भाकृ अनुप
ICAR

वार्षिक प्रतिवेदन
ANNUAL REPORT

2014 - 2015

भारतीय जल प्रबंधन संस्थान
ICAR-IIWM






भाकृअनुप-भारतीय जल प्रबंधन संस्थान

ICAR - Indian Institute of Water Management

(An ISO 9001:2008 Certified Organization)

Bhubaneswar-751 023, Odisha, India

ICAR-IIWM Annual Report 2014 - 15

भाकृ अनुप
ICAR

वार्षिक प्रतिवेदन
ANNUAL REPORT

भारतीय जल प्रबंधन संस्थान
ICAR-IIWM

2014-2015

भाकृअनुप-भारतीय जल प्रबंधन संस्थान
ICAR-Indian Institute of Water Management

(An ISO 9001:2008 Certified Organization)
Bhubaneswar-751 023, Odisha, India
Web: http://www.dwm.res.in
e-mail: director.iiwm@icar.gov.in

भाकृ अनुप
ICAR

Annual Report

2014-15

भारतीय जल प्रबंधन संस्थान
ICAR-IIWM

Published by
Dr. Sunil Kumar Ambast
Director

Editors
Dr. S. Roy Chowdhury
Dr. Amod Kumar Thakur
Dr. K.G. Mandal
Dr. P. Panigrahi
Dr. M.K. Sinha

Hindi translation
Dr. O.P. Verma

Citation:
ICAR-IIWM, 2015. Annual Report 2014-15. ICAR-Indian Institute of Water Management, Bhubaneswar, India 85p.

Printed by
Space Setter Press & Publicity Pvt. Ltd.
Bhubaneswar

Preface

Water, as a crucial natural resource is perpetually under pressure due to increasing population, industrialization, urbanization, deforestation and above all changed climate scenario. At national level, by the year 2050 the projected total water demand will be 1447 BCM against presently available utilizable water resources of 1123 BCM. In that demand in agriculture sector itself will be 1074 BCM. Therefore projected demand will be 324 BCM more than the present level of utilizable water resources. Hence the attendant challenges will be (1) to produce more from less water by efficient use of utilizable water resources in irrigated areas, (2) elevating the production level from sub-productive challenged ecosystems, like rainfed as well as water logged areas, and (3) making use of grey water (or waste water) for agriculture production. With this back ground, I avail the opportunity bringing out the Annual Report of ICAR-Indian Institute of Water Management for the year 2014-15 comprising the research achievements of the Institute under five different research programmes, *i.e.* rainwater management, canal water management, groundwater management, waterlogged area management and on-farm research and technology dissemination with other related information for the said period. The significant research achievements and developmental activities of the institute during the year is commercialization of ICAR flexi-check dam technology and signing of MoU between ICAR and industry for production and supply of rubber composites required for rubber dam installations in India. The technology has successfully increased crop production, cropping intensity and rural livelihood options in rainfed areas. The other important achievements include, evaluation of rice- maize cropping system under conservation agriculture for rainfed areas; development of a water balance simulation model for on-farm reservoir in rice fields; water budgeting in high-value shrimp monoculture and carp polyculture for development of water use efficient aquaculture technology; assessment of extreme climatic effects on major cropping systems (of Odihsa) and ground water resources, and crop evapotranspiration, water footprints (of some winter season crops); irrigation infrastructures development addressing the water resources scarcity problems in tribal areas; participatory management of water resources and integrated crop and aquaculture in irrigated areas; comprehensive water resource management in non-exploration zone in coastal areas; designing on-line filter to use urban waste water for periurban agriculture; impact assessment of waste water induced soil quality changes; identification of waterlogged areas for alternate crops and aquaculture, increasing fertilizer use efficiency in waterlogged areas : a web based portal with technological options on agriculture water management for various users from farmers to scientists associated with the related issues. Twenty six centres operating under the All India Coordinated Research Project on Irrigation Water Management have been engaged in research in different themes like basic studies on soil-water-plant relationship, rainwater harvesting and utilization, assessment of irrigation water demand and system supply and groundwater use, irrigation scheduling and water use efficiency, pressurised irrigation system and fertigation etc. The report presents findings of aforesaid different water management research programmes. I am sure that content of the report will be useful for the stakeholders at various levels engaged in the field of agricultural water management in the country.

As a recognition for significant contribution and excellence in research and developmental activities in agricultural water management, the institute has been upgraded to national institute with rechristened name of *ICAR-Indian Institute of Water Management*. The research accomplishment of the Institute has also been recognized through various awards like Rajdhani Gourav Sanman Award 2014-15, Purushottam Jiban Dash Memorial Bio-Research Best Paper award -2014, Plaque of Honour for outstanding contribution to popularize agricultural science, 'Best Poster Award' at 12th Agricultural Science Congress along with other recognitions.

During the year the Institute published 57 research papers in scientific peer reviewed journals of national and international repute along with fourteen research bulletins, information brochure, leaflets, training manual and books. In addition to meetings of Research Advisory Committee, Institute management Committee and Institute Research Council meetings, the institute has also organized farmers-scientists interface meet and farmers training programmes, 7- days short course on 'Management of cyclone disaster in agriculture sector in coastal areas', vigilance awareness week, 4-day workshop on 'Reuse options for marginal quality water in urban and peri-urban agriculture and allied services in the gambit of WHO guidelines', 6-day training programme on ''Micro-irrigation and protected cultivation for efficient use of water and enhanced crop productivity', a 2-day inception Workshop on 'Agri-Consortia research platform on water', 'institute foundation day' and 'world water day' etc.

I express my sincere gratitude to Dr. S. Ayyappan, Director General, ICAR and Secretary, DARE, Government of India for his constant support and guidance. I am grateful to Dr. A.K. Sikka, Deputy Director General (NRM), ICAR for his valuable guidance and suggestion for research and development planning of the Institute at each stage. I also express my thanks to Dr. S.K. Chaudhari, Assistant Director General (S &WM) for his help and cooperation for smooth functioning of the Institute. I place on record my appreciation for the admirable effort by all the members of publication committee to bring out the annual report in time.

May 2015

(S.K. Ambast)

CONTENTS

कार्यकारी सारांश

- ओडिशा में 20 वीं सदी के दौरान मानसून वर्षा के औसत एवं चरम मानकों की प्रवृति एवं परिवर्तनशीलता को जलवायु परिवर्तन मूल्यांक एवं सूचकांक (ETCCDMI) पर विशेषज्ञ दल द्वारा परिभाषित कुछ सूचकांकों में परिवर्तन होने का पता चला है। विशेष रूप से, मध्यम बारिश की घटनायें जो कि नम दिनों में गिरावट के कारण होती है, में 1960 के दशक के बाद से काफी कमी आई है। लगातार सूखे के दिनों में (CDD) बढ़ोतरी एवं लगातार नम दिनों (CWD) में कमी पायी गयी है।

- एक्वा क्रॉप मॉडल का अंशांकन एवं सत्यापन एरोबिक धान की फसल पर किया गया। सूखे की वजह से धान की उपज में होने वाले नुकसान का आकलन करने के लिये एक्वा क्रॉप मॉडल का इस्तेमाल किया गया। अंशांकित एक्वा क्रॉप मॉडल द्वारा सूखे की वजह से धान की उपज में 8% से 16% तक नुकसान को मूल्यांकित किया गया। एक जल संतुलन सिमुलेशन मॉडल भी धान के खेतों में कृषि जलाशय को विकसित करने के लिये किया गया। परत वाले तालाब का आकार खेत के क्षेत्रफल का 5% से 21% तथा बिना परत के तालाब का आकार खेत के क्षेत्रफल का 8% से 49% के बीच होना चाहिये।

- रबर बाँध की आधार संरचना को इनलेट एवं आउटलेट के साथ देश के 22 विभिन्न कृषि पारिस्थितिकी एवं भू-जल गर्भीय क्षेत्रों में स्थापित किया गया। मृदा एवं जल संरक्षण, सूखा बचाव, बाढ़ नियंत्रण एवं कृषि उत्पादन आदि बढ़ाने के लिये रबर बांधों के लाभ का विश्लेषण किया गया तथा दस्तावेज भी तैयार किए गये। कमांड क्षेत्र में रबड़ बांध फसल उत्पादन में वृद्धि, फसल तीव्रता एवं ग्रामीण आजीविका इत्यादि विकल्पों को बढ़ाने में मदद करता है। इस तकनीक का वाणिज्यीकरण किया गया एवं भारत में रबर बांध स्थापन तथा आवश्यक रबर कंपोजिट के उत्पादन एवं आपूर्ति के लिये एक समझौता ज्ञापन पर भारतीय कृषि अनुसंधान परिषद और उद्योगों के बीच हस्ताक्षर किये गये।

- ड्रिप सिंचाई पद्धति के तहत विनियमित घाटा सिंचाई (आर डी आई) एवं आंशिक जड़ क्षेत्र सुखाने (पी आर डी) की विधियों का आम के पेड़ पर होने वाली प्रतिक्रिया का अध्ययन किया गया। पूरी सिंचाई, 80% आर डी आई, 60% आर डी आई, 40% आर डी आई, 80% पी आर डी, 60% पी आर डी, 40% पी आर डी एवं केवल वर्षा पर आधारित आदि विधियों का प्रयोग किया गया। ड्रिप पद्धति की हाइड्रोलिक दक्षता ने 11% एमिटर बहाव परिवर्तन एवं 90% वितरण समानता को दर्शाया। पूरी सिंचाई में पौधों की वृद्धि के गुण जैसे पौधों की ऊंचाई, कॉलर परिधि, पत्तों का आयतन आदि अधिकतम पाये गये। अधिकतम फल की उपज 80% पी आर डी से प्राप्त हुई जबकि सबसे अच्छी गुणवत्ता वाले फल एवं जल उपयोग क्षमता 60% पी आर डी उपचार के तहत प्राप्त हुई।

- संरक्षित खेती तकनीक के तहत धान-मक्का फसल पद्धति का मूल्यांकन किया गया। संरक्षित खेती के लिये विभिन्न पद्धतियों का प्रयोग किया गया जैसे कि जुताई नहीं, कम से कम जुताई, तथा 100% रसायनिक उर्वरकों, 50% रसायनिक + 50% गोबर की खाद एवं 50% रसायनिक + 50% हरे पत्तों की खाद के साथ पारंपरिक जुताई आदि। जुताई से मिट्टी के वल्क घनत्व एवं पीएच में अधिक परिवर्तन नहीं हुआ। उसी प्रकार तत्व प्रबंधन विकल्पों से भी इन दो मिट्टी के गुणों में अधिक परिवर्तन नहीं हुआ। फसल कटाई के बाद अन्य पद्धतियों की तुलना में जुताई नहीं के तहत मिट्टी में उपलब्ध नाइट्रोजन एवं फॉस्फोरस के स्तर में वृद्धि पायी गयी। जुताई नहीं एवं कम से कम जुताई में पोटासियम का स्तर लगभग बराबर था। 50% रसायनिक + 50% गोबर की खाद का उपचार 100% रसायनिक उर्वरकों के उपचार की तुलना में उत्तम था एवं 50% रसायनिक + 50% हरे पत्तों की खाद के उपचार के बराबर पाया गया।

- कार्प पॉलीकल्चर पद्धति में विभिन्न स्टोकिंग डेन्सीटी के तहत अनुमानित कुल पानी का उपयोग (TWU), 3.81, 4.02 एवं 4.44 हेक्टेयर-मीटर था, जबकि आंकलित जल उपयोग उपभोगित इंडेक्स (CWUI) टी$_1$ (6000 फिंगरलिंग्स/हेक्टेयर), टी$_2$ (8000 फिंगरलिंग्स/हेक्टेयर) एवं टी$_3$ (10000 फिंगरलिंग्स/हेक्टेयर) उपचारों में क्रमशः 6.48, 5.71 एवं 5.99 घन मीटर प्रति किलोग्राम बायोमास पाया गया। इसी प्रकार पी मोनोडोन मोनोकल्चर में विभिन्न स्टोकिंग डेन्सीटी के तहत अनुमानित कुल पानी का उपयोग (TWU) 3.08, 3.34 एवं 3.69 हेक्टेयर-मीटर हुआ एवं आंकलित जल उपयोग उपभोगित इंडेक्स (CWUI) टी$_1$ (15000 पोस्ट लार्वा /हेक्टेयर), टी$_2$ (20000 पोस्ट लार्वा /हेक्टेयर) एवं टी$_3$ (25000 पोस्ट लार्वा /हेक्टेयर) में क्रमशः 5.22, 4.82 एवं 5.06 घन मीटर प्रति किलोग्राम बायोमास पाया गया। उच्च उपज, आर्थिक लाभ एवं NCWP को ध्यान में रखते हुए कार्प पॉली कल्चर एवं पी मोनोडोन मोनोकल्चर में स्टोकिंग डेन्सीटी 8000 फिंगरलिंग्स/हेक्टेयर एवं 20000 पोस्ट लार्वा /हेक्टेयर सबसे उपयोगी पाया गया।

- वैकल्पिक भूमि एवं फसल प्रबंधन के तरीकों के माध्यम से फसल उत्पादन तथा लाभ को बढ़ाने के लिये एक रनऑफ रीसाइक्लिंग मॉडल विकसित किया गया। खरीफ में धान की किस्म स्वर्णा से 3.84 टन/हेक्टेयर उपज प्राप्त हुई। संशोधित भूमि प्रणाली के ढलान

पर चंवला (Cowpea) को उगाने से 24 टन/हेक्टेयर हरे चारे की उपज हुई। रबी में संग्रहीत जल से सिंचाई के कारण 1.08 टन/हेक्टेयर सरसों (किस्म-NRCBH-101), 11 टन/हेक्टेयर ब्रोकोली हैड (किस्म-CHB-1), 1.04 टन/हेक्टेयर उड़द (किस्म-प्रसाद) एवं 0.9 टन/हेक्टेयर मूंग की उपज प्राप्त हुई।

- खेत में वर्षा जल संग्रहण के लिये एक तालाब को पुन:निर्मित किया गया एवं तालाब के अंदर नीचे के ढलान की ओर अतिरिक्त वर्षा अपवाह (Runoff) को एकत्रित करने के लिये एक अधिशेष संरचना का निर्माण किया गया। स्थानीय स्तर पर उपलब्ध लैटेरिटिक पत्थर का उपयोग करके एक इनलेट का निर्माण किया गया ताकि क्षेत्र के ऊपरी भाग से वर्षा अपवाह के एकत्रित होने से तालाब में अवसादन (सेडिमेंट) को कम किया जा सके। तालाब के तटबंध पर केला और पपीता के पौधों को उगाया गया। क्षेत्र की सीमा पर ग्लाइरीसिडिया के पौधों को लगाया गया ताकि नाइट्रोजन युक्त बायोमास एकत्रित हो सके और साथ ही इससे वर्मी कम्पोस्ट उत्पादन भी हो सके। खरीफ में धान की फसल के लिये ढैंचा के बीज को 20 किलो प्रति हेक्टेयर की दर से खेत में बोया गया ताकि नाइट्रोजन के साथ साथ इन-सीटू हरी खाद के रूप में भी इसका उपयोग किया जा सके।

नहरी जल प्रबंधन

- रबी की फसलों में इवेपोट्रान्स्पिरेसन एवं वाटर फुटप्रिंट पर जलवायु परिवर्तन के प्रभाव का विश्लेषण किया गया। [भिंडी (अप्रैल-जून)-धान (जुलाई-नवंबर)-टमाटर (दिसंबर-मार्च)] फसल पद्धति में सकल प्राथमिक उत्पादकता, पारिस्थितिकी तंत्र श्वसन, शुद्ध पारिस्थितिकी तंत्र विनिमय का अध्ययन किया गया। फसल काटने के बाद भिंडी, चावल एवं टमाटर की फसलों में शुद्ध पारिस्थितिकी तंत्र विनिमय क्रमश: -248, -315 और -173 ग्राम सी/वर्ग मीटर था। सब्जी आधारित खेती पद्धति में जल के बहुपयोग एवं ड्रिप फर्टिगेसन के द्वारा जल उत्पादकता में रूपये 14/घन मीटर तक की वृद्धि पायी गयी।

- ओडिशा में एक मध्यम सिंचाई कमांड क्षेत्र के तहत नहर के विभिन्न टैल, मध्यम एवं अंतिम छोर क्षेत्रों में जल संसाधनों का भागीदारी प्रबंधन तथा एकीकृत फसल उत्पादन एवं मछली पालन पद्धतियों को विकसित किया। एकीकृत कृषि पद्धति में कम अवधि वाली मछली पालन, बांध पर बागवानी फसलों (पपीता, केला, एवं खरीफ तथा रबी के मौसम की सब्जियों) को शामिल किया गया। वैकल्पिक फसल पद्धतियों जैसे धान+ (तालाब में मछली)-मीठी मक्का, धान+ (तालाब में मछली)-सूरजमुखी, धान+ (तालाब में मछली)-मूँग/उड़द, धान+ (तालाब में मछली) + अरहर (तटबंध पर)-मूँग, एवं धान+ (तालाब में मछली)-सब्जियाँ आदि की धान-परती फसल पद्धति के साथ तुलना की गयी। इन सब तालाब आधारित कृषि पद्धतियों से आर्थिक लाभ रु 1,57,224 प्रति हेक्टेयर से रुपये 1,99,776 प्रति हेक्टेयर तक प्राप्त हुआ।

- पोस्ट वनस्पति अवस्था के दौरान सभी जल प्रबंधन तरीकों के तहत पानी की प्रति इकाई मात्रा के प्रयोग से श्री पद्धति (6.3 किलो प्रति हेक्टेयर मिमी) में परंपरागत रोपाई प्रणाली (सीटीएस, 3.3 किलो प्रति हेक्टेयर मिमी) की तुलना में काफी अधिक अनाज उपज प्राप्त हुई। परंपरागत रोपाई प्रणाली के तहत उच्चतम जल उत्पादकता (3.5 किलो प्रति हेक्टेयर-मिमी) 1-दिन पानी के सूखने के बाद सिंचाई करने में प्राप्त हुई, जबकि श्री पद्धति में उच्चतम जल उत्पादकता (6.6 किलो प्रति हेक्टेयर-मिमी) 3-दिन के बाद पानी सूखने पर सिंचाई करने से प्राप्त हुई।

- बेबी कॉर्न, धान एवं शिमला मिर्च की फसलों में दो लेटरल लेआउट (1.4 मीटर एवं 1.0 मीटर) के साथ ड्रिप पद्धति के तहत डेफीसीट सिंचाई के प्रभाव का मूल्यांकन किया गया। बेबी कॉर्न की उपज (2.06 टन/हेक्टेयर) पूर्ण सिंचाई में अधिकतम थी हालांकि, 75% ET_C सिंचाई (1.94 टन/हेक्टेयर) के बराबर थी। यद्यपि, 50% ET_C सिंचाई से पूर्ण सिंचाई की तुलना में उपज में 33% कमी प्राप्त हुई लेकिन सिंचाई जल उत्पादकता में 32% की वृद्धि हुई। दोनों, सिंचित (एरोबिक धान) तथा वर्षा सिंचित धान में ड्रिप सिंचाई के तहत 100% ET_C सिंचाई में 8-12% तक फसल उपज में कमी हुई एवं 30-35% तक पानी बचत प्राप्त हुई। इस सिंचाई पद्धति में सतही सिंचाई पद्धति की तुलना में पानी की उत्पादकता में 40-50% वृद्धि हुई। सभी फसलों में कम से कम लेटरल दूरी (1.0 मीटर) ने उच्च पैदावार का उत्पादन किया।

भूजल प्रबंधन

- केंद्रपाड़ा जिले के महाकालपड़ा ब्लॉक में उचित फसल योजना बनाने के लिये सुनिती क्रीक में साल के अलग अलग मौसम में पानी की उपलब्धता के लिये क्रीक हाइड्रोलिक्स का अध्ययन किया गया। नवंबर, 2014 में पानी का वेग 0.28-0.43 मीटर/सेकंड दर्ज किया गया, जबकि जनवरी 2015 में यह 0.17-0.41 मीटर/सेकंड के बीच था। जल की गुणवत्ता विश्लेषण ने दर्शाया कि मानसून के बाद से गर्मियों एवं मानसून के पहले तक ई सी (EC) एवं एस ए आर (SAR) गुणों में तेजी से वृद्धि हुई। क्रीक के पानी की ईसी में 1.4 से 151 गुणा तथा एसएआर में 1.02 से 32.62 गुणा वृद्धि हुई। एक स्लूइस संरचना (डिस्चार्ज-25 घन मीटर/सेकंड, जलग्रहण क्षेत्र-2000 हेक्टेयर) का जल निकास को नियंत्रित करने तथा खारे पानी के प्रवेश को कम करने के लिये जल

संसाधन विभाग, ओड़ीशा सरकार के सहयोग से डिजाइन तैयार किया गया।

- कॉस (COS) बोर्ड पेपर मिल से प्राप्त अपशिष्ट जल का चार अलग अलग मिट्टीयों में प्रयोग के बाद पानी से धोने पर मिट्टी में बिना किसी हानिकारक प्रभाव के ई सी में 15.38 से 166% तक की कमी हुई। यह अपशिष्ट जल आर्द्र एवं उप आर्द्र क्षेत्रों में अम्लीय से न्यूट्रल एवं अलवणीय मिट्टियों के लिये सिंचाई के पूरक स्रोत के रूप में पाया गया। जगतपुर में पेपर मिल तथा खुर्दा में ब्रुअरीज उद्योग के आस-पास के क्षेत्र में अपशिष्ट जल के गुणवत्ता मूल्यांकन ने बताया कि 70 से 85% नमूनों में रॉक खनिजों का विघटन जल रसायनिकी को निर्धारित करता है जबकि, ढेंकानाल के हरीपुर एवं पंडुआ क्षेत्र में डिस्टिलरी ओद्योगिक इकाई के आस पास के क्षेत्र में 53 से 83% नमूनों में क्षार विनिमय जल गुणवत्ता में योगदान देता है। मानक जल गुणवत्ता मानदंडों के साथ पानी की गुणवत्ता की तुलना से ज्ञात हुआ कि सभी नमूने अच्छी तरह से सिंचाई एवं पीने के उपयोग के लिये उपयुक्त पाये गये और आसपास के जल स्रोतों पर संबंधित औद्योगिक इकाइयों का कोई प्रभाव नहीं पड़ता।

- पंजाब राज्य में धान-गेहूं कवरेज क्षेत्र को रिमोट सेंसिंग एवं जी आई एस उपकरणों के एकीकरण का उपयोग करते हुए चित्रित किया गया। वर्ष 1995 से 2011 तक प्रवृति विश्लेषण से धान एवं गेहूं के कवरेज क्षेत्रों पर कोई विशेष भिन्नता प्राप्त नहीं हुई। धान-गेहूं फसल अनुक्रम के तहत कुल क्षेत्र 2.053 मिलियन हेक्टेयर (राज्य की कुल खेती योग्य क्षेत्र का 49.06%) था। इसी तरह, संयुक्त रूप से धान-गेहूं की खेती की जाने वाला क्षेत्र 4.16 मिलियन हेक्टेयर (कुल खेती की जाने वाले क्षेत्र का 90% से अधिक) का अनुमान लगाया गया। एक्वाक्रॉप मॉडल को पहले के उपलब्ध उपज डेटा के साथ सत्यापित किया गया। पंजाब कृषि विश्वविद्यालय, लुधियाना के अनुसंधान क्षेत्र में प्रयोग से प्रतिरोपित धान (TP) की अधिकतम अनाज पैदावार (5.90 टन/हेक्टेयर) दर्ज की गई जो कि सांख्यिकीय रूप से श्री पद्धति (5.58 टन/हेक्टेयर) से प्राप्त उपज के बराबर थी, लेकिन सीधे धान बुआई विधि (5.37 टन/हेक्टेयर) से प्राप्त उपज से काफी अधिक थी। सीधे धान बुआई विधि में सिंचाई पानी कम लगा जिससे जल उत्पादकता (5.56 किलोग्राम/हेक्टेयर-मिमी) अधिकतम प्राप्त हुई। पानी की अधिकतम उत्पादकता किस्म पी आर- 122 से प्राप्त हुई जबकि किस्म पूसा-44 में उच्चतम अनाज पैदावार प्राप्त हुई।

- प्रयोगशाला में मूल्यांकन के बाद मोटे एवं महीन सामग्री के साथ छोटे पैमाने पर एक ऑन लाइन फिल्टर तैयार किया गया। इस ऑन लाइन फिल्टर के हाइड्रोलिक व्यवहार एवं निस्पंदन दक्षता का मूल्यांकन भी किया गया। एक एच पी पंप का उपयोग करके प्रति सेकंड 0.5 लीटर का अधिकतम डिस्चार्ज 50% प्रवाह क्षमता के अनुसार हासिल किया गया। यह निर्मित फिल्टर गंदे पानी से तलछट सामग्री एवं भारी हानिकारक धातु को कम करने में प्रभावी पाया गया।

- स्थलीय जल भंडारण (TWS) एवं भूमिगत जल भंडारण (GWS) का ग्रेविटी रिकवरी और जलवायु एक्सपरिमेंट (GRACE) की सहायता से अनुमान लगाया गया जिसको जल तुल्य गहराई के रूप में मापा गया। इसको भारत में हाल ही में वर्ष 2003 से 2013 के दौरान अनियमित मॉनसून वर्षा के कारण पानी के भंडारण में परिवर्तन को समझने के लिये इस्तेमाल किया गया। इसी तरह अन्य हाइड्रोक्लाइमेटिक एवं पारिस्थितिक कारकों जैसे CLM4.5 मॉडल की मिट्टी में नमी की विसंगतियाँ, पामर सूखा गंभीरता सूचकांक (PDSI), न्यूनतम तथा अधिकतम तापमान विसंगतियाँ (^{0}C), सामान्यीकृत भिन्न वनस्पति सूचकांक (NDVI) आदि को इनके संबंधों का मूल्यांकन करने के लिये इस्तेमाल किया गया।

- सतह एवं भूमिगत जल के संयोजी उपयोग के लिये एक डीसीजन सपोर्ट सिस्टम को विकसित करने के लिये एक मॉडल को दो भागों (कंप्यूटर प्रोग्राम एवं विशेष रेखिक प्रोग्राम) में विकसित किया गया। सिंचाई पानी की उपलब्धता के आधार पर उपयुक्त फसल योजना तथा फसल कैलेंडर भी विकसित किया गया।

- छोटे किसानों जिनका जल संसाधन उनके खेत से दूर स्थित है के लिये ग्रेविटी फेड ड्रिप पद्धति का डिजाइन विकसित किया गया। प्रारंभिक डिजाइन में बेयरिंग एवं अन्य कलपुर्जों को जोड़कर संशोधित किया गया है। इस पद्धति का प्रति घंटे 4 लीटर जल निष्पादन क्षमता के साथ संतरा के बगीचे को सिंचित करके मूल्यांकन किया गया तथा इस आधार पर इस पद्धति को लाभदायक पाया गया।

जलाक्रांत क्षेत्र प्रबंधन

- जलाक्रांत पारिस्थितिकी तंत्र में विभिन्न पोषक तत्वों का उपयोग करके धान की फसल का मूल्यांकन किया गया। जलमग्नता के मध्यवर्ती स्तर (25-50 सेमी) (3.38 टन/ हेक्टेयर) की तुलना में धान की अधिक उपज (3.68 टन/हेक्टेयर) उथले जल स्तर (10-25 सेमी) के तहत प्राप्त हुई। नाइट्रोजन उर्वरक का (60 किलोग्राम/हेक्टेयर) का छिड़काव (3.42 टन/हेक्टेयर) करने की तुलना में उसे भूमि की पट्टी में प्रयोग करने से अनाज पैदावार (3.64 टन/हेक्टेयर) में बढ़ोतरी पायी गयी। नाइट्रोजन उर्वरक का 60 किलोग्राम/हेक्टेयर की दर से डाइसाइनेमाइड (DCD) एवं पत्ता लेपित यूरिया के माध्यम से प्रयोग करने से क्रमशः अधिक उपज

3.9 एवं 3.83 टन प्रति हैक्टेयर प्राप्त होती है। और साथ ही अधिक एग्रोनोमिक नाइट्रोजन उपयोग क्षमता (ANUE) क्रमश: 23.5 एवं 22.3 किलो अनाज/हेक्टेयर किलोग्राम प्रयोग किया गया नाइट्रोजन भी प्राप्त हुई।

- एक अध्ययन से पता चला कि हानिकारक तत्व केडमियम की सांद्रता पौधे के विभिन्न भागों जैसे पत्ते तना, जड़ एवं फल में एक घटते हुये क्रम में पायी गयी। केडमियम का मिट्टी से पौधे में हस्तांतरण कारक केडमियम की उच्च सांद्रता के साथ कम पाया गया। केडमियम की उच्च सांद्रता के साथ प्रकाश संश्लेषण की दर में कमी हुयी। मिट्टी में अधिक पी एच के साथ मिट्टी में केडमियम की कमी के कारण भिंडी एवं चौलाई की फसलों में केडमियम की मात्रा का बहुत कम संचय हुआ। अपशिष्ट जल सिंचित किसान के क्षेत्र में, धान-सब्जी फसल पद्धति में धान-धान पद्धति की तुलना में हानिकारक भारी धातुओं का बहुत कम संचय पाया गया।

- जलाक्रांत क्षेत्रों में उपयुक्त फसलों की खेती एवं मछली पालन की गुंजाइश की पहचान करने के लिये लिस- तृतीय डेटा (1: 50,000 पैमाने पर 2005-2006) माध्यम की मदद से पश्चिम बंगाल के जलाक्रांत क्षेत्रों का जिलेवार चित्रण करके क्षेत्रों का मूल्यांकन किया गया। इन क्षेत्रों में जल निकाय एवं जलाक्रांत क्षेत्रों की चार प्रमुख श्रेणियों का, प्रचलित फसल पद्धतियों की भू-संदर्भित के साथ एआरसी जीआईएस सॉफ्टवेयर के साथ आगे के विश्लेषण के लिये चयन किया गया। विभिन्न जलीय पौधे जैसे सिंघाड़ा एवं कमल मछली पालन के साथ तथा हाइड्रोफाइटस जैसे टाइफा, शोला, शीतलपट्टी तथा कोर्स मैट आदि की इन चित्रित क्षेत्रों में उगाने के लिये उचित फसलों के रूप में उनकी अनुकूलनशीलता, मूल्य संवर्धन एवं विभिन्न जिलों में बाजार की मांग के आधार पर पहचान की गई।

- धान, गेहूं एवं मक्का के लिये जिले के हाइपोथेटिकल मौसम स्टेशनों एवं स्थानों के नामों की पहचान की गई। सभी जलवायु बफर क्षेत्रों के लिये उससे संबंधित जिला एवं उसके आस पास के जिलों की 100 किलोमीटर परिधि में पिछले 10 वर्षों में मुख्य फसलों की औसत उपज के आधार पर वास्तविक फसल उपज का अनुमान लगाया गया। प्रारंभिक आंकड़ों की प्रवृत्ति ने बताया कि धान की उपज में अंतर तेलंगाना के रंगारेड्डी जलवायु बफर क्षेत्र में 4.01 टन/हेक्टेयर से लेकर बिहार के गोपालगंज जलवायु बफर क्षेत्र में 5.94 टन/हेक्टेयर के बीच रहा। इसी तरह, गेहूं की फसल की उपज में अंतर पंजाब के पटियाला जलवायु बफर क्षेत्र में 2.51 टन/हेक्टेयर से बिहार के भागलपुर जलवायु बफर क्षेत्र में 4.51 टन/हेक्टेयर के बीच रहा।

- अखिल भारतीय समन्वित अनुसंधान परियोजना के सभी केन्द्रों द्वारा उत्पन्न कृषि जल प्रबंधन पर सफलता की कहानियों के प्रदर्शन के लिये एक वेब आधारित सूचना प्रणाली मॉड्यूल विकसित किया गया। उपयोगकर्ताओं द्वारा सूचना के अन्वेषण के लिये कृषि-पारिस्थितिकी क्षेत्र, फसल एवं तकनीक के लिहाज से वेबपेजों को तैयार किया गया। कृषि जल प्रबंधन पर संस्थान में विकसित तकनीकों को भी वेब पोर्टल में अपलोड किया गया। वेब पोर्टल में एक सुरक्षित पासवर्ड डेटा प्रबंधन मॉड्यूल नोडल अधिकारी /पीसी इकाई के उपयोग हेतु अनुसंधान उपलब्धियों, अलग-अलग केन्द्रों का व्यय लेखा-जोखा एवं ऑडिट यूटिलाइजेसन प्रमाण-पत्र अपलोड करने के लिये तथा एआईसीआरपी केंद्र के प्रमुख वैज्ञानिकों के प्रयोग के लिए बनाया गया।

कृषि अनुसंधान एवं तकनीकी प्रसार

- ओडिशा के चार चयनित गांवों से विभिन्न पैमाने पर नियमित रूप से उच्च आवर्ती डेटा- आर्थिक, सामाजिक और संस्थागत विकास की गतिशीलता एवं परिमाण को समझने के लिए एकत्र किये गये।

- ओडिशा के सुंदरगढ़ जिले के झिजबरना गांव में घुर्लिजोर लघु सिंचाई परियोजना के अंतर्गत जनजातीय उप-योजना के माध्यम से जल संचयन करने वाली नहर संरचना में सिंचाई जल संसाधन विकसित किये गये। इस परियोजना में जल निकासी गुणांक (136 मिमी/दिन) का उपयोग कर 5 साल की अवधि में जल संसाधनों की अनुपलब्धता की समस्याओं के समाधान के लिये प्रयास किया गया। इनलेट एवं आउटलेट डिवाइस में जल प्रवाह को नियमित करने के लिये नहर के हाइड्रोलिक्स गुणों का मूल्यांकन भी किया गया। इन उपायों द्वारा तथा नव विकसित जल संसाधनों ने लाभकारी फसलों की खेती के माध्यम से पचास (50) आदिवासी किसान परिवारों के बीच खेती करने के लिये आत्मविश्वास जगाया है।

EXECUTIVE SUMMARY

RAINWATER MANAGEMENT

- The 20th century trends and variability of the mean and extreme matrices of monsoon rainfall of Odisha revealed phase changes in some of the indices defined Expert Team on Climate Change Detection Monitoring and Indices (ETCCDMI). In particular, moderate category rain events decreased significantly since the 1960s, driven mainly by declines in wet days. Consecutive wet days (CWD) also consistently decreased, while consecutive dry days (CDD) showed rising trend.

- The calibration and validation of the AquaCrop model was done on aerobic rice. The calibrated AquaCrop model was used for estimation of loss in paddy yield due to dry spells. The loss in paddy yield due to dry spells assessed through calibrated AquaCrop model was found between 8 to 16%. A water balance simulation model was developed for on-farm reservoir in a rice fields. The size of the OFR was found between 5% to 21% of the farm for pond with lining and 8% to 49% of the farm for pond without lining.

- Base structure of rubber dam along with anchoring, inlet and outlet was installed at 22 different locations in different agro-ecological and geo-hydrological regions of the country. The benefits of rubber dams for soil and water conservation, drought proofing, flood control and enhancement in agricultural production etc. were analyzed and documented. Rubber dam helped in increasing crop production, cropping intensity and rural livelihood options of farmers in command area. The technology was commercialized and a memorandum of understanding was signed between ICAR and industry for production and supply of rubber composites required for rubber dam installations in India.

- Response of mango trees to regulated deficit irrigation (RDI) and partial root zone drying (PRD) under drip irrigation was studied. The treatments imposed were full irrigation, 80% RDI, 60% RDI, 40% RDI, 80% PRD, 60% PRD, 40% PRD and rainfed (control). The hydraulic performance of the drip system showed 11% emitter flow variation, (coefficient of variation 10%) and 90% distribution uniformity. Increase in vegetative growth parameters like plant height, collar diameter and canopy volume were highest under full irrigation treatment. Maximum fruit yield was obtained under 80% PRD treatment and best fruit quality and water use efficiency was obtained under 60% PRD treatment.

- Rice-maize cropping system was evaluated under conservation agricultural set up with no-till (NT), minimum tillage (MT) and conventional tillage with 100 % inorganic fertilizers, 50% inorganic + 50% FYM and 50% inorganic + 50% green leaf manure. Tillage treatments did not change bulk density and pH significantly. Similarly, various nutrient management options also had no significant effect on these two soil characteristics. Available N and P status of the soil after harvest of the crop was significantly improved under NT compared to MT, CT_1 and CT_2. K status of soil was at par in both NT and MT. 50%NPK+50% N through FYM proved significantly superior over 100% NPK and found at par with 50 %NPK+ 50 % N through green leaf manuring.

- In carp polyculture, under different stocking density, treatment-wise estimated total water use (TWU) was 3.81, 4.02 and 4.44 ha-m, while the computed consumptive water use index, CWUI (m^3 kg^{-1} biomass) was 6.48, 5,71 and 5.99, in T_1 (6000 fingerlings ha^{-1}), T_2 (8000 fingerlings ha^{-1}) and T_3 (10000 fingerlings ha^{-1}), respectively. Similarly, under different stocking density, treatment-wise estimated TWU was 3.08, 3.34 and 3.69 ha-m, while the computed CWUI was 5.22, 4.82 and 5.06 in T_1 [150000 post larvae (PL) ha^{-1}], T_2 (200000 PL ha^{-1}) and T_3 (250000 PL ha^{-1}), respectively in monoculture of *P. monodon*. Keeping the higher yield, economic benefit and NCWP in view, the desirable density was 8000 fingerlings ha^{-1} and 200000 PL ha^{-1} in case of carp polyculture and *P. monodon* monoculture respectively.

- A runoff recycling model was developed for enhancing crop production and profit through alternate land and crop management practices. During *kharif*, rice (var. Swarna) yielded 3.84 t ha^{-1}. Green fodder yield of 24 t ha^{-1} was obtained from cowpea grown on the side slope of the modified land system. During *rabi*, seed yield of 1.08 t ha^{-1} was obtained from mustard (var. NRCBH-101), head yield of 11 t ha^{-1} from Brocolli (var. CHB-1), 1.04 t ha^{-1} yield from black gram (var. Prasad) and 0.9 t ha^{-1} yield from green gram (var. Durga) using harvested water.

- A farm pond was renovated for harvesting rainwater and a surplus structure was constructed inside the pond at the down slope to allow excess run-off. An inlet was constructed using locally available lateritic stone to collect run-off from the upper reach of the farming system area to minimize sedimentation of the pond. On embankment of the pond, culinary banana and papaya was planted. *Gliricidia sp.* was planted along the boundary of the farming system area for harvesting nitrogen rich biomass and also for the production of vermi-compost. *Sesbania* was sown in the field @ 20 kg ha^{-1} for use as *in-situ* green manure for rice crop in *kharif* season.

CANAL WATER MANAGEMENT

- Impact of climate change on crop evapo-transpiration, water footprints of some winter season crops were analysed. Gross primary productivity, ecosystem respiration, net ecosystem exchange (NEE) over multiple cropping systems [okra (April-June)-rice (July-November)-tomato (December-March)] were studied. Study revealed that the seasonal NEE at the end of growing period was -248,-315 and -173 g C m^{-2} for okra, rice and tomato, respectively. Water productivity up to Rs. 14 m^{-3} enhanced through multiple use of water and drip fertigation based vegetable farming system.

- Participatory management of water resources and integrated crop and fish culture systems were developed in different head, mid and tail reaches of a medium irrigation command in Odisha. Integrated farming systems involved short duration fish culture, on-dyke horticultural crops (papaya, banana, dry/ winter season vegetables). The alternate cropping systems were rice + (fish in pond)-sweet corn, rice + (fish in pond)-sunflower, rice + (fish in pond)-greengram/ blackgram, rice + (fish in pond) + pigeonpea (on dyke)-greengram, and rice + (fish in pond)-vegetables compared to rice-fallow. The economic benefit ranged from Rs 1,57,224 to Rs 1,99,776 per ha of pond-based interventions.

- Throughout all the water management treatments during post-vegetative stage, significantly higher grain per unit quantity of water applied (6.3 kg ha-mm^{-1}) was obtained under SRI as compared to conventional transplanting system (CTS, 3.3 kg ha-mm^{-1}). Under CTS, the highest water productivity was obtained with the 1-day after disappearance (DAD) of ponded water treatment (3.5 kg ha-mm^{-1}), while under SRI, it was achieved in the 3-DAD treatment plots (6.6 kg ha-mm^{-1}).

- Effects of deficit irrigation under drip system with two lateral layouts (1.4 m and 1.0 m) in baby corn, rice and capsicum were evaluated. The yield of baby corn was maximum (2.06 t ha^{-1}) with full irrigation (FI, 100% ET_c) at par with the yield (1.94 t ha^{-1}) under irrigation at 75% ET_c. However, irrigation at 50% ET_c reduced yield by 33% and improved irrigation water productivity by 32% in comparison to FI. In both irrigated (aerobic rice) and rain-fed rice, the yield under drip irrigation at 100% ET_c yield reduced by 8-12% with 30-35% saving of irrigation water. This resulted in 40-50% improvement in water productivity compared to surface irrigation method. In all the crops, the lower lateral to lateral distance (1.0 m) produced higher yields.

