वार्षिक प्रतिवेदन
ANNUAL REPORT
2018-19

भाकृअनुप ICAR

ICAR-IIWM

भाकृअनुप - भारतीय जल प्रबंधन संस्थान
भुवनेश्वर, ओड़िशा-७५१०२३
ICAR-Indian Institute of Water Management
Bhubaneswar, Odisha-751023

जय किसान
जय विज्ञान

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भारतीय जल प्रबंधन संस्थान
ICAR-IIWM

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

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ICAR-IIWM Annual Report 2018-19

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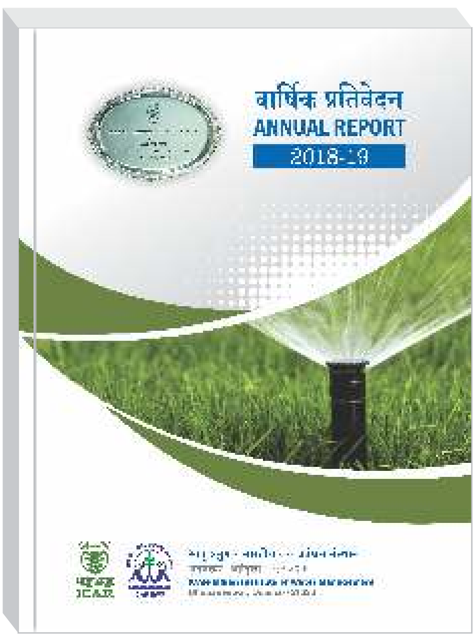

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PREFACE

Agricultural water management would play a key role in enhancing agricultural productivity and doubling farmer's income. Despite remarkable achievements in agricultural production, critical challenges still exist with respect to management of land and water resources in the country. There has been a growing population and urbanization led to decline in cultivable land, thereby growing pressure on land and water resources. Additionally, climate change, irregularity in rainfall, declining per capita availability of water, fall in decadal growth rate of net irrigated area, declining public investments in major and medium irrigation projects, sub-optimal utilization of irrigation potential, low irrigation efficiency, groundwater pollution and depletion, and regional imbalances in groundwater development, insufficient water storage structures for rainwater harvesting and auxiliary pond or tanks for storage of excess canal water delivered, low coverage of area under micro-irrigation practices, waterlogging and soil salinity, water pollution and enormous production of wastewater are major concerns. With these background and challenges, this premier Institute has been striving continuously towards research and development on agricultural water management for different agro-ecological sub-regions in the country, capacity building of associated personnel and farmers, and transfer of technologies. Significant achievements have been made on the lines of set targets through different schemes and projects undertaken during the year 2018-19, and I feel extremely happy to bring out the detailed presentation of Institute's progress in the form of this Annual Report of the Institute for the year 2018-19.

Significant research achievements for the year 2018-19 have been included in this annual report under four programs of the Institute i.e., rainwater management (including waterlogged area management), canal water management, groundwater management and on-farm technology dissemination (including wastewater management, water policy & governance). Our scientists are actively involved in development of irrigation plans; safe drainage of excess water; development of runoff water recycling, and land modification/shaping technique for enhancing productivity; water and nutrient self-reliant farming system for rainfed areas; climate resilient agriculture, groundwater management for enhancing adaptive capacity to climate change, design of groundwater recharge structures for hard rock areas, assessment of groundwater contamination and its management, socio-economic and environmental linkages of groundwater irrigation in the Godavari districts of Andhra Pradesh, mitigation of arsenic contamination through organic and chemical amendments; options for enhancing irrigation efficiency and development of integrated farming systems in canal commands, water saving techniques in rice and rice-fallow areas through pulse crops, standardizing micro-irrigation technologies etc. To cope with flood, post-flood disaster management and an index-based flood insurance has been suggested. Studies are being carried out for bioremediation of polluted water, impact assessment of industrial wastewater, development and evaluation of mini-pan evaporimeter for irrigation scheduling, intensive horticultural system for improving farm income from degraded lands, and socio-economic evaluation of water related interventions under MGNREGS. Our Institute has also initiated development of android-based mobile expert system on agricultural water management and mobile App for pump operation remotely. A substantial work has been done for livelihood improvement of scheduled tribe and tribal farmers through water management interventions and revival of village ponds through scientific intervention.

Our Institute played key-role in *Krishi Kalyan Abhiyan* of Government of India, and six teams of scientist of the Institute in collaboration with KVK, Malkangiri; state agriculture, horticulture and animal husbandry departments; and village *Sarpanch* organized trainings covering twenty five villages of Malkangiri district of Odisha. In addition, different agricultural water management related issues at the regional level are being addressed by different centres under the AICRP on Irrigation Water Management. Through ICAR-Agri-Consortia Research Platform on Water project, Institute has successfully installed rubber dams in different agro-ecological regions of India, initiated improvement strategies for higher water productivity in canal commands, drip-irrigation in horticultural crops, eco-friendly wastewater treatment, multiple-use of water in aquaculture production systems, addressing issues related to water governance and policy. With the aim of dissemination of technology and working with farmers, our scientists are involved with thirty adopted villages across seven blocks in Odisha under *Mera Gaon Mera Gaurav* (MGMG) program; conducted training programs for Government officials, farmers and students on various aspects of water management; and showcased technologies developed by the Institute through demonstration, *Kisan Mela, Kisan Gosthi*, exhibitions etc. Scientists of the Institute have published a good number of research papers in reputed and peer-reviewed journals, books/ bulletins/ training manuals and popular articles during the year 2018-19. I'm glad to apprise that ICAR-IIWM received 'The Sardar Patel Outstanding ICAR Institution Award-2017' amongst the ICAR Institutes of 'Small Institutes' Category. Our Scientists have received *Rajbhasha Gaurav Purushkar 2017* for best technical book in Hindi, BKJF-INCSW *Sookshma Sinchai Purashkar*-2018, Dr. K.G. Tejwani Award, Fellow of Indian Society of Soil Science, K.C. Das Memorial Award, Leadership Award-2018, Banabihari Mohanty Memorial Award, Best Poster Award, along with many others honours and recognitions.

I acknowledge sincerely the valuable guidance, suggestion and support of Dr. T. Mohapatra, Secretary, DARE and Director General, ICAR; Dr. K. Alagusundaram, Deputy Director General (Agricultural Engineering & NRM), ICAR; Dr. S.K. Chaudhari, Assistant Director General (S&WM), NRM, ICAR, New Delhi and other concerned officials of the Council. I express my sincere thanks to the esteemed Chairman and members of QRT, RAC and IMC for their valuable guidance, inputs and involved support. I thank all members of IRC, Chairman, program leaders and members of different Institute committee, staff of administration and finance section of the Institute for help, co-operation and smooth functioning of the Institute. The publication committee deserves applaud and appreciation for their untiring efforts in compilation and editing the Annual Report, and its timely publication. I hope that our Annual Report will be immensely useful for stake holders i.e. policy makers, researchers, development functionaries and the farmers.

SKAmbast

July 05, 2019
Bhubaneswar

(S.K. Ambast)
Director, ICAR-IIWM

कार्यकारी सारांश

वर्षा आधारित क्षेत्रों के लिए जल और पोषक तत्व आत्मनिर्भर कृषि पद्धति

धान की रोपाई के एक महीने बाद, आत्मनिर्भर कृषि पद्धति (SRFS) में पारंपरिक पद्धति की तुलना में मृदा में 116% अधिक केंचुआ की जनसंख्या घनत्व पाया गया। एसआरएफएस के तहत मृदा के जैविक कार्बन, उपलब्ध नाइट्रोजन, डिहाइड्रोजिनेज गतिविधि, माइक्रोबियल बायोमास कार्बन, मृदा घनत्व, कुल सरंध्रता और जल धारण क्षमता जैसे गुणों में उल्लेखनीय सुधार प्राप्त हुआ। परन्तु, एसआरएफएस के तहत धान की दाना और पुआल उपज पारंपरिक पद्धति से प्राप्त पैदावार से काफी अलग प्राप्त नहीं हुई। हालांकि, एसआरएफ़एस में ऊर्जा दक्षता (ऊर्जा आउटपुट : इनपुट अनुपात) पारंपरिक पद्धति (13.8) की तुलना में 63% अधिक (22.6) थी।

सूक्ष्म सिंचाई प्रणाली के उपयोग से दलहन फसलों की उत्पादकता में वृद्धि

मूँग फसल की दो महत्वपूर्ण विकास अवस्थाओं (फूल आने एवं फली निर्माण) में फव्वारा सिंचाई करने के परिणामस्वरूप एक अवस्था पर सिंचाई और नियंत्रण उपचार की तुलना में सबसे अधिक जल उत्पादकता प्राप्त हुई। यूरिया और राइजोबियम के माध्यम से 20 किलोग्राम नाइट्रोजन का प्रयोग करने एवं दो सिंचाईयां देने पर फसल की फली उपज में 0.49 से 0.98 टन/हे तक की वृद्धि हुई, और शुद्ध जल उत्पादकता में ₹ 2.43 से 6.70/घन मीटर तक वृद्धि हुई। मूँग की फसल में फसल विकास की अवस्थाओं पर आधारित वाटर प्रोडक्सन फंकसन्स ने फली की उपज और उपयोग किए गए जल के बीच रैखिक संबंध बताया (R^2 =0.79-0.92) और जिससे फसल की प्रारंभिक, मध्य-सीजन व लेट-सीजन की अवस्थाओं में उपज प्रतिक्रिया कारक क्रमशः 0.32, 1.18 और 0.21 प्राप्त हुए।

सिंचाई समय के निर्धारण के लिए मिनी-पैन वाष्पीकरण मीटर का विकास एवं मूल्यांकन

गैल्वेनाइज्ड आयरन (GI) शीट और पीवीसी (PVC) पाइप से 25 सेमी की ऊँचाई तथा तीन तरह के व्यास (10, 20 और 30 सेमी) के आकार वाले मिनी-पैन वाष्पीकरण मीटरों को बनाया गया। यूएसडब्ल्यूबी (USWB) ओपन पैन के वाष्पीकरण आँकड़ों साथ पीवीसी और गैल्वेनाइज्ड आयरन से निर्मित मिनी पैन वाष्पीकरण मीटर के वाष्पीकरण आँकड़ों के स्कैटर प्लॉट (ग्राफ) से पता चला कि 30 सेमी जीआई मिनी पैन वाष्पीकरण मीटर का गर्मियों (R^2=0.89) में यूएसडब्ल्यूबी ओपन पैन वाष्पीकरण मीटर के साथ निकटतम संबंध था, इसके बाद रबी (R^2=0.88) और खरीफ (R^2=0.86) मौसम में था। सभी मौसमों में पीवीसी से निर्मित 10 सेमी वाले पैन वाष्पीकरण मीटर के साथ सबसे कम संबंध पाया गया।

तटीय जलाक्रांत क्षेत्रों में आय बढ़ाने के लिए भूमि रूपान्तरण के विकल्प

तालाब में जल स्तर का मूल्यांकन किया गया। इस प्रयोग के एक अनुसंधान स्थान पर अक्टूबर से मार्च के बीच ऊँची क्यारियों (0-15 सेमी की गहराई) की मृदा की विद्युत चालकता (EC) 0.53 से बढ़कर 2.83 डेसी सिमन्स/मीटर तक बढ़ी। उसी प्रकार से एक अन्य स्थान पर समान अवधि के बीच यह 0.11 से बढ़कर 2.25 डेसी सिमन्स/मीटर तक बढ़ गई। किसान ने ऊँची क्यारियों के 1200 वर्ग मीटर क्षेत्र पर बैंगन, हरी मिर्च, साग, मूली, लौकी, तोरई, करेला और पोई (बैसिला अल्बा) को उगाने से वार्षिक सकल और शुद्ध आय क्रमशः ₹ 32,160/- और ₹ 24,000/- प्राप्त हुई।

बाढ़ के पश्चात तैयार प्रबंधन योजनाएं

बिहार राज्य के मुजफ्फरपुर और पूर्वी चंपारण जिलों तथा ओडिशा के केंद्रपाड़ा एवं पुरी जिलों में खरीफ मौसम के दौरान फसलों का बाढ़ से नुकसान का आकलन किया गया। इन जिलों में बाढ़ के पश्चात प्रबंधन योजनाएँ तैयार की गई और इनको कायान्वित भी किया गया। मक्का जैसी वैकल्पिक फसल की समय पर बुआई करने और बाढ़ के पश्चात प्रबंधन योजना को लागू करने के माध्यम से किसान बिना के व्यवधान के बाढ़ से क्षतिग्रस्त क्षेत्र की तुलना में लगभग ₹16,700/-हेक्टेयर- का अतिरिक्त शुद्ध लाभ प्राप्त कर सकते हैं।

जलवायु अनुकूल कृषि के लिए राष्ट्रीय नवाचार (NICRA)

धान-लोबिया कृषि पद्धति की CO_2 इनफ्लक्स/इफलक्स क्षमता को एडी कोवेरियंस तकनीक का उपयोग करके मापा गया जिससे धान फसल की अवधि के अंत में मौसमी शुद्ध पारिस्थितिकी तंत्र विनिमय (NEE) -307 ग्राम कार्बन/वर्ग मीटर प्राप्त हुआ। बदलती जलवायु (RCP 4.5 परिदृश्य) के तहत आधार रेखा (1976-2005) पर वर्ष 2018-2090 के दौरान भारत के गंगा तटीय क्षेत्र में अधिकतम तापमान में 2.95 से 4.07°C तक के दायरे में वृद्धि होने की संभावना है। इसके अतिरिक्त ओडिशा राज्य के पुरी जिले के सत्यबादी ब्लॉक में रिमोट सेंसिंग और जीआईएस तकनीकों का उपयोग करके तालाब आधारित पद्धति के साथ जल सरंक्षण के प्रभाव के अध्ययन से पता चला कि इस क्षेत्र में कुल 1063 जल सरंक्षण संरचनाओं (तालाब) का निर्माण किया गया। इसके अलावा, पुरी जिले के आलिशा गाँव में अल्प-अवधि और सूखा-प्रतिरोधी धान की किस्मों का खेत में ही परीक्षण किया गया तथा वर्षा आधारित, सिंचित और तटीय कृषि-पारिस्थितिक तंत्र के तहत जल के बहुआयामी उपयोग पर प्रकाश डालने हेतू कठोर चट्टान क्षेत्रों में ड्रिप-फर्टिगेशन का प्रयोग भी किया गया। वाटरशेड क्षेत्रों में बांध की संरचना पर 16 कुओं में भूजल स्तर और बहाव की अवधि के दौरान दैनिक वर्षा अपवाह का मूल्यांकन किया गया। वाटरशेड क्षेत्रों के लिए स्वाट मॉडल के सत्यापन का सह संबंध गुणांक 0.91 था और NSE का मान 0.78 था। इन क्षेत्रों के लिए भूजल बहाव मॉडल को विजुअल मोडफ्लो का उपयोग करके विकसित किया गया। इस मॉडल को 1.419 मीटर की औसत त्रुटि और 0.98 के सहसंबंध गुणांक के साथ सत्यापित किया गया।

जल बचत के लिए धान की खेती के तरीकों का मूल्यांकन

रिसर्च फार्म पर किए गए प्रयोग से पता चला कि रबी / गर्मी के मौसम के दौरान धान (किस्म -खंडगिरी') की फसल का प्रदर्शन वैकल्पिक गीली व सुखी (ए डबल्यू डी) विधि, जल सूखने के 3 दिन बाद सिंचाई (3-DAD) और लगातार जल भराव (CF) में समान था, जबकि जल बचत लगातार जल भराव विधि की तुलना में जल सूखने के 3 दिन बाद सिंचाई में 19.6% और वैकल्पिक गीली व सुखी (ए डबल्यू डी) विधि में 29.8% थी। परिणामस्वरूप, लगातार जल भराव विधि की तुलना में जल सूखने के 3 दिन बाद सिंचाई और ए डब्ल्यू डी विधि में जल उत्पादकता में क्रमशः 27 और 38% की वृद्धि हुई। एरोबिक धान की पैदावार सीधे बीज बुआई या रोपाई विधि की तुलना में 28% कम थी; एरोबिक धान की पैदावार छिडक़ाव सिंचाई, मेड़-नाली और बाढ विधि के साथ क्रमशः 2.41, 3.09 और 3.31 टन/हे प्राप्त हुई; बाढ विधि की तुलना में छिडक़ाव सिंचाई के तहत उपज में औसतन 27% की कमी आई। तथापि, सिंचाई जल का प्रयोग बाढ विधि की तुलना में छिडक़ाव सिंचाई (610 मिमी) में 26.4% और व्यापक मेड़ नाली विधि में 8.8% कम था और एरोबिक धान में सिंचाई के तीन तरीकों से जल उत्पादकता पर कोई महत्वपूर्ण प्रभाव नहीं पड़ा।

नहरी सिंचाई प्रणाली के प्रदर्शन के आकलन के लिए बेंचमार्किंग

विजुअल बेसिक में सिंचाई प्रणाली के बेंचमार्किंग हेतु टाइम सीरीज आंकड़ों के विश्लेषण के लिए एक अनुकूल सॉफ्टवेयर विकसित किया गया। इन टाइम सीरीज आंकड़ों को हाथ से दर्ज या एक्सेल फाइल के माध्यम से अपलोड किया जा सकता है। कमांड बटन का उपयोग करके इन आंकड़ों को संशोधित और अपडेट किया जा सकता है। वर्तमान में यह मॉडल नौ संकेतकों की गणना कर सकता है और आउटपुट मॉड्यूल को या तो टेबल के रूप में या ग्राफिकल रूप में प्राप्त किया जा सकता है। परिणामों को सिंचाई प्रणाली के प्रकार (मेजर, मीडियम और माइनर) और योजना समूह (अधिक, अत्यधिक, डेफीसिट और अत्यधिक डेफीसिट) के आधार पर देखे जा सकते हैं।

धान और मूँगफली की वृद्धि पर सुपर अवशोषक पॉलिमर (SAP) का प्रभाव

मूँगफली और धान की वृद्धि और उपज पर सुपर अवशोषक पॉलिमर की विभिन्न मात्रा का मूल्यांकन करने के लिये रिसर्च फार्म में एक प्रयोग किया गया। इस प्रयोग के परिणाम से यह प्राप्त हुआ कि फसलों की वृद्धि और पादप कार्यिकी के प्रदर्शन पर सुपर अवशोषक पॉलिमर के विभिन्न स्तरों (0, 25, 50, 75 और 100 किलोग्राम/ हे) ने महत्वहीन प्रभाव दिखाया। इसके अतिरिक्त, मूँगफली और धान में सुपर अवशोषक पॉलिमर के विभिन्न स्तरों से जल उत्पादकता क्रमशः 6% और 5% के बीच प्राप्त हुई।

नहरी सिंचाई कमांड में आर्थिक जल उत्पादकता को बढ़ाना

सिना मध्यम सिंचाई परियोजना जो कि महाराष्ट्र राज्य में डेफीसिट में चल रही सिंचाई प्रणाली है, जो कमांड क्षेत्र से परे अपना जल प्रभाव क्षेत्र रखती है। इस सिंचाई प्रणाली में नहर के जल की सुनिश्चित आपूर्ति के अभाव में फसल उत्पादन के लिए कुओं और नदी लिफ्टों के माध्यम से भूजल का अत्यधिक दोहन किया जाता है। प्रारंभिक अध्ययन से यह पता चला है कि 35 घन मीटर के सिंचाई योग्य जल उपयोग (WCU) के परिदृश्य के साथ और फलदार फसलों हेतु 22.5% और रबी/गर्मियों की फसलों जैसे गेहूं, ज्वार, सब्जियां, तिलहन और दलहन फसलों के लिए 15.7% जल आवंटित करने पर कुल कमांड क्षेत्र कवरेज यानी 81.5% से उत्पादन का कुल मूल्य ₹ 422 मिलियन तक प्राप्त किया जा सकता है।

क्षरित भूमि में गहन बागवानी प्रणाली

जल की उत्पादकता में सुधार और क्षरित भूमि से अधिक मुनाफा प्राप्त करने के लिये फूल नहीं आये हुये आम के बगीचे में इस प्रयोग को शुरू किया गया, जिसमें ड्रिप सिंचाई और धान के पुआल की पलवार के तहत पपीता और अनानास को अंत:सस्य पद्धति में उगाया गया। इन फसलों के वनस्पति विकास में कोई महत्वपूर्ण अंतर नहीं देखा गया। हालांकि, अनानास समतुल्य उपज आम के बगीचे में अंत:सस्य के रूप में उगाई गई अनानास की फसल (पुआल पलवार के तहत) से अधिकतम (18.9 टन/हे) प्राप्त हुई और इसके साथ-साथ इस फसल पद्धति से अन्य फसल पद्धतियों की तुलना में जल उत्पादकता (21.5 किग्रा/हे-मिमी) में काफी वृद्धि हुई।

भूजल सिंचाई के सामाजिक, आर्थिक और पर्यावरणीय संबंध

आंध्र प्रदेश राज्य की गोदावरी बेसिन के जिलों में भूजल स्तर में गिरावट के साथ घोषित महत्वपूर्ण संवेदनशील ब्लॉकों की पहचान की गई। भूजल स्तर के परिमाण का आकलन और मानचित्रण नीति प्रबंधकों को आवश्यक कार्रवाई करने में मदद करेगा। इसके अतिरिक्त, मुफ्त बिजली के सामाजिक-आर्थिक लाभों और परिणामस्वरूप इससे उत्पन्न ऊर्जा संकट का पता लगाया गया। इस क्षेत्र में तटीय स्थिति और सूर्य की धूप की उपलब्धता कों देखते हुए फसलों की महत्वपूर्ण वृद्धि अवस्थाओं के दौरान सौर ऊर्जा संचालित सिंचाई की हालिया नीति की व्यवहार्यता का अध्ययन करने की आवश्यकता है।

कठोर चट्टानी क्षेत्रों के लिए भूजल पुन: भरण संरचनाओं की डिजाइन

ओडिशा राज्य दसपल्ला ब्लॉक में स्थित बारघरीयानाला माइक्रो वाटरशेड के तहत आने वाले श्रीरामपुर और नचीपुर गाँवों में वर्षा जल संचयन संरचनाओं के जल संतुलन का अध्ययन किया गया। परिणामस्वरूप यह देखा गया कि एक 0.38 हेक्टेयर मीटर क्षमता वाली संरचना से वार्षिक आधार पर 0.03-0.25 मीटर (औसत 0.14 मीटर) का भूजल पुन:भरण प्राप्त हुआ। इसी प्रकार से 0.5 और 0.75 हेक्टेयर-मीटर क्षमता वाली वर्षा जल संचयन सरंचनाओं से क्रमश: 0.25 मीटर और 0.70 मीटर के रूप में वार्षिक भूजल पुन:भरण का अनुमान लगाया गया। इसके विपरीत, पुन:भरण कुंआ के साथ-साथ जल संचयन संरचना (0.20 हेक्टेयर-मीटर) से वार्षिक भूजल पुन:भरण 0.86 मीटर तक बढ़ गया। इन संरचनाओं का प्रभाव ओडिशा राजय के कठोर चट्टानी क्षेत्रों में 15 हेक्टेयर कमांड क्षेत्र के प्रभाव क्षेत्र को कवर करने के साथ 300 मीटर तक बढ़ गया है। मानसून पूर्व के मौसम के दौरान पुन:भरण संरचनाओं की उपस्थिति के कारण इस क्षेत्र के कुंओं में जल स्तर की गहराई 1 मीटर तक बढ़ गई।

गोदावरी बेसिन के निचले क्षेत्रों में भूजल प्रदूषण का आकलन

गोदावरी बेसिन का नीचे का क्षेत्र भारत में सबसे अधिक उपजाऊ और गहन रूप से खेती होने वाले क्षेत्र में से एक है। नलकूप से कुल 41 भूजल नमूनों और मृदा के कुल 88 नमूनों का विश्लेषण किया गया। यह देखा गया कि अधिकांश नमूनों का पीएच सिंचाई के लिए उपयुक्त है (pH<8.4)। इन नमूनों की विद्युत चालकता 0.01 से 2.88 डेसी सिमन्स/मीटर तक पाई गई। नमूनों में नाइट्रेट-नाइट्रोजन 0.2 से 8.9 मिलीग्राम/लीटर के बीच थी। कुल 24% नमूनों में नाइट्रेट-नाइट्रोजन की मात्रा 7.1-8.9 मिलीग्राम/लीटर के बीच थी। भूजल नमूनों के सोडियम अवशोषण अनुपात (SAR) की मात्रा (0.5 से 9.0) सिंचाई के लिए उपयुक्त है।

जैविक और रासायनिक सुधारकों के माध्यम से आसेर्निक प्रदूषण में कमी

भाकृअनुप-भारतीय जल प्रबंधन संस्थान के अनुसंधान फार्म में एक नेट हाउस प्रयोग शुरू किया गया। पहले प्रयोग में आसेर्निक के विभिन्न स्तरों (0, 10, 20, 40, 60 मिलीग्राम/किलोग्राम) का धान की फसल की वृद्धि और प्रदर्शन पर इसके प्रभाव को देखने के लिए किया गया। प्रारंभिक परिणामों में बढे.हुए आसेर्निक स्तर से धान के पौधों की ऊंचाई और किल्लों की संख्या में महत्वपूर्ण कमी देखी गई। दूसरे प्रयोग में मृदा को 30 मिलीग्राम/ किलोग्राम की दर से आसेर्निक के साथ संचित किया गया और विभिन्न जैविक तथा रासायनिक सुधारकों का उपयोग धान के पुआल और दाना में आसेर्निक के संचय को कम करने के लिए इनकी संभावित क्षमता का मूल्यांकन करने हेतु किया गया।

जलवायु परिवर्तन के तहत गन्ने की खेती में दक्ष भूजल प्रबंधन

उत्तरप्रदेश राज्य के मुजफ्फरनगर जिले के एक अतिदोहित क्षेत्र में भूजल स्तर की गिरावट को कम करने हेतु दो आयामी जल प्रबंधन तकनीकों (आपूर्ति पक्ष प्रबंधन और मांग-पक्ष प्रबंधन) को प्रभावी पाया गया। आरसीपी 4.5 मॉडल के उपयोग के पूर्वानुमान से पता चला कि जलवायु परिवर्तन के कारण भूजल स्तर में गिरावट भविष्य के लिए बहुत बड़ी जोखिम साबित हो सकती है और इसी बात को ध्यान में रखते हुए गन्ने जैसी अधिक जल आवश्यकता वाली फसल की सिंचाई के लिए भूजल के दोहन को इस फसल के अंतर्गत क्षेत्र को कम करके ही घटाया जा सकता है। इसके अलावा उन्नत सिंचाई के प्रयोग और जल वहन प्रणाली के तहत गन्ने की फसल के और अधिक क्षेत्र को बढ़ाकर और भूजल पुन:भरण जैसी कृत्रिम पुन:भरण संरचनाओं यानी रिचार्ज केविटी की स्थापना से भावी जोखिम को कम किया जा सकता है।

तिलहन फसलों पर औद्योगिक अपशिष्ट जल का प्रभाव

ओडिशा राज्य के अंगुल औद्योगिक क्षेत्र के तहत रबी मौसम के दौरान किसान के खेत में उगने वाली तिलहनी फसलों पर अपशिष्ट जल के प्रभाव से पता चला कि सरसों और सूरजमुखी की उपज और इनके उपज गुण ताजे जल की सिंचाई की तुलना में अपशिष्ट जल से अधिक प्राप्त हुए। अपशिष्ट जल के उपचार के तहत मृदा में उपलब्ध जैविक कार्बन, नाइट्रोजन, फॉस्फोरस, और सल्फर और विनिमेय पोटासियम में काफी सुधार प्राप्त हुआ।

प्रदूषित जल स्रोतों से क्रोमियम का बायोरीमेडिएशन

उपचार में रखने के 20 और 25 दिनों के बाद साल्विनिया मिनिमा ने क्रमश: 0.37 से 6.28 गुना अधिक क्रोमियम (VI) (0.83 से 1.29 मिलीग्राम/लीटर) और पिस्टिया स्ट्रैटिओट्स ने क्रमश: 0.94 से 1.72 गुना अधिक क्रोमियम (<1.0 मिलीग्राम/लीटर) ने अन्य पौधों की तुलना में इस धातु को कम कर दिया। इस प्रकार साल्विनिया $\geqslant$ 1.0 मिलीग्राम/लीटर की दर पर और पिस्टिया <1.0 मिलीग्राम/लीटर Cr (VI) के स्तर पर इन पौधों को फाइटोरीमेडिएशन के उद्देश्य के लिए पसंद किया जाता है। सुखने और पीसने के बाद Cr-समृद्ध पौधों के बायोमास को पेलेट्स और अन्य उत्पाद जैसे सीमेंट, मिट्टी, कोलतार, पैराफिन और अपशिष्ट पदार्थों का उपयोग कर अस्थिर किया गया।

अपशिष्ट जल से सुरक्षित सिंचाई के लिए जैविक फिल्टर का विकास

5 मिलीग्राम/लीटर Ni तथा Cd, Pb एवं Cr 10 मिलीग्राम/लीटर की धातु सहिष्णुता के साथ कुल 22 आइसोलेट्स पाए गए। इनमें से अधिकांश आइसोलेट्स को कैटेलेज, ऑक्सीडेज, जिलेटिन, लैक्टोज, सुक्रोज में धनात्मक पाया गया और इंडोल, एमआर, वीपी, फ्रुक्टोज, साइट्रेट और नाइट्रेट में नकारात्मक पाया गया। आइसोलेट्स के समय में 98 से 168 मिनट के बीच का अंतर था और कुल तेरह आइसोलेट्स ने > 50% की कंपेटिबिलिटी दिखाई।

कृषि जल प्रबंधन पर एंड्रोइड आधारित मोबाइल एक्सपर्ट प्रणाली का विकास

कृषि जल प्रबंधन पर एक एंड्रोइड आधारित मोबाइल प्रयोग एक्सपर्ट प्रणाली विकसित की गई जिसमें कृषि जल प्रबंधन, बागवानी, मत्स्य पालन और पशुपालन से संबन्धित जानकारी शामिल है।

रिमोट पंप संचालन के लिए मोबाइल ऐप का विकास

समय अंतराल को कम करने के लिए एमक्यूटीटी प्रोटोकॉल का उपयोग करके पंप को रिमोट से संचालित करने हेतु मोबाइल ऐप में सुधार की प्रक्रिया जारी है।

मनरेगा (MGNREGS) के तहत जल से संबंधित तकनीकों का सामाजिक-आर्थिक मूल्यांकन

ओडिशा राज्य में मनरेगा के तहत जल से संबंधित तकनीकों के सामाजिक-आर्थिक मूल्यांकन से पता चला कि जल से संबंधित कार्यों पर कुल व्यय का अनुपात 17.79% (2014-15) से घटकर 16.24% (2018-19) हो गया। इसी प्रकार, कार्यों की कुल संख्या में जल से संबंधित कार्यों की हिस्सेदारी 19.9% (2014-15) से घटकर 4.3% (2018-19) ही रह गई। इससे पता चलता है कि सभी कार्यों और प्राकृतिक जल संसाधनों से संबंधित कार्यों पर खर्च के बीच का अंतर वर्ष दर वर्ष व्यापक हो गया है और पिछले वर्षों के दौरान प्राकृतिक जल संसाधनों के कार्यों की हिस्सेदारी के साथ-साथ संख्या और जल से संबंधित कार्यों में लगातार गिरावट आई है। ओडिशा राज्य में जोशीपुर ब्लॉक की एकटली ग्राम पंचायत में जल से संबंधित कार्यों (तालाबों और चैक बांधों) का एक्स-पोस्ट मूल्यांकन कृषि उत्पादन और किसानों की आय पर सकारात्मक प्रभाव का सुझाव देता है। हालांकि, जल निकायों का खराब रखरखाव बहुत ही चिंता का कारण है।

एसटीसी परियोजना के तहत भूमि और जल उत्पादकता में वृद्धि

ओडिशा राज्य के रायगढ जिले में बिसमा कटक ब्लॉक के अंतर्गत कुंभर्धमुनी पंचायत के एक गाँव पूर्तिगुड़ा को ओडिशा के सुंदरगढ़ जिले को छोड़कर एस्पिरेशनल जिला श्रेणी के तहत अनुसूचित जनजाति घटक परियोजना (STC) में गतिविधियों के लिए पहचाना गया। यहाँ आम के पौधे बांटे गए; पाइप-आधारित सिंचाई प्रणाली को एचडीपीई सिंचाई कन्वेयन्स पाइप वितरित करके कुल 24 आदिवासी किसानों को सुविधा उपलब्ध करवाई गई। कुल 151 आदिवासी किसानों के लिए दो प्रदर्शन प्रशिक्षण कार्यक्रम और एक दिन का स्वच्छ भारत अभियान कार्यक्रम भी आयोजित किए गए।

फारमर्स फर्स्ट प्रोजेक्ट

विभिन्न गाँवों में लाइन रोपाई, धान गहनता पद्धति (SRI), पोषक तत्व प्रबंधन के साथ-साथ रोपित धान में जल की उपयोग दक्षता को बढ़ाना, एकीकृत कृषि प्रणाली, सर्दी के मौसम की सब्जियों के माध्यम से फसल तीव्रता में वृद्धि, पशुधन पालन प्रशिक्षण आदि में सुधार जैसी तकनीकों को इस परियोजना में कायान्वित किया गया। इन तकनीकों के प्रभाव के मूल्यांकन ने संकेत दिया कि उन्नत तकनीकों और कृषि पद्धतियों को अपनाने के बाद किसानों की कृषि आय में 108% तक की वृद्धि हुई। संसाधन भागीदारी के साथ समूह में खेती, पाइप्ड कन्वेयन्स सिस्टम और दक्ष जल प्रबंधन के उपयोग ने सिंचाई जल को 20% से अधिक तक बचाया। तीन दिवसीय किसान-प्रशिक्षण कार्यक्रम और एक फील्ड प्रशिक्षण कार्यक्रम दिवस के साथ तकनीकों के प्रदर्शन का आयोजन भी किया गया। विभिन्न फसलों/सब्जियों में बीमारियों और कीटों की पहचान करने और इनके समाधान हेतु व्हाट्सएप ग्रुप का उपयोग किया गया।

वैज्ञानिक तकनीकों के माध्यम से गाँव के तालाब का पुन:निर्माण

इस परियोजना के तहत जलग्रहण क्षेत्र और फसल योजना के मानचित्र तैयार किए गए और इनकी तुलना सेटेलाइट से प्राप्त चित्रों से की गई। ऐतिहासिक वर्षा के आंकड़ों (1975-2018) का विश्लेषण इनलेट और आपातकालीन स्पिलवे की डिजाइन के साथ-साथ तालाब की डिजाइन के लिए किया गया। साथ ही गाँव के तालाबों के निर्माण और प्रबंधन हेतु देशी तरीकों का दस्तावेजीकरण किया गया।

सिंचाई जल प्रबंधन पर अखिल भारतीय समन्वित अनुसंधान परियोजना (AICRP-IWM)

भाकृअनुप-भारतीय जल प्रबंधन संस्थान, भुवनेश्वर देश के विभिन्न कृषि उप पारिस्थितिकी सब क्षेत्रों में स्थित सिंचाई जल प्रबंधन पर अखिल भारतीय समन्वित अनुसंधान परियोजना के कुल 26 केन्द्रों के लिये एक समन्वयक केंद्र के रूप में कार्य करता है। इस संस्थान के निर्देशन में इन समन्वित केन्द्रों द्वारा मृदा-जल-पौधा संबंध

एवं इनकी परस्पर प्रतिक्रिया पर बुनियादी अध्ययन तथा जल की उपलब्धता का आकलन, अधिक वर्षा वाले क्षेत्रों में वर्षा जल प्रबंधन, भूजल आकलन एवं पुनःभरण, दवाब सिंचाई प्रणाली का मूल्यांकन, बागवानी एवं नकदी फसलों में जल प्रबंधन, नहरी जल एवं भूजल का संयोजी उपयोग, अपशिष्ट जल का सिंचाई हेतु प्रयोग तथा जल की उत्पादकता बढ़ाने के लिये जल निकासी अध्ययन आदि विषयों पर अनुसंधान एवं इनके प्रचार-प्रसार पर कार्य किया जाता है।

जल पर कृषि भागीदारी अनुसंधान मंच (AGRI-CRP on Water)

भाकृअनुप-भारतीय जल प्रबंधन संस्थान जल पर एग्री-सीआरपी के समन्वय केंद्र के रूप में कार्य करता है और इस संस्थान में छह अनुसंधान परियोजनाओं पर कार्य जारी है। इन परियोजनाओं के प्रमुख निष्कर्ष नीचे बिन्दूओं के रूप में दिए गए हैं -

