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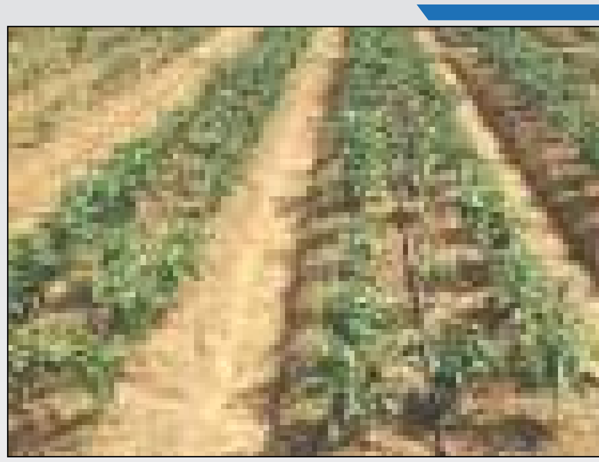
ICAR-IIWM



भाकृअनुप-भारतीय जल प्रबंधन संस्थान

ICAR-Indian Institute of Water Management

BHUBANESWAR, ODISHA, INDIA

भाकृ अनुप
ICAR

ANNUAL REPORT 2020

भारतीय जल प्रबंधन संस्थान
ICAR-IIWM

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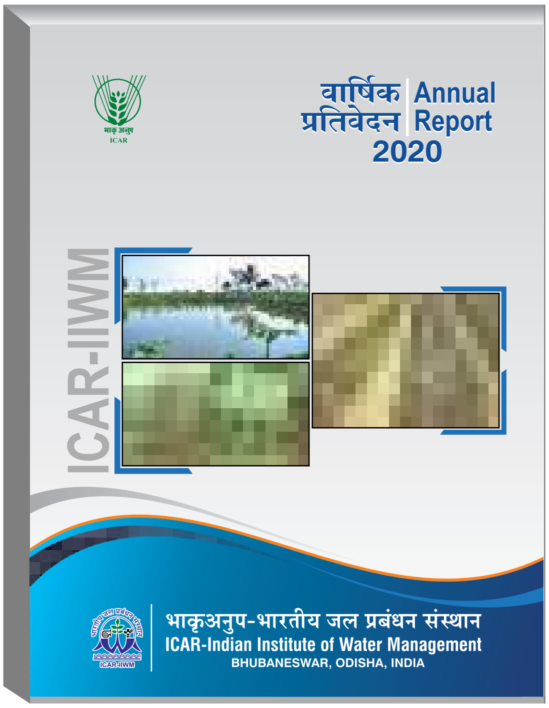
ICAR-IIWM Annual Report 2020

Published by
Dr. A. Mishra
Director

Editors
Dr. A.K. Thakur
Dr. K.G. Mandal
Dr. O.P. Verma

Program leaders
Dr. S.K. Rautaray (Rainwater Management)
Dr. R.K. Panda (Canal Water Management)
Dr. S. Mohanty (Groundwater Management)
Dr. M. Das (On-farm Technology Dissemination)

Hindi translation
Mr. K.K. Sharma



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PREFACE

Globally, agriculture accounts for 70% of freshwater withdrawals, and pressure on water supplies for industrial, domestic, and agricultural sectors is growing due to population rise. Water is most essential for food security and is vital for ecosystems, including forests, lakes and wetlands, on which our present and future food and nutritional security depend. Yet, per capita water availability is diminishing at an alarming rate. That's why sustainable water resource management to increase production and water productivity in food and agriculture remains a challenge.

The year 2020 was most challenging for all of us due to the COVID-19 pandemic, which forced us to rethink about our research strategies and the way we are managing our most valuable resource - Water. As we know, agriculture is also an important source of water contamination including microorganisms. Therefore, now our goal should be about ensuring access to safe water and sanitation, achieving sustainable water management, and reducing water pollution considering human health. There is a need to integrate both water and health while managing water resources for agricultural development, and consider these while developing plans, policies and strategies to protect the human, animal, ecosystem's health and nature.

With these backgrounds 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 under report, and I feel extremely happy to bring out the detailed presentation of the Institute's progress in the form of this Annual Report of the Institute for the year 2020.

Significant research achievements for the year 2020 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 the development of irrigation plans; studies on impacts of land-atmosphere interactions on dry-hot episodes in India and land modification/shaping technique for enhancing productivity; Impact of land use and land cover changes on groundwater storage, 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, basic studies on water stress, 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 phytoremediation of Cr (VI) from water in chromite mine areas for irrigation and development & evaluation of mini-pan evaporimeter for irrigation scheduling. Our Institute has also initiated site suitability analysis for crop planning and aquaculture development using geo-informatics, studies on water and nitrogen dynamics in the paddy field, evaluation of drip irrigated multistoried cropping systems and preparation of yield gap atlas for pulses and oilseeds. Substantial work has also been done for livelihood improvement of the scheduled tribe and caste farmers through water management interventions, in Farmers FIRST project, and revival of village ponds through scientific intervention.

Our Institute plays a keyrole in addressing different agricultural water management-related issues at the regional level by assigning targets to 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. In addition, our staff are actively involved in campaigning *Swachha Bharat Abhiyan* and organized many cleanliness program and distributed food packets to the migrant workers due to the COVID pandemic. 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 2020. I'm glad to apprise that our Scientists have received several awards and recognitions during this year.

I acknowledge sincerely the valuable guidance, suggestion and support of Dr. T. Mohapatra, Secretary, DARE and Director General, ICAR; Dr. S.K. Chaudhari, Deputy Director General (NRM), ICAR, New Delhi, Dr. Adlul Islam, ADG (S&WM), Dr. S. Bhaskar, ADG (AAF&CC) and other concerned officials of the Council. I express my sincere thanks to the esteemed Chairman and members of QRT and RAC for their valuable guidance, inputs and involved support. I thank all members of IRC, program leaders and members of different Institute committees, staff of administration and finance section of the Institute for help, co-operation and smooth functioning of the Institute. The publication committee deserves 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 different stake holders i.e. policy makers, researchers, development functionaries, and the farmers.