GROUNDWATER MANAGEMENT

- Creek hydraulics was studied for water availability in different season of the year at Sunity creek for crop planning in Mahakalapada block of Kendrapara district. In November, 2014, water velocity varied between 0.28 to 0.43 m s^{-1} while it was between 0.17 to 0.41 m s^{-1} in January, 2015. Water quality analysis revealed a sharp increase of EC and SAR from post-monsoon (October) to summer (March) to pre-monsoon (June) period. The EC of creek water increased from 1.4 to 151 times and SAR from 1.02 to 32.62 times. A sluice structure was designed (discharge: 25 m^3 s^{-1}, catchment area: 2000 ha) in collaboration with Department of Water Resources, GoO in the mouth of Sunity creek to control drainage and check saline water intrusion into the creek.

- Application of wastewater from COS Board paper mill in four different soil types followed by washing with water substantially decreased EC from 15.38 to 166% without persistent impact on soil. The wastewater has been found as a supplementary source of irrigation for acidic to neutral, non-saline soils in humid to sub-humid regions. Water quality appraisal at the surrounding of paper mill in Jagatpur, and breweries in Khurda indicated that dissolution of rock minerals is the governing process for determining water chemistry in 70 to 85% samples, while base exchange contributes to water quality in 53 to 83% samples in and around the distillery unit at Haripur and Pandua area in Dhenkanal. Comparison of water quality with standard water quality criteria revealed that all the samples are found suitable for use in irrigation and drinking as well, and no influence of respective industrial units on surrounding water sources was obtained.

- Rice-wheat coverage area was delineated for Punjab using the integration of remote sensing and GIS tools. Trend analysis on rice and wheat coverage areas from 1995 to 2011 showed no noticeable variation. The area under rice-wheat crop sequence were 2.053 million ha (49.06 % of state's total cultivated area). Similarly, combined rice-wheat cultivated areas were estimated at 4.16 million ha (more than 90% of cultivated areas). The AquaCrop model was validated with yield data reported in earlier literature. Field experiment at PAU Research farm, Ludhiana showed that maximum rice grain yield was recorded from transplanted paddy (TP) (5.90 t ha^{-1}) which was statistically at par with SRI (5.58 t ha^{-1}) but significantly higher than DSR (5.37 t ha^{-1}), which received least irrigation water and gave highest water productivity (5.56 kg ha-mm^{-1}). Even though, water productivity was maximum and significantly higher in PR 122 than Pusa 1121 and Pusa 44, the later gave highest grain yield.

- A small scale on-line filter was designed with the identified coarser and finer materials after laboratory evaluation. The hydraulic behaviour and filtration efficiency of the filter was evaluated. Maximum discharge of 0.5 litre per second was achieved using 1 HP pump with 50 per cent flow efficiency. The designed filter was found effective in reducing the sediment content and heavy metal from the wastewater significantly.
- The terrestrial water storage (TWS) and groundwater storage (GWS) estimated from the gravity solutions of the Gravity Recovery and Climate Experiment (GRACE), represented by water equivalent thickness (cm), were used to understand the water storage changes due to recent erratic monsoon rainfall during 2003 to 2013 in India. A suit of other hydroclimatic and ecological variables, like soil moisture (SM) anomalies (cm) of CLM4.5 model, palmer drought severity index (PDSI), minimum (T_{min}) and maximum (T_{max}) temperature anomalies (^{0}C), normalized difference vegetation index (NDVI) were used to evaluate their correspondence.
- To develop a decision support system for conjunctive use of surface and ground water, a model was developed in two parts: a computer program and standard linear program. A crop calendar was developed with suitable crop plan based on availability of water.
- A design of gravity fed drip system for sub-marginal farmers having water resource away from their field was developed. The initial design was further modified by adding bearings, changing the design of handle to push the system with addition of one air vent. This system was evaluated in irrigating an orange orchard and discharge with 4 liter per hour was found satisfactory.

WATERLOGGED AREA MANAGEMENT

- Performance of rice under different nutrient treatments in waterlogged ecosystem was evaluated. Superior grain yield (3.68 t ha^{-1}) of rice was obtained under shallow submergence (10-25 cm) compared to intermediate level of submergence (25-50 cm) (3.38 t ha^{-1}). Band placement of N @ 60 kg ha^{-1} was found significantly superior in terms of grain yield (3.64 t ha^{-1}) compared to broadcasting of nitrogen fertilizer (3.42 t ha^{-1}). Nitrogen @ 60 kg ha^{-1} applied through Dicyandiamide (DCD) and N application through urea coated with leaf extract have resulted in greater grain yield of rice (3.9 and 3.83 t ha^{-1} respectively) and greater agronomic nitrogen use efficiency (ANUE) of 23.5 kg grain kg^{-1} N applied and 22.3 kg grain kg^{-1} N applied, respectively compared to other nutrient treatments.
- In a field study, the concentration of Cd in plant parts was observed in the decreasing order of leaf followed by shoot/stem, root and fruits. The transfer factor of Cd from soil to plant decreased with higher concentration of Cd. The decrease in net photosynthetic rates with higher doses of Cd was observed. Reduced uptake/ accumulation of Cd in okra and amaranth was observed with increasing soil pH due to reduction in availability of Cd in soil. In wastewater irrigated farmer's field, paddy-vegetable system showed slower accumulation of heavy metals than paddy-paddy system.
- The district-wise delineation of waterlogged areas in West Bengal was carried out through assessment of waterlogged areas with the help of LISS III data (1:50,000 scale; 2005-2006), for identifying scope for cultivation of suitable crops and aquaculture in waterlogged areas. Four major categories of water bodies and waterlogged areas were considered for further analysis with ARC GIS software along with geo-referencing of prevalent cropping practices. Different aquatic and wetland crops like water chestnut (*Trapa bispinosa*), lotus (*Nelumbium speciosum*) with aquaculture, emergent hydrophytes like cat tail (*Typha elephantina*, *T. domingensis*), shola (*Aschynomene aspera), shitalpati (Clinogyne dichotoma)* and coarse mat *(Cyperus tegetum)* growing areas were identified as suitable crops in delineated areas based on their adaptability, scope for value addition and market demand in different districts.
- The names of location and district of hypothetical weather stations for rice, wheat and maize were identified. Actual crop yields based on the mean yield of previous 10 years were estimated for all the climatic buffer zones taking the respective district and surrounding district's weighted mean of major crops within 100 km radius. The initial trend revealed that the yield gap in rice crop ranged between 4.01 t ha^{-1} in Rangareddy climatic buffer zone of Telangana to 5.94 t ha^{-1} in Gopalganj climatic buffer zone of Bihar. Similarly, the yield gap of wheat crop ranged between 2.51 t ha^{-1} in Patiala climatic buffer zone of Punjab to 4.51 t ha^{-1} in Bhagalpur climatic buffer zone of Bihar.
- A web based information system module was developed for showcasing success stories on agriculture water management generated by coordinating centres of All India Coordinate Research Project (AICRP) on Water Management. Webpages on agro-ecological region-wise, crop-wise, technology-wise were also prepared for quick exploration of the information by the end users. Technologies developed at the Institute on agricultural water management were also uploaded into the web portal. A password secured data management module in the web portal was created for use of chief scientists of AICRP Centers for uploading research achievements,

expenditure of individual centers, audit utilization certificates etc. into the web portal for the access of Nodal Officer or PC Unit.

ON-FARM RESEARCH AND TECHNOLOGY DISSEMINATION

- Regular high frequecy data were collected to understand the dynamics of economic, social and institutional development at different scales and magnitudes from four selected villages of Odisha.
- Irrigation infrastructures were developed in one of the canal linkage water harvesting structure in Birjaberna village in Ghurlijore Minor Irrigation Project in Sundargarh district of Odisha through Tribal Sub Plan (TSP) project using drainage coefficient of 136 mm day^{-1} at 5-years return period for addressing the problems of non-availability of water resources. The canal hydraulics of the inlet device and the flow regulating pattern in the outlet device were monitored. These interventions developed confidence among fifty tribal farm families through cultivation of remunerative crops with newly developed water resources.

Introduction

The ICAR-Indian Institute of Water Management (erstwhile Directorate of Water Management or Water Technology Centre for Eastern Region) was established on 12th May, 1988 with the aim to cater the research and development need of agricultural water management at national level. The institute is located at Chandrasekharpur, Bhubaneswar on a 5.71 ha of land along with its main office-cum-laboratory building, guest house and residential complex. It is situated about 8 km north of Bhubaneswar railway station and at about 15 km away from Biju Patnaik International Airport, Bhubaneswar. The location of the Institute is at 20°15' N and 85° 52' E at 23 m mean sea level. The research farm of the Institute (63.71 ha of farm land) is located at Deras, Mendhasal (20°30' N and 87°48' E) and is 30 km away from main institute complex.

Mandate

- To undertake basic and applied research for developing strategies for efficient management of on-farm water resources to enhance agricultural productivity on sustainable basis.
- To provide leadership role and coordinate network of research with the State Agricultural Universities in generating location-specific technologies for efficient use of water resources.
- To act as a center for training in research methodologies and technology update in the area of agricultural water management.
- To collaborate with relevant national and international agencies in achieving the above objectives.

Research Achievements

Core research activities of the institute are carried out under five programmes *viz*, rainwater management, canal water management, groundwater management, waterlogged area management and on-farm research and technology dissemination to solve the agricultural water management related problems. The institute has experienced multi-disciplinary team of scientists. In addition to research and development efforts at Institute level, the various agricultural water management related issues at the national level are being addressed by the different centers under the AICRPs on Water Management and Ground Water Utilization. During this year upscaling research achievements to industry level, commercialization of ICAR flexi-check dam technology has been done through signing of MoU between ICAR and industry for production and supply of rubber composites required for rubber dam installations in the watersheds. Resource conservation technologies like, rice-maize cropping system, water management for System of Rice Intensification (SRI) were standardized. Performance assessment of deficit irrigation under drip irrigated system for rice-based cropping sequence in canal irrigated areas, water budgeting in high-value shrimp monoculture and carp poly culture has been done for increasing water productivity. The assessment of effects of extreme climate events on major cropping systems (of Odisha), on ground water resources, and on crop evapo-transpiration, water footprints (of some winter season crops) are few steps forward to understand impact of climate on agricultural water management. This would enable us to develop climate smart agricultural water management practices. Research-led development of irrigation infrastructures to address the problem of water scarcity in tribal areas; comprehensive water resource management technologies in non-exploration zone in coastal areas; design and development of on-line filter to utilize urban waste water for peri-urban agriculture; identification of suitable crops in waste water irrigated areas; delineation of waterlogged areas for alternate crops and aquaculture, increasing fertilizer use efficiency in waterlogged areas and development of a web based portal showcasing technological options on agriculture water management for various stake holders, etc. are major research activities and achievements during this year. The achievement of the Institute for excellence in science and technology for agricultural water management has been recognized at national and international levels and commensurate with up gradation of the status of the Institute to the level of national Institute as ICAR-Indian Institute of Water Management recognizing its contribution in the field of research and development for Agricultural Water Management.

Infrastructure facilities and Organization

The institute has state-of-the-art infrastructure facilities and has four well-equipped laboratories, *viz*, soil-water-plant relationship laboratory, irrigation and drainage laboratory, hydraulic laboratory, and plant science laboratory with all the analytical equipments for research activities. An engineering workshop also cater to the needs of the institute. The field laboratories at farm *viz*, meteorological laboratory, pressurized irrigation system and agricultural drainage system also add to the research related inputs. The institute has a state of the art communication facility with an automatic EPABX system and LAN. The institute has its own web server and regularly updated website (www.dwm.res.in). The entire network administration of the computers, internet and website management is looked after by the Agricultural Knowledge Management Unit (AKMU). The AKMU also accommodates a fully developed

GIS laboratory. The air-conditioned library of the Institute has more than 2000 reference books and subscribes to 14 international and 6 national journals. It has a CD-ROM Server with bibliographic, database from AGRIS, AGRICOLA and Water Resources Abstracts. The subscription of electronic journals and its access through LAN to all the scientists is another useful facility of the library. The installed video conferencing and IP Telephony System facility at the Institute as part of the project ICAR net is being utilized for related use from time to time.

The ICAR-IIWM has linkages with various agencies providing training, consultancy, collaboration or contract research services. It has provided a platform for public and private sector institutions dealing with water management research to address their scientific problems, monitor research and development activities and their evaluation in a cost effective manner. The institute has developed linkages with different state and central government agencies like Watershed Mission (Government of Odisha), Directorate of Agriculture (Government of Odisha), Central and State Ground Water Board, Command Area Development Agency, Government of Odisha, WALMI, ORSAC to implement farmer friendly water management technologies in the region. The institute has conducted several ICAR entrance examinations like JRF, SRF at national level. In addition to ongoing in-house research projects, the institute is awarded with many sponsored projects by various organizations like Ministry of Water Resources, GOI, Department of Science and Technology, GOI, IIT Kharagpur, NCAP, IRMARA and ISRO. International linkages have been established through collaborative project of ICAR with University of Nebraska, Lincoln, USA, University of Melbourne, ICRISAT, IWMI, and Bill and Melinda Gates Foundation.

Finances

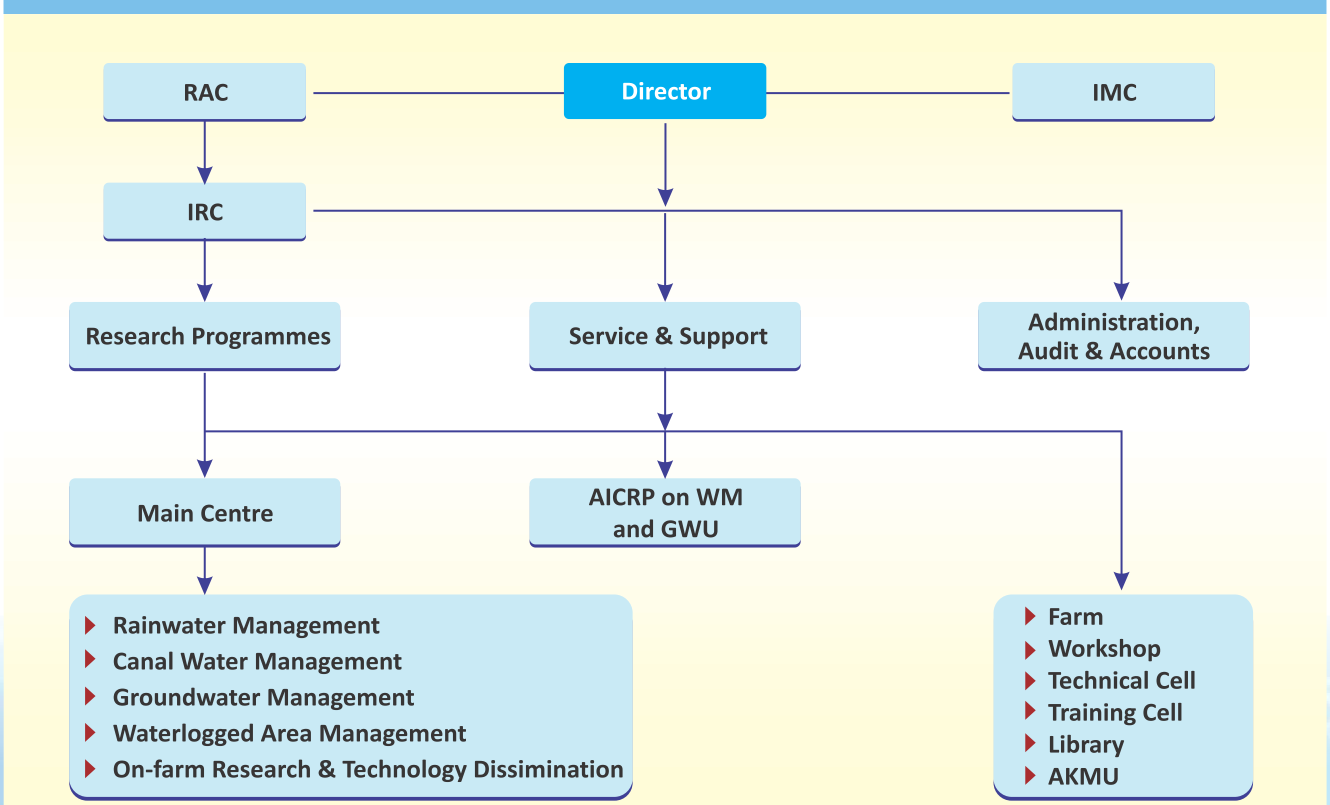
Summary of fund allocation, and expenditure during the year 2014-15 under plan and non-plan budget of the institute is presented at the end of this report(chapter 15).

Staff

At the end of March 2015, ICAR-IIWM had 80 sanctioned posts (including AICRP) out of which 56 are in position. The breakup of the posts under different categories is given below:

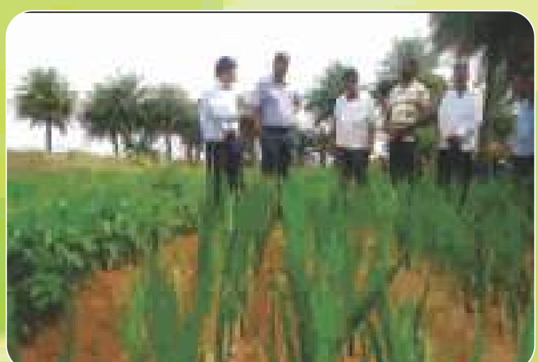
Cadre	Sanctioned	In Position	Vacant
RMP	01	01	nil
Scientific	35	25	10
Administrative	16	11	05
Technical	17	13	04
Supporting	11	06	05
Total	80	56	24

ORGANOGRAM



RESEARCH ACHIEVEMENTS





Rainwater Management

- Extreme Climatic Effects on Major Cropping Systems of Odisha
- Effect of Dry Spell Occurrence on Loss in Paddy Yield and Design of Water Harvesting Structures for its Mitigation
- Design and Development of Rubber Dams for Watersheds
- Performance Evaluation of Drip Irrigated Mango Under Deficit Irrigation
- Conservation Agricultural Practices in Rice Based Cropping System for Increasing Water and Nutrient Availability in a Rainfed Agro-ecosystem for Eastern India
- Water Budgeting in High-value Shrimp Monoculture and Carp Poly culture under Varying Intensification Levels
- Development of a Runoff Recycling Model for Production and Profit Enhancement through Alternate Land and Crop Management Practices
- Water and Nutrient Self-reliant Farming System for Rainfed Areas under High Rainfall Zone

Project Title : **Extreme Climatic Effects on Major Cropping Systems of Odisha**
Project Code : DWM/12/154
Funding Agency : Institute
Project Personnel: D. K. Panda, K.G. Mandal, A. Mishra, A. K. Thakur, R. C. Srivastava and A. Kumar

Odisha has experienced a decrease of about 9 mm monsoon rainfall (PRCPTOT) per decade during 1901-2004, though the first four decades (1901-1940) was characterized by a significant ($p < 0.05$) enhancement of 42 mm per decade (Fig. 1). The trend analysis suggest that the wet days (i.e. daily rainfall >2.5 mm) with a rising trend of 1.4 ($p < 0.05$) days per decade during 1901-1940 reversed the pattern since 1961 and dropped significantly at 2.3 days per decade thereafter. Specifically, it is the significant decrease of the moderate rainfall days (i.e. daily rainfall between 7.6 to 35.4 mm) at the rate of 1.3 days per decade during 1961-2004 (Fig. 2) that resulted in a significant negative trend in the century-long time series with consequent decreases in rainfall. Furthermore, the spell-based indices, such as CWD and CDD, which are important for meeting the agricultural water requirement and also sustain the hydrology, showed significant decrease and non-significant increase, indicating the rising moisture stress scenario since 1960. The aridity intensity index (AII), also showed significant decreasing trend.

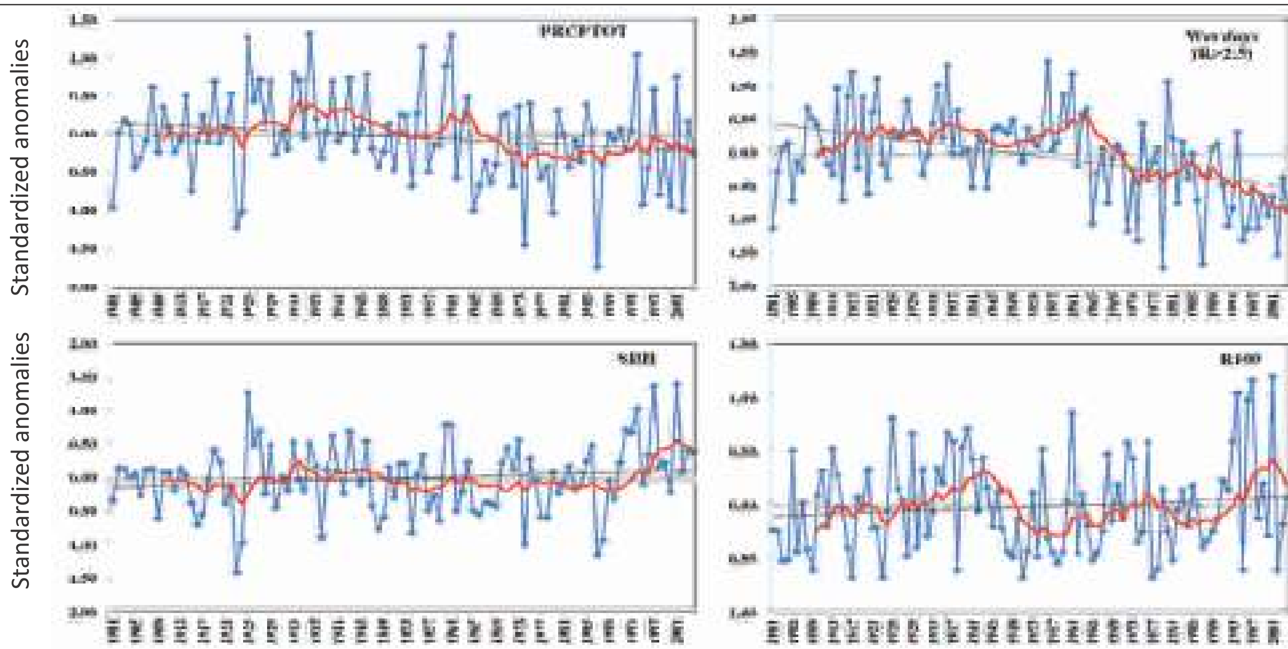


Fig. 1 Standardized anomalies of PRCPTOT, wet days, SDII and R100 during 1901-2004, along with the embedded linear regression line and 10-year moving means.

Analyses of the changes in the extreme matrices of rainfall, suggested that significant rise in heavy rain events of more than 100 mm (R100) before 1940, coincident with a similar pattern in the frequency of the depression over the Bay of Bengal, has contributed to the overall rise of the pre-1940 period. However, although the frequency of depressions have decreased significantly since 1960, the R100 has not decreased, rather increased non-significantly. Similarly, the simple daily intensity index (SDII), exhibited increase in later decades of the 20th century. Degree of correspondence indicates that the moderate rainfall events are significantly correlated with wet days (r = 0.89), AII (r = 0.86), CWD (r = 0.63), PRCPTOT (r = 0.54) and CDD (r = 0.48).

In order to understand the linkages with the large-scale global phenomenon, some of the indices were plotted with the 5-year moving mean of NINO3.4 index (Fig. 3), which was derived from the sea surface temperature (SST) anomalies averaged over the Niño 3.4 region (5^{0}N – 5^{0}S, 120^{0}W-170^{0}E). Since the 1970s, with the onset of global warming, the NINO3.4 index has increased significantly at the rate of 0.26 ^{0}C, which has switched from negative to positive anomalies since the 1990s. Consistently, most of the drought tendencies, as evident from the decreases in moderate rainfall events, wet days, CWD and AII, exhibit steady increased consistently.

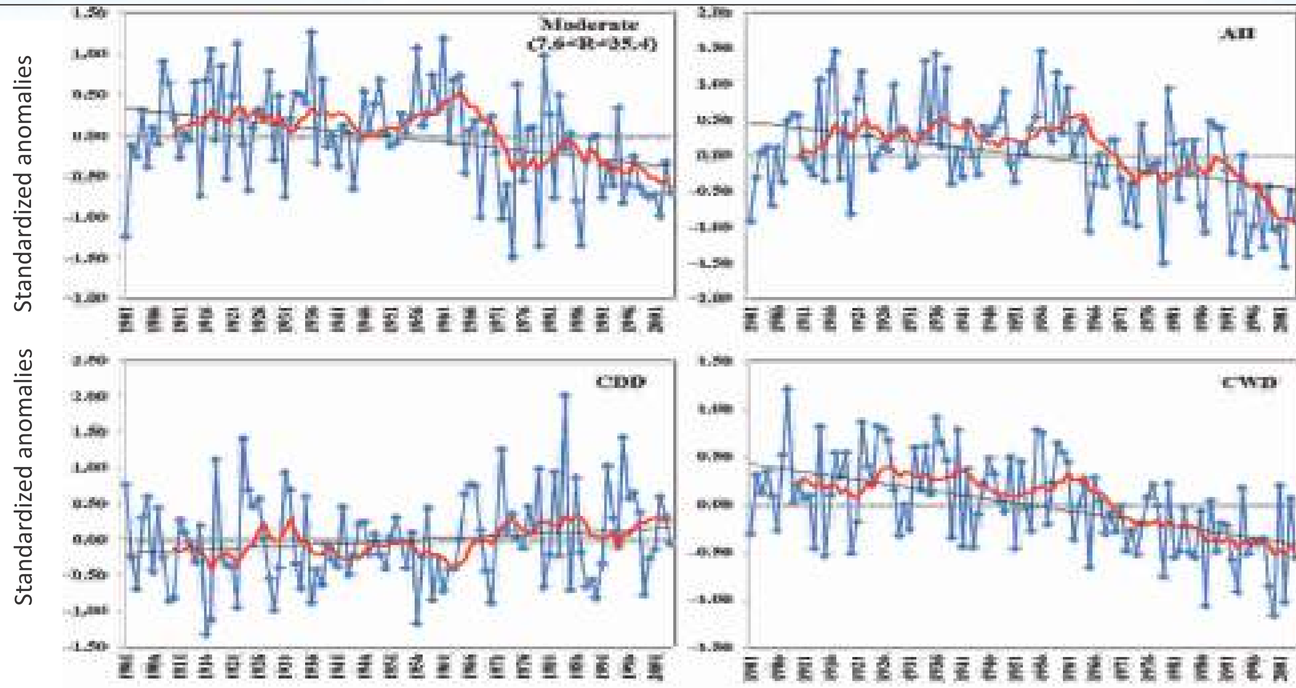


Fig. 2 Standardized anomalies of PRCPTOT, AII, CDD and CWD during 1901-2004, along with the embedded linear regression line and 10-year moving means

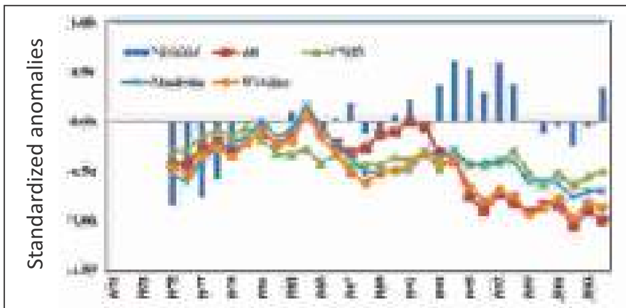


Fig. 3 Correspondence of the 5-year moving mean of NINO3. 4 index with moderate rainfall events, wet days, CWD and AII during 1971-2004.

Project Title	:	**Effect of Dry Spell Occurrence on Loss in Paddy Yield and Design of Water Harvesting Structures for its Mitigation**
Project Code	:	DWM/11/153
Funding Agency	:	Institute
Project Personnel	:	S. Mohanty, D. K. Panda, A. Mishra, D.U. Patil and B.C. Sahoo

The crop growth modeling was done using the FAO AquaCrop model. The data generated from a field experiment at Chiplima under AICRP on Water Management, on irrigation and nitrogen (N) management in aerobic rice, were used for calibration of the model. The experiments were conducted during the *rabi* season of 2013 and 2014. The various treatments of the experiment were irrigation at 5, 7 and 9 days interval, superimposed with different dose of N application. During the calibration of the model using the data of 2013, the model parameters were adjusted for matching the simulated and observed plant biomass and yield of rice; then the model was validated using data of corresponding season of 2014(Fig. 4).

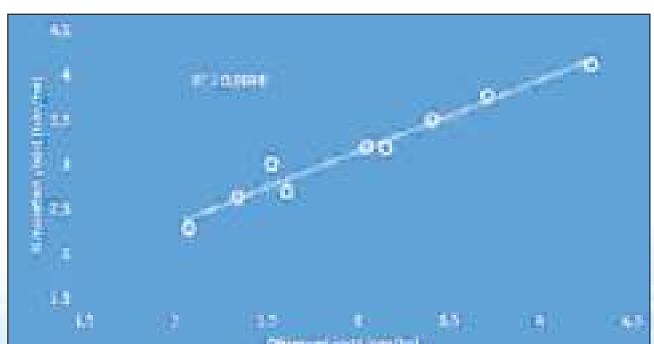


Fig. 4 Scatter diagram for crop yield during validation period

Estimation of yield loss of paddy due to dry spells

A field experiment on rice was also conducted at the ICAR-IIWM research farm, Mendhasal with the objective to generate data for use in the calibrated AquaCrop model for estimating yield loss due to dry spells. The estimation was done by keeping other parameters of the model constant and replacing only the normal rainfall year values with drought year rainfall. The analysis of the rainfall data of Bhubaneswar showed that drought occurred recently in the years 1987, 1988, 1996, 2000 and 2004; and the yield loss of *kharif* paddy varied from 8 to 16% due to dry spells.

Development of water balance model for optimum design of on-farm reservoir

A water balance simulation model was developed for optimum design of on-farm reservoir (OFR) in a paddy field under rainfed upland situation. The computer programme was written using Visual Basic 6.0 for simulation of water balance components. Computation of inflow and outflow of field water balance was carried out on daily basis from the sowing through the end of turn-in period every year and thus, the simulation continued for 30 years from 1985 to 2014. Simulation starts with an initial size of the OFR i.e. in 5% of the farm area. On any day during the simulation, if adequate balance is not available in the OFR then, the size of the OFR is increased by 0.1% and the simulation starts again from the day of sowing. Thus, the pond size would continue to increase till a size is reached at which the water demand of the crop matches with the available storage in the OFR. With the increase in OFR size, simultaneous decrease in crop area occurs. On the end day of turn-in period, the storage in the OFR should be adequate to meet the proposed water demands of winter crops. If the storage balance in the OFR is not sufficient to meet this requirement, then similar increment in the size of the OFR takes place and the simulation restarts from the day of sowing of rainy season crops till available storage becomes adequate. Thus, the size of OFR evolved is the actual size for that year. The simulation was done for two scenarios, pond with lining and pond without lining. The size of the OFR was obtained in the range of 5-21% of the farm for pond with lining, and 8-49% of the farm for pond without lining condition.

Project Title : **Design and Development of Rubber Dams for Watersheds**
Funding Agency : NAIP, ICAR, New Delhi
Project Personnel: S.K. Jena, A. Kumar, P.S. Brahmanand, A. Mishra and D.U. Patil

After the successful installation of rubber dams and realising its positive impact on enhancing irrigation water availability, agricultural production, socio-economic upliftment etc., it was planned to install several rubber dams in different agro-ecological and geo-hydrological regions of the country. The installation of rubber dam base structures was done successfully under NAIP with its proper design, development and fabrication of anchoring mechanism, inlet, outlet system and other necessary components. The rubber dam installations were initiated with completion of construction of base structures at locations Kanse-1 and Kanse-2 in Maharashtra; Dapoli-1, Dapoli-2 and Dapoli-3 in Maharashtra; Vansda-1, Vansda-2 and Navsari in Gujarat; Palampur-1 and Palampur-2 in Himachal Pradesh; Jaleswar-1, Jaleswar-2 and Jaleswar-3 in Odisha; Silala in Tamil Nadu; Nandahandi, Jogiput, Semiliguda and Pottangi in Odisha; and in CIFA farm, Kausalyagang and Khurda in Odisha. Impact assessment and evaluation of rubber dams for hydrologic and agricultural performance at different rubber dam sites at Khurda district of Odisha was done successfully. The installed rubber dams in Odisha and one at Gujarat were successfully operated during monsoon for control of flood, soil erosion, sedimentation and utilization of stored water for irrigation during long dry spells and post monsoon season.

Improvement in water storage

Water storage scenario considerably improved at Chandeswar, Odisha after installation of rubber dams. This facilitated irrigating additional crop area and improved crop productivity. At Chandeswar-1 site, when the rubber dam was fully inflated, water was stored up to an additional 1.5 m height in the upstream side of the Sagadianala i.e., Kusuminala up to a distance of 600 m. This additional amount of water at any point of time was 4,500 m^3 (live storage) extra in comparison to scenario when there was no rubber dam. When the inflow from the catchment was more than the storage capacity, the excess water was flowing over the rubber dam and going to the downstream side. However when the water stored above rubber dam was diverted for irrigation through pumping, it was filled by the water stored in the upstream side. During *kharif* season 68,000 m^3 of water was diverted for irrigation to provide four irrigation to *kharif* season crops in 17 ha which heitherto was not possible without rubber dam. During post-monsoon, water was stored in the dam. During the post-monsoon season the stored water was used to irrigate 5 ha area for cultivation of vegetables, pulses and oilseeds. Summer vegetables were also grown in 2 to 3 ha at the installation site. At Chandeswar-2 when the rubber dam was fully inflated, water was stored up to an additional 1.35 m height in the upstream side of the Sagadianala up to a distance of 1,200 m. This additional amount of water at any point of time was 4,050 m^3 (live storage) extra. During *kharif* season, 52,000 m^3 of water was diverted for irrigation to *kharif* season crop in 13 ha area. The stored water during post-monsoon season was sufficient to irrigate about 5 ha for growing of vegetables, pulses and oilseeds.

Rubber dam at Navsari, Gujarat

Improvement in cropping indices

There has been an improvement in cultivated land utilization index (CLUI) and multiple cropping index (MCI) in the sites due to installation of rubber dam. The CLUI increased from 43.3% with no or pre-installation stage to 57.3, 59.8 and 60% during first, second and third year, respectively after installation of rubber dam in Chandeswar. Similarly, there has been a jump in MCI from 123.5% with pre-installation stage to 183.8% during the third year after installation of rubber dam at the same site.

Improvement in socio-economic condition of farmers

The additional water resource created by installation of rubber dam resulted in higher cropping intensity, crop productivity and thereby additional net returns to the majority of farmers having small and marginal land holdings under the rubber dam command at Chandeswar, Khurda district of Odisha. The rubber dam technology has potential to enhance the gross returns of the farmers by 62% from Rs. 28,700 to 46,700 ha^{-1} if farmers grow only rice crop. The gross returns of the farmers increased from Rs. 45,184 to 70,792 ha^{-1} with rice-green gram, Rs. 72,500 ha^{-1} with rice-cucumber and Rs. 75,135 ha^{-1} with rice-sunflower cropping system with irrigation from the additional water available through rubber dam. The net returns increased from Rs. 12,400, 43,942, 43,200 and 47,935 ha^{-1} under sole rice, rice-green gram, rice-cucumber and rice-sunflower cropping systems, respectively. The rice-vegetable cropping system has potential to enhance net income by Rs.12,000 ha^{-1}. The migration rate of the farmers was also reduced by 22% compared to the pre-installation phase.

Farmer irrigating summer vegetables with rubberdam stored water at Chandeswar

Project Title : **Performance Evaluation of Drip Irrigated Mango under Deficit Irrigation**
Project Code : DWM/11/151
Funding Agency : Institute
Project Personnel: S. Mohanty, P. Panigrahi, M. Raychoudhury and Ashwani Kumar

The performance of drip irrigation in mango orchard was evaluated with regulated deficit irrigation (RDI) and partial root zone drying (PRD) at the DWM research farm, Mendhasal, Bhubaneswar during the period April to December 2014. Treatments comprised of full irrigation @ 100% ETc (FI), RDI @ 80, 60 & 40% ETc, PRD @ 80, 60 & 40% ETc and control, i.e. rainfed. Water was applied during the months of April to Mid-June with exception to the periods when some rainfall occurred. The monthly irrigation varied from 18 to 85 mm under various treatments, with the maximum amount during May and minimum in June. The hydraulic performance of the drip system was monitored and was found satisfactory with emitter flow rate variation of 11% with 10% coefficient of variation and 90% distribution uniformity. The plant growth was measured at half yearly interval (Jan-Jun and Jul-Dec).

Variation in soil moisture content and plant growth

The mean monthly soil moisture content observed at 30 cm interval within top 90 cm soil during April to June indicated that the full irrigation resulted in significantly higher moisture in comparison to other treatments. The moisture content in top 30 cm soil was significantly higher than that in 30-60 cm and 60-90 cm soil depths. However, the soil water depletion at 60-90 cm soil depth was lower than that in 0-30 cm and 30-60 cm soil depths. The magnitude of moisture content was significantly less under rainfed treatments over other treatments. The plant growth showed a decreasing trend with decrease in irrigation regimes, and it was the maximum with FI; further better growth was recorded in RDI compared to PRD treatments. The extent of the growth was higher during Jul-Dec than Jan-Jun period due to adequate soil moisture during rainy season.

Fruit yield, quality and nutrient status in soil and plants

The fruit yield and quality parameters were significantly affected by irrigation (Table 1). Higher number of fruits was harvested under FI followed by RDI at 80% ETc. However, the fruit weight was lower in FI compared to that in 80 & 60% RDI, and 80 & 60% PRD. In PRD treatments, even though fruit numbers were lower, overall yield was better due to greater fruit weight. Yield was highest in 80% PRD followed by FI, it was statistically at par with 60% PRD. There was 40% water saving and 85% improvement in water use efficiency in 60% PRD in comparison to FI. In general, fruit quality was better in PRD and RDI treatments compared to full irrigation. The Total soluble sugar (TSS) was the highest and acidity was the lowest in 60% PRD. However, in 40% PRD, fruit quality deteriorated slightly might be due to severe water stress. The available N, P and K in soil were higher in FI; these were statistically at par with PRD at 80% ETc and RDI at 80% Etc.

Table 1 Yield, water use efficiency (WUE) and fruit quality of mango under RDI and PRD treatments

Treatment	Yield parameters			Water applied (m^3 $tree^{-1}$)	WUE ($kg\ m^{-3}$)	Fruit quality		
	No. of fruits	Fruit weight (g)	Fruit yield (kg $tree^{-1}$)			Pulp (%)	TSS (^{o}Brix)	Acidity (%)
100% ETc	112	208.2	23.3	7.43	3.14	67.5	16.2	0.51
80% RDI	108	211.6	22.9	5.46	4.19	70.3	19.3	0.49
60% RDI	88	231.4	20.4	4.01	5.08	69.5	20.9	0.43
40% RDI	66	192.5	12.7	2.38	5.34	62.3	14.8	0.65
80% PRD	99	244.8	24.2	5.29	4.57	70.5	20.1	0.46
60% PRD	83	269.3	22.4	3.85	5.81	70.8	21.7	0.42
40% PRD	67	192.8	12.9	2.24	5.76	68.1	16.3	0.57
Control	62	171.5	10.6	--	--	62.8	12.4	0.62
LSD (P=0.05)	2	10.1	1.6	--	--	7.8	1.77	0.01

Project Title : **Conservation Agricultural Practices in Rice Based Cropping System for Increasing Water and Nutrient Availability in a Rainfed Agro-ecosystem for Eastern India**
Project Code : DWM/10/147
Funding Agency : Institute
Project Personnel: P. K. Panda, A. Mishra and S. K. Rautaray

The field experiment was conducted in research farm of the institute at Mendhasal under split-plot design with three replications. Four tillage practices *viz*. no tillage (NT), minimum tillage (MT), conventional tillage with maize in flat bed (CT_1) and conventional tillage with maize in raised bed (CT_2) were assigned to main plots, and three nutrient treatments *viz*. 100% recommended dose of NPK, 50% NPK + 50% N through farmyard manure and 50% NPK + 50% N through green leaf manuring were allotted to sub plots. The recommended dose of N, P_2O_5 and K_2O for *kharif* rice was 60, 35 and 35 kg ha^{-1}, respectively, and for *rabi* maize 120, 60 and 40 kg ha^{-1}, respectively. The various tillage treatments did not change bulk density and pH of the soil significantly after harvest of the maize crop. However variation due to nutrient treatments imposed on conservation tillage practices was significant on available N, P and K status of the soil after harvest of *rabi* maize i.e., on completion of the rice-maize crop sequence (Table 2). The available N and P were higher in NT over MT, CT_1 and CT_2 . Both NT and MT were found similar for available K. The nutrient treatments *viz*. 50% NPK + 50% N through FYM and 50% NPK + 50% N through green leaf manuring were better and significantly superior over 100% NPK for maintaining available N, P and K status in the soil under rice-maize crop sequence.