- विभिन्न कृषि-पारिस्थितिक क्षेत्रों में रबर बांधों के प्रभाव का मूल्यांकन किया गया। इनमें जल का भंडारण 3600 से 20000 घनमीटर के बीच था। और इससे खरीफ धान में 17%, मूँग में 26% और सब्जियों की फसलों में 38% तक पैदावार में वृद्धि हुई। खेती योग्य भूमि उपयोग सूचकांक में 56.5% तक वृद्धि हुई। ढेंकानाल जिले के कठोर चट्टानी क्षेत्र में रबर बांध, पुनःभरण कुआं एवं जल संचयन संरचना (WHS) के माध्यम से भूजल पुनःभरण का अध्ययन किया गया और वर्ष 2018-19 के दौरान इन जल संचयन संरचनाओं के माध्यम से संभावित भूजल पुनभरण का अनुमान लगभग 3876 घनमीटर लगाया गया।
- नागपुर माइनर में विद्यमान सहायक जल भंडारण संरचनाओं से पाइप आधारित सिंचाई प्रणाली एवं दबावयुक्त सिंचाई सुविधा उपलब्ध करवाई गई है। मूँगफली, तिल और सब्जियों की फसलों की औसत उपज में मामूली वृद्धि के परिणाम प्राप्त हुए और उनकी जल उत्पादकता क्रमशः 11-33% और 34-97% तक प्राप्त हुई।
- सेंसर आधारित स्वचालित सिंचाई ने केले (किस्म-G9) की फसल में मैनुअल ड्रिप सिंचाई की तुलना में 22% कम जल का उपयोग करके बेहतर गुणवत्ता वाले फलों के साथ 18% अधिक उपज का उत्पादन किया। उर्वर सिंचन पद्धति द्वारा केले की फसल में फूल आने से पहले की अवस्था पर 80%, फूल आने व फल-सेटिंग अवस्थाओं पर 100% तथा फल-विकास अवस्था पर 80% उर्वरकों की अनुशंसित खुराक के प्रयोग के साथ पूर्ण सिंचाई (100 Etc) करने से समान फल उपज का उत्पादन प्राप्त हुआ। केले की फसल के प्रति गड्ढे में दो पौधे 40% गीले क्षेत्र के साथ प्रति गड्ढे एक पौधे की तुलना में 28% तक अधिक फल की उपज और 30% तक अधिक जल उत्पादकता प्राप्त कर सकते हैं।
- घरेलू अपशिष्ट जल में कैडमियम (Cd) के प्रमुख स्रोत निकल-कैडमियम बैटरी, पेंट, प्लास्टिक, डिटर्जेंट, कॉस्मेटिक्स, निर्माण सामग्री, इंजन-तेल आदि हैं। नाली में स्थापित निस्पंदन प्रणाली उपचारित अपशिष्ट जल में निलंबित ठोस और बायोलोजिकल ऑक्सीजन डिमांड की मात्रा को क्रमशः 39 और 40% तक कम करती है। सब्जियों की फसलों को इस उपचारित अपशिष्ट जल की सिंचाई के साथ उगाया जाता है। इससे अनुपचारित अपशिष्ट जल की तुलना में इन फसलों के खाद्य भागों में क्रमशः 33, 40 और 42% कम केडमियम, क्रोमियम और निकल पाया गया।
- एकीकृत मछलीपालन, कृषि, तटबंध पर बागवानी और मुर्गीपालन द्वारा दक्ष जल-उपयोग एकीकृत कृषि पद्धति के मॉडल को विकसित किया गया। एक सम्पूर्ण पद्धति के परिणामस्वरूप ₹1,47,800/हे का शुद्ध लाभ प्राप्त हुआ और 2.6 आउटपुट मूल्य-खेती की लागत के अनुपात के साथ ₹16.20/घन मीटर की शुद्ध उपभोगीत जल उत्पादकता प्राप्त हुई।
- तटीय ओडिशा के जल मार्केट में जल की कीमतें आपूर्ति-मांग की मात्रा द्वारा नियंत्रित नहीं की जाती है। इन क्षेत्रों में भूजल का मार्केट कुल भूजल सिंचित भूमि के आधे क्षेत्र तक प्रभावी है। जल के ज्यादातर खरीदार सीमांत और छोटे किसान हैं जो भूजल की खरीद के लिए लगभग ₹ 2,600-3,000 /एकड़/मौसम का भुगतान कर रहे हैं। कुल 2-3 एकड़ धान की फसल की भूमि की सिंचाई के लिए उथले नलकूप (60-80 फीट) का किराया लगभग ₹ 50 प्रतिघंटे है। कुल 80% परिवार जल के मार्केट में भाग लेते पाए गए, 21% किसान जल बेचने और 57% किसान जल खरीदने की श्रेणी में शामिल थे।

प्रकाशन, पुरस्कार एवं सम्मान

भाकृअनुप-भारतीय जल प्रबंधन संस्थान के वैज्ञानिकों ने वर्ष 2018-19 के दौरान कुल 31 शोध पेपरों के अलावा 15 पुस्तकों/बुलेटिनों/प्रशिक्षण मैन्युअल एवं 13 लोकप्रिय लेखों को प्रकाशित किया। इस वर्ष भाकृअनुप-भारतीय जल प्रबंधन संस्थान ने सर्वश्रेष्ठ संस्थान का पुरस्कार प्राप्त किया जो लघु संस्थानों की श्रेणी के अंतर्गत सरदार पटेल उत्कृष्ट आईसीएआर संस्थान पुरस्कार 2017 था। हमारे संस्थान के वैज्ञानिकों को कई अन्य सम्मान और पहचानों के साथ हिंदी में सर्वश्रेष्ठ मौलिक पुस्तक लेखन के लिए राजभाषा गौरव पुरस्कार 2017, बीकेजेएफ-आईएनसीएसडबल्यू सूक्ष्म सिंचाई पुरस्कार 2018, डॉ के.जी. तेजवनी पुरस्कार, मृदा विज्ञान सोसाइटी फैलो, के.सी. दास मेमोरियल अवार्ड, लीडरशीप पुरस्कार-2018, बनबिहारी मोहंती मेमोरियल अवार्ड, सर्वश्रेष्ठ पोस्टर पुरस्कार आदि प्राप्त हुए।

अनुसंधान परियोजनाएं

भाकृअनुप-भारतीय जल प्रबंधन संस्थान के वैज्ञानिक कुल 22 संस्थान की अनुसंधान परियोजनाओं तथा 16 बाहरी वित्त-पोषित अनुसंधान परियोजनाओं के साथ-साथ पांच परामर्श परियोजनाओं पर अनुसंधान कार्य कर रहे हैं।

मानव संसाधन विकास, प्रशिक्षण और क्षमता निर्माण

हमारे संस्थान के 16 कर्मचारियों ने विभिन्न संगठनों से विभिन्न विषयों पर प्रशिक्षण प्राप्त किया; भाकृअनुप-भारतीय जल प्रबंधन संस्थान, भुवनेश्वर ने सरकारी अधिकारियों और छात्रों के लिए दस प्रशिक्षण कार्यक्रम आयोजित किए; आठ किसान-वैज्ञानिक सहभागिता या सह-व्यावहारिक प्रशिक्षण कार्यक्रमों से कुल 1209 किसान लाभान्वित हुए; 294 किसानों/ छात्रों के लिए खेत पर प्रदर्शनी का आयोजन किया गया; और भाकृअनुप-भाजप्रसं से विकसित तकनीकों के प्रदर्शन हेतु सात प्रदर्शनियां लगाई गई।

मेरा गाँव - मेरा गौरव कार्यक्रम

भाकृअनुप-भारतीय जल प्रबंधन संस्थान के वैज्ञानिकों के छह समूहों ने मेरा गाँव-मेरा गौरव कार्यक्रम के तहत ओड़िशा राज्य के पाँच जिलों (पूरी, खुर्धा, ढेंकानाल, केंद्रापड़ा एवं जगतसिंहपुर) में स्थित 7 ब्लॉकों के 30 गाँवों को अपनाया। वैज्ञानिकों द्वारा इस कार्यक्रम के तहत कृषि जल प्रबंधन सहित कृषि के विभिन्न विषयों पर जागरूकता के बारे में किसानों को जानकारी उपलब्ध करवाई, साथ ही साथ किसानों हेतु कई महत्त्वपूर्ण कृषि के विषयों पर प्रशिक्षण/संगोष्ठी/ बैठकें आयोजित की गई जिससे किसानों को बहुत लाभ मिला। इस प्रकार यह संस्थान गाँवों की समुचित प्रगति के लिए भी कार्य कर रहा है।

स्वच्छ भारत – स्वस्थ भारत अभियान

भाकृअनुप-भारतीय जल प्रबंधन संस्थान ने स्वच्छ भारत अभियान में सक्रिय रूप से भाग लेकर संस्थान के मुख्य परिसर, सार्वजनिक स्थानों और पर्यटन स्थलों पर वर्ष 2018-2019 के दौरान कुल 43 स्वच्छता कार्यक्रमों को आयोजित किया; विभिन्न छात्रों को स्वच्छता के लिए प्रेरित किया गया तथा इस वर्ष के दौरान कई वाद विवाद/सेमिनार/प्रशिक्षण कार्यक्रम भी आयोजित किए गए।

कृषि कल्याण अभियान

भारतीय जल प्रबंधन संस्थान, भुवनेश्वर ने भारत सरकार के कृषि कल्याण अभियान में महत्त्वपूर्ण भूमिका निभाई। इस अभियान के तहत इस संस्थान के वैज्ञानिकों की छः टीमों ने कृषि विज्ञान केंद्र, मल्कानगिरी, ओड़िशा राज्य के कृषि, बागवानी व पशु पालन विभागों एवं गाँव के सरपंच के साथ मिलकर इस जिले के 25 गाँवों में कुल छः दो दिवसीय किसान प्रशिक्षण कार्यक्रमों को आयोजित किया।

Executive Summary

Water and nutrient self-reliant farming system for rainfed areas

Self-reliant farming system (SRFS) showed 116% higher earthworm population density one-month after rice transplanting, compared to the conventional system. There was significant improvement in organic carbon, available N, dehydrogenase activity, microbial biomass carbon, soil bulk density, total porosity and water holding capacity of soil under SRFS. Rice grain yield and straw weight under the SRFS were not significantly different from the yields obtained under the conventional system. However, energy efficiency (energy output: input ratio) of SRFS was 63% higher (22.6) compared to the conventional system (13.8).

Enhancing pulses productivity using micro-irrigation

Sprinkler irrigation at two critical crop growth stages of green gram i.e., flowering and pod formation resulted in highest water productivity compared to single stage irrigation and control treatments. Two irrigations and N application at 20 kg ha^{-1} through urea and *Rhizobium* increased pod yield of the crop from 0.49 to 0.98 t ha^{-1} and net water productivity from ₹ 2.43 to 6.70 m^{-3}. The crop growth stage based water production functions of green gram revealed linear association (R^2 = 0.79–0.92) between pod yield and water used with yield response factors of 0.32, 1.18 and 0.21 in initial, mid-season and late-season stages of the crop, respectively.

Development and evaluation of mini pan-evaporimeter for irrigation scheduling

The mini pan-evaporimeters made from galvanized iron (GI) sheet and PVC pipes with diameters of 10, 20 and 30 cm, and height of 25 cm. The scatter plot of evaporation from PVC and GI mini pan-evaporimeters with USWB open pan showed that the evaporation from 30 cm GI mini pan had closest relationship with evaporation from USWB open pan in summer (R^2=0.89) followed by *rabi* (R^2=0.88) and *kharif* (R^2=0.86) seasons. Lowest relation was found with PVC 10 cm in all seasons.

Land shaping options for enhancing income in coastal waterlogged area

The water level in dug-pond was monitored. Soil EC of the raised bed (0-15 cm depth) increased from 0.53 to 2.83 dS m^{-1} between October to March at one location of the experiment. Similarly, at another location it increased from 0.11 to 2.25 dS m^{-1} between same periods. By growing brinjal, green chili, amaranth, radish, bottle gourd, ridge gourd, bitter gourd and poi (*Basella alba)* on raised bed in 1200 m^2 area farmer got annual gross and net income of ₹ 32,160/- and ₹ 24,000/- respectively.

Post-flood management plans prepared

Flood damage to agricultural crops during *kharif* season was assessed in Muzaffarpur and east Champaran districts of Bihar, and Kendrapara and Puri districts of Odisha. Post-flood management plans were prepared and implemented in these districts. Through timely sowing of alternate crops like maize, and implementing post-flood management plan, farmers could generate additional net returns of about ₹ 16,700/- ha^{-1} compared to flood damaged field without intervention.

National innovations for climate resilient agriculture (NICRA)

The CO_2 influx/efflux potential of rice-cowpea cropping system was measured using eddy covariance technique, with the seasonal net ecosystem exchange (NEE) at the end of growing period of rice showing -307 g C m^{-2}. Under changing climate (RCP 4.5 scenario), maximum temperature for the Indo-Gangetic region is likely to increase in the range of 2.95 to 4.07°C during 2018-2090 over the baseline (1976-2005). Moreover, the impacts of water harvesting with dyke based technology in Satyabadi block, Puri district of Odisha using remote sensing and GIS revealed that 1063 numbers of water harvesting structures were constructed in the study block. Also on-farm trial of short-duration and drought-resistant rice varieties was conducted at Alisha village, Satyabadi block, Puri; and drip-fertigation in hard rock areas to highlight the multiple uses of water under rainfed, irrigated and coastal agro-ecosystems. Groundwater level monitoring in 16 open dug-wells and daily gauging of runoff during the flow period was done at the weir structure in the watershed. Validation of the SWAT model for the watershed had correlation coefficient value of 0.91 and NSE value of 0.78. The groundwater flow model for the watershed was developed using the Visual MOFLOW. This model was calibrated with a mean error of 1.419 m and correlation coefficient of 0.98.

Performance evaluation of rice cultivation methods for water saving

Field trials showed that performance of rice (var. '*Khandagiri*') was similar in alternate wetting and drying (AWD), irrigation at 3-days after disappearance (3-DAD) and continuous flooding (CF) during *rabi*/ summer season; whereas water saving was about 19.6% in 3-DAD and 29.8% in AWD compared to CF. Consequently, water productivity increased by 27 and 38% in 3-DAD and AWD, respectively over CF. Aerobic rice yield was 28% lesser than either direct wet-seeding or puddle transplanting; aerobic rice yield was 2.41, 3.09 and 3.31 t ha^{-1} with sprinkler irrigation, bed-furrow and flood method, respectively; there was reduction in yield under sprinkler irrigation by an average of 27% compared with flood method. However, water application was 26.4% lesser in sprinkler irrigation (610 mm) and 8.8% lesser in broad-bed method than flood method of irrigation (829 mm) and obtained no significant difference in water productivity in three methods of irrigation to aerobic rice.

Benchmarking for assessing the performance of canal irrigation system

A user friendly software was developed for analysis of irrigation system's benchmarking time series data in Visual Basic. The time series data can be either entered manually or uploaded through Excel file. The data can be modified and updated using command buttons. Presently, the model calculates nine indicators and the output module can be obtained either in tabular or graphical form. The results can be seen based on irrigation system types (major, medium and minor) and on plan group wise (abundant, excess, normal, deficit and highly deficit).

Impact of super absorbent polymers (SAP) on crop growth of rice and groundnut

A field experiment was conducted to evaluate different doses of SAP on crop growth and yield of groundnut and rice. Results showed insignificant impact of different doses of SAP (0, 25, 50, 75 and 100 kg ha^{-1}) on crop growth and physiological performances. Moreover, water productivity varied 6% and 5% amongst different levels of SAP in groundnut and rice, respectively.

Enhancing economic water productivity in irrigation canal commands

The Sina medium irrigation project, a deficit irrigation system in Maharashtra, possesses its water influence area beyond the command area. In absence of assured canal water supply in the system, there is rampant exploitation of groundwater through wells and river lifts for crop production. Preliminary study revealed that the scenario with irrigation consumptive water use (CWU) of 35 Mm^3 and allocating the same to the fruit crops to the tune of 22.5% and 15.7% each to *rabi*/summer crops like wheat, jowar, vegetables, oilseeds and pulses, total value of production could be fetched to ₹ 422 million with 81.5 % of the total command area coverage.

Intensive horticultural system in degraded land

To improve water productivity and generate profits from degraded land, an experiment was conducted in pre-bearing mango orchard intercropped with papaya and pineapple under drip irrigation and paddy straw mulch. No significant differences were observed in vegetative growth. However, yield / pineapple equivalent yield in mango intercropped with pineapple under straw mulch (18.9 t ha^{-1}) as well as water productivity in the system (21.5 kg ha-mm^{-1}) was significantly higher compared with other cropping systems.

Socio-economic and environmental linkages of groundwater irrigation

The critical administrative blocks with pronounced water table declines in the Godavari districts of Andhra Pradesh were identified. Quantification and mapping of groundwater level patterns will help the policy managers to take necessary action. Moreover, the socio-economic benefits of free electricity and consequent energy crisis has been explored. Feasibility of the recent policy of solar energy-fed irrigation needs to be studied, given the coastal position and availability of sun-shine during critical stages of crop.

Design of groundwater recharge structures for hard rock areas

A water balance study was conducted in rain water harvesting structures (RWHS) at Srirampur and Nachhipur villages under Barghariananala micro-watershed, Daspalla block, Odisha. Result showed that annually 0.03-0.25 m (av. 0.14 m) of water was recharged from one structure of 0.38 ha-m capacity. Similarly, RWHS of 0.5 ha-m and 0.75 ha-m, the annual recharge of 0.25 m and 0.70 m, respectively was estimated. In contrast, RWHS (0.20 ha-m) along with recharge well, the annual recharge increased up to 0.86 m. The impact of these structures is extended up to 300 m aerial extents covering the area of influence of 15 ha command area in hard rock areas of Odisha. Due to presence of the recharge structures water table depth in dug-wells rises up to 1 m during pre-monsoon season.

Assessment of groundwater contamination in lower Godavari basin

Lower Godavari basin is one of the most fertile and intensively cultivated area in India. Forty one groundwater samples from bore well and 88 soil samples were analyzed. pH of most of the samples are suitable for irrigation (<8.4). Electrical conductivity of the samples ranged from 0.01 to 2.88 mS cm^{-1}. Nitrate-nitrogen in the samples varied from 0.2 to 8.9 mg L^{-1}. In 24% samples, nitrate-nitrogen content ranged between 7.1-8.9 mg L^{-1}. Sodium absorption ratio (SAR) value of the groundwater samples (0.5 to 9.0) are considered suitable for irrigation.

Mitigation of arsenic contamination through organic and chemical amendments

A net house experiment was initiated at the ICAR-IIWM research farm. In the first experiment, different level of arsenic were applied @ 0, 10, 20, 40, 60 mg kg^{-1} to observe its effect on growth and performance of rice crop. Initial results showed significant reduction in plant height and tiller number at elevated arsenic level. In the second experiment, soils were spiked with arsenic @ 30 mg kg^{-1} and different organic and chemical amendments were applied to evaluate their possible ability to mitigate arsenic accumulation in rice straw and grain.

Efficient groundwater management under climate change in sugarcane farming system

A two pronged water management (supply-side management and demand-side management) intervention has been found effective in reducing the decline of groundwater table in an overexploited area of the Muzaffarnagar district, UP. Prediction using the RCP4.5 model reveals that the future risk on decline of groundwater table due to climate change and over-abstraction for irrigating high water requiring crop like sugarcane can be minimized by reducing the area under sugarcane, bringing more area under improved irrigation application and conveyance system, and establishing artificial recharge structures such as recharge cavities.

Impact of industrial wastewater on oilseeds crop

The impact of wastewater from Angul industrial area, Odisha on oilseed crops growing in farmer's field during *rabi* season revealed that yield and yield attributes of mustard and sunflower were higher with wastewater than freshwater irrigation. Soil organic C, available N, P, and S; and exchangeable-K were substantially improved under wastewater treatment as well.

Bioremediation of chromium from polluted water sources

Salvinia minima removed 0.37 to 6.28 times more Cr (VI) from 0.83 to 1.29 mg L^{-1}, and *Pistia stratiotes* removed 0.94 to 1.72 times more Cr from <1.0 mg L^{-1} Cr level after 20 and 25 days of keeping in the treatments, respectively, than other plants. Thus, growing *Salvinia* at $\geqslant$ 1.0 mg L^{-1} and *Pistia* at <1.0 mg L^{-1} Cr (VI) levels is preferred for phytoremediation purpose. After drying and grounding, the Cr-enriched plant biomass was immobilized by making pallets and other products using cement, clay, bitumen, paraffin and waste materials.

Development of biological filter for safe wastewater irrigation

Twenty-two isolates were found with metal tolerance up to 10 mg l^{-1} of Cd, Pb and Cr; and 5 mg l^{-1} of Ni. Most of these isolates were found positive in catalase, oxidase, gelatin, lactose, sucrose, and negative in indole, MR, VP, fructose, citrate & NO_3^-. Doubling-time of isolates varied between 98 to 168 minutes and thirteen isolates showed >50% compatibility.

Development of android-based mobile expert system on agricultural water management

An android- based mobile application expert system on agricultural water management has been developed including agriculture, horticulture, fisheries and animal husbandry.

Developing mobile App for remote pump operation

An improvement in the mobile App to operate pump remotely is under process, using MQTT protocol to reduce time lag.

Socio-economic evaluation of water related interventions under MGNREGS

Socio-economic evaluation of water-related interventions under MNREGS in Odisha revealed that the proportion of total expenditure on water-related works declined from 17.79% (2014-15) to 16.24% (2018-19). Similarly, the share of water-related works in total number of works declined from 19.9% (2014-15) to 4.3% (2018-19). This suggests that the gap between expenditure on all works and NRM related works has got wider over the years, and the share of NRM works as well as water-related works in number has continuously declined over the past years. Ex-post evaluation of water-related works (farm ponds and check dams) in Ektali gram panchayat, Joshipur block, Odisha suggest its positive impact on farm production and farmer's income, however, poor maintenance of water assets is a cause of concern.

Enhancing land and water productivity under STC project

A village Purtiguda in Kumbhardhamuni Panchayat under Bisama Cuttack block in Rayagada district, Odisha was identified for Scheduled Tribe Component project (STC project) activities under aspirational district category apart from Sundargarh district, Odisha. Mango saplings were distributed; pipe-based irrigation system were facilitated to 24 tribal farmers by distributing HDPE irrigation conveyance pipes. Two exposure training programs for 151 tribal farmers and one day *Swatchha Bharat Abhiyan* programme were organized.

Farmer's FIRST project

Interventions like line transplanting, SRI method, increasing water use efficiency in transplanted rice along with nutrient management, integrated farming system, increasing cropping intensity through winter vegetables, improved livestock rearing trainings etc. were taken up in the project implementation villages. Impact evaluation of interventions indicated that on-farm income increased by 108% after adoption of improved technologies and farm practices. Group farming with resource sharing, use of piped conveyance system and scientific water management saved irrigation water by more than 20%. Three one-day farmer-training programs and one field training program-cum demonstration for were organized. WhatsApp group was used to identify and solve diseases and pests in crops/vegetables.

Revival of village pond through scientific interventions

Under this project, contour map of catchment and crop plan was prepared compared with satellite images. Historical rainfall data (1975-2018) was analyzed for pond design along with design of inlet and emergency spillway. Also, indigenous method of construction and management of village ponds were documented.

AICRP on Irrigation Water Management

ICAR-IIWM acts as a coordinating center of twenty six centers of AICRP-IWM to carry out basic studies on soil, water, plant relationship & their interaction and extension work in the field of assessment of water availability, rainwater management in high rainfall areas, enhancing productivity by multiple use of water, groundwater use at regional level, groundwater assessment and recharge, evaluation of pressurized irrigation system, water management in horticultural and high value crops, conjunctive use of canal and groundwater, and drainage studies for enhancing water productivity. Significant finding from different centers are presented.

Agri-CRP on Water

ICAR-IIWM acts as a coordinating center of Agri-CRP on Water and six research projects are continuing at this institute. Salient findings of these projects are-

- Impact evaluation of rubber dams in different agro-ecological regions were carried out. The water storage varied from 3600 to 20000 m^3 and there was enhancement of yield by 17% in *kharif* rice, 26% in green-gram, and 38% in vegetable. The enhancement in cultivated land utilization index was up to 56.5%. The groundwater recharge through rubber dam, recharge well and water harvesting structure (WHS) in hard rock region of Dhenkanal district was studied and the potential groundwater recharge from WHS was estimated at around 3876 m^3 during 2018-19.
- Pipe-based irrigation system connected to the existing auxiliary water storage structures along with pressurized irrigation facility in Nagpur minor resulted the increase in average crop yield of groundnut, *sesamum* and vegetable crops and their water productivity by 11-33% and 34-97%, respectively.
- Sensor-based automatic irrigation produced 18% higher yield with better quality fruits using 22% less water compared with manual drip irrigation in banana (cv. G9). Drip-fertigation at 80% recommended dose of fertilizers (RDF) at pre-flowering, 100% RDF at flowering and fruit-setting and 80% RDF at fruit-development stage produced the fruit yield at par with full irrigation (100% ETc). Two plants per pit with 40% wetting volume could produce 28% higher fruit yield and 30% higher water productivity compared with single plant per pit with 40% wetting volume in banana.
- Major sources of Cadmium (Cd) in domestic wastewater are Ni-Cd battery, paints, plastics, detergents, cosmetics, construction, engine-oils etc. Filtration system installed in drain reduced suspended solid and BOD by 39 and 40%, respectively in treated wastewater. Vegetables grown with treated wastewater had 33, 40 and 42% lesser Cd, Cr and Ni, respectively in their edible parts than untreated wastewater.
- A water-use efficient Integrated Farming System model has been developed integrating aquaculture, agriculture, on-dyke horticulture and poultry. System as a whole, resulted in net profit of ₹1,47,800 ha^{-1} with an output value-cost of cultivation ratio of 2.6 and net consumptive water productivity of ₹ 16.20 m^{-3}.
- Water price is not governed by the supply-demand forces in the water market in coastal Odisha. Groundwater market prevail by half of the total groundwater irrigated land in these areas. Water buyers, mostly are marginal and small farmers, are paying about ₹ 2,600-3,000/acre/season for the purchase of groundwater. The rent of shallow tube-wells (60-80 ft) for irrigating 2-3 acres of paddy land is around ₹ 50 per hour. 80% of the households were found participating in the water market, ~21% of the farmers were involved in water-selling and ~57% in water-buying.

Publication, awards and recognitions

During 2018-19, scientists of ICAR-IIWM published 32 peer reviewed research papers, 15 books / bulletins / training manuals / book chapters and 13 popular articles. ICAR-IIWM received Best Institute Award, i.e., 'The Sardar Patel Outstanding ICAR Institution Award-2017' amongst the ICAR institutes of 'Small Institutes' Category. Our Scientists have received *Rajbhasha Gaurav Purushkar 2017* for best technical book in Hindi, BKJF-INCSW *Sookshma Sinchai Purashkar*-2018, Dr. K.G. Tejwani Award, Fellow of Indian Society of Soil Science, K.C. Das Memorial Award, Leadership Award-2018, Banabihari Mohanty Memorial Award, Best Poster Award, along with many others honours and recognitions.

Research projects

Scientists of ICAR-IIWM working on 22 in-house and 16 externally-funded research projects, along with two consultancy projects and one collaborative project.

HRD, training & capacity building

Our 16 staff received trainings on various topics from different organizations; ICAR-IIWM conducted ten training programs for government officials and students; eight farmers-expert interaction cum-practical training programs benefiting 1209 farmers; exposure visit for 294 farmers/ students; and seven exhibitions to showcase ICAR-IIWM technologies.

Mera Gaon Mera Gaurav

Six groups of scientists of ICAR-IIWM adopted 30 villages across 7 blocks spreading over 5 districts of Odisha under the '*Mera Gaon Mera Gaurav*' program. Scientists of ICAR-IIWM provided information on awareness on various areas in agriculture to the farmers of adopted villages and conducted several trainings/ interaction meetings.

Swachh Bharat Abhiyan

ICAR-IIWM participated actively in *Swachh Bharat Abhiyan* and 43 number of cleanliness campaigns were conducted during 2018-2019 in the Institute main campus, public places and tourist spots; motivated students for cleanliness; organized debate, seminars and trainings.

Krishi Kalyan Abhiyan

ICAR-IIWM, Bhubaneswar played key-role in *Krishi Kalyan Abhiyan* of Government of India, and six teams of scientists of the institute in collaboration with *Krishi Vigyan Kendra* (KVK), Malkangiri; state agriculture, horticulture and animal husbandry departments; and village *Sarpanch* organized six 2-days trainings covering twenty five villages of Malkangiri district of Odisha.

CONTENTS

Introduction

The ICAR-Indian Institute of Water Management (erstwhile Directorate of Water Management or Water Technology Centre for Eastern Region) was established on May 12, 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

- Strategies for efficient management of non-farm water resources for sustainable agricultural productivity
- Co-ordinate research for generating location-specific technologies for efficient use of water resources
- Centre for training in agricultural water management

Research Achievements

Core research activities of the institute are carried out under four programs, viz., rainwater management (including waterlogged area management), canal water management, groundwater management and on-farm technology dissemination (including wastewater management, water policy & governance) to solve the agricultural water management related problems. The institute has experienced multi-disciplinary team of scientists.

Significant research achievements for the year 2018-19 have been included in this annual report under four programs of the Institute i.e., rainwater management (including waterlogged area management), canal water management, groundwater management and on-farm technology dissemination (including wastewater management, water policy & governance). Our scientists are actively involved in development of irrigation plans; safe drainage of excess water; development of runoff water recycling, and land modification/shaping technique for enhancing productivity; water and nutrient self-reliant farming system for rainfed areas; climate resilient agriculture, groundwater management for enhancing adaptive capacity to climate change, design of groundwater recharge structures for hard rock areas, assessment of groundwater contamination and its management, socio-economic and environmental linkages of groundwater irrigation in the Godavari districts of Andhra Pradesh, mitigation of arsenic contamination through organic and chemical amendments; options for enhancing irrigation efficiency and development of integrated farming systems in canal commands, water saving techniques in rice and rice-fallow areas through pulse crops, standardizing micro-irrigation technologies etc. To cope with flood, post-flood disaster management and an index-based flood insurance has been suggested. Studies are being carried out for bioremediation of polluted water, impact assessment of industrial wastewater, development and evaluation of mini-pan evaporimeter for irrigation scheduling, intensive horticultural system for improving farm income from degraded lands, and socio-economic evaluation of water related interventions under MGNREGS. Our Institute has also initiated development of android-based mobile expert system on agricultural water management and mobile App for pump operation remotely. A substantial work has been done for livelihood improvement of scheduled tribe and tribal farmers through water management interventions and revival of village ponds through scientific intervention.

Institute has played a major role in preparation of state irrigation plan for the Odisha. Apart from research and development efforts at the Institute level, different agricultural water management related issues at the regional level are being addressed by different centres under the AICRP on Irrigation Water Management. Through ICAR-Agri-Consortia Research Platform on Water project, institute has successfully installed rubber dams in different agro-ecological regions of India and evaluating its impact on crop production and groundwater recharge, initiated improvement strategies for higher water productivity in canal commands, soil water sensor-based automated drip irrigation in banana, eco-friendly wastewater treatment, multiple use of water in aquaculture production systems, addressing issues related to water governance and policy. With the aim of dissemination of technology and working with farmers, Scientists are involved with thirty adopted villages across seven blocks in Odisha under *Mera Gaon Mera Gaurav* (MGMG) programme; conducted several training programs for Government officials, farmers and students on various aspects of water management, played key-role in *Krishi Kalyan Abhiyan* at Malkangiri district of Odisha, and participated in exhibitions to showcase technologies developed by the institute. Based on institute's research achievements in past ten years, ICAR-IIWM received best institute award, i.e., 'The Sardar Patel Outstanding ICAR Institution Award-2017' amongst the ICAR institutes of 'Small Institutes' category.

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 latest equipment for research activities. An engineering workshop also cater to the needs of the institute. Four field laboratories at farm, viz., meteorological laboratory, pressurized irrigation system, solar photovoltaic pumping 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.iiwm.res.in). The entire network administration of the computers, internet and website management is looked after by the ARIS cell. The ARIS cell 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 is being utilized for related use from time to time.

The ICAR-IIWM has linkages with various agencies through 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. In addition to ongoing in-house research projects, the institute is awarded with many sponsored/ collaborative projects by various organizations like Ministry of Agriculture, GOI; IWMI, Colombo; DST and consultancy project by Panchayats and Rural Development, Govt. of West Bengal; Directorate of Soil Conservation & Watershed Development, Govt. of Odisha, Bhubaneswar and RKVY, Office of the Director of Horticulture, Odisha. The institute is coordinating center for AICRP on Irrigation Water Management and ICAR-Agri-Consortia Research Platform on Water, ICAR, New Delhi. Also, ICAR-IIWM has conducted ICAR entrance examinations for UG, PG, JRF and SRF at national level in 2018.

Finances

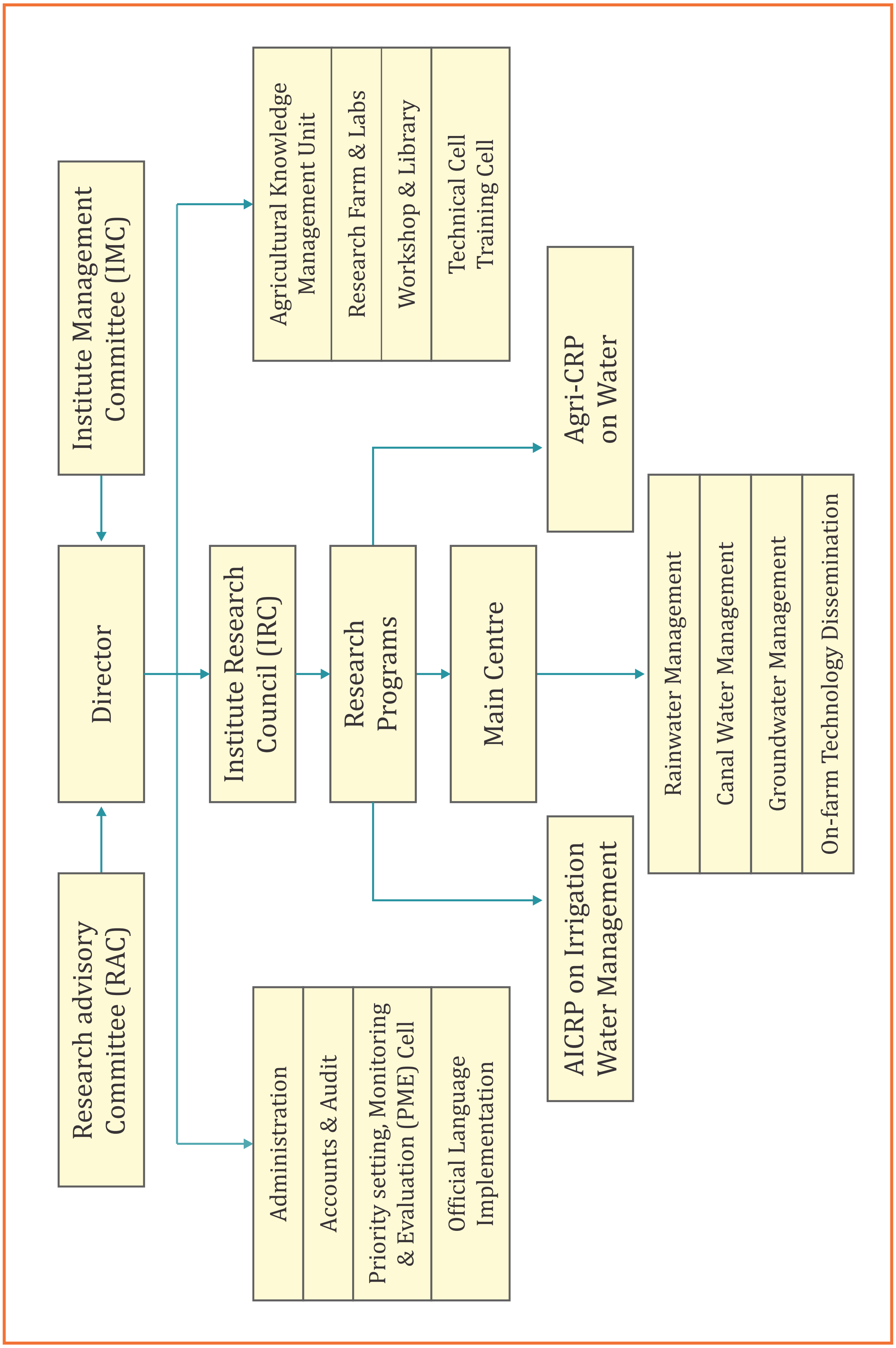
Summary of income & expenditure account and balance sheet of the institute during the year 2018-19 is presented at the end of this report.

Staff

At the end of March 2019, ICAR-IIWM had 80 sanctioned posts (including AICRP-IWM) out of which 61 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	29	06
Administrative	16	12	04
Technical	17	15	02
Supporting	11	04	07
Total	80	61	19

ORGANOGRAM



Research advisory Committee (RAC)
Director
Institute Management Committee (IMC)
Administration
Accounts & Audit
Priority setting, Monitoring & Evaluation (PME) Cell
Official Language Implementation
Institute Research Council (IRC)
Research Programs
Main Centre
Agricultural Knowledge Management Unit
Research Farm & Labs
Workshop & Library
Technical Cell Training Cell
AICRP on Irrigation Water Management
Agri-CRP on Water
Rainwater Management
Canal Water Management
Groundwater Management
On-farm Technology Dissemination

Rainwater Management

This program includes research projects on
rainwater management & waterlogged area management

Water and Nutrient Self-reliant Farming System for the Rainfed Farmers in High Rainfall Zone

Project Code: IIWM/15/168

Investigators: S.K. Rautaray, S. Mohanty, S. Raychaudhuri, R.K. Mohanty, R. Dubey and S. Pradhan

Experiments on self-reliant farming system (SRFS) were conducted during last three years (2015-2018). The cumulative effect of adoption of SRFS on rice crop and soil properties was studied on the fourth season crop (rice) in *kharif* 2018. Earthworm population density was measured using 0.5 x 0.5 m quadrat of GI sheet penetrated up to plough pan layer of 20 cm soil depth. The soft mud was scooped out from the marked area and cleaned in tap water to separate out the earthworms. The separated worms were collected in petridish for counting number and recording length and fresh weight. Earthworm population density was 41.3 m^{-2} at one week after incorporation of *Sesbania* green manure (before rice transplanting) under the SRFS plot. For the conventional system plot in which the nutrient requirement was provided using inorganic fertilizers, the earthworm population density before transplanting was 16.2 m^{-2} only. Thus, before rice transplanting, worm population density was higher by 147% with the SRFS plot as compared to conventional plot. The population density increased to 240.8 m^{-2} at one month after rice transplanting under the SRFS plot while it increased to 111.4 m^{-2} under conventional plot. At this stage, worm density was higher by 116% at the SRFS plot. A dense layer of worm cast was visible with the SRFS plot. The earthworm population was dominated by *Eisenia foetida,* an epigeic species living in surface soil and compost. Mean individual fresh weight was 0.42 g for the SRFS plot as compared to 0.51 g for the conventional plot. Mean body length of 9.0 and 9.4 cm were noted for SRFS and the conventional plots, respectively. SRFS plots with more organic matter resulted in more juvenile population at this stage of recording.

Self reliant farming system

Earthworm casts in SRFS (left) and control plot (right)

Rice grain and straw yields under the SRFS were 4810 kg ha^{-1} and 5730 kg ha^{-1}, respectively as compared to 4730 and 5690 kg ha^{-1} under the conventional system. Total energy input was 10.2 GJ ha^{-1} under the conventional system while 6.3 GJ ha^{-1} under SRFS. Total energy output from grain and straw was little higher with the SRFS (142.3 GJ ha^{-1}) as compared to the conventional (140.6 GJ ha^{-1}). Also, energy efficiency in terms of energy output: input ratio was higher (22.6) with the SRFS as compared to the conventional system (13.8). Further, the specific energy in terms of ton output per GJ energy input was higher (0.76 t grains GJ^{-1}) under the SRFS as compared to the conventional system (0.46 t grains GJ^{-1}). Net energy with SRFS was 13.6 GJ ha^{-1} while 13.0 for the conventional system. Net returns were higher (₹ 24558 ha^{-1}) under the SRFS as compared to the conventional system (₹ 21500 ha^{-1}) by considering a higher premium of ₹ 1750 t^{-1} for production under organic method.

