subsequent chapters.

TABLE 1: Percentage of CCA under different types of irrigation projects in Cuttack district

Type of Project	Total No. projects	No. of projects taken as sample	Total CCA in Kharif in the district	Total area of the sample projects	Percentage of sample area to the CCA of the district
Major Project	2	2	86905	9664.83	11.12
Medium Project	1	1	2226	1175	52.79
Minor	112	12	25553	5199	20.35
River Lift	704	63	22144	2230	10.07
Ground Water Lift (DTW)	454	72	34946	4422	12.65
Ground Water Lift	404	42	808	84	10.40
Total			172582	22774.83	13.18

Source: Secondary Information from DoWR

TABLE 2: Percentage of area under different types of schemes in Subarnapur District

Type of projects	Total No. Projects	No. of Projects taken as sample	Total CCA in Kharif in the district	Total Area of the sample projects	% age of sample area to the CCA of the district
Major	1	1	42854.00	4349.00	10.14
Medium	1	1	9450.00	1165.00	12.33
Minor	59	6	7372.41	2971	40.30
River Lift	891	90	22273	2561	11.50
Ground Water Lift (Bore well)	2582	260	5164	520	10.07
Total			87,113.41	11,566	13.27

Source: Secondary Information from DoWR

3.3.1 Project Wise Details and Percentage of Sample

Project wise details of sample covered in major and medium irrigation projects and the details of samples covering minor irrigation project, river lift and ground water schemes are mentioned in Annexure 2 to 7. While finalizing the samples, representative minor canals in major and medium irrigation projects were considered. Block wise list of river lift schemes and ground water schemes were taken as base for finalizing the sample projects. Block wise list of minor irrigation projects, no. of river lifts as well as ground water schemes covered are mentioned in the annexures.

3.3.2 Sample Details of Individual Farmers and Focus Group Discussion

Sample size of farmers and focus group discussions under different type of schemes are presented in Table 3 for Cuttack district and Table 4 for Subarnapur district.

TABLE 3: Project wise number of individual farmers and FGD in Cuttack district

Sl. No	Name of the project	Blocks	No of Scheme / project/ canal	No. of Study Location	No. of Individual Farmer Schedule	No. of FGD
1	Major project	Baranga, Kantapada, Mahanga, TangiChoudwar, Salepur, N.Koeli, Cuttack Sadar	15	45	225	15
2	Medium project	Mahanga	3	9	45	3
3	Minor project	Banki-II, Badamba, Tangi-chaudwar	12	60	254	37
4	River Lift	Mahanga, Banki-II, Kantapada, Badamba	63	63	73	10
5	Ground Water	Cuttack Sadar, Mahanga, Kantapada	114	114	114	10

TABLE 4: Project wise number of individual farmers and FGD in Subarnapur district

Sl. No	Name of the project	Blocks	No of Scheme / project/ canal	No. of Study Location	No. of Individual Farmer Schedule	No. of FGD
1	Major project	Binika, Dunguripali	9	27	135	9
2	Medium projects	Ulunda, BMPur	5	15	75	5
3	Minor Projects	Tarava, BMPur, Subarnapur	6	24	125	8
4	River Lift	Tarava, BMPur, Subarnapur	90	90	269	35
5	Ground Water	Tarava, BMPur, Subarnapur	142	142	142	0*
6	Check-dam	Tarava, BMPur, Subarnapur	9	9	18	0**

* Ground water schemes are individual based and hence no FGD has been conducted

** Pani Panchayats are not existing in case of check-dam

3.4 Irrigation Efficiency

3.4.1 Conveyance Efficiency

Conveyance Efficiency is ratio of the volume of irrigation water delivered by a distribution system to the water introduced into the system. In this study, an inflow-outflow method has been used for measurement of conveyance efficiency.

S = Qi – Qo

Where

S is conveyance loss in the canal segment,

Qi is inflow to the segment,

Qo is outflow from the segment,

Water flow at the beginning and end of the canal segment has been calculated using the velocity-area method. The canal cross-section at the measurement points, velocity values have been measured with

2-point method. For shallow water depth, velocity has been measured by single point method. Cup-type current meters and Pigmy-type current meters have been procured for measurement of velocity with the aim of using the velocity values in determination of conveyance efficiency. Current meters procured and used in this study are calibrated by Hydraulic Research Station Malakpur, Irrigation and Power Research Institute, Amritsar, Punjab.

The equations for computation of velocity after calibration of current meters are given below:

i. For cup type magnetic (Strd.) No - 716, **Equation V** = 0.6543 N + 0.0096

ii. For pigmy type no 13, **Equation V** = 0.2865 N + 0.0075

iii. For pigmy type no 12, **Equation V** = 0.2802 N + 0.0063

iv. For cup type Magnetic (Strd.), No-402, Equation for velocity, **V** = 0.6638 N + 0.0049

Where, **V** = velocity in m3/sec.

N = number of revolutions per second

3.4.2 Application Efficiency

Application Efficiency (AE) is a performance criterion that expresses how well an irrigation system performs when operated to deliver a specific amount of water. It is defined as the ratio of the average water depth applied and the target water depth during an irrigation event. It is computed by using the method given in the CWC guideline. In this guideline, it is mentioned that on-farm application efficiency may be worked out by the ratio of the crop water requirement as per modified Penman method for various crops for which irrigation is being provided by the project for each crop season i.e. Kharif, Rabi to the quantum of water which is made available through canal system.

3.4.2.1 Crop Water Requirement (CWR)

Seasonal crop water requirement has been calculated for paddy by multiplying the reference crop evapo-transpiration with crop coefficient. Crop coefficient for paddy applicable to Hirakud project command is mentioned in Table 5.

CWR = ETo X Kc: Crop coefficients for transplanted rice

Where, ETo is reference evapo-transpiration

Kc = Crop coefficient

TABLE 5: Crop coefficients for transplanted rice

Crop coefficient: Normal paddy				
Planting date	18 Jan to 31 Jan		: Mid-day	14.Jan.
Harvesting date	23 April to 05 May		: Mid-day	29.April
Stage	Days	Cumulative days after transplantation	Calendar days	Kc
Nursery	25			
Initial stage	0	0	24.Jan.02	1.15
	19	19	12.Feb.02	1.15
Crop development stage	20	39	04.Mar.02	1.23
Reproductive (Mid stage)	37	76	10.April	1.14
Maturity (Late stage)	19	95	19.April	1.02
Crop period	120			

Source: Research dissertation of Indian Institute of Remote Sensing, Dehradun & International Institute for Geo information science and earth observation Enschede, The Netherland.

3.5 Irrigation Potential

Irrigation potential created is the total area which can be irrigated from a project on its full utilization. Irrigation potential and utilization in the pilot districts have been studied. These terms have been used at different places in the report and are defined here. Planning commission has defined the terms Ultimate Irrigation Potential (UIP), Irrigation Potential Created (IPC) and Irrigation Potential Utilized (IPU) in the context of an irrigation project, which is described below:

3.5.1 Ultimate Irrigation Potential (UIP)

UIP is the gross area that can be irrigated from a project in a design year for projected cropping pattern and assumed water allowance, where the gross irrigated area (GIA) of a project is the aggregate of the areas irrigated in different crop seasons within a crop year. The areas under two seasonal and perennial crops are to be counted once and the areas of other projects (having water supply coming from different source) within the irrigation project command under consideration were not to be linked with the gross irrigation area of the project. GIAs were normally picked up from the cadastral maps (village maps) of the area and were arbitrary without any surveyed boundaries. It was suggested that the culturable command area (CCA) of an irrigation project should not be an arbitrary percentage of gross irrigated area but instead assessed from actual surveys.

3.5.2 Irrigation Potential Created (IPC)

Irrigation potential created is the total area which can be irrigated from a project on its full utilization. After the projects are constructed and canal works undertaken, irrigation potential created by new project, whether completed or under construction, is then considered as the total gross area actually irrigated by the project up to the year under construction. Irrigation potential creation varies as the development of the canals advances but becomes static once the canal network up to outlet level is completed. Before reporting the IPC, it is to be ensured that the storage, head-works and distribution system including outlets up to chak level of size 40 Ha or so are completed. New areas and the old stabilized areas are to be reported separately. The year in which the outlet becomes capable of receiving water, becomes the year of completion of IPC for the area commanded by the outlet.

3.5.3 Irrigation Potential Utilized (IPU)

IPU is the total gross area actually irrigated by a project during the year under consideration. It was suggested that the IPU could begin at least one year after the year of IPC, anticipating that the gap in potential would be bridged in about a year of completion by the Command Area Development Authorities (CADAs). Since no other deficiencies were foreseeable that would render the un-fulfilment of the created irrigation potential, command area development programme (CADP) was rightly required to bridge the gap in irrigation potential creation at outlet and its utilization at field gate through a network of micro infrastructure development and efficient farm water management practices.

3.6 Water Productivity

Water productivity is generally defined as crop yield per cubic metre of water consumption. The concept of water productivity (WP) is a robust measure of the ability of agricultural systems to convert water into food. It is used primarily to evaluate the function of irrigation systems – as 'crop per drop'.

The concept of productivity of water (PW) is increasingly becoming a cornerstone for sustainable management of irrigation projects. Improving water productivity (WP), a measure of performance generally defined as the physical quantity derived from the use of a given quantity of water, is one important strategy towards confronting future water scarcity. Increasing WP to obtain higher crop production, each drop of water used can play a key role in the strategy for improving performance of irrigation schemes.

Water Productivity has been computed by dividing crop productivity (Kg/Ha) to water delivered (M^3/Ha) in an irrigation system.

SECTION 4

Current Status of Irrigation Schemes

4.1 Introduction

Irrigation Potential Created (IPC) in pilot districts viz. Cuttack and Subarnapur are collected from the respective divisions and circles of Department of Water Resources, Government of Odisha. Major, Medium, Minor, River Lift, Ground Water Lift schemes are contributing to the created irrigation potential in the district. Irrigation potential for Cuttack and Subarnapur district and percentage of irrigation potential from different types of irrigation schemes are described here under.

4.2 Irrigation Potential and Utilization in Odisha State

The Department of Water Resources, Govt. of Odisha is making regular investment for creation of irrigation potential and its subsequent utilization. Status of potential created and utilized for a period 14 years from 2000-01 to 2013-14 is given in the Figure 6 below. While the Irrigation Potential Created (IPC) has increased continuously, the Irrigation Potential Utilised (IPU) has been a modest 70% for most parts. As observed and expected, IPU has been higher in Rabi than Kharif and had managed to achieve even 95% in 2007-08, though it has not sustained thereafter.

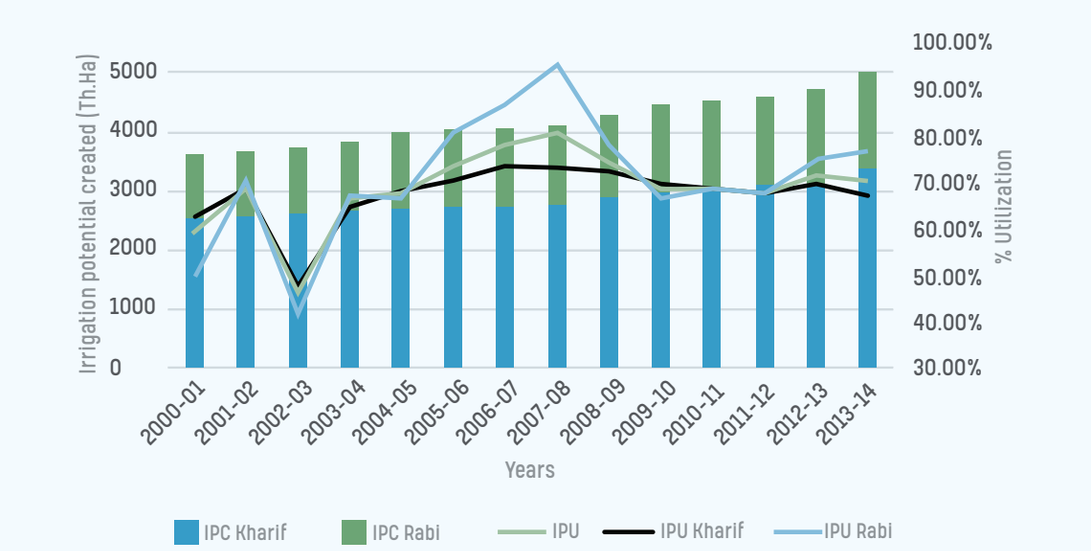


Figure 6: Irrigation Potential Created and Utilized from 2000-01 to 2013-14

Source: Annual report 2015-16 of DOWR

4.3 Irrigation Potential in Cuttack District

In Cuttack district, irrigation potential creation commenced with construction of Mahanadi stage–I project in pre-independence period. Post-independence, Mahanadi delta stage-II was constructed. During various plan periods medium, minor, river lift, ground water schemes are constructed, and irrigation potential are created in different part of the district. Distribution of design CCA of Cuttack district by type of irrigation projects is presented in Figure 5. Around 50% of the irrigation potential is from major projects followed by 20.80% of ground water schemes, 14.79% from minor schemes, 12.82% from river lift and only 1.29% from medium scheme.