Maize with no tillage

Table 2 Effect of conservation tillage and nutrient treatments on bulk density, pH and available N, P and K status of the soil after harvest of maize under rice-maize crop sequence

Treatments	Bulk density ($Mg\ m^{-3}$)	Soil pH	Available nutrient status of soil ($kg\ ha^{-1}$)		
			N	P_2O_5	K_2O
Conservation tillage treatments					
No-tillage (NT)	1.50	5.8	222	36.2	168.9
Minimum tillage (MT)	1.51	5.7	218	35.5	167.2
Conventional tillage with maize sown in flat bed (CT_1)	1.52	5.6	214	34.5	166.0
Conventional tillage with maize sown in raised bed (CT_2)	1.52	5.6	212	34.1	166.6
LSD(P=0.05)	NS	NS	3	0.5	2.2
Nutrient treatments					
100% NPK	1.53	5.6	218	34.6	166.7
50% NPK + 50% N through FYM	1.50	5.8	226	35.1	168.9
50% NPK + 50% N through green leaf manuring	1.51	5.7	224	35.6	167.2
LSD(P=0.05)	NS	NS	4	0.5	1.8

Interaction between conservation tillage and nutrient treatments was not significant

Project Title : **Water Budgeting in High-value Shrimp Monoculture and Carp Poly culture under Varying Intensification Levels**
Project Code : DWM/11/155
Funding Agency : Institute
Project Personnel: Rajeeb K. Mohanty, A. Kumar, D.K. Panda and D. U. Patil

In order to study the effect of different stocking densities on the consumptive and total water requirement and water productivity of Indian major carps in polyculture and black tiger shrimp in monoculture system, to assess the impact of varying intensification levels on water quality, sediment load, water productivity, growth and production performance of Indian major carps and *P. monodon,* and finanly to develop protocols for best water management practices (BWMPs) at different levels of intensification, experiment was conducted at Parikhi Village, Chandipur of Balasore District.

Fig. 6 Performance index (PI) of IMCs and black tiger shrimp *P. monodon* under varying intensity levels

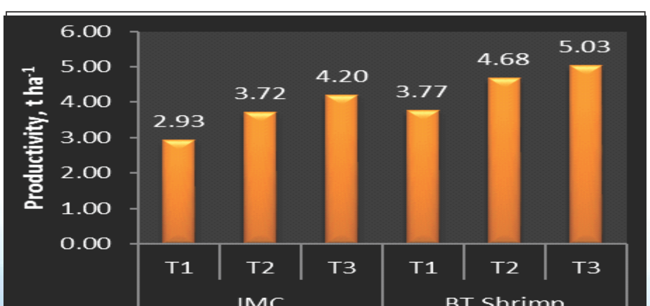


Fig. 5 Production performance of IMCs and black tiger shrimp(*BT Shrimp. monodon*)under varying intensity levels

During the second crop, productivity of commercially important carp polyculture IMCs ranged between 2.93 to 4.20 t ha^{-1}, while significantly higher productivity was recorded at densities 8,000 and 10,000 fingerlings per ha; productivity of *P. monodon* ranged between 3.77 to 5.03 t ha^{-1} and significantly higher productivity was obtained at density of 2,00,000 and 2,50,000 post-larva (PL) per ha (Fig. 5). Similar trend was also observed in case of species performance index (Fig. 6). Total water requirement as well as consumptive water use was estimated in carp polyculture and shrimp monoculture. In carp polyculture under different stocking density, total water use was 3.81, 4.02 and 4.44 ha m, while the computed consumptive water use index (CWUI) was 6.48, 5,71 and 5.99 m^3 kg^{-1} biomass at densities 6,000, 8,000 and 10,000 fingerlings per ha, respectively (Fig. 7). Similarly, under different stocking density of shrimp, estimated total water use (TWU) was 3.08, 3.34 and 3.69 ha m, while the computed CWUI was 5.22, 4.82 and 5.06 in 1,50,000, 2,00,000 and 2,50,000 PL ha^{-1}, respectively (Fig. 8). As density increased, TWU AND CWU, also increased due to incresed necessity of water replenishment. Evaporation and seepage losses CONTRIBUTE significantly to CWU. On an average,l evaporation loss was 2.9-3.1 and 2.4-2.8 m^3 water per kg production of IMCs and black tiger shrimp, respectively.

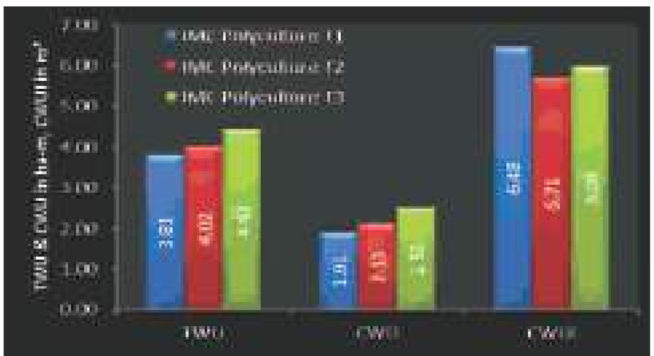


Fig. 7 Treatment-wise TWU, CWU and CWUI in carp polyculture under varying intensity levels

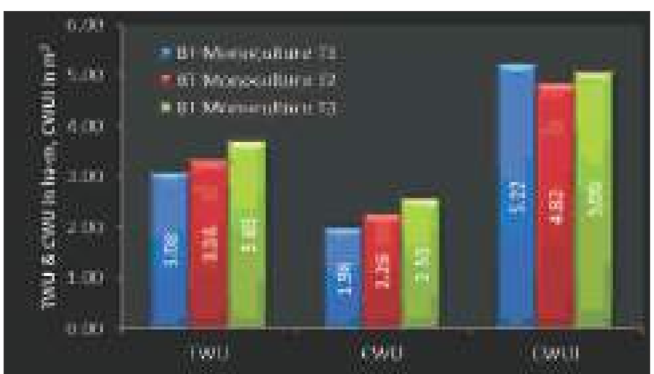


Fig. 8 Treatment-wise TWU, CWU and CWUI in black tiger shrimp (*P. monodon*) monoculture under varying intensity levels

The growth and yield performance was affected at higher intensity levels, and might be due to mutual competition for food and space that caused physiological stress, resulting in slow growth, size heterogeneity and weight distribution of fish or shrimp, which ultimately affected the water productivity (Fig. 9). Higher the density, higher was the sedimentation rate/load that ranged between 57.2 and 61.2, 39.1 and 45.4 m^3 t^{-1} biomass in carp polyculture and shrimp monoculture, respectively under varying intensity levels. Although higher intensity level increased the harvestable biomass substantially, it affected production cost significantly due to increase in the cost of more external inputs *viz*. feed, power, mechanical aeration, water, pumping cost and labour. Therefore, the desirable density that gives significantly higher yield, economic benefit *i.e.* output value/ cost of cultivation (OV: CC) and net consumptive water productivity (NCWP) was 8,000 fingerlings per ha and 2, 00,000 PL per ha in case of carp polyculture and black tiger shrimp monoculture, respectively.

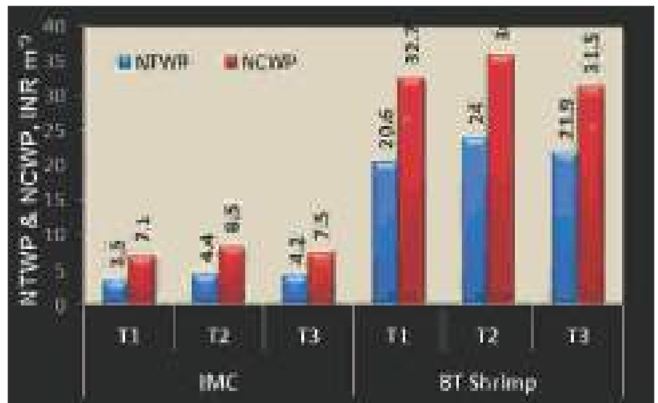


Fig. 9 Net total water productivity and net consumptive water productivity in carp polyculture and black tiger shrimp (*P. monodon*) monoculture under varying intensity levels

Project Title : Development of a Runoff Recycling Model for Production and Profit Enhancement through Alternate Land and Crop Management Practices
Project Code : DWM/12/157
Funding Agency : Institute
Project Personnel: P.K. Panda, A. Kumar, R.K. Mohanty and P. Panigrahi

A land area of 0.97 ha was selected in the research farm of IIWM, Bhubaneswar for implementing different activities under the project. After analyzing long term climatic, hydrologic parameters and contour map (Fig. 10), the size and location of runoff water harvesting structure was decided, and the pond was constructed. A portion of the excavated soil was put around the runoff harvesting structure to make suitable embankment for raising on-dyke horticultural crops. Remaining excavated soil was heaped in regular interval at a distance of 6.5 m with a dimension of parabolic shape with a radius of 2 m and height of 1 m having a gradual slope at both sides (Fig. 11). On the embankment of water harvesting pond, papaya, variety 'Red Lady' was planted. Acid lime, variety 'Sai Sarbati' and brought from ICAR-NRCC, Nagpur and was planted on the top of each heap and in the inter-row spaces, rice was grown during *kharif* season. On the outer side of heap, cowpea fodder crop, variety 'EC-4216', was grown. In the *rabi* season, crops *viz*. broccoli, mustard, blackgram and green gram were grown with recommended package of practices, and by using irrigation from harvested pond water. The standard procedure was followed for treating the bottom of the runoff harvesting pond and required quantity of cow dung was applied for development of planktons in the pond. Standard size fingerlings belonging to Indian major carp (IMC) were brought from ICAR-CIFA, Bhubaneswar and released in the pond. Recommended feeding schedule was followed. After six months, netting was done following standard sampling procedure and the average size of fish was 408.6 g per fingerling.

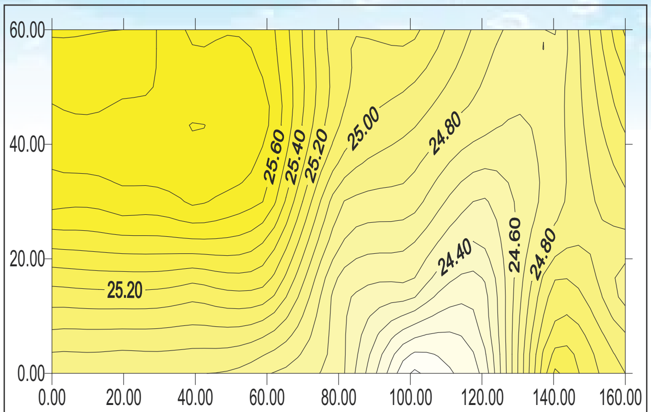


Fig. 10 Contour map of the project site at IIWM Research Farm,Mendhasal, Bhubaneswar (scale: vertical and horizontal interval is in m)

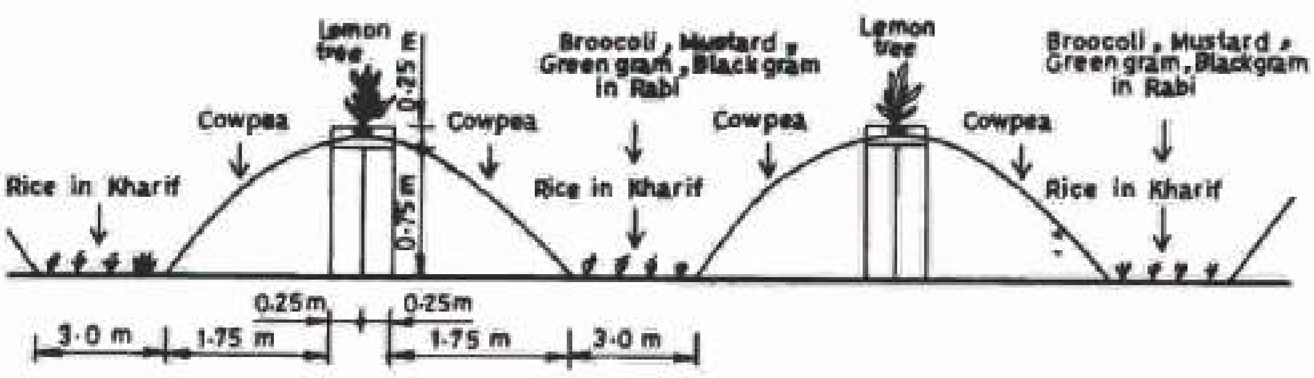


Fig. 11 Design of the modified land in the project site at IIWM Research Farm, Mendhasal, Bhubaneswar

Growth attributes of various crops was recorded periodically (Table 3). The rate of photosynthesis was measured during *kharif* and *rabi* seasons (Table 2). During *kharif* season, rice grain yield was 3.84 t ha^{-1} was obtained from the variety 'Swarna'; green fodder yield of cowpea grown in the side slope of the modified land system was 24.0 t ha^{-1}; maximum seed yield of 1.08 t ha^{-1} was obtained from mustard var. 'NRCBH-101'; fresh head of brocoli (var. CHB-1) was 11 t ha^{-1} (Table 4). Grain yield of black gram was higher in var. 'Prasad' (1.04 t ha^{-1}) compared to the var. 'Ujala' (0.96 t ha^{-1}). Similarly, grain yield of greengram 'Durga' (0.90 t ha^{-1}) marginally out yielded var. 'Kamadev' under identical management practice (Table 5).

Director, National Water Mission, MoWR, New Delhi visited the project site

A view of the modified land configuration

Papaya var. 'Red Lady' on the pond embankment

Table 3 Growth attributes of papaya and acid lime grown on the embankment of the pond and on the heaps, respectively under the land modified system

Name of the crop & variety	Growth attributes	Observation at different days after planting					
		30 DAP	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP
Papaya	Plant height (cm)	38.5	74.5	85.0	134.4	143.2	152.0
(var. Red Lady)	No. of leaves	11.0	15.5	18.4	16.8	17.3	17.6
Acid lime	Plant height (cm)	94.0	98.3	103.2	108.4	110.2	111.8
(var. Sai Sarbati)	No. of branches	7.0	10.1	28.9	30.4	32.4	37.2
	No. of leaves	72.5	103.3	296.2	304.2	316.5	340.4

Table 4 Rate of photosynthesis of various crops measured for different crops in different seasons

Name of the crop & variety	Rate of photosynthesis ($\mu mol\ CO_2\ m^{-2}\ s^{-1}$) in *kharif* season*	Rate of photosynthesis ($\mu mol\ CO_2\ m^{-2}\ s^{-1}$) in *rabi* season**
Papaya (var. Red Lady)	10.10 ± 0.50	8.56[#] ± 1.23 19.63[&] ± 1.04
Acid lime (var. Sai Sarbati)	8.90 ± 1.91	6.85 ± 1.21
Rice (var. Swarna)	17.60 ± 1.76	-
Fodder cowpea (var. EC -4216)	15.33 ± 0.59	-
Broccoli (var. CHB -1)	-	16.46 ± 1.31

[*]on 27.11.2014, [**]on 19.02.2015, [#]with normal fruiting, [&]with heavy fruiting; ± indicates SE of means.

Table 5 Yield of various crops grown in the experiment under land modification system

Name of crops	Name of the variety	Yield ($t\ ha^{-1}$)
Grain yield of rice	'Swarna'	3.84
Green fodder yield of cowpea	'EC-4216'	24.00
Fresh head yield of broccoli	'CHB-1'	11.00
Seed yield of mustard	'NRCBH -101'	1.08
	'Pusa Jaikissa n'	0.96
	'NDRE -7'	0.84
	'Rajendra Sulfan'	0.82
Grain yield of blackgram	'Prasad'	1.04
	'Ujala'	0.96
Grain yield of greengram	'Durga'	0.90
	'Kamadev'	0.88

Project Title : **Water and Nutrient Self-reliant Farming System for Rainfed Areas under High Rainfall Zone**
Project Code : IIWM/15/168
Funding Agency : Institute
Project Personnel: S.K. Rautaray, S. Mohanty, S. Raychaudhuri, R.K. Mohanty, R. Dubey and R. C. Srivastava

A farm pond measuring 71 m X 61 m width was renovated for harvesting rainwater. A surplus structure was constructed inside the farm pond at the down slope to allow excess run-off. An inlet was constructed using locally available lateritic stone to collect run-off from the upper reach of the farming system area to minimize sedimentation of the farm pond. On embankment of the farm pond, culinary banana was planted in two rows with a plant to plant spacing of 2 m. Pits were dug for planting papaya in a zigzag pattern for efficient utilization of space and sunlight between two rows of banana plant. Soil sample was collected from different points of the farming system area for initial status of N, P, K, organic carbon, and bulk density. *Gliricidia sp.* was planted along the boundary of the farming system area at a spacing of 2 m with the objective of harvesting nitrogen rich biomass for subsequent production of vermi-compost. *Sesbania* seeds were sown in the field @ 20 kg ha^{-1} for use as *in-situ* green manure for rice crop in *kharif* season of 2015. Cow pea variety EC-4216 for use as fodder and another variety as a summer vegetable were grown in the field

Canal Water Management

- National Initiative for Climate Resilient Agriculture
- Improving Water Productivity under Canal Irrigation Command through Conservation of Surface and Ground Water using Tanks and Wells
- System of Rice Intensification (SRI): Studies on Water Management, Micronutrient Uptake and Crop Rotation
- Evaluating Deficit Irrigation under Drip System for Rice-based Cropping Sequence in Canal Command Area

Project Title	: **National Initiative for Climate Resilient Agriculture**
Funding Agency	: NICRA, ICAR, New Delhi
Project Personnel	: G. Kar, A. Kumar, P.S. Brahmanand, D.K. Panda, A. Ravi Raj, P.K. Singh and H.D. Rank

A. Impact assessment

Projected change in maximum, minimum temperature and rainfall under different climate change scenarios

Using the MARKSIM data generator and HadGEM2-ES model under RCP 4.5 scenario, increase in maximum temperature by 1.25, 1.92 and 2.28 °C is projected by the year 2050, 2070 and 2095, respectively when compared to 2010 for the mid central table zone of Odisha (Dhenkanal). The increase in minimum temperature is projected to be 1.48, 2.28 and 2.56 °C by the year 2050, 2070 and 2095, respectively as compared to 2010 under the same scenario. The total rainfall will not change much by the year 2095 (only an increase of 3.73 mm) as compared to 2010. Under RCP 8.5 scenario, increase in maximum temperature of 1.5, 2.72 and 4.16 °C is estimated for the year 2050, 2070 and 2095, respectively as compared to 2010. The increase in minimum temperature of 1.66, 2.52 and 4.35 °C is estimated for the year 2050, 2070 and 2095, respectively as compared to 2010 under the same scenario. The rainfall amount is estimated to be increased by 16 mm by 2095 as compared to 2010. Average annual precipitation is not expected to be changed much, but the main change will be an altered seasonal distribution with more rainfall in winter and less in summer.

Crop evapotranspiration and water footprints under current and future climate scenarios

As a case study from Dhenkanal, Odisha, the crop evapotranspiration of potato, sunflower, wheat, cabbage, rice, groundtnut, maize and mustard having similar crop duration of under current (2010) and projected climate change scenario (RCP 4.5 and 8.5) was determined (Fig. 12 a, b). Water footprints of some winter crops were estimated (Fig. 13 a, b). Study revealed that as per the RCP 4.5 scenario, crop water demand is increased by 6.3 to 9.6% for the winter season crops considered under the study by the year 2095, and according to the RCP 8.5 scenario, the increase in crop water demand was 10.6 to 13.7% compared to current scenario.

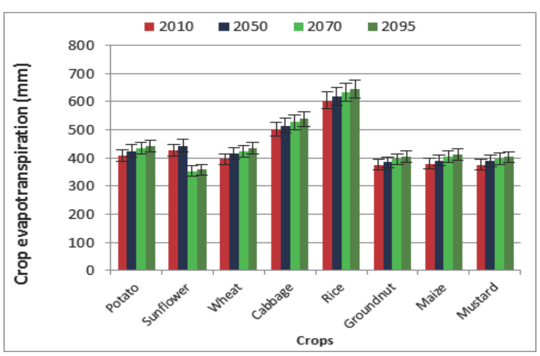


Fig. 12a. Crop evapotranspiration of some winter season crops of Dhenkanal, Odisha under current and projected climate change scenario, RCP 4.5

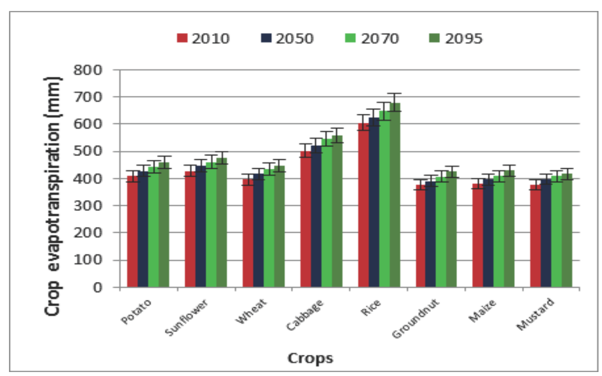


Fig. 12b. Crop evapotranspiration of some winter season crops of Dhenkanal, Odisha under current and projected climate change scenario, RCP 8.5

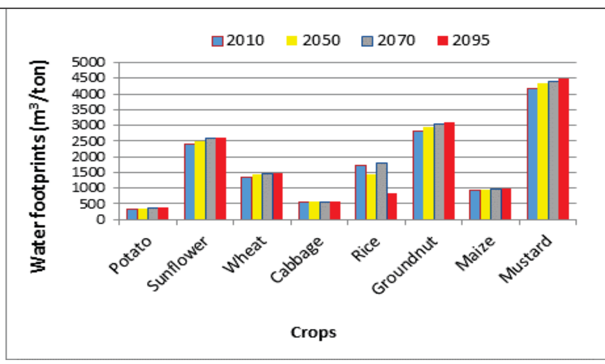


Fig. 13a. Water footprints of some winter season crops of Dhenkanal, Orissa under current and projected climate change scenario, RCP 4.5

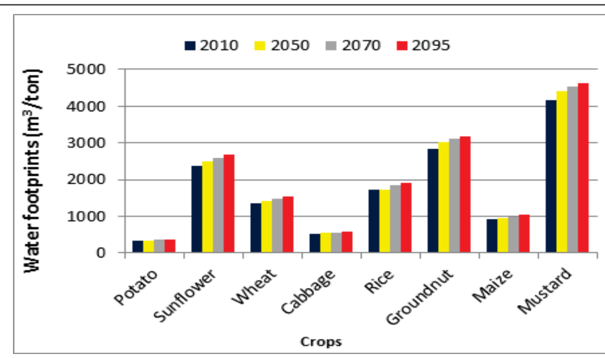


Fig. 13b. Water footprints of some winter season crops of Dhenkanal, Orissa under current and projected climate change scenario, RCP 8.5

Climate change impacts on crop productivity, water productivity and water footprints of groundnut

In this investigation, DSSAT 4.5 model was calibrated and evaluated to study the effect of elevated temperature and CO_2 conc. and their interaction on crop duration, growth and productivity of groundnut. It was revealed that under elevated temperature by 2070 as per IPCC RCP 4.5 scenario, crop duration would be reduced by 7 days under both 370 ppm (current) and 550 ppm CO_2 conc. (Table 6). Yield and yield components are adversely affected by increase in temperature under both 360 ppm and 550 ppm CO_2 conc. scenarios. However, increase in CO_2 conc. from 370 to 550 ppm had some additive effect on maize productivity. The reduction in simulated pod yield was -15.51% under 360 ppm and -9.71% under 550 ppm CO_2 conc. in 2070. The reduction in pod yield under future climate change scenarios might be attributed to adverse effects of climate extremes on yield components of groundnut.

Table 6 Impact of elevated temperature and CO_2 conc. scenarios in year 2070 based on RCP4.5 on crop duration, pod yield, water productivity and water footprints of groundnut (cv. Smriti)

Elevated CO_2 conc. scenarios	Year 2010	Year 2070	Diff (%)
A. 370 ppm CO_2 concentration			
Crop duration (days)	122	115	-5.74
Pod yield (kg ha^{-1})	1660	1440	-15.54
Crop evapotranspiration (mm)	381	402	5.51
Water productivity in terms of ETc (kg m^{-3})	0.44	0.36	-17.78
Water footprints (m^3 t^{-1})	2295	2792	21.63
B. 550 ppm CO_2 concentration			
Crop duration (days)	122	115	-5.74
Pod yield (kg ha^{-1})	1750	1580	-9.71
Crop evapotranspiration (mm)	381	402	5.51
Water productivity in terms of ETc (kg m^{-3})	0.46	0.39	-16.10
Water footprints (m^3 t^{-1})	2177	2544	16.86

B. Mitigation

CO_2 sequestration through rice-based cropping system, gross primary productivity and net ecosystem exchange

Gross primary productivity (GPP), ecosystem respiration, net ecosystem exchange (NEE) in relation to phenology and leaf area index over multiple cropping systems [okra (April-June)-rice (July-November)-tomato (December-March)] were studied. It was found that rice crop acted as a net CO_2 emitter during early vegetative growth phase; assimilated CO_2 as net sink during tillering to milk stage, and again acted as a net CO_2 emitter during the maturity stage. Other two crops *viz*. okra and tomato assimilated CO_2 as sink during mid vegetative to fruiting stages. The seasonal NEE at the end of growing period was recorded as -315, -248 and -173 g C m^{-2} for rice, okra and tomato respectively. Maximum NEE occurred at 11:30 hour and was highly influenced by leaf area index (LAI). For okra, the NEE was found negative during secondary branching (32 DAS) to about 10 days before last fruit picking (69 DAS) due to more assimilation of CO_2 than release of CO_2 due to respiration. The NEE of okra reached its peak at maximum LAI stage (55 DAS) with the midday uptake of –19.2 µmol CO_2 m^{-2} s^{-1} and night-time release of + 4.08 µmol CO_2 m^{-2} s^{-1}. Rice crop exhibited a distinct diurnal pattern in CO_2 fluxes also. It showed a daytime uptake (negative NEE, i.e. uptake of CO_2 due to photosynthetic assimilation) and night-time release of CO_2 (positive NEE, i.e. emission of CO_2 due to respiration) from the canopy. From the tillering stage, rice field became the net CO_2 sink and diurnal variation of NEE became prominent. NEE reached its peak at boot stage (76 DAS) with the midday uptake of –24.1 µmol CO_2 m^{-2} s^{-1} and night-time release of + 4.14 µmol CO_2 m^{-2} s^{-1}. Maximum NEE and GPP by rice crop was found between 11:30 and 12:30 h.

C. Adaptation

Improved irrigation (drip) and fertigation in vegetable based farming system to develop climate resilient agriculture

To assess the water and nutrient use efficiency and water productivity under drip and surface irrigation system along with surface application of fertilizer and fertigation, on-farm experiments were conducted separately on chilli, tomato, brinjal, potato, ladies finger, bitter gourd, cabbage in randomized block design with three replication. Pooled data of 2013-14 and 2014-15 show that significantly higher yield and water productivity by 62.1 to 177.3% under different treatments was achieved with drip irrigation over furrow method (Table 7). The soil moisture in the root zone remained fairly constant because irrigation water was applied slowly and frequently at a pre-determined rate. Due to higher water use efficiency, 38.3 to 64.9% less green plus blue water footprints were estimated under drip irrigation over surface irrigation method.

Table 7 Assessment of water productivity and water footprints under drip and surface irrigation methods

Treatment	Yield (t ha^{-1})	Yield increase over SI (%)	Water saving over SI (%)	GWP (kg m^{-3})	GWP increase over SI (%)	WFP (m^3 t^{-1})	WFP reduction over SI (%)
			Tomato				
Drip at 100% ETc	36.2	34.6	25.7	8.30	81.1	120.55	44.8
Drip at 80% ETc	38.2	42.0	40.1	10.86	137.2	92.04	57.9
Drip at 60% ETc	29.5	9. 7	54.6	11.06	141.4	90.44	58.6
SI (1.0 IW/CPE)	26.9	-	-	4.58	-	218.36	-
LSD (P=0.05)	2.95	-	-	-	-	-	-
			Cauliflower				
Drip at 100% ETc	34.7	32.9	26.9	8.15	81.9	122.68	45.1
Drip at 80% ETc	32.8	25.7	41.2	9.57	113.7	104.48	53.2
Drip at 60% ETc	29.5	13.0	55.4	11.36	153.6	88.03	60.6
SI (1.0 IW/CPE)	26.1	-	-	4.48	-	223.26	-
LSD (P=0.05)	2.8	-	-	-	-	-	-
			Potato				
Drip at 100% ETc	18.7	61.2	28.3	4.56	124.8	219.47	55.5
Drip at 80% ETc	19.1	64.7	42.2	5.77	184.9	173.19	64.9
Drip at 60% ETc	13.4	15.5	56.1	5.33	163.2	187.46	62.0
SI (1.0 IW/CPE)	11.6	-	-	2.03	-	493.45	-
LSD (P=0.05)	2.0	-	-	-	-	-	-
			Brinjal				
Drip at 100% ETc	29.3	32.0	18.6	5.62	62.1	177.82	38.3
Drip at 80% ETc	28.4	27.9	34.1	6.73	94.1	148.52	48.5
Drip at 60% ETc	24.2	9.0	49.6	7.50	116.3	133.31	53.8
SI (1.0 IW/CPE)	22.2	-	-	3.47	-	288.29	-
LSD (P=0.05)	2. 5	-	-	-	-	-	-
			Chilli				
Drip at 100% ETc	16.2	76.1	36.1	2.50	175.4	399.38	63.7
Drip at 80% ETc	15.1	64.1	40.8	2.52	177.3	396.69	63.9
Drip at 60% ETc	11.9	29.4	45.6	2.16	137.6	463.03	57.9
SI (1.0 IW/CPE)	9.2	-	-	0.91	-	1100.00	-
LSD (P=0.05)	1.8	-	-	-	-	-	-

SI, surface irrigation at 1.0 IW/CPE; GPP, gross water productivity; WFP, green+blue water footprints

A view of the improved irrigation (drip) and fertigation in vegetable based farming system

Experiments were also conducted to study the effect of fertigation on potato, chilli and ladies finger with different drip-fertigation and rate of fertilizer. Results revealed that fresh tuber yield of potato was 18.9 t ha^{-1} and fruit yield of okra was 16.8 t ha^{-1} when 80% of recommended dose of fertilizer was applied through drip-fertigation.

Multiple use of water of secondary reservoir in canal command

To enhance net return and water productivity of created water resources in different canal commands, the harvested water was utilized in multiple ways and net return of Rs. 43,015 to 72,495 were generated from the created water resources in the command area of minor No. 12 of Pattamundai canal command in Kendrapara district, Odisha. The water productivity enhanced from Rs. 1.5 m^{-3} from sole rice to about Rs. 14 m^{-3} through fish based farming system due to multiple use of water.

Multiple use of water of secondary reservoir in canal command

Project Title : **Improving Water Productivity under Canal Irrigation Command through Conservation of Surface and Ground Water using Tanks and Wells**

Funding Agency : INCSW (formerly INCID), MoWR, Govt. of India

Project Personnel : K.G. Mandal, R.K. Mohanty, M. Raychaudhuri and Ashwani Kumar

Most of the canal projects suffer from inadequate supply and poor reliability of water during lean season. Hence, interventions were made through construction of rain/ runoff water storage tanks and open wells in a medium irrigation command, and attempts were made to study the feasibility of harvesting, storage and conservation of canal water, seepage water, runoff and rainwater in storage tanks for irrigation and to develop integrated crop & fish culture system in Kuanria Medium Irrigation Project (KIP) at Daspalla, Nayagarh district of Odisha. It is located at 20°21′ N latitude and 84°51′ E longitude at an elevation of 122 m above mean sea level. The geographical area of Daspalla block is 571.57 km^2; the project irrigates i.e., CCA 3780 ha out of GCA of 4800 ha. This study site comes under Agro-Eco Sub-Region 12.2. The intervention was made in eight sites under eight sub-minors as indicated Table 8.

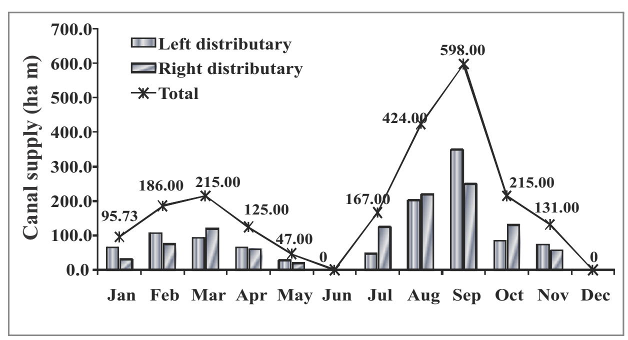


Fig. 14. Variation in monthly canal water supply (ha m) through left and right distributary (LD & RD) and the total supply (ha m) during the year 2011-2014

The total annual rainfall received at the project site was 1304 to 1895 mm in the years 2011 to 2014. The variation in rainfall was less during the pre-monsoon period; rainfall was quite low during November to May, with the maximum during the monsoon months i.e., 53.5 to 81.4. The least or no rainfall occurred during December to March. Maximum height of the dam from deepest level was 21 m, flood reservoir level (FRL) 135.7 m, dead storage level (DSL) 130.3 m. The reservoir level drops to 133.63 m in May and after monsoon it rises to about

135.6 m. in November. The canal delivery study showed much less delivery during lean period in comparison to the same during monsoon. After kharif rice, most of the area under the command remains fallow during rabi and summer season. The four years average showed no supply in June; it starts from July with 167.00 ha m, then it increases to 598 ha m in the month of September, thereafter it decreases from October and no supply in the month of December (Fig. 14). The supply during January through May was less than July to November. During the period of July to October major amount of water is released which is sufficient to irrigate 3780 ha of cultivable command area.

Table 8. Intervention points in different head, mid- and tail ends under different jurisdictions of water users association (WUA)

Name of the village	Name of sub -minor canal	WUA No.	Distributary	Canal reach
Kunjabanagarh	Mangalpur S/M	2	LD	Middle reach
Malisahi	Khairapankalsahi S/M	4	LD	Tail - end
Dwargaon	Madhyakhand S/M	5	LD	Tail - end
Odasar	Odasar S/M	6	RD	Head reach
Paikab aghuarani	Khamarasahi S/M	8	RD	Middle reach
Dendabhuin	Madhyakhand S/M -2	9	RD	Tail - end
Soroda	Lunisara S/M	10	RD	Tail end
Subalaya	Soroda S/M -II	10	RD	Tail end

Table 9. Fish production, performance indices of IMCs and fish water productivity for eight constructed water storage tanks

Pond in the sub - minor	Species	Initial MBW (g)	Final MBW (g)	PSI / PI	Productivity ($t\ ha^{-1}$ after210 d)	AFCR/ FE%	GWP ($Rs.\ m^{-3}$)	NWP ($Rs.\ m^{-3}$)
Mangalpur	Catla	20.0	566.5	546.9 / 275.2	2.76	1.47 / 53.5	7.28	5.36
	Rohu	14.0	466.0	245.6 / 198.2				
	Mrigala	12.0	485.5	326.4 / 202.2				
Khairapankalsahi	Catla	20.0	560.0	543.6 / 274.8	2.64	1.43 / 62.0	7.11	5.22
	Rohu	14.0	470.5	241.8 / 197.7				
	Mrigala	12.0	485.0	339.6 / 201.5				
Madhyakhanda (Dwargaon)	Catla	20.0	530.0	538.3 / 272.5	2.78	1.49 / 60.4	7.35	5.44
	Rohu	14.0	455.5	239.5 / 193.7				
	Mrigala	12.0	475.5	330.5 / 197.5				
Odasar	Catla	20.0	580.2	525.7 / 264.8	2.56	1.55 / 58.5	6.64	4.70
	Rohu	14.0	485.2	240.1 / 195.5				
	Mrigala	12.0	507.5	333.4 / 200.0				
Khamarsahi	Catla	20.0	572.0	543.5 / 276.2	3.06	1.65 / 61.3	8.05	5.98
	Rohu	14.0	482.5	244.0 / 199.0				
	Mrigala	12.0	505.0	348.6 / 209.5				
Madhyakhanda (Dendabhuin)	Catla	20.0	600.0	608.5 / 306.5	2.88	1.54 / 66.7	7.62	5.54
	Rohu	14.0	505.5	284.2 / 212.5				
	Mrigala	12.0	495.0	385.4 / 207.8				
Lunisara	Catla	20.0	588.5	604.2 / 300.0	2.90	1.46 / 65.5	7.85	5.71
	Rohu	14.0	490.5	265.8 / 208.8				
	Mrigala	12.0	485.0	361.0 / 207.4				
Soroda	Catla	20.0	615.0	610.5 / 290.2	2.83	1.58 / 59.2	7.58	5.47
	Rohu	14.0	510.0	247.5 / 204.0				
	Mrigala	12.0	540.0	382.0/212.5				

Fish productivity ($t\ ha^{-1}$ at 210 days), PSI- production-size index, PI- performance index, AFCR- apparent feed conversion ratio, FE- feeding efficiency, Fish sold @ Rs.90 kg^{-1}, GWP- gross water productivity, NWP- net water productivity

As one of the components of integrated faming system in the command area, low input-based medium-duration fish culture was undertaken in eight water harvesting structures to enhance the economic output and water productivity. During 2013-14, fish fingerlings of IMCs (*Catla catla, Labeo rohita* and *C. mrigala*) were stocked in the first week of September @ 5,000 ha^{-1} with a stocking composition of 30:30:40 (MBW- 20, 14 and 12 g for catla, rohu and mrigala, respectively) in each pond of 1630 m^3 each. Water temperature ranged from 27.2 to 35.8 ^{0}C, pH 6.7-8.7, dissolved oxygen 4.4-6.8 ppm, total alkalinity 83-127 ppm, dissolved organic matter 2.8-5.2 ppm, nitrite-N 0.006-0.08 ppm, nitrate-N 0.063-0.55 ppm, ammonia 0.01-0.3 ppm, transparency 31$\pm$7, and total suspended solid 178-389 ppm. The recorded fish production ranged between 2.56-3.06 t ha^{-1} in 210 days with gross water productivity of 6.64-8.05 while the net water productivity of 4.70-5.98 Rs m^{-3} (Table 9). Species-wise production-size index and performance index indicate the normal growth performance of the cultured species.

The integrated crop and fish farming systems were developed under different sites at Mangalpur S/M, Khairapankalsahi S/M, Madhyakhand S/M, Odasar S/M, Khamarasahi S/M, Madhyakhand S/M (second site) Lunisara S/M and Soroda S/M-II. The crops were grown under the command with the recommended package of practices. The performance of crops with water storage tanks were compared with the performance of crops without water storage tanks. For every site, rice was the primary crop during kharif season in the pond command as well as in the non-comand area. Fish was grown in the constructed pond. Rabi crops were grown with conjunctive use of water. On-dyke horticultural crops were grown for improving farm income.

The construction of rain/ runoff water storage tanks and open wells facilitated appropriate crop and fish farming system and crop diversification in the head, mid and tail ends of the command. The systems are: rice + (fish in pond) -greengram, rice + (fish in pond) -vegetables and rice + (fish in pond) -chickpea compared to rice-fallow in Odasar sub-minor (head reach), rice-greengram and rice-blackgram in the Khamarsahi (middle reach) sub-minor; rice + (fish in pond) +pigeonpea (on dyke) –greengram/ vegetables and rice + (fish in pond) + pigeonpea (on-dyke)- pigeonpea (on dyke) compared to rice-fallow and rice-greegram only in Madhyakhanda sub-minor; rice+(fish in pond) –sunflower/ sweet corn compared to rice-fallow cropping system in Khairapankalsahi sub-minor; and rice+(fish in pond) - greengram compared to rice-fallow cropping system in Soroda sub-minor,(all at tail end) under the command. The net income from the whole systems including fish culture varied from Rs 1.57 to 1.99 lakh per ha. The excess canal and rain water stored in tanks and dug wells provided irrigation to post-monsoon crops enhancing productivity of dry season crops and improved livelihood of farmers. This technology has potential to improve land and water productivity in canal command areas through augmented water resources and integrated farming systems involving muti-enterprise components.