Initial status (before the initiation of experiment, year 2015) of soil organic carbon (0.4%), available N (215 kg ha^{-1}), available P_2O_5 (38 kg ha^{-1}) and available K_2O (174.7 kg ha^{-1}) improved to 0.54%, 316.7 kg ha^{-1}, 45.8 kg ha^{-1} and 186.5 kg ha^{-1}, respectively, practising SRFS after harvest of fourth season rice crop in year 2018. The respective values of these parameters in plots following conventional cultivation using inorganic nutrition were 0.45%, 212.5 kg ha^{-1}, 48.4 kg $ha^{-1}$and 194.2 kg ha^{-1}. Metabolic status of a soil is reflected by dehydrogenase activity (DHA) and it suggests intensity of the microbial activity in soil. The DHA and microbial biomass carbon (MBC) was 30% and 34% higher in SRFS plot over the conventional plot. Both DHA and MBC were higher in rhizospheric soil as compared to non-rhizospheric soil. The soil bulk density after harvest of *kharif* rice crop (in 2018) was 1.46 and 1.80 g cm^{-3} for 0-15 and 15-30 cm soil layer, respectively, in the SRFS plot. The bulk density of 0-15 and 15-30 cm soil layer was marginally better compared to the bulk density observed after harvest of 2017 *kharif* rice crop (1.52 g cm^{-3} for 0-15 cm and 1.84 g cm^{-3} for 15-30 cm). Similarly, the total porosity increased from 43 to 45% in 0-15 cm soil layer and from 31 to 32% in 15-30 cm soil layer in 2018 compared to 2017. The corresponding improvement in maximum water holding capacity was 45 to 52% for 0-15 cm soil layer and 42 to 48% for 15-30 cm soil layer.

Water Use Efficient Practices for Successful Establishment and Yield Enhancement of Pulse Crops in Rice Based Cropping System

Project Code: IIWM/16/179

Investigators: P.S. Brahmanand, S. Roy Chowdhury, P. Panigrahi, P. Nanda and S. Raychaudhari

A field experiment was conducted in research farm of ICAR-IIWM, Mendhasal, Khurdha district of Odisha to investigate the effect of different water management and nutrient treatments on growth performance of greengram in rice-based cropping system. Split plot design was applied with three main plot treatments of irrigation (M_1: control (no irrigation); M_2: Sprinkler irrigation once at flowering stage; M_3: Sprinkler irrigation twice at flowering and pod formation stages) and four sub plot treatments of nitrogen application (S_1: control (no nitrogen) S_2: N@20 kg ha^{-1} through urea; S_3: N@20 kg ha^{-1} through urea along with *rhizobium* inoculation; S_4; N@40 kg ha^{-1} through urea) with three replications. In addition, six levels of irrigation (FI: full irrigation, 120% FI, 80% FI, 60% FI, 40% FI, 20% FI and control (without irrigation) were imposed in different crop growth stages (initial, mid-season and late-season) under both sprinkler and surface irrigation methods to develop water production function and yield response factor for greengram. The effects of irrigation on vegetative growth including leaf area index, soil water content, light interception, SPAD, available soil nutrients and leaf physiological parameters were recorded.

The results of the field experimentation during the second year of experimentation i.e. 2018 revealed that the pod yield of greengram was found to be significantly higher with two stage sprinkler irrigation (865 kg ha^{-1}) compared to one stage irrigation (770 kg ha^{-1}) and control (no irrigation) (580 kg ha^{-1}) treatments (Fig. 1). Similarly, the high pod yield of greengram was noticed with combined application of N@20 kg ha^{-1} supplied through urea and *rhizobium* inoculation (830 kg ha^{-1}) compared to N@20 kg ha^{-1} supplied through urea alone (716 kg ha^{-1}) and control (no nitrogen) (593 kg ha^{-1}). However, it was on par with the nitrogen @ 40 kg ha^{-1} applied through urea. Among the interaction treatments, the provision of two sprinkler irrigations with N@20 kg ha^{-1} supplied through urea and *rhizobium* inoculation resulted in the highest pod yield of 980 kg ha^{-1}. It was due to higher number of pods per plant and number of seeds per pod with increment in irrigation and nitrogen.

The application of irrigation water at two critical crop growth stages, i.e. flowering and pod formation resulted in highest water productivity compared to single stage irrigation and control treatments. Two irrigations (sprinkler system) and N @ 20 kg ha^{-1} through combined application of urea and *rhizobium* increased pod yield (from 0.49 t ha^{-1} to 0.98 t ha^{-1}) and net water productivity (from ₹ 2.43 m^{-3} to ₹ 6.7 m^{-3}) in greengram.

The water applied, total water used and volumetric water content in top 75 cm soil in different crop growth stage-based irrigation treatments were 32-192 mm, 57-208 mm and 15.1-23.8%, respectively under sprinkler irrigation. However, under surface irrigation, 15-25% higher amount of water was used compared with sprinkler irrigation. The pod yield under sprinkler irrigation treatments (0.43-1.05 t ha^{-1}) was 8-22 % higher than that under surface irrigation treatments. The SPAD (22.85-45.12) and PAR (774-1310 μmol m^{-2} s^{-1}) values were higher with higher irrigation level under both sprinkler and surface irrigation. The pod yield was observed to be linearly associated (R^2 = 0.79-0.92) with total water used of the crop and the yield response factors developed as per FAO guidelines were 0.32, 1.18 and 0.21 for initial, mid-season and late-season stages of the crop, respectively.

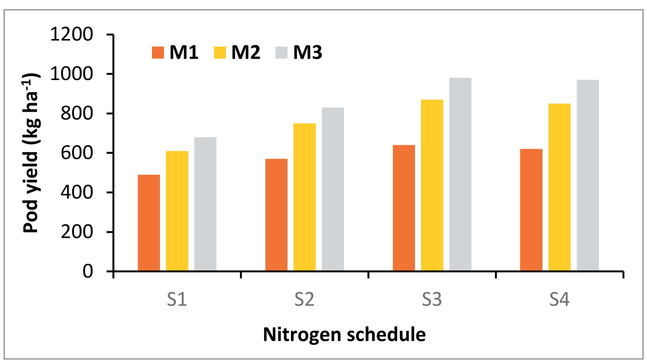


Fig. 1. Pod yield of greengram as influenced by irrigation and nitrogen application during 2018

Experimental field of green gram at research farm of ICAR-IIWM, Mendhasal during 2018

Development and Evaluation of Mini Pan-evaporimeter for On-farm Irrigation Scheduling

Project Code: IIWM/17/183

Investigators: N. Manikandan, P. Panigrahi, S. Pradhan, S.K. Rautaray and G. Kar

The development and evaluation of a low cost and farmers' friendly mini pan-evaporimeter was initiated for scientific irrigation scheduling at farm level. The evaporimeters were made up of galvanized iron (GI) sheet and PVC pipes with diameters of 10, 20, and 30 cm, each having height of 25 cm. The evaporation from mini pans was recorded at 8.30 am daily as well as at an intervals of 3-d, 5-d and 7-d intervals, and compared with USWB Class-A pan evaporation at ICAR-IIWM research farm, Mendhasal.

Regression analysis was carried out for evaporation data from different mini pan-evaporimeters and USWB open pan-evaporimeter during summer, *kharif* and *rabi* seasons. The results indicated that, 30 cm GI mini-pan had highest regression coefficient viz., 0.89, 0.88 and 0.86 during summer, *rabi* and *kharif*, respectively. The regression coefficients for PVC 30 cm mini-pan were 0.79, 0.76 and 0.73 during summer, *rabi* and *kharif* seasons, respectively (Fig. 2). The coefficient of determination (R^2) for GI 20 cm pan were 0.87, 0.85 and 0.80 in summer, *rabi* and *kharif* seasons, respectively, whereas for PVC 20 cm mini pan it varied from 0.68 to 0.75 in *kharif* and summer seasons. Lowest relation was found with PVC 10 cm (R^2 = 0.66, 0.63 and 0.61) followed by GI 10 cm (R^2 = 0.69, 0.64 and 0.63) during summer, *rabi* and *kharif* seasons, respectively.

Mini pan-evaporimeters (GI and PVC) of different sizes installed at ICAR-IIWM research farm, Mendhasal

The evaporation data from GI and PVC mini pans at 3-d, 5-d and 7-d intervals was compared statistically with cumulated 3, 5 and 7-d of daily evaporation. It was observed that there was no significant difference in evaporation rate between daily values and 3-d interval. However, evaporation data at 5-d & 7-d interval was different with cumulated daily values.

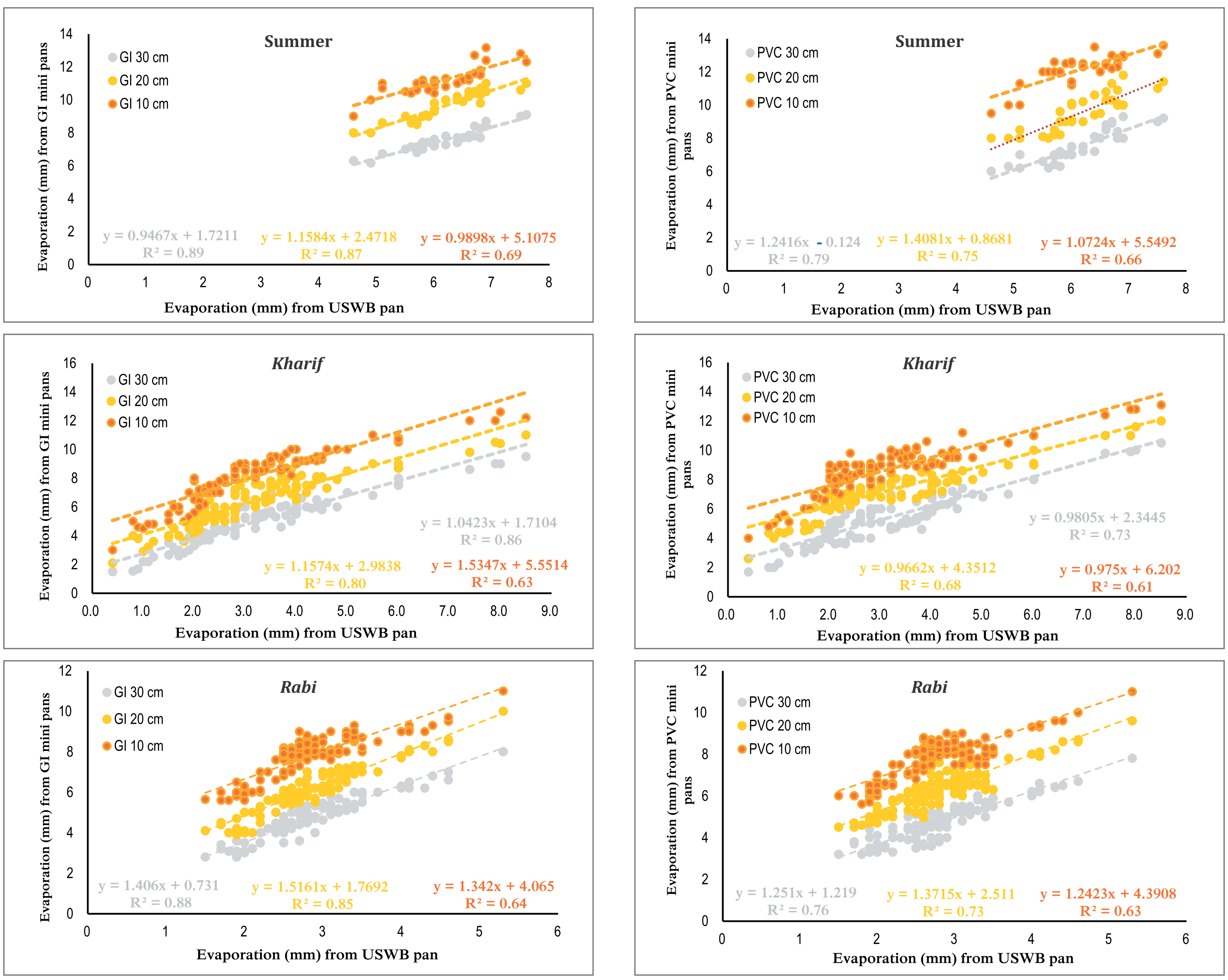


Fig. 2. Scatter graph of evaporation data from GI and PVC mini pans and USWB pan in different seasons

Evaluation of Land Shaping Options for Increasing Farm Income in Coastal Waterlogged Area

Project code: IIWM/17/184

Investigators: S. Roy Chowdhury, S.K. Rautaray, R.K. Mohanty, N. Manikandan, S. Mohanty, O.P. Verma and S.K. Ambast

The water level in dug-pond at experimental site, i.e. Baghadi village, Ersama showed increase from the month of June, 2018 (1.75 m) onwards reached its peak in September, 2018 (2.25m), thereafter, declined gradually. However, from October, 2018 onwards there was steady buildup of soil EC on the raised bed at soil depths 0-15, 15-30 and 30-45 cm. At 0-15 cm, it varied from 0.53 dS m^{-1} in October to 2.83 dS m^{-1} in March, 2019 at Hatiapal, whereas at Baghadi, the soil EC in first 15 cm soil depth steadily showed increase from 0.11 dS m^{-1} in October to 2.25 dS m^{-1} in March 2019. The buildup of soil EC was steepest at zone on raised bed closer to aquaculture pond. Increased salinity level affected crop growth performances. The pH of soil profile at 0-15 cm ranged between 5.31 to 6.60. In *Amaranth*, the photosynthesis rate also showed fall from 25.22 μmol m^{-2} s^{-1} to 19.37 μmol $m^{-2}s^{-1}$ under higher salinity level (Fig. 3). The annual net return from growing brinjal and green chili in *kharif* season green chili, amaranth, chili, radish, bottle gourd, ridge gourd, bitter gourd and poi (*Basella alba*) from April 2018 to March, 2019 on raised bed gave farmer gross and net income of ₹ 32160/- and ₹ 24000/- respectively from 1200 m^2 area.

An experiment was conducted at ICAR-IIWM research farm and land shape was modified by creating broad-bed and furrow (BBF). Different intercropping systems *viz.*, rice + maize, rice + bhindi and rice + cowpea were evaluated for greater income and suitability comparing with sole rice grown in flat land. Results revealed that rice yield during kharif season varied from 4.21-4.89 t ha^{-1} in furrows, while in flat land it was significantly lower, i.e. 3.95 t ha^{-1}. Cob yield of maize, and pod yield of bhindi and cowpea were 7.05 t ha^{-1}, and 2.25 t ha^{-1} and 5.6 t ha^{-1}, respectively.

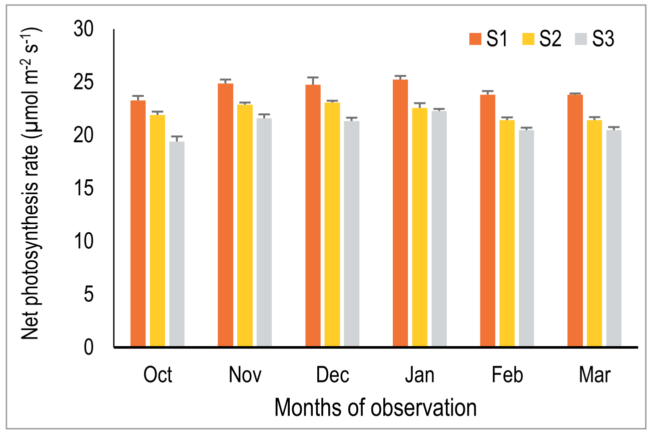


Fig. 3 Photosynthesis rate of *Amaranth* grown on raised bed at Hatiapal village, Ersama, Jagatsighpur district during 2018-19. The legends: S1 is 15 m, S2 10 m and S3 is 5 m distance away from aquaculture pond.

Crops in broad bed and furrow system

Index-based Flood Insurance (IBFI) and Post-disaster Management to Promote Agriculture Resilience in Selected States in India

Collaborative research project: ICAR-IIWM and IWMI, Colombo

Investigators: P.S. Brahmanand, S. Roy Chowdhury, S.K. Jena, S.K. Ambast, A.K. Singh, B.P. Bhatt, G. Amarnath and A.K. Sikka

The main thrust area of this project is to develop index based flood insurance model and to prepare and implement post-flood management plan. The project aims to develop multiple research products focusing on integrating remote sensing datasets, flood hazard model for data sensitive locations and crop loss module that can support in upscaling index based flood insurance (IBFI) to other locations, to implement and evaluate generated products under IBFI umbrella at developmental scale for multiple crop types in the near future and to create framework for innovative post-flood management activities in conjunction with IBFI to perpetuate agricultural resilience.

Initial survey was done to assess the crop damage in flood affected areas of operational area i.e. Garadpur block, Kendrapara district of Odisha and Gaighat block, Muzaffarpur district of Bihar. During this year, the crop specific post-flood management plan was prepared for

Kendrapara and post-flood management impact study was conducted in Muzaffarpur.

The problem identification exercise was done taking the opinion from farmers of six villages i.e. Madhurapatti, Bathgama, Belaur, Ladaur, Bhagavatpur and Paga of Gaighat block of Muzaffarpur district of Bihar. RBQ was estimated using the methodology of Sabarathnam and Vennila (1996). The frequent flood incidence caused by heavy rains and breach of embankment of Baghmati river was identified as the severe problem faced by them followed by lack of appropriate and timely crop insurance plan and lack of awareness among farmers about agricultural practices during post-flood phase. The other problems faced by the farmers of these villages are non-availability of quality / HYV seeds, pest and disease incidence, non-suitability of agricultural fields for cultivation due to late withdrawal of flood water, lack of assured irrigation during *rabi* season, poor market price for crop produce, unfavorable field condition for establishment of field crops during flood period and lack of awareness about government schemes in agricultural sector. The action plan for post-flood management has been prepared keeping these points into consideration.

Damaged paddy fields at Badhgama, Gaighat block, Muzaffarpur, Bihar

Maize field under post-flood management plan at Gaighat block, Muzaffarpur, Bihar

Impact of post-flood management interventions

The seeds of hybrid maize, vegetables like brinjal, tomato and cauliflower were provided to the affected farmers of Muzaffarpur district of Bihar. The seeds were sown / planted at optimum time under post flood environment and the impact study was conducted. The farmers could generate additional net returns of about ₹16,700/- per ha due to timely sowing of alternate crops and implementation of post-flood management plan compared to control *i.e.* flood damaged field without intervention (Table 1). The maize hybrid (Shaktiman-3) resulted in an average cob yield of 2.82 t ha^{-1} in post-flood environment and its yield varied between 2.56 t ha^{-1} to 3.15 t ha^{-1} in different farmers' fields. It has provided better cushion to the farmers compared to wheat cultivation which resulted in lower yield due to late planting and higher pest and disease incidence in post-flood scenario. The superior crop establishment and productivity of maize during post-flood environment was due to better physiological parameters like leaf area index and crop growth rate. In case of brinjal, tomato and cauliflower, the seed was supplied to few number of farmers and the average fruit yields of brinjal, tomato and cauliflower were 13.3 t ha^{-1}, 16.7 t ha^{-1} and 14.1 t ha^{-1} respectively.

Table 1. Scenario of crop yield and economics before and after post-flood management (PFM) intervention in Gaighat block, Muzaffarpur district, Bihar

Scenario of crop yield and economics				Scenario of crop yield and economics after				
Before post-flood management intervnetion				After post-flood management intervnetion				Additional net returns due to PFM
Crop	Yield (t ha^{-1})	Net returns (₹)	B:C ratio	Crop	Yield (t ha^{-1})	Net returns (₹)	B:C ratio	
Sole wheat	1.7	10500	1.55	Maize	2.82	27200	3.08	16700
				Brinjal	13.3	47000	2.02	36500
				Tomato	16.7	43700	1.77	33200
				Cauliflower	14.1	48200	1.95	37700

Canal Water Management

This program includes research projects on canal water management & related issues

Enhancing Water Productivity through Water Management in Transplanted and Aerobic Rice in Canal Command Area

Project Code: IIWM/15/174

Investigators: K.G. Mandal, A.K. Thakur, R.R. Sethi, M. Raychaudhuri and R.K. Panda

Rice is the staple food for half of the world's population, and rice farming is the livelihood for millions of farmers in India and Asian countries. Water or irrigation input to rice farming is typically very high, and of course, it depends upon growing season, climatic conditions, soil type and hydrological conditions. Reducing water requirement of this crop and enhancing water productivity is a challenge. Therefore, field experiments were conducted on rice during *rabi*/ summer season 2017-18 and *kharif* season 2018 at the Institute research farm, under Deras minor irrigation command to study the effects of various water management techniques on transplanted and direct seeded rice with the aim to enhance water productivity of this crop.

Performance of puddle rice with water-saving irrigation methods

A rice variety, 'Khandagiri' (OR 811-2) of 95-d was grown during *kharif* and *rabi*/ summer seasons. Direct wet-seeding and puddled transplanting treatments were imposed during both the seasons, whereas alternate wetting and drying (AWD), and irrigation at 3-days after disappearance (3-DAD) of water were compared with continuous flooding (CF) during *rabi*/ summer season, 2018. In another experiment, three treatments viz. sprinkler irrigation, bed-furrow and flood methods were imposed on aerobic rice during summer season 2018. In every treatment, crop was grown with recommended rate of N, P_2O_5 & K_2O at 80, 40 & 40 kg ha^{-1}. Farmyard manure was applied once before final ploughing and puddling during *kharif* season. Pre-germinated seeds were used for direct wet-seeding and nursery raising on the same day. Transplanting was carried out on the puddled soil with 18-21 d old seedlings. Standard practices were carried for manual weeding and plant protection measures against inset-pests and diseases.

Experimental findings show that the performance of rice was similar in AWD, 3-DAD and CF during *rabi*/ summer season (Fig. 4); whereas water saving was about 19.6% in 3-DAD and 29.8% in AWD compared to CF. Consequently, water productivity increased by 27 and 38% in 3-DAD and AWD, respectively over CF (Fig. 5). Further, water balance parameters were monitored through drum culture techniques; and it was estimated the average percolation, evaporation and transpiration rate as reported earlier i.e. 1.02, 3.42 and 4.34 mm d^{-1}, respectively from the puddled transplanted field during the crop growing period in *rabi*/ summer season. The physiological parameters of rice crop were measured as LAI (2.44 to 2.98), SPAD chlorophyll meter reading (34.4-42.5) and interception of PAR (61-76%) in maximum tillering stage; yield components viz. number of spikelet per panicle in CF, 3-DAD and AWD under direct-seeded or transplanted conditions. Performance of rice was similar with direct wet-seeding and puddled transplanting during *kharif* season 2018. This implies that direct-seeding of rice and two methods viz. alternate wetting and drying and irrigation at 3-days after disappearance hold promise with significant saving of irrigation for rice farming in the region.

Performance of aerobic rice with sprinkler irrigation

Results show that average grain yield was 28% lesser than either direct seeding or transplanting under puddled rice. Aerobic rice yield was 2.41, 3.09 and 3.31 t ha^{-1} with sprinkler irrigation, bed-furrow and flood method, respectively. Although statistically similar yield was obtained in bed-furrow and flood method, there was reduction in grain yield under sprinkler irrigation by an average of 27% compared with flood method of irrigation to aerobic rice. Due to sprinkler irrigation method, water application during the crop was 26.4% lesser in sprinkler irrigation (610 mm), and 8.8% lesser in broad-bed method than flood method of irrigation (829 mm); there was no significant difference in water productivity (average of 0.41 kg m^{-3}) in three methods of irrigation under aerobic rice.

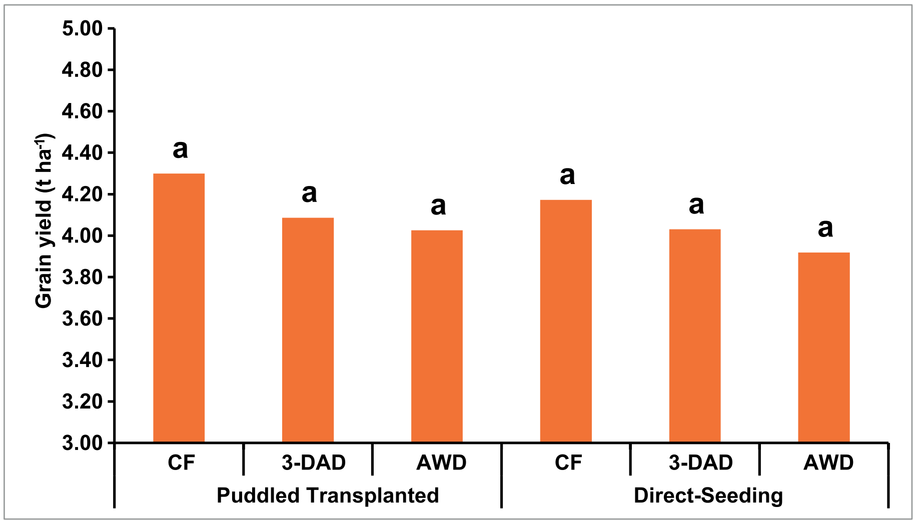


Fig. 4. Grain yield (t ha^{-1}) of rice (var. 'Khandagiri') with different water management treatments under puddled transplanted and wet direct-seeding conditions during *rabi*/ summer season 2018; CF: continuous flooding, 3-DAD: irrigation at 3 days after disappearance of water, AWD: alternate wetting and drying; different letters above bars indicate significant difference at $p < 0.05$ according to Duncan's multiple range test.

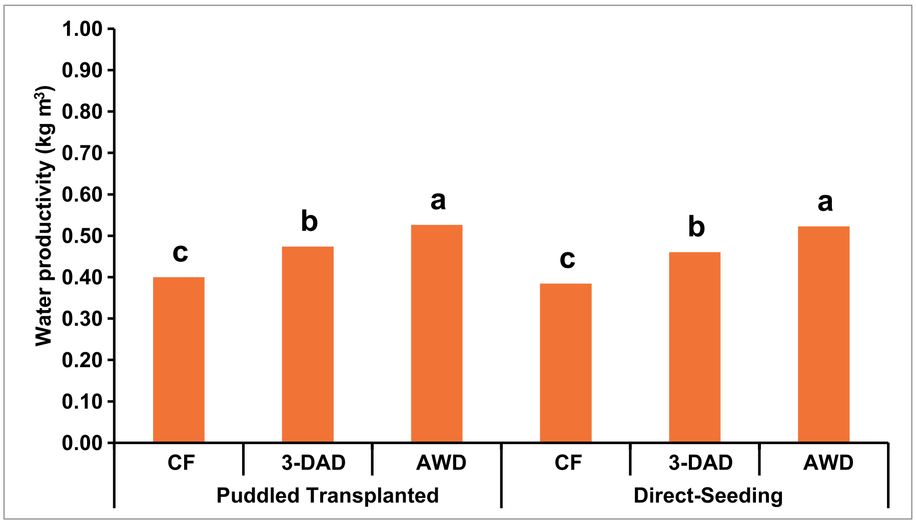


Fig. 5. Water productivity (kg m^{-3}) of rice (var. 'Khandagiri') with different water management treatments under puddled transplanted and wet direct-seeding conditions during *rabi*/ summer season 2018; CF: continuous flooding, 3-DAD: irrigation at 3 days after disappearance of water, AWD: alternate wetting and drying; different letters above bars indicate significant difference at $p < 0.05$ according to Duncan's multiple range test.

Direct wet-seeded rice with alternate wetting drying (AWD) method of irrigation during *rabi*/ summer season 2017-18 at IIWM Research Farm, Mendhasal

Aerobic rice with sprinkler irrigation during *rabi*/ summer season 2017-18 at IIWM Research Farm, Mendhasal

Benchmarking of Public Irrigation Schemes for Improving Performance of Irrigated Agriculture

Project Code: IIWM/16/177

Investigators: A. Mishra, A.K. Nayak, D.K. Panda, P. Nanda and S.K. Ambast

A user friendly database software for analysis of benchmarking irrigation systems was developed in Visual Basic. The described software consists of a database module with Microsoft Access as back end tool for storing and accessing of benchmarking information of irrigation systems (Fig. 6).

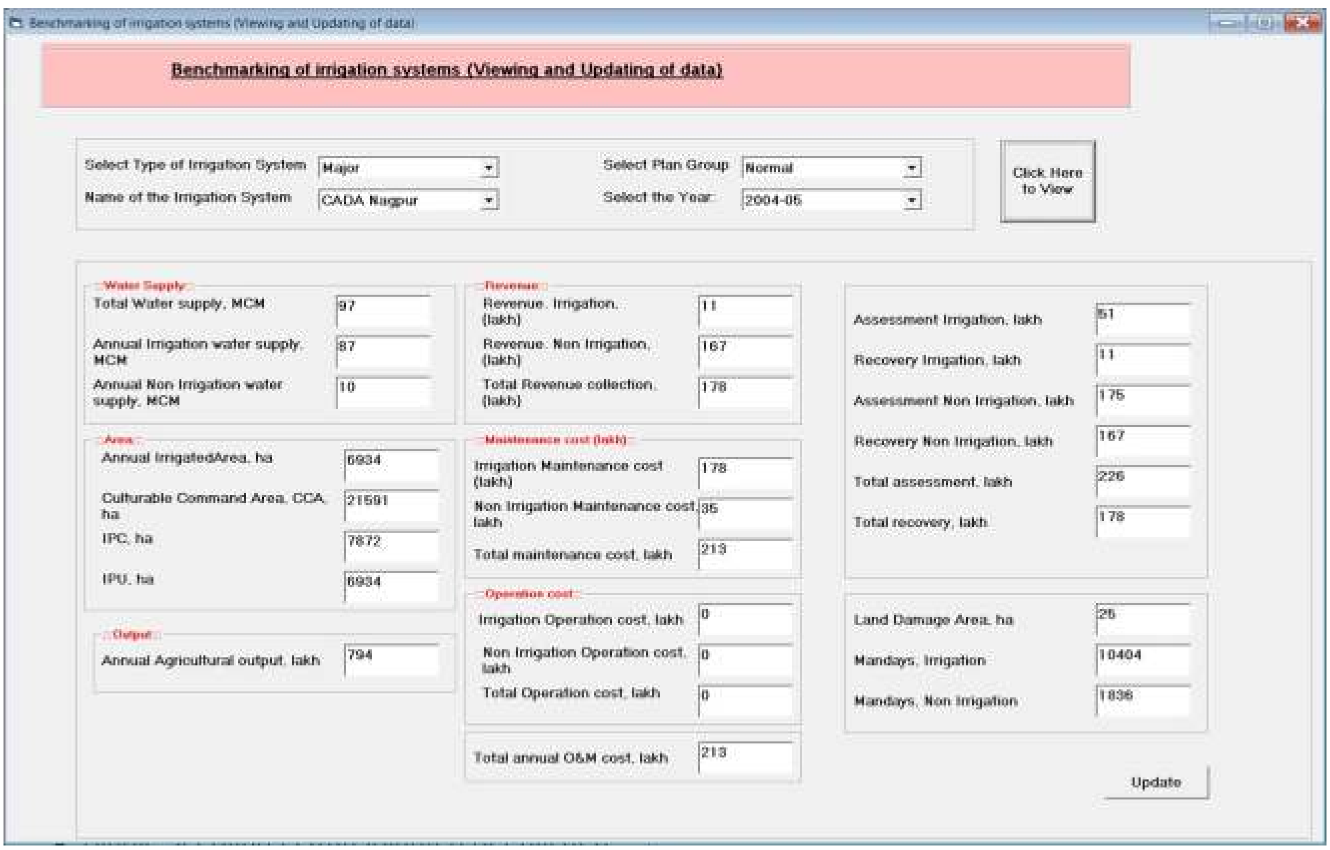


Fig. 6. Viewing and updating of benchmarking data

The module analyzes various performance indicators such as system performance, agricultural productivity, and financial performance etc . Presently, a total of nine indicators were analyzed in the module. The total output modules for two indicators in system performance (Annual irrigation water supply per unit irrigated area; and Ratio of irrigation potential utilized (IPU) to irrigation potential created (IPC)), three indicators in agricultural productivity (Agricultural annual output per unit command area; Agricultural annual output per unit irrigated area; Agricultural annual output per unit irrigation water supply) and four indicators in financial performance (Cost recovery ratio, Total O & M cost per unit irrigated area, Total revenue per unit volume of irrigation water supplied, Total O & M cost per unit water supplied) were prepared. The output can be seen either in tabular form or in graphical form.

A user can see the result of performance indicator through graphs based on the irrigation system types such as major, medium and minor irrigation system (Fig. 7) and also can see the comparison of performance indicator based on different plan group wise such as abundant, excess, normal, deficit and highly deficit.

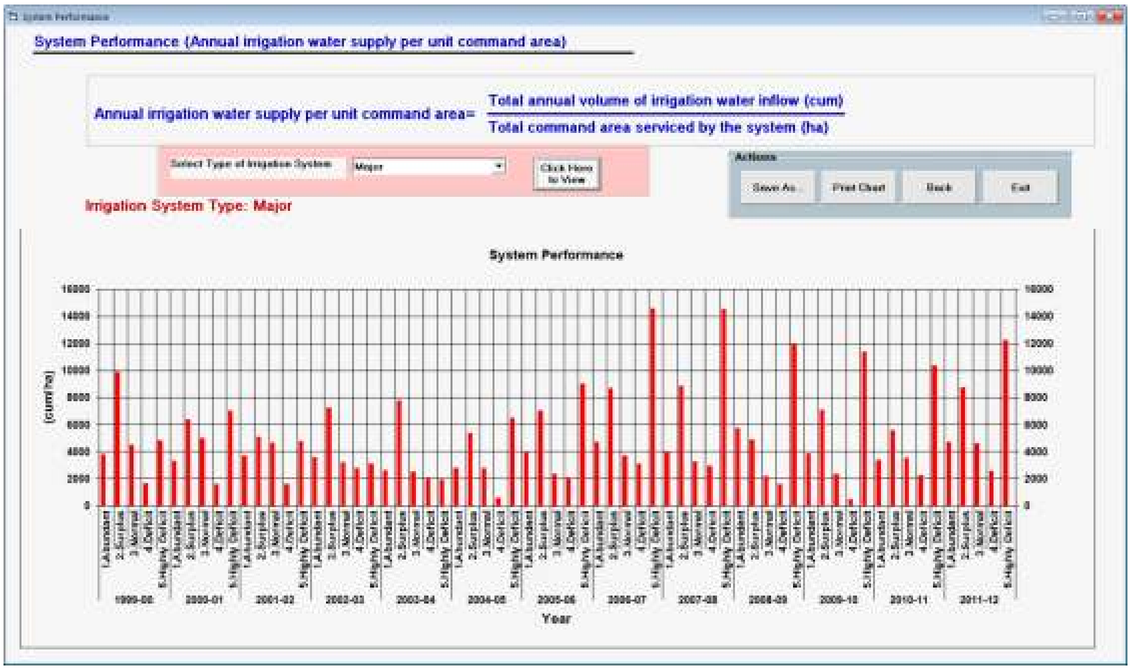


Fig. 7. Graphical presentation of a performance indicator for Major irrigation system

Enhancing Yield and Water Productivity in Rice Fallows of Eastern India through Super Absorbent Polymers (SAP)

Project Code: IIWM/16/182

Investigators: S. Pradhan, O.P. Verma, A.K. Thakur and S.K. Ambast

A field experiment was conducted for the second year during the *rabi* season of 2017-18 at the research farm of ICAR-IIWM, Mendhasal, Bhubaneswar, Odisha to investigate the effect of super absorbent polymer (SAP) on growth, yield and water productivity of groundnut (cv. Smruti). The SAP treatments [SAP100 (100 kg SAP ha^{-1}), SAP75 (75 kg SAP ha^{-1}), SAP50 (50 kg SAP ha^{-1}), SAP25 (25 kg SAP ha^{-1}) and C (No application of SAP)] were laid out in randomized complete block design with four replications. The plot size of the experiment was 5 × 4 m. The groundnut was sown with a spacing of 30 × 20 cm. The results showed that groundnut pods/pant varied from 12 (SAP50 and SAP75) to 13 (C, SAP25 and SAP100), kernel weight from 979 (SAP50) to 1064 kg ha^{-1} (C), pod weight from 1580 (SAP50) to 1613 kg ha^{-1} (C), shelling percentage from 61 (SAP50) to 66 (C), haulm yield 2678 (SAP75) to 3581 kg ha^{-1} (SAP100). All the yield and yield attributes of groundnut crop were not significantly ($P<0.05$) affected by the SAP treatments (Table 2). Similarly, the growth and physiological parameters like plant height and spread, LAI, intercepted PAR and SPAD were not significantly affected by the SAP levels. The water use and water productivity of groundnut crop showed 6% variations among the SAP treatments.

Table 2. Yield and yield parameters of groundnut crop grown under different SAP levels

Treatment	Pods plant^{-1}	Kernel weight (kg ha^{-1})	Pod weight (kg ha^{-1})	Shelling (%)	Haulm yield (kg ha^{-1})	Water used (mm)	Water productivity (kg m^{-3})
Control (SAP0)	13	1064	1613	66	3466	280	0.38
SAP25	13	1051	1605	65	3209	274	0.38
SAP50	12	979	1607	61	3198	265	0.37
SAP75	12	1008	1580	64	2678	278	0.36
SAP100	13	1029	1590	65	3581	274	0.38
$CD_{0.05}$	ns	ns	ns	ns	ns	ns	ns

After groundnut, rice crop (cv. Lalat) was grown on the same plot. At flowering stage, LAI of rice crop varied from 3.93 (SAP75) to 4.06 (C), greenness index as measured by SPAD from 37.7 (SAP100) to 39.2 (SAP75), intercepted PAR from 94% (SAP25 and SAP75) to 96% (SAP50), and were not significantly (P<0.05) affected by the SAP levels. The mean residual soil moisture after rice harvest was 0.28 cm^3 cm^{-3} and 0.29 cm^3 cm^{-3} for 0-15 and 15-30 cm soil layers. The rice grain and straw yield varied from 4.23 (C) to 4.48 (SAP50) and 6.03 (C) and 6.97 (SAP50), respectively. Similar to growth and physiological parameters of rice, the grain and straw yield were not significantly (P<0.05) affected by the various SAP levels. The water productivity of rice showed 5% variation among the SAP treatments being lowest value of 0.41 kg m^{-3} in control and SAP25 plots to 0.43 kg m^{-3} in SAP50 and SAP100 plots.