July 15, 2021
Bhubaneswar

(Atmaram Mishra)
Director, ICAR-IIWM

कार्यकारी सारांश

विकसित मिनी-पैन वाष्पीकरण मीटर के प्रदर्शन का मूल्यांकन

सिंचाई के समय के निर्धारण हेतु यूएसडब्ल्यूबी (USWB) ओपन पैन की तुलना में मिनी पैन वाष्पीकरण मीटरों (गेल्वेनाइज्ड आयरन से निर्मित 20 और 30 सेमी व्यास वाले मिनी पैन) के प्रदर्शन का मूल्यांकन करने के लिए रबी मौसम 2019-20, जायद, 2020 एवं खरीफ 2020 के दौरान एक प्रयोग आयोजित किए गए। यह देखा गया कि फसल की पैदावार (रबी में टमाटर, गर्मियों में मक्का और खरीफ मौसम में धान) और पैदावार के मापदंडों में मिनी पैन वाष्पीकरण मीटर और यूएसडब्ल्यूबी क्लास ए पैन वाष्पीकरण मीटर के तहत बहुत अधिक अंतर प्राप्त नहीं हुआ।

ओडिशा राज्य के तटीय जलाक्रांत क्षेत्रों में भूमि को रूपांतरित करने के लाभ

तटीय जलाक्रांत क्षेत्र के एरसमा गाँव में वैकल्पिक ऊंची एवं नीची क्यारी और कृषि वानिकी प्रणाली में मछलीपालन' की तुलना और खेत में तालाब के लिए एक तिहाई (1/3) क्षेत्र को रूपांतरित करने के भूमि के विकल्प का अध्ययन करके की गई। इससे यह प्राप्त हुआ कि खेत में तालाब के लिए एक तिहाई (1/3) क्षेत्र को रूपांतरित करने (शुद्ध लाभ-₹121908/हे एवं लाभ:लागत अनुपात-2.38) की तुलना में वैकल्पिक ऊंची एवं नीची क्यारी और कृषि वानिकी प्रणाली में मछलीपालन शुद्ध लाभ (₹ 192381/हे**)** और लाभ:लागत अनुपात (2.51) के साथ अधिक लाभकारी साबित हुआ। खोर्दा जिले के मेंढ़ासल गाँव के सूखा प्रभावित वर्षा पोषित उथले तराई क्षेत्र में ऊंची एवं नीची क्यारी का इष्टतम आकार क्रमशः 4 मीटर और 5 मीटर पाया गया।

जीरो जल विनिमय झींगा पालन प्रणाली में कृत्रिम सब्सट्रेट इंडयुस्ड पेरिफाईटोन बायोमास

जीरो जल विनिमय स्थिति में सब्सट्रेट इंडयुस्ड पेरिफाईटोन बायोमास का उत्पादन झींगा की काफी अधिक उपज (11.53 टन/हे, 120 प्रति दिन) और शुद्ध कुल जल उत्पादकता (₹73.1/ घन मीटर) देता है इस स्थिति के कारण अधिक आर्थिक लाभ (आउट मूल्य : CC, 2.3) और कम तलछट भार (28.6 घन मीटर/टन बायोमास) प्राप्त हुआ। इससे जल की गुणवत्ता में भी काफी सुधार प्राप्त हुआ, जल की कुल आवश्यकता (43.7%) में कमी हुई और 8.6-15.2% तक पैदावार में वृद्धि हुई। पेरिफाईटोन बायोमास ने जल में कुल विब्रिओ काउंट (1.18×10^3 सीएफयू/मिलीलीटर) को कम करने में मदद की, जबकि कुल हेटेरोट्रोफिक बैक्टीरिया (3.6×10^5 सीएफयू/मिलीलीटर) की गिनती में वृद्धि हुई)। कुल विब्रिओ काउंट/कुल हेटेरोट्रोफिक बैक्टीरिया का कम प्रतिशत हेटेरोट्रोफिक बैक्टीरिया के स्थान और पोषक तत्वों के लिए प्रतिस्पर्धी दृष्टिकोण का सुझाव देता है। ऑटोट्रॉफ़िक इंडेक्स (197.1-243.2) ने व्यवस्थित रूप से गैर-प्रदूषित परिस्थितियों (<400) का संकेत दिया।

बाढ़ के पश्चात प्रबंधन योजनाओं की तैयारी

बिहार राज्य के मुजफ्फरपुर और पूर्वी चंपारण जिलों तथा ओड़िशा राज्य के केंद्रपाड़ा एवं पुरी जिलों के बाढ़ प्रभावित क्षेत्रों में बाढ़ प्रबंधन योजनाओं को कार्यान्वित किया गया। बाढ़ के पश्चात प्रबंधन योजनाओं को लागू करने के माध्यम से किसान बिना किसी व्यवधान के बाढ़ से क्षतिग्रस्त खेतों की तुलना में बिहार के मुजफ्फरपुर एवं ओड़िशा के पूरी जिलों में क्रमशः ₹ 29,800/हे एवं ₹ 25,200/हे का अतिरिक्त शुद्ध लाभ प्राप्त कर सकते हैं।