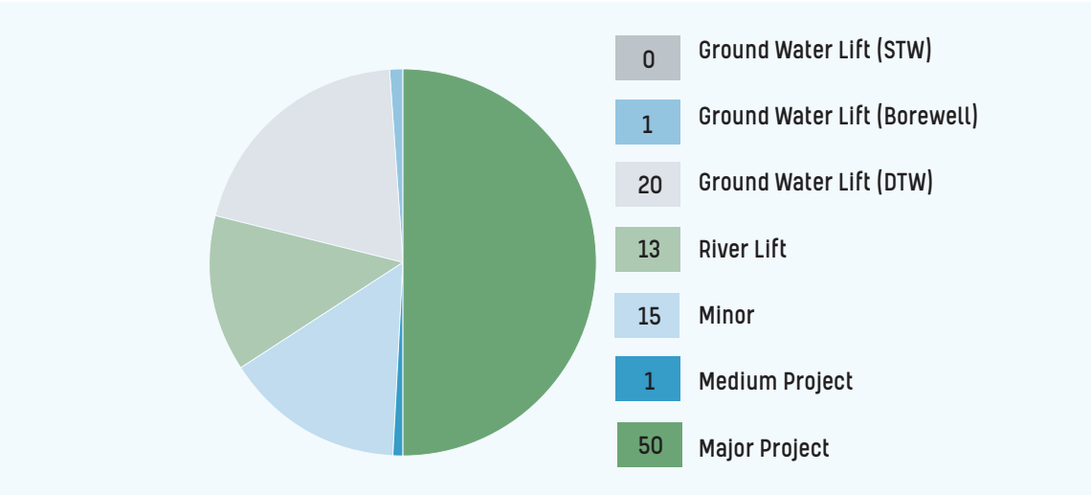


FIGURE 7: Percentage of Different types of irrigation schemes to total design CCA in Cuttack district

Source: Secondary data from DoWR

4.4 Irrigation Potential in Subarnapur District

In Subranapur district, 64.75 % of total irrigation potential created is from Hirakud Major Irrigation Project. There are many rivers and rivulets (locally called as Jore) from which water is lifted by pumps that has created 17.74% of irrigation potential. Medium scheme has created 7.53%, minor schemes have created irrigation potential of 5.87% and ground water lift schemes have contributed to 4.11%. Details of potential created from different type of schemes are mentioned above (Figure 6).

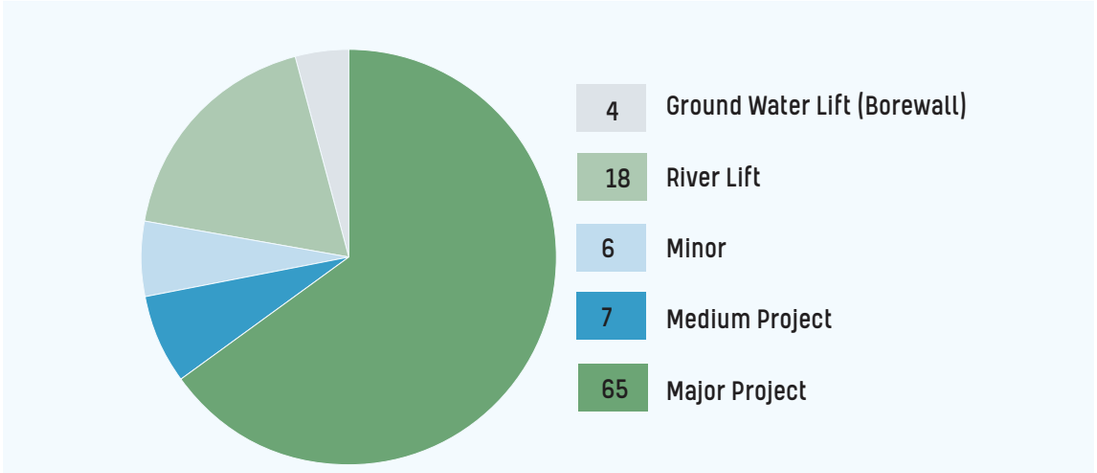


FIGURE 8: Percentage of Different types of irrigation schemes to total design CCA in Subarnapur district

Source: Secondary Information from Department of Agriculture, Subarnapur

4.5 Surface Water Irrigation

Surface water schemes in the pilot districts constitute 2 major irrigation projects, 1 medium irrigation project, 112 minor irrigation projects, and 704 river lift schemes lifting water from surface water resources. Brief details about different types of schemes/projects are furnished here under.

4.5.1 Major Irrigation Project

Irrigation projects having more than 10,000 hectares of ayacut are classified as major irrigation projects. Mahanadi delta stage-1, Mahanadi delta stage-2, Hirakud are the three major irrigation projects from which irrigation potential is created in the pilot districts. Water released from power channel from Hirakud project and reservoir spill are used for irrigation through barrages located in Cuttack district.

In Mahanadi stage-1 project there are three barrages constructed across branches of Mahanadi. Birupa barrage having a length of 203 meter was completed in 1991. Naraj barrage major project with CCA 183.211 thousand ha on river Kathjodi having a barrage of length 940 meters is constructed. Mahanadi barrage with barrage length of 1928 meter pond level 232 meter and crest level 16.2 meter and 79 spillway gates was completed in 1991.

Hirakud is a major project of India, started and commissioned after the country's independence and has served the aspirations of the people effectively and efficiently over the last fifty years. Irrigation achieved its full development within a short record time and the area benefited is much more than planned.

Flood control remained as the main purpose during monsoon and the reservoir is filled by 1st October every year, for meeting demands for irrigation, power generation, industrial needs, domestic water supply and ecological requirements during the post monsoon period.

TABLE 6: Average monthly runoff, irrigation, power and Spill - Post Hirakud from 1959 - 2006

Month	Average monthly runoff in MAF	Average monthly Irrigation in MAF	Average monthly Power in MAF	Average monthly spill in MAF	Average monthly Evp. Loss in MAF
January	0.192	0.167	0.474	0.018	0.031
February	0.14	0.183	0.419	0.021	0.035
March	0.1	0.221	0.488	0.013	0.055
April	0.07	0.214	0.506	0.012	0.064
May	0.044	0.049	0.491	0.004	0.066
June	1.041	0.056	0.518	0.4	0.049
July	5.964	0.161	0.906	4.062	0.046
August	9.937	0.17	1.057	6.664	0.051
September	6.72	0.195	0.974	4.304	0.064
October	1.918	0.22	0.778	0.943	0.052
November	0.537	0.061	0.559	0.047	0.04
December	0.247	0.089	0.487	0.006	0.032
Total	26.91	1.786	7.657	16.494	0.585

Source: Report of High level technical committee, Aug 2007, DOWR

The Hirakud irrigation project has three main canals namely Bargarh canal, Sasan canal and Sambalpur canal. Bargarh, the main canal of Hirakud Project, supplies irrigation water to Subarnapur district which is constructed on the right bank of the dam near Burla. In Subarnapur district, Retamunda branch canal of Bargarh main canal, covers substantial irrigation potential. The command area of Hirakud major project lies in Binika and Dunguripali blocks. Paddy is the major crop in both Kharif and Rabi season. Culturable Command Area (CCA) for the district with tehsil wise break up is given in Table 7.

FIGURE 9: Hirakud Dam

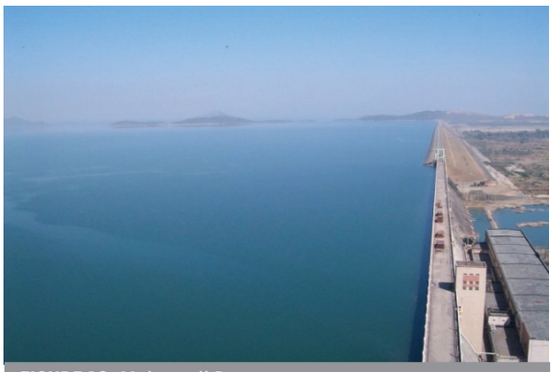


FIGURE 10: Mahanadi Barrage

TABLE 7: Supply of irrigation water to Subarnapur district from Bargarh canal

Sl. No	Tehsil	CCA (Hectares)
1	Rampur	22164.00
2	Binika	20690.00
	Subarnapur district total	42854.00

Source: Secondary Information from DOWR

Release of water from Hirakud dam is harnessed at Cuttack for the major irrigation projects constructed in the deltaic region. Even after meeting irrigation demand under major project in Subarnapur, sufficient water is available to meet the irrigation requirement of the canal command area of Cuttack.

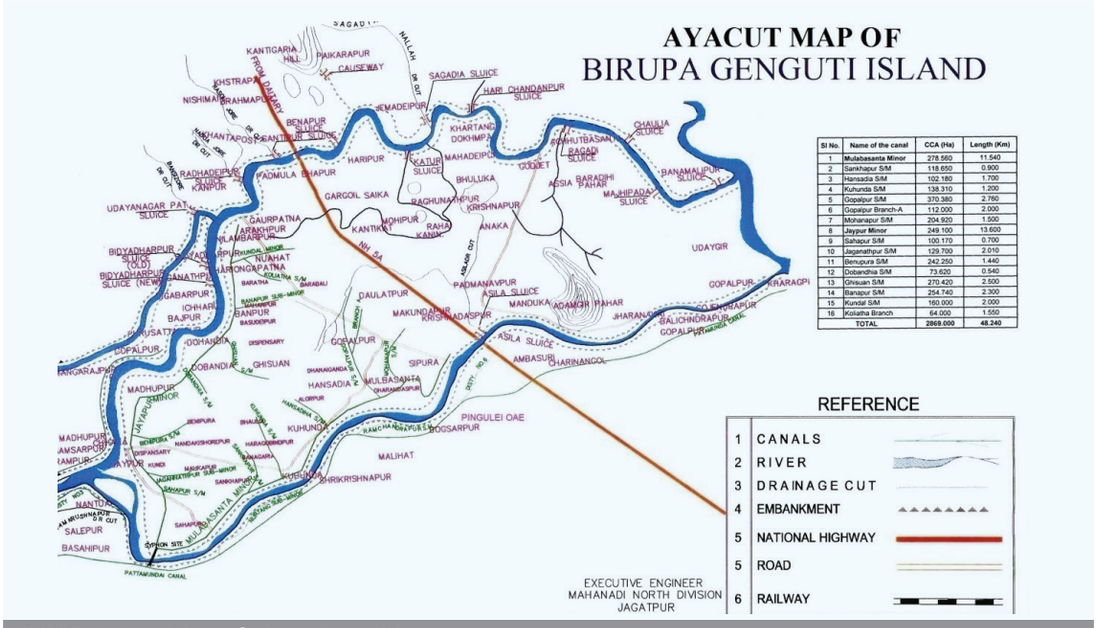
4.5.2 Birupa-Genguti Island Medium Project

Irrigation projects having command area above 2000 hectares and below 10,000 hectares are classified as medium irrigation projects. The Birupa-Genguti Island project was taken up during 1995-96 and completed during 2003-04 and Irrigation potential of 2500 ha has been created with funding from RIDF, NABARD. This is a medium project with CCA 3870 ha and ultimate irrigation potential of 8086 ha. (Figure 9)

Jaypur Minor and Mulabasanta Minor are two main canals in Birupa-Genguti Island Irrigation project. These two canals feed water from Pattamundai canal at RD 24.05 km through a canal syphon constructed across river Birupa at Tribeniswar. Design discharge of the canal siphon is 4.41 M^3/sec, which is the head discharge for this medium project in Cuttack district.

Mulabasant minor and its distribution system have been completed and Irrigation potential for 1325ha has been created. Design discharge of Mulabasanta minor is 1.85M^3/sec having total length of 11.54 km. 6 numbers of off taking Sub-Minors and three numbers of Pani Panchayats have been constituted in Mulabasant minor and its distribution system.

Jaypur Minor and its distribution system have been completed from RD 00 km to 9.85 km and irrigation potential for 1175 ha has been created. Design discharge of Jaypur minor is 2.56 M^3/sec having total length of 13.60 km. Now 6 nos. of off taking sub-minors and three nos. Pani Panchayats are in Jaypur minor and its distribution system.



Sl No.	Name of the canal	CCA (Ha)	Length (Km)
1	Mulabasanta Minor	278.560	11.540
2	Sankhapur S/M	118.650	0.900
3	Hansadia S/M	102.180	1.700
4	Kuhunda S/M	138.310	1.200
5	Gopalpur S/M	370.380	2.760
6	Gopalpur Branch-A	112.000	2.000
7	Mohanapur S/M	204.920	1.500
8	Jaypur Minor	249.100	13.600
9	Sahapur S/M	100.170	0.700
10	Jagannathpur S/M	129.700	2.010
11	Benupura S/M	242.250	1.440
12	Dobandhia S/M	73.620	0.540
13	Ghisuan S/M	270.420	2.500
14	Banapur S/M	254.740	2.300
15	Kundal S/M	160.000	2.000
16	Kolatha Branch	64.000	1.550
	TOTAL	2869.000	48.240

FIGURE 11: Ayacut Map of Birupa-Genguti Island

4.5.3 Hariharjore Medium Project

The Hariharjore medium irrigation project is located at a longitude of 21^0-2′ N and latitude 84^0-2′ E near Luhakhandi village of Subarnapur district of Odisha. The head work is constructed on Hariharjore River which is a left bank tributary of Mahanadi River. The total length of Hariharjore River is 80 km and the project head work is located at 30 km upstream of its confluence with Mahanadi River. The dam is homogeneous rolled filled earth dam having length of 2296 m. and controlled ogee type spillway having length of 128 m. The catchment area of the dam is 425 sq. Km. within the territory of Sambalpur and Subarnapur districts. The spillway having a total length of 128.00 m., has 9 nos. of radial gates having size of (12.00 m. X 6.00 m.) and the maximum discharge capacity of the spillway is 3785 M3/sec. The head regulator of Hariharjore main canal is constructed at right side of earth dam installed with two

nos. of vertical gates having size of (2.50 m X 2.50 m). The discharge capacity of the head regulator is 13.60 M3/sec. The length of main canal is 14.912 km and 4 nos. of distributaries having a total length of 25.763 km. Total length of the minor and sub-minor is 152 km. Altogether there are 802 no. of structures in the canal system.

4.5.4 Minor Irrigation Project

Irrigation projects having command area of less than 2000 hectares are classified as minor irrigation projects. In Odisha, Chief Engineer Minor Irrigation, Department of Water Resources has the mandate of constructing Minor Irrigation (MI) projects tapping surface flow. The status of MI projects in the state is as follows.