Rice crop growth in control (left) and SAP100 treatment (right)

National Innovations for Climate Resilient Agriculture (NICRA)

Externally funded project: NICRA, ICAR, New Delhi

Investigators: G. Kar, S. Mohanty, P.S.B. Anand, D.K. Panda, A. Raviraj, R.D. Rank and P.K. Singh

Trend of temperature change due to global warming

In this study, climate change is projected for the Indo-Gangetic region to reduce water footprints and enhance water productivity in agriculture under climate change scenarios. Projections under RCP4.5 scenario indicated maximum temperature to increase in the range of 2.95 to 4.07 °C during 2018-2090 over the baseline (1976-2005) temperatures, while minimum temperatures are to increase in the range of 2.74-3.53°C (2018 to 2090) (Figs. 8 & 9).

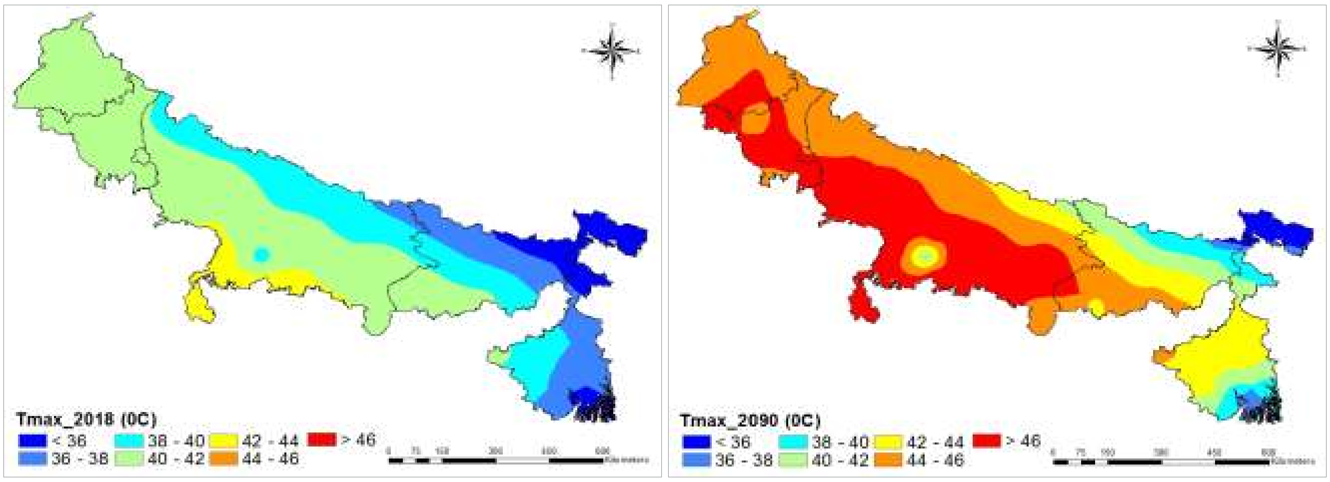


Fig. 8. Maximum temperature under RCP 4.5 scenario, 2018(left), 2090 (right)

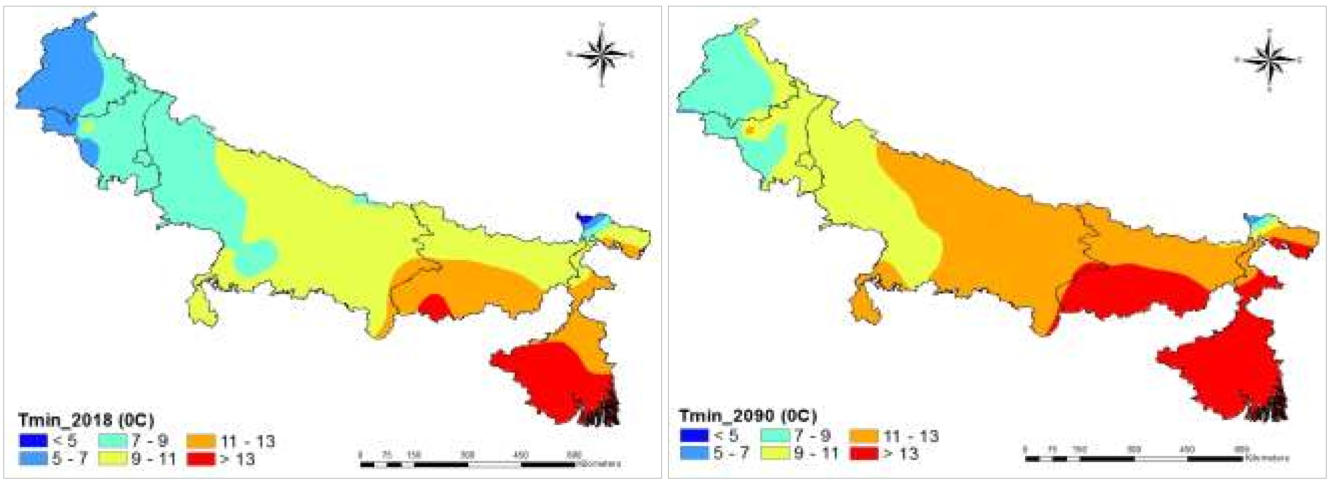


Fig. 9. Minimum temperature change under RCP 4.5 scenario, 2018(left), 2090 (right)

The spatial distribution of the mean monthly potential evapotranspiration (ET0), important for irrigation requirements and scheduling, in response to the projected temperature changes indicates that at the end of the century 8.5 to 14.3% water footprint increase in rice and wheat in different districts of the Indo-Gangetic region (Figs. 10 & 11).

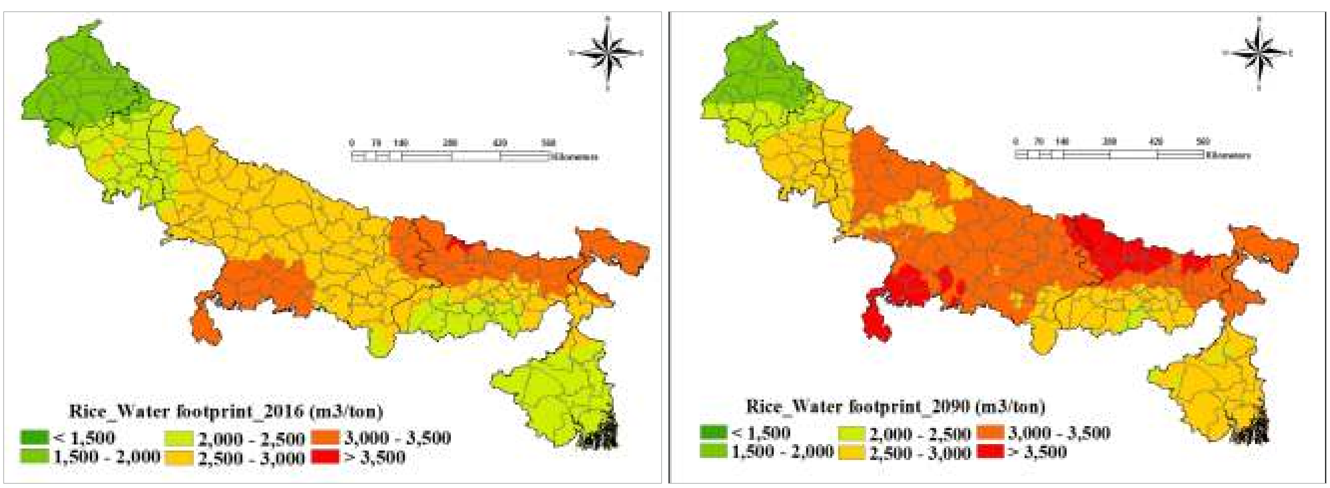


Fig. 10. Impact of climate change (RCP 4.5) on water footprints of rice productivity in Indo-Gangetic region

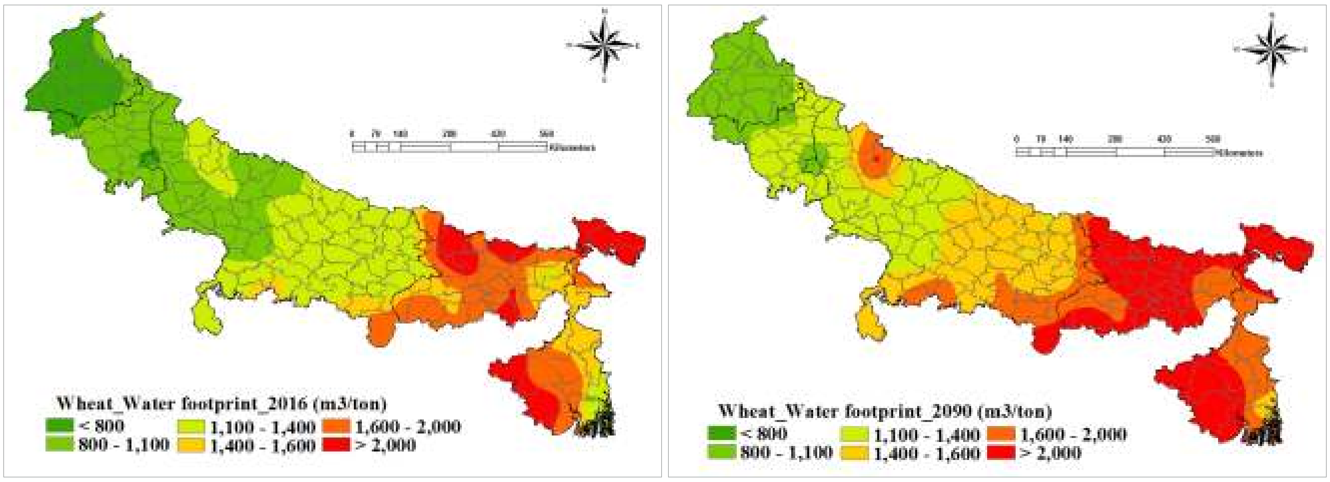


Fig. 11. Impact of climate change (RCP 4.5) on water footprints of wheat in Indo-Gangetic region

CO_2 efflux/influx through maize crop, Gross primary productivity and net ecosystem exchange

Gross primary productivity (GPP), plant respiration, net ecosystem exchange (NEE) in relation with phenology and leaf area index over rice (July-November,18)-cowpea (December,18-March,19) were studied. Study revealed that the crop behaved as net CO_2 sink from vegetative stage (22 DAS) to milking stage and acted as a net CO_2 emitter during the maturity and early vegetative periods. The seasonal net ecosystem exchange (NEE) at the end of growing period of rice was recorded as -307 g C m^{-2}. The diurnal variation of NEE revealed that its maximum value occurred at 1130 hour and highly influenced by leaf area index (LAI). Net Ecosystem Exchange (NEE) of rice reached its peak at maximum leaf area index stage (65 DAS) with the midday uptake of –19.9 µmol CO_2 m^{-2} s^{-1} and night-time release of +5.50 µmol CO_2 m^{-2} s^{-1}.

Fertigation in vegetable based farming system to develop climate resilient agriculture

On-farm trials were conducted on drip-fertigation with treatments T_1: Surface irrigation + 100% Recommended Dose of Fertilizer (soil application), T_2: Drip + 100% RDF (soil application); T_3: Drip + 100% RDF (fertigation); T_4: Drip + 80% RDF (fertigation); T_5: Drip + 60% RDF (fertigation) with 3 replications under the RBD on bitter gourd, chilli and cucumber during *kharif* and potato, okra, cowpea during *rabi* in separate fields (Table 3). The irrigation was applied through drip under 80% ETc along with 100% soluble fertilizer (19:19:19 N, P_2O_5, K_2O). Highest yield in bitter gourd and cowpea was observed in drip irrigation with 100% RDF through fertigation, while in ladies finger it was with drip irrigation with 80% RDF through fertigation. Interestingly, there was no significant differences in yield between drip with 1005 RDF and 80% RDF in all the three vegetable crops.

Table 3. Crop productivity (t ha^{-1}) of vegetable crops under drip-fertigation and soil application of fertilizers

Treatments	Bitter gourd fruit yield (t ha^{-1})	Ladies finger fruit yield (t ha^{-1})	Cowpea pod yield (t ha^{-1})
T_1: Surface irrigation + 100% RDF (soil application)	7.1	8.7	4.8
T_2: Drip + 100% RDF (soil application)	8.8	11.5	8.3
T_3: Drip + 100% RDF (fertigation)	11.6	13.2	11.6
T_4: Drip + 80% RDF (fertigation)	10.9	14.5	11.4
T_5: Drip + 60% RDF (fertigation)	8.2	12.4	7.9
LSD (P=0.05)	1. 5	1. 8	1.6

Secondary reservoir in canal command

Mulching in *capsicum* at research farm of ICAR-IIWM

The average relative water supply (ratio of water supply and water demand over a period of time) in post-*kharif* rice season was 0.55-0.65 at the head reach and 0.35- 0.50 at the tail reach of water courses in selected canal commands of Nayagarh, Puri and Kendarpara districts of Odisha. This clearly indicates the insufficiency of the available canal water supply to meet the demands. Erratic rainfall due to climatic variability and climate change aggravate the problem. To supplements the canal water supply to irrigate crops, rainwater harvesting system (secondary reservoir) was designed and implemented in the above 3 canal commands/minors. Through integrated farming with secondary reservoir, (crops, on-dyke horticulture, fisheries), water productivity of the adopted site enhanced from ₹ 1.1-1.42 m^{-3} through sole rice to ₹ 18-20.0 m^{-3} through integrated farming. Due to assured source of water in the first year of study, the cropping intensity of the command area of the ponds was 200-240%.

Water harvesting with dyke based agro-forestry system

Moreover, water harvesting with dyke based agro-forestry system was implemented to develop climate resilient agriculture in coastal waterlogged and flood prone areas in Satyabadi block, Puri district of Odisha. Use of remote sensing and GIS tools revealed that 1063 numbers of water harvesting structures were constructed in the study block. Also on-farm trial with 4 short duration, drought resistant varieties *viz*., (CR-Dhan 100, CR-Dhan 203, CR-Dhan 311, CR-Dhan 101 and Kamesh in Alisha village of Satyabadi block of Puri.

Mulching in *capsicum*

Experiments were also conducted in Deras research farm of ICAR-IIWM on mulching in *Capsicum* with the treatments T_1: Single row without mulch, T_2: Paired row without plastic mulch, T_3: Single row with plastic mulch, T_4: Paired row with plastic mulch. Highest fruit yield of 780 g/m^2 was obtained under T_4 treatment which was 62.8 % higher than that of the production under T_1 treatment.

Development of conjunctive use strategy under changing climate scenarios in Brahmani River basin

Monthly groundwater monitoring was carried out in 16 open dug wells spread across the watershed. In the month of May, the groundwater level varied from 2.7 m to 13.0 m (i.e., below the ground level) across the study area. In the month of August, the groundwater level varied from 0.6 m to 7.25 m. In the month of December, the groundwater level varied from 0.66 m to 8.52 m. Daily gauging of runoff in the flow period was done at the weir structure at Giridhariprasad site. Highest average daily discharge of 5.56 $m^3 s^{-1}$ was observed in the month of September and the flow continued upto mid-January.

The calibrated ArcSWAT model for the Badajor watershed was used to validate the model using the runoff at gauging structure data for the period July 2018 to January 2019. The comparison of simulated and observed streamflow data at the gauging site for the validation period is shown in Fig. 12(a). The correlation coefficient and NSE values were 0.91 and 0.78 respectively.

A groundwater flow model for the Badajor watershed was developed using Visual MODFLOW software. The groundwater recharge value obtained from the calibrated SWAT model was used as input to the groundwater flow model. The pumping data in the study area were obtained from the response of farmers and officials of Block Agriculture Office. Calibration of the model was done using the groundwater level data for the period June 2016 to May 2018. The zone-wise hydraulic conductivity and specific yield values were used as calibration parameters which were adjusted during the calibration process. A combination of trial and error method and automated calibration code 'PEST' were used for the calibration of the model. The scatter diagram of the observed and calibrated groundwater levels is shown in Fig. 12 (b). The mean error and correlation coefficient values were 1.419 m and 0.98 respectively.

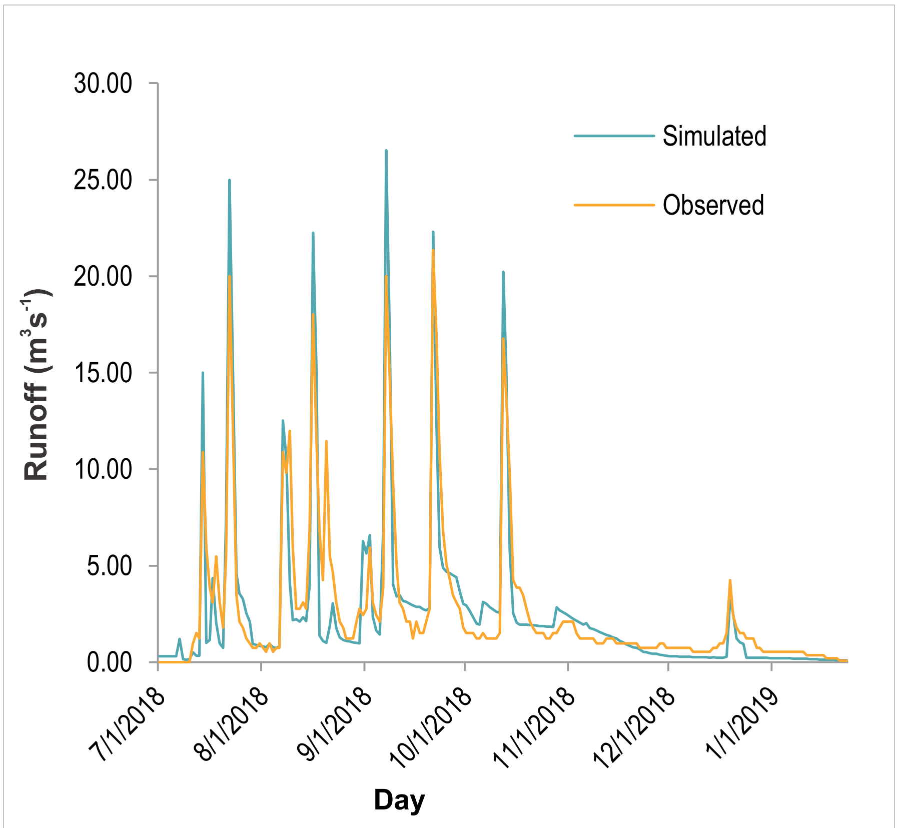


Fig. 12(a) Comparison of observed and simulated streamflow for the validation period,

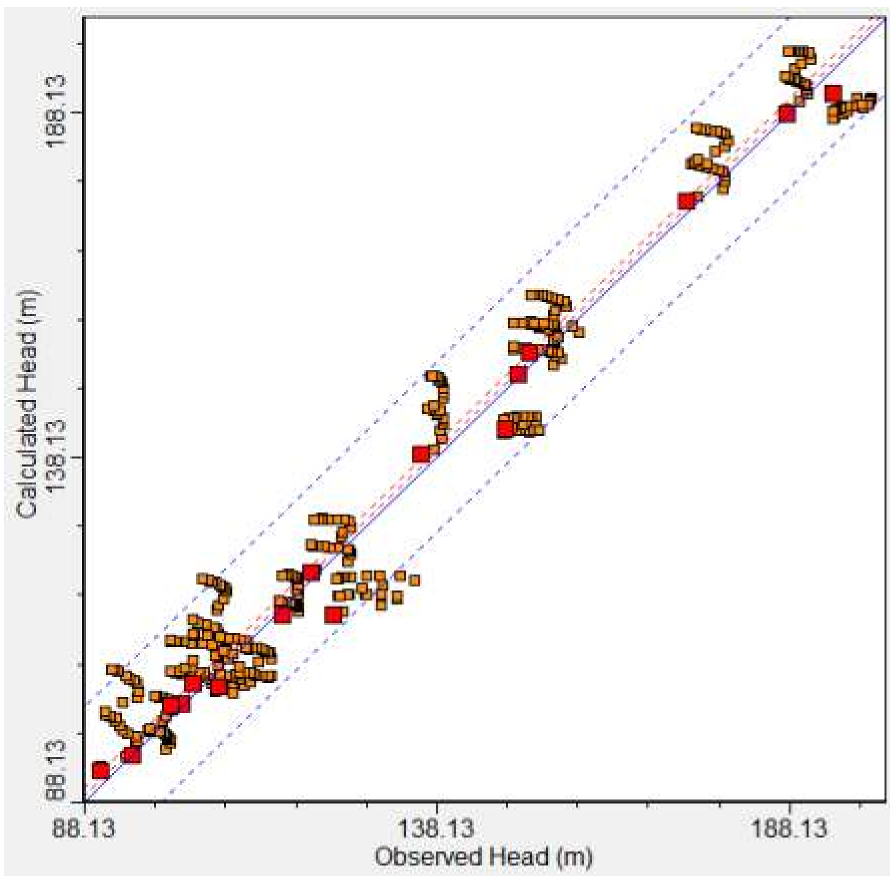


Fig. 12(b) cluster diagram of observed and simulated groundwater level for the calibration perioid

Enhancing Economic Water Productivity in Irrigation Canal Commands

Externally funded project: IWMI, Colombo, Sri Lanka

Investigators: R.K. Panda, S.K. Ambast, S.D. Gorantiwar, S. Bodake, S.A. Kadam, U. Amarasinghe and A.K. Sikka

A collaborating research project was taken up in the Sina medium irrigation Project in Maharashtra between International Water Management Institute (IWMI) and ICAR-Indian Institute of Water Management & AICRP (IWM), Rahuri (Maharashtra) with the objective of identifying the physical and institutional interventions for increasing the economic water productivity. A detailed survey was carried for groundwater use in the command area and interaction with the farmers' and state irrigation department officials was made for ascertaining possible profitable crop combinations in the present water resources availability scenario. The study revealed that there are 3 major sources of water use for irrigation purposes i.e. canal lift, groundwater lift through open well and bore wells and direct river lift. As a preliminary attempt, total six crop scenarios are developed for improving economic water productivity in the command area through comparison with actual value of production obtained during 2016-17. Scenario A, B and C are proposed for allocating 100% irrigation consumptive water use (CWU) to only high value annual crops like fruits (pomegranates), sugarcane and vegetables, respectively. Scenario D: allocating irrigation CWU of 22.5 % to fruits (pomegranates) to generate present value of output of 2016-17 (₹ 238 million, total cropped area 7545 ha, and total irrigation CWU of 35 Mm^3). Scenario E: allocating rest of CWU equally among other crops and scenario F: allocating more CWU among high value perennial crops. Among all the above scenarios, scenario E, which is more fitting to Sina irrigation system with irrigation CWU of 35 Mm^3 and allocating fruits to 22.5 % and 15.7 % each to *rabi*/hot weather crops like wheat, jowar, vegetables, oilseeds and pulses, total value of production could be ₹ 422 million (Table 4).

Table 4. Various crop scenarios developed in Sina medium irrigation command

Season	Crops	Cropping pattern (% of total area)							
		Recommended plan	2016-17	S* - (A)	S-(B)	S-(C)	S-(D)	S-(E)	S-(F)
1	2	3	4	5	6	7	8	9	10
Rabi and summer	Wheat Jowar Fodder Vegetables Oilseeds Pulses	27 47 7 7 7 -	2 73 3 9 1 5			100		15.6 15.6 - 15.6 15.6 15.6	13.1 13.1
Annual	Sugarcane Fruits (Pome-granate) Cotton	4 1 -	5 1 2	100	100		22.5	22.5	13.0 22.5
Total area	(ha)	4982	7548	4369	2821	6832	939	6880	5888
Total value of production	(Million ₹)	213	238	1104	489	359	238	422	392
Total irrigation	(Mm^3)	21	35	35	35	35	6.5	35	35

S* = Scenario

Groundwater Management

This program includes research projects on groundwater management & related issues

Enhancing Water Productivity through Intensive Horticultural System in Degraded Land

Project Code: IIWM/15/176

Investigators: S. Pradhan, K.G. Mandal and P. Panigrahi

Field study was conducted for the second year to evaluate the performance of pre-bearing mango plants (cv. Amrapali) with different intercrops (papaya, pineapple and combination of papaya and pineapple) under drip irrigation at ICAR-IIWM, Bhubaneswar. Two rows of papaya (cv. Red lady) in either side of mango plants, two paired rows of pineapple (cv. Queen) in either side of mango plants and, one row of papaya and one paired row of pineapple in either side of mango plants using on-line and in-line drip irrigation systems were grown. Fertilizer application and other management practices were done following the recommendations for the crops in the region.

The hydraulic study of drip irrigation in field was found satisfactory with emitter flow rate variation (Q_v) of 5%, co-efficient of variation (CV) of 4% and distribution uniformity (DU) of 95%. Water applied, growth, yield and water productivity of the plants is given in Table 5. Irrigation was done in daily basis during April-June and November-March of the study period, as per the water requirement of the crops in the region. Water applied in mango, papaya and pineapple were 636 mm, 591 mm and 364 mm, respectively, under drip irrigation. The soil water content in top 0.60 m soil in mango, papaya and pineapple were 21.2-24.2%, 21.3-24.3% and 22.2-24.5% in volume basis, respectively. The vegetative growth parameters viz. plant height, canopy diameter and trunk girth of the mango plants were not affected significantly either by papaya and/ pineapple intercrops. The highest yield or pineapple equivalent yield (18.89 t ha^{-1}) with highest water productivity (21.47 kg ha-mm^{-1}) was observed in mango intercropped with pineapple under straw mulch. The net profit from pineapple intercropping with straw mulch was highest (₹140000/ ha) with benefit-cost ratio of 1.67, followed by papaya-pineapple intercropping with straw mulch in mango.

Papaya and pineapple intercropped with pre-bearing mango under drip irrigation

Table 5. Vegetative growth, water use and yield of plants under different treatments (2018-19)

Treatments	Mango			Papaya			Pineapple			Water used (mm)	Yield / PEY (t ha^{-1})	WP (kg ha^{-1} mm^{-1})
	Plant height (m)	Canopy diameter (m)	Trunk girth (cm)	Herb height (m)	Canopy diameter (m)	Fruit set (No.)	Shrub height (cm)	No. of leaves	No. of suckers slips^{-1}			
Mango+ Papaya+ Pineapple	3.43	3.2	38.38	1.39	1.28	9	32.2	32	5	1591	12.75	8.01
Mango+ Pineapple	3.50	3.5	41.45	-	-	-	35.1	34	5	1000	18.63	18.63
Mango+ Papaya	3.49	3.1	38.90	1.44	1.32	10	-	-	-	1227	6.87	5.60
Mango+ Papaya+ Pineapple+ Straw mulch	3.47	3.3	38.58	1.45	1.37	9	34.1	33	5	1400	13.13	9.38
Mango+ Pineapple+ Straw mulch	3.59	3.6	43.67	-	-	-	35.3	37	6	880	18.89	21.47
Mango+ papaya + Straw mulch	3.55	3.2	42.30	1.58	1.46	10	-	-	-	1080	6.93	6.41
Mango + Straw mulch	3.69	3.9	44.23	-	-	-	-	-	-	560	-	-
Mango	3.66	3.8	44.18	-	-	-	-	-	-	636	-	-
CD (p=0.05)	ns	ns	ns	ns	ns	ns	ns	ns	ns	-	0.96	0.89

PEY: Pineapple equivalent yield, WP: Water productivity

Socio-economic and Environmental Linkages of Groundwater Irrigation in Coastal Aquifers of Eastern India

Project Code: IIWM/16/178

Investigators: D.K. Panda, S. Mohanty, M. Das and O.P. Verma

It is perceived that the groundwater depletion in the east Godavari district is not as alarming compared to that of the west Godavari, however, several administrative blocks of the district have witnessed a significant rate of water table decline. Prominent among them are the blocks of Gandepali, Rajanagaram (Mukkinada) and Rangampeta, representing the upland central part of east Godavari (Fig. 13a); note that Mukkinada and Rangampeta experienced declines since 2010, with the water table fallen by 20.48 m and 8 m, respectively during 2010-16. However, Gandepali's decline is persistent since 2002, with a cumulated drop of 20.98 m during 2002-17 compared to 11.7 m during 2010-16. This block, in fact, stands out not only as one of the worst affected regions of groundwater depletion of east Godavari but also ranks eleventh in the state. The existing land-use pattern indicates that the rapid rise in area under oil palm, from 200 ha in 1993 to 26522 ha, could be a major reason of depletion in upland region of east Godavari.

In west Godavari, depletion has taken place across the domain, but most - notable cases are observed in the middle and upper part. The largest decline is seen in the D. Tirumala (G. Kothapalli-2) block, i.e., 16.85 m during 2010-16. This is followed by 10.94 m in Koyyalagudem-2, 8.84 m in Pedapadu (Kokkirapadu-1), and 8.08 m in Lingapalem (K. Gokavaram) (Fig. 13b). Interestingly, in Polavaram, where the multi-purpose dam on Godavari river has been initiated, water table has declined only by 1.87 m during 2010-16. Quantification and mapping of groundwater level patterns (Fig. 13c) will assist the policy managers to undertake recharge measures in the middle portion of both the districts, particularly by using water from the proposed Polavaram dam through optimum canal network.

Moreover, the socio-economic benefits versus energy crisis of both the districts have been explored. The major problem, after years of free electricity supply has now turned out to be unreliable supply of electricity. Realizing the financial burden and groundwater loss of free electricity, the policy of solar energy-fed irrigation has been initiated. Under this policy, a financial assistance of about one lakh rupees is allowed to a group of four farmers. Still, the cost of solar system, along with the delivery system, is too high for the poor farmers and thus the takers of this proposal are only the rich farmers, who practice floriculture or grow cash crops, but not rice. These farmers also face problem of cloud-free bright sunlight continuously. To save the crops under such situation, they also need an additional diesel pumping system. Analysis of daily sunshine hours from observatory since 1980 indicates that the annual mean sunshine hour of the region is 6.4 hours, compared to 7.8 hours in northwest India. The sunshine hour during critical stages of the crop versus evapotranspiration demand is an important point to understand about the feasibility of solar system.

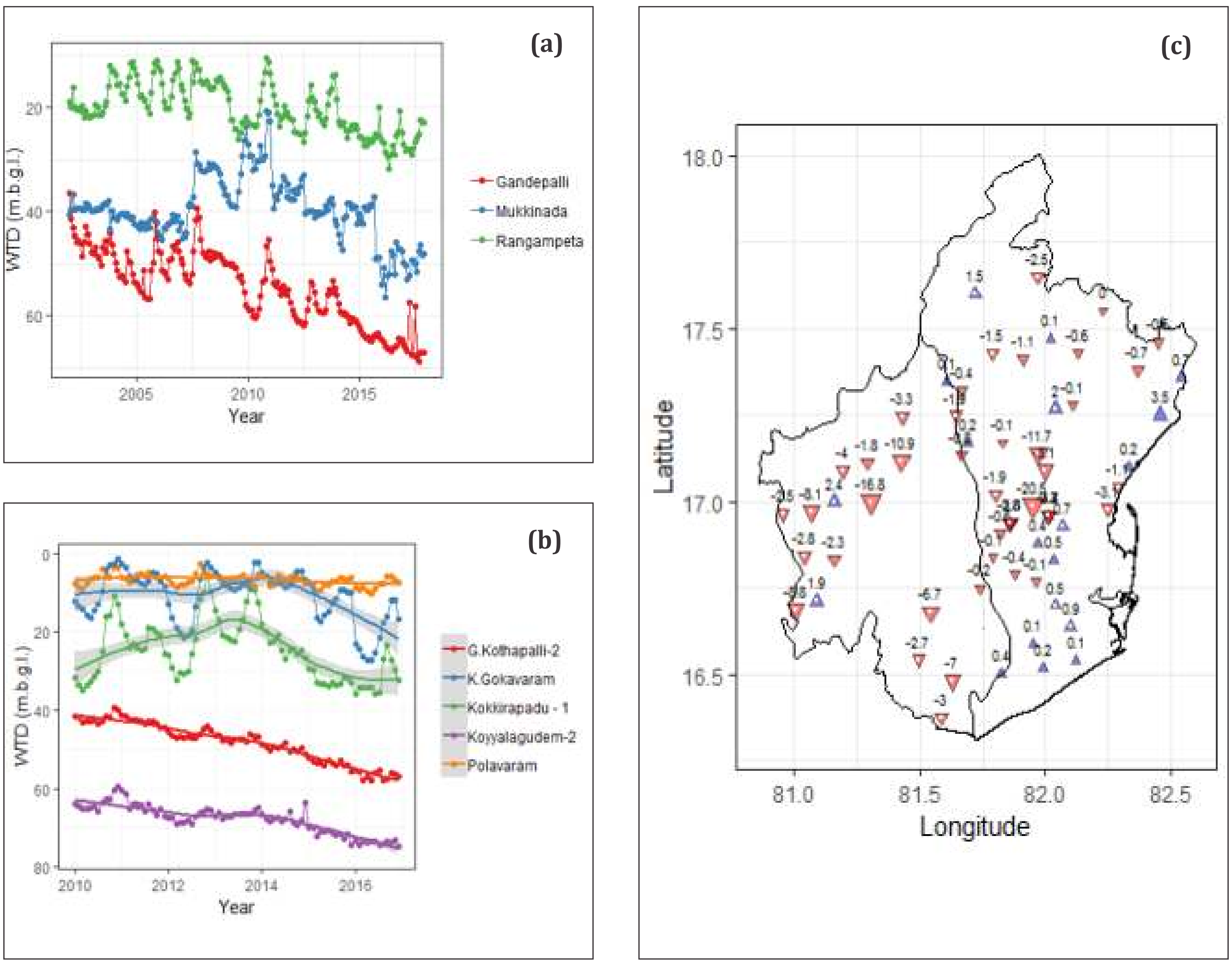


Fig. 13. Administrative blocks with critically declined water table depth (WTD, meter below ground level) in east (a) and west (b) Godavari districts of Andhra Pradesh. The inscribed robust lines with confidence interval indicate the broad changes. (c) The map depicts the cumulated WTD trend (m) during 2010-2016, differencing depletions with inverted triangles and significance (p =0.05) with centred dots.

Design and Field Evaluation of Groundwater Recharge Structures in Hard Rock Areas

Project Code: IIWM/16/180

Investigators: R.R. Sethi, M. Das, B. Panda and S.K. Ambast

Under this study, the summer season (April to June) water levels, monitored from Rain Water Harvesting Structures (RWHS), dug wells, recharge wells and monitoring wells, showed 3.27 m, 1.28 m and 0.9 m depth of water in the RWHS 1, 2 and 3, respectively in Srirampur village. In Nachhipur village, 0.8 m of depth of water was available during summer 2018. Three numbers of RWHS along with a recharge well in Srirampur village and one RWHS in Nachhipur village was selected for estimation of water budget parameters. The water balance model for recharge structure was accomplished by including all inflow and outflow components.

$$(R_i+RO_i) - (I_i+E_i+S_i) = \Delta WL_i$$

Where, R_i = Rainfall during i^{th} month, m; RO_i = Surface runoff entering to the structure in i^{th} month, m; I_i = Water abstracted from structures for irrigation; E_i = Water lost due to evaporation; S_i = Seepage/percolation loss, ΔWL= Change in water level in structures occurring between i^{th} and $i+1^{th}$ time steps.

Estimation of inflow and outflow components

All inflow/outflow components of water balance model for RWHS 1, 2 and 3 in 2018 illustrated in Table 1 showed that 4976.30 m^3 3149.34 m^3, 1725.49 m^3 of water was contributing towards subsurface or recharge including storage in the structures.

Furthermore, to estimate the sub-surface flow and recharge, monthly inflow outflow and water level fluctuation was analyzed. It showed that during the year 2018, sub-surface flow of 0.63 m $month^{-1}$ and recharge of 0.11m $month^{-1}$ during monsoon (July to November) was contributing towards inflow to the structure of 0.75 ha-m capacity in RWHS-1. In case of RWHS-2 (0.5 ham), 0.47m $month^{-1}$ as subsurface flow and 0.18 m $month^{-1}$ of recharge during monsoon months was adding to the structure. In case of RWHS-3 along with recharge well, 0.38 m $month^{-1}$ as subsurface flow and 0.153 m of recharge during monsoon months were inflow to the structures, with 1.69 m of pumping from the structure. Hence recharge contribution was nearly 1.84 m due to impact of recharge well.

Similarly, in Nachhipur village, about 2051.75 m^3 of water was contributing towards subsurface flow/recharge (Table 6). In 2018, the sub-surface flow of 0.4 m $month^{-1}$ and recharge of 0.25 m during monsoon were observed. On an average during 2017-18 0.14 m of water was recharged the RWHS of 0.38 ha-m capacity.

Table 6. Inflow and outflow components for water balance model of rainwater harvesting structures for two years in Bargharianala micro watershed, Daspalla

Water balance components (m^3)	Srirampur village						Nachhipur village	
Year	2017			2018			2017	2018
Structures	1	2	3	1	2	3		
Rainfall	2533.58	2230.63	1072.42	2470.46	2175.05	1045.70	2010.78	1960.68
Runoff to the structure	1975.80	974.03	289.73	1962.47	1227.90	474.41	1612.99	1595.64
Total Inflow	4509.38	3204.65	1362.15	4432.93	3402.95	1520.11	3623.77	3556.32
Evaporation losses	3396.33	2990.21	1437.60	3396.33	2990.21	1437.60	2695.50	2695.50
Percolation/seepage	1077.30	948.48	456.00	1077.30	948.48	456.00	855.00	855.00
Irrigation extraction	2894.40	648.00	-	4935.60	2613.60	1352.00	1071.43	2057.57
Storage	189.00	-	240.00	-	-	-	1350.00	-
Total outflow	7368.03	4586.69	1893.60	9409.23	6552.29	3245.60	4621.93	5608.07
Subsurface flow/Recharge	3047.65	1382.04	291.45	4976.30	3149.34	1725.49	2348.16	2051.75

Water spread area of RWHS 1, 2 and 3 for Srirampur village was 1890 m^2, 1664 m^2 and 800 m^2 respectively. Water spread area in Nachhipur RWHS was 1500 m^2

Area of influence of the structures

To demarcate the area of influence of recharge from RWH structures, depth to water level was monitored monthly from dug wells and monitoring wells located in 5, 20, 50,100, 300, and 320 m away. It was compared with the depth to water table in RWH structures. Hydrograph in Fig. 14 showed that wells located up to 300 m away from the structure are showing nearly same trend as that of water level in RWH, indicating the influence of RWH. Enquiries with the local farmers revealed that the impact of structure is visible up to 250 to 300 m downstream. Beyond 300m the water table fluctuations was depending on other factors like canal flow nearby areas. In the influenced area of nearly 15 ha, vegetable crops were grown during 2017-18. About 15 dug wells in this zone have been benefited due to recharge from these structures. The farmers in the area have switched over to more water intensive crops. A rise in the pre-monsoon water level up to 1.9 m was observed during 2018 with respect to 2016. The increase in pumpage hours of dug wells by 3-4 hours per day during *rabi* and 1-2 hours in summer was also observed within the area of influence of the structure. In Nacchipur village, it was observed that the influence of one structure was upto the areal distance of 300 m from the structure and nearly 7-8 ha area is being brought under cropped area.