धान की चयनित किस्मों में एरोबिक स्थिति के तहत स्प्रिंकलर सिंचाई

बहुत सी फसलों में सिंचाई के जल की बचत के लिए स्प्रिंकलर सिंचाई प्रणाली बहुत अच्छा विकल्प साबित हुआ है, लेकिन धान की फसल में सिंचाई जल की आवश्यकता को कम करना आज भी चुनौती बना हुआ है। एरोबिक और पडल्ड दोनों स्थितियों में प्रयोगों के परिणाम से प्राप्त हुआ कि एरोबिक स्थितियों में धान की औसत पैदावार 2.95 टन/हे प्राप्त हुई जो कि पडल्ड स्थिति में धान की रोपाई से प्राप्त उपज से लगभग 28% कम प्राप्त हुई; जबकि सिंचाई जल की बचत लगभग 43% हुई, तथा स्प्रिंकलर सिंचाई से जल की उत्पादकता में वृद्धि में 28% प्राप्त हुई। धान की तीन किस्मों की उपज की तुलना की गई तो एनपीएच-150 किस्म की पैदावार अधिक प्राप्त हुई और' 'एरोबिक स्थिति के तहत सहभागी 'और' सीआर-202 किस्मों की उपज समान प्राप्त हुई। अधिक पैदावार के रूप में एनपीएच -150 '> सीआर-202'> सहभागी क़िस्मों का क्रम इस प्रकार प्राप्त हुआ। जबकि, रोपित परिस्थितियों में इन्ही किस्मों की पैदावार 4.54, 4.20 और 3.48 टन/हे प्राप्त हुई।

विभिन्न धान फसल प्रबंधन प्रणालियों के तहत जल के स्ट्रेस का मूल्यांकन

सूखे की आशंका वाले क्षेत्रों की उत्पादकता तथा उत्पादन में सुधार के लिए गर्मी के मौसम, 2019 के दौरान धान की फसल पर खेत में प्रयोग किया गया। इस प्रयोग में जल के तनाव की विभिन्न अवधि के तहत धान की फसल का मूल्यांकन करने के लिए उन्नत किस्मों और फसल प्रबंधन के संयोजनों का उपयोग किया गया। सबसे अधिक दाना उपज धान गहनता पद्धति के तहत प्राप्त हुई, उसके बाद पारंपरिक रोपाई विधि (टीपी) और सबसे कम उपज प्रत्यक्ष-बीजारोपण (डीएस) विधि के तहत प्राप्त हुई। विभिन्न जल तनाव के स्तरों के कारण पारंपरिक रोपाई विधि (टीपी) और प्रत्यक्ष-बीजारोपण (डीएस) विधि के बजाय धान गहनता पद्धति में दाना की पैदावार क्रमश: 57 और 29% अधिक हुई। इसके अलावा, पारंपरिक रोपाई विधि में भी प्रत्यक्ष-बीजारोपण की तुलना में दाना उपज में 13% तक बढ़ोतरी हुई। विभिन्न जल तनाव स्तरों के बीच खेती की सभी विधियों से सबसे कम उपज तब प्राप्त हुई जब धान में वानस्पतिक फसल विकास की अवस्था के दौरान सिंचाई जल की कमी शुरू की गई।

सिना मध्यम सिंचाई परियोजना के लिए फसल योजना रणनीतियों का विकास और नीति का सुझाव

महाराष्ट्र राज्य में जल-दुर्लभ सिना सिंचाई प्रणाली में किए गए अध्ययन के आधार पर जल प्रभाव क्षेत्र (WIZ) पर विचार करने के परिणामस्वरूप वार्षिक उपयोगी सिंचाई क्षमता/निर्मित सिंचाई क्षमता का अनुपात एक से अधिक प्राप्त हुआ। जल प्रभाव क्षेत्र में कल्चेबल कमांड क्षेत्र (CCA), कल्चेबल कमांड क्षेत्र के आसपास 1 किमी का बफर क्षेत्र और जलाशय लिफ्ट सिंचाई क्षेत्र शामिल था। निम्न, मध्यम और अधिक वर्षा की स्थितियों के आधार पर अध्ययन ने आर्थिक जल उत्पादकता को बढ़ाने के लिए जल लागत वक्र के विकास के माध्यम ने फसल योजना की रणनीतियों को विकसित करने में मदद की। जल प्रभाव क्षेत्र में रिमोट सेन्सिंग/जीआईएस विधियों का उपयोग करके वास्तविक सिंचित का सटीक अनुमान, वाटर अकाउंट्स का आकलन, भूजल पुन:भरण क्षेत्रों का आकलन और फसल उत्पादन का समर्थन करने के लिए जल की मात्रा का उपयोग इत्यादि के आधार पर नीतिगत सिफारिशों का सुझाव दिया गया।

भारत में शुष्क-गर्म प्रकरणों पर भूमि-वायुमंडल के परस्पर प्रभाव का अध्ययन

तापमान में वृद्धि का एक महत्वपूर्ण हिस्सा मुख्य रूप से मानसून की वर्षा में कमी होने के कारण होता है, दोनों को एक प्रतिक्रिया संयोजन में युग्मित किया जा सकता है यह प्रतिक्रिया वर्षा की तीव्रता को प्रभावित करती है और यहां तक कि मध्यम सूखे की स्थिति को भारी सूखे में बदलाव कर सकती है। इसलिए, कृषि उत्पादक क्षेत्रों में गर्मी और सूखे की बढ़ती प्रवृत्ति सिंचाई की आवश्यकताओं को बढ़ाएगी, जो विशेष रूप से भूजल से सिंचाई पर निर्भर रहते हैं।

बैतरणी नदी बेसिन में भूजल के भंडारण पर भूमि उपयोग और भूमि कवर में परिवर्तन का प्रभाव

डिजिटल एलिवेसन मॉडल, भूमि ढ़लान, जल भराव, प्रवाह की दिशा, प्रवाह का संचय, धारा का नेटवर्क और स्ट्रीम ऑर्डर पर विचार करके बैतरणी नदी बेसिन के लिए हाइड्रोलॉजिकल विश्लेषण किया गया। यह बेसिन 6 वें क्रम की ड्रेनेज बेसिन है। प्रथम क्रम की धाराओं की कुल लंबाई 3446.33 किमी है जिसकी औसत लंबाई 1.18 किमी है; 6 वें क्रम की धारा की लंबाई 138.27 किमी है, जिसकी औसत लंबाई 0.78 किमी है। इस नदी बेसिन (1901-2020) के 8 ब्लॉकों से 120 (1901-2020) वर्षों के वर्षा के आंकड़ों का विश्लेषण वार्षिक, मानसून, मानसून के बाद, सर्दियों और गर्मियों के मौसम के लिए किया गया। कुल 111 कुओं, 108 नलकूपों और 43 बोर कुओं से जल स्तर के आंकडों (वर्ष 1994-2019); नदी बेसिन के भीतर दो गेजिंग स्टेशनों से स्ट्रीम डिस्चार्ज और वर्षा के आंकड़ों को एकत्रित किया गया और इनका विश्लेषण किया गया।