On-dyke horticultural crops like banana and other


Construction of tank facilitates fish culture, storage of water for irrigation and on-dyke horticulture

Project Title	:	**System of Rice Intensification (SRI): Studies on Water Management, Micronutrient Uptake and Crop Rotation**
Project Code	:	DWM/12/156
Funding Agency	:	Institute
Project Personnel	:	A.K. Thakur, K.G. Mandal, S. Raychaudhuri and A. Kumar

System of Rice Intensification (SRI) gives better rice grain yield and saves more water than flooded rice. The present standard SRI recommendation for water management is to apply a minimum quantity of water during the vegetative growth stage, and thereafter maintaining a thin layer of water (1-3 cm) during the reproductive i.e., grain-filling stage. However, there is limited water available during the latter stage of rice crop growth. Moreover, till now no information is available regarding water requirement during post-vegetative phase of rice crop for the best results. The present study was carried out to investigate the impact of continuous *vis-à-vis* alternate flooding of paddy fields during post-vegetative stage on the root growth, grain yield and water productivity achieved under two alternative management systems, namely SRI as compared to conventional transplanting system (CTS) of rice production in rabi season. During vegetative stage of crop growth, CTS plots were kept under continuous flooding and in SRI plots irrigation treatment at three days after disappearance (3-DAD) of ponded water was given. During post-vegetative stage, four water management treatments viz., continuous flooding (CF), 1-DAD (irrigation at one day after disappearance of ponded water), 3-DAD and 5-DAD were imposed on both CTS and SRI.

Effect on root growth

Crops grown with SRI practices with alternate wetting and drying system through irrigation at 3-DAD during vegetative stage had significantly larger amount of roots as indicated by increased root dry weight per hill at the grain-filling stage (Fig. 15), eventhough SRI had only one plant per hill and CTS had three plants per hill. On an average, hills with SRI had nearly three times more root at grain-filling stage than CTS. In spite of lower plant density in SRI, root dry weights per unit area were also greater under SRI compared to CTS. Amongst different water management treatments highest root dry weight was found in 1-DAD treatment under CTS and 3-DAD under SRI method.

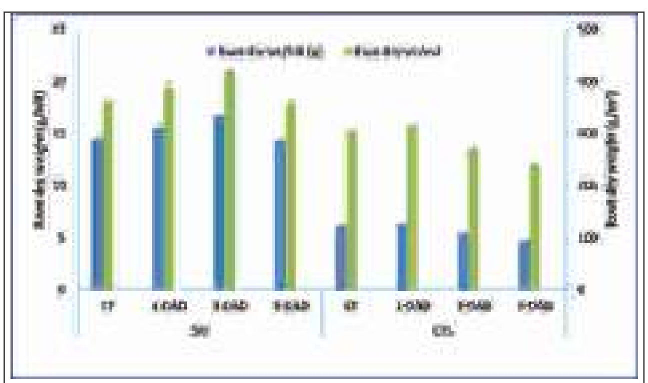


Fig.15 Effect of rice cultivation systems and water management during post-vegetative stage on root growth at grain-filling stage during *rabi* season 2014

Effect on grain yield

Cultivation systems and water management treatments significantly influenced grain yields. Grain yield with SRI was about 52% higher than those with CTS across all water management treatments (Table 10). With SRI, highest grain was obtained under 3-DAD treatment, and there was no significant difference in grain yield between continuous flooding and 1-DAD treatments. However, with CTS the grain yield was highest at 1-DAD and CF treatments.

A view of the experimental plot of SRI at ICAR-IIWM Research Farm, Mendhasal, Bhubaneswar

Water requirements and water productivity

Cultivation systems and water management treatments had significant impact on water use and water productivity (Table 10). Across all water management treatments, the total water used was 1184 mm in CTS and 958 mm in SRI management during the entire crop growth period. Hence, there was 19% saving of water in SRI compared to CTS. Among different water management treatments, the most water was required with continuous flooding and the least was with 5-DAD treatment under both methods of cultivation. Overall, throughout all the water management treatments, significantly higher grain was produced per unit quantity of water applied (6.3 kg ha mm^{-1}) under SRI as compared to CTS, which produced only 3.3 kg grain from the same amount of water. Therefore SRI was nearly 50% more efficient in utilizing water for grain production. Under CTS, the highest water productivity was obtained with the 1-DAD treatment (3.51 kg ha mm^{-1}), while under SRI, it was achieved in the 3-DAD treatment (6.56 kg ha mm^{-1}).

Table 10 Effect of rice cultivation systems and water management during post-vegetative stage on grain yield, water use and its productivity during *rabi* season 2014.

Cultivation systems	Water management treatments (post-vegetative stage)	Grain yield (t ha^{-1})	Total water use (mm)	Water productivity (kg ha mm^{-1})
Conventional Transplanting System	CF	4.16 d	1214.0 a	3.43 c
	1-DAD	4.22 d	1201.7 a	3.51 c
	3-DAD	3.82 e	1171.0 b	3.26 d
	5-DAD	3.50 f	1148.3 b	3.05 e
	Av.	*3.93*	*1183.8*	*3.31*
System of rice intensification	CF	6.04 b	986.0 c	6.12 b
	1-DAD	6.01 b	970.7 d	6.19 b
	3-DAD	6.21 a	947.3 e	6.56 a
	5-DAD	5.72 c	927.0 f	6.17 b
	Av.	*5.99*	*957.8*	*6.26*
Analysis of variance				
Cultivation system (CS)		**	**	**
Water management (W)		*	*	*
CS X W		*	ns	*

CF: Continuous flooding; DAD: Days after disappearance of ponded water *, $p < 0.05$; **, $p < 0.01$; ns, not significant

Project Title : Evaluating Deficit Irrigation under Drip System for Rice-based Cropping Sequence in Canal Command Area

Project Code : DWM/12/158

Funding Agency : Institute

Project Personnel : P. Panigrahi, R. K. Panda, A. K. Thakur, S. K. Rautaray and S. Raychaudhuri

Field experiments were conducted at ICAR-IIWM research farm, Mendhasal, Bhubaneswar to study the response of rice to drip irrigation and compare the effects of deficit irrigation (DI) in both capsicum and baby corn under drip system in rice-based crop sequence. The system performance of rice-capsicum-baby corn and rice-rice-baby corn were assessed for yield, water productivity and profitability. Three levels of irrigation (50, 75, 100% of ET_c) were imposed on baby corn and capsicum during November-February and March-May, respectively. The effects of drip irrigation at 75, 100 and 125% of ET_c on *kharif* rice, as supplemental irrigation were evaluated under drip system and was compared with surface irrigation. Drip irrigation system was installed and evaluated with 2 lateral layouts (lateral distance of 1.4 & 1.0 m) for all crops. The hydraulic performance of the drip system was found satisfactory i.e., the variation of mean emitter flow was 5% with 6% coefficient of variation and 96% distribution uniformity. Irrigation was applied to baby corn once in two days during March to May. Total of 205 to 410 mm water was applied through different drip irrigation treatments. The growth, yield and irrigation water productivity (IWP) of crops were monitored and assessed (Table 11).

Drip irrigation at 100% ET_c i.e. with full irrigation (FI) and lateral distance of 1.0 m produced the highest yield (2.06 t ha^{-1}) of baby corn, and it was statistically at par with the yield (1.94 t ha^{-1}) under irrigation at 75% ET_c. However yield reduced by 33% at 50% ET_c with 32% increase in irrigation water productivity compared with FI. The higher level of irrigation with 1.0 m lateral showed higher nutrients (N, P and K) uptake and leaf physiological parameters in baby corn (Table 11). The higher soil water depletion from 15-30 cm soil depth might be due to greater root density in the soil layer.

The response of irrigated rice (aerobic rice) to different level of irrigation (75, 100 and 125% of ET_c) under drip system was assessed and compared with surface irrigation. The grain yield at 100% ETc was marginally lower (12%) but saved 35% water over surface irrigation. Lateral distance of 1.0 m resulted in better crop growth and grain yield of rice. Weed infestation was more (65-87%) in drip-irrigated plots compared to surface irrigation. Drip-irrigated plants developed finer roots with shallow rooting depth compared with plants under surface irrigation.

Table 11 Vegetative growth, yield and IWP of baby corn under drip irrigation

Treatments		Vegetative growth			Yield parameters				Irrigation (mm)	IWP (kg m^{-3})
		Plant height (m)	LAI	Plant girth (cm)	Cob yield (t ha^{-1})	Baby corn yield (t ha^{-1})	Fodder yield (t ha^{-1})	TSS (Brix)		
DI_{100}	L_1	1.04	5.4	6.47	6.57	1.68	29.81	8.93	410	0.41
	L_2	1.10	6.6	6.52	7.82	2.06	30.88	8.87	410	0.50
DI_{75}	L_1	0.93	5.1	6.21	6.27	1.59	27.23	9.80	307	0.52
	L_2	1.02	6.5	6.32	7.51	1.94	27.50	9.54	307	0.63
DI_{50}	L_1	0.87	4.4	5.84	5.61	1.24	23.11	7.61	205	0.60
	L_2	0.98	5.0	5.72	5.92	1.37	23.59	7.79	205	0.66
DI_{50}	L_1	0.91	4.8	5.91	6.02	1.40	23.28	8.11	282	0.49
EKHS to PT	L_2	0.82	5.2	5.80	6.14	1.51	23.72	8.26	282	0.53
LSD	I	0.05	0.2	0.12	0.38	0.43	1.83	0.70		
(P=0.05)	L	0.01	0.1	ns	0.49	0.51	0.89	ns	-	-
	IxL	0.17	0.4	2.70	0.81	0.90	2.01	1.10		

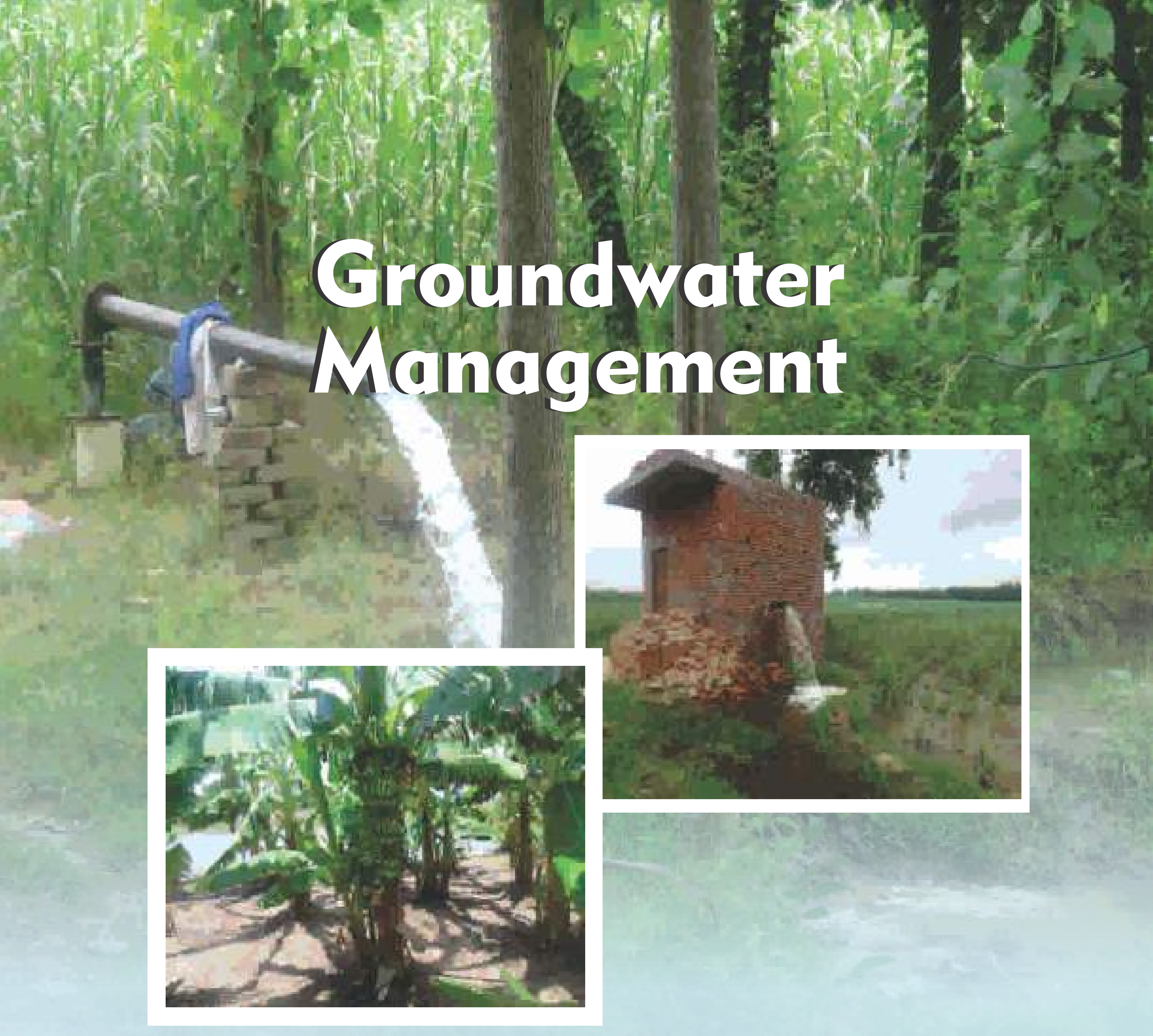
DI_{100}: drip irrigation at 100% ETc, DI_{75}: drip irrigation at 75% ETc, DI_{50}: drip irrigation at 50% ETc, L_1: 1.4 m lateral distance; L_2: 1.0 m lateral distance; EKHS: except knee high stage and PT: pre-tasseling stage; LAI: Leaf area index at harvest; TSS: total soluble sugar of baby corn; IWP: irrigation water productivity

Different levels of deficit irrigation (75, 50 and 50% of ET_c except flowering and fruiting stage and FI were evaluated in drip-irrigated capsicum. The maximum fresh fruit yield (26.83 t ha^{-1}) was harvested from FI with 1.0 m lateral layout. However, the highest water productivity was obtained in irrigation at 75% ET_c. The soil water content and available N, P and K at 15 and 30 cm depths were higher with higher level of irrigation. The significant variation in soil water content up to 0.3 m depth suggested confinement of effective root with in top 30 cm soil. The leaf photosynthesis, transpiration and stomatal conductance were higher with FI, whereas higher leaf water use efficiency was observed at 75% ET_c.

A view of the baby corn crop grown under drip irrigation

In rainfed rice, there was 8% reduction in yield under drip irrigation at 100% ET_c with 1.0 m lateral layout, whereas irrigation water saving was 30% with improvement in water productivity by 47% compared to surface irrigation. The vegetative growth was better under surface irrigation. The weed infestation was 45% higher in drip irrigated plots compared to surface irrigation. The available N and K status at 0-30 cm and 60-90 cm soil depths were significantly affected by irrigation treatment.

Groundwater Management



- Development of Technological Options for Comprehensive Water Resource Management in Non-exploration Zone (CRZ III) of Coastal Odisha
- Impact of Wastewater Use on Soil Properties and its Prospect of Utilization in Crop Production
- Decision support system for enhancing water productivity of irrigated rice-wheat cropping system
- Design and Development of Small Filters for Reducing Contaminants in Poor Quality Water at Farmers' Level for Safe Irrigation in Peri-urban Areas
- Impact of Climate Variability and Anthropogenic Factor on Groundwater Resources of India
- Development of decision support system for conjunctive use of surface and ground water
- Portable Drum based Drip Irrigation System for Sub-marginal Farmers
- Development of decision support system for conjunctive use of surface and ground water.
- Portable drum based drip irrigation for system for sub-marginal farmers.

Project Title	: **Development of Technological Options for Comprehensive Water Resource Management in Non-exploration Zone (CRZ III) of Coastal Odisha**
Project Code	: DWM/12/164
Funding Agency	: Institute
Project Personnel	: Ranu Rani Sethi, R.C. Srivastava, Jugal Tripathy, M. Das, P.S.B. Anand and A. Kumar

A study was carried out at Sunity gram Panchayat, Mahakalapada block of Kendrapara district of Odisha to know the water availability from different sources, spatio-temporal variation in water quality from surface (creek) and sub-surface sources. The study area of 3600 ha was divided into 36 grids of 1 km ×1 km size. Detail information on water sources, soil characteristics was collected. Nearly 65 water harvesting structures, 19 creek sections were identified through survey of India toposheets and GIS analysis. The length of creeks within the study area varied between 0.43 to 23 km. The capacity of the water harvesting structures varied within 823-3568 m^2 with average capacity of 1800m^2. Two representative water harvesting structures (980m^3 and 1200 m^3) were identified in Sunity East village. The depth-capacity curves were plotted based on the water level during different months of the year. It showed that out of 52 standard weeks, the structures remained dried between 14^{th} (March) to 28^{th}(July) week *i.e.* during summer season. The structures remained almost full capacity during monsoon and post monsoon period. The water availability in these structures was directly related to water availability in nearby creeks.

Rainfall and runoff analysis

Rainfall data of 21 years (1994 to 2014) showed that average annual rainfall and runoff of Kendrapara is 1507mm and 510mm respectively with 59 numbers of rainy days. Season wise rainfall-runoff analysis (Table 12) showed that monsoon months received 73% of annual rainfall. Nearly 69% of total annual flow was during monsoon season only. Suitable control structures at appropriate locations could minimize the runoff in these coastal areas.

Table 12 Season wise rainfall/runoff analysis of Kendrapara (1994-2014)

Season	Minimum, mm		Maximum, mm		Average,mm		% contribution to annual, %		Standard Deviation, mm		Coefficient of variation	
	Rf	Ro	Rf	Ro	Rf	Ro	Rf	Ro	Rf	Ro	Rf	Ro
Pre-monsoon	36.0	0.9	513.0	349.8	109.4	49.9	7.3	9.8	103.4	76.4	0.9	1.5
Monsoon	462.0	71.4	2130.0	963.1	1096.1	350.3	72.7	68.6	411.7	211.9	0.4	0.6
Post-monsoon	15.0	0.0	760.0	567.1	284	108.0	18.8	21.2	230.9	134.0	0.8	1.2
Winter	0.0	0.0	109.0	41.8	17.1	2.3	1.1	0.5	25.5	8.9	1.5	3.9

Rf: Rainfall, Ro: Runoff

Soil and water quality analysis

Grid based soil samples (0-15 cm) were collected from 20 locations and were analyzed for textural classes (Fig. 16). The clay was the dominating soil with clay content of 48 to 65% in the study area. The soil moisture characteristics curves were plotted for 0.033, 0.1, 0.2, 0.3, 0.5, 1.0 and 1.5 MPa with pressure plate apparatus. Soil profile (top soil of 0-15 cm) information of 20 representative sites showed that soil water held at 0.033 MPa (field capacity) and 1.5 MPa (permanent wilting point) varied between 0.301 to 0.579 and 0.132 to 0.213 m^3m^{-3} respectively. The bulk density of top soil ranged between 1.1 to 1.6 with mean of 1.3 g m^{-3}.

Spatio-temporal variation (Fig.16) in water quality from both surface (creek) and subsurface (hand operated bore wells) showed that creeks get water has higher salinity (EC of 6 to 27dSm^{-1}) from March onwards upto monsoon season. The pH of tubewell water (hand pump operated) was comparatively higher than the surface water (Creek) in almost all seasons. EC of shallow groundwater wells (20-40m) was higher than the deeper wells with more than 100m depth (Fig.17). It was also observed that pH of groundwater samples were slightly alkaline (7.43 to 7.88) along the coast line, whereas it ranged within 6.48 to 7.12 in other areas of Sunity during pre-monsoon season. Electrical conductivity (EC) varied between 1 to 3.42 dSm^{-1} and EC ranged between

2.62 to 3.42 dSm^{-1} in areas where creek density (number of creeks per unit area) was higher.

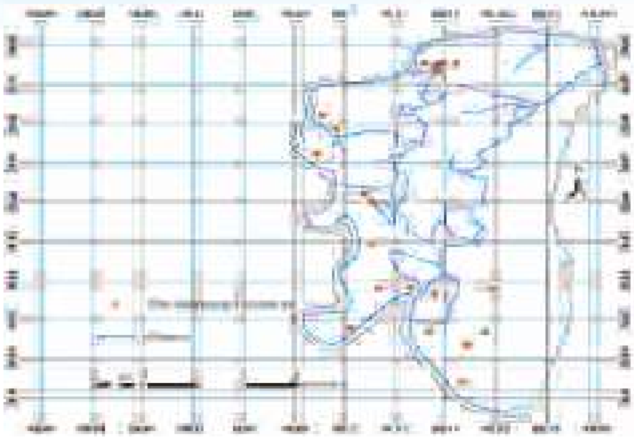


Fig. 16Soil sampling locations and creek sections in the study area

Periodical analyses of water quality revealed a sharp increase of EC and SAR from post-monsoon (October) to summer (March) and pre-monsoon (June) periods irrespective of sources. The EC of creek water enhanced in a tune of 1.4 to 151 times and SAR from 1.02 to 32.62 times. The Ca/Mg ratio however decreased in most of the samples from post to pre-monsoon periods, which might be attributed to increasing concentration of Mg in samples over the periods. An increasing trend of EC in a range of 1.14 and 19.83 and SAR from 1.11 to 5.1 without any consistent trend was noticed in bore well samples. Overall, the Ca/Mg ratio ranged from 0.14 to 2.64, with a relatively low value registered during post-monsoon period. Considering EC and SAR, 62% creek and 11 to 55% bore well samples were found suitable for irrigation during summer and pre-monsoon period although 100% suitability was observed during post-monsoon period.

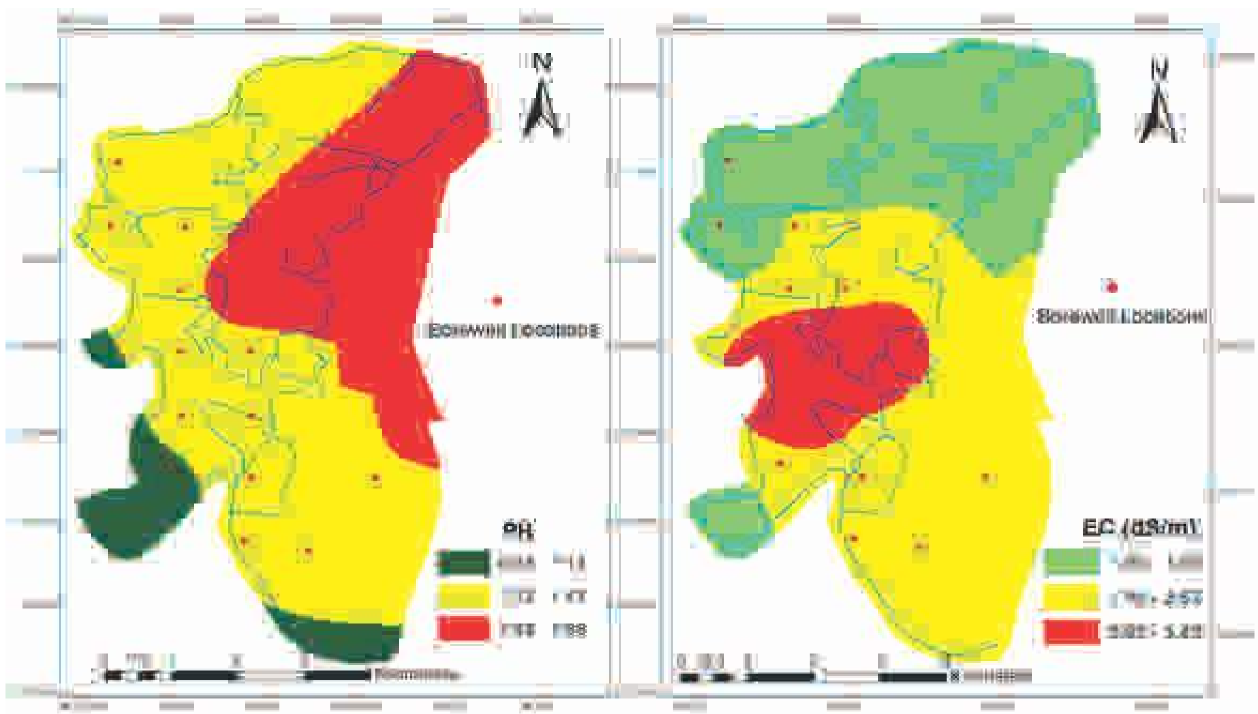
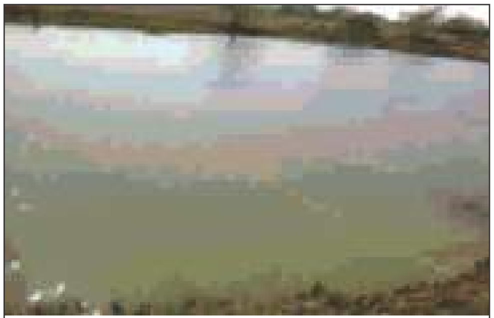


Fig. 17 Spatial variation in groundwater quality of study area during June 2014

Creek hydraulics

Velocity of water was measured at different segments of Sunity creek during May 2014 (Summer), November 2014 (post monsoon) and January 2015 (winter) with a current meter. It was observed that most of the creeks remained dry during summer season and the water quality was not suitable for irrigation purposes due to high electrical conductivity. During monsoon season, all the creeks flow with the full capacity. During November 2014, water velocity measured from 11 segments of Sunity creek varied within 0.28 to 0.43 m sec^{-1} with a mean of 0.34 m sec^{-1}. During January 2015, the water velocity measured from 34 segments of Sunity creek varied within 0.17 to 0.41 m sec^{-1} with mean of 0.31m sec^{-1}. Top width was measured from different segments of the creek and based on the design slope (1:1.5), bottom width was calculated. Hence discharge/flow of water in different segments of Sunity creeks was calculated. Then crop planning for the study area was proposed based on fresh water availability in different season. A sluice structure was designed in collaboration with Department of Water Resources, Govt of Odisha in the mouth of Sunity creek (Mahakalapada block, Kendrapara district) to control drainage and check saline water entry into the creek. The design discharge was 25 $m^3 sec^{-1}$, with a catchment area of 2000 ha. The structure will be operational from monsoon season (June 2015) onwards.

Measurement velocity of water by current meter in Sunity creek at different sections (November 2014)



Measurement of top width of Sunity creek at different sections (January 2015)

Project Title : **Impact of Wastewater Use on Soil Properties and its Prospect of Utilization in Crop Production**

Project Code : DWM/11/152

Funding Agency : Institute

Project Personnel : Madhumita Das, O.P. Verma, A.K. Nayak and R. R. Sethi

A. Impact of paper mill effluent application on soil properties

Soils, leached with paper mill effluent (PME of COS Board Industries Ltd., Jagatpur, Odisha) at constant head method in laboratory, followed by washing with water after attaining the equilibrium, were analyses for important characteristics. There was a sharp fall of EC from pre- to post- washing of PME leached soils from 15 to 166% more so in sandy loam red and lateritic, and red and yellow soil types (Table 13). Lowest reduction was observed in fine textured alluvial soil. Potassium and Mg concentration also showed a decreasing trend. A declining trend of organic C, NO_3-N and P concentrations was evident at post-washed PME leached soils. But micronutrient (Zn, Cu, Fe and Mn) concentrations did not show significant change before and after washing of PME leached soils. Therefore without having any negative impact on soil, paper mill effluent (from COS Board Industries) could be a supplementary source of irrigation for acidic to neutral, non-saline soils in humid to sub-humid regions.

Table 13 Soil fertility parameters before and after washing of paper mill effluent (PME) leached soils

Soil type	pH	EC (dS m^{-1})	Org. C (%)	NO_3-N (%)	Exchangeable cations (meq per 100 g)			Available P (mg kg^{-1})
					K	Ca	Mg	
Red & lateritic soil								
PME leached	6.07	0.16	0.71	0.083	0.44	4.28	1.90	148.3
After washing of PME leached	6.30	0.06	0.34	0.012	0.40	4.28	1.43	147.6
Red & yellow soil								
PME leached	5.89	0.15	0.66	0.075	0.35	4.76	3.81	111.7
After washing of PME leached	6.05	0.11	0.48	0.011	0.29	4.28	3.57	96.2
Alluvial - sandy loam soil								
PME leached	7.18	0.11	0.68	0.041	0.22	3.81	3.33	263.1
After washing of PME leached	7.15	0.09	0.74	0.048	0.25	5.24	2.14	268.8
Alluvial - sandy clay loam soil								
PME leached	6.37	0.15	1.06	0.022	0.31	11.42	5.47	356.8
After washing of PME leached	6.21	0.11	0.99	0.028	0.27	9.99	6.66	193.3

B. Water quality at the surroundings of breweries, paper mill and distillery units in Odisha

Water samples, mainly collected from surface (pond, canal and drain) and groundwater (open dug and bore well) sources during pre-monsoon period i.e. mid-April to last week of May were analysed for pH, EC, Na, K, Ca, Mg, Cl, SO_4, HCO_3, CO_3, NO_3, Zn, Cu, Fe and Mn. No traces of nitrate, Cd and Cr were found in collected samples.

Khurda: Twenty water samples (six from surface and fourteen from groundwater sources from a depth of 9 to 90 m) were collected from in and around United Breweries Limited, Khurda. Using Piper tri-linear diagram the samples were found to be represented by Ca-Na-Mg-HCO_3-Cl (45%) > Na-Ca-Cl-HCO_3 (30%) > Na-Cl (15%) with meagre appearance of Na-Cl-SO_4-HCO_3 and Ca-Na-Mg-Cl hydrochemical facies types. Calculation of Gibbs ratio I and II and its variation with TDS (mg l^{-1}) revealed that the dissolution of minerals from host rocks due to weathering is the main reason for chemical make-up of water irrespective of sources. The 1:1 diagram of Na+K versus Cl indicates that all Cl ions were balanced by Na+K except in 30% samples (Fig. 18). Deviation of samples from 1:1 equiline of Ca+Mg versus HCO_3+SO_4 further supported the presence of chloride salts other than Na or K. However, considering the standard water quality guidelines for irrigation and drinking, all water samples were found to be of good quality and no effect of breweries wastewater on the water samples were evident.

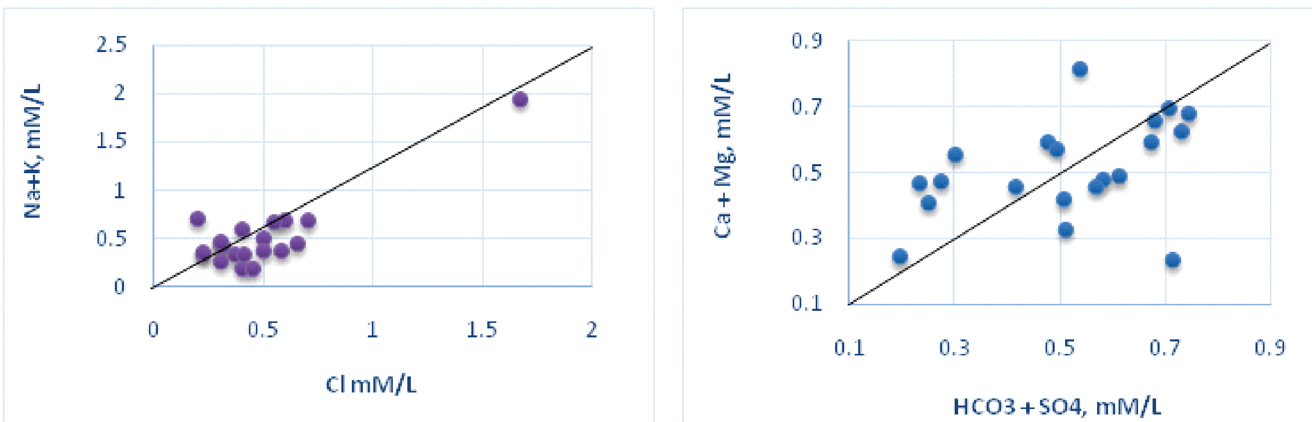


Fig. 18 Distribution of Na+K and Ca+Mg against Cl and HCO_3+SO_4 in Khurda water samples

Jagatpur: Twenty one water samples (six from surface and fifteen from groundwater sources) were collected from the surroundings of COS Board Industries Ltd., Jagatpur, Cuttack, Odisha. As per the concentrations of major ions the samples are represented by Na>Mg>Ca>>K and Cl>HCO_3>SO_4. Distribution of ions in Piper tri-linear diagram revealed that 33% samples are represented by Mg-Ca-HCO_3, 29% by Mg-Ca-HCO_3-Cl, 9% each by Mg-Na-Cl-HCO_3 and Mg-Ca-Na-HCO_3-Cl and mixed hydrochemical facies like Ca-SO_4-HCO_3, Mg-Na-Ca-Cl, Na-HCO_3-Cl-SO_4 and Mg-HCO_3-SO_4 types. Around 19% samples deviate from 1:1 equiline of Na+K against Cl (Fig. 19) that presumably indicates that halite dissolution is the primary process for Na and Cl contents in water. Illustration of data in Gibbs diagrams subsequently indicated the prevalence of rock dominance for dissolution of aquifer minerals. The influence of industrial discharge on water quality was not evident.

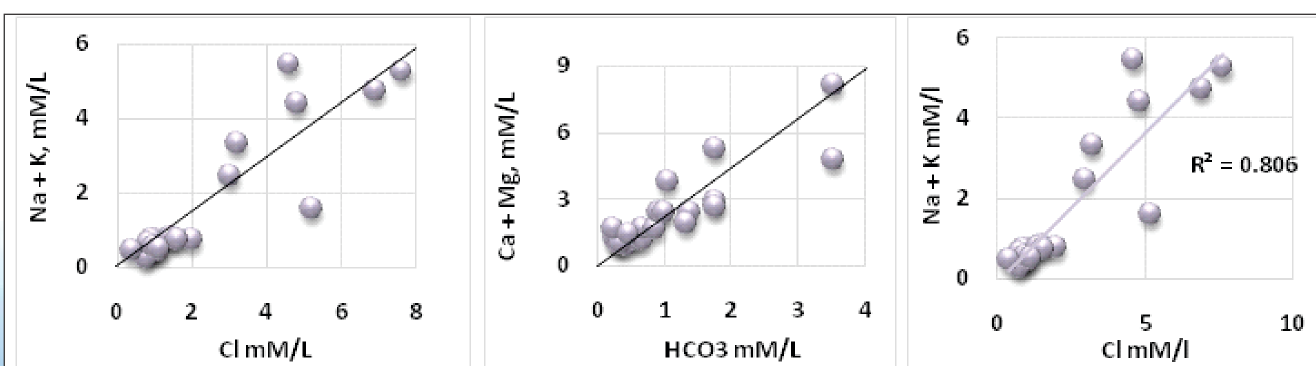


Fig. 19 Relative distribution of relevant ions and their relations in Jagatpur water samples

Haripur: Nineteen water samples (two from surface and seventeen from groundwater sources) from depth of 9-90 m were collected in and around Sakthi Sugars Limited, Haripur, Dhenkanal. Samples were dominated by Na>Ca>Mg>>K and Cl>SO_4>HCO_3 based on concentration. Using Piper tri-linear diagram, 21% waters are found to represent by each of Ca-Na-HCO_3-Cl, Na-Ca-Cl-HCO_3 and Na-Cl-HCO_3 with meagre presence of mixed hydrochemical facies types viz. Ca-Cl-HCO_3, Ca-Mg-Na-Cl, Na-Cl-HCO_3-SO_4, Na-Cl and Na-Cl-SO_4-HCO_3. Distribution pattern of samples in Gibbs diagrams reveals that in 50% samples, dissolution of minerals from weathering of rocks is a major factor while evaporation is the dominant cause of water chemistry in rest 50% samples. Without showing excess salt (EC), K, Mg, Mn, SO_4, NO_3 and phosphate concentration as observed in distillery effluent of Sakthi Sugars Ltd, all the samples are found suitable for use in irrigation and drinking as well.

Pandua: Twelve water samples (three from surface and nine from groundwater sources) were collected from the surroundings of farmers' fields where Sakthi Sugars Limited distillery effluent were used for rice crop at Pandua village in Kamakhyanagar block of Dhenkanal district. The depth of groundwater varied from <17 to 67 m. As per presence of major ions the samples were represented by NaCa>Mg>>K and SO_4>Cl>HCO_3. Analyses reveal that 42% samples were of Mg-Ca-Cl-SO_4, 25% were Mg-Ca-HCO_3-SO_4-Cl, 16% are Mg-Na-Ca-HCO_3-Cl and mixed hydrochemical facies types (Na-SO_4-HCO_3-Cl, Mg-Cl-HCO_3). Rock dominance was found as major process to determine water chemistry in 83% samples in Gibb's diagram. Illustration of Na+K against Cl reflected that 42% samples deviate from 1:1 equiline, samples below the equiline indicate the contribution of cations other than Na+K (Fig. 20). Positive values of CA I and CA II subsequently revealed the predominance of base exchange phenomenon for determining ionic constituents in water samples. All the collected water samples were found good in quality for their use in irrigation or drinking purposes and there was no effect of industrial effluent on surrounding water bodies.

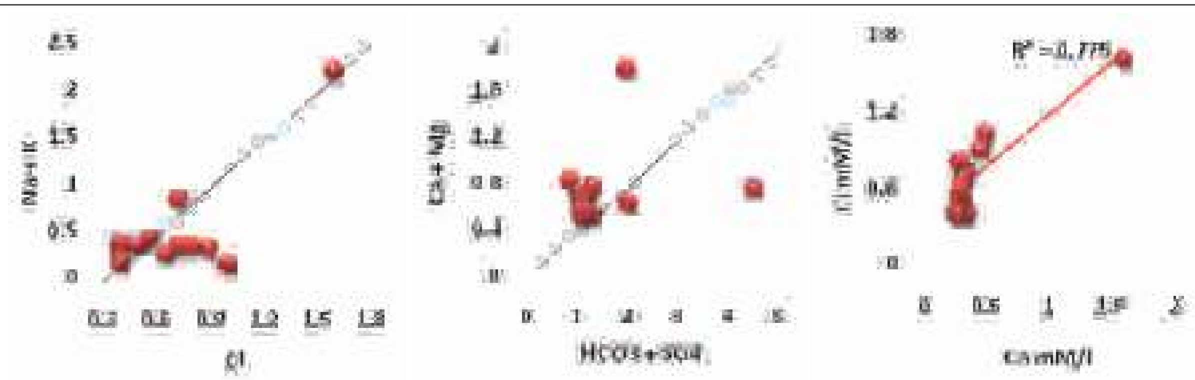


Fig. 20 Relative distribution of relevant ions and their relations in Pandua water samples

Project Title	: **Decision support system for enhancing water productivity of irrigated rice-wheat cropping system**
Funding Agency	: NFBSFARA, ICAR, New Delhi
Project Personnel	: Ranu Rani Sethi, K.G.Mandal, Ashwani Kumar, S.K. Ambast, Rajan Agrawal and A.S. Brar

Delineation and estimation of rice-wheat cultivated areas for Punjab

Rice-wheat cropping area was delineated for the state of Punjab using remote sensing and GIS. Landsat ETM+ and IRS LISS III data with maximum likelihood classifier approach in image classification were used for delineation of crop coverage in the study area. District wise rice area cultivated, wheat area cultivated, area under rice-wheat sequence, and total rice and wheat area (including the area under rice-wheat sequence) were estimated for Punjab. Trend analysis on rice and wheat areas for the period of 1995 to 2011 showed no noticeable variation in terms of crop coverage areas. It was estimated that rice and wheat areas covered around 2.70 and 3.51 million ha, respectively. Areas under rice-wheat crop sequence were 2.05 million ha, which is around 49% of state's total cultivated area. Similarly combined rice-wheat cultivated areas were estimated as 4.16 million ha which more than 90% of cultivated areas.

Spatial analyses on effective rainfall distribution for Agro Climatic Region (ACR-VI)

District-wise average pre-monsoon (March-May), monsoon (June-September) and post-monsoon (October-December) effective rainfall was calculated for 46 districts under the ACR VI. Effective rainfall was estimated by using FAO CROPWAT model (Fig.21). Effective rainfall during monsoon period varied between 27 and 466 mm in the study area but the rice-wheat areas received an effective rainfall between 230 and 466 mm. Rice is the major crop during *kharif* season and the water requirement of *kharif* rice in Punjab and Haryana is about 1200 mm. Thus only rainfall is not sufficient to meet the crop water requirement. Supplimental irrigation from other water resources would be required to meet full requirement. Similarly, effective rainfall during pre-monsoon and post-monsoon varied from 7 to 64 mm and 3 to 32 mm, respectively. Majority of the area was dominated by wheat crop during *rabi* season (post-monsoon). It reveals that effective rainfall during *rabi* season ranged from 3 to 32 mm for rice-wheat cropping system in ACR-VI (Fig 21).

Irrigation scheduling based on rainfall analysis for Ludhiana

Rainfall analysis of 43 years (1974-2013) for Ludhiana showed that average annual rainfall was 754 mm within 39 rainy days. Weekly rainfall was computed and used for initial, conditional and consecutive dry and wet spell analysis based on Markov chain probability model; 20-mm or more rainfall in a week was considered as wet week otherwise, it was considered dry. Literature revealed that water requirement of rice in Ludhiana is about 1200 mm during crop growing period. Hence, apart from effective rainfall, additional about 600 mm water needs to be supplemented through irrigation. Rice growing period coincides with standard meteorological week (SMW) of 26 to 43. The probability of getting wet week during SMW 28 to 33 is 50-80% i.e., mostly wet and additional irrigation is not required. But supplemental irrigation would be required during initial, mid-development stage and maturity stage as the probability of getting wet week is less than 50%.