Total number of MI projects in the State	**4152**
No of MIPs completed and operational	2461
No of partially derelict projects (PD)	713
No of completely derelict projects (CD)	321
No of projects under renovation (RP)	276

4.5.4.1 Gravity Flow

In Cuttack district, there are 112 Gravity flow Minor Irrigation Schemes with total designed CCA of 21,789 hectares. 64 Pani Panchayats are constituted in Minor Irrigation Schemes in Cuttack District.

Block-wise designed CCA of minor irrigation projects in Cuttack district is presented in Figure 12. Detailed data can be seen in the annexures.

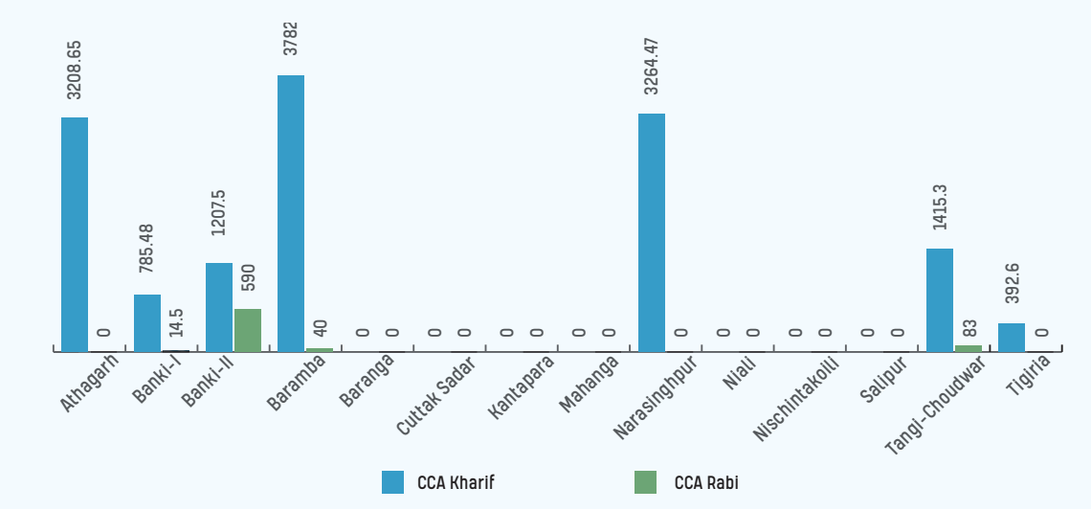


FIGURE 12: Block wise design CCA of Minor Irrigation schemes in Cuttack district in Kharif and Rabi

In Subarnapur district, there are 60 Minor Irrigation Schemes with total designed CCA of 7372 hectares. The design CCA ranges from a minimum of 41 hectare to 2630 hectares in Nibrutijore project. Actual area being irrigated in Nibrutijore is around 2000 hectares and is therefore kept under the category of MI scheme. Block wise designed CCA of minor irrigation projects in Subarnapur district is depicted in Figure 13.

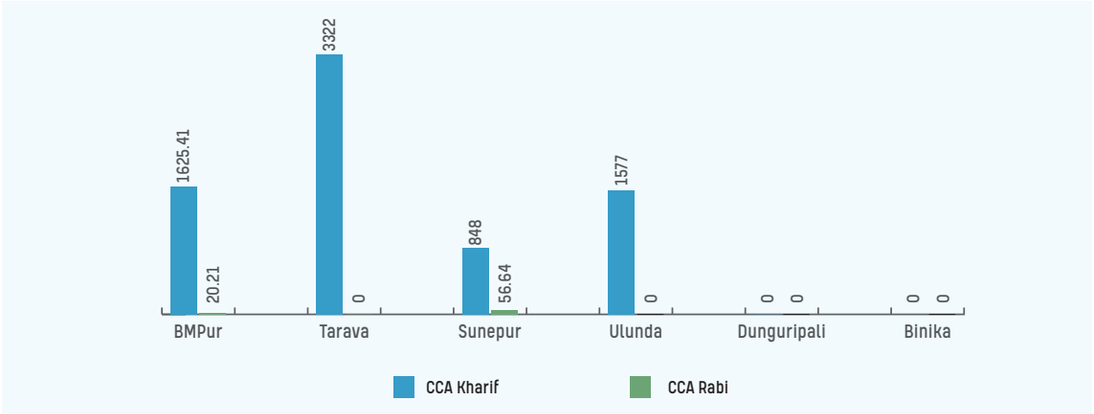


FIGURE 13: Block wise design CCA of Minor Irrigation Schemes in Subarnapur District

Source: Secondary Information from DOWR

4.5.4.2 River Lift

Lift irrigation schemes involve pumping of water from sources which are below the ground level -either from a a river, lake, tank or aquifer. River lift schemes are constructed on the bank of perennial rivers in different parts of the state. The schemes are mainly constructed to lift water from Mahanadi, Birupa, Genguti, and other Nallaa. In Cuttack district, 704 river lift schemes are constructed with designed CCA of 22,144 hectares. The smallest schemes are having 40 ha of CCA and the biggest one is having 360 ha of CCA. In Subarnapur district, there are 891 river lift schemes with ayacut area of 22,273 hectares.

Block wise designed CCA of river lift schemes in Cuttack district is presented in Figure 14.

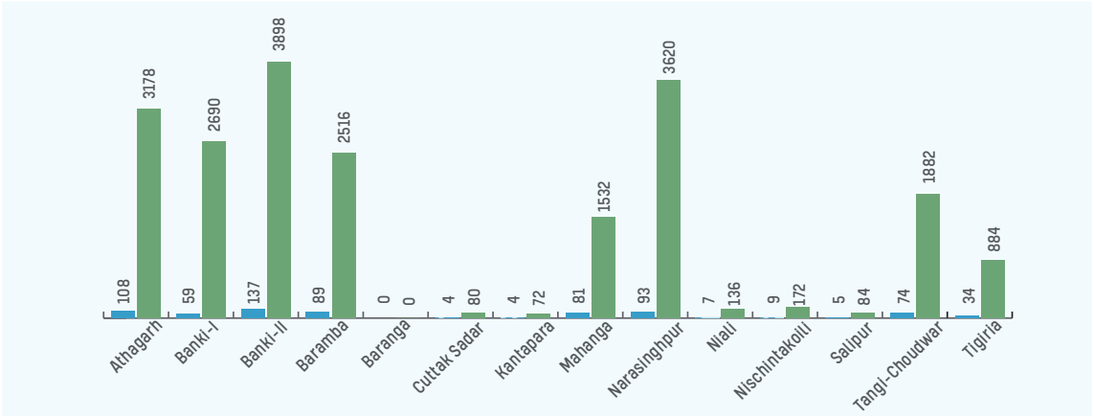


FIGURE 14: Block wise design CCA of River Lift schemes in Cuttack district

In all blocks of Subarnapur district, river lift schemes have been installed for lifting water from perennial rivers and rivulets. Block-wise schemes and designed CCA is presented in Figure 15.

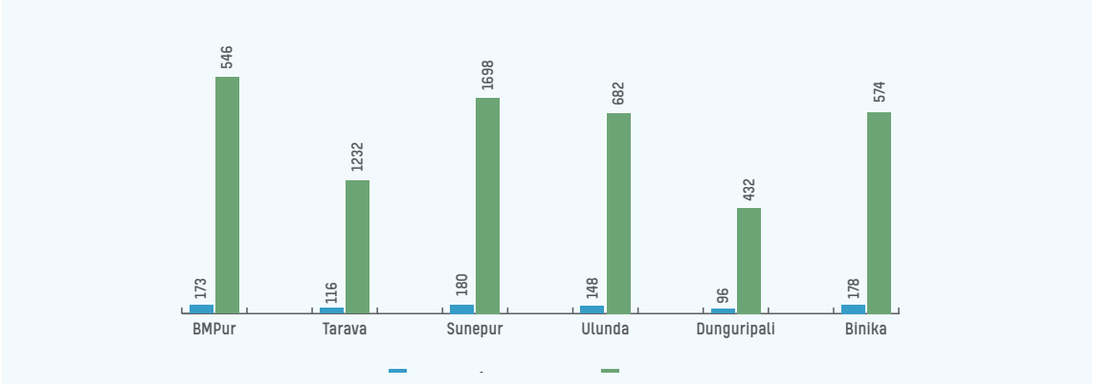


FIGURE 15: Block wise design CCA of River Lift schemes in Subarnapur district

Source: Secondary Information from OLIC, DOWR

4.5.4.3 Mega Lift Schemes.

In recent years, Department of Water Resources, Government of Odisha has taken up construction of Mega Lift Schemes. In Cuttack district, there is a plan to construct Mega Lift scheme in Narsingpur block to provide irrigation to 16,750 hectares. In Subranapur district, there are 4 Mega Lift Schemes as per the list below (Table 8). All these 4 schemes are under construction.

TABLE 8: Mega lift irrigation Scheme in Subranapur district

SL. No.	Block	Name of the Scheme	CCA (Ha)	Design discharge	No. of Pumps
1	Tarva	Ainapalli Mega lift Project	1500	1.5 Cumec	4
2	Tarva	Gunjimunda Mega Lift Project	800	0.8 Cumec	3
3	Tarva	Pandikimal Mega Lift Project	1600	1.6 Cumec	4
District Total			3900		

Source: Secondary Information from DOWR

4.6 Ground Water Irrigation

Ground water is extracted for providing irrigation under different programmes. Community tube well, shallow tube well, bore wells are the main ground water extraction structures. In all ground water schemes constructed through Govt. agencies, electric pump sets are used for pumping water. Block wise details of ground water schemes for Cuttack district is depicted in Figure 16. The same of Subarnapur district is shown in Figure 17.

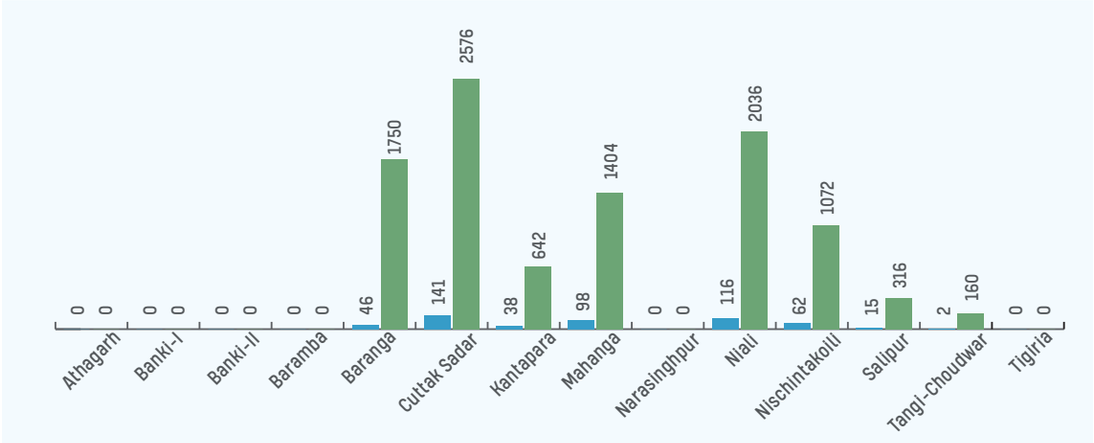


FIGURE 16: Block wise design CCA of Ground water schemes in Cuttack district

Source: Secondary Information from OLIC, DOWR

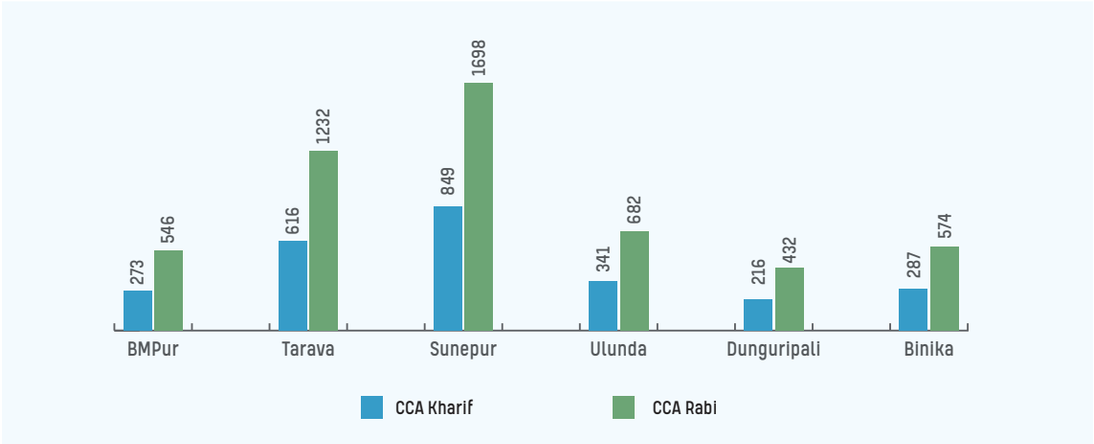


FIGURE 17: Block wise design CCA of Ground water schemes in Subarnapur district

Source: Secondary Information from OLIC, DOWR

SECTION 5

Current Usage Pattern

Current usage of irrigation in the study districts has been determined by physical verification of irrigation projects, conducting measurements of canal sections and water velocity in canals, walk through survey of irrigation canals and field channels as well as command area, interaction with farmers in the command area and Pani Panchayats.

5.1 Mapping Irrigation Schemes at District Level

For studying the current usage pattern of irrigation water, the study team made efforts to obtain a district irrigation map from different offices of Department of Water Resources and Agriculture Department. Such maps are not readily available in Govt. offices. Hence, district irrigation maps of the study districts have been prepared.

5.1.1 Irrigation map of Cuttack District

From latest imageries, layers of canals, rivers are extracted. In Cuttack district Mahanadi, Kathjodi, Birupa, Genguti, Prachi, Rana Rivers are primary sources of surface water for irrigation schemes. In Kathojodi, Mahanadi and Birupa rivers, barrages are constructed under major irrigation schemes which are extracted from Google earth. MI Schemes have been mapped using GPS coordinates in irrigation map of Cuttack District as point layers.