निचली गोदावरी बेसिन में भूजल प्रदूषण का आकलन

निचली गोदावरी बेसिन में वर्ष 2019 के मॉनसून की पूर्व अवधि के दौरान विभिन्न गहराई से भूजल के नमूने एकत्रित किए गए और विभिन्न रासायनिक मापदंडों के लिए इनकाविश्लेषण किया गया। इन नमूनों में 7.2 की औसत पीएच के साथ 6.5 से 8.8 तक पीएच में बदलाव रहा और विद्युत चालकता 0.07 से 3.04 डेसी सिमन्स/मीटर तक पाई गई। अधिकांश नमूने बाइकार्बोनेट प्रकार के पाए गए जिनमें इस लवण की मात्रा अधिक नहीं पाई गई। और कुछ नमूने क्लोराइड प्रकार के पाए गए। भूजल के नमूनों में नाइट्रेट-नाइट्रोजन सामग्री अधिक पाई गई। इस क्षेत्र में धान-धान फसल प्रणाली (0.8 मिलीग्राम/लीटर) और ताड़ वृक्षारोपण (0.3 मिलीग्राम/लीटर) की तुलना में धान-मक्का फसल प्रणाली (2.7 मिलीग्राम/लीटर और केला बागान प्रणाली (4.4 मिलीग्राम/लीटर) में नाइट्रेट नाइट्रोजन की अधिक मात्रा पाई गई।

पॉट में मृदा कल्चर के माध्यम से धान की फसल पर आर्सेनिक के प्रभाव का अध्ययन

भाकृअनुप- भारतीय जल प्रबंधन संस्थान के अनुसंधान फार्म में रबी मौसम 2020 के दौरान नेट हाऊस की स्थिति के तहत एक पॉट प्रयोग किया गया। आर्सेनिक की मात्रा 30 मिलीग्राम/किलोग्राम की दर से मृदा में मिश्रित की गई और धान की फसल में दो जल स्तरों यानि लगातार फल्डिंग एवं जल सूखने के 3 दिनों के बाद पेनीकल शुरुआत की अवस्था पर फल्डिंग के साथ अलग-अलग कार्बनिक और रासायनिक उपचार प्रयोग किए गए। दोनों जल स्तरों यानि लगातार फल्डिंग एवं जल सूखने के 3 दिनों के बाद पेनीकल शुरुआत की अवस्था पर सिंचाई की स्थितियों के तहत फॉस्फोरस युक्त खाद के माध्यम से फॉस्फोरस की 50% सुझाई गई मात्रा तथा 276 व 552 किलोग्राम/हे की दर से जिप्सम के प्रयोग से नियंत्रण उपचार की तुलना में अधिक धान पुआल उपज प्राप्त हुई। ऊपर बताई गई सिंचाई की दोनों परिस्थितियों के तहत फॉस्फोरस युक्त खाद के माध्यम से फॉस्फोरस की 50% सुझाई गई मात्रा तथा 276 व 552 किलोग्राम/हे की दर से जिप्सम, 223 और 100 किलो/हे की दर से चूना + फेरस सल्फेट के प्रयोग से काफी अधिक दाना उपज प्राप्त हुई। लगातार सिंचाई के मामले में धान के पुआल एवं दाना में आर्सेनिक की सामग्री क्रमश: 5.4 एवं 0.95 मिलीग्राम/किलोग्राम पाई गई जबकि,जल सूखने के ३ दिनों के बाद पेनीकल शुरुआत की अवस्था पर सिंचाई के मामले में पुआल और दाना में क्रमशः 5.1 और 0.85 मिलीग्राम/किलोग्राम के रूप में आर्सेनिक की मात्रा पाई गई।

भारत की प्रमुख नदी बेसिनों में ग्रेविटी रिकोर्ड्स का उपयोग करके सूखा एवं गर्मी की अवधि का आकलन

बेसिन के पैमाने पर सूखा एवं तापमान की अत्यधिक अवधि के स्थानिक एवं सामयिक वितरण का मूल्यांकन किया गया। 21 वीं सदी के प्रारम्भ से जल की कमी में बहुत अधिक वृद्धि हुई है और गंगा नदी बेसिन में इसको स्पष्ट रूप से देखा जा सकता है। दक्षिणी गंगा, महानदी, ब्राह्मणी एवं सुबर्णरेखा की नदी बेसिनों के अधिक वर्षा वाले क्षेत्रों ने मध्यम वर्षा की घटनाओं का सबसे अधिक अनुभव किया है। गंगा नदी बेसिन के उत्तरी सूखे क्षेत्र में जहाँ, भूजल सिंचित धान-गेहूँ फसल पद्धति मौजूद है जो कि

मुख्यतया वर्षा द्वारा जलवाही के पुन:भरण पर निर्भर है वहाँ, भूजल की अधिकतम कमी पाई गई है। इसके परिणामत: वर्ष 2000 से पहले के औसत भूजल स्तर की तुलना में वर्ष 2011-2015 के दौरान समान रूप से 1.48 मीटर तक भूजल स्तर में गिरावट का अनुमान लगाया गया है।

भूजल प्रदूषण का आकलन करने के लिए धान के खेतों में जल एवं नाइटोजन डाइनेमिक्स का अध्ययन

धान की फसल में नाइट्रोजन के 3 स्तरों (90, 120 एवं 150 किलोग्राम नाइट्रोजन/हे) का प्रयोग किया गया जिससे यह पता चला कि नाइट्रोजन के स्तर में वृद्धि से दाना उपज में थोड़ी वृद्धि हुई लेकिन हार्वेस्ट इंडेक्स में कमी प्राप्त हुई।