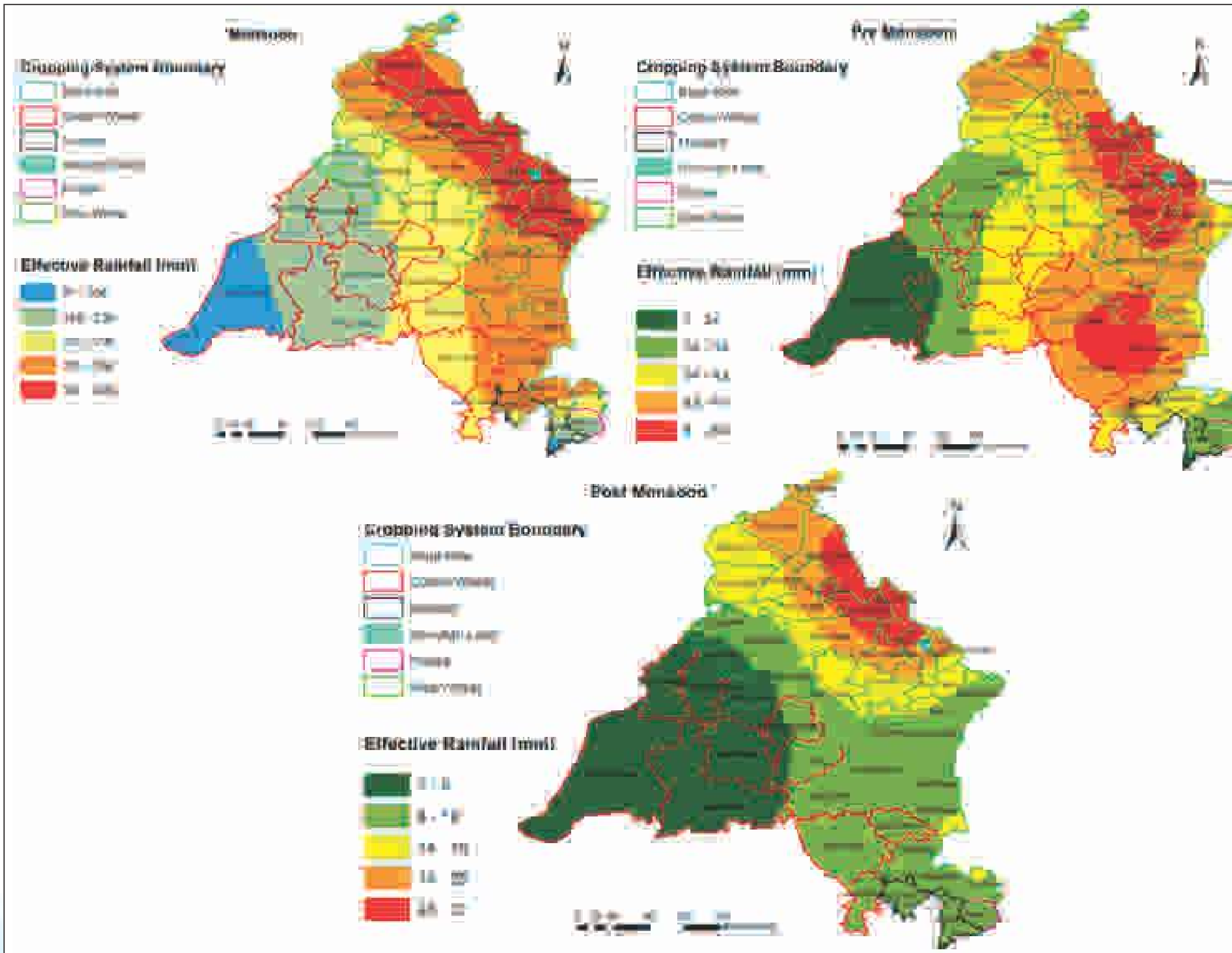


Fig. 21 Effective rainfall distribution in 46 districts under Agro Climatic Region (ACR-VI) during pre-monsoon, monsoon and post-monsoon in different cropping systems

A field experiment was conducted on rice at the research farm of Department of Agronomy PAU, Ludhiana during *kharif* season, 2014 and the data was used in the decision support system models. The maximum grain yield of rice was recorded from transplanted paddy (TP) which was statistically at par with SRI but significantly higher than direct seeded rice (DSR, Table 14). However, irrigation water applied was the lowest in DSR, which resulted in the highest water productivity. Among three cultivars Pusa 44 gave the highest and significantly higher grain yield than other two cultivars, however water productivity was maximum and significantly higher in PR 122 than Pusa 44 and Pusa 1121 (Table 14).

A view of the rice experiment site at Research Farm of PAU, Ludhiana

Parshall flume installed for measurement of irrigation water

Table 14 Effect of different rice establishment systems and irrigation schedules on grain yield and water productivity of rice cultivars during 2014

Treatments	Grain yield ($t\ ha^{-1}$)	Irrigation water (cm)	Irrigation water productivity ($kg\ ha\ mm^{-1}$)
Rice established system			
DSR	5.37	97.90	5.56
TP	5.90	111.60	5.34
SRI	5.58	103.00	5.47
LSD (P=0.05)	0.37	-	NS
Cultivars			
Pusa 44	6.82	116.50	5.70
PR 122	6.26	103.50	6.16
Pusa 1121	4.09	92.50	4.50
LSD (P=0.05)	0.23	-	0.23
Irrigation			
Full irrigation	5.73	119.00	4.78
Deficit irrigation (25% deficit)	5.51	89.30	6.13
LSD (P=0.05)	0.18	-	0.18

The field experiment was continued during *rabi* season 2013-14 by growing wheat crop in DSR , SRI and TP grown plots. Results indicated that wheat crop after DSR produced statistically higher grain yield as compared to that grown after TP or SRI, which resulted in significantly higher water productivity (Table 15). Full irrigation resulted in significantly more yield than deficit irrigation. All three cultivars produced statistically similar grain yield. Water productivity was statistically more in DSR plots and was significantly higher in deficit irrigation, but it did not differ significantly among different varieties.

Table 15 Effect of different rice establishment systems, varieties and irrigation on grain yield and water productivity of wheat 2013-14

Treatments	Grain yield ($t\ ha^{-1}$)	Total water used* (mm)	Irrigation water (mm)	Irrigation water productivity** ($kg\ ha\ mm^{-1}$)
Rice establishment systems				
DSR	6.23	343.1	245.7	25.6
SRI	6.03	343.1	245.7	24.8
PTP	5.97	343.1	245.7	24.5
LSD (P=0.05)	0.18	--	--	0.7
Cultivars				
HD 2967	6.12	343.1	245.7	25.1
PBW 621	6.08	343.1	245.7	25.0
DBW 17	6.03	343.1	245.7	24.8
LSD (P=0.05)	NS	--	--	NS
Irrigation				
Full irrigation	6.15	366.9	270.0	22.8
Deficit irrigation (25% deficit)	6.00	318.2	221.3	27.1
LSD (P=0.05)	NS	--	-	0.6

*Total water used is effective rainfall plus irrigation water applied; **Irrigation water productivity is the ratio of yield to irrigation water applied: NS, non significant.

Project Title : **Design and Development of Small Filters for Reducing Contaminants in Poor Quality Water at Farmers' Level for Safe Irrigation in Peri-urban Areas**

Project Code : DWM/13/161

Funding Agency : Institute

Project Personnel : M. Raychaudhuri, R.C. Srivastava, S. Raychaudhuri and Ashwani Kumar

Urban wastewater contains considerable amount of cadmium (Cd) and other heavy metals. This wastewater is used for irrigation to crops grown in the peri-urban areas near Bhubaneswar. Trace elements are essential for plant growth and required in small quantity. However, their excess accumulation in plant tissues may lead to heavy metal toxicity. Wastewater is generated from households, hospitals, small scale industries, schools, Infocity etc. and is drained through Patia drain in Bhubaneswar. Water samples from Patia drain was collected in bulk and analysed for physico-chemical characteristics and showed the presence of Cd beyond permissible limit.

Chemical characteristics of the Patia drain wastewater

The pH ranged from 6.73 to 6.98. The range of EC and DO was 0.42 to 0.49 dS m^{-1} and 0.21 to 0.35 mg l^{-1}, respectively. Bicarbonate alkalinity (4.40 to 5.20 meq l^{-1}) was present. There was no carbonate alkalinity in the samples. The Na, K, Ca and Mg content ranged from 1.75 to 1.88, 0.37 to 0.42, 0.4 to 0.6 and 0.4 to 0.7 meq l^{-1}, respectively. The phosphate and sulphate ranged from 0.10 to 0.31 and 0.025 to 0.034 meq l^{-1}, respectively; ammonia and nitrate content was 4.5-5.0 and 0.08-0.17 meq l^{-1}, respectively. The concentration of some trace elements and heavy metal were: Fe 1.45-1.61 ppm, Cu 1.22-1.46 ppm, F 0.06-0.31 ppm, Pb 0.77-0.91 ppm, phenol 0.27-0.49 ppm, Cd 0.15-0.18 ppm, Cr 0.15-0.18 ppm. The concentration of Cu, phenol, Cd and Cr were higher than the recommended maximum; Fe, F and Pb are within the permissible limit as per guidelines for irrigation water quality.

Design of a small scale filter

Some coarser materials viz. granite, gravels, sand, quartz sand, coconut and jute fibres were tried for use as filter. These materials are locally available, inexpensive, simple and easy to use. Column study was conducted using these coarser materials to evaluate the most suitable one for reduction of sediment and microbial load. Coconut shell charcoal (CSC) was prepared under anaerobic condition and was modified by increasing the pH to increase its adsorption efficiency. Batch test was carried out with varying concentration of Cd (0.1-1.0 ppm) to determine the efficiency of CSC and modified CSC (mCSC) to reduce the concentration of contaminants *viz*. Cd, Fe and Mn to a safe level. Models were developed on Cd adsorption by CSC and mCSC using the Langmuir and Freundlich isotherm. The laboratory results suggested that a combination of gravel, quartz sand particles (<2 mm) and jute fibre could reduce the sediment and microbial load. The coconut shells were burnt to form charcoal, which could remove Cd from wastewater economically. The filter was designed (Fig. 22) for online use in irrigation with suitable material after being tested in the laboratory. As the design of filter is patentable the components used in the filter is expressed as a, b, c and d and their size/ volume and thickness are presented in Table 16.

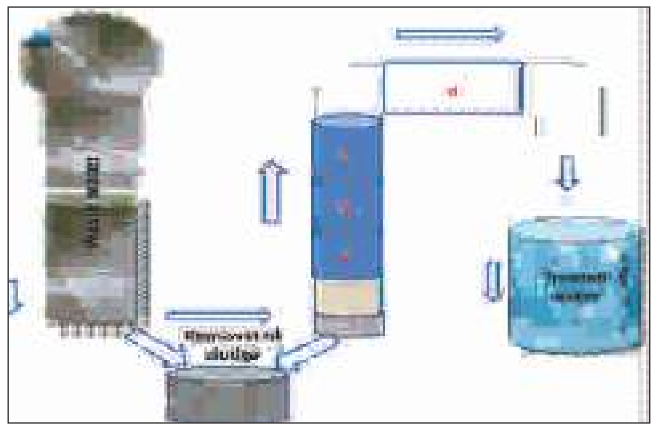
Table 16 Design of a filter using suitable components

Material	Size/volume	Thickness (cm)
a	9.5 - 15.5 mm	15
b	0.6 - 2.0 mm	15
c	663 cm^3	15
d	1326 cm^3	30

Hydraulic behaviour and flow efficiency of the developed filter

The developed filter was tested through an open flow with a head of 1 m. The discharge was 1 liter min^{-1} with 100% efficiency to remove sediment and Cd. Further, the filter was modified by increasing the size of finer particles and the discharge was increased with 1 HP pump and the output flow was 0.5 litre s^{-1} with 50% efficiency. However, further testing is under progress to estimate the head loss due to filter.

Six simulated wastewater samples with varying sediment, heavy metal and trace element content were tested to evaluate the efficiency of the designed filter. With a head of 1 m and discharge of 1 litre min^{-1} it was observed that the pH of water samples increased significantly (Fig. 23). When it was tested with varying concentration of Cd in water samples the efficiency increased to 96.9% (Fig. 24). With increasing the discharge rate to 0.5 l s^{-1} the efficiency of filter was 60 and 82.5% in reducing sediment and Cd, respectively.



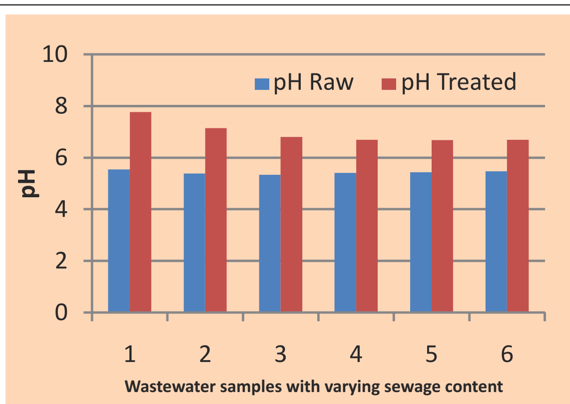


Fig. 23 Changes in pH of wastewater after filtering through designed filter

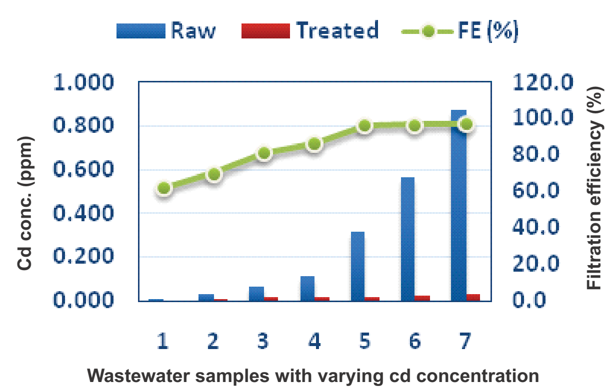


Fig 24. Filter efficiency of the designed filter to remove Cd

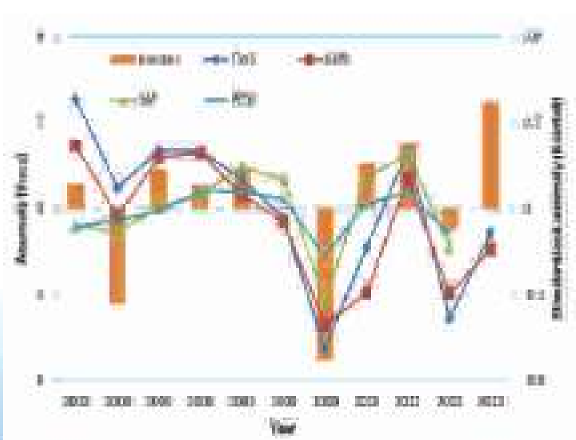
Evaluating the hydraulic behaviour and efficiency of the designed filter by using 1 HP pump

Project Title	:	**Impact of Climate Variability and Anthropogenic Factor on Groundwater Resources of India**
Project Code	:	Funded project
Funding Agency	:	ICAR Challenge Research Project associated with LBS Award, 2011
Project Personnel	:	D.K. Panda

The time series based on hydrological year (starting from June and ending with May of following year, Fig. 25) indicated that most of the water storage depletions, both terrestrial water storage (TWS) and groundwater storage (GWS), have occurred during the 2008-2010 period, consistent with a drop in monsoon rainfall, soil moisture (SM), palmer drought severity index (PDSI), and exacerbated by a string of high temperature anomalies. In general, influence of the drought years 2004, 2009 and 2012, with consequent vegetation losses (normalized difference vegetation index, NDVI) (Fig. 25) and a fall in food grain production of India, were very well captured by the Gravity Recovery and Climate Experiment (GRACE) records in the spatiotemporal context (Fig. 26), though overall correlation of rainfall with TWS and GWS are 0.63 ($p< 0.05$) and 0.57 ($p< 0.07$), respectively. It is pertinent to mention that the largest GWS loss of about 4.5 cm occurred in 2009, one of the worst drought years of last century. The mean water table from observation wells in the north Indian Indo-Gangetic region showed a declining rate of 0.11 m yr^{-1}, as reflected through of negative TWS anomalies in north India, particularly since 2009 (Fig. 26).

To assess whether the groundwater storage loss is due to drought or anthropogenic withdrawal, version 4.5 of the Community Land Model (CLM4.5) was used, which captured the naturally varying groundwater component. It is evident that CLM4.5 groundwater is significantly correlated with rainfall (r= 0.75), PDSI (0.76), NDVI (0.68) and CLM4.5 SM (0.82), but was least correlated with the GRACE-derived TWS (0.13) and GWS (0.08). This suggested that the significant groundwater storage losses at the rate of 0.57 cm per year, accelerated particularly with the onset of the drought 2009. This could be attributed to the combined influence of a drying monsoon climate and the anthropogenic factor. For example, in the backdrop of a normal monsoon rainfall in 2010, GWS showed a country-wide decline of 2.93 cm and a decline of 6.9 cm in the Indo-Gangetic north India (Fig. 26). Although north India experienced a deficit rainfall in 2010, a surplus of surface vegetation index (NDVI) suggest the anthropogenic withdrawal of groundwater is maximum in that year to meet the water requirement of crops, that led to a food grain production of about 240 million tonnes, exceeding that of previous years.

Tank-cum-well system of 80 m length, 60 m width and 2 m depth, with a harvested volume of 10,000 m^3 during the monsoon season of 2014



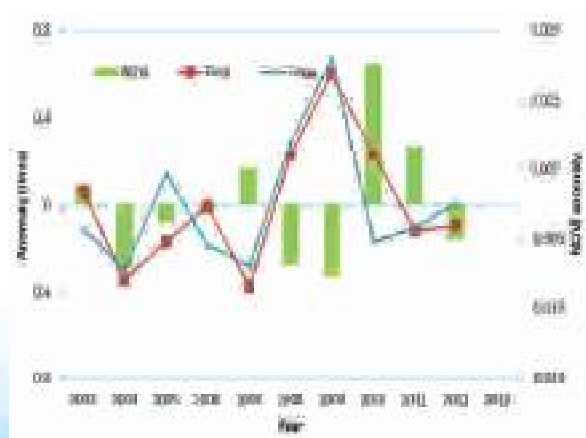


Fig. 25 Hydroclimatic and vegetation (NDVI) correspondence depicting clearly the influence of extreme events.

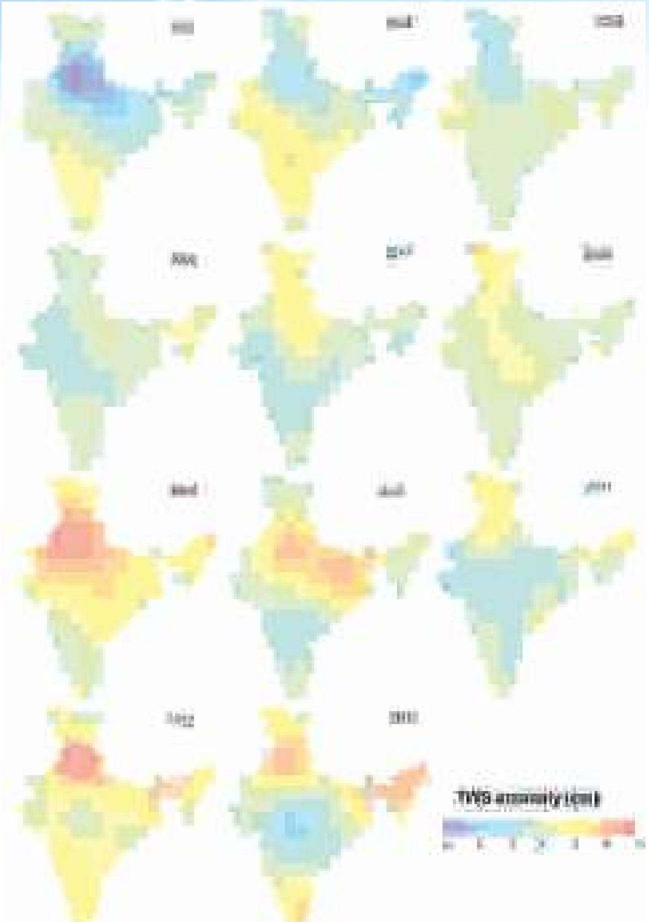


Fig. 26 Spatial evolution of terrestrial water storage (TWS) changes in each of the hydrological year during 2003 to 2013.

In order to create awareness for the groundwater users of an overexploited aquifer in lower Subernarekha River basin of north Odisha, a tank-cum-well system was created for storing surface water and using it for irrigation during dry spell. Moreover, to improve the water productivity, fish farming was taken up and showed a growth of about 450 gram of individual fish within a span of 3 months.

Project Title	:	**Development of decision support system for conjunctive use of surface and ground water**
Project Code	:	DWM/14/165
Funding Agency	:	Institute
Project Personnel	:	O.P. Verma, R.C. Srivastava, R.R. Sethi and A.K. Nayak

As a supplementary source for surface water, groundwater stabilizes the fluctuations in surface water availability. During wet season, the surface reservoirs capture large flows when water cannot be used productively because of low irrigation demand. Whereas in dry season, the groundwater is used to offset the deficit in surface water supplies. Therefore, modeling in the field of water resources is of prime importance where some of the components of water sources cannot be measured accurately. Hence, optimization of water availability from different sources to enhance land and water productivity is necessary. A model development was attempted through computer programme, creation of an objective function, coefficient of variable and RHS values of the constraints along with the sign of ≤ or ≥. These data would be recorded/created in an excel file. The number of variables and constraints can be any value only to be limited by

Table 17 Crop calendar of different crops

Crop	Months (Sowing to harvest)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Kharif rice						■	■	■	■	■	■	
Rabi rice	■	■	■	■								■
Kharif maize						■	■	■	■			
Rabi maize	■	■	■									■
Groundnut	■	■	■									■
Potato	■	■	■									■
Green gram	■	■										■
Tomato	■	■	■									■
Lady's finger	■	■	■	■	■							■
Chilli	■	■	■									■

computing capacity of the processor. This makes the model open ended to include all the local factors. Presently, >100 variables with all possible constraints have been formulated taking care of different types of water sources i.e. canal/groundwater, and ponds along with different crops at different irrigation levels. Another part of the model is standard linear program of SAS software for which the excel file would serve as input. A crop calendar was developed with a suitable crop plan depending on water availability (Table 17). Water requirement of different crops like rice, groundnut etc. was also estimated.

Project Title	:	**Portable Drum based Drip Irrigation System for Sub-marginal Farmers**
Project Code	:	IIWM/15/167
Funding Agency	:	Institute
Project Personnel	:	R.C. Srivastava, S. Mohanty, P.K. Panda and D.U. Patil

This project was initiated with objective of developing a design of gravity fed drip system for sub-marginal farmers having water resource away from their field. The system was felt necessary to reduce the drudgery of the farmer carrying water in bucket and watering plants with pots. The initial design was further modified by adding bearings as well as changing the design of handle to push the system with addition of one air vent.

The system was evaluated in an orange orchard of 12 trees with two pressure compensating drippers of 4- and 2 lph discharge. The discharge with 2 lph was found quit low and it was satisfactory with 4 lph dripper. The discharge from 6 alternate drippers was measured after 5, 20 and 35 minutes. Based on these evaluation parameters mentioned in the table 18 were estimated and were found within limits.

Portable drum based on an elevated platform to irrigate 12 orange trees

Table 18 Evaluated parameters of performance of portable drum based drip irrigation system

Parameter	5 min	20 min	35 min
Average discharge(lph)	1.66	1.47	1.47
Reduction in discharge of initial discharge (%)		11.57	11.57
Manufacturer's coefficient of variation	5.53	5.56	6.43
Uniformity coefficient	0.90	0.90	0.90

Waterlogged Area Management

- Eco-efficient Agricultural Practices for Enhancing Nutrient Use Efficiency of Rice (*Oryza sativa*) under Waterlogged Ecosystem
- Identification of Suitable Crops for Wastewater Irrigation
- Delineation of Waterlogged Areas in Eastern India and Formulating Strategies for Fitting in Suitable Crops and Aquaculture through Harnessing Agro-biodiversity for Enhancing Water Productivity
- Global Yield Gap and Water Productivity Atlas (GYGA)
- Development of Agriculture Water Management Portal (AWMP)

Project Title	:	**Eco-efficient Agricultural Practices for Enhancing Nutrient Use Efficiency of Rice (*Oryza sativa*) under Waterlogged Ecosystem**
Project Code	:	DWM/12/163
Funding Agency	:	Institute
Project Personnel	:	P. S. Brahmanand, S. Roy Chowdhury and A. Kumar

Field experiment was conducted during *kharif* season for the second year at the farmers' field in a village Balisahi under Pipli block of Puri district of Odisha to study the performance of rice under waterlogged ecosystem with different nutrient treatments. The experimental design was split-split plot having three replications with two main-plot treatments of depth of water logging *i.e.* submergence with 10-25 cm and 25-50 cm, two sub-plot treatments of method of fertilizer application (broadcasting and band placement), and five sub-sub plot treatments of type of N fertilizer [control, N application @ 60 kg ha^{-1} through urea alone, nitrification inhibitor i.e. dicyandiamide (DCD), neem coated urea (NCU) and through urea coated with leaf extract of *Azadirachta indica* and *Pongamia pinnata*]. The leaf extracts of *Azadirachta indica* and *Pangamia pinnata* were used as they have the property to deter the rate of release of nitrogen due to alkaloids *viz*. azadirachtine and karanjin, respectively. The residual effect of nutrient application was monitored for *rabi* season crops namely groundnut, greengram, potato and rice.

A view of groundnut field at Balisahi village, Puri district during *rabi* season, 2013-14

A view of experimental rice field at Balisahi village, Puri district during *kharif* season, 2014

The growth parameters like plant height, tiller number, leaf area index and dry matter accumulation were higher at shallower submergence, band placement and N application @ 60 kg ha^{-1} through DCD. Plant height, tiller number and dry matter accumulation was greater with shallow submergence (10-25 cm) compared to medium level of submergence (25-50 cm); band placement of N @ 60 kg ha^{-1} was found to be more effective than broadcasting of N fertilizer. The same trend continued up to physiological maturity of rice plants. This has resulted in superior yield attributes such as panicle number and filled grains per panicle; consequently greater grain yield of rice was obtained with these treatments. Significantly higher grain yield (3.68 t ha^{-1}) was noticed at shallower submergence (10-25 cm) compared to intermediate level of submergence (25-50 cm) (3.38 t ha^{-1}; Fig. 27) and band placement of N @ 60 kg ha^{-1} gave significantly higher grain yield (3.64 t ha^{-1}) compared to broadcasting of N fertilizer (3.42 t ha^{-1}; Fig. 28).

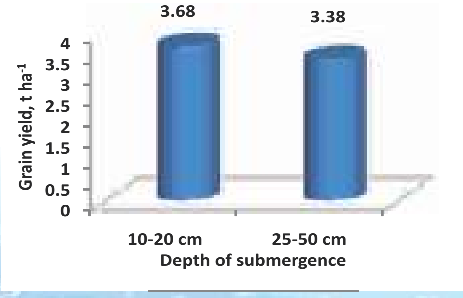


Fig.27 Grain yield of rice as influenced by level of submergence

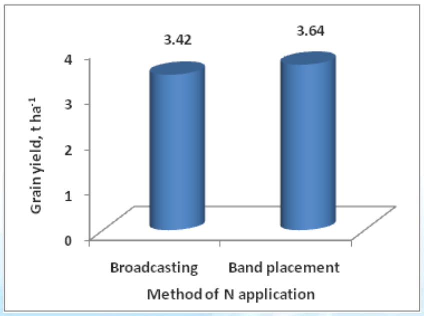


Fig. 28 Grain yield of rice as influenced by method of application of N fertilizer

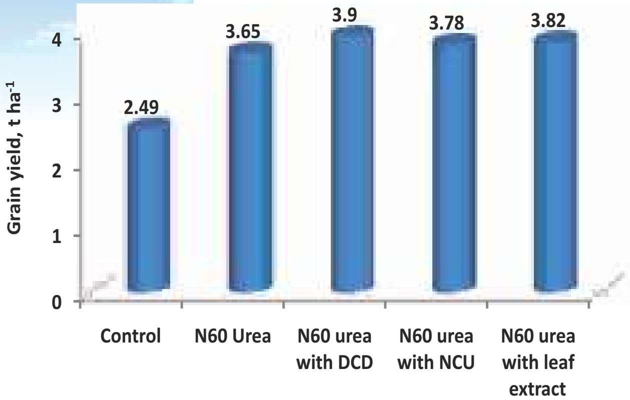


Fig. 29 Grain yield of rice as influenced by type of N fertilizer; N application @ 60 kg ha^{-1} through urea only, urea with dicyandiamide (DCD), neem coated urea (NCU) and leaf extract of *Azadirachta indica* and *Pongamia pinnata*

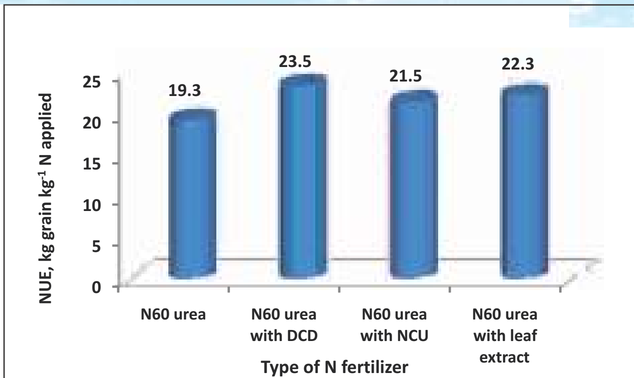


Fig. 30 Nitrogen use efficiency of rice as influenced by type of N fertilizer; N application @ 60 kg ha^{-1} through urea only, urea with dicyandiamide (DCD), neem coated urea (NCU) and leaf extract of *Azadirachta indica* and *Pongamia pinnata*

Nitrogen application @ 60 kg ha^{-1} through DCD and through urea coated with leaf extract had given in superior grain yield (3.9 t ha^{-1} and 3.83 t ha^{-1}, respectively) compared to other nutrient treatments (Fig. 29). The nitrogen use efficiency (*i.e.*, agronomic efficiency) of 23.5 and 22.3 kg grain per kg N applied was also obtained with N @ 60 kg ha^{-1} through DCD and through urea coated with leaf extract, respectively, and were greater than the nitrogen use efficiency obtained with application of urea alone and NCU (Fig. 30). The residual effect of different nutrient treatments on *rabi* crops namely greengram, groundnut, potato and rice was also evaluated. It is revealed that the application of N @ 60kg ha^{-1} with nitrification inhibitor and urea coated with leaf extract of *Azadirachta indica* and *Pongamia pinnata* gave significantly higher productivity of *rabi* season crops compared to other nutrient treatments.

Project Title	: **Identification of Suitable Crops for Wastewater Irrigation**
Project Code	: DWM/12/159
Funding Agency	: Institute
Project Personnel	: S. Raychaudhuri, M. Raychaudhuri, S.K. Rautaray and S. Roy Chowdhury

Studies on graded levels of cadmium (Cd) on some vegetable crops

Field experiment was conducted at IIWM research farm, Mendhasal to study the graded levels of cadmium (Cd 0, 3, 6 and 9 ppm) on six vegetable crops *viz*. okra, tomato, ridgegourd, frenchbean, radish and *Amaranthus,* in a split-plot design. The Cd concentration in plant parts of vegetables was analysed; transfer factors (TF) were calculated as the ratio of concentration of Cd in plant parts and that in soil. In general, conc. of Cd in plant parts decreased in the order, leaf> shoot/stem> root>fruit. The TFs of Cd were higher in french bean and amaranthus compared to other crops (Fig. 31). The TF of Cd decreased with higher concentration of Cd in ridge gourd and *Amaranthus.* It was greater where no Cd was applied except radish; almost similar with 3 and 6 ppm in okra, tomato and radish; 0 and 3 ppm were similar in french bean (Fig. 31). Higher Cd might have interfered with the physiological functioning of plants; decrease in rate of photosynthesis with higher doses of Cd was observed.

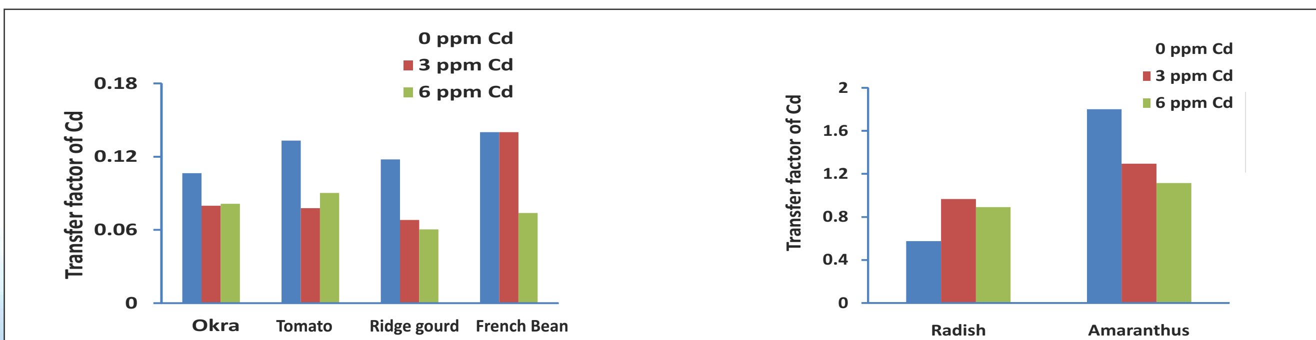


Fig. 31 Transfer factor of Cd in edible parts of some vegetable crops under different level of Cd in soil

Studies on graded levels Cd at different soil pH

A pot experiment was conducted to study the accumulation of Cd in different plant parts of okra and *Amaranthus* with variable soil pH (5.5, 6.5 and 7.5). Each earthen pot contained 2 kg of soil having initial pH 5.5 and 0.56% organic carbon variation in pH was created through application of lime; variation in Cd concentration (0, 3, 6 and 9 mg kg^{-1}) by application of $CdCl_2$. The okra and *Amaranthus* plants were grown up to 90 days. The accumulation of Cd was minimum in fruits and it was maximum in leaves; accumulation decreased with increase in soil pH. The concentration of Cd Increased with higher level of Cd in plant parts of okra at each pH level (Fig. 32).

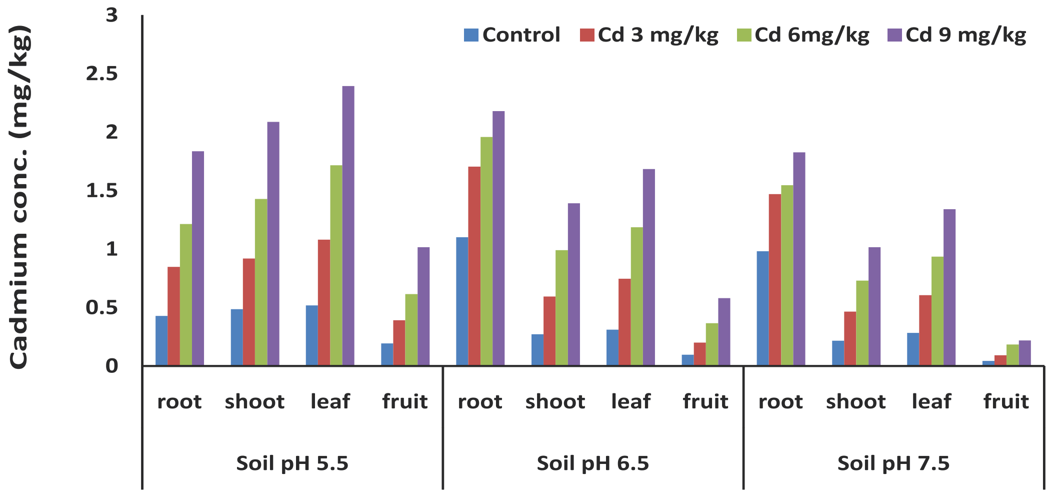


Fig. 32 Cd concentration in different plant parts of okra under different doses of Cd and variable soil pH

There was decrease in rate of photosynthesis in okra and *Amaranthus* with increase in levels of Cd in soil (Fig. 33). However, the rate of decline was slower in lime treatment. The comparative study of net photosynthesis rate (p_n : µ mol CO_2 $m^{-2}s^{-1}$) and stomatal conductance (g_s : mol $m^{-2}s^{-1}$) suggested that in limed treatment, at lower (3 ppm) level the inhibitory effect of $CdCl_2$ is non-stomatal in nature whereas with increase in concentration of $CdCl_2$ the effect was predominantly appeared under stomatal control

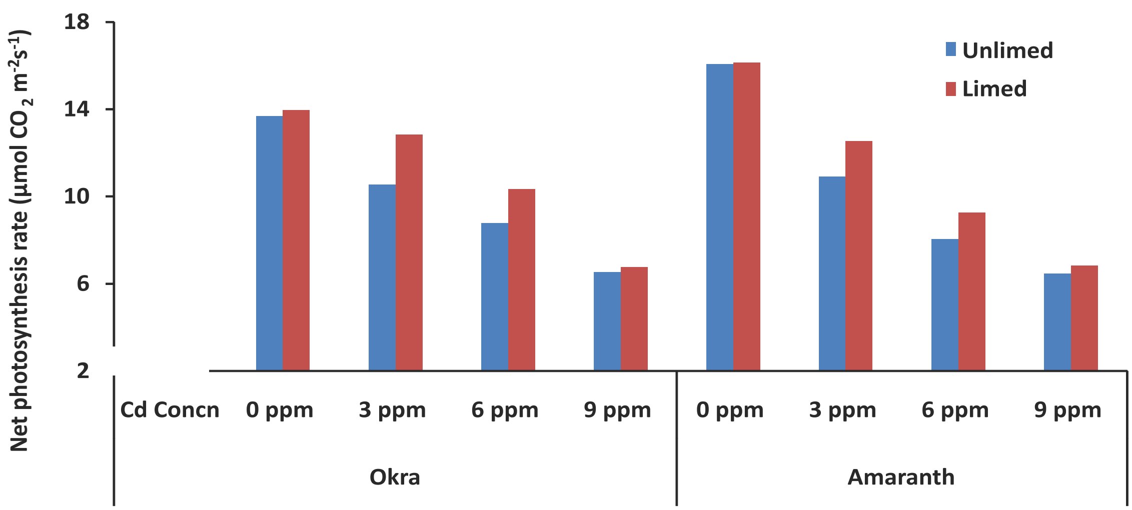


Fig. 33 Net photosynthesis rates of okra and *Amaranthus* at different Cd levels in soil.

Periodic analyses for mass balance of heavy metal in rice-vegetable and rice-rice crop sequence

Periodically soil and crop samples collected from six farmers' field at Joypurpatna, near Bhubaneswar round the year starting from winter season of 2014 to study the mass balance of heavy metals *viz*. Cd, Cr and Pb in rice-vegetable and rice-rice crop sequence. It reveals that the concentration of Cd, Pb and Cr increased to 0.05, 5.62 and 0.34 mg kg^{-1}, respectively in one year in *rabi* rice irrigated with wastewater. It is estimated that due to irrigation with wastewater Pb and Cr build up in the surface soils will take 75 and 400 years respectively to reach beyond permissible limit. The total uptake of Cd by different vegetable crops and rice grown with waste water at Joypurpatna village with wastewater was variable with type of crop (Table 19).

Table 19 Total uptake of Cadmium by rice and vegetable crops

Rice/ vegetable crop	Total uptake of Cd (g ha^{-1})	Rice/ vegetable crop	Total uptake of Cd (g ha^{-1})
Okra	3.47	French Bean	7.36
Tomato	3.91	Radish	20.27
Ridge gourd	3.63	Amaranthus	18.99
Rice	19.01		

Studies on die-off period of pathogens

Survivability of microbial species on different vegetables was monitored in a laboratory experiment. The vegetables were dipped in wastewater containing 5.62, 4.98 and 5.83 log cfu of total coliform (TC), *E. coli* and other bacteria, respectively. The microbial loads were enumerated on 0, 3, 5, 7 and 10 days. The initial load was maximum in ridge gourd and bitter gourd (3.92 and 3.52 log cfu of *E. coli* per g vegetable) and was minimum for tomato. Probably the rough surfaces in ridge gourd and bitter gourd retained more microbes. The bacterial load decreased substantially between 5 and 7 days. The mean reduction of 1.29, 2.08 and 1.66 log cfu per g vegetables were observed after 10 days for TC, *E. coli* and other bacteria, respectively.