GPS coordinate are not available in Lift Irrigation Project (LIP) census provided by Odisha Lift Irrigation Corporation (OLIC). GPS readings have been taken for River Lift Schemes (RLS) and Ground Water Schemes (GWS) during the study for sample schemes.

In the District Irrigation Map for Cuttack, all main canals i.e. Taladanda Canal, Kendrapada Canal, Patamundai Canal, High Level Canal, Puri main canal and distributaries off-taking from this canal such as Distributary No. 6 & 8 of Kendrapada Canal, L1 distributary of Taladanda canal, Phulnakhara distributary are extracted from Google Earth.

The irrigation map of Cuttack district showing district boundary, block boundary, rivers, canals, BGIP, MIPs, RLS, GWS is given in Figure 18.

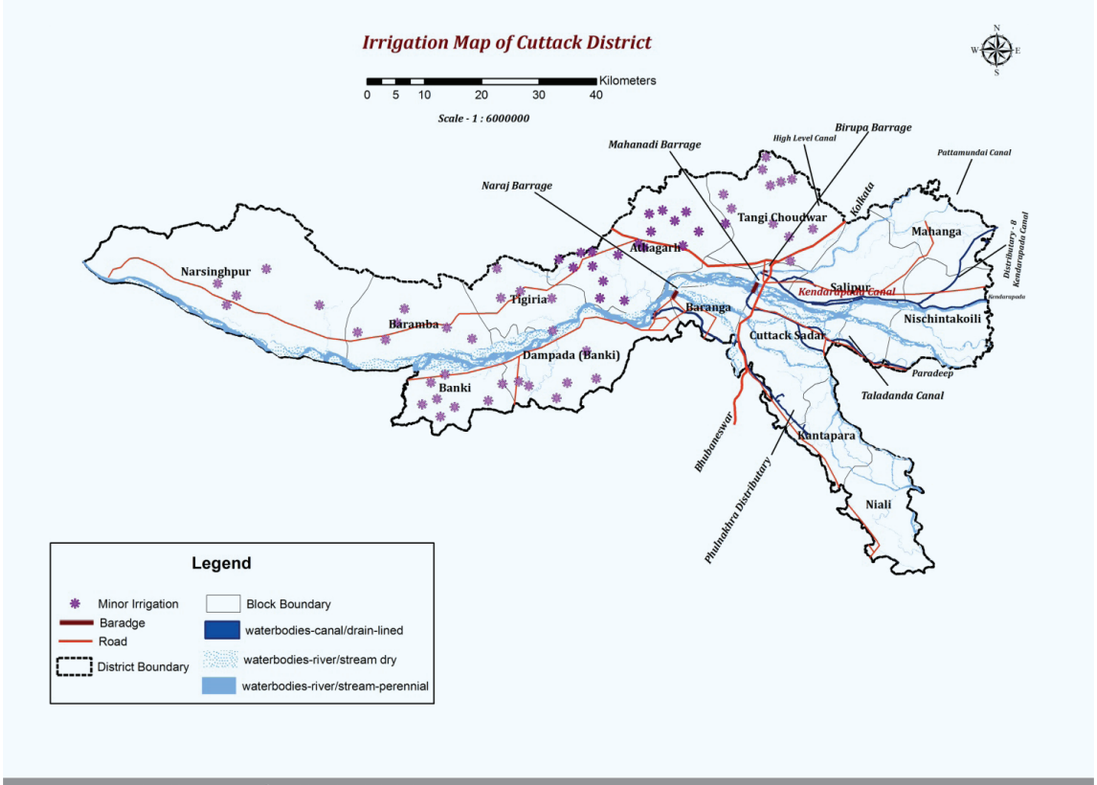


FIGURE 18: Irrigation Map of Cuttack District

5.1.2 Irrigation map of Subarnapur District

In the same method, irrigation map of Subarnapur District is prepared under this project. In the map, dam and canals namely Main Canal, Hingma distributary, Champamal distributary of Hariharjor medium irrigation project, Bargarh main canal and Retamuda branch canal of Hirakud major project are shown. Similarly, MIPs, RLSs, GWSs and Check dams are mapped as point layers.

Layers of Mahanadi River, Hariharjore, Tel, Suktel, Laxmijore, and Ong are important perennial rivers have been prepared and shown in this district irrigation map. River Lift Schemes are lifting water from such rivers.

The irrigation map of Subarnapur district showing district boundary, block boundary, rivers, canals, MIP, RLS, GWS is given in Figure 19

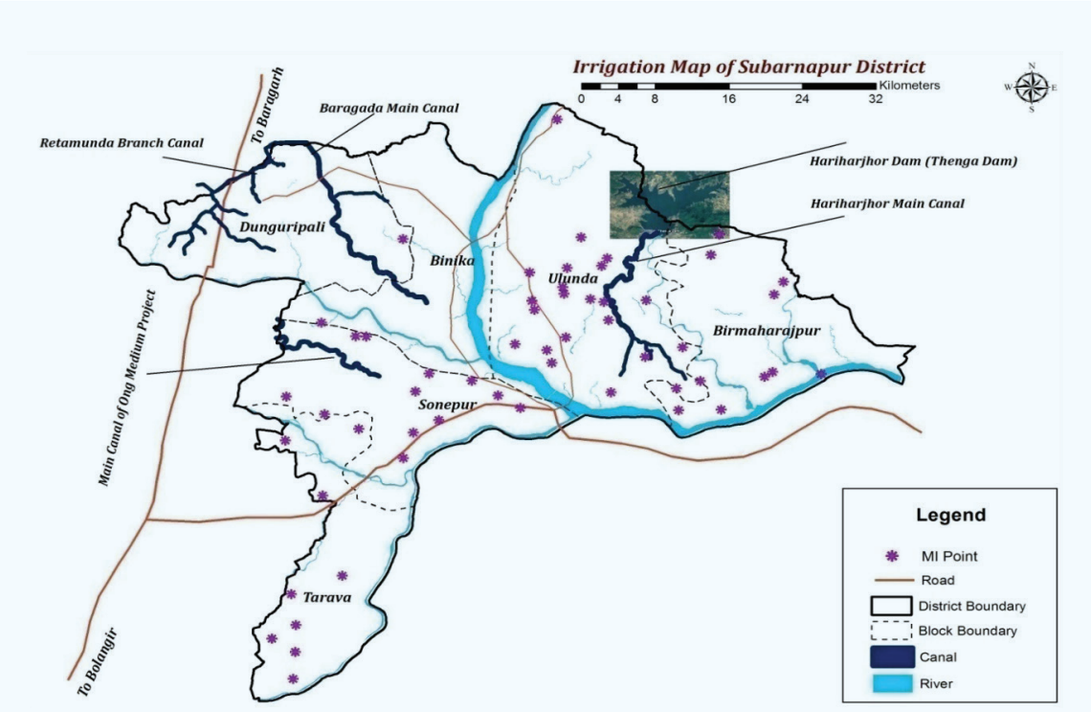


FIGURE 19: Irrigation Map of Subarnapur District

5.1.3 Irrigation map of Major Projects

Separate maps for major and medium irrigation projects are prepared by extracting canal network visible in Google earth. Map for Hariharjore medium project, part of Hirakud major project in Subarnapur district, Mahanadi Delta major irrigation project in Cuttack district are prepared and presented in Figure 20 and 21.

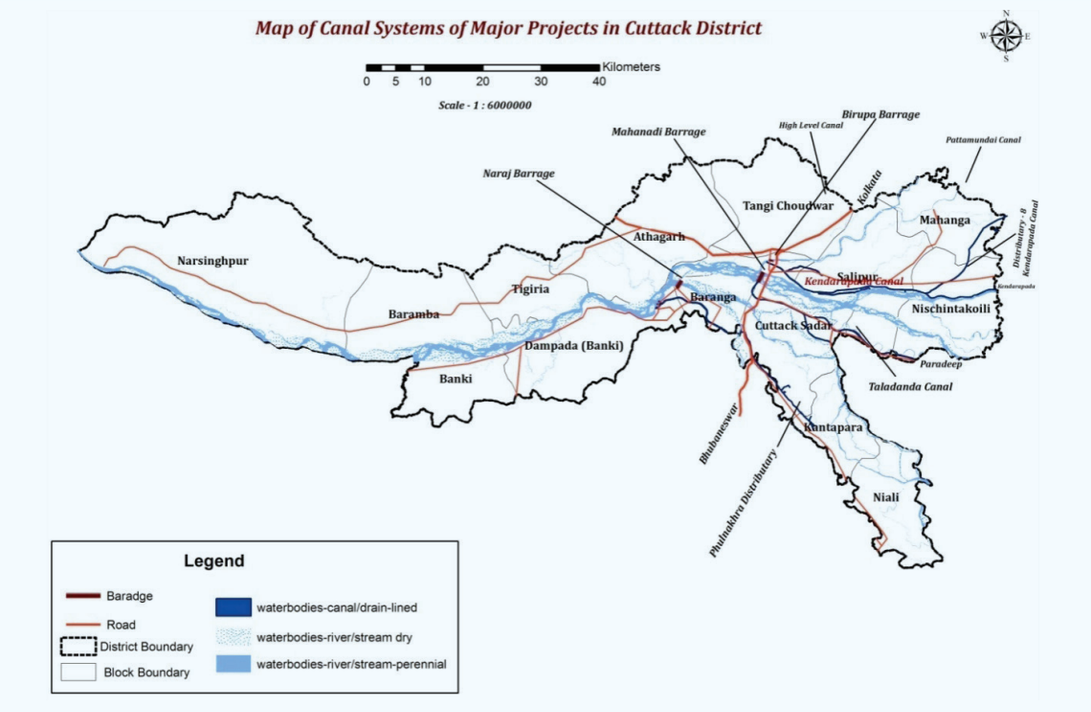


FIGURE 20: Map of Canal systems of Major Project in Cuttack District

5.1.4 Mapping of Study Locations

GPS readings for all study locations have been taken. The study locations include head regulators of distributaries and minors, outlets, location for measurements of canal cross sections, places of physical verification of structures and canal condition, tail end of sample canal and field channels in major, medium and minor flow irrigation projects. In case of river lift and ground lift schemes, GPS readings of pumping stations, distributions point, bore well and tube well points are mapped for each district. Maps showing field study locations on the base map are shown in Figure 22 for Cuttack district and Figure 23 for Subarnapur district.