ड्रिप सिंचित बहुस्तरीय फसल प्रणालियों का मूल्यांकन

भाकृअनुप-भारतीय जल प्रबंधन संस्थान के अनुसंधान फार्म में ड्रिप सिंचित बहु-स्तरीय फसल प्रणालियों के मूल्यांकन के लिए एक अध्ययन शुरू किया गया। इसके लिए सौर ऊर्जा संचालित ड्रिप सिंचाई प्रणाली का उपयोग करके केले की दो पंक्तियों के बीच विभिन्न फसल प्रणालियों जैसे कि तुरई + भिंडी, ककड़ी + लोबिया और लौकी + मूंग का सहरोपण (इंटरक्रॉप) किया गया।

क्रोमाइट खदान क्षेत्रों के जल से सिंचाई के लिए क्रोमियम का इन सीटू फाइटोरेमेडियसन

क्रोमियम के फाइटोरेमेडियसन के लिए जलीय मेक्रोफाइट्स का उपयोग करके एक इन सीटू संग्रहण सुविधा निर्मित की गई। जल संचयन सरंचना 1 एवं जल संचयन सरंचना 2 के जल में क्रोमियम की मात्रा क्रमश: 0.348 से 0.112 मिलीग्राम/लीटर के बीच पाई गई। नेट हाउस की स्थिति के तहत टमाटर (किस्म-केएसजी 1201) की फल उपज पर क्रोमियम युक्त दूषित जल (0.3-0.37 मिलीग्राम/लीटर) की सिंचाई का कोई प्रभाव नहीं पड़ा।

अपशिष्ट जल से सुरक्षित सिंचाई के लिए बायोलोजिकल फिल्टर का विकास

इमोबिलाइज्ड आक्सेनिक हाइड्रोजेल बीड्स के साथ बेक्टेरियल इनकम्पेटिबिलिटी के मुद्दे का समाधान किया गया। आक्सेनिक हाइड्रोजेल बीड्स ने प्रदूषित सामग्री को हटाने में विश्वसनीय परिणाम दिया लेकिन बाद में आक्सेनिक हाइड्रोजेल बीड्स के कन्सोर्टीया की विभिन्न प्रजातियों ने अधिक स्पष्ट क्षमता दिखाई। कुल चार बायोफिल्टर्स का विकास किया गया जिनका नाम इस प्रकार है (i) बायोबेड (ii) टनल (iii) गेबियन एवं (iv) कॉलम इत्यादि। तीन नई प्रजातियों के 16s-rRNA को सीक्वेंस्ड भी किया गया।

विभिन्न सिंचाई कमांडों में जल उपयोगकर्ता संस्थाओं के संचालन पर अध्ययन

ओड़िशा राज्य के नयागढ़ जिले की मध्यम सिंचाई कमांड में जल उपयोगकर्ता संस्थाओं के माध्यम से संचालित सिंचाई सेवाओं और जल प्रबंधन के मुद्दों का अध्ययन किया गया। खरीफ मौसम के दौरान जल की आपूर्ति, डिलिवरी बिन्दु, जल की धारा का आकार, अवधि, समय, बारंबारता, समानता इत्यादि के प्रति किसान संतुष्ट पाये गए। लेकिन, किसानों ने रबी मौसम के दौरान अनियमित जल आपूर्ति और अनुपलब्धता आदि मुख्य समस्याएं व्यक्त की। नहर के अंतिम छोर पर जल की उपलब्धता के मामले में किसानों की हालत बहुत खराब पाई गई । खरीफ मौसम में धान प्रमुख फसल थी और रबी मौसम में सब्जियाँ, दलहन और मक्का आदि प्रमुख फसलें उगाई जाती हैं।

उत्पादकता एवं आय में वृद्धि हेतु जल प्रबंधन तकनीकों का संचालन (एससीएसपी परियोजना के तहत)

ओड़िशा राज्य के कालाहांडी जिले के डांगरीगूड़ा गाँव (ब्लॉक-भवानीपट्टना) में कृषि की समस्याओं एवं महत्त्व पर चर्चा करने के लिए विभिन्न प्रशिक्षण कार्यक्रम एवं विचार विमर्श बैठकों को आयोजित किया गया। वहाँ, किसान परिवारों के बीच उनके अपने बाड़े में कृषि करने तथा उनकी आजीविका में सुधार के लिए आम, नींबू, सहजन एवं पपीता, बैंगन एवं टमाटर की पौध को वितरित किया गया। धान की सीधी बुआई वाली

परती भूमि में फसल विविधिकरण की संभावना का अध्ययन करने के लिए 0.2 हेक्टर भूमि पर मूंग (दलहन) की फसल का प्रदर्शन किया गया।

फारमर्स फर्स्ट परियोजना

इस परियोजना के तहत ओड़िशा राज्य में केंदुझर जिले के विभिन्न गाँवों में महत्त्वपूर्ण तकनीकें जैसे फव्वारा सिंचाई प्रणाली, धान की पंक्तियों में रोपाई, धान गहनता पद्धति (SRI) का प्रदर्शन, नमी संरक्षण के लिए सब्जियों की खेती में पॉलिथीन पलवार का प्रयोग, कम अवधि वाली संकर धान की किस्मों को लोकप्रिय बनाना, सूखे की पुष्टि के लिए वैज्ञानिक सिंचाई व्यवस्था और जल उत्पादकता में सुधार इत्यादि का कार्यान्वयन किया गया। कई किसानों ने धान गहनता पद्धति को अपनाया और धान की उपज में उल्लेखनीय वृद्धि प्राप्त की। केला और अनानास की रोपण सामग्री, सब्जियों की पौध तथा मछली के बीज (Fingerlings) का वितरण किया गया। तीन एक दिवसीय किसान-प्रशिक्षण कार्यक्रम आयोजित किए गए। विभिन्न फसलों/सब्जियों में रोग और कीटों की पहचान करने तथा इस समस्या का निदान करने के लिए व्हाट्सएप ग्रुप का उपयोग 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 की देख-रेख में इन समन्वित केन्द्रों द्वारा अधिक वर्षा वाले क्षेत्रों में वर्षा जल प्रबंधन, जल के बहुआयामी उपयोगों से कृषि उत्पादकता में वृद्धि, क्षेत्रीय स्तर पर भूजल उपयोग, भूजल मूल्यांकन और पुन:भरण, दबाव सिंचाई प्रणाली का मूल्यांकन, बागवानी और नकदी फसलों में जल प्रबंधन, नहर और भूजल का संयोजी उपयोग तथा जल निकासी अध्ययन इत्यादि 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 परियोजना के समन्वय केंद्र के रूप में कार्य करता है और इस संस्थान में कुल छह अनुसंधान परियोजनाओं पर कार्य किया जा रहा है। इन परियोजनाओं के प्रमुख निष्कर्ष इस प्रकार हैं-