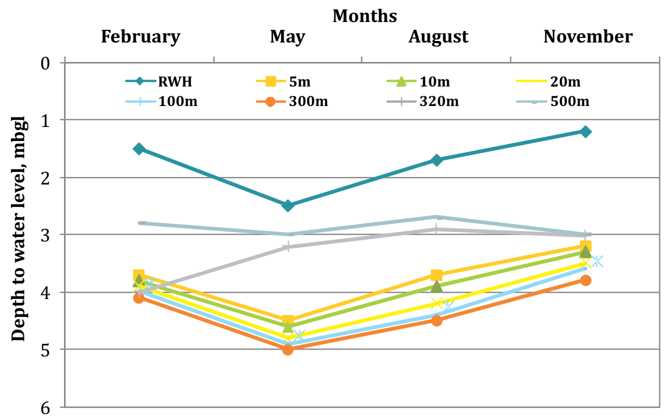


Fig. 14. Water table fluctuations in dug wells and monitoring wells away from the rainwater harvesting structures in 2018

Assessment of Groundwater Contamination Due to Excess Fertilizer and Pesticide Uses and Its Management in Lower Godavari Basin

Project code: IIWM/17/185

Investigators: P. Deb Roy, D.K. Panda and S. Mohanty

A base map prepared by merging road layer with the study area in ARC GIS 9.3 software for survey and collection of samples. Thereafter, a survey was conducted in lower Godavari basin during November 2018. 41 groundwater samples from bore well of different depth were collected. Also, 88 soil samples from two depths viz. 0-15 cm and 15-30 cm were collected from the study area. Soils were collected from the field adjacent to the groundwater collection point with diversified land use. Water pH and electrical conductivity was measured in the field with portable pH and EC meter. Nitrate-nitrogen and other major cations and anions were measured as soon as the samples reached to the laboratory. pH of most of the groundwater samples were found suitable for irrigation, i.e. below 8.4. Whereas, high pH in groundwater was measured at Tallapudi (9.3) and Chidipi (8.6) area near Godavari river. Electrical conductivity (EC) of the samples ranged between 0.01 to 2.88 mS cm^{-1}. High EC was found in the samples collected from Rajanagaram (2.58 mS cm^{-1}) and Srirangapatnam (2.88 mS cm^{-1}) in the north eastern part of the study area as well as in Draksharaman (1.4 mS cm^{-1}) in the southern part of the study area. Nitrate-nitrogen in the samples varied between 0.2 to 8.9 mg L^{-1} (Table 7). We found no samples were having higher nitrate-nitrogen content than the maximum permissible contaminant level, i.e. 10 mg L^{-1} for drinking purpose. Although, 24% samples having higher nitrate–nitrogen content between 7.1-8.9 mg L^{-1}, closed one to the maximum permissible limit. Higher nitrate-nitrogen in groundwater was found at Mulasthanaam, Kadium, Dulla, Gopalapuram, Tallapudi, Kovvur and Srirangapatanam. Fluoride content in the samples ranged between 0.2 to 1 mg L^{-1}. Sodium absorption ratio (SAR) value of the groundwater samples (ranged between 0.5 - 9.0) are considered suitable for irrigation. Except two samples, all the samples had residual sodium carbonate (RSC) values were in the suitable range, i.e. < 1.25 me L^{-1}.

Collection of groundwater sample from a bore well in lower Godavari basin

Table 7. Chemical water quality parameters of groundwater samples collected from lower Godavari basin in post-monsoon season (n=41)

	pH (1:2.5)	EC (mS cm^{-1})	K (mg L^{-1})	Na (mg L^{-1})	Ca (me L^{-1})	Mg (me L^{-1})	NO_3-N (mg L^{-1})	HCO_3^- (me L^{-1})	F (mg L^{-1})	SAR
Av.	7.1 (6.1-9.3)	1.06 (0.01-2.88)	5.6 (1-43)	149.8 (18-470)	7.6 (2.4-13.8)	5.4 (0.6-26.4)	3.3 (0.2-8.9)	8.7 (3.4-16.2)	0.5 (0.2-1.0)	2.7 (0.5-9.0)
Sd	0.53	0.62	6.70	116.70	2.59	4.73	3.16	2.92	0.23	2.16

Values in parentheses are range

Efficient Groundwater Management for Enhancing Adaptive Capacity to Climate Change in Sugarcane Farming System in Muzaffarnagar district, UP

Funded by DoAC&FW, Ministry of Agriculture & Farmers Welfare, Government of India

Investigators: A. Mishra, S. Mohanty, R.R. Sethi and P. Panigrahi

Various water management interventions were executed in the farmer's field of Rasulpur Jattan village in an attempt to enhance the adaptive capacity to climate change in a sugarcane-based farming system. In this context, underground conveyance pipe lines were earlier laid in 60 farmer's field by ICAR-IIWM. This year, two drip irrigation systems were installed in the farmer's field. As a part of self-reliant farming system model, two solar powered pump sets coupled with drip irrigation system were also commissioned (in the same farmers field where earlier vermin-compost units were made) by ICAR-CIRC, Meerut. In order to monitor the groundwater table fluctuation in the vicinities of the two recharge cavities (at Kutba and Nirmana), constructed for artificial groundwater recharge by CSSRI, Karnal and two check dams constructed by ICAR-IISWC, Dehardun, 11 piezometers were installed by ICAR-CSSRI, Karnal.

The current and future risk to groundwater table was assessed by estimating the irrigation water demand under different scenarios. The scenarios which were conceptualized last year was further modified. The modified scenarios consider the variables such as area under different crops, provision of underground pipeline conveyance system, use of improved irrigation application methods such as drip and rain gun etc. and are as follows:

(a) Scenario 1: Business as Usual (BAU); Scenario 2: 50 % reduction of sugarcane cultivated area; Scenario 3: 50 % of total cultivated area is considered having provision of underground pipeline conveyance system and improved irrigation methods (drip and rain gun system); Scenario 4: combination of scenario 2 and 3 where the sugarcane cultivated area is reduced by 50 %, and 50 % of total cultivated area is considered to have conveyance pipeline system and improved irrigation methods such as drip and rain gun system; Scenario 5: 100% sugarcane cultivated area is considered to be provided with underground conveyance pipeline system and improved irrigation methods (drip and rain gun system); Scenario 6: combination of scenario 4 along with provision of recharge cavity wells of different densities; Scenario 7: combination of scenario 5 along with provision of recharge cavity wells of different densities.

In case of all the scenarios (Fig. 15), the irrigation water requirement rises till mid-century, and thereafter declines up to 2080. Amongst all the scenarios, the lowest irrigation demand is found for scenario 4 where sugarcane area is reduced by 50 % and about 50 % of total cultivated area was considered under conveyance pipeline and improved irrigation methods. The second lowest irrigation water demand is observed for scenario 5. The highest irrigation demand is noticed in scenario 1 (i.e., prevailing practice).

The irrigation water demand for different scenarios has been reduced from the BAU scenario due to adaptation of various water saving/climate resilient irrigation

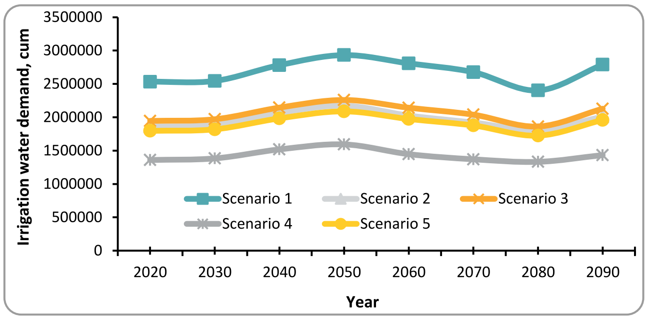


Fig. 15. Irrigation water requirement of Rasulpur Jattan for future years (scenario 1 to 5)

interventions. Table 8 shows the percentage reduction of irrigation water demand from the BAU scenario for different years. As evident, on average 46.69% of irrigation water requirement can be reduced in scenario 4. Thus, there is need to reduce the sugarcane area as well as apply irrigation in sugarcane and other crops through improved conveyance (underground pipe line system) as well as improved application system (drip, sprinkler and raingun system). Similarly, about 23 % of irrigation water requirement can be curtailed by adopting scenario 3 (50 % of total cultivated area under conveyance pipeline system and improved irrigation methods). By creating improved conveyance and application system for the entire sugarcane cultivated area (168 ha) (scenario-5), the percent reduction in irrigation water demand from BAU works out to be 29.07%.

Table 8. Percentage reduction of irrigation water demand from BAU scenario

Year	2020	2030	2040	2050	2060	2070	2080	2090	Average
Scenario-2	26.56	25.90	25.70	25.88	27.87	28.23	24.63	27.97	26.59
Scenario-3	23.20	22.58	22.89	22.95	23.69	23.82	22.49	23.73	23.17
Scenario-4	46.33	45.63	45.41	45.66	48.48	48.81	44.54	48.64	46.69
Scenario-5	29.09	28.50	28.69	28.77	29.70	29.86	28.19	29.75	29.07

Arsenic Contamination in Rice and Possibility of Mitigation through Organic and Chemical Amendments

Project code: IIWM/18/190

Investigators: P. Deb Roy, S.K. Rautaray and A.K. Thakur

A net house experiment was started during *rabi* season 2019 at the ICAR-IIWM research farm, Mendhasal. Soils were collected from farmer's field from Alisha village, Puri district for the experiment. Physico-chemical properties of the soil was analyzed. It is moderately acidic in reaction (pH=5.74) and non-saline (EC= 1.4 mS cm^{-1}) in nature. Soil texture is clay with 52% clay, 32% silt and 1 2% sand. Rice seeds (var. Shatabdi) were collected from Gayeshpur, Nadia district, West Bengal for the experiment. Two sub-experiments were started, in first experiment, different levels of arsenic were applied through sodium arsenate heptahydrate salt @ 0, 10, 20, 40, 60 mg kg^{-1} to observe its effect on growth of rice plant. Besides, arsenic was applied with irrigation water @ 0.2 mg/l^{-1}. In the second experiment, soils were spiked with arsenic @ 30 mg kg^{-1} and different organic and chemical amendments were applied at two moisture regime viz. continuous flooding and flooding at 3 days after disappearance of ponded water (DAD) to evaluate their ability to mitigate arsenic accumulation in rice straw and grain.

Stunted growth of rice plant at elevated arsenic level in treated pots

In the first experiment, plant height and tiller numbers were recorded at 20 days after transplanting (DAT). Significant reduction in plant height and tiller numbers at higher arsenic level was observed. Plant height ranged between 38.9 - 52.1 cm (av. 45.2 cm) and 29.5 to 56.2 cm (av. 43.8 cm) where arsenic was spiked @ 40 and 60 mg kg^{-1}, respectively, whereas in control, it ranged between 41.0 to 60.2 cm with an average of 50.8 cm. Tiller number varied between 1.3 to 6.3 (av. 4) and 2.3 to 4.7 (av. 3.4) under treatments where arsenic was applied @ 40 and 60 mg kg^{-1}, respectively, and in control, it ranged between 4.3 to 9.7 (av. 7.3).

ON-FARM TECHNOLOGY DISSEMINATION

On-farm Technology Dissemination

This program includes research projects on OFTD, wastewater management, water policy & governance

Impact Assessment Study of Using Industrial Wastewater on Sunflower (*Helianthus annus* L.) and Mustard (*Brassica nigra* L.) Grown in Peri-industrial Area of Angul, Odisha

Project Code: IIWM/15/170

Investigators: Rachana Dubey, Mausumi Raychaudhuri and P.S. Brahmanand

An experiment was conducted at farmer's field located at peri-industrial area of Angul, Odisha to demonstrate the impact of industrial wastewater in comparison with freshwater irrigation on sunflower and mustard grown during rabi season (2017-18). The pH, EC, NH_4-N and NO_3-N, P, K and SO_4-S of the wastewater were 7.51, 0.52 dS m^{-1}, 15.8 mg l^{-1}, 24.6 mg l^{-1}, 3.2 mg l^{-1}, 4.2 mg l^{-1} and 348.7 mg l^{-1}, respectively. 40 and 30 cm depth of wastewater was applied for irrigating sunflower and mustard crops, respectively through surface irrigation. The mean achene yield of sunflower (var. MSFH-17) was found significantly superior with wastewater irrigation (Table 9). It was 9.5% higher than the achene yield recorded with freshwater irrigation. This was mainly contributed by higher head diameter (15.3 cm), number of achenes $head^{-1}$ (467) and 1000 achene weight (69 g) with wastewater irrigation. Similarly, the treatment of wastewater irrigation resulted in significantly superior seed yield of mustard (var. PT-303) which was 11.3% higher than that of freshwater irrigation (Table 9). This was mainly contributed by higher number of siliquae per plant (179), number of seeds / siliquae and test weight with wastewater irrigation.

Table 9. Seed yield and yield attributes of sunflower and mustard as influenced by wastewater irrigation

Yield/Yield attributes	Treatments					
	Sunflower		LSD (0.05)	Mustard		LSD (0.05)
	Fresh-water	Waste-water		Fresh-water	Waste-water	
Seed yield (kg ha^{-1})	1205	1320	14.0	474	532	6.3
Head diameter (cm)	14.4	15.3	3.2	-	-	-
Number of achenes/head	392	467	6.7	-	-	-
Number of silique/plant	-	-	-	162	179	3.8
Number of seeds/siliquae	-	-	-	10.6	12.1	5.8
1000 achene / seed weight (g)	61	69	4.0	4.2	4.6	1.4

Analyses of post-harvest soil (0-15 cm) revealed that soil pH in sunflower and mustard increased from 6.13 to 6.70and 7.20 to 7.32, EC by 103.2 to 184.3 µS cm^{-1} and 78.4 to 89.7µS cm^{-1}, organic carbon by 0.51 to 1.11 g kg^{-1} and 0.27 to 0.46 g kg^{-1} respectively in freshwater and wastewater irrigated fields. Available N, P and S, and exchangeable K also increased under wastewater irrigated fields (Fig. 16).

The nutrient and oil concentration of the harvested mustard and sunflower seeds (Table 10) revealed that the seeds of crops under wastewater irrigation had higher concentration of N (9.1% in sunflower and 6.5% in mustard), P (47.5% in sunflower and 24.4% in mustard), K (13.7% in sunflower and 36.8% in mustard) and oil content (14.1% in sunflower and 23.2% in mustard) as compared to crops grown with freshwater irrigation.

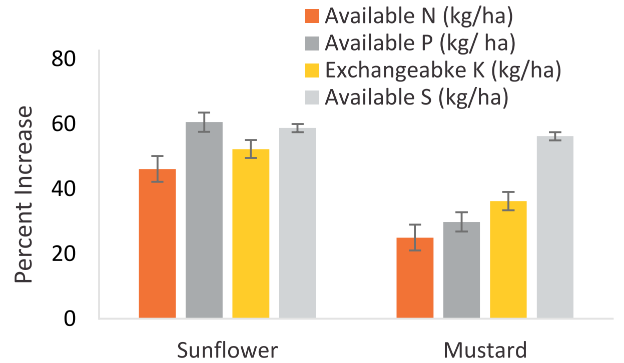


Fig. 16. Percent increase in soil nutrient status after wastewater irrigation compared with freshwater irrigation for sunflower and mustard crops

Table 10. Nutrient concentration in seeds of sunflower and mustard

Concentration (%)	Sunflower		LSD (0.05)	Mustard		LSD (0.05)
	Freshwater	Wastewater		Freshwater	Wastewater	
N	2.71	2.98	0.16	2.88	3.08	NS
P	0.53	1.01	0.48	0.41	0.54	0.11
K	1.45	1.68	0.47	0.89	1.40	0.41
Oil	28.6	33.3	2.6	35.0	45.6	4.8

Developing the Process for Remediation of Chromium from Polluted Water Sources

Project Code: IIWM/15/171

Investigators: Madhumita Das, S. Roy Chowdhury, P.S. Brahmanand and K. Laxminarayana

Study the efficiency of different plant species to remove Cr (VI) from aqueous media

An experiment was conducted with five Cr (VI) levels i.e. 0.2 (T_5), 0.71 (T_4), 0.83 (T_3), 1.07 (T_2) and 1.29 (T_1) mg L^{-1} in 0.6 m^3 of water with four different plant species in two factorial CRD with three replications in cemented tanks under net-house. 200±10 g fresh weight of each plant species - *Pistia stratiotes, Salvinia minima, Ipomoea aquatica* and water hyacinth (*Eichhornia crassipes)* were put in the tank on February 16, 2018. Plant fresh weight and Cr (VI) concentration in each species were estimated after 5, 15, 20, 25, 31, 37 and 43 days after application. The plant growth rate reduced in T_1, T_2 and T_3 after 5 days, but enhanced thereafter from 6.6 to 69.6, 18.2 to 38.8, 3.3 to 16.5 and 33 to 71.6-times in *Pistia, Salvinia, Ipomoea* and Water hyacinth, respectively. Amongst different species, *Salvinia* removed maximum Cr followed by *Pistia* and water hyacinth; it removed 0.37 to 7.03 times more Cr in T_1, T_2, T_3 and T_5 and *Pistia* removed 0.94 to 1.72 times more Cr in T_4 than other plant species. Growing *Salvinia* at $\geqslant$1.0 mg L^{-1} and *Pistia* at < 1.0 mg L^{-1} Cr (VI) levels may be preferred to remove Cr than *Ipomoea* and Water hyacinth as evident from the study.

There was 65 to 94% reduction in Cr in the treatments inconsistently with the observation period and Cr-concentration levels. It was reduced to safer level i.e. 0.1 mg L^{-1} up to 0.71 mg L^{-1} across the treatments. Decrease in plant's biomass in T_1, T_2 and T_3 and their subsequent decompositions may be attributed to the inconsistent trend in Cr-concentration.

Immobilization of harvested Cr (VI) enriched plant biomass

Harvested biomass was dried and grounded to reduce the volume in a range of 98 to 99%. Grounded plant materials either individually or in mixtures were solidified using cement, clay, bitumen, paraffin, wax and other waste materials at different proportions. These materials fixed the waste matrix, imparted physical stability and reduced access by external agents. Dissolution of Cr (VI) from the product was tested after continuous leaching with water for 1-5 hours and no release of Cr (VI) confirms the efficiency of an additives.

Development of Biological Filter for Safe Wastewater Irrigation Exploiting Microbial Bioremediation Trait

Externally funded project: National Agricultural Science Fund, New Delhi

Investigators: S. Raychaudhuri, M. Raychaudhuri, Asheesh Yadav, Sony Pandey and Manish Kumar

Isolation and screening of micro-organisms for metal biosorption and organic degradation was initiated through survey and sample collections. Water, soil, sludge samples were collected from active and inactive mines from Sukinda mining areas at Jajpur district, Odisha, wastewater drains from Bhubaneswar and the installed wastewater treatment system at the drain from Chandrasekharpur.

Isolation and screening of microbes

The samples were spread over nutrient agar media. A number of microbes were isolated from the individual colonies through repeated streaking. The isolates were further screened for their potential to absorb heavy metals on nutrient agar media impregnated with graded concentrations of Cd, Cr, Ni and Pb. A total of twenty two (22) bacterial isolates were found with different levels of metal tolerance (Fig. 17). Isolates B, C and X1 exhibited maximum tolerance up to 10 mg l^{-1} of Cd; A, B, C, E, L, A1, E1, I1, L1, A2, E2, N2, L2 showed tolerance up to 10 mg l^{-1} Pb; B, C, E1, L2, N2 showed more 10 mg l^{-1} Cr and Pb tolerance and B, C, O, E1, L1, X1, N2, I2 showed tolerance up to 5 mg l^{-1} Ni. Most of the screened isolates showed at least 2 mg l^{-1} of metal tolerance.

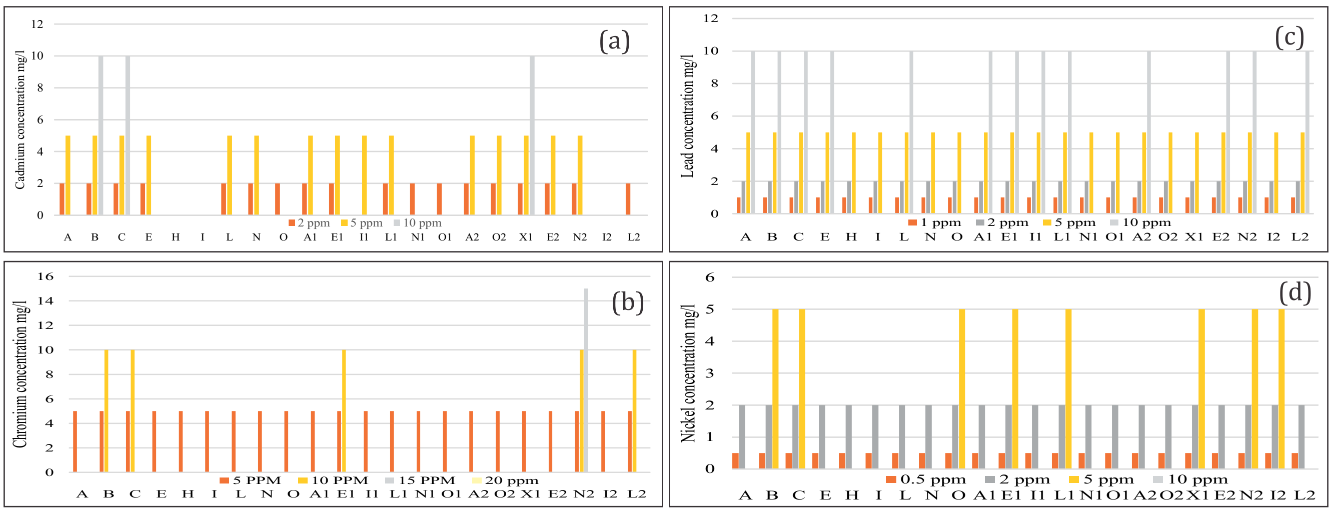


Fig. 17. Metal tolerance (a) cadmium, (b) chromium, (c) lead & (d) nickel of isolates

Characteristics of isolates

Most of the isolates were catalase, oxidase, gelatine, glucose, lactose, sucrose positive and indole, MR, VP, fructose, citrate, nitrate negative. All the strains could not produce hydrogen sulphide and showed motility. Based on the biochemical characterization, out of the 22 isolates, 5 isolates X1, B, E, E1 and E2 were presumed to be *Pseudomonas* as they were gram negative, rod shaped, oxidative fermentation and amylase negative while others A, C, H, I, L, N, O, A1, A2, I1, I2, L1, L2, O1, O2, N1 and N2 were presumed to be *Bacillus* as they are gram positive, rod shaped, oxidative fermentation and amylase positive. However, the maximum growth in terms of OD was found with isolates H and O in 10th hour indicating maximum bacterial biomass and growth rate as well.

Organic degradation capacity

Organics degradation capability of the isolates in terms of BOD removal were tested with raw sewage having known BOD (97 and 111 mg l^{-1}). Isolates O1, A2, A, I, showed more than 60% BOD removal, while most of the isolates showed more than 50% BOD removal. Isolates N, O, E2 were found with least capabilities of BOD removal.

Compatibility of isolates

Among the isolates, A showed compatibility with majority of the isolates (72%) and B, E and L2 showed minimum (≤20%) compatibility. The isolates C, H, L, N, O, E1, I1, L1, N1, A2, E2, I2 were compatible with more than 50% of the isolates. The isolates with compatibility with majority of isolates were better candidates for consortia designing.

Development of Web-based Expert System on Agricultural Water Management

Project Code: IIWM/16/181

Investigators: A.K. Nayak, P.K. Panda and R.K. Mohanty

An android version of the expert system in agricultural water management was developed to categorize water management practices in agriculture, horticulture, high value aquaculture and animal husbandry. In the mobile application (App), the agriculture segment contained four sub- menus: Cereals, Pulses, Oilseeds and Commercial crops. In the cereal crop module, the water management practices of various major crops, like rice, wheat, maize, sorghum and pearl millets are available. Whenever one user selects any crop, the system will ask to choose for the season, land type, water availability and method of cultivation. The output in the form of best water management for the enquired crop will be displayed in the mobile app as shown in Fig. 18. Similar options are also created for pulses, oilseeds and commercial crops.

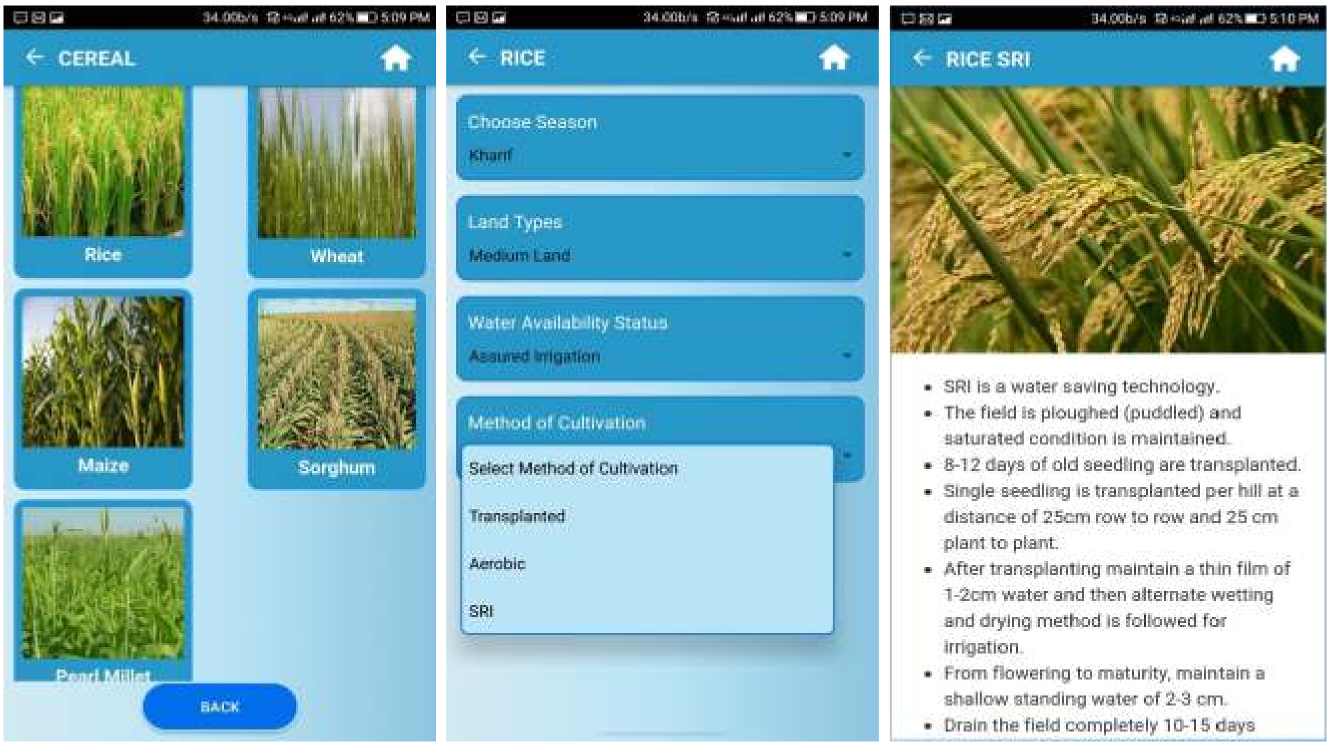


Fig. 18. Snapshot of the agriculture module of the mobileApp

In the horticulture module, the sub-menus are vegetables, fruits and flowers. Whenever one user chooses any one of these options, the application will ask to choose the season and water availability status. Based on the user's input, the best water management practices will be displayed on the mobile, such as when the crop should be sown, best suited varieties of the crop and when to irrigate.

In the aquaculture module, the program has been created to display suitable water management interventions in different land type, such as upland, medium land, low land and coastal areas. Based on the land type selection, the aquaculture interventions are further classified as cold water aquaculture, production of carp fry or fingerlings, grow out technology, catfish culture, freshwater prawn culture, ornamental fish culture, freshwater pearl culture, integrated rice-fish cultivation and shrimp culture. The system will display the general information, culture techniques, water quality indicators and other options as per the user's requirements.

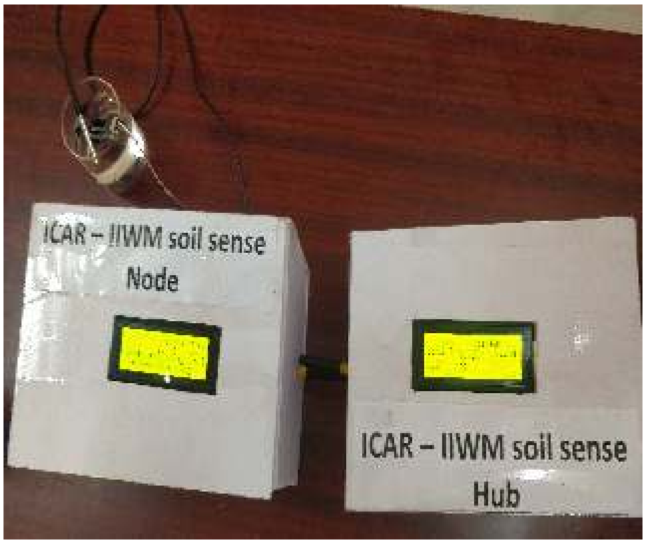
In the animal husbandry module, options are created to select drinking water requirement and service water requirement for various animals, such as cattle, goat, pig, horse, chicken etc. The system will display the general information, animal type with water requirements and average water use per day for the selected animal.

Smart Water Management System in Agriculture

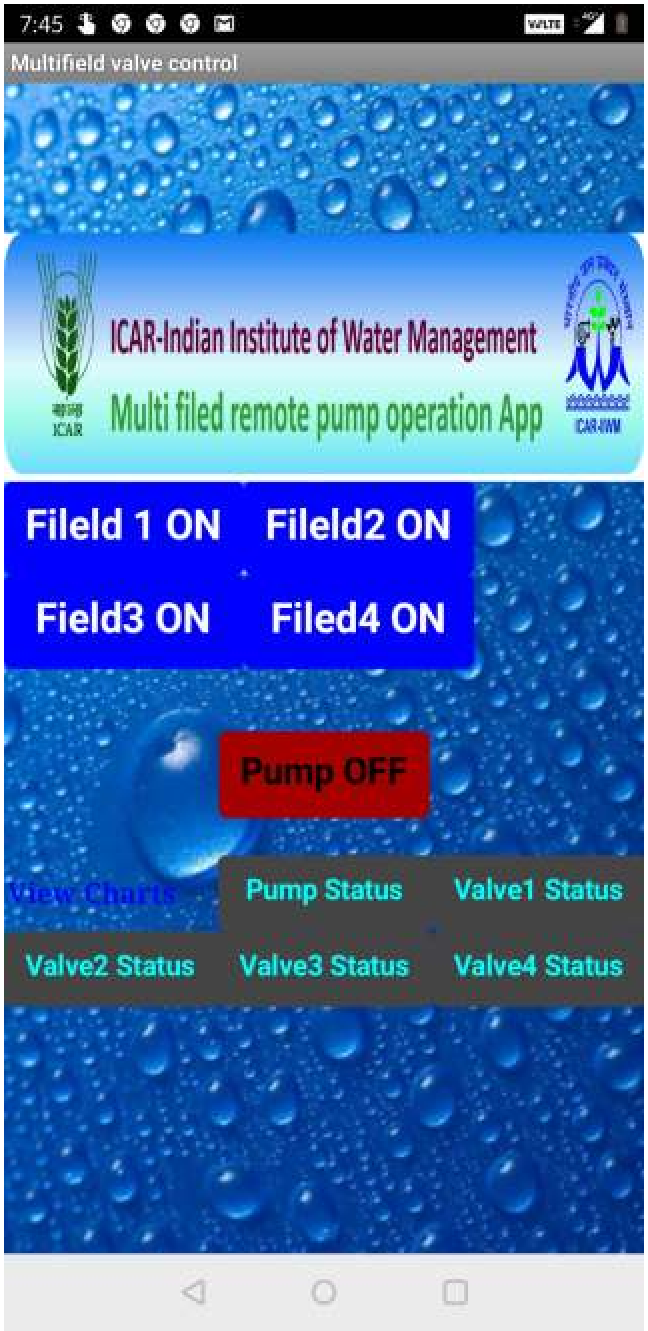
Project Code: IIWM/17/186

Investigator: D. Sethi

The remote pump operation system developed under the project was modified to reduce hanging of the device. The earlier TCPIP protocol was replaced with MQTT protocol. The new device is able to respond within one second time lag, as compared to 25 seconds in the case of previous system. The new system is operated through Blynk cloud service, but recording the data in the cloud server is yet to be done. A mobile app has been developed for irrigation to specific fields in case of multiple field operations. In order to get soil moisture and soil temperature data from multiple fields, a wireless sensor network-based standalone device has been developed. The device operates in free band, and has low energy consumption. The device works in a star network with a wireless Hub with many nodes placed at different fields. Being a low power consuming device, it can work for months with single charging. A device prototype was also developed for monitoring water level using ultrasonic sensor.



Wireless soil moisture and soil temperature device prototype



Both soil moisture and water level devices are under calibration.

Socio-economic Evaluation of Water-related Interventions under MGNREGS in Odisha

Project code: IIWM/17/187

Investigators: H.K. Dash and D. Sethi

(a) Scenario of water-related works

Under MGNREGS, water-related works are important interventions for not only providing wage security, but also for creating durable assets for rural poor including farmers. In 2014-15, ₹ 1246.85crore was spent on all works in Odisha, of which ₹ 540.82 crore was spent on NRM expenditure and ₹ 221.86 crore was spent on water related works. In 2018-19, out of ₹ 2210.19 crore spent on all works, expenditure on NRM works was ₹ 932.02 crore and expenditure on water related works was ₹ 358.71 crore. This means between 2014-15 and 2018-19, while expenditure on all works increased by about 77%, the corresponding increases for NRM works and water related works was 72.3% and 61.6%, respectively. Similarly, the proportion of total expenditure on NRM works in Odisha which was 43.38% in 2014-15 went up to 53.91% and then declined to 42% in 2018-19. Share of expenditure on water related works declined from 17.79% in 2014-15 to 16.24% in 2018-19. All this suggest that the gap between expenditure on all works and NRM related works has got wider over the years.

Another significant finding is that the share of NRM works and water-related works in total number of works has continuously declined during past years. The proportion of NRM works which was 42.26% in 2014-15 declined to 14.54% in 2018-19. Similarly the share of water related works in total number of works declined from 19.9% in 2014-15 to 4.3% in 2018-19 (Fig. 19).

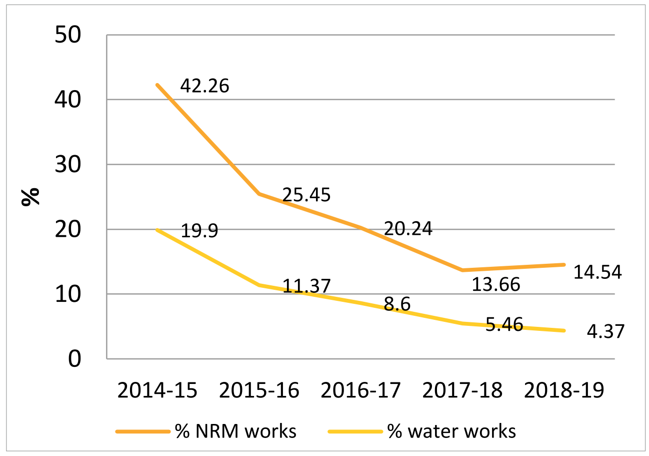


Fig. 19. Share of different categories of work under MGNREGS in Odisha

(b) Impact of water-related works

A study of 42 farm ponds created under MGNREGS in 2007-08 and 2008-09 in Ektali GP of Joshipur block of Mayurbhanj district, Odisha revealed positive impact of farm ponds on farm production and income. The cumulative net benefit accrued to the farmers due to farm ponds by the end of 2017-18 was about ₹ 55.8 lakh, with a B:C ratio of 3.3. A major part of the benefit was from the cultivation of rabi crops which was made possible only due to availability of pond water till the end of March. Similarly, evaluation of 12 check dams constructed in 2013-14 in the area showed a cumulative net benefit of ₹ 65.45 lakh by the end of 2017-18, with a B:C ratio of 1.75.

Enhancing Land and Water Productivity through Integrated Farming System (Scheduled Tribe Component Project)

Investigators: R.K. Panda, R.R. Sethi, S.K. Rautaray and R.K. Mohanty

A village Purtiguda in Kumbhardhamuni Panchayat under Bisama Cuttack block in Rayagada district, Odisha was identified for Scheduled Tribe Component project (STC project) activities under aspirational district category apart from Sundargarh district, Odisha. Under created physical assets and services, 20 mango saplings each were distributed to the tribal farmers in the adopted Purtiguda village in Rayagada district and Sundargarh district. Four farmers in Birjaberna village have gone for creating their own dug well facilities in their crop fields. To encourage the farmers, pipe based irrigation system were facilitated to 24 tribal farmers by distributing HDPE irrigation conveyence pipes in Birjaberna and Mohuljhore villages in Sundargarh district. Two exposure training programmes were organised in Sundargarh. Total 151 tribal farmers were benefited in both the training programmes. Apart from these activities, one day *Swatchha Bharat Abhiyan* programme was also organised in Birjaberna village.