Project Title	:	**Delineation of Waterlogged Areas in Eastern India and Formulating Strategies for Fitting in Suitable Crops and Aquaculture through Harnessing Agro-biodiversity for Enhancing Water Productivity**
Project Code	:	DWM/12/162
Funding Agency	:	Institute
Project Personnel	:	S. Roy Chowdhury, P.S. Brahmanand, A.K. Nayak, R.K.Mohanty and Ashwani Kumar

In West Bengal, LULC 2005-06 data showed that Medinipur district has total of 66,907 ha of waterlogged area under different categories like inland and coastal wetlands/water bodies including river/stream/canals, reservoir/lakes/ponds. The waterlogged area is more in East Medinipur district. The East and West Medinipur districts are suitable for fitting of different crops and aquaculture intervention such as capture fisheries of autorecruited ichthyofonal biomass, bhery or ghery culture. In the districts, *kharif* season cultivation of aquatic crops like water chestnut (*Trapa bispinosa* L.) and lotus (*Nelumbium speciosum*)are taken up whereas adjoining upland area is utilized for paddy cultivation in Kolaghat block (22° 26′ N, 87° 52′ E). In tidal waterlogged areas and near coast wetlands i.e., along banks of downstream areas of Rupnarayan river, cat tails (*Typha elephantina*, *T. domingensis*) are grown as economically important crops.

The Howrah district has 5,530 ha area under rivers/streams/canals and 1,723 ha is under inland wetland (Fig. 34) and 365 ha area is under reservoir/lakes/ponds. A large part of the wetland in Bagnan, Uluberia and Sankrail blocks in the district is utilized for water chestnut, lotus with aquaculture or cat tail (*Typha* sp.) cultivation. The leaves of cat tail is used for making thatching material. The two districts of 24 Pargana have total 2, 90,667 ha under water bodies and waterlogged area category. Among four main categories of waterlogged areas, the South 24 Pargana have total 1, 95,608 ha under wetlands/ water bodies, river/ stream/ canals. About 933 ha area is under permanent waterlogging under wetlands/ water bodies, reservoir/ Lakes/ ponds. Wet land plant '*shola*' (*Aschynomene aspera)* produced through farming in wet regions like Bonga, Habra, Boshirhat, Kalyani in the district is of superior quality shola. The value added products of 'shola' are decorative materials and mainly used for marriage and religious purpose. In Bardhaman district, about 16,277 ha area is under waterlogging under rivers/streams/canals and 961 ha are under wetland. About 5,492 ha area is under reservoir/lakes/ponds. However, a part of the areas occupied by lakes/ponds can be utilized for cultivation of aquatic crops and aquaculture in the district. Water chestnut and lotus are main aquatic crops in the district.

The Hooghly district has 6,292 ha area under rivers/streams and canals and 2,482 ha is under inland wetland. A large part of the wetland in the district is utilized for seasonal water chestnut cultivation in and around Kamarkundu (22^0 82′ N, 88^0 20′ E) in Haripal block. About 1,132 ha area is under reservoir/lakes/ponds, out of which the area occupied by lakes and ponds are suitable for aquaculture and also for lotus and water chestnut cultivation due to market demand. Similarly, Murshidabad and Nadia districts have 6,689 and 6,138 ha area under wetland/water bodies/inland wetland category, respectively (Fig. 34).

In North Bengal, among different districts, Jalpaiguri district has highest 58,291 ha area followed by Coochbihar with 29,477 ha. under above categories of waterlogged area. Apart from aquaculture and aquatic crops cultivation, part of low lying wet land/ waterlogged areas of few blocks of Coochbihar district, i.e. Coochbihar I & II, Mathabhanga I & II, and Dinhata are suitable for growing *Clinogyne dichotoma* and the produce is utilized for knitting premium quality mats '*sitalpati*' and also for cultivation of ordinary mat grass (*Cyperus tegetum*) for coarse quality mats.

In Assam, Sonitpur district has highest total 83,505 ha area under waterlogging including wetlands, inland wetlands, reservoirs, water bodies, rivers, streams canals, lakes and ponds followed by Didrugarh district with 78,477 ha, Dhemaji district (71,011 ha), Barpeta (68,448 ha) etc. Dhemaji (22,621 ha) has highest area under wetland, water bodies and inland wetlands followed by Cachar (17,478 ha) and Nagaon district (14,179 ha). North Cachar district has highest area under reservoir/lakes and ponds (2,301 ha), followed by Kamrup (878 ha), Dhuburi (789 ha) and Karbi Anglong district (734 ha).

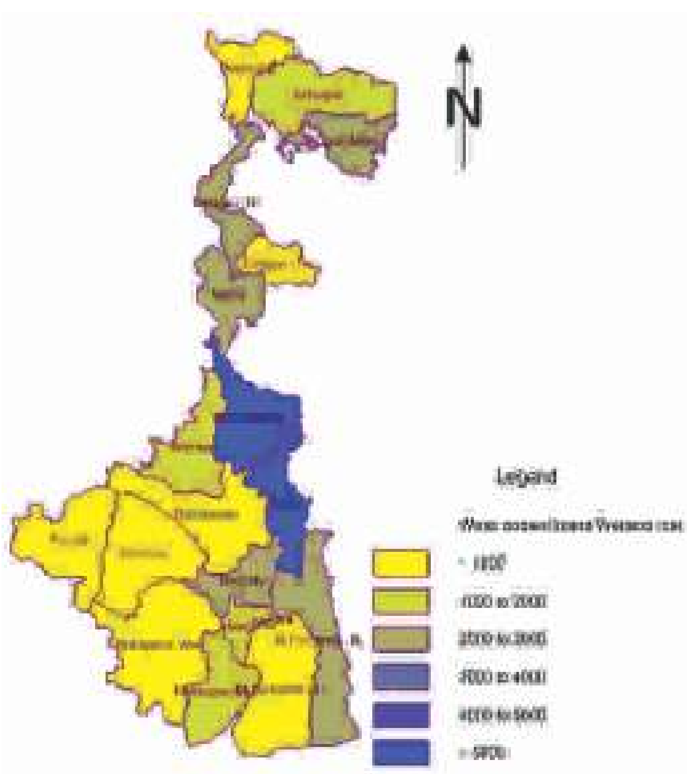
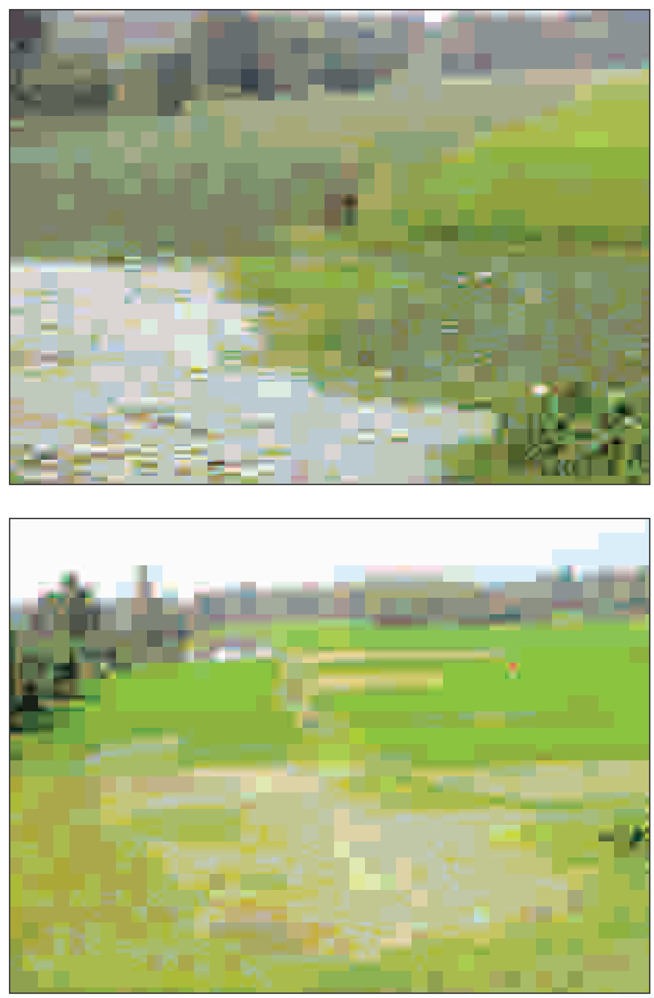


Fig. 34 District-wise area under water bodies and inland wet land in different districts of West Bengal



Year-round cropping by growing of water chestnut and lotus during *kharif* season, and rice after harvest of water chestnut during *rabi* season in low lying areas under Kolaghat block (22° 28′ N, 87° 53′ E) of East Medinipur district, West Bengal

Project Title	**: Global Yield Gap and Water Productivity Atlas (GYGA**
Funding Agency	: University of Nebraska, USA and Bill & Melinda Gates Foundation, USA
Project Personnel	: P.S. Brahmanand, N. Subash, S.K. Ambast, Ashwani Kumar and B. Gangwar

The objective of this project is to collect and compile the data on actual yields, yield potential and yield gaps in India to prepare an atlas for five major crops namely maize, rice, wheat, sorghum and pearl millet. The name of locations and district of hypothetical weather stations for three crops viz. rice, wheat and maize, out of five crops were identified based on the prioritization of crop harvested area (Table 20, 21 and 22).

Table 20 List of reference weather stations of India with their exact location and districts for global yield gap analyses for rice

Sl. No	Site	District	State	Latitude °N	Longitude
1	Kalyani	Nadia	West Bengal	23.4	88.5
2	Hypothetical_1 (Sirabahal)	Bragarh	Odisha	21.5	83.5
3	Hypothetical_2 (Tipi Gerya)	West Midnapur	West Bengal	22.5	87.5
4	Hypothetical_3(Nawagaon)	Raipur	Chhattisgarh	21.5	82.5
5	Bhubaneshwar	Khurdha	Odisha	20.2	85.8
6	Hypothetical_4 (Jhanpara)	Purulia	West Bengal	23.5	86.5
7	Patna	Patna	Bihar	25.6	85.1
8	Hypothetical_5 (Magurmari)	Sonitpur	Assam	26.5	92.5
9	Patiala	Patiala	Punjab	30.3	76.5
10	Maruteru	West Godavari	Andhra Pradesh	16.6	81.7
11	Ranchi	Ranchi	Jharkhand	23.3	85.3
12	Barnala	Barnala	Punjab	30.5	75.5
13	Hypothetical_7 (Misrikh cum Neemsar)	Sitapur	Uttar Pradesh	27.5	80.5
14	Hypothetical_8(Walipur)	Gopalganj	Bihar	26.5	84.5
15	Guwahati	Guwahati	Assam	26.1	91.6
16	Jorhat	Jorhat	Assam	26.8	94.2
17	Hypothetical_9 (Baula Khaladi)	Mayurbhanj	Odisha	21.5	86.5
18	Amritsar	Amritsar	Punjab	31.6	74.9
19	Kurnool	Kurnool	Andhra Pradesh	15.8	78.1
20	Modipuram	Meerut	Uttar Pradesh	29.1	77.7

Table 21 List of reference weather stations of India with their exact location and districts for global yield gap analyses for wheat

Sl. No	Site	District	State	Latitude °N	Longitude °E
1	Hypothetical_1 (Bairuda)	Kaushambi	Uttar Pradesh	25.5	81.5
2	Indore	Indore	Madhya Pradesh	22.7	75.8
3	Hypothetical_2 (Damadiya)	Hoshangabad	Madhya Pradesh	22.5	77.5
4	Hypothetical_3 (Ghanakalam)	Raisen	Madhya Pradesh	23.5	78.5
5	Varanasi	Varanasi	Uttar Pradesh	25.5	82.9
6	Kanpur	Kanpur Nagar	Uttar Pradesh	26.4	80.4
7	Amritsar	Amritsar	Punjab	31.6	74.9
8	Palampur	Kangra	Himachal Pradesh	32.1	76.1
9	Lucknow	Lucknow	Uttar Pradesh	26.8	80.9
10	Faizabad	Faizabad	Uttar Pradesh	26.8	82.1
11	Pune	Pune	Maharashtra	19.5	74.2
12	Ahmedabad	Ahmedabad	Gujarat	23.1	72.6
13	Sabour	Bhagalpur	Bihar	25.4	87.1
14	Hypothetical_4 (Ladanpur)	Moradabad	Uttar Pradesh	28.5	78.5
15	Patiala	Patiala	Punjab	30.3	76.5
16	Modipuram	Meerut	Uttar Pradesh	29.1	77.7
17	Pusa	Samastipur	Bihar	25.7	85.5
18	Hisar	Hisar	Haryana	29.2	75.7
19	Jaipur	Jaipur	Rajasthan	26.6	75.5
20	Midnapur	West Midnapur	West Bengal	22.5	87.5

Table 22 List of reference weather stations of India with their exact location and districts for global yield gap analyses for maize

Sl. No	Site	District	State	Latitude °N	Longitude °E
1	Hypothetical_1(Kundlakhurd)	Banswara	Rajasthan	23.5	74.5
2	Hypothetical_2(Maghraj)	Sabarkantha	Gujarat	23.5	73.5
3	Hypothetical_3(RameekiJhanpariyan)	Bundi	Rajasthan	25.5	75.5
4	Hypothetical_4(Udaigarh)	Jhabua	Madhya Pradesh	22.5	74.5
5	Hypothetical_5(Kanwaliya)	Bhilwara	Rajasthan	25.5	74.5
6	Hypothetical_6(Lingadahalli)	Tumkur	Karnataka	13.5	76.5
7	Hypothetical_7(Chetara)	Bahruich	Uttar Pradesh	27.5	81.5
8	Indore	Indore	Madhya Pradesh	22.7	75.8
9	Hypothetical_8(Jhalawar)	Jhalawar	Madhya Pradesh	24.5	76.5
10	Udaipur	Udaipur	Rajasthan	25.4	74.6
11	Hypothetical_9(Majharau Road)	Etah	Uttar Pradesh	27.5	78.5
12	Ahmadabad	Ahmedabad	Gujarat	23.1	72.6
13	Aurangabad	Aurangabad	Maharashtra	19.9	75.4
14	Hypothetical_10(Dharmasagar)	Gulbarga	Karnataka	17.5	77.5
15	Hypothetical_11(Shawajpur)	Moradabad	Uttar Pradesh	28.5	78.5
16	Kanpur	Kanpur	Uttar Pradesh	26.4	80.4
17	Hyderabad	Hyderabad	Andhra Pradesh	19	78.9
18	Sabour		Bihar	25.4	87.1
19	Hypothetical_12(Sakraili)	Katihar	Bihar	25.5	87.5
20	Hypothetical_13(Khagaria)	Khagaria	Bihar	25.5	86.5
21	Patna	Patna	Bihar	25.6	85.1
22	Hypothetical_14(Yawal, Jalgaon)	Jalgaon	Maharashtra	21.5	75.5
23	Hypothetical_15(Mandai)	Seoni	Madhya Pradesh	22.5	79.5
24	Palampur(Kangra)	Kangra	Himachal Pradesh	32.1	76.1
25	Hypothetical_16(Bamooriya)	Guna	Madhya Pradesh	24.5	77.5
26	Hypothetical_17(Amjhor)	Shahdol	Madhya Pradesh	23.5	81.5
27	Lucknow/Amausi	Lucknow	Uttar Pradesh	26.8	80.9
28	Hypothetical_18(Muchkur)	Nizamabad	Telangana	18.5	78.5
29	Hypothetical_19(Kanlane)	Nashik	Maharashtra	20.5	74.5
30	Pendra Road (Bilaspur)	Bilaspur	Chhattisgarh	22.8	81.9

The crop management, phenology and soil data were compiled for reference weather stations as per the protocol of Global Yield Gap and Water Productivity Atlas (GYGA) project. The Agricultural Production Systems Simulator (APSIM) model is being used for simulation of potential yield of rice and wheat. Actual crop yield based on the mean yield of previous 10 years was estimated for all climatic buffer zones. Based on the proportionate area of central district and surrounding districts, weighted mean of major crops within 100 km radius of climatic buffer zone was computed. The average grain yield of winter rice for 10 years (2001 to 2010) was 1.38 t ha^{-1} for Jorhat climate buffer zone in Assam (0.88 t ha^{-1} in 2009 to 1.90 t ha^{-1} in 2003). The average grain yield of *kharif* rice for 10 years (2002 to 2011) was 2.86 t ha^{-1} for Maruteru climate buffer zone in Andhra Pradesh (1.97 t ha^{-1} in 2005 to 3.42 t ha^{-1} in 2004). The average grain yield of rice for 5 years (2004 to 2008) was 1.44 t ha^{-1} for Ranchi climate buffer zone in Jharkhand (0.44 t ha^{-1} in 2006 to 3.5 t ha^{-1} in 2010). The average grain yield of wheat for 10 years (2002 to 2011) was found to be 4.02 t ha^{-1} for Hissar climate buffer zone in Haryana (3.2 t ha^{-1} in 2005 to 4.69 t ha^{-1} in 2009). The average grain yield of pearl millet for 10 years (2002 to 2011) was 1.17 t ha^{-1} for Jaipur climate buffer zone in Rajasthan which ranged from 0.40 t ha^{-1} in 2003 to 1.67 t ha^{-1} in 2004. The trend revealed that the yield gap between potential and actual yield in rice crop ranged between 4.01 t ha^{-1} in Rangareddy climatic buffer zone of Telangana to 5.94 t ha^{-1} in Gopalganj climatic buffer zone of Bihar. Similarly, the yield gap of wheat crop ranged between 2.51 t ha^{-1} in Patiala climatic buffer zone of Punjab to 4.51 t ha^{-1} in Bhagalpur climatic buffer zone of Bihar.

Project Title	:	**Development of Agriculture Water Management Portal (AWMP)**
Project Code	:	DWM/12/160
Funding Agency	:	Institute
Project Personnel	:	A.K. Nayak, R.C. Srivastava, M. Das, P. Nanda, A. Kumar, R.G. Patil, U.M. Khodke and B.S. Yadav

A web based information system i.e., Agricultural Water Management Portal (AWMP) was developed which depicts the success stories on agricultural water management of different coordinating centres of All India Coordinate Research Project (AICRP) on Water Management. The success stories and/ or technologies are categorized on the basis of different agro-ecological regions, crops, irrigation methods for easy interpretation of the data by end users. The website address is *http://www.dwm.res.in/awmp* and accessible by public (Fig. 35). The web pages were also prepared on various technologies developed under different research aspects at this Institute viz. rainwater conservation, micro level water resource development, farm pond based agriculture, crop diversification, rubber check dam for watersheds, raised and sunken bed, system of rice intensification, sub-surface water harvesting structure and waterlogged area management. The information has also been created in Hindi language. A directory of water research organizations in the country has also been included in the portal.

Another data management module was prepared under AWMP for use by Chief Scientists of coordinating centres under AICRP on Water Management. There is option provided for uploading information on research achievements, manpower and monthly expenditure. Provision has been made to provide username and password by Chief Scientists of each coordinating centre. The data uploading may be made monthly, quarterly as well as annual based on requirement. Another option has been created for attaching the research output files, photographs, audit utilization certificates etc. into the web portal for access by Nodal Officer at the project coordinating unit (Fig. 36). The access to this module of the web portal is secured with password

Fig. 35 A snapshot of the Agricultural Water Management Portal (AWMP)

Fig. 36 A snapshot of data management module of the web portal

On-farm Research and Technology dissemination

- Tracking Change in Rural Poverty in household and Village Economies in South Asia
- Enhancing Land and Water Productivity through Integrated Farming System (Tribal Sub Plan Project)

Project Title : **Tracking Change in Rural Poverty in household and Village Economies in South Asia**

Funding Agency : Bill and Melinda Gates Foundation

Project Personnel : M.K. Sinha, P. Nanda, A. Kumar and S.K. Ambast

Regular high frequency household panel data on agriculture, labour, expenditure, incomes and other related social indicator was collected at monthly interval to understand the dynamics of economic, social and institutional development.Meso level data on the agriculture and related variable also collected and analyzed. Database was prepared in a user-friendly format of Census and Survey Processing (CSPro) system software.

Data analysis revealed that farmers across size and class in sampled village were more attractive towards non-farm activities such as small business, wage earning, caste occupation, remittance, pension etc. as these activities provides them regular income and employment without any seasonality like farming activities (Fig.37). Farm activities are seasonal in nature and non-farm activities provides income to the farmers also during lean period.

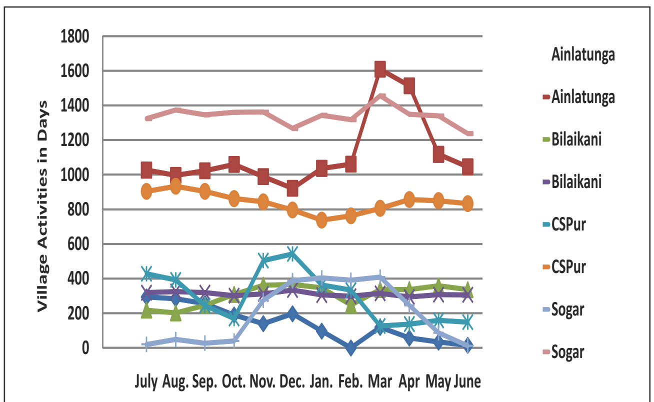


Fig. 37 Month-wise variations in farm and non-farm activities (in days)

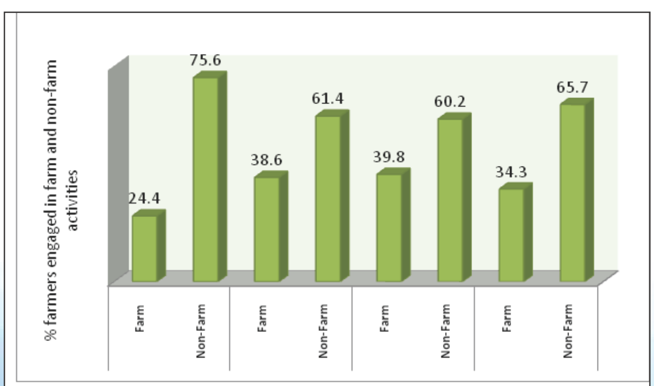


Fig.38 Household engagement of farmers (%) in farm and non-farm activities in four villages of Odisha

Across sampled village, percentage household engaged in farm and non-farm activities presented in Fig.38. Household in farm activity being absorbed from 34.3 to 38.6%, where the rest 61.4 to 65.7 % being supported by non- farm activities in Biliakani, CSPur and Sogar villages of the study area. At Ainlatunga, only 24.4 percent households were involved in farming activities and rest was found engaged in non-farm activities. This might be due to inferior crop avenue which was unable to absorb the sizable population for sustained livelihood. Further, income status of the farmers of four villages were also assessed and found that average per capita income (Rs./person/month) was highest in Bilaikani (1004) followed by Sogar (970) and CSPur (848). The lowest per capita income (566) was in Ainlatunga village.

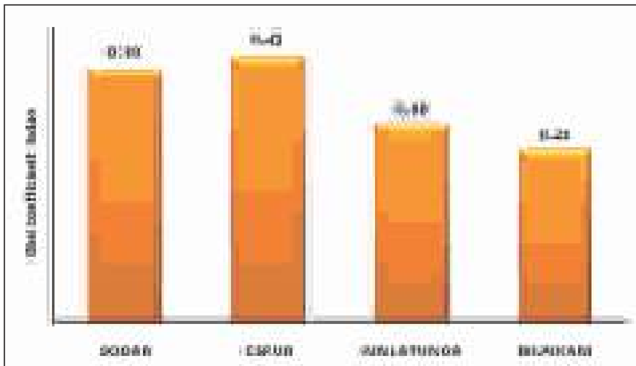


Fig.39 Gini index measuring income inequality across study village

To assess the income inequality across village, Gini coefficient index was calculated (Fig. 39). Gini index measures the extent to which the distribution of income among households deviates from a perfectly equal distribution. It is used to measure income inequality, ranges from 0 corresponds to perfect income equality (i.e. everyone has the same income) and 1 corresponds to perfect income inequality (i.e. one person has all the income, while everyone else has zero income). The coefficients index ranged from 0.26 to 0.41 showing maximum equality index in CSPur (0.41) followed by Sogar (0.39), Ainlatunga (0.30) and Bilaikani (0.26).

Project Title	: **Enhancing Land and Water Productivity through Integrated Farming System (Tribal Sub Plan Project**
Funding Agency	: Institute
Project Personnel	: R.K. Panda, R.R. Sethi, S.K. Rautaray and R.K. Mohanty

Improvement of the land and water productivity and development of integrated farming system was aimed by utilizing surface and groundwater resources through augmentation of the irrigation infrastructure at Birjaberna village under Ghurlijore Minor Irrigation Project (MIP) in Sundargarh district of Odisha (22° 07' N, 84° 01' E) and 18 km away from Sundargarh district headquarters. Total designed command area of the MIP is 364 ha and 210 ha during *kharif* and *rabi* seasons, respectively having total of 7,866 m long canal system. Out of which, 7,713 m of right main canal and 153 m left main canal need regular maintenance for efficient flow. The farmers of four villages in the study area are engaged in agricultural practices with the participation of Amrutganga pani panchayat water users group.

Land and rainfall characteristics

The un-supervised classification of land under Ghurlijore MIP showed that maximum area is under forest cover (1,521.36 ha) followed by settlements (Fig. 40). It was also observed that nearly 25% of the area is under arable land, which is mostly barren. As the area falls under plateau region, water availability during the non-monsoon period is either nil or meagre. Daily rainfall data of 9 years (2005-2013) was used for computation of maximum 1 day to 5 day consecutive rainfall. The probabilities of exceedence for the rainfall values were computed using the Gringorten's formula as:

$$P(Y \geq Yr) = (m-b)/(n+1-2b)$$

where, P (Y>Yr) is probability of rainfall greater than or equal to Yr; m is rank number; n is the total number of years and the value of b is 0.44. Rainfall values for 1-day through 5-days consecutively with frequency of 2-years, 5-years, 10-years and 15-years were plotted (Fig. 41). Accordingly, the drainage coefficient for 5-year return period for 1-day period was computed as 136 mm day^{-1}. Based on the drainage coefficient value, the inlet, outlet and surplus escape structures were constructed in the linkage tank.

Hydraulic parameters

Three variables i.e. depth, width and the slope of the canal section was measured in the inlet and outlet sections during the monsoon season of 2014. The rating curves and the flow versus the specific energy relations for the constructed structures were developed and for both the cases, the Froude numbers were computed to be less than 1.0, which implied a continuous subcritical flow in the canal regime. As most of the open canal flow is subcritical, the occurrence of velocity of flow were observed as lower than the critical flow, which was characterized by non-scouring deep slow flows.

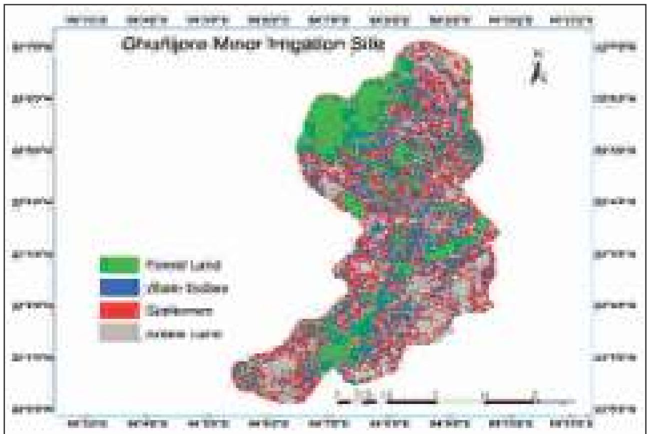


Fig. 40 Unsupervised classified image of the study area

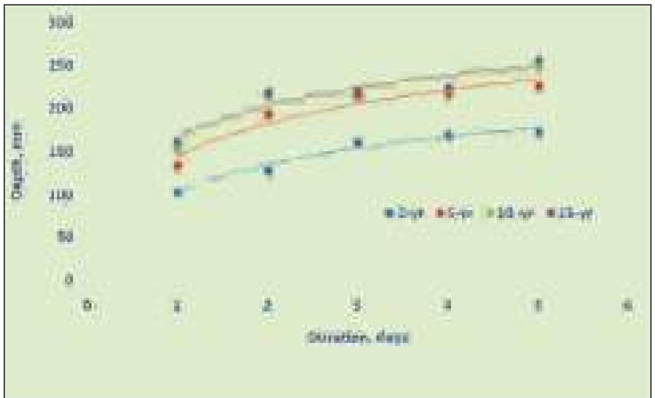


Fig. 41 Depth-duration-frequency relationships of rainfall

Intervention through integrated crop-fish culture system

A lowland field was modified for crop diversification on traditional practice of lowland rice -fallow system. A raised bed of 5 m width and 0.4 m height was separated by sunken bed of 5 m depth. Lowland rice was grown in sunken beds and 5 different crops were grown on raised beds and harvested crop yield was 9, 35, 31, 8 and 29 t ha^{-1} for pointed gourd, papaya, brinjal, green chilli and tomato, respectively. Average rice yield in sunken beds was 3.1 t ha^{-1}. Total of twenty thousand fish fingerlings of 3.5 gm mean body weight (MBW) were stocked in the linkage tank during mid-September, 2014. The species composition was *catla, rohu* and *mrigal* with a ratio of 30:30:40, respectively. At the end of six months of rearing, the MBW of cultured species ranged between 350 and 550 g per fish.

3. Events / Trainings Organizedfor Women Empowerment

- A farmers training programme was organised under TSP project at Brijabarna village of Sundargarh district of Odisha during 25-26th September 2014 and was attended by 30 women participants. They were exposed to different modern agriculture water management practices for increasing the water productivity, including package of practices of aquaculture activities, care and maintenance of flow irrigation, benefits of drip irrigation and government schemes.
- Four one-day farmers field day program were organized on Crop diversification for improving livelihood under VDSA Project on Rural Poverty at Balangir and Dhenkanal districts during February-March, 2015 and 63 women participants were trained with scientific technical know-how and advanced farming practices on agricultural water management to enhance income, employment and livelihood.
- A group of forty-five students from School of Rural Management, KIIT University, Bhubaneswar were given exposure to different techniques of water saving and efficient use of water for farming in visit to the Institute on 16 July, 2014.
- A group of forty-three students from College of Forestry, OUAT Bhubaneswar were shown different techniques of agricultural water management during their visit to the Institute on 18th December 2014.




4. All India Coordinated Research Project

AICRP on Water Management

During the year 2014-15, 26 centers across the country were involved in research and extension activities for assessment of water availability, groundwater recharge, groundwater use at regional level, evaluation of pressurized irrigation system, groundwater assessment and recharge, water management in horticultural and high value crops, basic studies on soil, water, plant relationship, conjunctive use of canal and underground saline water, drainage studies for enhancing water productivity, enhancing productivity by multiple use of water and rainwater management in high rainfall areas. Salient achievements during the year are given below:

Assessment of irrigation water demand and system supply and groundwater use

At Jammu, in the Rainbir canal system the maximum deficit of irrigation of 4568.8 ha-m was found between 9th to 30th September during panicle initiation to flowering stage of rice crop. Therefore, either frequency of rotation of irrigation supply should be reduced from present 7 days to alternate day or sub-surface irrigation potential to the tune of 4568, 8 ha-m need to be developed at disaggregated level of said command by stakeholders and supplied in the shape of conjunctive water use for improving water productivity of rice crop in the study area i.e. basmati bowl R.S. Pura and similar approach needs to be followed for entire command area.

At Bilaspur, groundwater recharge planning using remote sensing and GIS was conducted for Bilaspur district. Out of 146 blocks in the state, 15 were semi-critical as the stage of groundwater development in these area is more than 70% but less than or equal to 90%. Various thematic maps including drainage map, slope map, district and block boundary maps, soil texture and maps were generated using available data.

At Coimbatore, in Amaravathy basin, average annual rainfall was 1009.8 mm and more number of normal years was observed at the head end of basin and number of deficit years was high in the tail end. The recharge was estimated using the empirical formulas range from 17 to 30 %. The number of blocks in the basin is 33, out of which 16 were over exploited, 2-critical, 12- semi critical and remaining blocks were found safe.

At Junagarh, the groundwater quality maps for Saurashtra region were prepared. Based on the EC, SAR and RSC of the groundwater, 56.24%, 18.4%, 6.64% and 18.68% samples were found under categories of good water, saline water, high SAR saline water and alkali water class respectively. Based on daily water balance in 2014, total recharge was found 14420 cu.m, runoff from check dam was 12582 cu.m, and total runoff from catchment was 19997 cu.m. Total water resource available from rainfall (check dam catchment) was 88017 cu.m. Structure cost was Rs. 95000, so recharge was Rs. 0.33 per cu.m of recharge volume @ 20 years effective service of structure. Recharge per sq.m of catchment was observed 0.19 cu.m. Evaporation loss excluding stream flowing period was 834 cu.m and during stream flowing period it was 3123 cu.m. During monsoon season total 33381 cu.m of runoff volume was generated from catchment area of recharge basin, out of that 15510 cu. m was trapped in to the basin and 17870 cu.m escaped from the basin. Evaporation loss from the water storage of recharge basin was 657 cu.m. and net recharge was 14853 cu.m. Out of total 0.87 cu.m runoff per square meter of roof, 0.26 cu.m contributed as ground water recharge and 0.61 cu.m of runoff was collected in to sump. Cost of system was Rs.172 per square meter.

At Ludhiana, during the past 14 years, the area under water table depth of 3-10 m has reduced from 53.0 to 21.9 per cent, whereas the area with water table depth greater than 20 m increased from 0.0 to 24.6 per cent indicating that central Punjab is under severe problem of declining water table. The pump density maps (no of pumps per 1000 ha) for both diesel and electric operated tubewells were prepared for the individual years. The electric pumpset in SC-III had sharply increased and followed an exact linear trend from 2000-2011. SC-III and BM-III witnessed a 67% and 42% increase in electrical pumpset density respectively during the study period. In case of diesel pump sets, UB-III and SC-III witnessed a 11% and 7% decrease in the density respectively whereas BD-III and BM-III showed an increase of 49% and 46% respectively during the study period

Artificial groundwater recharge technique for recharge of bore well was developed by Rahuricentre to tackle the problem of declining groundwater table. The experiment was conducted at the Instructional Farm and the tests were conducted during the period from July, 2014 to October 2014. The filters made from various locally available materials were tested for the constant suspended load concentration of 200 NTU. The filter were developed in single layer, two layer, three layer and four layer with combination of filter material viz. sand- I (0.6-0.2mm), angular gravel- I (9.5-15.5mm), angular gravel- II (15.5-21.5), pea gravel –I (20-24mm), pea gravel –I (24-28) and brick flacks (24-28mm). The layer thickness in single layer was 100 cm, in two layer it was 25cm, 75cm, in three layer 25cm, 37.5cm, 37.5cm and in four layers 25cm, 25cm, 25cm and 25cm. The four layer filter has performed better in terms of filtration efficiency (92.3%) and discharge (1.156 lps) amongst all.

At Raipur in Chakranal watershed, the aquifer properties were found for DaldalSeoni (RGI EW-IV and RGI OW-I) ranges showed transmissivity 2.93 to 3.16 $m^2 day^{-1}$ and storativity 3.17 x 10-5 to 3.46 x 10-5 and for FAE well, IGKV Raipur, transmissivity ranged from 9.37 to 9.51 $m^2 day^{-1}$.

From Udaipur center, major limiting factor in groundwater quality of Bhilwara district was salinity (90.90 % water samples were under high to very high saline classes, C3 and C4). Only 9.99 % groundwater samples had the problem of high to very high sodic water (S3 and S4 classes). Similarly, the alkalinity problem existed only in very small area (8.18 % groundwater samples were reported to have more than 2.5 meL^{-1} of RSC). About 87.18 per cent of the basin is under poor/ moderate groundwater potential zones and the area suitable for artificial recharge is 279 km^2, which contributes only 15.02 per cent of the total study area.

Evaluation of conjunctive water use techniques in the Mandhar branch canal showed that available, utilizable and utilized surface water as 5.35 Mm^3, 4.81 Mm^3 and 3.07 Mm^3 respectively whereas groundwater availability was 2.55 Mm^3 in which 1.62 Mm^3 is utilizable and currently 0.31 Mm^3 is utilized. To meet the deficit of available water optimal crop plan was assigned 631.7 ha and 33.2 ha area in *kharif* to paddy and vegetables where as in *rabi* 22.2 ha, 15.6 ha, 4.44 ha area was assigned to wheat, gram and *Lathyrus* respectively.

Irrigation scheduling and water use efficiency

At Bhavanisagar, safe alternate wetting and drying (SAWD) irrigation in rice gave higher WUE of 5.77 kg $ha\text{-}mm^{-1}$ under irrigation after 15 cm DPW from 7 DAT to 10 days prior to harvest while lower WUE of 5.17 kg $ha\text{-}mm^{-1}$ was observed under the conventional irrigation practice. The net return and B: C ratio (2.62) also was higher with conventional irrigation practice and irrigation after 15 cm DPW up to maximum tillering and continuous submergence up to 10 days prior to harvest.

At Bilaspur, delaying irrigation up to 3-5 days after subsidence of ponded water was best water regime for paddy in clay-loam to clay as about 40-60% of irrigation water could be saved without yield loss in comparison to continuous shallow submergence of ± 5 cm ponded water.

At Faizabad, the improved water management practice (6 cm water per irrigation through checks of 10x10m) gave higher grain yield of 4.17, 4.14 and 4.0.5 t ha^{-1} at head, middle and tail end of Chandpur distributary in comparison to farmer's practice in which these were 3.15, 3.14 and 2.98 t ha^{-1}, respectively. Thus, about 31.76–35.50% higher grain yield was obtained under improved water management practice over farmer's practice in wheat crop. The water expense efficiency (WEE) was highest (14.99 kg $ha\text{-}mm^{-1}$) at head followed by middle and tail end at which it was 14.86kg $ha\text{-}mm^{-1}$ and 14.53 kg $ha\text{-}mm^{-1}$ under improved irrigation practices, respectively. The water expense efficiency was quite low in case of farmers practice which were 8.54, 8.42 and 8.11 kg $ha\text{-}mm^{-1}$ at head, middle and tail end of the distributary respectively. Maximum pigeon pea equivalent yield (2.21 t ha^{-1}) was recorded when pigeon pea was grown on raised bed in paired row intercropping with rice at farmer fields under poor availability of canal water at tail end of distributary. The above intercropping system was most economical and gave maximum net return of Rs. 67988 per hectare. Integrated farming system including pisciculture and duckery was found more productive and remunerative than conventional cropping system (rice-wheat) It gave highest net return of Rs. 129471 ha^{-1} yr^{-1} with B:C ratio 2.67 against conventional system (net return Rs. 73625.00 ha^{-1} yr^{-1} and B:C ratio 1.62). The transplanted rice gave significantly higher yield of 4.33 t ha^{-1} compared to other planting method of rice. Drum seeding gave the second highest yield of 3.75 t ha^{-1} and was significantly higher over planting with zero tillage machine and seeding under dry condition but at par with that of broadcasting of sprouted seeds under puddled condition. Irrigation of 7cm irrigation at 1- days after disappearance of ponded water (DADPW) gave significantly higher yield of rice 4.61 t ha^{-1} over other irrigation schedules in which 7cm irrigation was applied at 4, 7 and 10 DADPW and gave 4.11, 3.25 and 2.61 t ha^{-1} respectively. It was observed that improved irrigation practice of 6 cm water at critical stages (CRI, late jointing and milking, two irrigation from canal and one from tube-well water) by check basin (100m^2) produced significantly higher grain yield (4217.14 kg ha^{-1}) of wheat as compared to farmers practices (3087.86kg ha^{-1}) with 37% yield increase and 54.5% better WUE.

At Gayeshpur wheat yielded 3340 kg ha^{-1} with highest frequency of irrigation at 20% MAD of ASM and was at par with irrigation at 40% MAD of ASM (3187 kg ha^{-1}). Similarly, the highest grain yield was obtained with 160:80:80kg ha^{-1} N: P_2O_5: K_2O fertilizer level. The nutrients (NPK) uptake was maximum with irrigation at 20% MAD of ASM (84.6, 22.7 and 71.9 kg/ha of NPK, respectively) and also with highest level of 160:80:80 kg ha^{-1}N: P_2O_5: K_2O fertilizers (99.0, 26.9, 84.6 kg ha^{-1} of NPK, respectively). The interaction between irrigation and fertilizer levels showed that maximum yield (4153 kg ha^{-1}) and water use efficiency of 13.8 kg $ha\text{-}mm^{-1}$ was recorded with irrigation at 20 and 60% MAD of ASM, respectively both supplemented with 160:80:80 kg ha^{-1} N: P_2O_5: K_2O fertilization.

At Hissar, wheat cultivar WH 711 under FIRBS resulted in higher irrigation and total water productivity (5.20 and 1.41

kg m^{-3}) as compared to conventional sowing (3.70 and 1.25 kg m^{-3}), however, the yield did not differ significantly in both the systems of sowing.

At Jammu, it was found that there is need for critical irrigation during CRI stage-November and booting stage-March of wheat to meet minimum (1) irrigation of 60 mm in view of canal closure during the period. The quantum of this additional irrigation potential is 1798.5 ha-m at disaggregated level of study area. It needs to be supplied to the farmers through shallow tube-wells and would enhance water productivity of rice-wheat sequence.