रबर बांधों के प्रभाव का मूल्यांकन: विभिन्न कृषि-पारिस्थितिकी क्षेत्रों में रबर बांधों के प्रभाव मूल्यांकन किया गया। इन बांधों में जल संग्रहण की क्षमता 3600 से 20000 घनमीटर के बीच प्राप्त होती है और इस जल की सिंचाई के कारण खरीफ मौसम के धान की उपज में 17%, मूँग की उपज में 24% तथा सब्जियों की पैदावार में 27-38% तक की वृद्धि हुई। कुल चार वर्षों का औसत वार्षिक भूजल पुन:भरण का अनुमान 3630 घन मीटर पाया गया। खामरा गाँव में रबर बाँध, जल संरक्षण सरंचना और भूजल पुन:भरण कुओं के निर्माण के कारण भूजल स्तर में 25 मिमी की वृद्धि देखी गई। जल संचयन संरचना के साथ रबर बाँध से धान की कुल 24 हेक्टेयर भूमि की पूरक सिंचाई की गई।

नहरी कमांड में जल उत्पादकता को बढ़ाना: ओड़िशा राज्य के पूरी जिले की नागपुर माइनर में दबाव वाली सिंचाई सुविधा के साथ मौजूदा सहायक जल भंडारण संरचनाओं से जुड़ी पाइप-आधारित सिंचाई प्रणाली के विकास के परिणामस्वरूप मूंगफली, तिल और सब्जियों की फसलों की औसत पैदावार और उनकी जल उत्पादकता में वृद्धि हुई।

केला की फसल में स्वचालित ड्रिप सिंचाई और ड्रिप फर्टिगेशन: केला (किस्म-जी 9) की फसल में मृदा जल सेंसर आधारित सिंचाई से मैन्युअल रूप से संचालित ड्रिप सिंचाई की तुलना में 16% अधिक उपज के साथ 20% तक सिंचाई जल को बचाया जा सकता है। मृदा जल सेंसर आधारित सिंचाई से मैन्युअल रूप से संचालित ड्रिप सिंचाई

की तुलना में मृदा में उपलब्ध नाइट्रोजन, फॉस्फोरस एवं पोटेशियम की अधिक मात्रा पाई गई। इसी प्रकार, ड्रिप सिंचाई विधि के माध्यम से फूल बनने से पहले 60% फसल वाष्पोत्सर्जन (ईटीसी), फूल बनने व फलों की सेटिंग के समय 80% फसल वाष्पोत्सर्जन तथा फल विकास की अवस्था पर 60% फसल वाष्पोत्सर्जन की दर से सिंचाई को जब फूल बनने से पहले उर्वरकों की सुझाई गई 80% मात्रा, फूल बनने व फलों की सेटिंग के समय उर्वरकों की 100% मात्रा तथा फल विकास की अवस्था में 80 % उर्वरकों की मात्रा के प्रयोग द्वारा एकीकृत प्रयोग से 100% फसल वाष्पोत्सर्जन पर सिंचाई एवं 100% उर्वरकों की मात्रा का ड्रिप सिंचाई द्वारा प्रयोग की तुलना में मृदा एवं पत्तों दोनों में उपलब्ध नाइट्रोजन, फॉस्फोरस एवं पोटेशियम की अधिक मात्रा पाई गई। ड्रिप सिंचाई प्रणाली के तहत 5,000 पौधे/हे के घनत्व की तुलना में 3,333 पौधे/हे (प्रति गड्ढे में 1 पौधा) के घनत्व वाले पौधों की वनस्पति विकास अधिक पाया गया और केले की पत्तियों में नाइट्रोजन एवं पोटेशियम की अधिक मात्रा पाई गई।

मछलीपालन के लिए अपशिष्ट जल का फिर से उपयोग करना और मछली के शरीर के अंगों पर इसका प्रभाव: उपचारित अपशिष्ट जल के साथ मछली के शरीर के अंगों में भारी धातु का संचय कम हो जाता है, जल के डाइल्यूट होने पर और भी कम हो जाता है। ज्यादातर उपभोगीत मांसपेशियों में भारी धातुओं की सांद्रता सबसे कम पाई गई। भारी धातुओं के संचय का क्रम लीवर में Cr> Pb> Ni> Cd, जबकि, मांसपेशियों में Cr> Ni> Cd ~ Pb, गिल्ल्स में Cr> Ni> Cd ~ Pb और गुर्दों में Cr> Ni> Cd> Pb के रूप में होता है।