Plantation drive in Birjaberna village

Dug well facility created by farmers own contribution

HDPE irrigation pipes provided in Mohuljore village

Mango saplings distributed in Purtiguda village (Rayagada)

Activities under STC project

Enhancing Water and Livelihoods Security and Improving Water Productivity in Tribal Dominated Paddy Fallow Rainfed Agro Ecosystem of Odisha (Farmer's FIRST Project)

Investigators: P. Nanda, D. Sethi, A. Mishra, S. Mohanty, M. Das, R.K. Mohanty, P.S. Brahmanand, A.K. Thakur, A. Das and B. Das

During the year 2018-19, interventions like line transplanting, SRI method, increasing water use efficiency in transplanted rice along with nutrient management, integrated farming system, increasing cropping intensity through winter vegetables, improved livestock rearing trainings etc. were taken up in the project implementation villages. Number of beneficiary farmers are 405. Besides, the impact evaluation of 2017-18 interventions indicated that on-farm income increased by 108% in comparison to 2016-17 after adoption of improved technologies and farm practices. Based on the findings of a detailed water budgeting, farmers were advised to use water for increasing water use efficiency. Owing to our interventions, about 15 ha land are under improved vegetable cultivation in three villages; notably, three farmers' groups (consisting of young members) have gone for group farming of vegetables, and electric paddy threshers (9 nos) were used to reduce threshing cost and drudgery in those villages. Group farming with resource sharing, use of piped conveyance system and scientific water management saved irrigation water by more than 20%.

Three one-day farmer-training programs on 'Water Resource Management and Agricultural Diversification for Enhancing Water Productivity and Ensuring Livelihood of Farmers' were organized under Farmer's FIRST Project at Khuntapingu, Malarpada and Jamuda villages (Dist. Keonjhar) on October 23, 24 and 25, 2018, respectively. A total of 394 farmers including women farmers actively participated in the training programs. Scientists from ICAR-IIWM, district-level as well as block-level personnel of watershed, agriculture, veterinary, horticulture and fishery departments provided training to the farmers. Resource personnel delivered lectures to farmers on various aspects of agricultural water management to enhance water productivity. Emphasis was given on 'Per drop more crop and doubling farmer's income'. Also, success stories of farmers under this project were highlighted to encourage fellow farmers to adopt profitable vegetable cultivation.

A field training program-cum demonstration for farmers on 'SRI-System of Rice Intensification' at Malarpada village was organized on January 11, 2019 for 42 farmers, they were encouraged for adopting SRI in 37 acres of rice-fallow land during *rabi* season. An exposure visit of 51 farmers to state level *kisan mela* at ICAR-NRRI, Cuttack was organized. Demonstration of vegetables cultivation (35,000 seedlings of brinjal, tomato, and chili) and tuber crops (2000 planting material of Tapioca, 200 kg of Yam) was done in farm and backyard of more than 200 farmers of the project site. Also, kitchen gardening was encouraged by distribution of seeds of okra, radish and *Amaranthus*. Use of pheromone trap and sticky trap was also demonstrated in the farms of the stake holders. Farmers of Malarpada village were motivated to repair one defunct lift irrigation point. The activities of the Farmer's FIRST project has been published as seven news stories in local newspapers. WhatsApp group was used to identify and solve diseases and pests in crops/vegetables.

Farmers training programme

Field training on SRI

Radish and mustard crops at farmers field

Fish harvest from project site

Activities under Farmer's FIRST project

Revival of Village Pond through Scientific Interventions

Externally funded project: DST, Ministry of Science & Technology, New Delhi

Investigators: S.K. Jena, P. Nanda, P.S. Brahmanand and S. Mohanty

Project was implemented at Kendrapra and Puri districts of Odisha with the help of gram panchayat office bearers, farmers and also in consultation with government departments in participatory mode. Coastal belt, like Kendrapada and Puri seawater intrusion and waterlogging are the common problems. In. The implementation sites are in the deltas of Mahandi river, thereby vulnerable to the natural calamities like, flood, cyclone etc. Catchment area of Garadpur pond was surveyed and contour map was prepared with 1 m contour interval in 1: 3000 scale, so that distinct contour are visible on the bund and side of the bund. Contour maps were also generated from the ASTER DEM of the catchment area. Since the catchment area was only 29 ha, an accuracy of the auto-generated contour from ASTER DEM was less accurate. However, the dumpy level survey and mapping in a scale of 1:3000 gave a good contour map and crop planning was done for the catchment and command areas of the pond. Pond at Kapileswarpur was desilted by the gram panchayat and nutrient richsediments were spread around the pond for floriculture and agro-forestry plantation with funds provided by Govt. of Odisha implementing plans prepared by the project team.

Aquaculture activities were under taken by Maa Santoshi self-help group in Garadpur pond (Digi pokhari). Indian major carp in the proportion of 30:30:40 (Catla: Rohu: Mrigal) were released to the pond in August, 2018. Around 2,00,000 fry/fingerlings were released to the pond considering the rate of mortality due to presence of other predator fishes. In Naindipur pond of Garadpur block, 2500 fingerlings were released, which will be harvested in June, 2019. Soil and water samples were collected on regular basis from pond and catchment area for primary analysis. Pond was cleaned and water hyacinth and other aquatic plants were removed with the co-operation and active participation of gram panchayat. Aquaculture was taken by the villagers of Kapileswarpur and Gardapur. Three bathing ghats were constructed at Garadpur and two bathing ghats and one changing room were constructed at Kapileswarpur from the fund obtained from Govt. of Odisha to prevent water quality reduction of pond water. Two automated digital rain-gauges were installed, one each at Garadpur, Kendrapada and another at Kapileswarpur, Puri. Rainfall was recorded at each four hour intervals and were collected and analyzed.

Historical rainfall for the period 1975 to 2018 was analyzed. It was found that average annual rainfall = 1536.3 mm, rainfall during monsoon = 1233 mm, rainfall during pre-monsoon= 201.5 mm, rainfall during post-monsoon= 101.8 mm, extreme one day rainfall = 400.3 mm (1999), average onset of monsoon = 16th June (167th day), average recession of monsoon = 07th October (280th day), average no of rainy days in a year = 70 days, year receiving highest rainfall = 2001 (2218.7 mm), year receiving lowest rainfall = 1996 (837.1 mm), number of rainy days highest in the year = 1990 (70 days), number of rainy days lowest in the year = 2016 (54 days), month receiving highest rainfall = August (358.5 mm), month receiving lowest rainfall = December (5.3 mm), percentage of rainfall occurs in monsoon = 86% (June-October), month having highest no of rainy days = August (15 days), month having lowest no of rainy days = December (0 days), week having highest average rainfall = 32nd week (85.1 mm), week having lowest average rainfall = 52nd week (0.3 mm). These information should be used for pond design and crop planning in the catchment and command of the pond.

In situ measurement of water parameters of the village ponds of Kapileswarpur

Garadpur pond along with bathing ghat

AICRP on Irrigation Water Management

The AICRP on Irrigation Water Management (AICRP-IWM) scheme is in operation in nineteen agro-ecological regions on the country. Twenty six centers of AICRP-IM carried out research and extension work in the field of 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 and their interaction, 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

Assessment of availability and quality of surface water and groundwater

Optimization of land and water resources of Tawi-Lift canal command area of Jammu (18,000 ha) for the rice-wheat sequence revealed that the difference in output per unit irrigated command at middle and tail reaches was 13% and 34% lower, respectively compared to the head reach. Whereas, production value per unit of water consumed at middle and tail reaches were 13.7% and 34.2% higher compared to head reach. Farmers at the tail reach get only 65% water supply to meet crop demand, whereas in head and middle reaches the relative water supply needs to be improved by 9% and 18% to meet the crop demand.

Moreover, water budgets of 38 blocks of five districts of upper Narmada basin, namely, Dindori, Mandla, Jabalpur, Narsinghpur and Hoshangabad were prepared by considering water demand of domestic, livestock, industrial and agricultural sectors. The existing areas under different crops were taken to compute water demand based on crop water requirement of each crop. The analysis showed a water surplus of 49624 ha-m and 126256 ha-m for Dindori and Mandla districts, respectively, while some blocks showed a deficit water.

Design, development and refinement of surface and pressurized irrigation systems

A study at Navsari of sugarcane (cv. CoN 5071) grown with subsurface laterals placed at 7.5 cm depth at 1.80 m spacing having in line dripper of varying discharge rates and spacings showed maximum return with dripper discharge of 4 lph and dripper spacing of 60 cm. This discharge rate and dripper spacing also caused minimum damage to the laterals with least amount of clogging in the drippers.

The response of four irrigation schedules (surface irrigation at 1.0 IW/CPE, drip irrigation at 0.6, 0.8 and 1.0 ETc) and four mulching treatments (no-mulch, black polythene, paddy straw and jute geotextile) on water and crop productivity of strawberry was studied at Gayeshpur. Results showed that interaction effects of drip irrigation at 0.8 ETc and 1.0 ETc and jute mulch proved to be beneficial in fetching higher number of fruits per plant (19.27 and 21.38, respectively), fruit weight (26.74 and 19.70 g, respectively) and water productivity (21.85 and 15.37 kg m^{-3}, respectively) compared to surface irrigation without mulch. In another experiment, performance of growth, flowering parameters and spike yield of tuberose were assessed under four irrigation schedules (gravity fed drip at 0.6, 0.8 and 1.0 E_0 and surface irrigation) and three mulch conditions (no mulch, paddy straw mulch and black polythene mulch (BPM). Results of the two-year study showed that drip irrigation at 1.0 E_0 with BPM recorded maximum growth, flowering characteristics and number of spikes (Spike yield= 224690 and 239910 ha^{-1}) in first crop and ratoon tuberose which were at par with drip irrigation at 0.8 E_0 with BPM. Maximum WUE (533.01 spikes ha-mm^{-1}) was obtained with drip irrigation at 0.8 E_0 with BPM. Spike yield was observed to be highest at 300 mm of irrigation water.

Performance evaluation of sprinkler irrigation, fertility levels and bio-regulator on the productivity of z*aid* green gram grown after mustard crop at Kota revealed that *zaid* green gram with sprinkler irrigation at IW/CPE ratio of 1.2 with 125% recommended doses of fertilizers and foliar spray of 100 ppm thiosalicylic acid at flowering stage increases grain yield by 48% and water use efficiency by 9.4%.

At Pantnagar, drip irrigation in vegetable pea in sandy loam soil (field capacity moisture- 20%, PWP-8%) at 75% CPE and fertilization with 75% RDF (25% basal+75% through water soluble fertilizer) at 3 days interval saved maximum amount of irrigation water (65.3%) compared to flood irrigation and recorded highest irrigation WUE (208.1 kg ha-mm^{-1}), water productivity (17.57 kg m^{-3}) and economic water productivity (₹1914 mm^{-1}).

Basic studies on soil-plant–water-environment relationship

Four irrigation regimes (rainfed, CPE at 250, 175 and 100 mm) and three levels of hydrogel (0, 2.5 and 5.0 kg ha^{-1}) in zero-till green gram-jute relay system at Gayeshpur showed strong positive correlation between system yield with actual evapotranspiration rate. Gel conditioner met the ET demand of the relay crops for longer time. Under low soil moisture condition, hydrogel was effective in augmenting crop yields, but ineffective in promoting crop yield under wet soil moisture regime. Hydrogel @ 2.5 kg ha^{-1} with irrigation at CPE 100 mm increased the system yield (4.50 t ha^{-1}) and water productivity (0.61 kg m^{-3}), being at par with hydrogel @ 5.0 kg ha^{-1} and irrigation at CPE 100 mm (4.87 t ha^{-1} and 0.66 kg m^{-3}). The arsenic recovery from broccoli head through conjunctive use of 50% arsenic contaminated groundwater and 50% safe surface (pond) water (4.92 mg kg^{-1}) on alternate *rabi* rice like broccoli was at par with 100% pond water (4.78 mg kg^{-1}). This irrigation management strategy can concurrently solve the problems of scarce groundwater resources and arsenic toxicity without compromising marketable yield and water productivity.

Adoption of rotavator puddling gave 9.9% higher water use efficiency (WUE) compared to cultivator puddling (Farmers' practice) and puddler puddling in basmati rice grown in sandy loam soil of Jammu. Rotavator puddling along with irrigation applied three days after disappearance of ponded water (3-DADPW) resulted in 30.6% water saving over continuous ponding in sandy loam soil of Ranbir canal command area.

In sandy loam soil of *Tarai* region of Uttarakhand

Drip irrigation in sugarcane

(Pantnagar), characterized by low rainfall events, drip irrigation to chickpea at vegetative and pod development stages through sprinkler saved 41.8% irrigation water compared to flood irrigation. Irrigation to chickpea at vegetative stage recorded maximum economic water productivity WP (₹ 597/mm). Raised bed sowing recorded higher I_{WUE} (28.1 kg ha-mm^{-1}) and WP (2.14 kg m^{-3}) than flat sowing (I_{WUE} 22.6 kg ha-mm^{-1} and WP 1.80 kg m^{-3}). Further, it had 24.7% higher EWP than flatbed chickpea (₹ 441 mm^{-1}). Sprinkler irrigated chickpea also gave ₹ 325 more return per mm use of irrigation water than flood irrigation (₹ 355 mm^{-1}).

A study on crop diversification under poor availability of canal water at Faizabad, showed that intercropping of mustard with gram at the ratio 1:4 is the most economic venture as it gave the highest equivalent wheat yield of 5.24 t/ha and benefit-cost ratio of 3.59, followed by intercropping of mustard with wheat (1:9) and pure stand of gram with wheat equivalent yields of 5.18 and 4.67 t/ha, respectively.

To evolve management strategies for conjunctive use of surface and groundwater

At Gayeshpur, arsenic recoveries from broccoli head through conjunctive use of 50% arsenic contaminated groundwater and 50% safe surface (pond) water (4.92 mg kg^{-1}) on alternate *rabi* rice like broccoli was at par with 100% pond water (4.78 mg kg^{-1}). This irrigation management strategy can concurrently solve the problems of scarce groundwater resources and arsenic toxicity without compromising marketable yield and water productivity.

Lysimetric study showed highest yield of chickpea (3.64 t/ha) obtained with two sprinkler irrigations applied at 40% depletion of available soil moisture at Pantnagar. The average crop coefficient (Kc) for chickpea (cv. Pant Gram-3) was 1.00 ranging from 0.25 to 1.57 during *rabi* season. This Kc value can be used to determine water requirement of chickpea crop if required data for computation of potential evapotranspiration is available for that area.

Spatial recharge information generated by SWAT for 16 years (2000-2015) have been used to precisely predict the ground water behavior of Jabalpur. The hydrological response units generated by SWAT have been up scaled and adjusted for 7 blocks of study area to check ground water status and it's dynamics for efficient management and policy planning purpose.

Sprinkler irrigation in greengram

Agri-CRP on Water

Development and Management of Integrated Water Resources in Different Agro-ecological Regions of India (Theme-I)

Investigators: S.K. Jena, S. Mohanty, P.S. Brahmanand, R.R. Sethi and S.K. Ambast

Collaborating Institutes: ICAR-IISWC, Dehradun; ICAR-CRIDA, Hyderabad; ICAR-RC NEHR, Barapani; ICAR-NBSSLUP, Nagpur; IIT, Kharagpur; PDKV, Akola

Under the Agri-CRP on water project, installation of rubber dams were completed at Nabarangpur and Jaleswar in agro-climatic zone XI (East coast plains and hills region) during 2018-19. Moreover, the water storage capacity created earlier at different locations were measured. At Dapoli it is 20000 m^3 with a command of 30 ha; at Ootty a command of 5 ha was created; at Palampur-1 it is 4200 m^3; at Plampur -2 it is 3600 m^3; at other locations it varied between 4000 m^3 to 10000 m^3 depending upon the slope and cross section of the stream.

The impact of installed ICAR-flexi rubber check dams were studied in different agro-climatic zones i.e. Chandeswar, Khurda district of Odisha; Semiliguda and Jogiput of Koraput district and Kadalipatraguda of Nabarangpur district of Odisha; Udhakamandalam, Tamil Nadu; and Sriwalgarh and Selakui of Dehradun district and Bhatoli of Tehri-Garhwal district of Uttarakhand along with Navsari, Gujarat; Kanse, and Dapoli, Maharashtra; and Pyllun, Meghalaya.

The impact of installed rubber dams on agricultural performance in Chandeswar-1 and Chandeswar-2 sites of Khurda district of Odisha was evaluated. During *kharif* season, the rice grain yield was found to be enhanced from 4.14 t ha^{-1} during pre- installation period to 4.84 t ha^{-1} during post-installation of rubber dam due to optimum time of transplanting and assured irrigation during mid-season dry spells. During *rabi* season, the pod yield of green-gram was found to be enhanced from 0.72 t ha^{-1} to 0.91 t ha^{-1}. At the same time, the yield of brinjal and ridge gourd were enhanced by 31% (from 7.4 t ha^{-1} during pre-installation period to 9.7 t ha^{-1} during post-installation of rubber dam) and 38% (from 6.1 t ha^{-1} during pre- installation period to 8.4 t ha^{-1} during post-installation of rubber dam), respectively. The farmers could irrigate *rabi* crops using water from rubber dam at critical crop growth stages (flowering and pod formation) which resulted in minimization of water as a limiting factor for pod growth and yield.

The rubber dam has also resulted in positive impact on productivity of summer vegetable crops. For example, the fruit yield of brinjal was enhanced from 4.8 t ha^{-1} during pre-installation stage to 5.9 t ha^{-1} during post-installation. Similarly, the fruit yield of watermelon and cowpea has increased from 9.2 t ha^{-1} and 5.2 t ha^{-1} to 12.4 t ha^{-1} and 6.7 t ha^{-1}, respectively during corresponding period due to additional available water after installation of rubber dam at Chandeswar. Yield of ridge gourd and cucumber was found to be enhanced by 26% and 42% respectively. The fruit yield of ridge gourd and pumpkin was enhanced from 5.5 t ha^{-1} and 6.9 t ha^{-1} during pre-installation stage to 7.8 t ha^{-1} and 11.1 t ha^{-1}, respectively. The installation of rubber dam resulted in improvement in cultivated land utilization index (CLUI), which was enhanced from 43.3% in pre-installation stage to 56.5% during post-installation of rubber dam (2018-19).

Farmers in Kadalipatraguda and Jogiput of Odisha could enhance yield of brinjal (12.6 t ha^{-1} to 17.0 t ha^{-1}), potato (16.1 t ha^{-1} to 19.5 t ha^{-1}) and tomato (14.5 t ha^{-1} to 18.3 t ha^{-1}) in an additional area of 4 ha during *rabi* season due to assured irrigation provided by rubber dam. The farmers of Semiliguda had transplanted paddy in 3.20 ha of area in the command of the rubber dam during 1st week of February 2019, which they were unable to take before the installation of rubber dam.

The farmers in Udhagamandalam (Ootty) of Tamil Nadu benefited from vegetable like carrot (13.6 t ha^{-1} to 18.1 t ha^{-1}) and beetroot (11.7 t ha^{-1} to 13.8 t ha^{-1}). The quality and leaf yield of tea plantation improved due to assured irrigation provided from the water stored due to rubber dam.

The productivity of wheat and mustard at Bhatoli during 2018 enhanced by 21% and 25% respectively compared to pre-installation period. The yield of long duration crops like ginger and chilli enhanced by 35% and 27% respectively. Similarly, in Sirwalgarh of Uttarakhand, the yield of maize during *kharif* season was enhanced by 21% and the yield of wheat and beans was enhanced by 21% and 28% respectively due to installation of rubber dam.

In Pyllun, Meghalaya, the Jalkund was refilled by the water stored in the upstream side of the rubber dam. The stored water was also used in irrigating maize, vegetable and providing drinking water and water required for washing milch animals as well as pigs and poultry.

Groundwater recharge in hard rock regions of Dhenkanal

Multiple use of water in the water harvesting structures in terms of pisciculture, on-dyke horticulture and supplementary irrigation in *kharif* season was done. Fish yield of 0.15 and 0.1 tonnes were recorded in the water harvesting structures at Khamara and Khallibandha village respectively. The rubber dam along with the water harvesting structure constructed in the Khamara village provided supplementary irrigation to 50 acre of paddy land. In the constructed recharge well, the filtration chamber consisted of a gravel layer of 40 cm height at the bottom, a coarse sand layer of 30 cm height above it and a fine to medium sand layer of 30 cm height above it. Regular monitoring of water level in the water harvesting structures, observation wells and recharge well was continued. Due to construction of rubber dam, water

Carrot and tea cultivation in the command of rubber dam at Ootty, Tamil Nadu

Vegetable cultivation in the command of rubber dam at Chandeswar, Odisha

Rubber dam at Dapoli, Maharashtra

Rubber dam at Jogiput, Koraput, Odisha

Rubber dam at Kanse, Maharashtra

Vegetable cultivation in the command of rubber dam at Nabarangpur, Odisha

Rubber dam at Pyllun, Meghalaya

Summer paddy cultivation in the command of rubber dam at Semiliguda, Odisha

harvesting structure and recharge well in the Khamara village, an average increase of 13 mm of groundwater level was observed.

A water balance study in the water harvesting structure in Khallibandha village was done with a view to estimate the groundwater recharge. The water balance components were rainfall, runoff into the WHS, evaporation, percolation and change in storage. The periods with no rainfall and runoff into the water harvesting structure were considered so as to simplify the water balance equation to only three components, i.e., evaporation, percolation and change in storage. The daily percolation losses, i.e. potential groundwater recharge was estimated by deducting the evaporation component from the change in water storage in the pond. Using the relation between the water level in the pond and the potential groundwater recharge per day (Fig. 20), the day-wise potential groundwater recharge from the water harvesting structure was estimated to be 3876 m^3.

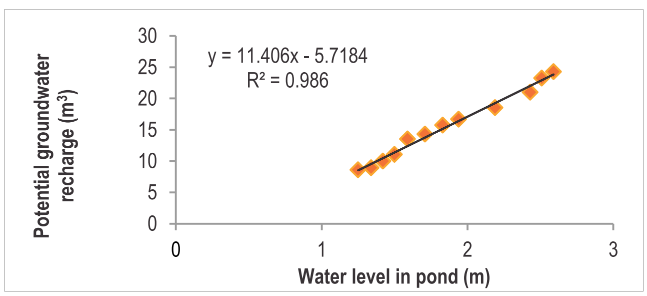


Fig. 20. Variation of potential groundwater recharge with water level in the pond

Evaluation of Irrigation System and Improvement Strategy for Higher Water productivity in Canal Commands (Theme-II)

Investigators: R.K. Panda, S.K. Rautaray, P. Panigrahi, S. Raychoudhuri, M.K. Sinha, A.K. Thakur, R.K. Mohanty, O. P. Verma and S.K. Ambast

Collaborating Institutes: ICAR-RCER, Patna; ICAR-CSSRI, Lucknow Centre; ICAR-NRRI, Cuttack; ICAR-IISR, Lucknow; ICAR-IIWBR, Karnal

Irrigation provision of PVC pipe conveyance system, PVC along with sprinkler irrigation system and PVC along with drip irrigation system were laid out in head, middle and tail reaches in Nagpur minor under Puri canal command system (Odisha). The created conveyance facilities were connected to the existing auxiliary water storage structures. During *rabi* and summer seasons of 2017-18, groundnut and *sesamum* were grown in upper reach and observed that the yield and water productivity of the crops were increased by 11% and 34%, respectively, using 17% less water under pipe conveyance system in comparison with channel conveyance system. In middle reach, for the same crops, there had been increase in yield and water productivity of 29% and 74%, respectively with 25% less water use in under sprinkler comparison with pipe conveyance and channel conveyance systems. Similarly, in lower reaches, it was observed that the yield and water productivity increased by 33% and 97%, respectively, using 31% less water under drip irrigation in ground nut, pointed gourd and bitter gourd compared with pipe conveyance and channel conveyance systems (Table 11).

Table 11. Yield and water productivity under pressurized irrigation systems

Location	Crops	Yield (t ha^{-1})	Water applied (mm)	Water productivity (kg m^{-3})	
Upper reach	Groundnut	Pipe conveyance	1.8	300	0.60
		Channel conveyance	1.66	360	0.46
	Sesamum	Pipe conveyance	1.1	150	0.73
		Channel conveyance	0.96	180	0.53
Middle reach	Groundnut	Pipe conveyance	1.93	300	0.64
		Sprinkler	2.24	280	0.80
		Channel conveyance	1.71	360	0.47
	Sesamum	Pipe conveyance	1.16	150	0.77
		Sprinkler	1.37	130	1.05
		Channel conveyance	1.07	180	0.59
Lower reach	Groundnut	Pipe conveyance	1.92	300	0.64
		Drip	2.46	240	1.02
		Channel conveyance	1.82	360	0.50
	Pointed gourd	Pipe conveyance	17.8	300	5.93
		Drip	22.31	240	9.29
		Channel conveyance	16.5	350	4.71
	Bitter gourd	Pipe conveyance	14.6	250	5.84
		Drip	18.12	210	8.62
		Channel conveyance	13.7	300	4.56

Water saving irrigation with alternate wetting and drying (AWD) method in transplanted rice was taken up during kharif 2018. The results revealed that rice grain yield was statistically at par with continuous submergence with AWD (4.25 t ha^{-1}) with water level inside the perforated PVC pipe of 5 cm below the soil surface. Therefore, the safe level of AWD for rice was found to be 5 cm below the soil surface for economizing the water use at similar yield.

Automatic Irrigation and Fertigation in Drip-irrigated Banana (Theme-III)

Investigators: P. Panigrahi, S. Raychaudhuri, A.K. Thakur, A.K. Nayak and S.K. Ambast

Collaborating Institutes: ICAR-IIHR, Bangalore; ICAR-IIVR, Varanasi; ICAR-NRCP, Solapur

Performances of automatic irrigation (sensor based and timer based) based on crop evapotranspiration (ETc), variable rate fertigation, and different plant densities with different soil wetted volume (SWV) under drip irrigation were studied in banana (cv. Grand Naine) at ICAR-IIWM research farm at Mendhasal, Khurda, Odisha. Under automated irrigation, different time based irrigation (1 hr interval 3 times daily at 80% ETc, 2 hr interval 2 times daily at 80% ETc, 1 hr interval 3 times daily at 60% ETc, 2 hr interval 2 times daily at 60% ET_c) were compared with soil water sensor based irrigation and manually operated irrigation (at 100% ETc, 80% ET_c and 60% ET_c) under drip system in the crop. In the second experiment, crop growth stage (pre-flowering, PF; flowering and fruit setting, F & FS; fruit development, FD) based irrigation and fertigation were studied. Different irrigation treatments imposed based on crop evapotranspiration (ET_c) were I_1: 60% ET_c at PF+ 80% ET_c at F & FS +60% ET_c at FD; I_2: 80% ET_c at PF+100% ET_c at F & FS + 80% ET_c at FD and I_3 : 100% ET_c throughout the season, whereas fertigation doses applied based on recommended dose of fertilizer (RDF) were F_1 : 60% RDF at PF + 80% RDF at F&FS + 60% RDF at FD; F_2 : 80% RDF at PF + 100% RDF at F&FS + 80% RDF at FD and F_3: 100% RDF throughout the season. In the third experiment, the response of different number of plants (1 plant, 2 plants and 3 plants) per pit with different plant to plant and row to spacing (2.0 m × 1.5 m; 2.0 m × 2.0 m; 2.0 m × 2.5 m) and different wetted soil volume (WSV: 20%, 40%, 60% and 80%) were studied under drip-fertigation.

The hydraulic performance of drip irrigation system installed for the study was found satisfactory with emitter flow rate variation (Q_v) of 5%, Co-efficient of variation (CV) of 6% and distribution uniformity (DU) of 95%. The water applied in various automatic irrigation treatments varied from 363 mm to 580 mm compared with 744 mm under manual irrigation. The soil water content under manual irrigation at 100% ET_c (21.2–24.1%, v/v) was marginally higher than that under sensor based irrigation (20.8–23.7%, v/v) and time based irrigation (19.8%–21.27%, v/v). The available N, P and K content in soil was highest under sensor based irrigation, followed by that under time based irrigation and manual irrigation. However, manual irrigation resulted higher light interception (60–72%) and SPAD values (45–60) than sensor based and time based irrigation schedules. The vegetative growth of plants increased with increase in irrigation level from 60% ETc to 100% ET_c, whereas irrigation at 80% ET_c resulted in yield at par with 100% ET_c under manual irrigation. The plant height, canopy diameter, number of leaves, stem girth, leaf area index of the plants under manually irrigation was 9-16% higher than sensor based irrigation. The sensor based irrigation produced 18% higher yield with better quality fruits (higher TSS and lower acidity), resulting in 51% improvement in water productivity compared with manual irrigation (Table 12).

Table 12. Growth, yield, fruit quality and water productivity of banana under automatic irrigation

Irrigation Treatments	Water applied (mm)	Vegetative growth		Yield (t ha^{-1})	WP (kg mm^{-3})	TSS (^{0}Brix)	Acidity (%)
		PH (m)	CD (m)				
Sensor-based irrigation at 20% ASWD	580	2.13	1.81	68.82	11.86	18.32	0.72
1 h interval 3 times daily at 80% ETc	564	1.75	1.76	61.94	12.79	18.41	0.75
2 h interval 2 times daily at 80% ETc	564	1.67	1.69	61.14	12.83	18.36	0.78
1 h interval 3 times daily at 60% ETc	363	1.52	1.66	53.71	14.79	17.17	0.94
2 h interval 2 times daily at 60% ETc	363	1.47	1.60	53.16	14.64	17.09	0.93
Manual irrigation	744	2.32	1.89	58.33	7.84	17.38	0.82
$CD_{0.05}$	----	0.11	0.05	2.14	3.51	0.13	0.04

ASWD: Available soil water depletion; PH: Plant height; CD: Canopy diameter

In crop growth stage based irrigation and fertigation study, irrigation at 60% ET_c during pre-flowering, 80% ET_c at flowering and fruit setting and 60% ET_c at fruit development integrated with fertigation at 80% RDF at pre-flowering, 100% RDF at flowering and fruit setting and 80% RDF at fruit development produced the fruit yield (56.48 t ha^{-1}) which was statistically at par ($p>0.05$) with that in irrigation at 100% ETc with 100% RDF. However, the superior fruit qualities (higher TSS, lower acidity) and higher water productivity (30%) were observed in differential irrigation with fertigation treatment in compared to FI with RDF. The vegetative growth of the fully irrigated plants with RDF was 5-30% higher than that in variable irrigation and fertigation treatment. The SWC, available N, P and K in soil, light interception and SPAD were higher under 100% ET_c with RDF compared with other treatments. Among different planting techniques (1 plant, 2 plants and 3 plants per pit) with plant density of 3333, 5000, 6000 plants ha^{-1} and WSV, 2 plants per pit (5000 plants per ha) with 40% WV produced 30% higher yield resulting 28% higher water productivity compared with 1 plant per pit with 40% WSV. The yield under 60% WSV (79.96 t ha^{-1}) was 12% higher than that under 40% WSV with 2 plants per pit. The available N, P and K, leaf nutrients, SPAD and vegetative growth of plants (height, canopy spread diameter, stem girth) under 1 plant per pit were 13–46% higher than other treatments. However, light interception was highest with 2 plants per pit among the treatments.

Automatic drip irrigation in banana (cv. Grand Naine)

Eco-friendly Wastewater Treatment for Re-use in Agri-sectors: Lab to Land Initiative (Theme-IV)

Investigators: S. Raychaudhuri, M. Raychaudhuri S.K. Rautaray, S.K. Jena and Rachana Dubey

Collaborating Institutes: ICAR-IARI (WTC), New Delhi

The Chandrasekharpur drain adjacent to ICAR-IIWM gate receives domestic discharges from about 350 families from adjacent LIC residential colony having population of 1400 people along with discharges from small enterprises like automobile repairing unit, xerox/photography, roof and road runoff containing cements, tyre dusts, plastics, pigments, runoff from gardening or horticultural activities using fertilizers. The possible sources for higher Cd level ($\geqslant$0.2 mg kg^{-1}) in the this drain are Ni-Cd battery, paints and pigments, plastics, detergents, personal care products, cosmetics (0.14-1.74 mg Cd kg^{-1}), cement/concrete dust from construction activities, automobile engine oils, tyres, P-fertilizers (109-303 mg Cd kg^{-1}), medicinal products (0.0011 to 0.5559 µg Cd).

Performance of filtration system

The installed wastewater treatment system in drain adjacent to the ICAR-IIWM gate without spillway in the month of May has found to reduce suspended solids and BOD of wastewater by 60 and 45%, respectively. With the spillway, percent reduction of suspended solid decreased to 39% after 20 months of installation. The reductions in BOD were in the range of 27 to 32% after 20 months of installation, even after the upper part of the gabions were removed. This reduction in BOD could be associated with the sedimentation of suspended particles in the 1^{st} chamber. Silt particles coated with pollutants of organic nature might be retained in the first chamber itself.

Impact on crop and aquaculture

A study on the impact of treated and untreated wastewater was repeated in pots. The available NPK and organic C of soils with untreated wastewater were 5, 15, 4 and 2.5% higher than with treated wastewater, but it was not significantly different. The soil EC was 19% higher in soil with untreated wastewater than with treated. The biomass yield with treated and untreated wastewater were found similar. The mean Cd, Cr and Ni concentrations in edible parts of vegetables with treated wastewater were found 33, 40 and 42% lower than with untreated wastewater.

The impact of wastewater on IMC (Indian major carps) has been initiated under laboratory condition with five treatments having different combinations of treated wastewater (TWW) and fresh water (FW) viz., T_1 (100% FW), T_2 (75% FW + 25% TWW), T_3 (50% FW + 50% TWW), T_4 (25% FW+75% TWW) and T_5 (100% TWW). One control using 100% untreated wastewater showed non-survivability of IMCs. The % growth in length and weight is presented in Fig. 21. Maximum 33% increase in body weight was found with T_5 (100 % TWW) followed by T_4 and T_3, probably due to availability of nutrients in wastewater.

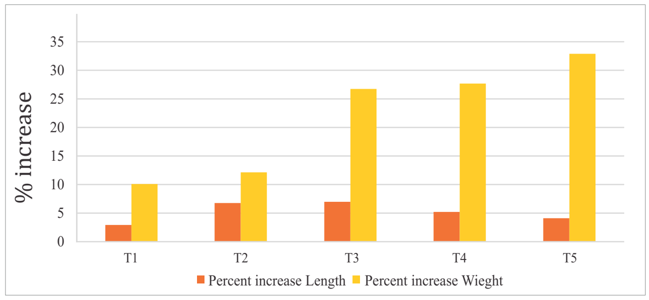


Fig. 21. Impact of wastewater treatment on growth characteristics of IMC

Water Budgeting and Enhancing Water Productivity by Multiple Use of Water in Different Aquaculture Production Systems (Theme-V)

Investigators: R.K. Mohanty, P. Panigrahi and S.K. Ambast

Collaborating Institutes: ICAR-CIFA, Bhubaneswar

A water-use efficient pond based IFS model has been developed at ICAR-IIWM research farm integrating aquaculture, agriculture, on-dyke horticulture and poultry. On-dyke horticulture with 120 plants of banana (cv. G-9) in two rows and 60 papaya plants (cv. Red Lady) in single row planting on the dyke were carried out. Adjacent 0.3 ha area was used for cultivation of *kharif* rice, followed by green gram while, 0.1 ha area was used for ladies' finger cultivation followed by pumpkin. Poultry birds (*Vanaraja*, 50 nos.) had also been introduced as an integrated component. Lifesaving irrigation to on-dyke crops and on-field agriculture crops was provided using the nutrient rich water from the pond of IFS system. System-wise water budgeting (total and consumptive water use), water productivity (gross water productivity, net water productivity, consumptive water use index) and ratio of output value to the cost of cultivation were estimated after harvest of the crops.

Out of System's total crop water use (3.14×10^4 m^3 240 d^{-1}), the estimated total water use (TWU) and consumptive water use index (CWUI) in carp polyculture was 2.9×10^4

Banana and papaya on dyke of pond

m^3 240 d^{-1} and 6.6 m^3 kg^{-1} fish production, respectively. The estimated evaporation and seepage loss were 2.8 m^3 water kg^{-1} and 2.1 m^3 water kg^{-1} fish production respectively. Both these parameters contributed significantly to consumptive water use (CWU). In *C. catla* faster rate of growth and biomass production (%) contributed to yield maximally followed by *C. mrigala* and *L. rohita*. In aquaculture alone, 1 cubic meter of water produced 188 g of carp biomass. The output value: cost of cultivation ratio was 2.6; net consumptive water productivity was ₹ 8.40 m^{-3} and lower average food conversion ratio was 1.62. The net profit was ₹ 79,617 per ha in 240 days activity cycle. The yield from aquaculture was 2.86 t ha^{-1}. The on-dyke horticulture from adjacent 0.3 ha area was the yield of *kharif* rice was 3.42 t ha^{-1}, green gram 0.98 t ha^{-1}.Thereafter, from 0.1 ha area ladies finger yield was 17.1 t ha^{-1}) followed by pumpkin (26.3 t ha^{-1}). The system as a whole, gave net profit of ₹ 1,47,800 ha^{-1} with an output value: cost of cultivation ratio of 2.6 and net consumptive water productivity of ₹ 16.20 m^{-3}. This integrated farming model integrated different crops diversification, enhanced productivity, generate additional employment, increased income and provided nutritional security to resource poor farming community in addition to mitigating the risk factor (both biological and economic), by involving two or more subsystems rather than depending on single-commodity based farming system.

Institutional and Market Innovations Governing Sustainable Use of Agriculture Water (Theme-VIII)

Investigators: P. Nanda and A.K. Nayak

Collaborating Institutes: UAS, Bangalore; NLSIU, Bangalore

Development of groundwater-based irrigation has facilitated the emergence of groundwater market in Balasore district, Odisha. The study of water market and water governance reveals that the water market is informal and it is participated mostly by the small and marginal farmers. The groundwater economy of Balasore district is dominated by centrifugal electric pumps mounted on shallow tube-wells of 60-80 ft. The water rates are fixed on the basis of acreage for whole crop season and also sometimes hourly basis. During *kharif* season, farmers mostly depend upon the rainwater. In case of additional requirement of water during non-rainy days, farmers buy water at the rate of ₹ 1400/- per acre per season. During *rabi* season, sellers charge an average amount of ₹ 2600/- per acre per season, whereas in case of hourly contract of groundwater transaction, sellers charge ₹ 50 h^{-1}. Out of the 81 households surveyed at Balasore district, 80% are actively participated in water market. Nearly 21% of the farmers are involved in water-selling, while a major portion of the farmers (~ 57%) are water-buyers.