At Jorhat, pooled yield of three years revealed that two irrigations, one each at flowering and siliqua development stage recorded significantly higher seed yield of yellow sarson than one irrigation either at flowering or siliqua formation stage and rainfed crop. Pooled yield data also revealed that application of 90-60-60 kg ha^{-1} N: P_2O_5: K_2O or 75-50-50 kg ha^{-1} N: P_2O_5: K_2O gave significantly higher seed yield than 60-40-40 kg ha^{-1} N: P_2O_5: K_2O.

In Assam lemon the highest drainage coefficient (4.28 cm h^{-1}) was obtained for PVC pipe with mineral envelope followed by PVC pipe with organic envelope. Bamboo pipe with organic envelop resulted in the lowest drainage coefficient of 0.669. The plastic pipe irrespective of envelope material lowered the water table better than other treatments during the rainy season.

At Navsari, in pigeon pea (*rabi*), irrigation through drip at 0.6 PEF with laying of 50µ black plastic as mulch (BPM) with 56 per cent coverage area gave higher yield and net profit.

At Shillong, zero tillage for both *kharif* and *rabi* rice resulted in 15% higher grain yield as compared to conventional tillage. Zero tillage also had a significant influenced on the yield of succeeding rabi crops: pea (2108.4 kg ha^{-1}), mustard (943.1 kg ha^{-1}) and buckwheat (723.6 kg ha^{-1}) as well as the water use efficiency as compared to conventional tillage.

Pressurized irrigation system and Fertigation

At Faizabad, the drip irrigation system gave in general significantly higher sugarcane yield in comparison to surface irrigation system. Drip irrigation treatment (Irrigation @ 80% PE with 100% N) was found most economical with B:C ratio of 4.03, 7.74 and 7.62 during three consecutive years (2012-2014). Drip irrigation saved about 59.46, 69.53 and 79.67% irrigation water under 80%, 60% and 40% of PE irrigation levels in comparison to surface irrigation in sugarcane cultivation respectively.

At Hissar, irrigation applied at 0.8 PE through drip and surface methods irrigation at IW/CPE=0.75 by furrow method gave highest seed cotton yield and water productivity. Mulching with wheat straw @ 4 or 6 t ha^{-1} produced similar yield and water productivity but was considerably superior to no mulch. Irrigation with mini-sprinklers of wetting diameter of 6 m in wheat saved 40 mm water with an additional grain yield of 231 kg ha^{-1} as compared to surface irrigation. After 5 years of operation of mini-sprinklers (6 m dia), a net profit of Rs. 28427 ha^{-1} was achieved over surface irrigation. The productivity of irrigation and total water use was also higher under mini-sprinkler as compared to surface irrigation.

At Bhavanisagar, assessment of water productivity in integrated farming system in western zone of Tamil Nadu revealed that the water use efficiency (WUE) was higher in CO4 CN hybrid grass (179.4 kg ha-mm^{-1}) and among the other annual crops -Bhendi resulted in higher WUE (45.4 kg ha-mm^{-1}).

At Chalakudy, full dose of N and K as drip fertigation with conventional fertilizers (Urea and MOP) at weekly intervals (8 times) and full P as basal could increase the yield of salad cucumber and drip Irrigation @ 2 l $plant^{-1}$ on alternate days using inline drippers along with mulching is recommended. Soluble fertilizers had a B:C ratio of 1.89 whereas conventional fertilizers recorded a B: C ratio of 2.41 and therefore was more economical.

At Gayeshpur, the 3-year pooled analysis showed that the gravity drip irrigation scheduling at 1.0 E_o coupled with the conjunctive use of 50% inorganic N plus 50% organic N through vermicompost produced highest number of spikes per plot (72.6), number of florets per spike (10.3), longer spike length (65.9 cm), higher weight of single spike (43.2 g) and spike yield (9886 kg ha^{-1}) of gladiolus.

At Jammu, the pooled data for three years (2012-14) showed that sprinkler method recorded significantly higher yield of potato over flooding. Irrigation schedule of 0.3 and 0.5 PE recorded significantly higher yield over 0.7 PE. Water use efficiency recorded highest with sprinkler irrigation 42.74 kg ha-mm^{-1} followed by skip-furrow 40.89 kg ha-mm^{-1} and flooding irrigation 30.47 kg ha-mm^{-1}, respectively.

At Palampur, irrigation at three day interval with gravity fed drip irrigation system gave maximum yield of broccoli crop. The quantity of water applied per irrigation should be equal to 1.0 time of cumulative pan evaporation of preceding three days. Hundred per cent of soil test based recommended NPK dose is recommended for eight fertigation with an interval of at least 11 days between two successive fertigation.

At Pantnagar, in lysimeter the rice yield of 4.65 t ha^{-1} was obtained with an average water requirement of 701.3 mm, WUE as 6.68 kg ha-mm^{-1} during the *kharif* season of 2014. The higher grain yield of mustard was obtained under shallow water table (30 cm) with sprinkler irrigation method in comparison to flood method.

Rainwater harvesting and utilization

At Dapoli, from the three years study it was observed that, use of dry grass mating and 75% shading net retained more water in Jalkund compared to other treatments. Use of dry grass mating and 75% shading net retained (56.5%) more water than control treatment. The application of 6 ha-mm water up to 40 days after the peanut stage of cashew nut increased the cashew yield of fully grown crop to 1.30 t ha^{-1} with the WUE of 216.7 kg $ha\text{-}mm^{-1}$.

At Shillong, turmeric grown under terrace condition with FYM + straw mulch significantly recorded higher yield (27740.6 kg ha^{-1}) compared to other treatments. Weed population and density was also significantly influenced by different manures and mulching. The control plots recorded highest weed population. It was found that zero tillage gave higher maize equivalent yield (5940.03 kg ha^{-1}) compared to conventional tillage. Among the intercropping system/ residue management treatments, the maize equivalent yield (MEY) was 57.87% higher under Maize + Groundnut Paired Row (residue retention) than sole maize. The yield of succeeding toria was also higher under Maize + Groundnut Paired Row (residue removal) which was 43.75% higher as compared to Sole Maize (residue retention).

At Palampur, under irrigation depth of 2 cm in Brinjal, application of plastic mulch resulted in significantly higher gross and net returns than either organic mulch or no mulch and application of organic mulch after planting of crop resulted in significantly higher (14.27 %) gross returns than under application of no mulch. However, in case of net returns, application of organic mulch had no effect when compared with no mulch treatment.

Basic Studies on Soil-water-plant relationship

At Ludhiana, it was predicted that the average yield of adequately irrigated and fertilized rice for Ludhiana district may reduce by 14.8% in MC and by 30.4% in EC during *kharif* season. However, in *rabi*, wheat may marginally increase by 0.2% in MC and reduced by 12.5% in EC. In MC and EC (averaged over soil series), crop duration would be shortened by 17 days (16.3%) and 24 days (23.1%) in rice; and 8 days (5%) and 22 days (13.4%) in wheat, respectively. Rice yield in MC and EC would decrease almost in all the years compared to that of the PTS. The irrigation requirement in MC and EC would decrease by 48.7% and by 51.0% during the *kharif* season; and 25.3% and 41.7% in *rabi* season, respectively.

5. List of Publications

A. RESEARCH PAPERS IN REFERRED JOURNALS

Behera, M.S., Mahapatra, P.K., Singandhupe, R.B., Verma, O.P., Brahmanand, P.S. and Kumar, A. 2014. Effect of resource conservation technology on rice based medicinal cropping systems. *Journal of Interacadamicia* 18 (3): 411-414.

Behera, M.S., Verma, O.P., Mahapatra, P.K., Singandhupe, R.B., Kumar, A., Kannan, K. and Brahmanand, P.S. 2013. Effect of fertigation on Stevia (*Stevia rebaudiana*) under drip irrigation. *Indian Journal of Agronomy* 58 (2): 243-250.

Bhattacharyya, T. *et al.* 2014. Soil information system: use and potentials in humid and Semi-Arid Tropics. *Current Science* 107(9) 1550-1564.

Bhattacharyya, T. *et al*. 2014. Georeferenced soil information system: assessment of database. *Current Science* 107(9): 1400-1419.

Brahmanand, P.S., Kumar, A., Roy Chowdhury, S., Ghosh, S., Kundu, D.K., Mandal, K.G., Singandhupe, R.B., Nanda, P. and Reddy, G.P. 2014. Performance evaluation of rice under intermittent irrigation and drainage in eastern India. *GCBR Bio Research* 1 (2): 24-30.

Brahmanand, P.S., Sahoo, N., Roy Chowdhury, S., Ghosh, S., Mohanty, R.K., Mandal, K.G., Nayak, A.K. and Kumar, A. 2015. Performance evaluation of water chestnut based farming system in seasonal waterlogged areas. *Journal of Interacadamicia* 19 (1):46-50.

Chandran, P. *et al*. 2014. Development of soil and terrain digital database for major food - growing regions of India for resource planning. *Current Science* 107(9): 1420-30.

Chatterji, S. *et al*. 2014. Land evaluation for major crops in the Indo-Gangetic plains and black soil regions using Fuzzy model. *Current Science* 107(9): 1502-11.

Das, M., Swain, P., Verma, O.P. and Sinhababu, D.P. 2014. Impact of brackish water shrimp culture on natural resources – a case study in coastal Odisha. *Journal of Coastal Agricultural Research* 32(1): 70-72.

Ghosh S. and Mohanty, R.K. 2014. Group approaches in aquaculture development. *GCBR Bio Research* 1(1): 28-32.

Ghosh, S., Panda, D.K., Nayak, A.K., Nanda, P. and Verma, H.C. 2015. Links between irrigation, agriculture, level of living and poverty scenario in West Bengal. *Indian Journal of Extension Education* 51(1&2):1-8.

Ghosh, S., Srivastava, S.K., Nayak, A.K., Panda, D.K., Nanda, P. and Kumar, A. 2014. Why impacts of irrigation on agrarian dynamism and livelihoods are contrasting: Evidence from eastern Indian states. *Irrigation and Drainage* 63:573-583.

Hati, K.M., Chaudhary, R.S., Mandal, K.G., Bandyopadhyay, K.K., Singh, R.K., Sinha, N.K., Mohanty, M., Somasundaram, J. and Saha, R. 2014. Effects of tillage, residue and fertilizer nitrogen on crop yields, and soil physical properties under soybean-wheat rotation in vertisols of central India. *Agricultural Research*, DOI 10.1007/s40003-014-0141-7.

Jena, S. K. 2014. ICAR Flexi-check Dam (Rubber dam). *Indian Farming* 64(2):106-108.

Kar, G. and Kumar, A. 2014. Forecasting rain-fed rice yield with biomass of early phenophases peak intercepted PAR and ground based remotely based vegetation indices. *Journal of Agro-meteorology* 16 (1): 94-103.

Kar, G. and Kumar, A. 2014. Water footprints of crop production under different agro-management. *Journal of Sustainable Planet* 5(2): 14-33.

Kar, G., and Kumar, A. 2015. Effect of phenology based irrigation scheduling and nitrogen on light interception, water productivity and energy balance of maize (*Zea mays* L.). *Journal of Indian Society of Soil Science* 63(1):1-13.

Kar, G., Kumar, A. and Mohapatra, S. 2014. Radiation utilization efficiency nitrogen uptake and modeling crop growth and yield of rainfed rice under different nitrogen rate. *Journal of Indian Society of Soil Science* 62(2):39-51.

Kar, G., Kumar, A., Brahmannad, P.S., Raychoudhuri, M., Mayilsami, C., Singh, P. K. and Rank, H. D. 2014. Impacts of climatic variability on crop water demand productivity and groundwater table with some climate change adaptation options. *Journal of Sustainable Planet* 5(2):52-76.

Kar, G., Kumar, A., Sahoo, N. and Singh, R. 2014. Acid soil amelioration with paper mill sludge and its impacts on biomass grain yield water footprints and nutrient uptake of rainfed groundnut. *Journal of Indian Society of Soil Science* 62 (3):1-10.

Kar, G., Kumar, A., Sahoo, N. and Singh, R. 2014. Use of paper mill sludge as an alternative liming material and its impacts on light interception radiation utilization efficiency of groundnut in acid soils of eastern India. *Indian Journal of Agricultural Physics* 14(1): 10-21.

Kar, G., Kumar, A., Sahoo, N. and Singh, R. 2014. Farm level water footprints of rice production based on measured and estimated crop evapo-transpiration. *Journal of Agro-meteorology* 16(2): 157-163.

Mandal, C. *et al*. 2014. Revisiting Agro-ecological sub regions of India – A case study of two major food production zones. *Current Science* 107(9):1519-1536.

Mandal, K.G., Kumar, A., Padhi, J., Ghosh, S., Mohanty, R.K., Majhi, P. and Raychaudhuri, M. 2015. Improving water productivity in a canal command through conservation of surface and ground water using tanks and wells. *International Water Resources Association (India) Journal* 4(1): 3-10.

Mandal, K.G., Wanrong, Gu, Zhang Ming, Cai, Duan, Liusheng and Li, Zhaohu 2014. Effect of nutrient- N, P & K starvation on root growth of soybean [*Glycine max* (L.) Merrill] seedlings. *Ecology, Environment and Conservation* 20 (2): 459-466.

Mangaraj, S., Goswami, T. K. and Panda, D.K. 2014. Modeling of gas transmission properties of polymeric films used for MA packaging of fruits. *Journal of Food Science and Technology*. DOI 10.1007/s13197-014-1682-2.

Mishra, A., Ghosh, S., Mohanty, R.K., Brahmanand, P.S. and Verma, H.C. 2014. Secondary storage reservoir: A potential option for rainwater harvesting in irrigated command for improved irrigation and agricultural performance. *Economic Affairs* 59(3): 389-402.

Mishra, A., James, B. K., Mohanty, R.K. and Anand, P.S.B. 2014. Conservation and efficient utilization of rainwater in the rainfed shallow lowland paddy fields of Eastern India. *Paddy and Water Environment* 12: 25-34.

Mohanty, R.K. 2014. Effects of feed restriction on compensatory growth performance of Indian major carps in a carp–prawn polyculture system: a response to growth depression. *Aquaculture Nutrition* doi: 10.1111/ anu.12173

Mohanty, R.K. and Jiban Dash S.S., 2014. Hydrobiology and fisheries of chilika lagoon. *GCBR BioResearch* 1(2): 13-23.

Mohanty, R.K., Mishra, A. and Patil, D.U. 2014. Water budgeting in black tiger shrimp *Penaeus monodon* culture using different water and feed management systems. *Turkish Journal of Fisheries and Aquatic Sciences* DOI: 10.4194/1303-2712-v14_2_20

Mohanty, R.K., Mishra, A., Panda, D.K. and Patil D.U. 2014. Effects of water exchange protocols on water quality, sedimentation rate and production performance of *Penaeus monodon* in earthen ponds. *Aquaculture Research* doi :10. 1111/are. 12404.

Mohanty, R.K., Mishra, A., Panda, D.K. and Patil, D.U. 2015. Water budgeting in a carp-prawn polyculture system: impacts on production performance, water productivity and sediment stack. *Aquaculture Research*, doi:10.1111/are.12659

Nayak, A.K., Das, M., Sethi, R.R. and Kumar, A. 2014. Development of information system for evaluating ground water quality in an urban city of eastern India. *Journal of Indian Society of Coastal Agricultural Research* 32(1):59-62.

Panda, P.K., Singh, A. K., and Dubey, S.K. 2014. Participatory technology development for enhancing farm income with chickpea cultivation in watershed of central India. *Journal of Food Legumes* 27(4): 315-318.

Panigrahi, P. 2014. Integrated irrigation and drainage management for citrus orchards in Vertisol. *Irrigation and Drainage* 63:621–627.

Panigrahi, P., Raman, K.V. and Sharma, R.K. 2014. Sensing tree for yield forecasting under different irrigation. *International Journal of Agriculture and Forestry* 11 (2): 23–30.

Patil, N.G. *et al.* 2014. Natural resources of the Indo-Gngetic plains: a land-use planning perspective. *Current Science* 107(9):1537-49.

Rautaray, S.K. 2014. Flowering behavior of rice varieties and its economic importance. Indian Farming 64(6): 16-18.

Ray, S.K. *et al*. 2014. Soil and land quality indicators of the Indo-Gangetic plains of India. *Current Science* 107(9): 1470-86.

Raychaudhuri, M., Kundu, D.K., Mandal, K.G., Kumar, A., Kar, G., Raychaudhuri, S., Mohapatra, S., Sidhu, G.S., Sahoo, A.K., Das, K., Singh, R.S., Das, T.H., Pal, D.K., Ray, S.K., Sarkar, D. and Bhattacharya, T. 2013. Relationship of saturated hydraulic conductivity with moisture constants and some soil physical and chemical properties. *Journal of Water Management* 21 (1): 1-5.

Roy Chowdhury, S. Brahmanand, P.S., Kundu, D.K., Thakur, A.K. and Kumar, A. 2014. Influence of seedling age and nitrogen application on photosynthesis and yield of rice (*Oryza sativa*) grown under waterlogged condition. *Indian Journal of Plant Physiology* 19:83-86.

Roy Chowdhury, S., Mohanty, R.K., Brahmanand, P.S. and Kumar, A. 2015. Impact of walking catfish *Clarius batrachus* on growth and production characteristics of water chestnut (*Trapa bispinosa*) and water hyacinth (*Eichhornia crassipes*) in a waterlogged ecosystem. *Journal of Aquatic Plant Management (USA)* 53:113-120.

Satapathy, B.S., Pun, K. B., Singh, T. and Rautaray, S.K. 2014. Effect of liquid seaweed sap on yield and economics of summer rice. *Oryza* 51(2): 131-135

Satapathy, B.S., Singh, T., Pun, K.B. and Rautaray, S.K. 2014. Assessment of High yielding varieties of rice for integrated rice-fish-horticulture farming system under lowland ecosystem of northeastern India. *Annals of Agricultural Research New Series* Vol. 35 (2): 188-192.

Sethi, R.R., Kaledhonkar, M.J., Das, M., Srivastava, S.K., Nayak, A.K. and Kumar, A. 2014. Groundwater pumping options in coastal areas of Odisha. *Journal of Indian Society of Coastal Agricultural Research* 32(1):49-53.

Sethi, R.R., Sahu, A.S., Kaledhonkar, M.J., Sarangi, A., Rani, P., Kumar, A. and Mandal, K.G. 2014. Quantitative determination of rice cultivated areas using geospatial techniques. *Journal of Environmental Science, Toxicology and Food Technology* 8(4): 76-81.

Sethi, R.R., Sahu, A.S., Srivastava, R.C., Das, M., Kumar, A. and Tripathy, J.K. 2014. Monitoring land cover changes in coastal tract of Odisha using Landsat ETM + Imagery. *Current World Environment* 9(2): 430-436.

Sethi, R.R., Singhadhupe, R.B. and Kumar, A. 2014. Conjunctive Planning of Surface and Groundwater Resources in Canal Command Area of Odisha-A Success Story. *IOSR Journal of Agriculture and Veterinary Science* (IOSR-JAVS) 7(9): 43-48.

Sidhu, G.S. *et al*. 2014. Impact of management levels and land - use changes on soil properties in rice- wheat cropping system of the Indo-Gangetic Plains (IGP). *Current Science* 107(9): 1487-1501.

Sinha, M.K., Thombare, N.N. and Mondal, B. 2014. Subclinical mastitis in dairy animals: Incidence, economics, and predisposing factors. *The Scientific World Journal* http://dx.doi.org/10.1155/2014/523984.

Srinivas, S. *et al*. 2014. Impact of management levels and land - use changes on soil properties in rice- wheat cropping system of the Indo-Gangetic Plains (IGP). *Current Science* 107(9): 1487-1501.

Srivastava, A.K. *et al*. 2014. Impacts of agro-climates and land use systems on culturable microbial population in soils of the Indo-Gangetic Plains, India. *Current Science* 107(9): 1464-1469.

Srivastava, S.K., Srivastava, R.C., Sethi, R.R., Kumar, A. and Nayak, A.K. 2014. Accelerating groundwater and energy use for agricultural growth in Odisha: Technological and policy issues. *Agricultural Economics Research Review* 27(2):259-270.

Tiwary, P. *et al*. 2014. Pedotransfer functions: a tool for estimating hydraulic properties of two major soil types of India. *Current Science* 107(9): 1431-1439.

Velmourougane, K. *et al*. 2014. Impacts of bio-climates, cropping systems, land use, and management on the cultural microbial population in black soil regions of India. *Current Science* 107(9): 1452-1463.

Venugopalan, M.V. *et al*. 2014. INFOCROP-Cotton Simulation model – its application in land quality assessment for cotton cultivation. *Current Science* 107(9): 1412-1418.

B. RESEARCH BULLETIN/ INFORMATION BROCHURE /LEAFLET

Kar, G., Singh, R., Kumar, A. and Sikka, A.K. 2014. Farm level water footprints of crop production: Concept and accounting. Research Bulletin No. 67, Directorate of Water Management. Bhubaneswar, 48p.

Kar, G., Sahoo, N. and Kumar, A. 2015. Enhancing water productivity of seasonal coastal flood prone areas of Orissa through innovative water and crop management strategies. Success Story, Published by ICAR-Indian Institute of Water Management, Bhubaneswar, 16p.

Kar, G., Kumar, A. and Sahoo, N. 2015. Acid soils management for higher crop productivity: an integrated approach. ICAR-Indian Institute of Water Management, Bhubaneswar, 8p.

Mayilswami, C., Valliammai, A., Jothimani, P., Pandian, B.J., Gokila, J., Balathandayutham, K., Raychaudhuri, M. and Kumar, A. 2014. A Handbook on groundwater perspectives of Parambikulam-Aliyar-Palar (PAP) basin. AICRP on Groundwater Utilization. Water Technology Centre, Tamilnadu Agricultural University, Coimbatore, 153p.

Mishra, A., Sharma, C.S., Panda, S.N., Jena, S.K., Panda, D.K., and Kumar, A. 2014. Flood Induced Land Use Land Cover Changes and River Dynamics Assessment in Gujarat State, India. Research Bulletin No. 68, Directorate of Water Management. Bhubaneswar, 44p.

Raychaudhuri, M., Raychaudhuri, S., Jena, S.K., Kumar, A., and Srivastava, R.C. 2014. WQI to Monitor Water quality for Irrigation and Potable Use. Research Bulletin No. 71, Directorate of Water Management. Bhubaneswar, 43p.

Mohanty, S., Jha, M.K., Kumar, A. and Srivastava, R.C. 2014. Groundwater Modeling for Sustainable Aquifer Management in a River Island of Eastern India. Research Bulletin No. 72, Directorate of Water Management. Bhubaneswar, 37p.

Rank, H.D., Vekariya, P.B., Vadher, P.G., Kelaiya, J.H., Paradava, D.M., Majethiya, G.K., Hala, Y.H. Subbaiah, R., Gontia, N.K., Parakhia, A.M., Dangaria, C.J., Patel, N.C., Kar, G., Raychaudhuri, M. and Kumar, A. 2015. Climate change impact assessment, modelling and simulating the groundwater level behaviour for Bhadar basin of Gujarat, 46p.

Thakur, A.K., Singh, Rajbir and Kumar, A. 2014. The Science behind the System of Rice Intensification (SRI). Research Bulletin No. 69, Directorate of Water

Management, Bhubaneswar, 58p.

Thakur, A.K., Mohanty, R.K., Raychadhuri, S., Verma, O.P., Panda, R.K. and Kumar, A. 2014. Integrated System of Rice Intensification (ISRI) for enhancing land and water productivity. Research Bulletin No. 70, Directorate of Water Management, Bhubaneswar, 38p.

Singh, P.K., Yadav, K.K., Singh, M., Kar, G. and Kumar, A. 2014. Augmentation under of groundwater resources climate change in Rajasthan. Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, 125p.

Singh, P.K., Yadav, K.K., Kumar, A., Raychaudhuri, M. and Singh, M. 2014. Field investigations and delineation of groundwater potential zones using RS and GIS in Wakal river basin. Technical Bulletin, AICRP on Groundwater Utilization. Department of Soil and Water Engineering, College of Technology and Engineering, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, 40p.

C. BOOKS/ TRAINING MANUAL

Kumar, A., Brahmanand, P.S. and Nayak, A.K. (eds.) 2014. Management of cyclone disaster in agriculture sector in coastal areas. Training Manual. ICAR-Indian Institute of Water Management, Bhubaneswar, 117p.

Panigrahi, P., Mohanty, S., Srivastava, R.C. and Ambast, S.K. 2015. Micro Irrigation and Protected Cultivation for Efficient use of Water and Enhanced Crop Productivity. Training Manual. ICAR-Directorate of Water Management, Bhubaneswar, 67p.

6. Awards / Honours / Recognitions

- Dr. Gouranga Kar, Principal Scientist, received the "RAJDHANI GAURAV SAMMAN AWARD" for the year 2014-15 for his outstanding contribution in the field of agricultural science. He received the award from Hon'ble Speaker of Orissa Legislative Assembly, Shri Niranjan Pujari on the occasion of 67th Capital Foundation Day of Bhubaneswar.

- Dr. P.S. Brahmanand, Senior Scientist has been awarded with Plaque of Honour for outstanding contribution to popularize agricultural science among school children from Pipli Sanskrutika Parishad, Pipli, Puri and Swadhinata Sangrami Saheed Smruti Sanshad, Odisha, Bhubaneswar on 14th May 2014.

- DWM Proficiency Award for the year 2013 was given by Director, Dr. Ashwani Kumar to different categories of staff (Scientific, Administrative, Technical and Supporting) on the DWM foundation day celebration (12th May) for their significant achievements. The recipients of the award in different categories were as follows:

Scientist	
1.	Dr. Rajbir Singh
2.	Dr. M. Raychaudhuri
3.	Dr. M.K. Sinha
4.	Dr. O.P. Verma
Technical	
1.	Mr. P. Barda
2.	Mr. A.K. Binakar
3.	Mr. A. Mallik
Supporting	
1.	Mr. H.K. Bal

- Dr. P.S.Brahmanand, Senior Scientist and his team has been awarded with 'Purushottam JibanDash Memorial Bio-Research Best Paper Award-2014' for the article entitled 'Performance evaluation of rice under intermittent irrigation and drainage in eastern India' authored by Brahmanand, P.S., Kumar, A., Roy Chowdhury, S., Ghosh, S., Kundu, D.K., Mandal, K.G., Singandhupe, R.B., Nanda, P. and Reddy, G.P. published in GCBR Bio Research Journal 2014:1(2):24-30.

- Dr. S.K. Jena, Principal Scientist and his team was awarded with 'Best Poster Award' for the paper entitled 'ICAR flexi-check dam for sustainable livelihood security for small holder farmers' by Jena, S.K., Brahmanand, P.S., Chattopadhyay, S.K., Bharimalla, A.K., Raj Kumar, K., Talukdar, M.K., Roy Choudhury, P., Sahoo, N. and Patil, D.U at 12th Agricultural Science Congress held at ICAR-NDRI, Karnal during 3-6 February 2015.

- Dr. S. Mohanty, Senior Scientist received 'GCBR Award- 2014'for his contribution in the field of Biological Sciences.

- Dr. S. Mohanty and his co-authors received 'K.C. Das Memorial Award' from 'The Institution of Engineers, Orissa Chapter' for the research paper entitled 'Artificial Neural Network Modeling for Groundwater Level Forecasting of a Group of Wells in a Deltaic Aquifer of Eastern India.'

- Dr. P.S. Brahmanad, Senior Scientist received "Certificate of Appreciation" from Director, ICAR-IIWM, Bhubaneswar for securing first position in Elocution competition on "Combating corruption: Technology as an enabler" held on the occasion of Vigilance Awareness Week.

- Dr. S.K. Jena, Principal Scientist has been nominated by ICAR as Member, Assessment Committee for promotion; NIRJAFT, Kolkata, Expert member, Assessment Committee for promotion of Technical personnel, ICAR-CRRI, Cuttack and appointed as an academic counsellor for IGNOU diploma course on "Watershed management".

- Dr. S. Raychaudhuri, Principal Scientist was elected as Councilor in the Council of the Society (Indian Society of Soil Science, New Delhi) for the two years 2015 and 2016.

- Dr. S. Raychaudhuri, Principal Scientist has been appointed as counsellor, IGNOU and E-content writerof UGC.

- Dr. S.K. Jena, Principal Scientist was appointed as an external examiner for evaluation of PhD. Thesis of TNAU, Coimbatore and M. Tech. Thesis of MPKV, Rahuri.

- Dr. Gouranga Kar, Principal Scientist, ICAR-IIWM has been elected as VICE PRESIDENT of the Association of Agro-meteorologists for the period 2015-17 and selected as Co-convener of the Orissa chapter of National Academy of Agricultural Science.

- Dr. S.K. Jena, Principal Scientist has been nominated by ICAR as Member, Institute Management Committee (IMC) of ICAR Research Complex for NEH Region, Barapani, Meghalaya and Chairman, Assessment Committee of CRIJAF, Kolkata.

- Dr. K.G. Mandal has been selected as Editorial Board Member for the 'Journal of Food, Agriculture and Environment', published by WFL Publisher, Helsinki, Finland.

- Dr. S. Roy Chowdhury, Principal Scientist and Dr. A.K. Thakur, Senior Scientist has been selected as editor for Indian Journal of Plant Physiology (Springer), ISPP, New Delhi.

- Dr. S. Roy Chowdhury, Principal Scientist and Dr. A.K. Thakur, Senior Scientist has been selected as co-organizing secretaries for conducting National Conference of Plant Physiology (NCPP-2014), organized by Indian Society for Plant Physiology, New Delhi and OUAT, Bhubaneswar during November 23-25, 2014.

Visit Abroad on Deputation

- Dr. Amod K. Thakur, Senior Scientist visited on deputation to attend and present paper entitled '*Integrated System of Rice Intensification (ISRI): Climate-resilient technology to enhance crop and water productivity*' in 4th International Rice Congress 2014 held at Bangkok, Thailandduring 27 October-01 November, 2014.

- Dr. P. Nanda, Principal Scientist and Dr. M.K. Sinha, Senior Scientist visited on deputation to attend and present paper on '*Adoption pattern of improved rice varieties and their farm level impacts in rain fed areas of Odisha*' in 8th Asian Society of Agricultural Economics International Conference held at BRAC Centre for Development, Savar, Dhaka, Bangladesh during 13-18 October, 2014.

7. RAC/ IRC/ IMC/ AICRPs Meetings

RESEARCH ADVISORY COMMITTEE (RAC) MEETING

The third meeting of sixth Research Advisory Committee of ICAR-Indian Institute of Water Management (formerly Directorate of Water Management) was organized on 13 and 14th March 2015 at IIWM, Bhubaneswar. The meeting was chaired by Dr. S.R. Singh, former Vice Chancellor, RAU, PUSA and Project Director, DWMR, Patna. The meeting was attended by Chairman, RAC Dr. S.R. Singh, Former VC, RAU PUSA and PD, DWMR, Patna, and other RAC members, Dr. S.D. Sharma, Ex-Dean (Agric. Engg.) OUAT, Bhubaneswar, Dr. S.K. Tripathi, Professor, IIT Roorkee, Dr. K.N. Tiwari, Professor, IIT Kharagpur, Dr. S.K. Chaudhari, Asst. Director General (S & WM), ICAR, New Delhi and Dr. S.K. Ambast, Director, ICAR-IIWM, Bhubaneswar along with the scientists of ICAR-Indian Institute of Water Management, Bhubaneswar. At the beginning of the meeting, Dr. S.K. Ambast, Director, IIWM, welcomed the Chairman and all other members. Dr. S.R. Singh, Chairman in his opening remark, while recapitulating the genesis of ICAR-IIWM, he handed over the first concept paper in the form of a technical bulletin of ICAR-IIWM authored by him to the Director. He sought the role of ICAR-IIWM for design of check dam structures in the catchments of low order streams, ponds, recharge wells and water harvesting structures in all the catchments. Director presented the progress and achievements of the institute and AICRPs during 2014-15 followed by presentation of work under different programmes by programme leaders and AICRPs by Principal Scientists of AICRPs. The Chairman and other members appreciated the work of the scientists and the achievements made by ICAR-IIWM, AICRP on WM as well as AICRP on GWU projects during the said period. The program was coordinated by Member Secretary, Dr. S. Roy Chowdhury.

3rd meeting of 6th Research Advisory Committee of ICAR-IIWM

INSTITUTE RESEARCH COUNCIL (IRC) MEETINGS

During the year 2014-15, Institute's Research Council (IRC) meetings were organized during 7th – 8th July and 22nd December, 2014. The results of the on-going research projects were presented and deliberated in the meeting and new research project proposals were presented and discussed. The first IRC meeting was organized by Dr. R.C. Srivastava, Principal Scientist and Member Secretary, IRC and was chaired by Dr. Ashwani Kumar, the then Director, ICAR-IIWM, Bhubaneswar. Second IRC meeting was organized by Dr. S.K. Jena, Principal Scientist and Member Secretary, IRC and was chaired by Dr. R.C. Srivastava, Director (In-charge), ICAR-IIWM, Bhubaneswar. During the first IRC meeting RPF II of 15 projects were presented and was approved after thorough discussion. Two new projects were presented and was suggested for revision and was discussed during second IRC meeting. In the second IRC meeting, ten new project proposals were presented and were approved.

Institute Research Council Meeting at ICAR-IIWM

INSTITUTE MANAGEMENT COMMITTEE (IMC) MEETING

The seventeenth Institute Management Committee (IMC) meeting of the ICAR-Indian Institute of Water Management was organized on 14th October 2014. The members of IMC present in the meeting were: Dr. P.C. Mohapatra, Principal Scientist, ICAR-CRRI, Cuttack, Dr. R.K. Panda, Principal Scientist, ICAR-IIWM, Bhubaneswar, Dr. M. Abdul Hassan, Principal Scientist, ICAR-CIFRI, Barrackpore, Dr. M.P.S. Arya, Principal Scientist, ICAR-DWRA, Bhubaneswar, Mr. S.R. Khuntia, Chief F & AO and Mr. S.C. Sheet, AO & Member-Secretary, ICAR-IIWM, Bhubaneswar.

CHIEF SCIENTISTS' MEET OF AICRP-WM and AICRP-GWU

The Chief Scientists' Meet of AICRP on Water Management and AICRP on Groundwater Utilization was organised at CSKHPKV, Palampur during 24th June to 27th June 2014. About 75 scientists, line department personnel, NGOs, press and media participated in the meet. Inaugural function of Chief Scientists' meet of AICRP on Water Management and AICRP on Groundwater Utilization was organized at Palampur campus on 24th June 2014 morning. The programme started with Saraswati Vandana. Lighting the lamp was done by Chief Guest Hon'ble Smt. Vidya Stokes, Irrigation and PWD Minister, Govt. of H.P, Dr. K. Katoch, Vice-chancellor, CSKHPKV, Local MLA Er. Yoginder Goma and Dr. Ashwani Kumar, the then Director, ICAR-IIWM, Bhubaneshwar were Guests of Honour. The Inaugural session was followed by presentations on water management scenarios of Gujarat. Brain storming session on 'Water Management, Water quality, Impact of Climate Change on Water Resources and Economic Use of Water' was also organized at CSK HP Agricultural University Palampur on 24th June, 2014. Technical proceedings were conducted for reviewing of concluded and ongoing projects, approval of new projects presented by AICRP on WM and AICRP on GWU centres during 25-27 June. On 27 June, plenary session was conducted, jointly chaired by the Director of Research, CSKHPKV and Dr. Ashwani Kumar, the then Director, ICAR-IIWM. Dr. Prabhakar Nanda, Pr. Scientist, PCU, WM at IIWM outlined the future course of work under AICRP on Irrigation Water Management after merging of AICRP on WM and GWU schemes during XII Plan, monitoring mechanism, convergence under the scheme and scaling up of technologies generated through AICRP.