कार्प पॉलीकल्चर के साथ जल-उपयोगी दक्ष एकीकृत कृषि प्रणाली (IFS) मॉडल का विकास: मछलीपालन, कृषि, तटबंध पर बागवानी और मुर्गीपालन को एकीकृत करके जल-उपयोगी दक्ष एकीकृत कृषि प्रणाली (IFS) मॉडल का विकास किया गया, जिसके परिणामस्वरूप कुल शुद्ध आय ₹ 111,020/हे/वर्ष एवं शुद्ध उपभोज्य जल उत्पादकता ₹ 16.08/घनमीटर प्राप्त हुई। इसके अलावा, जल उपयोग की दक्षता (0.57 किलो/घनमीटर), उत्पादकता (4.6 टन/हे), फ़ीड रूपांतरण अनुपात (1.51), कुल वाटर फूटप्रिंट्स (998 घनमीटर/टन) और शुद्ध जल की उत्पादकता (₹ 9.2/घन मीटर) के मामले में विभिन्न मीठे जल की पॉलिकल्चर पद्धति की जल की आवश्यकता इंगित करती है कि मल्टी-स्टॉक और मल्टी-क्रॉप सिस्टम (MSMH) अधिक कुशल, उत्पादक और लाभदायक है।

ओड़िशा राज्य के नयागढ़ जिला में जल का बाजार: ओड़िशा राज्य में जल के बाजार अनौपचारिक और स्थान-विशिष्ट होते हैं, और जल के मूल्य का निर्णय ज्यादातर खरीददार और विक्रेताओं की सुविधा पर आधारित होता है। ओड़िशा राज्य के नयागढ़ जिले के दो ब्लॉकों खंडपारा और रणपुर में भूजल उपयोग और इसके विपणन पर सर्वेक्षण किया गया। रणपुर ब्लॉक में खरीफ मौसम के दौरान जल की कीमत ₹ 150 प्रति घंटे और रबी मौसम के दौरान ₹ 200 प्रति घंटे पाई गई। हालाँकि, खंडापारा ब्लॉक में जल के मूल्य का निर्धारण भूमि क्षेत्र के आधार पर किया जाता है और यह खरीफ मौसम में ₹11250/हे से लेकर रबी के मौसम में ₹ 15000/हे के बीच पाया गया। यह भी पाया गया कि नयागढ़ जिले के सर्वेक्षित किसानों में से अधिकतम शुद्ध लाभ जल विक्रेताओं द्वारा अर्जित किया गया।

प्रकाशन, पुरस्कार और सम्मान

भाकृअनुप-भारतीय जल प्रबंधन संस्थान, भुवनेश्वर के वैज्ञानिकों द्वारा वर्ष 2020 के दौरान कुल 34 शोध पेपरों के अलावा 9 /बुलेटिनों/प्रशिक्षण मैन्युअल/पुस्तक अध्याय एवं 7 लोकप्रिय लेखों को प्रकाशित किया गया। इसके अलावा, हमारे संस्थान के वैज्ञानिकों ने कई अन्य सम्मान और पहचान के साथ कई पुरस्कार भी प्राप्त किए हैं।

अनुसंधान परियोजनाएं

भाकृअनुप-भारतीय जल प्रबंधन संस्थान, भुवनेश्वर के वैज्ञानिक इस संस्थान की कुल 18 अनुसंधान परियोजनाओं तथा बाहरी वित्त-पोषित कुल 15 महत्त्वपूर्ण अनुसंधान परियोजनाओं पर अनुसंधान कार्य कर रहे हैं। यह सभी परियोजनाएं कृषि में कुशल एवं उचित जल प्रबंधन से संबन्धित हैं।

मानव संसाधन विकास, प्रशिक्षण और क्षमता निर्माण

हमारे संस्थान के कर्मचारियों ने अलग-अलग संगठनों से विभिन्न विषयों पर कुल 12 प्रशिक्षण प्राप्त किए हैं; भाकृअनुप-भारतीय जल प्रबंधन संस्थान ने ऑनलाइन के माध्यम से कई बैठकों / कार्यक्रमों कों आयोजित किया; किसानों के लिए भी बहुत से प्रशिक्षण कार्यक्रम आयोजित किए गए और विचार विमर्श बैठकों का आयोजन किया गया तथा इस संस्थान से विकसित की गई महत्त्वपूर्ण जल प्रबंधन तकनीकों का प्रदर्शन दो प्रदर्शनियों के माध्यम से किया गया।

स्वच्छ 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 2020 के दौरान स्वच्छता के प्रति जागरूकता के कुल 82 कार्यक्रमों को आयोजित किया; इस अभियान के दौरान विभिन्न छात्रों को स्वच्छता के लिए प्रेरित किया गया तथा इस वर्ष के दौरान स्वच्छता के विषय पर कई वाद विवाद/सेमिनार/प्रशिक्षण कार्यक्रम भी आयोजित किए गए।

EXECUTIVE SUMMARY

Performance evaluation of developed mini-pan evaporimeter

A field experiment was conducted to evaluate the performance of mini pan evaporimeters (GI mini pan with 30 and 20 cm diameter) for on-farm irrigation scheduling against USWB Class A Open Pan evaporimeter during *rabi* (2019-20), summer (2020) and *kharif* (2020) seasons. It was observed that the crop yield (tomato in *rabi*, maize in summer and paddy in *kharif* seasons) and yield parameters did not vary significantly under mini pan evaporimeters and USWB Class A pan treatments.

Land shaping benefits in coastal waterlogged areas in Odisha

Comparison of 'Alternate raised and furrow bed and aquaculture in an agroforestry system' and 'Land shaping option of converting 1/3rd area for farm pond and 1/3rd area for raised bed' in coastal waterlogged Ersama revealed that the former was beneficial with higher net return ₹192381 ha^{-1} and B: C ratio 2.51 as compared to the latter system (₹121908 ha^{-1} and 2.38, respectively). In a drought prone rainfed shallow lowland at Deras, optimum size of raised bed and sunken bed were 4 m and 5 m, respectively.

Artificial substrate induced periphyton biomass in zero-water exchange shrimp culture system

Substrate induced periphyton biomass in zero-water exchange condition gives significantly higher yield (11.53 t ha^{-1} 120d^{-1}), economic benefit (OV:CC, 2.3), net total water productivity (₹ 73.1 m^{-3}) and lesser sediment load (28.6 m^{3} t^{-1} biomass). This also significantly improved water quality, minimized the total water requirement (43.7%) and enhanced yield by 8.6-15.2%. Periphyton biomass helped in reducing the TVC count (1.18 x 10^{3} CFU ml^{-1}) in water while increased the THB count (3.6 x 10^{5}CFU ml^{-1}). Lowest percentage of TVC/THB (0.33), suggesting competitive approach of heterotrophic bacteria for space and nutrients. Autotrophic index (197.1-243.2) was an indicative of organically non-polluted conditions (<400).