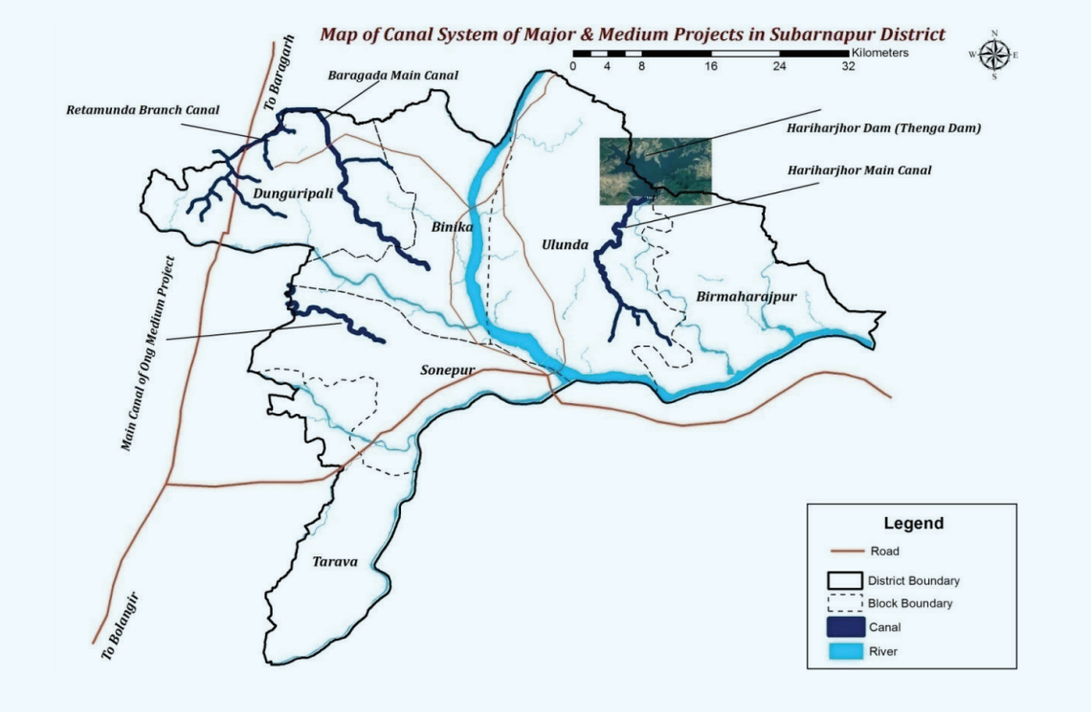


FIGURE 21: Map of Canal System of Major Projects in Subarnapur District

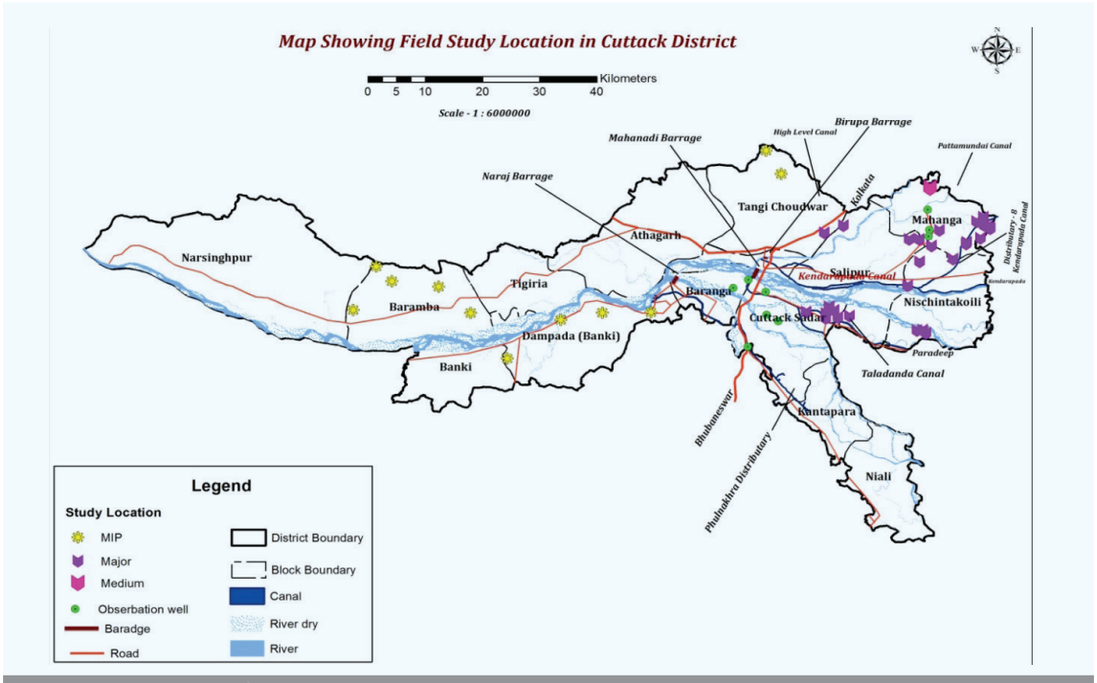


FIGURE 22: Map showing field location in Cuttack District

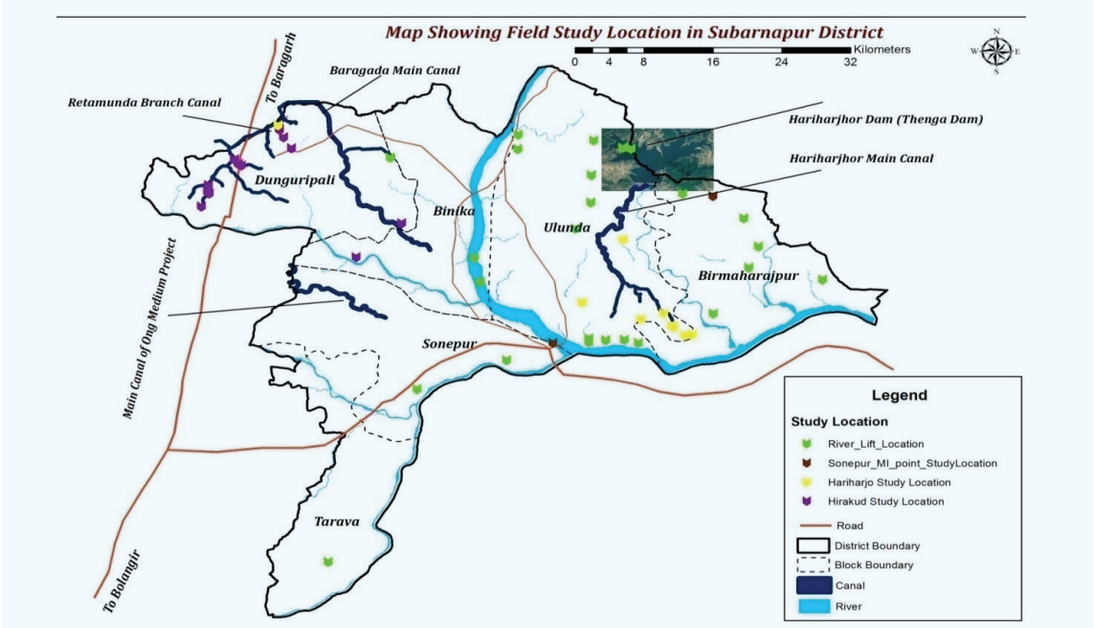


FIGURE 23: Map showing field Study Location in Subarnapur District

5.2 Potential Created Vs. Actual Area Irrigated

Irrigation potential created for sample area under different category of projects/schemes have been analysed in the following sections. Based on detailed field assessment, irrigation potential currently utilized for different categories of schemes have been assessed. In major irrigation projects, actual cross sections of canals are measured, and physical verification of structures and canal network has been conducted to assess the current carrying capacity of the distribution system.

5.2.1 Gap between IPC and IPU

When a Detailed Project Report is prepared, ayacut area is fixed considering the water available for supply of irrigation, terrain of command area, cost-benefit analysis, etc. But when the project is constructed, and water is released for irrigation, often there are certain short comings that lead to less area coverage from the project in different years. This is usually called as gap. Such gap assessment is made in this study for Kharif 2016 and Rabi 2017. This is represented for different schemes for the two districts in Figure 24-28.

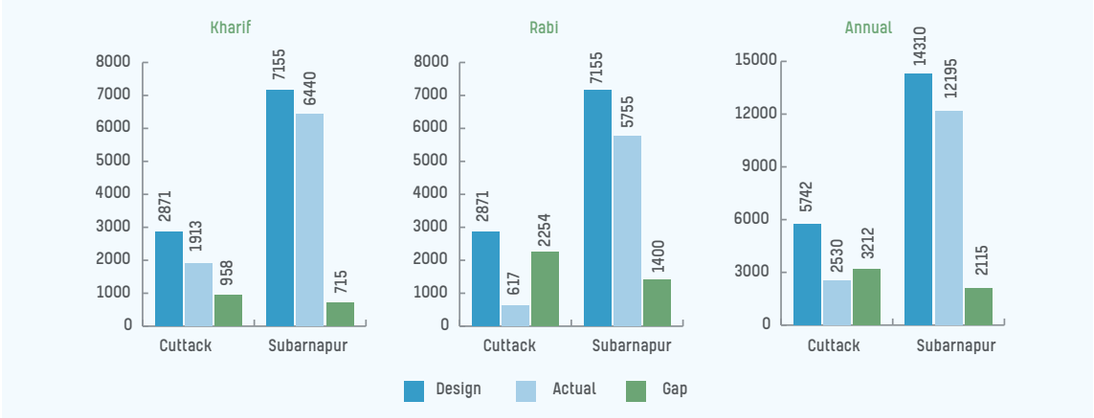


FIGURE 24: IPC, IPU and average gap in major irrigation project in study districts

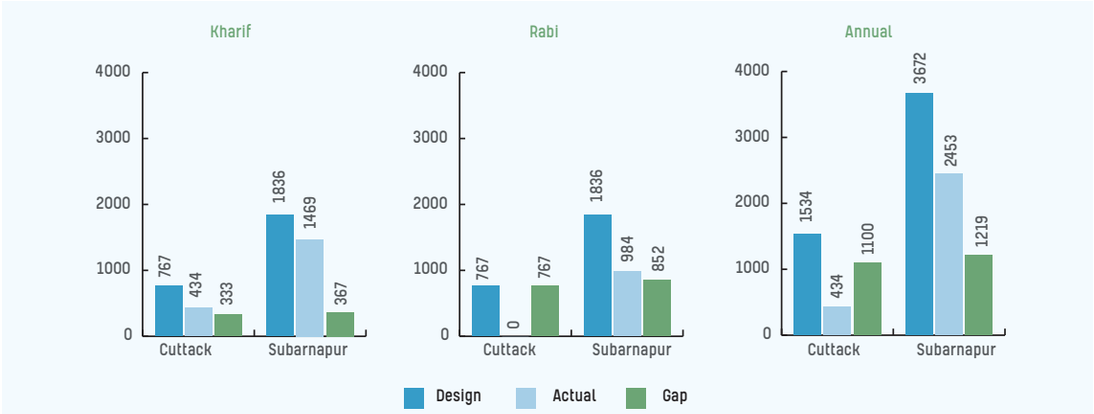


FIGURE 25: IPC, IPU and average gap in medium irrigation project in study districts

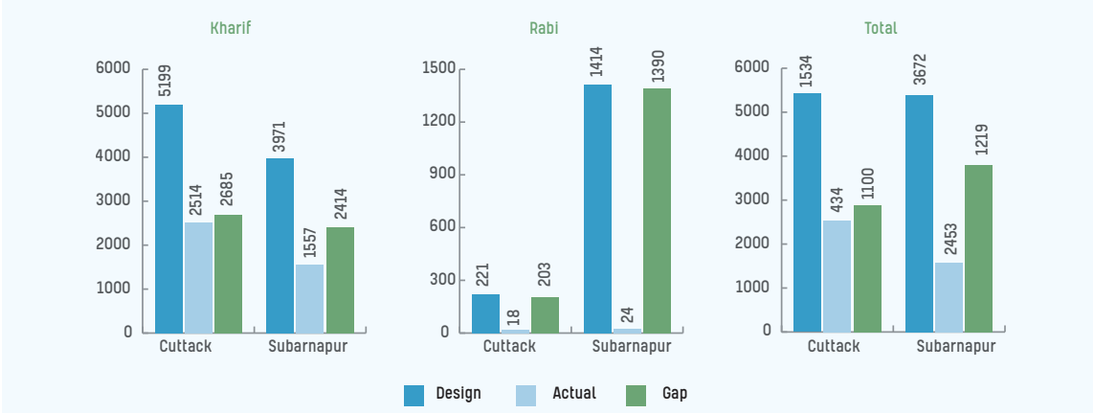


FIGURE 26: IPC, IPU and average gap in Minor irrigation project in study districts

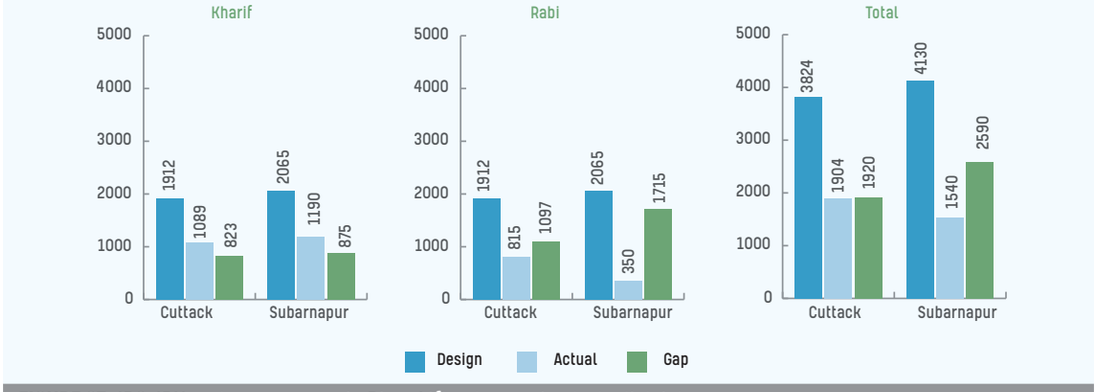


FIGURE 27: IPC, IPU and average gap in River Lift schemes in study districts

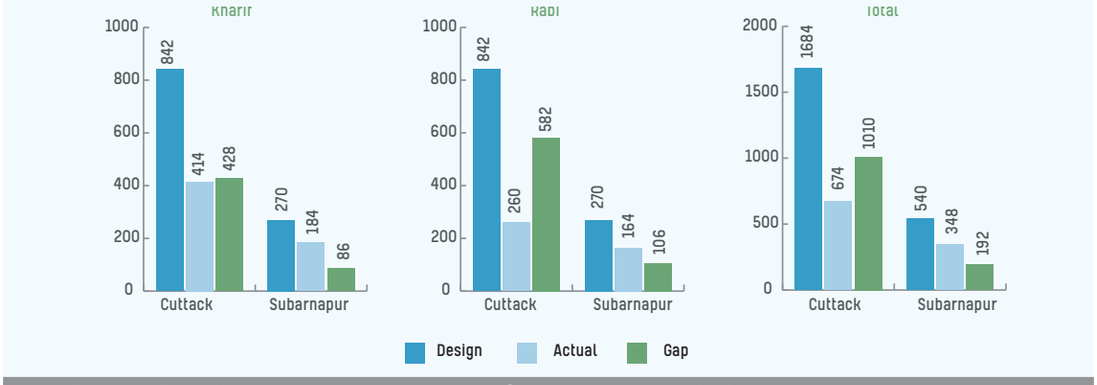


FIGURE 28:IPC, IPU and average gap in Ground water lift schemes in study districts

TABLE 9: IPC, IPU and average gap in all types of irrigation projects/schemes in Cuttack district

Type	Kharif			Rabi			Annual		
	IPC	Gap	% Gap	IPC	Gap	% Gap	Gross Irrigation Potential	Gap	% Gap
Major	2871	958	33.37	2871	2254	78.51	5742	3212	55.94
Medium	767	333	43.42	767	767	100.00	1534	1100	71.71
Minor	5199	2685	51.64	221	203	91.86	5420	2888	53.28
River Lift	1912	823	43.04	1912	1097	57.37	3824	1920	50.21
Ground water	842	428	50.83	842	582	69.12	1684	1010	59.98

TABLE 10: IPC, IPU and average gap in all types of irrigation projects/schemes in Subarnapur district

Type	Kharif			Rabi			Annual		
	IPC	Gap	% of Gap	IPC	Gap	% Gap	Gross Irrigation Potential	Gap	% Gap
Major	7155	715	9.99	7155	1400	19.57	14310	2115	14.78
Medium	1836	367	19.99	1836	852	46.41	3672	1219	33.20
Minor	3971	2414	60.79	1414	1390	98.30	5385	3804	70.64
River Lift	2065	875	42.37	2065	1715	83.05	4130	2590	62.71
Ground water	270	86	31.85	270	106	39.26	540	192	35.56

It has been found that, there is a considerable gap in current utilization of created irrigation potential in both the study districts. In case of major irrigation projects, assessed gap is 55.94% in part of Mahanadi delta project located in Cuttack district (Table 9) but only 14.78% in part of Hirakud project located in Subarnapur district (Table 10). The reason behind lesser gap in Subarnapur is the cultivation of second crop (paddy) in the entire command area in Binika and Dunguripalli blocks. The gap is more in Cuttack due to cultivation of green gram in limited area and very little area under second crop (paddy) and also due to repairing of canal network under ADB assisted OIIAWMP project.