The electric-operated pumps are predominant in the surveyed area for which farmers have to pay a fixed amount of ₹ 7,000/- as electricity charge. This induces farmers to overuse their pump-sets as electricity charges do not vary with the extent of use of pumps. Each seller supports to an average of 2.71 buyers. Total (gross) area irrigated by sellers in the surveyed area of Balasore district is 107.37 ha. On an average, each seller supported 41.72% of their own irrigated area and 58.28% of buyer's irrigated area. The cost of extraction (including both fixed and operating cost) turns out to ₹ 22,688 /year, whereas the average selling price turns out to ₹ 38,511/year (Table 13). The water sellers earned a profit of ₹ 38,708 /year over operating cost and ₹ 24,020/year over total cost. Thus, selling water turns out to economically profitable business for the water sellers. On an average the net profit earned by a seller is around ₹ 52,805/year whereas a water buyer earns net benefit of ₹ 33,236/year. Self- users prefer to use their own irrigation sources; therefore they receive more profits as compared to as the water buyers. However, neither selling nor buying of groundwater takes place amongst the farmers in Cuttack.

Table 13. Cost of water extraction and returns from water selling at Balasore, Odisha

Particulars	(₹/year)
Cost of water extraction	
a. Fixed cost on WEM	14,688
b. Operating cost on WEM	8,000
Total cost	22,688
Average selling price (₹)	38,511
Average net income per seller per year	
a. Over operating cost	38,708
b. Over total cost	24,020

WEATHER REPORT OF RESEARCH FARM

Weather Report of Research Farm

The weekly rainfall and open pan evaporation data was recorded during 2018-19 at ICAR-IIWM Research Farm, Deras Mendhasal, Khurda and were analysed, presented in presented Fig. 22. The total rainfall between April 2, 2017 and April 1, 2018 was 1820.1 mm and standard meteorological week (SMW) 29 received the highest rainfall of 294.2 mm. Total evaporation was 1270.8 mm and highest evaporation was observed during SMW 21 (46.2 mm) and thereafter it declined during monsoon period.

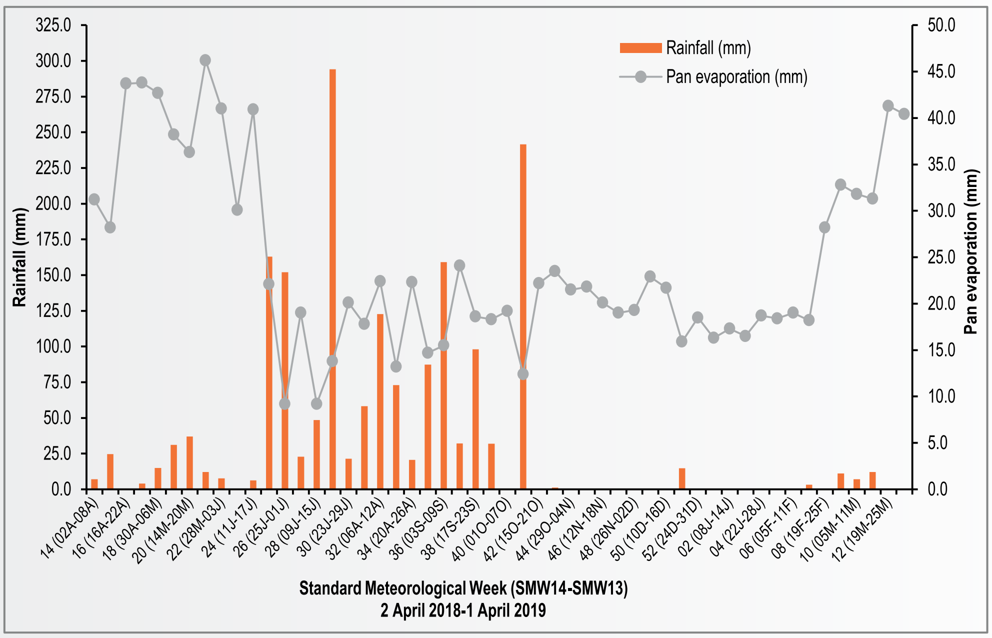


Fig. 22. Weekly rainfall and pan evaporation during April 2018-March 2019 (SMW14-SMW13)

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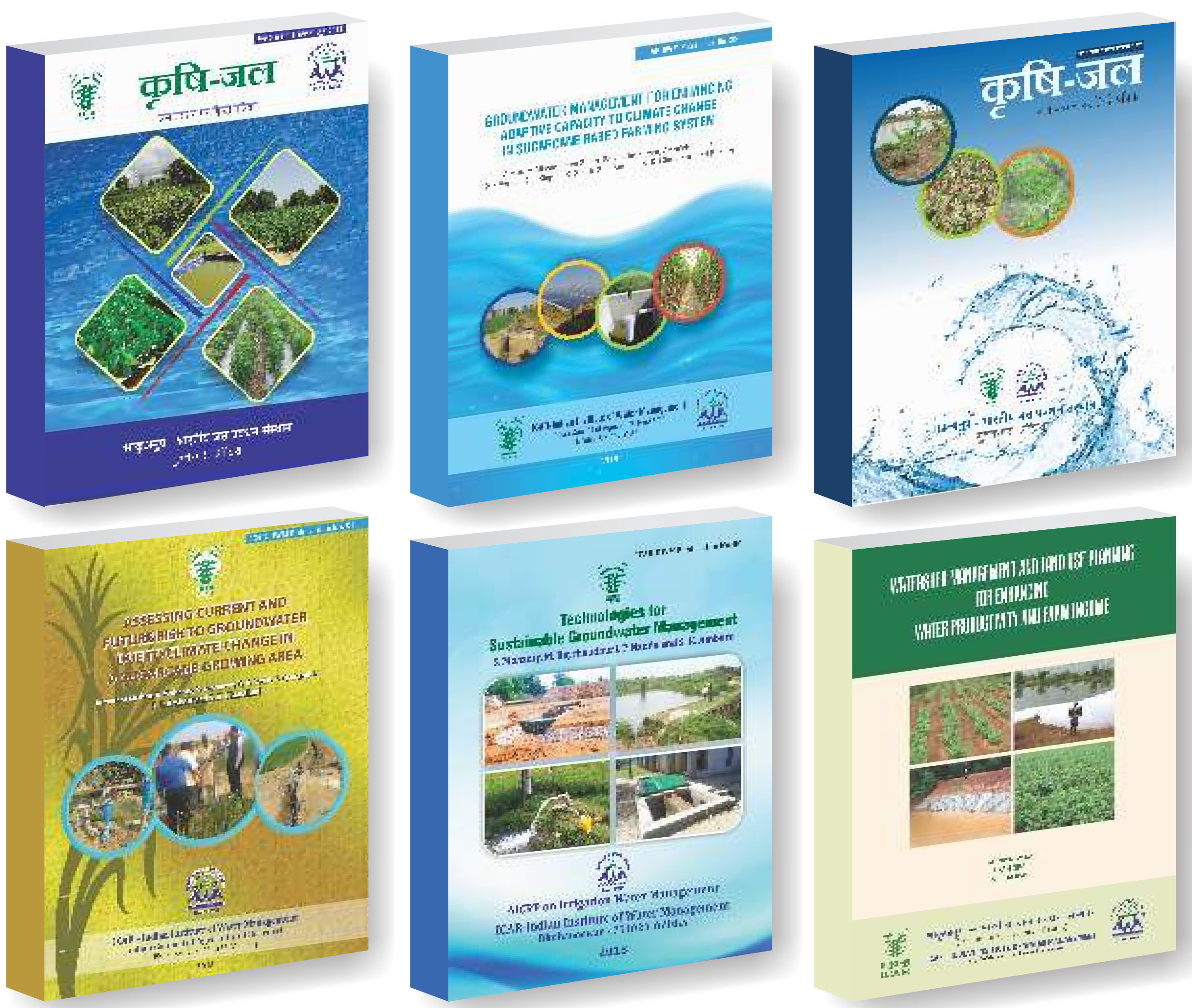
Our Publications



RESEARCH PROJECTS

Research Projects

In-house Projects (2018-19)

Completed Research Projects

Sl. No.	Project Code	Project Title	PI Name
1.	IIWM/15/169	Drainage planning of eastern coast delta using geo-informatics	Dr. S.K. Jena
2.	IIWM/15/172	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.	IIWM/15/173	Inter-regional virtual water trade in India through agro-based products	Dr. G. Kar
4.	IIWM/15/175	Density dependent water use in coastal aquaculture of *Litopenaeus vannamei*	Dr. R.K. Mohanty
5.	Exploratory trial	Evaluating rice ratooning under different management practices to crop and water productivity	Dr. A.K. Thakur

Ongoing Research Projects

Sl. No.	Project Code	Project Title	PI Name
1	IIWM/15/168	Water and nutrient self-reliant farming system for rainfed area under high rainfall zone	Dr. S.K. Rautaray
2	IIWM/15/170	Impact assessment study of using industrial wastewater on sunflower (*Helianthus annus* L.) and mustard (*Brassica nigra* L.) grown in peri-industrial area of Angul, Odisha	Dr. R. Dubey
3	IIWM/15/171	Developing the process for remediation of chromium from polluted water sources	Dr. M. Das
4	IIWM/15/174	Enhancing water productivity through water management in transplanted and aerobic rice in canal command area	Dr. K.G. Mandal
5	IIWM/15/176	Enhancing water productivity through intensive horticultural system in degraded land	Dr. S. Pradhan

6	IIWM/16/177	Benchmarking of public irrigation schemes for improving performance of irrigated agriculture	Dr. A. Mishra
7	IIWM/16/178	Socio-economic and environmental linkages of groundwater irrigation in selected aquifers of India	Dr. D. K. Panda
8	IIWM/16/179	Water use efficient practices for successful establishment and yield enhancement of pulse crops in rice based cropping system in seasonal waterlogged ecosystem	Dr. P.S. Brahmanand
9	IIWM/16/180	Design and field evaluation of groundwater recharge structures for hard rock region	Dr. R.R. Sethi
10.	IIWM/16/181	Development of web-based expert system on agricultural water management	Dr. A.K. Nayak
11.	IIWM/16/182	Enhancing yield and water productivity of rice-fallow areas of eastern India through super absorbent polymers (SAP)	Dr. S. Pradhan
12.	IIWM/17/183	Development and evaluation of mini pan-evaporimeter for on-farm irrigation scheduling	Mr. N. Manikandan
13.	IIWM/17/184	Evaluation of land shaping options for increasing farm income in coastal waterlogged area	Dr. S. Roy Chowdhury
14.	IIWM/17/185	Assessment of groundwater contamination due to excess fertilizer and pesticide uses and its management in lower Godavari basin	Dr. A. Sarkar / P. Deb Roy
15.	IIWM/17/186	Smart water management system in agriculture	Dr. D. Sethi
16.	IIWM/17/187	Socio-economic evaluation of water related interventions under MNREGA	Dr. H.K. Dash

New Research Projects

Sl. No.	Project Code	Project Title	PI Name
1.	IIWM/18/188	Water management using artificial substrate induced periphyton biomass in zero-water exchange shrimp culture system	Dr. R.K. Mohanty
2.	IIWM/18/189	Impact of water stress on growth and physiology of rice under different crop management practices	Dr. A.K. Thakur
3.	IIWM/18/190	Arsenic contamination in rice and possibility of mitigation through organic and chemical amendments	Mr. Partha Deb Roy
4.	IIWM/18/191	Refinement of small scale online wastewater filter for safe irrigation practice	Dr. M. Raychaudhuri
5.	IIWM/18/192	Analysing the functioning of water user association in different irrigation command	Dr. M.K. Sinha
6.	IIWM/18/193	Impacts of land-atmosphere interactions on dry-hot episodes in India	Dr. D.K. Panda

Research Projects

Externally Funded (2018-19)

Title	Budget (Rs. in lakh)	Duration	PC / NO / PI / CCPI	Sponsored by
All India Co-ordinated Research Project on Irrigation Water Management	7484.64	2017-20	Dr. S.K. Ambast, PC	ICAR, New Delhi
Agri-Consortia Research Platform on Water	1302.19	2017-20	Dr. S.K. Ambast, LCPC Dr. P. Panigrahi, Dy LCPC	ICAR, New Delhi
I. Development and Management of Integrated Water Resources in Different Agro-ecological regions of India	-	-	Dr. S.K. Jena	Agri-Consortia Research Platform on Water, ICAR, New Delhi
II. Evaluation of Irrigation System and Improvement Strategy for Higher Water productivity in Canal Commands	-	-	Dr. R.K. Panda	Agri-Consortia Research Platform on Water, ICAR, New Delhi
III. Automatic Irrigation and Fertigation in Drip-irrigated Banana under Efficient Water Management in Horticultural Crops	-	-	Dr. P. Panigrahi	Agri-Consortia Research Platform on Water, ICAR, New Delhi
IV. Eco-friendly Wastewater Treatment for Re-use in Agri-sectors: Lab to Land Initiative	-	-	Dr. S. Raychaudhuri	Agri-Consortia Research Platform on Water, ICAR, New Delhi
V. Water Budgeting and Enhancing Water Productivity by Multiple Use of Water in Different Aquaculture Production Systems	-	-	Dr. R.K. Mohanty	Agri-Consortia Research Platform on Water, ICAR, New Delhi
VI. Institutional and Marketing Innovations Governing Use of Agriculture Water	-	-	Dr. P. Nanda	Agri-Consortia Research Platform on Water, ICAR, New Delhi
National Initiative for Climate Resilient Agriculture (NICRA)	600.00	2012-2020	Dr. G. Kar	ICAR, New Delhi
Index Based Flood Insurance (IBFI) and Post-Disaster Management to Promote Agriculture Resilience in Selected States in India	171.71 (USD268305)	2017-2020	Dr. S.K. Ambast, Nodal Officer; Dr. P.S. Brahmanand (PI)	International Water Management Institute (IWMI), Colombo
Enhancing Economic Water Productivity in Irrigation Canal Commands	112.32 (USD175500)	2017-2020	Dr. S.K. Ambast, Nodal Officer; Dr. R.K. Panda (PI)	International Water Management Institute (IWMI), Colombo
Revival of Village Ponds Through Scientific Intervention	28.82	2017-2019	Dr. S.K. Jena	DST, Ministry of Science & Technology, New Delhi
Development of Biological Filter for Safe Wastewater Irrigation Exploiting Microbial Bioremediation Trait	138.684	2017-2020	Dr. S. Raychaudhuri	National Agricultural Science Fund, ICAR, New Delhi
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. A. Mishra	Ministry of Agriculture, Govt. of India

Enhancing Land and Water Productivity through Integrated Farming System (Scheduled Tribe Component Project)	25.00	2013-2018	Dr. R.K. Panda	ICAR, New Delhi
Enhancing Water and Livelihoods Security and Improving Water Productivity in Tribal Dominated Paddy Fallow Rainfed Agro Ecosystem of Odisha (Farmer's FIRST Program)	40.00	2018-20	Dr. S.K. Ambast, Nodal Officer; Dr. P. Nanda (PI)	ICAR, New Delhi
Optimizing Soil Organic Carbon Stock in Rice Based Cropping System Under Irrigated Ecosystem	43.59	2019-22	Dr. R. Dubey	Science & Engineering Research Board, DST, Ministry of Science & Technology, New Delhi

Collaborative

Title	Budget (Rs. in lakh)	Duration	CCPI	Sponsored by
Assessment of Soil Fertility and Preparation of Soil Fertility Maps for Various Agro-Ecosystems of Odisha (with ICAR-CTCRI Regional Center, Bhubaneswar)	84.53	2014-2018	Dr. M. Das	RKVY, Office of the Director of Horticulture, Odisha

Consultancy

Title	Budget (Rs. in lakh)	Duration	P.I. / CCPI	Sponsored by
Training Program on 'Watershed Management and Land Use Planning for Enhancing Water Productivity and Farm Income' under MGNREGS, Govt. of West Bengal (5 Training Programs)	33.32	July 23-September 27, 2018	Course Director: Dr. S.K. Ambast Course Coordinators: Dr. G. Kar Dr. P. Panigrahi	Additional Secretary, Govt. of West Bengal, Commissioner, MGNREGS. Govt. of West Bengal Panchayats and Rural Development
Preparation of State Irrigation Plan for the State of Odisha	49.737	May 1, 2018-February 15, 2019	Dr. S.K. Ambast Dr. R.R. Sethi Dr. R.K. Panda Dr. P.S. Brahmanand	Directorate of Soil Conservation & Watershed Development (DSC&WD), Govt. of Odisha, Bhubaneswar

Awards, Honours & Recognitions

Best Institute Award-2017

ICAR-Indian Institute of Water Management received '**The Sardar Patel Outstanding ICAR Institution Award-2017**' amongst the ICAR institutes of 'Small Institutes' Category.

राजभाषा गौरव पुरस्कार

जलवायु परिवर्तन के प्रतिकूल प्रभावों को ध्यान में रखते हुए कृषि क्षेत्र में उचित जल के आवंटन एवं प्रबंधन के साथ साथ जलवायु परिवर्तन के प्रतिकूल प्रभावों में कमी लाने तथा महत्वपूर्ण जलवायु अनुकूलित कृषि पद्धतियों का वर्णत करके राजभाषा हिन्दी में एक मौलिक पुस्तक लिखी गई, जिसका शीर्षक 'भारत में जल एवं खाद्य सुरक्षा के लिये जलवायु परिवर्तन के अनुकूल कृषि' है। यह पुस्तक डॉ. गौरांग कर, डॉ. ओम प्रकाश वर्मा एवं डॉ. सुनील कुमार अम्बष्ट, भाकृअनुप - भारतीय जल प्रबंधन संस्थान, भुवनेश्वर, ओडिशा द्वारा लिखी गई। इक पुस्तक को वर्ष 2017 के लिये मौलिक पुस्तक लेखन की श्रेणी के अंतर्गत केन्द्र सरकार के कार्मिकों हेतु गृह मंत्रालय, भारत सरकार का राजभाषा गौरव पुरस्कार (प्रथम) प्राप्त हुआ है। यह पुरस्कार 14 सितंबर 2018 को हिन्दी दिवस समारोह के अवसर पर भारत के उपराष्ट्रपति माननीय श्री एम.वेंकैया नायडु के कर कमलों द्वारा प्रदान किया गया। इस समारोह की अध्यक्षता माननीय गृहमंत्री, भारत सरकार, श्री राजनाथ सिंह जी ने की। इस समारोह में श्री हंसराज गंगाराम अहीर जी तथा श्री किरेन रीजीजू जी, माननीय गृह राज्य मंत्री, भारत सरकार भी उपस्थित थे।

- Dr. K.G. Mandal, Dr. R.K. Mohanty, Dr. S. Ghosh, Dr. M. Raychaudhuri, Dr. A. Kumar & Dr. S.K. Ambast have received the 'BKJF-INCSW Sookshma Sinchai Purashkar-2018', conferred jointly by the INCSW of CWC, Ministry of Water Resources, River Development & Ganga Rejuvenation, Govt. of India and the Bhavarlal & Kantabai Jain Foundation (BKJF), Jalgaon.

- Dr. K.G. Mandal, Principal Scientist has received 'Dr. K.G. Tejwani Award' for biennial 2016-2017 for outstanding contributions to management of natural resources; conferred by the Indian Association of Soil and Water Conservationists (IASWC), Dehradun.

- Dr. M. Das, Principal Scientist recognized as 'Fellow of Indian Society of Soil Science', New Delhi during 83rd Annual Convention of ISSS held during November 27-30, 2018 at AAU, Gujarat.

- Dr. S. Mohanty, Dr. K.G. Mandal, Dr. S.K. Rautaray, Dr. R.K. Mohanty, Dr. S.K. Ambast and Dr. B. Behera have received 'K.C. Das Memorial Award', conferred by The Institution of Engineers (India), Odisha State Centre, Bhubaneswar.

- Dr. P.S. Brahmanand, Principal Scientist awarded with 'Leadership Award-2018' of Soil Conservation Society of India by Shri Banwarilal Purohit, Hon'ble Governor, Govt. of Tamil Nadu for his significant contribution in the field of soil and water conservation on January 31, 2019 at Ooty, Tamail Nadu.

- Dr. A. Mishra, Dr. S.K. Rautray, Mr. Abhishek Waghye and Dr. C. Chatterjee bestowed with 'Banabihari Mohanty Memorial Award' from the Institution of Engineers (India), Odisha Chapter, Bhubaneswar during the 60th Annual Technical Session on March 30, 2019 for the paper entitled 'Rainwater management in mango orchards through micro-catchments'.

- Dr. P.K. Panda, Dr. R.K. Mohanty, Dr. P. Panigrahi and Dr. S.K. Ambast received 'Best Poster Award' at National Conference on Farmers First for Conserving Soil and Water Resources in Eastern Region at ICAR-IISWC Regional Centre, Koraput, Odisha held during February 6-8, 2019 for the paper entitled 'Water resource conservation and its management in rainfed area for doubling farm income'.

- Dr. Rachana Dubey, Scientist has received DST project entitled 'Optimizing Soil Organic Carbon Stock in Rice Based Cropping System under Irrigated Ecosystem' under 'Early Career Research Award' by the Science and Engineering Research Board (SERB).

- Dr. S.K. Jena, Principal Scientist, has been nominated by ICAR as member, Institute Management Committee (IMC) of ICAR-Indian Institute of Soil & Water Conservation, Dehradun and ICAR Research Complex for Eastern Region, Patna, Bihar.

- Dr. S.K. Rautaray, Principal Scientist, has been nominated by ICAR as member, Institute Management Committee (IMC) of ATARI Bengaluru.

- Dr. P.S. Brahmanand, Principal Scientist has been selected as Vice-president (East Zone), Soil Conservation Society of India for the period of two years (2019-2021).
- Dr. M. Raychaudhuri, Principal Scientist appointed as recorder for the section-'Agriculture and Forestry Sciences' for 2018-2020 by Indian Science Congress Association; Chaired technical session in workshop on 'Advances in Environmental Protection and Sustainability' held at IIT, Guwahati on June 2, 2018.
- Dr. M. Das, Principal Scientist, has been nominated as an evaluator of 25th National Children Science Congress (NCSC) organized by Dept. of Science and Technology, Govt. of India, held at SoA University, Bhubaneswar during December 27-31, 2018.
- Dr. M. Raychaudhuri, Principal Scientist has been invited to deliver lead lecture on 'Agribusiness Ventures to Sustain Irrigation Water and Soil Health in Indian Agriculture' in the technical session Theme 2: 'Agribusiness venture: Track 1 Agriculture, Horticulture, Forestry and Food Processing' on February 11, 2019 at ICAR Research Complex for NEH region, Umiam, Meghalaya.
- Dr. S. Raychaudhuri, Principal Scientist has been nominated for presentation in Science Communicator's Meet in the 106th Indian Science Congress held at Lovely professional University, Jalandhar, during January 3-7, 2019.
- Dr. M. Raychaudhuri, Principal Scientist has been invited to deliver lecture on 'Soil health build up as the prime need in organic management and conversion to organic with soil health management' at Regional Centre for Organic Farming, Bhubaneswar, Department of Agriculture and Cooperation, GoI.
- Dr. S.K. Jena, Principal Scientist, has been nominated as member, Research Advisory Committee, OUAT, Bhubaneswar for M. Tech student.
- Dr. R.K. Panda, Principal Scientist has been invited as an expert in the selection committee to assess the scientist under CAS in the discipline of Soil & Water Conservation Engineering at ICAR-NIASM, Baramati, Maharashtra; and in the discipline of Soil & Water Conservation Engineering at ICAR-NBSSLUP, Nagpur, Maharashtra.
- Dr. M. Raychaudhuri, Principal Scientist has been invited as an expert in the selection committee by Dr. RPCAU, Pusa for the post (s) of SMS (Soil Science).
- Dr. S.K. Rautaray, Principal Scientist has been invited as an external examiner for M.Tech. students in the discipline of Agricultural System Management at IIT, Kharagpur; and for M.Sc. (Ag) students in the discipline of Agronomy, OUAT, Bhubaneswar.
- Dr. M. Raychaudhuri, Principal Scientist has been invited as an expert in the selection committee by UBKV, Coochbehar for the promotion of teachers, subject matter specialist (Soil Science) and programme assistant (Lab. Technician); Career Advancement Scheme (CAS) in the discipline of Soil Science and Agricultural Chemistry.
- Dr. S. Roy Chowdhury, Principal Scientist has been invited as an external examiner for M. Sc. students in the discipline of Plant Physiology and Molecular Biology at Viswa Bharati Central University, Santiniketan, West Bengal.
- Dr. P.S. Brahmanand, Principal Scientist has been invited for an inaugural speech as Chief Guest CSIR-IMMT, Bhubaneswar on the occasion of *Hindi Pakhwada*.
- Dr. P.S. Brahmanand, Principal Scientist has been invited to talk on 'Ideology of Swami Vivekananda and Its Relevance to Present Society" on the occasion of National Youth Day (January 12, 2018) at Vivekananda Siksha Kendra, Bhubaneswar.
- Dr. M. Raychaudhuri, Principal Scientist co-chaired technical session on 'Soil Engineering and Technology I' in 83rd Annual Convention of Indian Society Soil Science held at Anand Agricultural University (AAU), Gujarat during November 27-30, 2018.
- Dr. S. Raychaudhuri, Principal Scientist has been invited to deliver plenary lecture in the workshop on 'Advances in Environmental Protection and Sustainability', organized by IIT, Guwahati.
- Dr. S. Raychaudhuri, Principal Scientist has been invited for keynote address in the workshop on 'Polluted River Stretches-Preparation of Action Plan (For North East States)' under National Hydrology Project (NHP) Advances in Environmental Protection and Sustainability organized by IIT, Guwahati.
- Dr. S. Raychaudhuri, Principal Scientist has been invited as Guest of Honor in the inaugural ceremony of the Training on Water conservation at Red Cross Bhawan, Bhubaneshwar, organized and invited by NIHIDA, Odisha.
- Dr. M. Raychaudhuri, Principal Scientist became women chess and women table tennis champion during 'ICAR Zonal Sports (Eastern Zone) Tournament 2018' at ICAR-IINRG, Ranchi, Jharkhand held during October 5-8, 2018.

Deputation Abroad

- Dr. P.S. Brahmanand, Principal Scientist & PI of IBFI project visited University of Georgia, USA during May 14-19, 2018 on deputation to participate an International Training Program on DSSAT-4.7 Version with a theme 'Assessing Crop Production, Nutrient Management, Climatic Risk and Environmental Sustainability with Simulation Models'.
- Dr. A.K. Thakur, Principal Scientist, visited Singapore and Malaysia to attend and present paper in 5th International Rice Congress (IRC2018) during October 15-17, 2018 at Singapore; and attended 'Workshop to Enhance Cooperation and Sharing among SRI National Networks and Stakeholders in Asia' during October 18-19, 2018 at Malaysia.
- Dr. S. Mohanty, Principal Scientist visited Egypt to attend a training program on 'Soil and Water Management' at Egyptian International Center for Agriculture' at Cairo during October 18 - December 15, 2018.
- Dr. S.K. Ambast, Director, visited at Tel Aviv, Israel as leader of the Indian delegation on behalf of Bureau of Indian Standard (BIS) to attend International Standards Organization (ISO) meeting during October, 20-25, 2018.
- Dr. A.K. Thakur, Principal Scientist, invited to present his research work and as an external examiner for Ph.D. Thesis defense at Wageningen University and Research (WUR), The Netherlands during March 4-8, 2019.

DD Kisan/ Radio Talk

- Dr. P. Nanda and Dr. P.K. Panda participated as an experts in the panel discussion on '*Pradhan Mantri Krishi Sinchai Yojana* and its implications', telecasted on June 8, 2018 on Doordarshan.
- Dr. P.K. Panda participated as an expert in the panel discussion on '*Pradhan Mantri Krishi Sinchai Yojana* (PMKSY)', telecasted on July 5, 2018 and on 'How to ensure water security to all?' on the occasion of World Water Day on March 19, 2019 on Doordarshan.
- Dr. P.K. Panda participated as an expert to discuss on the topic 'Strategies for Doubling Farm Income' on All India Radio, Cuttack on June 10, 2018.
- Dr. P.K. Panda, Principal Scientist of this institute delivered a radio talk on '*Khadya Surakhya Pain Mati Maara Jatna* (Soil Health Maintenance for Food Security)' on December 4, 2018 on the occasion of World Soil Day; and on 'Aim and objective of world water day celebration' on March 19, 2019 at All India Radio, Cuttack.
- Dr. P.K. Panda, Principal Scientist of this institute participated as an expert to discuss on the topic '*Bivinna Fasala Pain Jalara Suparichalana* (Efficient Water Management Practices for Various Crops)' at All India Radio, Cuttack on December 28, 2018.

ICAR-IIWM Sports Team at ICAR-IINRG, Ranchi

RESEARCH MANAGEMENT MEETINGS

Research Management Meetings

Institute Research Council (IRC) Meeting

Institute's Research Council (IRC) meeting was organized during May 17-19, 2018 at ICAR-IIWM under Chairmanship of Dr. S.K. Ambast, Director of the institute. Results of the twenty on-going in-house research projects under different programs were presented and deliberated in the meeting. Also, eight new research project proposals were presented and discussed. Dr. S.K. Ambast, Director & Chairman, IRC concluded with remarks and encouraged scientists to continue good work, timely reporting and systematic record keeping. He also emphasized to find out parameters like water use efficiency, water productivity, agricultural productivity, net return and water saving from most of the projects, and publication after completion of each project.

2nd meeting of the Institute Research Council (IRC) was organized during October 30-31, 2018. Results and achievements of nine projects, viz. six projects under Agri-CRP on Water, AICRP on Irrigation Water Management and two institute ongoing projects were presented and discussed. Also, two new research project proposals were also presented and discussed during the meeting. Dr. S.K. Ambast, Director & Chairman, IRC concluded with remarks and encouraged scientists to continue good work as well as timely reporting and systematic record keeping. He also encouraged scientists for bringing externally funded projects. Dr. S.K. Jena, Principal Scientist & Member Secretary, IRC organized the meeting.

ICAR-IIWM Organized Biennial Workshop of AICRP-IWM

The Biennial Workshop of All India Coordinated Research Project on Irrigation Water Management (AICRP-IWM) was organized at Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth (DBSKKV), Dapoli, Maharashtra during June 13-15, 2018. Dr. S.K. Chaudhari, ADG (S&WM) graced the inaugural function as Chief-Guest and Dr. S.S. Magar, Ex-Vice Chancellor of the university presided over the session. Dr. Chaudhari expressed the need to extend the developed technologies to the farmers. Dr. Magar emphasized the importance of water for future. Dr. S.K. Ambast, Director, ICAR-IIWM and Project Coordinator, AICRP-IWM, Bhubaneswar, welcomed the dignitaries on and off the dais and briefed about the achievements of AICRP-IWM. Dr. P. Nanda and Dr. S. Mohanty, Principal Scientist, ICAR-IIWM organized this workshop.

Review Meeting of 'Agri-Consortia Research Platform on Water' Project of ICAR

Dr. S.K. Chaudhari, ADG (S&WM), NRM, ICAR and Dr. S.K. Ambast, Director, ICAR-IIWM reviewed the progress and achievements of eight major themes under 'Agri-Consortia Research Platform on Water' project of ICAR during 2018-19 on December 7, 2018 at ICAR-IIWM, Bhubaneswar. The PIs and CCPIs of all the research projects from twenty five different Institutes/ Universities presented their technical and financial progress of the projects during first six months of FY 2018-2019 during this meeting. Dr. Chaudhari expressed satisfaction on performance of these projects and emphasized the need for further strengthening the research methodology with data recording and analysis to come up with new scientific information, protocols and guidelines in the field of agricultural water management. Dr. Ambast stressed on the better ways of presentation of the results and documentation of the information generated under different themes of the project. Dr. P. Panigrahi, Senior Scientist and Dy LCPC, CRP-Water coordinated this review meeting.

HRD, TRAINING AND CAPACITY BUILDING

HRD, Training and Capacity Building

Participation in trainings (Category-wise)

Official & Designation	Subject	Organization	Period
Dr. S.K. Jena, Principal Scientist	Training on ERDAS/IMAGINE Professional -2016 software	Intergraph, Kolkata at ICAR-IIWM, Bhubaneswar	April 11-13, 2018
Dr. S.K. Jena, Principal Scientist	Training on ESRI ARC GIS DESKTOP 10.5.1 software	ESRI India, Kolkata at ICAR-IIWM, Bhubaneswar	April 18-20, 2018
Mr. S.C. Das, LDC	Hospitality Management	ICAR-NAARM, Hyderabad	April 20-25, 2018
Dr. P.S. Brahmanand, Principal Scientist	International Training Program on DSSAT-4.7 Version with a theme “Assessing Crop Production, Nutrient Management, Climatic Risk and Environmental Sustainability with Simulation Models'	University of Georgia, USA	May 14-19, 2018
Dr. S.K. Rautaray, Principal Scientist Dr. M.K. Sinha, Principal Scientist	MDP on Leadership Development (a pre-RMP program)	ICAR-NAARM, Hyderabad	June 4-15, 2018
Dr. O.P. Verma, Scientist	MTC on 'Soil and Water Conservation Technologies for Ensuring Water Availability to Farmers'	IGKV, Raipur	August 24-31, 2018
Mr. A. Parida, ST	Farm Management	ICAR-IIFSR, Modipuram	September 14-20, 2018
Dr. A.K. Nayak, Principal Scientist	Advances in Web and Mobile Application Development	ICAR-NAARM, Hyderabad	October 5-10, 2018
Dr. S. Mohanty, Principal Scientist	International Training Program on 'Soil and Water Management'	Egyptian International Centre for Agriculture (EICA), Cairo	October 17 - December 15, 2018

Dr. R. Sethi, Principal Scientist	Aquifer-based Participatory Groundwater Management	National Institute of Agricultural Extension Management (MANAGE), Hyderabad	November 12-16, 2018
Dr. M. Raychoudhuri, Principal Scientist	MDP on Leadership Development (a pre-RMP program)	ICAR-NAARM, Hyderabad	December 18-27, 2018
Mr. L. Singh Tiyu, STA	Automobile Maintenance; Road Safety & Behavioral Skill	ICAR-CIAE, Bhopal	January 16-22, 2019
Mr. S.K. Singh, AO Mr. V.K. Sahoo, FAO	Sensitization Workshop of E-Office	ICAR-IASRI New Delhi	January 23-24, 2019
Dr. M. Das, Principal Scientist	Geospatial Analysis using QGIS and R	ICAR-NAARM, Hyderabad	February 1-6, 2019

Training organized by ICAR-IIWM

Subject	Place	Period	Participants
Summer training program for M. Tech. students of CAET, OUAT, Bhubaneswar on various aspects of water management	ICAR-IIWM, Bhubaneswar	May 16-June 16, 2018	3
Summer training program for M. Tech. student of Junagarh Agriculture University, Gujarat on various aspects of water management	ICAR-IIWM, Bhubaneswar	July 5-30, 2018	1
Watershed Management and Land Use Planning	ICAR-IIWM, Bhubaneswar	July 23-28, 2018 August 6-11, 2018 August 27-September 1, 2018 September 10-15, 2018 September 22-29, 2018	125
Stakeholders' workshop on State Irrigation Plan of Odisha under PMKSY	ICAR-IIWM, Bhubaneswar	October 1, 2018	17
On-farm Water Management Technologies for Improving Water Productivity	ICAR-IIWM, Bhubaneswar	January 21-24, 2019	41
Stakeholders' workshop on State Irrigation Plan of Odisha under PMKSY	ICAR-IIWM, Bhubaneswar	February 4, 2018	15

Farmers' training programs organized by ICAR-IIWM

Subject	Place	Period	Participants
Field diagnosis of crop and water management problems and suggestions under STC project	Moulijor village, Sundergarh	May 2-3, 2018	100
Awareness camp and Training program on 'Kitchen gardening, aquaculture and *kharif* crop advisory'.	Birjaberna village, Sundargarh	September 25-26, 2018	60
Farmer's training program under Farmer's FIRST project	Khuntapingu, Malarpada and Jamuda villages, Keonjhar	October 23-25, 2018	394
Farmer's Fair cum Farmers-Scientists Interaction Meet	Parbatiya village, Dhenkanal	November 9, 2018	200
Celebration of 'World Soil Day'	Durgapur village, Chhatabar GP, Khurda	December 5, 2018	75
Farmer's Fair cum Farmers-Scientists Interaction Meet	Alisha village, Puri	December 14, 2018	250
Farmer's training program cum demonstration on 'System of Rice Intensification (SRI) method of rice cultivation' under Farmer's FIRST project	Malarpada village, Keonjhar	January 11, 2019	30
Kisan Mela for 'Enhancing economic water productivity in irrigation command'	Sina Medium Irrigation Project Site, Maharashtra	February 14, 2019	100

Farmers/Students-Experts Interaction-cum-Exposure Visit Programs

Farmers/ Students from	Date	Participants
Sutahata Block, Purba Midnapur, West Bengal	April 4, 2018	45
KIIT Rural Management, Bhubaneswar	July 11, 2018	-
Purba Midnapur, West Bengal	July 16, 2018	40
Egra Block II, Purba Midnapur, West Bengal	July 25, 2018	30
College of Forestry, OUAT, Bhubaneswar	November 13, 2018	44
CAU, Tura, Meghalaya	December 21, 2018	40
Srikulam District, AP	January 28, 2019	25
Jharkhand Agriculture and Management Institute, Ranchi	February 2, 2019	51
Agro Polytechnic Centre (OUAT), Bhadrak	February 19, 2019	19

HRD Fund Allocation and Utilization during 2018-2019

Figures in lakhs

Budget Head	Budget (RE)	Expenditure	% Utilization
H.R.D.	2.68	2.62	97.6

Exhibitions

Institute's achievements were displayed/ showcased in the following exhibitions held in different locations:

Events	Place	Date / Period
Foundation Day Celebration of ICAR - NRRI, Cuttack	ICAR-NRRI, Cuttack	April 23, 2018
9^{th} *Krishi* Fair	*Shree Shrikhetra Soochana*, Puri	June 3-7, 2018
International Science Festival 2018, jointly organized by Institute of life Science (ILS), Bhubaneswar and ICMR-RMRC, Bhubaneswar	ILS Campus, Bhubaneswar	September 22-23, 2018
State-level Exhibition (*Krushi* Odisha 2019)	Barmuda, Bhubaneswar	January 15-19, 2019
Exhibition organized by ICAR-IISWC, Dehradun and IASWC, Dehradun	Sunabeda, Koraput	February 6-8, 2019
Exhibition	ICAR-CIFA, Bhubaneswar	February 18-19, 2019
State-level *Kisan Mela*	ICAR-NRRI, Cuttack	February 26, 2019

Prof. Ganeshi Lal, Governor, Odisha visited exhibition stall of ICAR-IIWM

Women Empowerment

Mahila Kisan Divas Celebrated

ICAR-IIWM organized '*Mahila Kisan Diwas*' at Research Farm, Deras, Mendhasal on October 15, 2018. Sixty five woman farmers from Durgapu, Jamujhari, Giringaput, Haridamada and Jamujhari villages participated in the interaction meeting between scientists and farmers. They were informed about the importance of agriculture, women-friendly and water saving technologies. Interaction meeting was followed by field visit and they were exposed to various technologies, viz., micro-irrigation, land modification for storing excess rainwater, growing papaya at the embankment of rainwater harvesting structure etc. Dr. M. Das and Dr. P.K. Panda, Principal Scientists coordinated the program.