AICRP Chief Scientist Meet 2014 at Palmpur

8. List of Completed / Ongoing / New In-House Projects

A. LIST OF IN-HOUSE RESEARCH PROJECTS COMPLETED DURING 2014-15

Sl. No.	Project Code	Project Title	PI Name
1.	DWM/10/147	Conservation agriculture practices in maize based cropping system with special emphasis on nutrient and water availability for the rainfed sub-humid agro-ecosystem	Dr. P.K. Panda
2.	DWM/11/151	Performance evaluation of drip irrigated mango (*Mangifera indica* L) under deficit irrigation	Dr. S. Mohanty
3.	DWM/11/152	Impact of wastewater effluents on soil productivity constituents and its prospect of utilization in farming	Dr. M. Das
4.	DWM/11/153	Effect of dry spell occurrence on reduction in paddy yield and optimum design of rain water harvesting structure for its mitigation	Dr. S. Mohanty
5.	DWM/12/154	Extreme climate effects on major cropping systems of Odisha	Dr. D. K. Panda
6.	DWM/12/155	Water budgeting in high value shrimp monoculture and carp poly culture under varying intensification levels	Dr. R. K. Mohanty

B. LIST OF IN-HOUSE ONGOING RESEARCH PROJECTS DURING 2014-15

Sl. No.	Project Code	Project Title	PI Name
1.	DWM/12/156	System of Rice Intensification: Studies on water management, micronutrient uptake and crop rotation	Dr. A.K. Thakur
2.	DWM/12/157	Development of runoff recycling model for production and profit enhancement through alternate land and crop management practices	Dr. P.K. Panda
3.	DWM/12/158	Evaluating deficit irrigation under drip system for rice based cropping sequence in canal command area	Dr. P. Panigrahi
4.	DWM/12/159	Identification of suitable crops for wastewater irrigation	Dr. Sachidulal Raychaudhuri
5.	DWM/12/160	Development of Agricultural Water Management Portal (AWMP)	Dr. A.K. Nayak
6.	DWM/12/161	Design and development of small filters for reducing undesirable substances in poor quality water at farmers level for safe irrigation in peri urban areas	Dr. M. Raychaudhuri
7.	DWM/12/162	Delineation of waterlogged areas in eastern India and formulating strategies for fitting in suitable crops and aquaculture through harnessing agro-biodiversity for enhancing water productivity	Dr. Somnath Roy Chowdhury
8.	DWM/12/163	Eco-efficient agricultural practices for enhancing nutrient use efficiency of rice (*Oriza Sativa*) under waterlogged ecosystem	Dr. P.S. Brahmanand
9.	DWM/12/164	Development of technological options for comprehensive water resource management in non exploration zone (CRZ III) of coastal Odisha	Dr. R.R. Sethi

10.	DWM/14/165	Development of decision support system for conjunctive use of surface and ground water	Dr. O.P. Verma
11.	IIWM/15/166	Assessment of technological intervention on water management for its adoption and sustainability	Dr. M.K. Sinha
12.	IIWM/15/167	Design and evaluation of a portable drum based drip irrigation system	Dr. R.C. Srivastava
13.	IIWM/15/168	Water and nutrient self-reliant farming system for rainfed area under high rainfall zone	Dr. S.K. Routaray
14.	IIWM/15/169	Drainage planning of eastern coast delta using geoinformatics	Dr. S.K. Jena
15.	IIWM/15/170	Impact assessment study of wastewater and air pollution on sunflower grown in peri-industrial area of Odisha	Mrs. Rachana Dubey

C. LIST OF IN-HOUSE NEW RESEARCH PROJECTS APPROVED DURING 2014-15

Sl. No.	Project Title	PI Name
1.	Developing the process for remediation of chromium from polluted water sources	Dr. M. Das
2.	Evaluation of feasibility of enhancing irrigation efficiency in canal command through improved surface and pressurized irrigation methods by adding adjunct service reservoir and open dug well	Dr. R.K. Panda
3.	Inter-regional virtual water trade in India through agro-based products	Dr. G. Kar
4.	Density dependent water use in coastal aquaculture of *Litopenaeus vannamei*	Dr. R.K. Mohanty
5.	Water management in medium and minor canal commands for rice-rice systems to enhance water use efficiency and nutritional water productivity	Dr. K. G. Mandal

9. Human Resource Development

Participants	Name of the Seminar / workshop / training / conference	Organized by	Date of events
Dr. M.K. Sinha	VDSA Project Progress Review and Planning Meeting for East India 2014-15	International Crop Reserach Institute for Semi Arid Tropics (ICRISAT), Hyderabad	April 3-4, 2014
Dr. P. K. Panda	National Seminar on 'Organic Agriculture Challenges & Prospects'	Department of Organic Agriculture, CSK HPKV, Palampur	May 28-29, 2014
Dr. R. C. Srivastava	Meeting at ICAR-RCER Patna to decide the future technical program of institute	ICAR-RCER Patna	May 29, 2014
Dr. R. C. Srivastava	Global conference on Technological Challenges and Human-resource for Climate Smart Horticulture- issues and Strategies	ASMF, New Delhi	May 2014
Dr. R. C. Srivastava	Regional Committee Meeting, Kolkata,	CIFRI, Kolkata	June 2014
Dr. S. Mohanty	Training Program on 'Groundwater Resource Estimation'	CGWB, Raipur	June 9-13, 2014
Dr. A.K. Thakur	International W orkshop on 'Changes in rice production and rural livelihoods: New insights on the System of Rice Intensification (SRI) as a socio-technical movement in India'	Wageningen University, The Netherlands and NCS, New Delhi	June 19-21, 2014
Dr. R. C. Srivastava Dr. M. Raychaudhuri	Brain storming session on 'Water Management, Water quality, Impact of Climate Change on Water Resources and Economic Use of Water'	CSK HP Agricultural University Palampur & ICAR-Directorate of Water Management, Bhubaneswar	June 24, 2014
Dr. P. K. Panda	National Conference on 'Water, Environment and Society (NCWES-2014)'	Centre for Water Resources, Institute of Science & Technology, JNTU, Hyderabad	June 30- July 1, 2014
Dr. A.K. Thakur	Seminar cum workshop on 'Science behind SRI-Progress in Tripura'	Tripura State Agricult ure Department	August 4, 2014
All Admin. & Finance staff	Training Program on MIS/FMS	ICAR-IIWM, Bhubaneswar	August 5-31, 2014
Dr. P.S. Brahmanand	Divisional Review meeting of foreign aided projects	NRM division, ICAR, New Delhi	August 6, 2014
Dr. A.K. Thakur	National Conference on ‚System of Rice Intensification: Research Issues, Priorities and Prospects'	Livolink Foundation, Bhubaneswar	August 12-13, 2014
All scientists of ICAR IIWM	-Training on 'Enterprise Resource Planning (ERP)'	ICAR-IIWM, Bhubaneswar	August 26, 2014
Dr. R.R. Sethi Dr. D.K. Panda	3rd International Conference on 'Hydrology and Meteorology'	OMICS Group, Hyderabad	September 15-16, 2014
Dr. M.K. Sinha	Dynamics of Rural Labor Markets: Implications for Agricultural Growth and Rural Transformation in New Delhi	International Crop Reserach Institute for Semi Arid Tropics (ICRISAT), Hyderabad	September 15-16, 2014

Dr. S.K. Rautaray	'Conservation Agriculture: Developing Resilient Systems'	CSSRI, Karnal	September 27 - October 4, 2014
Dr. M.K. Sinha	8th Asian Society of Agricultural Economics International Conference	Asian Society of Agricultural Economics	October 13-18, 2014
Dr. G. Kar	International Symposium on 'New dimensions in agrometrology for sustainable agriculture'	Association of Agro - meteorologists	October 16-18, 2014
Dr. R. K. Panda	Mid-term review meeting on the progress of RFD 2014-15	NRM Division, New Delhi	October 28, 2014
Dr. A.K. Thakur	4th International Rice Congress at Bangkok, Thailand	IRRI, Philippines	October 27-November 01, 2014
Dr. S.K. Rautaray Dr. K.G. Mandal Dr. S. Mohanty Dr. P. K. Panda Dr. O. P. Verma	National Symposium on 'Management Options for Enhancing Farm Productivity and Livelihood Security under Changing Climate'	Indian Society of Agronomy, Odisha Chapter & OUAT, Bhubaneswar.	October 29-31, 2014
Dr. P. Panigrahi	4th International Conference on 'Hydrology and Watershed Management'	JNTU, Hyderabad	October 29-November 1, 2014
Dr. S. Raychaudhuri	Workshop on 'Water for cities and Agriculture' – From Confrontation-Competition to Cooperation	Robert Bosch Centre for Cyber Physical Systems, Indian Institute of Science, Bangalore	October 31-November 1, 2014
Dr. R. C. Srivastava	6th Indian Horticulture Congress	Indian Horticulture Society and TNAU, Coimbatore	November 2014
Dr. P.S. Brahmanand	All India Rajbhasha Conference	Vishwamukhti Samsthan and KIIT University, Bhubaneswar, Odisha	November 14-16, 2014
Dr. S. Roy Chowdhury Dr. A.K. Thakur Dr. P.S. Brahmanand Mrs. Rachana Dubey	National Conference of 'Plant Physiology on Frontiers of Plant Physiology Research; Food security and environmental challenges'	Indian Society for Plant Physiology, New Delhi and OUAT, Bhubaneswar	November 23-25, 2014
Dr. Madhumita Das Dr. S. Raychaudhuri	79th Annual Convention of Indian Society of Soil Science	Indian Society of Soil Science, Hyderabad Chapter, ANGRAU	November 24 - 27, 2014
Dr. D.K. Panda	Advanced soft computing techniques in hydrology and its applications (ASCTHA-2014)	National Institute of Hydrology, Roorkee	November 27-December 2, 2014
Dr. R. K. Panda	Management Development Programme (MDP) on Leadership (a pre-RMP programme)	ICAR-NAARM, Hyderabad	December 1-12, 2014
Dr. S.K. Jena Dr. A.K. Nayak	National seminar on 'Sustainable agriculture under the prevalence of natural disasters'	Gugly Centre for Biological Research, Bhubaneswar	December 12-13, 2014
Dr. A.K. Nayak	Workshop on 'Aadhar Enabled Bio - metrics Attendance System -AEBAS'	National Informatics Centre, Bhubaneswar	December 24, 2014
Dr. K.G. Mandal Dr. P.S. Brahmanand Dr. D.K. Panda	102nd Indian Science Congress	The Indian Science Congress Association (ISCA) & University of Mumbai	January 3-7, 2015

Dr. R. C. Srivastava Dr. M. Raychaudhuri Dr. S. Raychaudhuri Dr. S. Mohanty	India Water Week-2015	Ministry of Water Resources, Govt. of India, at New Delhi	January 13-17, 2015
Dr. R.R. Sethi	India Water Week-2015	Minor Irrigation Division, Sundargarh, sponsored by Ministry of Water Resources, river development and Ganga rejuvenation, New Delhi	January 16, 2015
Dr. R.R. Sethi	NRSC User Interaction Meet-2015	National Remote Sensing Centre, Balanagar, Hyderabad	January 21-22, 2015
Dr. P.S. Brahmanand	Divisional Review meeting of foreign aided projects	NRM division, ICAR, New Delhi	January 27, 2015
Dr. R.R. Sethi	International Workshop on Water Security and Groundwater Management for Agriculture in the age of climate change	TERI, University of Melbourne and University of Western Sydney, Australia	February 3-4, 2015
Dr. S.K. Jena	12th Agricultural Science Congress on 'Sustainable livelihood security for small holder farmers'	ICAR-NDRI, Karnal	February 3-6, 2015
Dr. R.R. Sethi	Advisory committee meeting of projects under Decision support system and water productivity thematic area of NFBSFARA.	WTC, New Delhi	February 10, 2015
Dr. Madhumita Das Dr. G. Kar Dr. M.K. Sinha Dr. P. K. Panda Dr. R.R. Sethi Dr. S. Mohanty Dr. D.K. Panda Dr. P. Panigrahi Dr. A.K. Nayak	International conference on 'Natural Resource Management for Farming Systems and Rural Livelihood'	Soil Conservation Society of India, New Delhi	February 10-13, 2015
Dr. M. Raychaudhuri	National Seminar on 'Water Management and Climate Smart Agriculture'	Junagadh Agricultural University, Junagadh, WASMO, Govt of Gujarat, ICAR, New Delhi and Climate Change Department, GOI	February 13-14, 2015
Dr. S. Roy Chowdhury	International Workshop 'Global Social Science Conference -2015 on management of sustainable livelihood systems'	International Soc. of Extension Education, OSEE and OUAT, Bhubaneswar	February 14-16, 2015
Dr. K.G. Mandal Dr. D.K. Panda Dr. A.K. Nayak	17th Annual Conference on 'Statistics & information for smart decisions in managing resources: issues and challenges'	Society of Statistics, Computer and Applications (SSCA), New Delhi and BIMTECH, Bhubaneswar	February 23-25, 2015
Dr. R.R. Sethi	49th Annual convention of ISAE and symposium on 'Engineering solutions for sustainable agriculture and food	Indian Society of Agricultural Engineers (ISAE) and College of Agricultural Engineering and	February 23-25, 2015

All scientists of ICAR-IIWM	Final International Workshop on 'Reuse Options for marginal Quality of Water in Urban and Peri-urban Agriculture and Allied Services in the Gambit of WHO Guidelines (REOPTIMA-NEW INDIGO)'	ICAR-IIWM, Bhubaneswar	March 9-12, 2015
Dr. D.K. Panda	Inception workshop of ICAR Network Project-'Impact Assessment of Agricultural Research & Development'	ICAR-NIAP, New Delhi	March 17, 2015
Dr. R. K. Panda Dr. S.K. Jena Dr. R.R. Sethi	Workshop on 'Water and sustainable development'	The Institution of Engineers (India), Odisha state centre, Bhubaneswar	March 22, 2015
All scientists of ICAR-IIWM	Inception workshop on 'Agri-consortia research platform on water'	ICAR-IIWM, Bhubaneswar	March 25-26, 2015
Dr. R. K. Panda Dr. O. P. Verma	Sayunkt Rajbhasha Vaigyanik Sangoshthi	CSIR-IMMT, Bhubaneswar	March 27, 2015

10. List of Sponsored / Collaborative / Consultancy Projects

Title	Budget (Rs. in lakh)	Duration	P.I. / CCPI	Sponsored by
Design and development of rubber dams for watersheds	900.84	2008 to June 2014	Dr. S.K. Jena	NAIP, ICAR, New Delhi
Georeferenced soil information system for land use planning and monitoring soil and land quality for agriculture	35.16	2010 to June 2014	Dr. M. Raychaudhuri	NAIP, ICAR, New Delhi
Improving water productivity under canal irrigation command through conservation and recycling of runoff, seepage, rainwater and groundwater using tanks and wells	45.49	2010 -2015	Dr. K.G. Mandal	INCSW (formerly INCID), Ministry of Water Resources, GOI, New Delhi
National Initiative for Climate Resilient Agriculture	600	2011 -2017	Dr. G. Kar	ICAR, New Delhi
Reuse options for marginal quality water in urban and peri-urban agriculture and allied services in the gambit of WHO guidelines	19.78	2012 - March 2015	Dr. Ashwani Kumar	DST, GOI under New Indigo
Decision Support System for Enhancing Water Productivity of Irrigated Rice-Wheat Cropping System	54.90	June 2012 - May 2016	Dr. R.R. Sethi	National Fund for Basic, Strategic & Frontier Application Research in Agriculture, ICAR, NewDelhi
Appropriating the use of Sakthi Sugars Limited-distillery effluent in different cropping practices	2.00	Aug. 2012 - Aug. 2014	Dr. M. Das	Sakthi Sugars Limited
Impact of climate variability and anthropogenic factor on groundwater resources of India	35.00	Nov. 2012 - Oct. 2015	Dr. D.K. Panda	ICAR-Challenge project
Evaluation of IWMP (2010-11) watersheds (Consultancy)	56.00	2013 - Aug. 2014	Dr. G . Kar	Odisha Watershed Mission, Bhubaneswar
Efficient groundwater management for enhancing adaptive capacity to climate change in sugarcane based farming system in Muzaffarnagar district, Uttar Pradesh	459.00	2015 -2018	Dr. R.C. Srivastava	Ministry of Agriculture, Govt. of India
Tracking Change in Rural Poverty in Household and Village Economies in South Asia	70.35	May 2010 - July 2015	Dr. M.K. Sinha	Bill and Melinda Gates Foundations, USA
Global Yield Gap and Water Productivity Atlas (Collaborative project of ICAR with University of Nebraska, Lincoln, USA)	$56,000	2013 -2015	Dr. P.S. Brahmanand	University of Nebraska, USA and Bill & Melinda Gates Foundation, USA

11. Events Organized

Workshops Organized

- Two days Field workshop on drip fertigation technique was organized at on-farm NICRA project sites of Dhenkanal and Cuttack districts of Odisha on 12th and 13th May, 2014. Hands on training was imparted during workshop to adopted farmers on maintenance of different components of drip system, development of irrigation and fertilizer application schedule, types of fertilizers to be used in fertigation system, maintenance of fertilizers tank and filters etc.

- An Inception workshop on 'Agri-Consortia Research Platform on Water' organized at ICAR-IIWM, Bhubaneswar during 25-26 March, 2015, where projects were presented by different collaborative network partners. Dr. S.K. Chaudhary, ADG (SWM) from NRM Division of ICAR, New Delhi was graced the occasion for guidance.

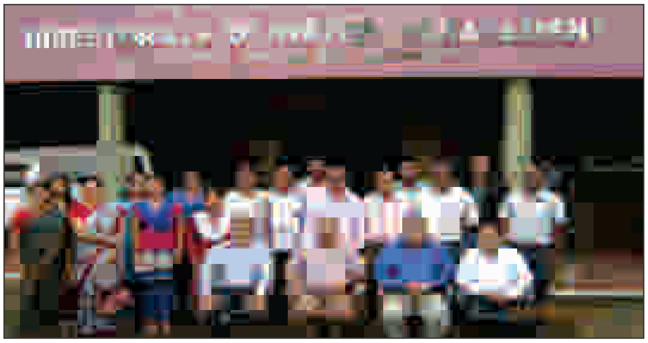
- Final International Workshop under the project on 'Reuse options for marginal quality water for urban and peri-urban agriculture in the gambit of WHO guidelines' funded by Department of Science and Technology, GoI, New Delhi was organized during 9 – 12 March, 2015. About 70 invited experts from DST and TIFAC, New Delhi, various universities, research organizations, related government departments and delegate from The Netherlands and Germany participated in the workshop. Dr. S. Raychaudhuri and his team organised this event.

- Sensitization workshop on 'Groundwater Management' was conducted on 26th January 2015 at Sugo, Jaleswar, Odishawith the participation of the shallow tube well users of the blocks. Dr. D. K. Panda organized this workshop.

Short Course /Training Organized

- A 7-day short course "Management of Cyclone Disaster in Agriculture Sector in Coastal Areas" was organized at ICAR-IIWM, Bhubaneswar during 16-22 July 2014. Various state government functionaries, researchers and teaching faculty from OUAT, Central

Ground Water Board and ICAR institutes participated in this training. Dr. A. Kumar was the Course-Director and Drs. P.S. Brahmananad and A.K. Nayak were the course conveners.



- One week training program on 'Micro-irrigation and Protected Cultivation for Efficient Use of Water and Enhanced Crop Productivity' functionaries of Water User Associations (WUAs) during 16-21 March 2015. Dr. P.Panigrahi and Dr. S.Mohanty were the course directors of this programme.

Field day cum farmers' awareness programme Organized

- A field day cum farmer's awareness programme was organized on 'Climate resilient agriculture through drip fertigation based vegetable farming system' on 7th May 2014 at Dhenkanal, Orissa. On that occasion farmers-experts interacting meeting was held and more than 150 farmers participated in the programme. Dr. A.K. Sikka, Deputy Director General (NRM), ICAR was the chief guest on the occasion. Dr. Gouranga Kar, PI, NICRA project organized the event.

- One Farmers' exposure training programme was conducted under TSP project in the Birjaberna village during 25-26th September 2014. About 60 farmers (more than 83% ST farmers) including 30 women farmers participated in the training programme. Dr. R.K.Panda and his team organized this programme.

- A field day was observed at Birjaberna village, Sundargarh district of Odisha on 25th November 2014 under TSP project, where scientist were intently interacted with farmers on availability of irrigation water and efficient water utilization under farming.Dr. R.K. Panda and his TSP team organized the event.

- One day farmers' training programme cum farmer researcher interface meet was coordinated on "Improvement in productivity of waterlogged areas" at Raisar village, Garadpur block, Kendrapara district of Odisha on 30th March, 2015. Director, ICAR-IIWM Dr. S.K. Ambast was the chief guest on this occasion. Dr. P.S. Brahmanandand his team organized this event.

- One Day Farmer's Training cum researcher-farmer interface meeting was organized under waterlogged area management on "Safe use of Waste water in Agriculture for Reclamation of Waterlogged Areas" on 30th June, 2014 at Jaypurpatna village, Bhubaneswar block, Khurda district, Odisha. Dr. S. Raychaudhuri and team organized this event.

- Two farmers' interactive meet cum field day program was organized at Ainlatunga and Bilaikani villages of Balangir district on 28th February and 28th March 2015. Total 238 farmers participated in the meeting and interacted with the experts on need of soil analyses, cropping practices, micro-irrigation technique and pest management in the fields.Dr. M.K. Sinha and his team coordinated this event.

- Two farmers' training program on crop diversification for livelihood improvement at Sogar and Chandrasekharpur villages in Dhenkanal district of Odisha were organized on 20th and 21st March 2015. More than two hundredsfarmers participated in the meeting and discussedon water conservation techniques, vegetable production practices, plant protection etc. for enhancing agricultural water productivity at farm level. Dr. Mukesh K. Sinha, PI, VDSA Project organized this event.

ICAR Foundation Day

- Interactive meet was organized on 'Emerging Issues in Water Management for Sustainable Agriculture' on the occasion of Foundation Day of ICAR on 16th July 2014 at the Institute.

Exhibition Organized

- Displayed Institute's exhibits on 23rd April 2014 on 68th Foundation Day of ICAR-CRRI, Cuttack. Around 230 farmers participated in the program and had shown keen interest in different farm water management techniques.

- Discussed with the farmers and other stakeholders on situation specific water management through displaying Institute's achievements in the exhibition at ICAR-CRRI, Cuttack on 21-22 October 2014.

- Displayed Institute's achievements in the exhibition organized by ICAR-NBFGR, Lucknow on 10th Indian Fisheries and Aquaculture Forum during 12-15 November 2014.

- Farmers were exposed and got firsthand information on agricultural water management techniques through displaying Institute's achievements in a “Kisan Goshti-cum-Exhibition” held at Rasalpur Jattan and Barwala villages of Muzaffarnagar district, U.P. during 13–14 December, 2014.

- Technologies / achievements of the Institutes on various aspects of water management are disseminated through displaying exhibits in “India Water Week' from 14 – 17 January 2015 at New Delhi.

- Scientists of ICAR-IIWM interacted with the researchers and other stakeholders on various issues of on-farm water management through displaying Institute's achievements in the exhibition on 'Management of Sustainable Livelihood Systems' during Global Social Science Conference -2015 jointly organized by International Society of Extension Education and OUAT, Bhubaneswar during 14-17 Feb, 2015.

- Showcased the achievements / technologies of the Institute to fifty progressive farmers of Balaghat district, M.P. in their exposure visit to this Institute on 16 March 2015.

Drought Contingency Advisory

Scientists of ICAR-IIWM were deputed to different districts of Odisha, *viz*. Sundargarh, Khurda, Dhenkanal, Bolangir, Baleswar, Kendrapada, Nayagarh, Cuttack and Puri to assess the drought scenario arising out of delayed arrival of monsoon and appropriate contingent measures including periodic progress of rice transplanting in drought affected areas. The teams also provided farmers season specific advisory services on agricultural water management.

World Water Day-2015

ICAR-IIWM celebrated World Water Day-2015 on 23rd March 2015. On this Occasion, Dr. A.S. Kereketta, Scientist-E of RMRC, Bhubaneswar delivered lecture on 'Water for health'. Dr. S.K. Jena was the organizing secretary of this event.

Swachha Bharat Abhiyan

ICAR-IIWM actively participated in Swachh Bharat Abhiyan taking inspiration from message of our Hon'ble Prime Minister Shri Narendra Modi and as per the directive from Prime Minister's Office. On the occasion of Birth Anniversary of Father of Nation, Mahatma Gandhi, on 2nd October 2014, the Director and staff of the institute initiated the Swachh Bharat Abhiyan at its main campus by taking pledge and conducting intensive cleanliness drive. The redundant practices were identified and removed and internet facilitated online communication was utilized for faster dissemination and higher transparency. On the occasion of the New Year day on 1st January 2015, human chain was formed and pledge on Swachh Bharat Abhiyan was taken. Also, Swachh Bharat Abhiyan was conducted by scientists of ICAR-IIWM at a tribal village namely Birjaberna, Sundargarh district of Odisha on 20th March 2015. The Director and staff of the institute participated in cleanliness drives organized at main entrance gate, guest house premises, technology park area and vehicle parking area of the institute during 21st February 2015 and 21st March 2015. Dr. P.S.Brahmanand, Senior Scientist coordinated these activities.

ICAR-IIWM Foundation Day

ICAR-IIWM celebrated its foundation day on 12th May 2014. On this occasion, a brain storming session on 'Agricultural Water Management: Challenges Ahead' was organized. Dr. S. K. Routaray organised this event.

Hindi Pakhwada Celebrated

Hindi Pakhwada was organized at ICAR-IIWM, Bhubaneswar during 15th -27th September, 2014. During this period, various competitions for staff members were organized and prizes were distributed. Dr. O.P. Verma organized this pakhwada.

B. Tech. students Exposed

Nine B. Tech. Students from Dr. Ulhas Patil College of Agricultural Engg. and Aditya Agric. Engg. & Tech. College Maharashtra get trained on various aspects of water management for better water use and water efficiency in the Institute during May and June 2014. Another B. Tech. student of KIIT University, Bhubaneswar has exposed to different water management issues and techniques during six months summer training programs at the Institute.

Seminar cum Monthly Meet

Twelve seminars organized on different issues of water management including sensor based applications, aquifer recharge, waste water use, hydrologic modeling, varietal adoption, watershed management and arsenic pollution, etc at ICAR-IIWM, Bhubaneswar. Besides four deputation report were also presented by scientist visited abroad.

Field Visit of European Scientists

Dr. Thilo Streck, Professor of Bio geophysics, Institute of Soil Science and Land Evaluation, University of Hohenheim, Germany and Dr Katarzyna Kujawa Rooleveld, Wageningen University, The Netherlands visited waste water treatment plants at Puri, Cuttack and farmer's field at Joypurpatna during 11 – 12 March 2015. Dr. S. Raychaudhuri organised this visit.

Vigilance Awareness Week

Vigilance awareness week was observed from 27 October to 1st November 2014 at ICAR– IIWM, Bhubaneswar. The main focus of the week was 'Combating corruption- technology as an enabler'. In this occasion a pledge was administered on inaugural day by Director-in-charge Dr. Madhumita Das. An elocution activity was also organized during this week. All the participants expressed their views about improving efficacy of the vigilance activities in order to combat corruption through adoption of different modern state of the art technologies which can bring transparency and thereby eradicating corruption.

12. Weather Report

Meteorological data 2014-15

The daily rainfall and open pan evaporation data was recorded at ICAR-IIWM Central Research Farm at Deras Mendhasal, Khurda and were analysed. The monthly rainfall and mean monthly evaporation data are presented in Figure 42. The total annual rainfall was 1823.7 mm during 2014-15 and August month was wettest with the highest rainfall of 536 mm. The monthly average pan evaporation data varied from 2.17 mm during January to 6.94 mm during the month of May.

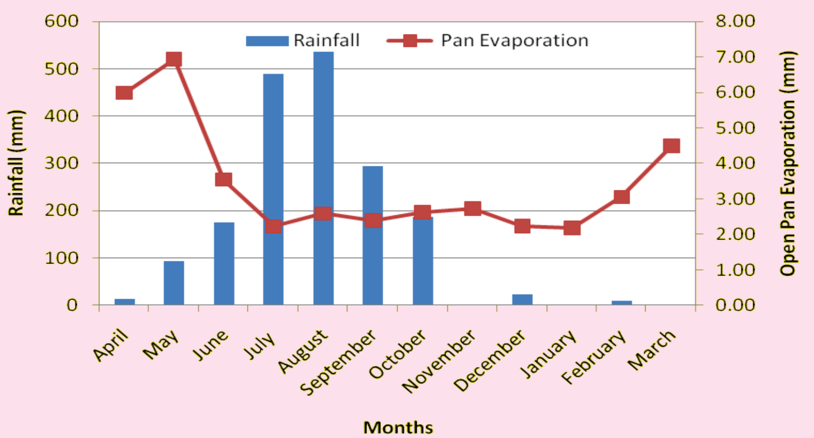


Fig. 42 Monthly rainfall and pan evaporation during April 2014-March 2015

13. Joining / Promotion / Transfer / Retirement

- Dr. Sunil Kumar Ambast joined as Director of this Institute on 22.01.2015 (FN).
- Mrs. Rachana Dubey joined as Scientist on 09.04.2014 (FN).
- Dr. A.K. Nayak has been promoted from RGP Rs.8000/- to Rs.9,000/- under CAS w.e.f. 27.12.2013.
- Dr. R.R. Sethi has been re-designated as Senior Scientist w.e.f. 04.09.2013.
- Dr. Pravukalyan Panigrahi has been promoted from RGP Rs.7000/- to Rs.8000/- under CAS w.e.f. 11.9.2012 and re-designated as Senior Scientist w.e.f. 30.11.2012.
- Shri A. Mallik has been promoted to Asst. Administrative Officer w.e.f. 06.09.2014.
- Shri B.N. Nayak has been SSS promoted from GP Rs.1900/- to GP Rs.2000/- under MACP w.e.f. 23.04.2013.
- Shri S.K. Das, Finance & Accounts Officer was transferred to CRRI, Cuttack on 05.04.2014.
- Dr. Ashwani Kumar, Ex-Director retired on superannuation from his duty on 31.10.2014.

14. Personnel

Director
Dr. Sunil Kumar Ambast

Principal Scientist

Dr. R.C. Srivastava
Dr. Atmaram Mishra[b]
Dr. M. Das
Dr. S. Roy Chowdhury
Dr. P. Nanda
Dr. R.K. Panda
Dr. S.K. Rautaray
Dr. G. Kar
Dr. S.K. Jena
Dr. (Mrs.) M. Raychaudhuri
Dr. S. Raychaudhuri
Dr. R.K. Mohanty

Senior Scientist

Dr. M. K. Sinha
Dr. K.G. Mandal
Dr. S. Mohanty
Dr. P.K. Panda
Dr. A.K. Thakur
Dr. P.S. Brahmanand
Dr. S. Ghosh [b]
Dr. D.K. Panda
Dr. A.K. Nayak
Dr. Ranu Rani Sethi
Dr. P. Panigrahi

Scientist

Dr. O.P. Verma
Mrs. Rachana Dubey

Chief Technical Officer

Er. D.U. Patil

Asst. Chief Technical Officer

Mrs. Sunanda Naik

Technical Officer

Dr. V.K. Tripathi [b]
Mr. Chhote Lal

Senior Technical Assistant

Mr. R.C. Jena
Mr. P.C. Singh Tiyu
Mr. S.K. Dash
Mr. B.K. Acharya
Mr. S. Lenka

Technical Assistant

Mr. A.K. Binakar
Mr. P. Barda
Mr. L. Singh Tiyu

Senior Technician

Mr. A. Parida

Administrative Officer

Mr. S.C. Sheet

Finance & Accounts Officer

Mr. S.K. Das [a]

Assistant Administrative Officer

Mr. A. Mallik

Private Secretary

Mrs. M. Padhi

Personal Assistant

Mr. Trilochan Raut

Assistant

Mr. J. Nayak
Mr. R.K. Dalai

Upper Division Clerk

Mr. A.K. Pradhan
Mr. N.K. Mallick

Lower Division Clerk

Mr. C.R. Khuntia
Mr. B.S. Upadhyaya
Mr. S.C. Das

Skilled Support Staff

Mr. Sanatan Das
Mr. H.K. Bal
Mr. B.N. Naik
Mr. B. Bhoi
Mr. S.K. Panda
Mr. B. Dutta

a- Transferred;b- Lien

15. Finance

(Rupees in Lakh)

Sl. No.	Head of A/C	Non-Plan		Plan	
		Budget 2014-15	Expenditure 2014-15	Budget 2014-15	Expenditure 2014-15
1.	Establishment Charges	520.00	505.00	-	-
2.	O.T.A .	-	-	-	-
3.	T.A.	3.00	2.98	10.00	9.99
4.	Other charges including equipment	7.38	7.33	-	-
5.	Other charges -IT	-	-	-	-
6.	Repair & maintenance of building	0.86	0.81	-	-
7.	Works	-	-	3.50	2.35
8.	Library Books & Journals	-	-	8.50	8.50
9.	H.R.D.	-	-	4.00	3.98
10.	Others including loan & Advances	61.76	56.59	91.00	86.01
	Total	**593.00**	**572.71**	**117.00**	**110.83**
11.	**AICRP on Irrigation Water Management**	-	-	**2049.00**	**2049.00**

AICRP IWM-PC Unit

Sl. No.	Head of A/C	Sanctioned (2014-15)	Actual Expenditure (2014-15)
1.	Establishment	44.00	43.36
2.	T.A.	1.00	0.99
3.	Other charges including equipment	-	-
	Total	**45.00**	**44.35**

APPENDIX

RESULTS-FRAMEWORK DOCUMENT FOR ICAR-INDIAN INSTITUTE OF WATER MANAGEMENT (2013-2014)

RFD
Results-Framework Document
For
ICAR- Indian Institute of Water Management
(2013-2014)

Section 1
Vision, Mission, Objectives and Functions

Vision

Sustainable development of on-farm water management technologies for enhanced agricultural productivity and improved livelihood under different agro-ecological regions.

Mission

Basic, applied and strategic research activities to address diversified water management issues with institutional linkages, infrastructural support and capacity building to achieve sustainability and growth.

Objectives

- Integrated water management and conservation measures
- Enhancing water productivity
- Capacity building and human resources development

Function

- To develop efficient utilization, management and conservation of on-farm water resources for sustainable agricultural production.
- To manage excess water in agricultural lands.
- To develop sustainable cropping systems in relation to the availability of water.
- Devising multiple uses of water in agricultural production programmes to enhance water productivity.
- To reuse poor quality groundwater, industrial and municipal waste waters.
- To disseminate technologies through peoples' participation.

Section 2

Inter se Priorities among Key Objectives, Success Indicators and Targets

S. No.	Objectives	Weight	Actions	Success Indicators	Unit	Weight	Target / Criteria Value				
							Excellent 100%	Very good 90%	Good 80%	Fair 70%	Poor 60%
1	Integrated water management and conservation measures	49	Improving irrigation practices	Technologies for enhancing irrigation efficiency to be developed	No.	19	3	2	1	-	-
			Judicious use of water	Technologies for enhancing water use efficiency to be developed	No.	15	2	1	-	-	-
			Water harvesting and groundwater recharge	Technologies for rainwater conservation and augmenting groundwater storage through recharge to be developed	No.	15	4	3	2	1	-
2	Enhancing water productivity	20	Multiple uses of water	Models for multiple uses of water to be evaluated	No.	14	2	1	-	-	-
				Techniques for use of waste water in agriculture to be developed	No.	6	2	1	-	-	-
3	Capacity building and human resources development	20	Transfer of technology	Training & demonstrations to be organized	No.	14	16	15	14	13	12
				Knowledge of the scientists & officials to be updated	No.	6	5	4	3	2	1
	Efficient functioning of the RFD system	3	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	2	May 15, 2013	May 16, 2013	May 17, 2013	May 20, 2013	May 21, 2013
			Timely submission of Results for RFD (2012-13)	On-time submission	Date	1	May 1 2013	May 2 2013	May 5 2013	May 6, 2013	May 7, 2013
	Administrative Reforms	4	Implement ISO 9001 as per the approved action plan	% Implementation	%	2	100	95	90	85	80

		Prepare an action plan for Innovation	On-time submission	Date	2	Jul 30, 2013	Aug. 10, 2013	Aug. 20, 2013	Aug, 30, 2013	Sept. 10, 2013
Improving internal efficiency /responsiveness / service delivery of Ministry / Department	4	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	2	100	95	90	85	80
			Independent Audit of implementation of public grievance redressal system	%	2	100	95	90	85	80

Section 3
Trend Values of the Success Indicators

S. No.	Objectives	Actions	Success Indicators	Unit	Actual values 2011-12	Actual values 2012-13	Target value 2013-14	Projected values 2014-15	Projected values 2015-16
1	Integrated water management and conservation measures	Improving irrigation practices	Technologies for enhancing irrigation efficiency to be developed	No.	3	2	2	2	3
		Judicious use of water	Technologies for enhancing water use efficiency to be developed	No.	1	1	1	2	3
		Water harvesting & groundwater recharge	Technologies for rainwater conservation and augmenting groundwater storage through recharge to be developed	No.	4	3	3	3	3
2	Enhancing water productivity	Multiple uses of water	Models for multiple uses of water to be evaluated	No.	1	1	1	1	2
			Techniques for use of waste water in agriculture to be developed	No.	-	-	1	1	1
3	Capacity building and human resources development	Transfer of technology	Training & demonstrations to be organized	No.	12	15	15	15	16
			Knowledge of the scientists & officials to be updated		-	-	4	5	5

Efficient functioning of the RFD system	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	-	-	May 16, 2013	-	-
	Timely submission of Results for RFD (2012-13)	On-time submission	Date	-	-	May 2 2013	-	-
Administrative Reforms	Implement ISO 9001 as per the approved action plan	% Implementation	%	-	-	95	-	-
	Prepare an action plan for Innovation	On-time submission	Date	-	-	Aug. 10, 2013	-	-
Improving internal efficiency /responsiveness / service delivery of Ministry / Department	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	-	-	95	-	-
		Independent Audit of implementation of public grievance redressal system	%	-	-	95	-	-

Section 4
Description and Definition of Success Indicators and Proposed Measurement M ethodology

S. No.	Success Indicator	Description	Definition	Measurement	General Comments
1	Technologies for enhancing irrigation efficiency to be developed	Pressurized irrigation systems like drip and sprinkler irrigation methods shall be evaluated.	Irrigation efficiency is to characterize irrigation performance, evaluate irrigation water use, and to promote better or improved us e of water resources in agriculture.	Irrigation efficiencies will be measured through study of irrigation performance, irrigation water use etc.	Modern irrigation practices and management will yield better irrigation water use efficiency over the farmers' practices in agriculture.
2	Technologies for enhancing water use efficiency to be developed	Engineering with bio -engineering propositions shall be developed to enhance water use efficiency	Water use efficiency is defined as yield of plant product per unit of crop water use.	Water use efficiency will be measured through crop performance against total water use through evapo - transpiration.	This will help in enhancing agricultural crop water pro ductivity and profitability.
3	Technologies for rainwater conservation and augmenting groundwater storage through recharge to be developed	Low cost location specific ground water recharge techniques shall be developed.	Groundwater recharge is a hydrologic process where water moves downward from surface water to groundwater.	Groundwater recharge measurement will be studied through development of location specific filter systems.	Groundwater recharge technique shall help in aug menting the groundwater table through minimization of surface runoff.
4	Models for multiple uses of water to be evaluated	Models shall be conceptualized, developed and evaluated for multiple uses of water.	Multiple use of water are low-cost, equitable water use models that provide water for both domestic needs and high -value agricultural production including rearing of livestock.	Under multiple use managements total water use against production of various components will be measured.	This system will h elp in livelihood improvement, assured production in adverse conditions as well as creation of water resources.
5	Techniques for use of waste water in agriculture to be developed	The use of waste water in agriculture shall be addressed to enhance water productivity.	Waste water is the marginally polluted water having potentiality of reusing in agriculture.	Waste water quality parameters will be measured using standard methods following recommended guidelines.	To reduce dependency on surface and groundwate r, use of treated waste water in agriculture can be a viable proposition.
6	Training & demonstrations to be organized	In order to disseminate the various developed on-farm technologies, the training programmes for the farmers and trainers shall be undertaken.	Transfer of t echnology through training and demonstration is the process of transferring skills, knowledge, technologies, methods etc to a wider range of users.	Impact assessment of training and demonstration will be measured through systematic questionnaire feedback approach.	Training and demonstration are the effective tools in rapid dissemination of technologies to end user level for enhancing agricultural productivity.
7	Knowledge of the scientists & officials to be updated	Knowledge of the scientists and officials shall be developed on recent advancement techniques through various training programmes.	Human resource development is a framework for the expansion of human capital within an organization through the development of both the organization and the individual to achieve performance improvement	Enhanced knowledge will be measured through aided trainings on new and emerging subjects/tools.	This will update and enh ance the existing knowledge level of scientific and other officials of the organization.

Section 5

Specific Performance Requirements from other D epartments

Location Type		Organization Type	Organization Name	Relevant Success Indicator	What is your requirement from this organization	Justification for this requirement	Please quantify your requirement from this organization	What happens if your requirement is not met
Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Section 6

Outcome / Impact of Activities of Organization/ Ministry

S. No.	Outcome / Impact of organization	Jointly responsible for influencing this outcome / impact with the following organization (s) / departments / ministry (ies)	Success Indicator	Unit	2011-12	2012-13	2013-14	2014-15	2015-16
1	Enhancing agricultural water productivity through multiple uses and improving livelihood	Departments of agriculture / water resources of state Governments	Increase in agriculture productivity through judicious utilization of water	%	2	2	2	2	2
			Enhancement in adoption of drip and sprinkler system	%	15	15	16	17	17

Performance Evaluation Report

RFD (April 1, 2013 to March 31, 2014)

Name of the Division : Natural Resources Management
Name of the Institution : ICAR-Directorate of Water management, Bhubaneswar
RFD Nodal Officer : Dr. R. K. Panda, Principal Scientist

S.N.	Objective (s)	Weight	Action(s)	Success Indicator(s)	Unit	Weight	Target / Criteria Value					Achievements	Performance		Percent achievements against Target values of 90% Col.	Reasons for shortfalls or excessive achievements, if applicable
							Excellent 100%	Very Good 90%	Good 80%	Fair 70%	Poor 60%		Raw Score	Weighted Score		
1	[1] Integrated water management and conservation measures	49	[1.1] Improving irrigation practices	[1.1.1] Technologies for enhancing irrigation efficiency developed	No.	19	3	2	1	-	-	3	100	19	150*	Achieved as targeted (100 %)
			[1.2] Judicious use of water	[1.2.1] Technologies for enhancing water use efficiency developed	No.	15	2	1	-	-	-	2	100	15	200	Achieved as targeted (100 %)
			[1.3] Water harvesting and groundwater recharge	[1.3.1] Technologies for rainwater conservation and augmenting groundwater storage through recharge developed	No.	15	4	3	2	1	-	4	100	15	133	Achieved as targeted (100 %)
2	[2] Enhancing water productivity	20	[2.1] Multiple uses of water	[2.1.1] Models for multiple uses of water evaluated	No.	14	2	1	-	-	-	2	100	14	200	Achieved as targeted (100 %)
				[2.1.2] Techniques for use of waste water in agriculture developed	No.	6	2	1	-	-	-	2	100	6	200	Achieved as targeted (100 %)
3	[3] Capacity building and Human Resources Development	20	[3.1] Transfer of technology	[3.1.1] Training & demonstrations organized	No.	14	16	15	14	13	12	16	100	14	107	Achieved as targeted (100 %)
				[3.1.2] Knowledge of the scientists & officials updated	No.	6	5	4	3	2	1	5	100	6	125	Achieved as targeted (100 %)
	* Efficient functioning of the RFD system	3	Timely submission of Draft RFD	On-time submission	Date	2	15/05/2013	16/05/2013	17/05/2013	20/05/2013	21/05/2013	27/04/2013	100	2	100	Achieved as per schedule

* Efficient functioning of the RFD system	3	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	2	15/05/2013	16/05/2013	17/05/2013	20/05/2013	21/05/2013	27/04/2013	100	2	100	Achieved as per schedule
		Timely submission of Results for RFD (2012-13)	On-time submission	Date	1	01/05/2013	02/05/2013	05/05/2013	06/05/2013	07/05/2013	18/04/2013	100	1	100	Achieved as per schedule
*Administrative Reforms	4	Implement ISO 9001 as per the approved action plan	% Implementation	%	2	100	95	90	85	80	100	100	2	100	Achieved as per schedule
		Prepare an action plan for Innovation	On time submission	Date	2	30/07/2013	10/08/2013	20/08/2013	30/08/2013	10/09/2013	29/07/13	100	2	100	Achieved as per schedule
* Improving Internal Improving Internal Efficiency /responsiveness / service delivery of Ministry / Department	4	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	2	100	95	90	85	80	100	100	2	100	Achieved as per schedule
			Independent Audit of implementation of public grievance redressal system	%	2	100	95	90	85	80	100	100	2	100	Achieved as per schedule

Total Composite Score: 100

Procedure for computing the Weighted and Composite Score

1. Weighted Score of a Success Indicator = Weight of the corresponding Success Indicator x Raw Score / 100
2. Total Composite Score = Sum of Weighted Scores of all the Success Indicators

N.B. : * Under Column 16, the calculation of percent achievement was carried out as shown below.
(100/2) X 3 = 150 %

भाकृअनुप
ICAR

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch

भाकृअनुप-भारतीय जल प्रबंधन संस्थान
ICAR - Indian Institute of Water Management

(An ISO 9001:2008 Certified Organization)
Bhubaneswar-751 023, Odisha, India
Web: http://www.dwm.res.in
E-mail: director.iiwm@icar.gov.in