In case of medium irrigation project, the gap is 71.71% in Birupa-Genguti Island project in Cuttack district (Table 9) because of non-supply of irrigation water during Rabi, incomplete canal network and deterioration of the canal condition in tail reaches of minors and sub minors. Gap of 33.2% in Hariharjore medium irrigation project (Table 10) due to less storage in the reservoir to meet the demand for paddy in Rabi season, siltation and deterioration of canal condition in minors and sub minor irrigation channels.

In minor irrigation projects, the gap is 53.28% in Cuttack district and 70.64% in Subarnapur district. The reasons for the same could be attributed to non-availability of water at source during Rabi season, inadequate distribution system and field channels.

In river lift schemes, there is gap of 50.21% in Cuttack district and 62.71% in Subarnapur district mainly due to defunct power supply, faulty billing of electricity charges, shifting away of flowing water from the suction point and inadequate distribution system.

In case of ground water, there is gap of 59.98% and 35.56% in Cuttack and Subarnapur district respectively. The reason lies with lesser discharge rate in bore wells, underutilization of ground water in Rabi season due to non-cultivation of Rabi crops, deviation from the agreement on cropping pattern between OLIC and Pani Panchayat.

FIGURE 29: (a) View of tail reach of Rampa minor of L1 distributary; (b) View of tail reach of 8H minor of distributary no.8 (Kendrapada canal)

FIGURE 30(a) View of minor 6c of distributary no-6 of Kendrapada canal in deteriorated condition; (b) View of tail reach of Champamal minor Hariharjore (Medium Project)

Other than the scheme-wise reasons for the irrigation gap, there are a few general issues with all the schemes which also contribute to the gap. These are: (i) water is not reaching tail end (ii) excess irrigation where water is available in plenty in the system, (iii) non-functional gates, (iv) Non-adoption of rigid operational schedules for canal operation, (v) less area coverage under drip and sprinkler irrigation, (vi) improper field channel network for efficient on-farm water management, (vii) Non-involvement of community institutions in canal water distribution

5.3 Cropping Pattern and Crop Productivity

Present cropping pattern in the study areas of both districts has been assessed. Paddy is main crop during Kharif season. Sugarcane is grown in limited area. In the command area of Hirakud major project, paddy is grown as second crop from January to April. Green gram is grown in both the districts in Rabi season. Groundnut crop is grown in Kharif season in Subarnapur district. The existing cropping pattern in the study districts are presented in Table 11.

TABLE 11: CROPPING PATTERN IN THE STUDY DISTRICTS

District	Kharif	Rabi
Cuttack	Paddy, Sugarcane	Paddy, Green gram
Subarnapur	Paddy, Ground nut, Green gram	Paddy, Green gram

Irrigation is one of the important factor for crop production and productivity. Attempt has been made to assess the productivity of different crops grown in the command area during Kharif and Rabi season in the study districts. It is depicted from the study that, paddy productivity is 46.09 Qt/Ha in Kharif and 49.99 Qt/Ha in Rabi season in Cuttack district where as in case of Subarnapur district, the productivity of paddy is 39.44 Qt/Ha in Kharif and 49.4 Qt/Ha in Rabi. This is higher than the average yield of India which is 28.2 Qt/ha but lower than benchmark figures of China, Japan and Korea which exceeds 59 Qt/ha. In Cuttack district, productivity of sugarcane is 557.72 Qt/Ha which is lower than sugarcane yields in states like Maharashtra where the average yield is 889 Qt/ha. This could have been higher with adequate irrigation given in critical stages of the crop. Productivity of green gram in Kharif has been found to be 2.98 Qt/Ha in Cuttack district and 3.2 Qt/Ha in Subarnapur district. Productivity of green gram in Rabi is 3.95 Qt/Ha in Cuttack district and 3.48 Qt/Ha in case of Subarnapur district. Compared to Punjab where the productivity of gram is 11 Qt/ha, this could be considered quite low and may directly be attributed to the irrigation gap in Rabi. Productivity of groundnut crop was found to be 9.88 Qt/Ha in Subarnapur district which is again almost half of the productivity in Punjab (18.5 Qt/ha). This emphasizes the need for better irrigation during critical stages of the crop along with timely application of appropriate dose of nutrients and other critical inputs.

Crop productivity in study districts, average productivity of district and state are furnished in Table 12.

TABLE 12: Crop Productivity in study districts

District	Kharif				Rabi			
	Crops	Productivity of sample area (Qt/Ha)	District* Average Productivity (Qt/Ha)	State** Average Productivity (Qt/Ha)	Crops	Productivity of sample area (Qt/Ha)	District* Average Productivity (Qt/Ha)	State** Average Productivity (Qt/Ha)
Cuttack	Paddy	46.09	45	25.72	Paddy	49.99	50	51.84
	Sugarcane	557.72	704.9	719.8	Green gram	3.95	4.94	4.8
	Green gram	2.98	3.85	4.64				
Subarnapur	Paddy	39.44	43.06	25.72	Paddy	49.4	46.19	51.84
	Groundnut	9.88	16.95	14.62	Green gram	3.48	4.18	4.8
	Green gram	3.2	3.3	4.64				

Source: *Dy. Director of Agriculture (Cuttack/Subarnapur) & **Odisha Agriculture statistics (2013-14)

TABLE 13: Project type wise Paddy Productivity in Cuttack district

Type of Scheme	Kharif Area (Ha)	Kharif Production (Qt)	Kharif Productivity (Qt/Ha)	Rabi Area (Ha)	Rabi Production (Qt)	Rabi Productivity (Qt/Ha)
Major	575.6	22023	38.26	66.8	2796	41.86
Medium	154	5755	37.37	0	0	0
Minor	405.2	12791	31.56	61.81	1636	26.47
Lift Irrigation	226	7969	35.26	56.4	2242	39.76

It is observed from Table 13 that in Cuttack district the productivity of paddy is lowest (31.56 Qt/Ha) in minor followed by lift irrigation (35.26Qt/Ha). The reasons for low productivity in minor irrigation project are sloping terrain of the command area, inadequate water distribution network as compared to other types of scheme where the command area is flat and levelled and water availability is comparatively better.

TABLE 14: Project type wise Paddy Productivity in Subarnapur district

Type of Scheme	Kharif Area (Ha)	Kharif Production (Qt)	Kharif Productivity (Qt/Ha)	Rabi Area (Ha)	Rabi Production (Qt)	Rabi Productivity (Qt/Ha)
Major	273.78	11594.2	42.35	393.6	16987	43.16
Medium	137.77	5767	41.86	29.6	1187	40.13
Minor	157.92	5755	36.44	62.8	2123	33.81
Lift Irrigation	433.97	15540	35.81	216.8	8968	41.37

In Subarnapur district, as depicted in Table 14, the productivity of paddy is found to be lowest in lift irrigation schemes (35.81 Qt/Ha) followed by minor schemes (36.44 Qt/Ha). The productivity is comparatively less in lift irrigation schemes due to fluctuation in voltage and subsequent reduction in total water pumped compared to crop water requirement. The productivity is found to be highest in major irrigation scheme as the crop water requirement is also met from irrigation canal drawing water from Hirakud dam.

FIGURE 31: (a) Paddy cultivation in the command area of Gandapali minor & (b) Sugarcane cultivation in command

5.4 Irrigation Management

Irrigation management practices are adopted by farmers based on their inherited experience. There is no involvement of water users in scheme irrigation project management for water distribution in canal system. Similar assessment of on-farm water distribution among the farmers' plots revealed that there was no roster or schedule for water distribution to farmer's plots from the water courses or field channels. Pani Panchayats, who were mandated to maintain the minor schemes, are not adequately informed about the carrying capacity, discharge rate in canals.

In Cuttack district, there is no rotational system of irrigation water delivery among the distributaries. In Subarnapur district, water delivery system in Hirakud canal network includes one-day closure and six days supply of irrigation water in distributaries. Rigid canal operation plans are not yet developed by the concerned irrigation divisions.

5.4.1 Water Application Practice

Water application practices followed in the study area have been analysed through interaction with farmers. It has been observed that, flood irrigation is prevalent in the command area of all project/ schemes. Water from the water course/field channel moves to farmers' field and then moves from one field to another till the entire outlet command (chak) is irrigated in an unregulated manner. Flood irrigation implies that water distribution being uncontrolled is inherently inefficient. Efficient micro irrigation methods like drip irrigation and sprinkler irrigation are not found to be used by farmers in the study area.

5.4.2 Equitable Use of Irrigation Water

It was found that there is inequity in water distribution from government-controlled irrigation projects. Main causes are (i) overdrawing of irrigation water in head reach than the designed supply, (ii) canals being operated below designed full supply depth resulting in inadequate head over sill level of outlets, (iii) lack of maintenance in tail reaches and reduction of carrying capacity. Equitable distribution is not a priority by the irrigation service providers. Equity aspects are yet to be mainstreamed in the operational procedures followed by the Department of Water resources.

5.5 Irrigation Efficiency

Efficiency of irrigation systems were studied by computing conveyance efficiency and application efficiency. During the study period, canals were found to be closed in Cuttack district due to repairing work in the head reaches of main canals. In Subarnapur district, canals were in fully operational condition in Hirakud irrigation project.

5.5.1 Conveyance Efficiency

In Gravity flow schemes in both districts, water is conveyed through open canals. Conveyance efficiencies of two representative canals in Subarnapur district for Hirakud irrigation project have been assessed. Conveyance efficiency values computed are presented in Table 15.

TABLE 15: CONVEYANCE EFFICIENCY OF HIRAKUD MAJOR PROJECT

Sl. No.	Name of the minor	Conveyance Efficiency (%)
1	Bishalpali minor of Hirakud Major Project	58.55
2	Mahulpali minor of Hirakud Major Project	66.96
	Average	62.74

5.5.2 Application Efficiency

Application efficiency for representative canal systems is computed. Computed application efficiency is presented in Table 16. Water application pattern was observed to be inefficient as bulk water drawn from outlets was distributed through movement by overland flooding of one plot after another.

TABLE 16: APPLICATION EFFICIENCY OF HIRAKUD MAJOR PROJECT

SL. No	Name of Minor	Application Efficiency (%)
1	Bishalpali Minor of Hirakud Major Project	69.98
2	Mahulpali Minor of Hirakud Major Project	60.60
	Average	67.20

5.5.3 Overall Irrigation Efficiency

There are losses in the conveyance of water in canals and also loss of irrigation water at farm level which is revealed from the values of conveyance efficiency and application efficiency depicted in Table 15 and 16. Overall irrigation efficiency is an indicator which is easy to compare across different projects. It is computed by multiplication of conveyance efficiency and application efficiency and is furnished in Table 17.

TABLE 17: Overall Irrigation Efficiency in Hirakud Major Projects

Sl. No.	Name of the minor	Overall Irrigation Efficiency (%)
1	Bishalpali Minor of Hirakud Major Project	40.97
2	Mahulpali Minor of Hirakud Major Project	40.57
	Average	40.77

Thus, average Conveyance efficiency of canal system studied is 62.74% and average application efficiency is 67.20%. The overall average irrigation efficiency of part of the Hirakud Major project in Subarnapur district is 40.77%.

FIGURE 32: (A) Measurement water velocity with Cup type current meter in a minor of Hariharjore medium project; (b) Measurement of actual cross section of Sakma Minor of Bhimtikira distributary, Hirakud Major Project

FIGURE 33: (a) Water velocity measurement through Cup type current meter in minor-6; (b) Measurement of canal section of Jaloi minor near Saharapali Village of Hariharjore Medium Project

5.6 Water Productivity

Water Productivity for paddy crop has been computed for both Cuttack and Subarnapur district. The water productivity in different distributaries varied between 0.124 Kg/m^3 and 0.730 Kg/m^3. The average water productivity is found to be 0.450 Kg/m^3. The water productivity for paddy computed for 6 irrigation systems is mentioned in Table 18.

TABLE 18: Water productivity

District	Name of the Canal	Water Productivity (Kg/m^3)
Subarnapur	Sukha Distributary	0.124096
	Rampur Distributary	0.473025
	Sarasamal Minor	0.729526
	Dhanbasa Minor	0.498336
Cuttack	Phulnakhara Distributary	0.562766
	Distributary No.8 of Kendrapada Canal	0.313329
	Average of projects in Cuttack and Subarnapur District	0.450179

Water productivity of rice globally varies between 0.15 kg/m^3 to 1.1 kg/m^3 with 0.6 kg/m^3 being the median range. Thus, the water productivity is a bit on the lower side. Water productivity can be enhanced by bringing in improvement in irrigation efficiency. Runoff from outlet command can be minimised by regulation of water in the outlets and application efficiency can be improved. Wastage of water during canal operation can also be minimised by introduction of canal operational plans. Such interventions may trigger other efficient practices and increase water productivity.

Based on the current usage pattern, there is scope for reducing gap between the irrigation potential created and utilized. This will also increase the production of rice. A 5% reduction in irrigation gap could lead to an increase in paddy production of 3981 MT in Kharif season and 105 MT in Rabi season in Cuttack district and 2476 MT in Kharif season and 3101 MT in Rabi season for Subarnapur district. Through agricultural extension program in the study districts, area under non-paddy crops like green gram and groundnut could be increased by diversification of area under paddy that would save irrigation water and help in improving efficiency and reducing gap between irrigation potential and utilization.

5.7 Gender Equity and Mainstreaming

Efforts were made to understand gender issues in water management and agriculture in irrigation projects villages during the focus group discussion. Of the total 711 farmers interviewed, approximately 20% were women farmer/ agriculture worker. Women are not the main stream of decision makers in the village set up on matters related water management and agriculture. Interaction with farm families leads to a conclusion that women are not decision makers even in one-tenth of the cases relating to farm-related decisions. Mostly women participate in agricultural activities of the family as farm labour for transplanting, carrying of inputs (fertilizers, manure, seeds etc.), inter cultural operations, harvesting and transporting harvested produces. This has happened due to patriarchal pattern of society that is inherited over generations as a tradition.