Interaction with women farmers at research farm

International Women's Day Celebrated

An interaction meeting was organized to celebrate International Women's Day on March 8, 2019 at ICAR-IIWM Research Farm, Deras, Mendhasal. Forty three women farmers from five MGMG selected villages viz., Giringaput, Durgapur, Chhatabar, Haridamada and Jamujhari participated in the meeting. Scientists from ICAR-IIWM discussed on issues like, importance of women in agriculture especially in agricultural water management, various water management technologies, promoting entrepreneurship ability of women's and rearing of farm animals with proper mediation and supplements etc. Dr. P.K. Panda, Dr. R. Dubey and Dr. D. Sethi organized this meeting.

Interaction with farm women during International Women's Day

WOMEN EMPOWERMENT

Training Programme Organized

A women farmers' training was organized on September 25, 2018 at Birjaberna village, Sundargarh district for encouraging backyard cultivation using pipe based irrigation system. Sixty tribal women farmers attended this training program. Dr. R. K. Panda organized this program.

Farmer's Training under Farmer's FIRST Project

Three one-day farmer-training programs on 'Water Resource Management and Agricultural Diversification for Enhancing Water Productivity and Ensuring Livelihood of Farmers' were organized under Farmer's FIRST Project at Khuntapingu, Malarpada and Jamuda villages (Dist. Keonjhar) on October 23, 24 and 25, 2018, respectively. A total of 394 farmers including women farmers actively participated in the training programs. One women farmer Mrs. Mina Mahanta of village Khuntapingu was awarded the 'best farmer' award for her innovative role in using and popularizing sprinker irrigation in vegetable cultivation.

Smt. Meena Mohanta, Khuntapingu village, Keonjhar, receiving Award from Hon'ble Union Minister of Agriculture and Farmer Welfare on February 26, 2019

PARTICIPATIONS

Participations

Conferences, Meetings, Workshops, Symposia, Deputations

Official	Name of the Conference / meeting / workshop / symposium / Seminar	Organized by	Period
Dr. R.K. Panda	Workshop on 'Enhancing Economic Water Productivity in Irrigation Canal Commands' under ICAR-IWMI Collaborative Project at Pune, Maharashtra	AICRP-IWM, Rahuri, Maharashtra	April 9, 2018
Dr. K.G. Mandal Dr. A.K. Thakur	72nd Foundation Day Lecture on 'Towards Enhancement of Water Use Efficiency in Rice'	ICAR-NRRI, Cuttack	April 23, 2018
Dr. P.S. Brahmanand	Pre-project Meeting on IBFI	ICAR-IIWM, Bhubaneswar	May 7, 2018
All Scientists of ICAR-IIWM	Workshop on 'Management of Water Related Risks- Floods and Droughts'	IWMI, New Delhi & ICAR-IIWM, Bhubaneswar	May 8, 2018
All Scientists of ICAR-IIWM	Brainstorming Workshop on 'Way Forward for Application of Agricultural Technologies in Developing Aspirational Districts of Odisha'	ICAR-IIWM, Bhubaneswar	May 12, 2018
Dr. S. Raychaudhuri	Workshop on 'Advances in Environmental Protection and Sustainability (AEPS-2018)'	Centre for the Environment, IIT, Guwahati	June 1, 2018
Dr. G. Kar	25th General Body Meeting and Foundation Program	National Academy of Agricultural Sciences, New	June 4-5, 2018
Dr. P. Nanda	Biennial Workshop at BSKVV Dapoli	AICRP on IWM and BSKVV Dapoli	June 12-13, 2018
Dr. R.K. Panda	Odisha Vikash Conclave 2018 on River Ecology	ICAR-IIWM, Bhubaneswar	June 14, 2018
Dr. R.K. Panda Dr. M. Raychaudhuri Dr. S. Raychaudhuri	24th Meeting of the Regional Committee II of ICAR	ICAR-CIFRI, ICAR-CIFA & OUAT, Bhubaneswar	June 22, 2018
Dr. P.S. Brahmanand	ICAR-IWMI Steering Committee Meeting	NASC Complex, New Delhi	June 25, 2018

Dr. R.K. Mohanty	National Workshop on 'Aqua One Centre: An ICT Enabled Aquaculture Support Service'	NFDB and ICAR-CIFA, Bhubaneswar	July 3, 2018
Dr. P.S. Brahmanand	Divisional Review Meeting of Foreign Aided Projects	NRM division, ICAR, New Delhi	July 4, 2018
Dr. S.K. Rautaray	'State Level Executive Committee' Meeting for PKVY *(Paramparagat Krishi Vikas Yojana)*	Directorate of Agriculture and Food Production, Odisha	July 16, 2018
Dr. D.K. Panda	DST sponsored National Workshop on 'Application of Spatial Data Infrastructure for Irrigation Management' under US-India 21st Century Knowledge Initiative Grant Program with the University of Nebraska, Lincoln	ICAR-IARI, New Delhi	July 25-27, 2018
Dr. S. Raychaudhuri	State Level Executive Committee Meeting on Soil Health Card and Soil Health Management Scheme under NMSA	Directorate of Agriculture and Food Production, Govt of Odisha, Bhubaneswar	July 27, 2018
Dr. S. Mohanty Dr. D.K. Panda	National Workshop on 'Artificial Intelligence in Agriculture: Status and Prospects'	ICAR, New Delhi	July 30-31, 2018
Dr. S.K. Jena	Seminar on 'Geo-vision'	ESRI, India at Bhubaneswar	August 3, 2018
Dr. R.K. Panda	Workshop cum Review Meeting on Agri-CRP on Water (Theme-2)	CSSRI, Regional Research Station, Lucknow	August 13, 2018
Dr. R.R. Sethi Mr. N. Manikandan Mr. P. Deb Roy	Audit Review Meeting of ISO 9001:2015	TUV India Pvt. Limited, Kolkata	August 24, 2018
Dr. A. Mishra Dr. M. Das	*'Odisha Vikas Conclave'* on the Theme 'River Ecology'	IIWM, Bhubaneswar	August 25, 2018
Dr. K.G. Mandal	Workshop on 'Precision Agriculture in India- Way Forward'	ICAR- National Agricultural Science Fund (NASF), New Delhi	August 27, 2018
Dr. A. Mishra Dr. M. Das Dr. R.K. Panda Dr. M. Raychaudhuri Dr. R.R. Sethi	SAARC Regional Expert Consultation on 'Women's Empowerment for Agriculture Development in South Asia: Enabling Policies'	ICAR-CIWA, Bhubaneswar	September 5, 2018
Dr. P.S. Brahmanand	Meeting on 'GIS Planning for Efficient Utilization of Resources in Agricultural Sector in Aspirational Districts'	NITI AYOG, Government of India, New Delhi	September 10, 2018
Dr. P.S. Brahmanand	Workshop on 'Preparation of Manual and Strategy Document on Crop Plan'	ICAR-IIFSR, Modipuram	September 18, 2018
Dr. S.K. Jena Dr. A.K. Nayak	Seminar on 'The 5th Dimension- Smart Digital Reality'	Hexagon Geospatial, Intergraph SG & India Pvt. Ltd. at Bhubaneswar	September 28, 2018

Dr. S. Roy Chowdhury Dr. G. Kar	12th National Symposium of ISCAR on 'Coastal Agriculture: Boosting Production Potential under Stressed Environment'	ISCAR, Canning Town and DVSSKKV, Dapoli	September 28-October 1, 2018
Dr. R.K. Panda	Global Water Security Conference for Agriculture and Natural Resources'	American Society for Agricultural and Biological Engineers (ASABE) and Indian Society of Agricultural Engineers (ISAE) at Hyderabad	October 3-6, 2018
All Scientists of ICAR-IIWM	National Workshop on 'Sustainability of Indian Agriculture: Natural Resource Perspective with Special Reference to Water'	ICAR- IIWM, Bhubaneswar and ICAR-NIAP, New Delhi	October 11, 2018
Dr. A.K. Thakur	5th International Rice Congress at Singapore	IRRI, Philippines	October 15-17, 2018
Dr. A.K. Thakur	Workshop on 'To Enhance Cooperation and Sharing Among SRI National Networks and Stakeholders in Asia'	University of Technology, Malaysia	October 18-19, 2018
Dr. R.K. Panda Dr. G. Kar	Workshop on 'Prioritizing Smart Agriculture Interventions for Scaling-up Climate Smart Village Approach in Odisha'	IMAGE, Bhubaneswar	October 23, 2018
Dr. S.K. Rautaray	21st Biennial Symposium of Indian Society of Agronomy on 'Doubling Farmers Income through Agronomic Interventions under Changing Scenario'	Indian Society of Agronomy and MPUAT, Udaipur	October 24-26, 2018
Dr. A. Mishra	60th Foundation Day of *'Odisha Krushak Samaj'*	IEI, Bhubaneswar	October 25, 2018
Dr. O.P. Verma Mr. K.K. Sharma	*Nagar Rajbhasha Karyanvayan Samiti*, Bhubaneswar Ki 63vi *Ardhvarshik Baithak*	IIT, Bhubaneswar	November 9, 2018
Dr. S.K. Rautaray	State Level Pre-seasonal Orientation Workshop-cum-Rabi Campaign 2018	Directorate of Agriculture and Food Production, Odisha	November 14-16, 2018
Dr. M.K. Sinha	26th Annual Conference of AERA on 'Agriculture and Sustainable Development Goals'	ICAR- National Dairy Research Institute, Karnal	November 15-17, 2018
Dr. S.K. Jena	IMC Meeting at ICAR- RCER, Patna	ICAR-RCER, Patna	November 19, 2018
Dr. D.K. Panda	IIT-Delhi and ICAR Joint Workshop	IIT-Delhi	November 22, 2018

Dr. A. Mishra Dr. M. Das Dr. S. Roy Chowdhury Dr. R.K. Panda Dr. S.K. Rautaray Dr. S.K. Jena Dr. M. Raychaudhuri Dr. S. Raychaudhuri Dr. R.K. Mohanty Dr. P.S. Brahmanand Dr. O.P. Verma Mr. P. Deb Roy	National Conference on 'Revisiting Agricultural Research and Monitoring System for Developing Innovations: To Meet the Newer Challenges'	ARSSF & ICAR-CIWA, Bhubaneswar	November 24-25, 2018
Dr. M. Das Dr. M. Raychaudhuri Dr. S. Raychaudhuri	83rd Annual Convention of Indian Society of Soil Science	Anand Agricultural University, Anand and Indian Society of Soil Science, New Delhi	November 27-30, 2018
Dr. S.K. Jena	Review Workshop of the DST Funded Project on 'Revival of Village Ponds Through Scientific Interventions'	PAU, Ludhiana	November 28-29, 2018
Dr. P.K. Panda	Policy Dialogue on Odisha Start Ups : Agriculture on 'Doubling of Farm Income by 2022 through Agricultural Startups and Agri-skilling'	*Pravashi Odia Vikash Samiti*, New Delhi & OUAT, Bhubaneswar	December 2, 2018
Dr. D.K. Panda	3rd National Workshop of Officer In-charge, Data Management ICAR Research Data Repository for Knowledge Management Initiative	ICAR-IASRI, New Delhi	December 4-5, 2018
Dr. S.K. Rautaray	State-level Celebration of World Soil Day	Directorate of Agriculture and Food Production, Odisha	December 5, 2018
All Scientists of ICAR-IIWM	Review Meeting of the 'Agri-CRP on Water'	ICAR-IIWM, Bhubaneswar	December 7, 2018
Dr. P.S. Brahmanand	Stakeholder Meeting of NAIP-sponsored Sub-project on 'Design and Development of Rubber Dams for Watersheds'	ICAR-CIRCOT, Mumbai	December 14, 2017
Dr. G. Kar	National Symposium on 'Integrated Development of Mines and Mineral Based Industries with Waste Management'	Natural Resources Development Foundation, Bhubaneswar	December 14-15, 2018
Dr. R.R. Sethi	Inception workshop on 'Green Climate Fund-Groundwater Recharge and Solar Micro-irrigation to Ensure Food Security and Enhance Resilience in Vulnerable Tribal Areas of Odisha'	Government of Odisha, Bhubaneswar	December 18, 2018
Dr. P.S. Brahmanand	Insurance Payout Ceremony of IBFI Project	ICAR-RCER, Patna	December 26, 2018
Dr. M. Das	26th National Children Science Congress	DST, GoI at SoA University, Bhubaneswar	December 26-31, 2018

Dr. S.K. Jena	Review Meeting of the 'Agri-CRP on Water'	ICAR, New Delhi	December 28, 2018
Dr. M. Das Dr. M. Raychaudhuri Dr. S. Raychaudhuri Dr. K.G. Mandal Dr. M.K. Sinha	106th Indian Science Congress (106th ISC) at Jalandhar	The Indian Science Congress Association (ISCA), Kolkata	January 3-7, 2019
Dr. S.K. Ambast Dr. K.G. Mandal	9th International Micro-Irrigation Conference (9IMIC) on 'Micro Irrigation in Modern Agriculture' at Aurangabad	INCSW, Central Water Commission (CWC), MoWR, RD & GR, Govt. of India, New Delhi	January 16-18, 2019
Dr. P.S. Brahmanand	Divisional Review Meeting of Foreign-aided Projects	NRM division, ICAR, New Delhi	January 24, 2019
Dr. S.K. Jena	53rd Annual Convention of ISAE and International Symposium on 'Engineering Technologies for Precision and Climate Smart Agriculture'	ISAE at BHU, Varanasi	January 28-30, 2019
Dr. G. Kar	Workshop on 'Policy Dialogue on Environment and Climate Change'	Bhubaneswar	January 29-30, 2019
Dr. S. Raychaudhuri	5th Annual Review Meeting of NASF Projects	National Agricultural Science Fund, ICAR, New Delhi	January 30, 2019
Mr. P. Deb Roy	International Symposium on 'Entrepreneurship: A Need of Sustainable Agriculture'	CCS Haryana Agricultural University,Hisar	February 2-3, 2019
Dr. S. Mohanty Dr. D.K. Panda Dr. R.R. Sethi	Awareness Raising Program under National Hydrology Project	CGWB, Bhubaneswar	February 6, 2018
Dr. R.K. Panda Dr. P. Nanda Dr. K.G. Mandal Dr. R.K. Mohanty Dr. H.K. Dash Dr. P.K. Panda	Conference on 'Farmers First for Conserving Soil and Water Resources in Eastern Region (FFCSWR-2019)'	Indian Association of Soil and Water Conservationists & ICAR-IISWC, RRS, Koraput, Odisha	February 6-8, 2019
All Scientists of ICAR-IIWM	Interactive Workshop on 'Roadmap to Sustainable Water Management: Future Pathways'	ICAR-IIWM, Bhubaneswar	February 9, 2019
Dr. M. Raychaudhuri	'National Agri.-Business Entrepreneurship Conclave (NABEC 2019)'	ICAR Research Complex for NEH region, Umiam, Meghalaya	February 9-11, 2019
Dr. P. Panigrahi Dr. S. Pradhan Mr. N. Manikandan	International Symposium on 'Advances in Agrometeorology for Managing Climatic Risks of Farmers'	Association of Agrometeorologists, IMD, ICAR-IARI and JNU	February 11-13, 2019
Dr. S.K. Jena	13th International Conference on 'Development of Dry Lands: Converting Dry Land Areas from Gray into Green'	IWMI, Colombo at ICAR-CAZRI, Jodhpur	February 11-14, 2019

Dr. A.K. Thakur	National Convention 2019: Revitalizing Rainfed Agriculture	National Rainfed Area Authority, New Delhi	February 14-15, 2019
Dr. R.K. Mohanty	National Workshop on 'Aquaculture as a Livelihood Option for Tribal Farmers of India'	ICAR-CIFA, Bhubaneswar	February 18-19, 2019
Dr. O.P. Verma Mr. S.K. Singh Mr. K.K. Sharma	Nagar *Rajbhasha Karyanvayan Samiti*, Bhubaneswar Ki 64^{vi} *Ardhvarshik Baithak*	Institute of Physics, Bhubaneswar	February 19, 2019
Dr. P.K. Panda Dr. G. Kar	XIV Agricultural Science Congress 2019	NAAS, New Delhi	February 20-23, 2019
Dr. O.P. Verma	*Rashtriya Vaigyanik Rajbhasha Parisanvad* (Symposia)	ICAR-CIFE, Mumbai	February 25-26, 2019
Dr. S. Raychaudhuri	Workshop on 'Polluted River Stretches-Preparation of Action Plan (For North East States)' under National Hydrology Project (NHP)	Centre for the Environment, IIT, Guwahati	February 25, 2019
Dr. S.K. Jena	Farmers' Fair Meeting	ICAR-NRRI, Cuttack	February 26, 2019
Dr. A.K. Thakur	Seminar on 'The Ecology and Management of Sustainable and Climate-smart Rice Systems'	Wageningen University & Research, The Netherlands	March 5, 2019
Dr. D.K. Panda	User's Training Workshop on 'Geospatial Applications in Data Enrichment of ICAR KRISHI Geoportal'	ICAR-NBSSLUP, Nagpur	March 7-8, 2019
Dr. R.R. Sethi	State-level Convention of the International Women's Day	ILS, Bhubaneswar	March 8, 2019
Dr. D.K. Panda	Interaction-meeting of ICAR Scientists/Experts and Artificial Intelligence Team of NITI Aayog	ICAR, Krishi Bhavan, New Delhi	March 11, 2019
Dr. H.K. Dash	State-level Interaction for Agricultural Extension Activities	IMAGE, Bhubaneswar	March 14, 2019
Dr. S.K. Ambast Dr. S.K. Rautaray Dr. K.G. Mandal Dr. S. Mohanty	60th Annual Technical Session of The Institution of Engineers (India), Odisha State Centre	The IEI, Odisha State Centre, Bhubaneswar	March 30, 2019

Major Events 2018-19

Hon'ble Prime Minister's interaction with farmers through direct DD Kissan telecast on June 20, 2018

Dr. V.N. Sharda, Ex-member, Agricultural Scientists Recruitment Board (ASRB) & Dr. H. Pathak, Director, ICAR-NRRI, Cuttack on the occasion of ICAR-IIWM's 31st Foundation Day Celebration on May 12, 2018

MAJOR EVENTS 2018-19

Dr. K. Alagusundaram, Deputy Director General (Agricultural Engineering & Natural Resource Management), ICAR, New Delhi visited ICAR-IIWM during workshop on 'Water Related Risks - Flood and Drought' on May 8, 2018


Celebrated International Yoga day on June 21, 2018


Hindi Pakhwada during September 14-28, 2018


Independence Day Celebration on August 15, 2018

Farmers training at Parbatia, Dhenkanal on November 9, 2018

Dr. T. Mohapatra, Hon'ble Secretary, DARE, GoI and DG, ICAR visited ICAR-IIWM during training on 'Watershed Management and Land Use Planning' held on September 22-29, 2018

Shri Chhabilendra Roul, Hon'ble Special Secretary, DARE & Secretary, ICAR visited ICAR-IIWM during workshop on 'Sustainability of Indian Agriculture: Natural Resource Perspective with Special Reference to Water' on October 11, 2018

Presentation of State Irrigation Plan for Odisha in stakeholders workshop on October 1, 2018

ICAR-IIWM celebrated *'Mahila Kisan Divas'* on October 15, 2018

Integrity Pledge by ICAR-IIWM Staff during Vigilance Awareness Week (October 29-November 3, 2018)

Celebration of World Soil Day on December 5, 2018

ICAR-IIWM conducted training program on 'On-farm water management technologies for improving water productivity' during January 21-24, 2019

Republic Day Celebration on January 26, 2019 at ICAR-IIWM

ICAR-IIWM celebrated 'National Productivity Week' during February 12-18, 2019

ICAR-IIWM celebrated 'International Women's Day' on March 8, 2019

Mera Gaon Mera Gaurav

Six groups of scientists of ICAR-IIWM adopted thirty villages across seven blocks spreading over five districts of Odisha under the '*Mera Gaon Mera Gaurav*' program. Farmers' have been given trainings /demonstrations for pest and disease control in crops, soil collection method for its testing, water storage and use, *in-situ* rainwater conservation technique, micro-irrigation, vermicomposting, importance of *swachhata* along with creating general awareness and imparted need based training on various aspects of farming. Linkages have been established with state government offices (seed production, Organic farming, state agriculture and horticulture departments etc.), OUAT, Bhubaneswar, KVKs, ICAR-CIFA, Bhubaneswar and other allied organizations.

Information on villages adopted under MGMG Program

Group ID	Name of the villages	Name of Block and District	Number of farm families
Group A	Khalibandha, Nuagaon, Sadeiberini, Gajamara, Saptasajyapada	Block-Dhenkanal Sadar District- Dhenkanal	631
Group B	Bhakarsahi, Poijhari, Haladibasanta, Naranpur, Sarata	Block-Balipatna District-Khorda	439
Group C	Sukala aisanyapara, Alisha, Churali, Parimanoipur, Sukalapara	Block-Satyabadi and Kanas District-Puri	674
Group D	Chhatabar, Durgapur, Giringaput, Haridamada, Jammujhari	Block- Bhubaneswar and Jatni District-Khorda	755
Group E	Khadal, Irikundal, Hasimnagar, Dhinkia, Bindhapada	Block-Tirtol District- Jagatsinghpur	271
Group F	Madana, Naindipur, Chandapalla, Patakura, Jagannathpur	Block-Garadpur District- Kendrapara	820

Information on general awareness created

Sl. No.	Subject matter
i)	Irrigation scheduling for field crops
ii)	Kitchen gardening
iii)	Awareness towards harmful effects of *Parthenium sp.*
iv)	Benefit of line transplanting and fertilizer application in rice
v)	SRI method of rice cultivation

MERA GAON MERA GAURAV

vi)	Package of practices of vegetable crops
vii)	Pest and disease control in rice and vegetable crops
viii)	Pond-based farming system
ix)	Swaccha Bharat Abhiyan, Soil health card, Awareness Gram Sabha
x)	Soil sample collection and water conservation techniques
xi)	Micro-irrigation
xii)	Rainwater conservation and rice-fish farming
xiii)	Demonstration-cum-training program on vermicomposting
xiv)	Integrated farming systems, pisciculture and poultry farming

Training and interaction meeting organized under adopted villages

Details of program	Place and Date	No. of beneficiary farmers
Training program on package of practices of summer crops like green gram, okra, watermelon, bitter gourd, brinjal, pointed gourd, ridge gourd etc.	Patkura, Chandapalla and Naindipur villages, Kendrapara April 28, 2018	10
Discussion on *Paramparagat Krishi*	Balipatna Block May 26, 2018	23
Awareness training program involving NGO on improved water management strategies for *kharif* season crop and optimal cropping pattern	Madana village, Kendrapara May 30, 2018	12
Discussion on package and practices of rice crop with emphasis on line transplanting	Bindhapada village, Tirtol block, Jagatsinghpur May 30, 2018	18
Awareness on insect pests, diseases and weeds of pumpkin crop	Bhakarsahi village June 23, 2018	21
Farmers'-scientists' interaction meeting on fresh water aquaculture cultivation techniques	Hasimnagar village July 20, 2018	20
Interaction meeting on problems in of *kharif* crops cultivation including rice crop; awareness towards harmful effects of *Parthenium* sp.	Madana, Jagannathpur, Patkura, Chandapalla and Naindipur villages July 25, 2018	10
Farmer's-Scientist's interaction meet on *kharif* rice cultivation in water logged areas, poultry farming and drinking water problem	Alisha village, Puri July 25, 2018	18
Farmers'-scientists' interaction meeting	Bhakarsahi village August 24, 2018	40
Farmers'-scientists' interaction meeting on fertilizer scheduling of rice	Khadala village August 29, 2018	24

Awareness program on conservation and management of rainwater and use of farm equipment in rice cultivation	Gajamara village September 29, 2018	27
Management measures for control of pests and diseases of vegetable crops; sensitization about '*Swachhta Hi Sewa*' to school children	Jagannathpur village September 29, 2018	08
Gram sabha meeting; awareness on improved water management practices; pests and diseases control management in *rabi* crops	Madana, Jagannathpur, Patakura, Chandapalla and Naindipur villages November 2, 2018	30
Farmers'-scientists' interaction meeting on kitchen gardening	Bindhapada village November 3, 2018	11
Farmer-Scientist interaction on *rabi* crop planning, SRI method, soil testing and pisciculture	Saptasajyapada and Sadeiberini villages November 17, 2018	66
Farmer's-Scientist's interaction on cultivation of *kharif* rice under waterlogged areas, poultry farming and problem of drinking water	Alisha village, Puri December 1, 2018	19
Farmer's-Scientist's interaction cum training (Farmers Fair) on problems related to cultivation of crops and climate-resilient water management practices in waterlogged areas; use of drum-seeder and development of pond-based agroforestry system etc.	Alisha village, Puri December 14, 2018	200
Swachhta activities; a cleanliness cum sanitation drive; awareness campaign on 'Importance of *swachhta* in keeping healthy society'	Chandpalla village December 19, 2018	11
Discussion on land preparation, seed sowing and seedling making processes for *rabi* vegetables	Gajamara and Khalibandha villages December 22, 2018	51
Farmers' interaction meet on integrated farming system, soil management, fish culture, water management in *rabi* and summer crops, crop diversity and nutritional security, and distribution of *Amaranthus* seeds	Hasimnagar village February 2, 2019	16
Demonstration-cum-training program on vermi-composting	Bhakarsahi village, Balipatana block February 15, 2019	50

Scientist-Farmer interaction

Interaction with farmers regarding brinjal cultivation

SWACHA BHARAT ABHIYAN

Swachha Bharat Abhiyan

The Director and staff of ICAR-IIWM, Bhubaneswar participated actively in *Swachh Bharat Abhiyan* and 43 number of cleanliness campaigns were conducted during 2018-2019 at the Institute main campus, public places, schools and villages. Under Digital India campaign, ICAR-ERP system of all the staff of the Institute was updated and Government e-Market (GeM) is being utilized for e-procurement. Other activities viz. clearance of E-waste, pruning of shrubs and beautification of the Institute were also performed during the period. Plantation of horticultural saplings was done in the main campus on June 29, 2018. Special awareness campaigns were organized on eradication of *Parthenium* weed in MGMG villages of Garadpur block of Kendrapara district, Odisha. Some staff of ICAR-IIWM participated in *Swachhata* activities at Pipli, Puri district and Dangmal, Kedrapara district of Odisha.

The Director, ICAR-IIWM administered *Swachhta Shapath* to all the officers and officials of the Institute on September 15, 2018, October 2, 2018 and December 16, 2018 during celebration of *Swachhta Hi Sewa* (September 15 - October 2, 2018) and *Swachhta Pakhwada* (December 16-31, 2018). *Swachhta* awareness drive-cum-cleanliness was conducted at Chandpalla village of Kendrapara district, Srimukundpur village of Puri district and Koraput, Odisha. *Swachhta* awareness drive cum cleanliness was conducted at Berjaberna tribal village of Sundargarh district of Odisha where farmers participated. Some staff of ICAR-IIWM have participated in *Swachhta* activities at Bhubaneswar railway station. Awareness talks on 'Conversion of agricultural waste to wealth' and 'Application of bio-compost' were delivered to trainees of watershed management and land use planning training held during September 22-27, 2018. Similarly, awareness was created among school children and teachers on eradication of *Parthenium* and cleanliness of tube-wells under *Swachha Bharat Abhiyan* at Vivekananda Siksha Kendra, Bhubaneswar. A quiz competition was also organized amongst the school children and prizes were distributed to winners and participants. A lecture on 'Conversion of waste to wealth under *Swachha Bharat Abhiyan*' was delivered by Dr. P.S. Brahmanand, Principal Scientist & Nodal Officer.

A brief account on *Swachha Bharat Abhiyan* at ICAR-IIWM (April 1, 2018-March, 31 2019)

S. No.	Nature of Activities	Number of Events	Number of Hours
1	Digitization of Office Records/ e-office	03	03
2	Basic Maintenance	33	66
3	Sanitation and SWM	03	03
4	Cleaning and Beautification of Surrounding Areas	04	04
5	Vermi-composting / Composting of Bio-degradable Waste Management & Other Activities on Generate of Wealth for Waste	03	03
6	Used Water for Agriculture/ Horticulture Application	03	03
7	*Swachhta* Awareness at Local Level	33	33

8	*Swachhta* Workshops	01	02
9	*Swachhta* Pledge	04	01
10	Display and Banner	05	-
11	Foster Healthy Competition	02	02
12	Involvement of Print and Electronic Media	03	-
13	Involving and with the Help of the Farmers, Farm women and Village Youth in Their Adopted Villages (No. of Adopted Villages)	06	12
	Total Number of Staff Involved in the Activities	**1368 (Combined Number on All Basic Cleanliness Activities (43) with an Average of 31.8 Persons per Activity)**	

Activities under *Swachha Bharat Abhiyan* at ICAR-IIWM, Bhubaneswar

Krishi Kalyan Abhiyan

ICAR-IIWM, Bhubaneswar played key-role in *Krishi Kalyan Abhiyan* of Government of India, and six teams of scientists of the institute in collaboration with *Krishi Vigyan Kendra* (KVK), Malkangiri; state agriculture, horticulture and animal husbandry departments; and village *Sarpanch* organized six 2-days trainings covering twenty five villages of Malkangiri district of Odisha.

Mini-kits of HYV seeds of pumpkin, okra, ridge gourd, cucumber and *Amaranthus* were distributed to 1269 farm families. Scientists of ICAR-IIWM, Bhubaneswar also organized awareness and sensitization campaign on improved agro-techniques, training to the farmers for doubling farm income, '*Kisan Gosthis*', cultivation practices of rice and non-rice crop, aquaculture, soil fertility and health awareness, water saving technologies along with drip and sprinkler irrigation etc. KVK staff distributed waste decomposer kits while state agriculture and horticulture department distributed pulse (black gram) / oilseed kits (*Sesame*), groundnut, green gram seeds and mango planting materials to the farmers, respectively.

Team	Team members from ICAR-IIWM	Villages covered	Number of beneficiary farm families	Duration
Team 1	Drs. S. Roy Chowdhury, S.K. Jena, P.S. Brahmanand and A.K. Nayak	Jharapali, Boilapari, Nilimari, Podaghat and Kumbharput villages	233	June 19-20, 2018
Team 2	Drs. A. Mishra, M. Das, P.K. Panda and P. Debroy	Tandabai, Jaduguda, Bhaluguda and Gangla villages	208	June 21-24, 2018
Team 3	Drs. S. Raychaudhuri, R.K. Mohanty, A.K. Thakur and P. Panigrahi	Jagannath Pali, Himansu Palli, Pangam, Dhungiaput villages	205	June 25-26, 2018
Team 4	Drs. S.K. Rautaray, P. Nanda, H.K. Dash, S. Mohanty and D. Sethi	Chimtapali, Girkanpali, Phulkankonda and Koikunda villages	200	June 28-29, 2018
Team 5	Drs. M. Raychaudhuri, K.G. Mandal, R.R. Sethi, S. Pradhan and N. Manikandan	Sindhabeda, Temurupali, Bijapadar and Kianga villages	200	July 1-2, 2018
Team 6	Drs. R.K. Panda, G. Kar, D.K. Panda and O.P. Verma	Salimi, Eraganda, Tamanpalli and Supulur villages	223	July 6-7, 2018

Activities undertaken by ICAR-IIWM Scientists at Malkangiri, Odisha

Personnel

Dr. Sunil Kumar Ambast, Director

As on 31-03-2019

SCIENTIFIC		
Sl. No.	**Name**	**Designation**
1	Dr. Atmaram Mishra	Principal Scientist
2	Dr. M. Das	Principal Scientist
3	Dr. S. Roy Chowdhury	Principal Scientist
4	Dr. P. Nanda	Principal Scientist
5	Dr. R.K. Panda	Principal Scientist
6	Dr. S.K. Rautaray	Principal Scientist
7	Dr. G. Kar	Principal Scientist
8	Dr. S.K. Jena	Principal Scientist
9	Dr. M. Raychaudhuri	Principal Scientist
10	Dr. S. Raychaudhuri	Principal Scientist
11	Dr. R.K. Mohanty	Principal Scientist
12	Dr. M. K. Sinha	Principal Scientist
13	Dr. K.G. Mandal	Principal Scientist
14	Dr. H.K. Dash	Principal Scientist
15	Dr. P.K. Panda	Principal Scientist
16	Dr. A.K. Thakur	Principal Scientist
17	Dr. P.S. Brahmanand	Principal Scientist
18	Dr. S. Mohanty	Principal Scientist
19	Dr. D.K. Panda	Principal Scientist
20	Dr. Ranu Rani Sethi	Principal Scientist
21	Dr. A.K. Nayak	Principal Scientist
22	Dr. P. Panigrahi	Senior Scientist
23	Dr. O.P. Verma	Scientist
24	Dr. Sanatan Pradhan	Scientist
25	Dr. Debabrata Sethi	Scientist
26	Dr. Rachana Dubey	Scientist
27	Mrs. Prativa Sahu*	Scientist
28	Mr. N. Manikandan	Scientist
29	Mr. Partha Deb Roy	Scientist

TECHNICAL		
Sl. No.	**Name**	**Designation**
1	Mrs. Sunanda Naik	Asst. Chief Technical Officer
2	Mr. Chhote Lal	Senior Technical Officer
3	Mr. R.C. Jena	Technical Officer
4	Mr. P.C. Singh Tiyu	Technical Officer
5	Mr. S.K. Dash	Technical Officer
6	Mr. B.K. Acharya	Technical Officer
7	Mr. S. Lenka	Technical Officer
8	Mr. P. Barda	Senior Technical Assistant
9	Mr. A.K. Binakar	Senior Technical Assistant (Driver)
10	Mr. L. Singh Tiyu	Senior Technical Assistant (Driver)
11	Dr. Subodha Kumar Karna	Technical Assistant (Lab)
12	Mr. Kamlesh Kumar Sharma	Technical Assistant (Hindi Translator)
13	Mr. Sunanda Kumar Sahoo	Technical Assistant (Library)
14	Mr. Sitesh Kumar Mohapatra	Technical Assistant (Farm)
15	Mr. A. Parida	Senior Technician

ADMINISTRATION		
Sl. No.	**Name**	**Designation**
1	Mr. S.K. Singh	Administrative Officer
2	Mr. Vinod K. Sahoo	Finance & Accounts Officer
3	Mr. A. Mallik	Asst. Administrative Officer
4	Mrs. M. Padhi	Private Secretary
5	Mr. Trilochan Raut	Personal Assistant
6	Mr. J. Nayak	Assistant
7	Mr. R.K. Dalai	Assistant
8	Mr. A.K. Pradhan	Upper Division Clerk
9	Mr. N.K. Mallick	Upper Division Clerk
10	Mr. C.R. Khuntia	Lower Division Clerk
11	Mr. B.S. Upadhyaya[#]	Lower Division Clerk
12	Mr. S.C. Das	Lower Division Clerk

SUPPORTING		
Sl. No.	**Name**	**Designation**
1	Mr. Sanatan Das	Skilled Support Staff
2	Mr. B.N. Nayak	Skilled Support Staff
3	Mr. S.K. Panda	Skilled Support Staff
4	Mr. B. Dutta	Skilled Support Staff

*-on study leave
#-on deputation

JOINING, PROMOTION, TRANSFER & RETIREMENT

Joining, Promotion, Transfer & Retirement

Dr. Subodha Kumar Karna and Mr. Kamlesh Kumar Sharma joined ICAR-IIWM on October 29, 2018 (FN) as Technical Assistant (T-3) Laboratory Technician and Hindi Translator, respectively.

Mr. Sunanda Kumar Sahoo, joined ICAR-IIWM as Technical Assistant (T-3) Library on November 9, 2018 (FN).

Mr. Sitesh Kumar Mohapatra, joined ICAR-IIWM as Technical Assistant (T-3) Farm on January 23, 2019 (FN).

Mr. Nilakantha Mallick, UDC (Level 4) promoted to UDC (Level 5), and Mr. Bhaskar Dutta, SSS (Level 2) promoted to SSS (Level 3) under Modified Assured Career Progression (MACP) scheme w.e.f. November 26, 2016 and April 07, 2018, respectively.

Mr. Abhijit Sarkar, Scientist (Soil Science) transferred to ICAR-IISS, Bhopal.

Dr. R.C. Srivastava, Principal Scientist of ICAR-IIWM superannuated from his ICAR service on June 30, 2018.

BUDGET & EXPENDITURE 2018-19

Budget & Expenditure 2018-19

The Budget & Expenditure for the financial year 2018-19 in respect of ICAR-IIWM, Bhubaneswar.

Income & Expenditure Account

(Figures in ₹)

A. Income	Schedule	Current Year	Previous Year
Income from Sales/Service	8	4659084	2113242
Grants in aid/subsidies	9	374033931	324954970
Fees/Subscriptions	10	0	0
Income from Investments	11	0	0
Income from Royalty, Publications	12	0	0
Interest earned	13	5591148	1885635
Other Income	14	2915209	580542
Prior Period Income	15	0	0
Total (A)		**387199372**	**329534389**
B. Expenditure			
Establishment expenses	16	118178691	76806719
Research & Operational Expenses	17	14396809	9886069
Administrative expenses	18	18404753	9413123
Grants and subsidies	19	222535000	223610000
Miscellaneous expenses	20	1014452	1000673
Depreciation	5	14551021	14194611
Prior period expenditure	21	0	
Total (B)		**389080728**	**334911195**
Balance being surplus/(Deficit) carried to corpus/Capital Fund		-1881356	-5376806

Balance Sheet

(Figures in ₹)

Corpus/Capital Fund & Liabilities	Schedule	Current Year	Previous Year
Capital Fund	1	125479873	133251414
Reserves	2	0	0
Earmarked/Endowment Fund	3	0	0
Current Liabilities & Provisions	4	62613505	47676586
Total		**188093378**	**180928000**
Assets			
Fixed Assets	5	113875061	124466448
Investments – Earmarked/Endowment Funds	6	0	0
Current Assets, Loans & Advances	7	74218317	56461552
Total		**188093378**	**180928000**
Significant Accounting Policies	22		
Contingent Liabilities & Notes to Accounts	23		

भाकृअनुप
ICAR

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

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