Because of recent thrusts by the government on financial and social inclusion (driven mainly by the Sustainable Development Goals, gender budgeting), women self-help groups (SHGs) are formed and leveraged to take up livelihood activities at household level or village level. This kind of thrust is necessary to be promoted in agricultural and irrigation management programs supported by government. Gender budgeting in irrigation sector, agricultural sector, and special incentive for women in terms of credit and subsidy to take leading role, is envisaged to be integrated in the DIAP. Pani Panchayats should be motivated to ensure women as members in chak committee, works sub-committee, water management sub-committee, finance and resource sub-committee and executive committee. This policy can be incentivised by giving priority to those PPs who have women as decision makers and handle the affairs of Pani Panchayat. Government may move a step forward to make Pani Panchayat exclusively managed by women wherever possible. Such steps will trigger gender main streaming and better role of women in agricultural and irrigation management.

SECTION 6

Issues in Irrigation Management

In the previous sections, information and data provide insight on the current scenario of irrigation management in the pilot districts. Some key issues concerning irrigation management in each study district are elaborated here under.

6.1 Issues in Cuttack District

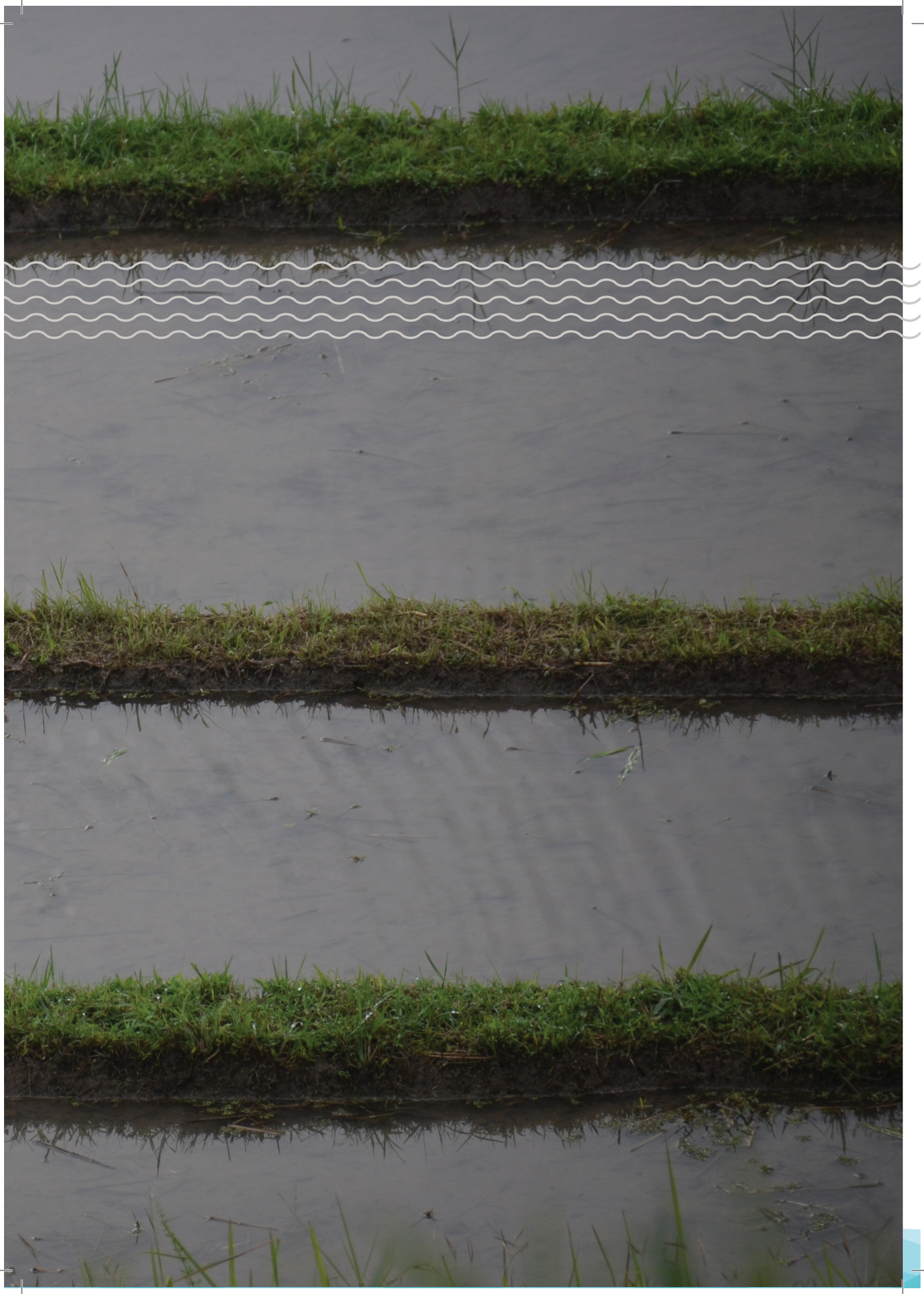
- Mahanadi Delta Stage-I Project has the capacity to provide irrigation to much more area in Rabi season. Currently Green gram is grown in Rabi season and a vast area remains fallow. Agricultural extension programmes to fully utilise the water available from the barrages is lacking.
- In Phulanakhara distributary, gates of few sub-minors are not in working condition. Water is not reaching command areas of some minors.
- In Birupa-Genguti Island Project (BGIP), head portion of the main canal is lined with laterite stone. Therefore, the canal cross section in head portion almost conforms to the design cross section, but towards tail reach there is siltation and reduction in the canal cross sectional area.
- BGIP has two minors named Jaypur minor and Mulabasanta minor. In the head regulators, the design discharge is being released but at tail the designed discharge is not passing in the canals.
- From the sample minor irrigation project studied, it was seen that no gauge discharge observation or any kind of flow measurement is being made to quantify the water released for irrigation in Kharif and Rabi season in BGIP.
- In Tail end area of Jaypur, minor water is not distributed properly as the carrying capacity is reduced due to non-maintenance of cross section.
- There is no rigid canal operational plan for any of the canals in major, medium and minor projects in the district. As a consequence, farmers as well as Pani Panchayats are not able to know when and how much water will be supplied to them.

- Distributaries' committees are not assigned specific roles to plan and monitor water distribution in Mahanadi Delta and BGIP.
- Subsequent to enactment of Pani Panchayat act and framing of irrigation rules, the responsibility of managing irrigation is handed over to Pani Panchayat, distributaries' Committee, and Project Committee. The system of beats which were managed by patrols of the govt. department is abandoned. New system is yet to be made functional and effective.
- Pani Panchayat institutions have not been properly trained on water distribution resulting in improper irrigation water distribution in canal network and inequity.
- There is no monitoring of water release to areas under different Pani Panchayats at present.
- There is no map for each outlet command (chak) showing field channels for preparation of water distribution roster or Warabandi schedule.
- Flow measurement structures like Parshall flumes are not installed in canal systems as is done in states like Maharashtra.
- Rabi Plan for 2016-2017 for Cuttack district was not prepared taking cognizance of water availability in different schemes.
- There is no programme to implement Warabandi type practices for water distribution in chaks below outlet leading to inefficiency.
- Monitoring of discharge released in different distributaries of major schemes and entire minor schemes are seldom made by higher level officials in hierarchy of water resources department.
- Pani Panchayats do not have information regarding irrigation fees collected in different seasons. There is no mechanism in place for fixing responsibility for collection of irrigation fees/ cess at field level.
- Frequency of interaction between officials of irrigation divisions and officials of Agriculture Department in the district is less. At present only two meetings are being convened under the agenda of Kharif irrigation plan and Rabi irrigation Plan.
- In river lift irrigation schemes in Cuttack district, neither government agencies nor farmers are making efforts for growing crops in Rabi season. Farmers are not found to be much involved in river lift schemes in Cuttack district.
- In river lift irrigation schemes, irrigation water is carried through PVC pipes. In certain cases, the pipes are damaged due to inadequate earth cushion.
- Most of the head regulators of sub minor of Jayapur minors are having problems due to damage of gates.
- Most of the river lifts are found non-operational during study period as most farmers are not interested about Rabi crops. Due to dry season, the river channel moves away from the suction point /foot valve and irrigation is not assured.

6.2 Issues in Subarnapur district

- Discharge release in the main canal in Hariharjore project on daily basis was not available for Hariharjore projects. There is no arrangement of discharge measurement in this medium project, neither is discharge measurement available for distributaries and minors of Hariharjore project.
- Irrigation water has not reached to tail end in Champamal and Hingma distributaries for last 4 years of Hariharajore Project. They are not operated on rotation basis properly during scarce period. There is no arrangement of measurement of gauge and discharge in BGIP.
- Many minors off taking from main canal are not in good shape due to lack of maintenance.
- There was insufficient storage in the dam during the study period. As a result, water was not released from the dam to meet the requirement of command area. Water was released for few days with flow rate less than the design discharge. This creates problems for maintaining head above the outlet for flow of water to the chaks.

- Hariharajore medium project has main canal concrete lined which was done in 2015. But Head Regulator of some minors have problems.
- Cross regulator in the main canal was found to be collapsed.
- The present system of canal operation as informed by section level staff is to release water for six days and closed for one day in rotation, is not scientifically done.
- As there is no canal operational plan, water distribution in distributaries and minors are being done arbitrarily which results in equitable distribution of irrigation water.
- Irrigation tax collection is not encouraging.
- Most of the minor irrigation schemes do not have capacity to provide irrigation in Rabi season in the district.
- Transformers do not exist in many river lift schemes. Only poles or Iron sections are seen on which probably transformers were installed in past.
- There is faulty billing of electricity charges, sometimes farmers opine that the bill amount is more compared to the usage. In a number of river lift projects, there are no meters to give bill on actual consumption. The bills are coming every month for a fixed amount, whereas farmers are using it at variable times and pump are being operated partially.
- In river lift schemes water being pumped from river and delivered into a sump / distribution well which were found to be damaged in some schemes.
- Proper design/maintenance of the sumps/distribution wells was found to be missing.
- In most cases, 8-inch PVC pipe are laid underground. In some cases, the depth of underground pipe line is less, which leads to breakage of pipes. The pipes are damaged due to human interaction and movement of farm machinery.
- The length of pipe network is insufficient for equitable distribution to the design CCA in river lift schemes.
- Number of river lift projects installed in Suktel river is much more. The cumulative discharge of all pumps seems to be less than the flow in the river during Rabi season.
- Pani Panchayat collect irrigation fees from water users based on crops grown and area covered. In turn, the Pani Panchayat makes payments of electric bills from this collection from water users. After handing over by the OLIC, entire operation and maintenance is responsibility of farmers. No guideline is given to them regarding operation & maintenance.
- In many villages, new RL are being constructed every year. At the time of water scarcity, farmers take mutual help and run the river lift scheme.
- Most of the ground water lift schemes were operational in March and April 2017. All ground water schemes were operated by electric motors. But designed command was not being covered.
- Ground water lift schemes are operated and maintained like river lift scheme by the Pani Panchayat. The management was observed to be deficient in most cases.



SECTION 7

Conclusion and Way Forward

7.1 Conclusion

Understanding the present water use pattern and quantification of certain parameters related to present water use is vital and can be considered as pre-requisite to develop realistic strategy for better planning of water distribution and application system. From the water use study conducted and presented in this report, it can be concluded that there is gap between irrigation potential created and irrigation potential utilised during the year 2016-17.

Planning of annual irrigation, taking all factors that may influence proper utilisation, is not being considered at present. There is no regular coordination between irrigation and agriculture department and it impacts growth in irrigated agriculture.

Estimation of water requirement for the Rabi season is particularly important to fully utilize the command area with the designed irrigation intensity which is not done at present. Water is being released from the reservoirs particularly in minor and medium irrigation projects in kharif which is in excess of the real crop water requirement. In such situation, the utilisation of irrigation potential is bound to be less as no seasonal allocation of water is decided.

In non-monsoon season, in many projects paddy is not included in the design cropping pattern. Farmers grow paddy without heeding to the planned cropping pattern and only a limited no of farmers located at the head end of the canal system grow paddy and consume all available water. Such phenomenon impacts the project performance in terms of less area coverage in Rabi season and makes the farmers vulnerable to drought-like situations or droughts in the subsequent kharif season. It is necessary to draw up season-wise and month-wise water allocation to the command area of different sub systems of a particular project or to the Pani Panchayats to whom it is transferred.

Even in the monsoon (kharif) season during long dry spells, many minor irrigation projects or distributary canals are not capable of meeting the crop water requirements, so that the crop doesn't suffer water stress and subsequent reduction in crop yield. The water regime/schedule to be maintained during such dry spells are not informed to the water users or farmers through an effective agricultural system. It results in uneven water distribution and lack of confidence of farmers to get irrigation dependably. In such scenarios, farmers often do not take risk in spending money on good quality seeds (to be procured from

market), manure and fertilizer and plant protection chemicals. Ultimately, traditional system of cultivation continues to prevail and modern technology having potential for realising higher productivity is not adopted by the farmers. Emphasis should be placed on advanced intimation to the water users regarding the water regime that can be maintained through irrigation in different parts of the canal command. Such practice will make the irrigation manager responsible and accountable to the needs of crops grown in the command and farmers.

Topographic and climatic conditions, spatial and temporal variation in water resources, present level of technology adoption in water management in the study area offers vast scope for improvement in irrigation management and enhancement of agricultural production. Studies conducted in the pilot districts and the analysed data corroborates this. Existing gap between irrigation potential created and current utilization is high and need to be addresses by proper strategy. Rotation of water distributaries and minor canals with a well worked out canal operational plan will be quite useful. Involvement of Pani Panchayat institutions by way of receiving the allocated water and its distribution among its members can also be planned as an improvement over the current practices.

It is found that the irrigation systems operate at lower level of overall efficiency of around 42%. There is also substantial gap between the irrigation potential created and actual area irrigated during the study year i.e. baseline. Gap in utilisation in Cuttack district in Kharif is 38.17% and in Rabi is 74.14%. Similarly gap in Kharif is 29.14% and Rabi is 42.88% in Subarnapur district. In the next five years, DoWR should take up programmes to bridge the gap. Activities like development of on-farm water distribution infrastructure with concrete lined field channels, division boxes, field drains, modernisation of water delivery system, use of efficient water application at farm level are important interventions to bridge the gap and improve efficiency. DoWR can take up bench-marking of important parameters that will reflect the water usage pattern and performance by conducting surveys over longer periods of one or two years. Innovative changes in irrigation planning, monitoring, canal operation in the main system, water distribution in the on-farm system can bring much desired improvement in the irrigation management scenario. Irrigation service delivery system needs to be realigned for sustainable, efficient climate resilient crop water management. Integrated irrigation and agriculture planning at district level and its implementation through PMKSY mechanism is the need of the hour. Innovative changes in water governance that would be focussed on optimum and efficient water use and enabling Pani Panchayat institutions and striving for more crop per drop should be the future approach.

Pilot projects can be launched by DoWR, Government of Odisha in few minor irrigation projects or one medium project to showcase improved practices and develop a sustainable, efficient and productive model of irrigation project management.

7.2 Way Forward

There are specific actionable measures towards bridging the gap between irrigation potential and its current utilization which will help the resource-constrained farmers to cope with climate change impacts by properly utilising the already available resources. These will be dealt in greater details in the next phase of the work while developing the water use strategy. Many workable interventions are possible in near term with available finances and budgetary support. Most of them will be management-oriented interventions and will not be capital intensive. Broadly, the measures are:

- Preparation of operational plan for each distributary in major and medium irrigation projects as well as main canal in minor irrigation projects followed by strict implementation
- Preparation of crop water budget reflecting water allocation
- Conduct annual water audit to assess water utilization against proposed plan and target
- Creation of enabling environment for the Pani Panchayat institutions for equitable and gender inclusive water distribution and irrigation management. It is envisaged to be transformative which will ultimately lead to adaptation of the water users' community to the impacts of climate

change. To make the adaptation truly effective, management of physical infrastructure of irrigation projects and distribution of available irrigation water has to be climate resilient.

- Introduction of sprinkler irrigation system particularly in lift irrigation schemes for non-paddy Rabi crops. A target for bringing at least 10% of the command area of major, medium and minor irrigation projects under drip irrigation could be considered.
- Crop diversification, particularly in Rabi season and cultivation of less water requiring crops for increasing utilization of irrigation potential.
- Infrastructure audit once in three years to diagnose the defects in irrigation infrastructure. Preparation of such audit report would provide prioritization mechanism to take up capital maintenance.
- For effective implementation of rotational canal operation, proper functioning of gates has to be ensured. It must be ensured that when a gate is closed, no water flows in the canal whose gate is closed at the head regulator. Wherever gates are fitted, it should be always in operational condition and DoWR has to draw up plans to ensure this. Proper action plans to be drawn up and budget provision to be made accordingly. It is a sequential activity to make the gates functional first and then follow the rotational system of water distribution.
- Small service reservoirs or ponds/farm ponds could augment and supplement irrigation from the main source during the deficit periods. These are presently not constructed in a planned manner.

Suggestions put forth in the way forward will be implementable if there is commensurate financing for the new works/activities proposed. Department of Water Resources has an allocation of INR 80305.4 million for work related activities in the State Annual Budget (Figure 34) with provisions for major irrigation, medium irrigation, minor irrigation and command area development activities. Since most of the action points suggested above require very little investment in terms of capital outflow, it may be inferred that financing will not be an issue.

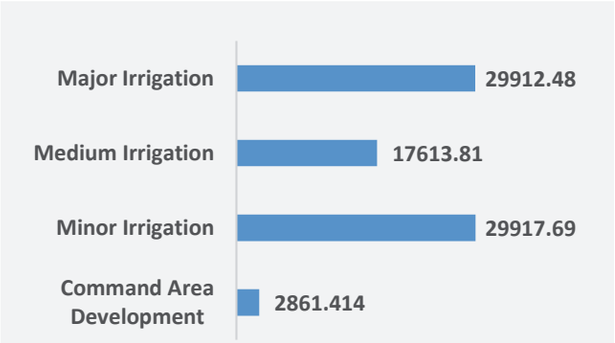


FIGURE 34: Financing of Irrigation Development and Management, FY 2017-18 (Rs. in Millions)

However, prioritizing the activities suggested above requires a change in the functional approach of the departmental officers in both irrigation as well as agriculture department. This will be a major issue, as the new activities like preparation of database, operational plans, benchmarking, efficient water management practices will require devoting time and developing capacity within the department personnel. On acceptance of the DIAP model by DoWR, Govt. of Odisha, executive orders, instructions from government to the field divisions would be required to bring much needed change in the entire water governance spectrum.

Annexures

Annexure 1:

Number of irrigation projects of different categories in both districts

Category	Districts	
	Cuttack	Subarnapur
Major	2	1
Medium	1	2
Minor	112	59
River Lift	704	891
Ground Water	941	2582

Annexure 2:

Details of Selected samples, their CCA and its percentage to area under major and medium schemes in Cuttack and Subarnapur District

Sl. No	Name of the schemes	Name of the main canals	Total Design CCA	Name of Distributaries and minors taken as samples	Sample CCA	Percentage of Sample CCA to Total CCA
1	Mahanadi Delta Irrigation Scheme stage-I and II	High Level Canal, Kendrapada Canal, Taladanda Canal, Puri Canal	38666.01	Raura Minor, Badapatasunderpur Minor. Padhansahi SM Distributary, Harianta Minor, Sardala Minor, Arada Minor, 6 C, 6 D, 6 F of Kendrapada canal, 8 K, 8G and 8 A of Kendrapada canal, Dharina Minor, Rampa Minor Brahmanakandha Minor of Taladanda canal,	9664.84	24.99
2	BGIP (Medium Scheme) in Cuttack district	Pattamundai main canal	2225.654	Benupura SM, Gheesuan SM, Banapur SM of Jaypurmian canal	1175	52.8
3	Hirakud Major Scheme in Subarnapur district	Bragarh Main Canal	81290.00	Retamunda branch canal, Bhimtikira Distributary, Sukha Distributary, Barkoli distributary	8349.00	10.27
4	Hariharjore Medium scheme in Subarnapur district	Hariharjor main canal	9450	Jaloi minor, Champamal minor, Hingma Dist., Saradhapali minor, 6L minor, Gurupanga minor	1165	12.33

Annexure 3:

Selected Sample CCA and its percentage to area under Minor schemes

Name of District	Name of the Blocks having Minor schemes	No. of projects in the district	Total Design CCA	Name of the sample Blocks	No of schemes taken as Sample	CCA of Sample Schemes	Percentage of CCA of sample schemes to Total CCA of the district
Minor Irrigation Projects							
Cuttack	Atthagarh, Banki-I, Banki-II, Badamba, Narsinghpur, TangiChoudwar, Tigiria	112	25553	Badamba, Banki-II, Tangi-chaudwar	12	5199	20.35
Subarnapur	Subarnapur, BMpur, Tarava, Ulunda	59	7372.41	Subarnapur, BMpur, Tarava	6	2971	40.30
River Lift Irrigation Projects							
Cuttack	Atthagarh, Banki-I, Banki-II, Badamba, Narsinghpur, TangiChoudwar, Tigiria, Niali, Cuttack Sadar, Kantapada, Mahanga, Salepur, N.Koeli	704	22144	Badamba, Banki-II, Mahanga, Kantapada	63	2237	10.07
Subarnapur	BMPur, Binika, Sonpur, Dunguraipali, Tarava, Ulunda	891	22273	Subarnapur, BMPur, Tarava	90	2561	11.5
Ground Water Irrigation Projects							
Cuttack	Cuttack Sadar, Baranga, Kantapada, Niali, Mahanga, Salepur, N.Koili	858	35754	Cuttack Sadar, Baranga, Kantapada, Niali, Mahanga, Salepur, N.Koili	114	4506	12.60
Subarnapur	BMPur, Binika, Sonpur, Dunguraipali, Tarava, Ulunda	2582	5164	BMPur, Binika, Sonpur, Dunguraipali, Tarava, Ulunda	260	520	10.07
Check Dam Irrigation Projects							
Subarnapur	BMPur, Binika, Sonpur, Tarava, Ulunda	94	NA	Subarnapur, Tarava, BMPur	10	NA	10.63

Source: Secondary Information from DoWR

Annexure 4:

List of Minor Irrigation schemes taken as sample for field study with name of Blocks in Cuttack District

Sl. No.	Block	Name of Project	Name of GP	Design CCA		Type	Design Discharge (s) in m^3/sec	No. of Canals	No. of PPs
				Kharif	Rabi				
1	Banki-II	Baghakhi-analla	Talabasta	61.00	20.00	Reservoir	0.07	1	1
2	Banki-II	Dandajhar	Talabasta	146.00	32.00	Reservoir	0.17	1	1
3	Banki-II	Rahania	Gopala-pur	41.00	41.00	Reservoir	0.05	1	1
4	Banki-II	Nuabundha	Nanagaon	46.00	0	Reservoir	0.05	0	0
5	Baramba	Chakunda-palli	Bada-khambilo	61.00	8.00	Reservoir	0.07	1	0
6	Baramba	Jharananalla	Bad-abarsing	121.00	0	Diversion-weir	0.14	5	0
7	Baramba	Khambeswari	Abhiman-pur	81.00	0	Reservoir	0.10	3	1
8	Baramba	Nareijani	Bada-khambilo	445.00	80.00	Reservoir	0.52	7	1
9	Baramba	Siaria	Baramba	486.00	162.00	Diversion-weir	0.58	4	0
10	Baramba	Hadua	Kharod	2,144.00	850.00	Diversion-weir	2.52	8	0
11	Tangi - Choudwar	Kusunpur	Safa	890.00	243.00	Reservoir	1.05	3	2
12	Tangi - Choudwar	GandhaNadi	Safa	677.00	121.00	Diversion-weir	0.80	5	0
Total				5199.00	1557.00		6.12	39	7

Annexure 5:

List of Minor Irrigation schemes taken as sample for field study with name of Blocks of Subarnapur District

S. No	Block	Name of the project	CCA in Ha	Design discharge(s) in Cusecs	No. of Canals
1	Bmpur	Guduguda	56.00	3.03	1
2	Subarnapur	Dablang	93.00	5.04	0
3	Subarnapur	Kharjura	42.00	2.28	0
4	Tarva	Nibrutijore	2630.00	142.46	2
5	Tarva	Bandhkol	63.00	3.41	2
6	Tarva	Charvata	87.00	4.71	1
G. Total			2971.00		6
% of sample selected to district total values			40		14

Annexure 6:

Minor Irrigation Statistics

Name of District	No of Block	No. of Project	Total CCA of all Projects	CCA	% sample CCA	Total No. of Canals in the district	No. of Canals taken in sample	% sample nos. of Canal
Cuttack	3	12 projects	25553	5199	24	212	39	18.4
Subarnapur	3	6	7372.41	2971.00	40	42	6	14

Annexure 7:

River Lift Irrigation Statistics

Name of District	No of Block	No. of Project	Total CCA of all Projects	CCA of Sample projects	% sample CCA
Cuttack	4	63	22144	2237	10.07
Subarnapur	3	91	22273	2561	11.50

Annexure 8:

Details of Sample of Hirakud Major Project in Subarnapur

Sl No.	Reach	Name of sample canal	Total Length of Minors in the reach	Length of sample Minors	% of Sample Length	Total Area of all Minors in the reach	Area of Sample Minors	% of Sample Area
1	Head	BehermalDy of Retamunda Branch Canal		3581			498.68	
2	Head	Mahulpali minor of BarkaliDy of Bar-garh Main Canal		5791			1424.5	
3	Head	Kuibahal Minor of BhimtikiraDisty. of Bargarh Main Canal		7924			1074	
		Sub-Total	35447	17296	48.79	9790	2997.2	30.62
4	Middle	Gandapali minor of sukhaDisty. of Retamunda Branch Canal		2667			691.63	
5	Middle	BishalPali Minor of BarkoliDisty.		3581			972.89	
6	Middle	Sankara Minor		6019			962.37	
		Sub-Total	63913	12267	19.19	15893	2626.9	16.53
7	Tail	Sargali Minor of sukhaDisty of retamunda Branch canal		2743			500.2	
8	Tail	Barkoli Tail		3000			500	
9	Tail	Sakma Minor		838			339.54	
		Sub-Total	51300	6581	12.83	8706	1339.7	15.39
		G. Total	150660	36117		34388	6963.8	
		Project Average			26.93			20.84

Annexure 9:

Block wise design CCA of Minor Irrigation Projects in Cuttack district in Kharif and Rabi

Sl No	Name of the Blocks	CCA Kharif (Ha)	CCA Rabi (Ha)
1	Athagarh	3,208.65	0
2	Banki-I	785.48	14.50
3	Banki-II	1,207.50	590.3
4	Baramba	3,782.60	40
5	Baranga	0	0
6	Cuttack sadar	0	0
7	Kantapara	0	0
8	Mahanga	0	0
9	Narasinghpur	3,264.47	0
10	Niali	0	0
11	Nischintakoili	0	0
12	Salipur	0	0
13	Tangi-Choudwar	1,415.30	83
14	Tigiria	392.6	0
	Total	14,056.60	727.8

Source: Secondary Information from DOWR

Action on Climate Today (ACT)
For more information,
Email: info@actiononclimate.today
www.actiononclimate.today

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Department of
Water Resources,
Government of Odisha