Post-flood management plans implemented

The post-flood management plans were implemented in flood prone areas of Muzaffarpur and East Champaran districts of Bihar, and Kendrapara and Puri districts of Odisha. The farmers could generate additional net returns of about ₹29,800 ha^{-1} in Muzaffarpur district and ₹25,200 ha^{-1} in Puri district due to implementation of post-flood management plan compared to the flood-damaged field without intervention.

Sprinkler irrigation in selected rice varieties under aerobic condition

Sprinkler irrigation is a proven option for irrigation water saving in other crops, but for rice, reducing water requirement of puddled rice remains a challenge. Results of field experiments under both aerobic and puddled conditions show that average rice yield in aerobic conditions was 2.95 t ha^{-1}, which was about 28% less than puddled transplanting; whereas irrigation water saving was about 43%, increase in water productivity was 28% in sprinkler irrigation. Among three varieties, yield performance was the best in 'NPH-150', and 'Sahabhagi' and 'CR-202' were similar under aerobic; the performance was in the order 'NPH-150'>'CR-202'>Sahabhagi' with yield of 4.54, 4.20 and 3.48 t ha^{-1} under puddled transplanted conditions.

Performance evaluation of water stress under different rice crop management systems

To improve the productivity and the production of drought-prone areas, a field experiment was conducted on rice during *rabi* / summer season 2020 with a combination of improved varieties and crop management to evaluate rice crop performance under different duration of water stress. The highest grain yield was obtained under SRI cultivation methods followed by conventional transplanted system (CTS) and least under direct-seeding (DS) method. Averaged over the different water stress treatments, grain yield in SRI was 57 and 39% higher than direct seeding and CTS, respectively. Also, CTS out-yielded DS by 13%. Amongst different water stress treatments, lowest grain yield was found when water stress treatment started during late vegetative crop growth stage under all the methods.

Developed crop plan strategies and policy recommendation for Sina medium irrigation project

The annual IPU/IPC was resulted as more than one considering the water influence zone (WIZ) based on the study conducted in Sina water-scarce irrigation system in Maharashtra. The WIZ was comprised of culturable command area (CCA), 1 km buffer zone around the CCA and reservoir lift irrigated area. Based on low, medium and high rainfall conditions, the study helped in developing crop plan strategies through development of water cost curve to enhance the economic water productivity. Policy recommendations have been suggested on the accurate estimates of actual irrigated area in the WIZ using RS/GIS methods, estimation of water accounts, assessment of the groundwater recharge zones and the water volume to support crop production.

Study on land-atmosphere interaction impacts on dry-hot episodes in India

A significant part of the temperature rises is mainly because of the drying monsoon rainfall, both of which are coupled in a feedback loop driving the intensity, translating even moderate droughts into major ones. So, the increasing tendency of hotter droughts will enhance the irrigating requirements, especially in the agriculturally productive regions sustained by groundwater irrigation.

Impact of land use and land cover changes on groundwater storage in Baitarani river basin

Hydrological analysis for Baitarini river basin has been carried out by considering DEM, slope, fill, flow direction, flow accumulation, stream network and stream order. This basin is of 6th order drainage basin. The 1st order streams have the highest total length of 3446.33 km with mean length of 1.18 km; 6th order stream has the lowest length of 138.27 km with a mean length 0.78 km. Rainfall data of 120 years (1901-2020) from 8 blocks within the river basin (1901-2020) were analyzed for annual, monsoon, post-monsoon, winter and summer season. Water level data (1994-2019) from 111 dug wells, 108 tube wells, and 43 bore wells; time series data of stream discharge and rainfall from two gauging stations within the river basin was collected and analyzed.

Assessment of groundwater contamination in lower Godavari basin

Groundwater samples were collected from different depths in lower Godavari basin during pre-monsoon season in 2019, and analysed for different chemical parameters. The pH varied from 6.5 to 8.8 with a mean of 7.2; electrical conductivity ranged from 0.07 to 3.04 dS m^{-1}. Majority of samples are of bicarbonate type followed by samples with no dominant type and a few samples with chloride type. Higher nitrate-nitrogen content were found in ground water samples where cropping systems, rice-maize (2.7 mg L^{-1}) and banana plantation (4.4 mg L^{-1}) are prevailed as compared to rice-rice (0.8 mg L^{-1}) and oil palm plantation (0.3 mg L^{-1}).

Study on effects of As on rice through soil culture in pots

A pot experiment under net house conditions at the ICAR-IIWM research farm during the *rabi* season 2020 was conducted. Soils were spiked with arsenic @ 30 mg kg^{-1} and different organic and chemical amendments were applied at two water regimes viz. continuous flooding and flooding at 3 day after disappearance (DAD) of ponded water; up to PI stage. Straw yield increased significantly over control with application of P enriched manure to supply 50% RDF of P_2O_5, application of gypsum @ 276 and 552 kg ha^{-1} in both continuous flooding and flooding at 3 day after disappearance etc. Grain yield increased significantly in treatments viz. application of P enriched manure to supply 50% RDF of P_2O_5; application of gypsum @ 276 and 552 kg ha^{-1}, treatment with ferrous sulfate + lime @ 223 and 100 kg ha^{-1}, respectively in case of both continuous flooding and 3 DAD etc. In case of continuous flooding arsenic content was found 5.4 and 0.95 mg kg^{-1} whereas, in case of irrigation at 3DAD As was measured as 5.1 and 0.85 mg kg^{-1} respectively, in straw and whole grain.

Drought and hot-spell assessment using gravity records in major river basins of India

The spatial and temporal distribution of drought and extreme temperatures are evaluated at the basin scale. The water stress has markedly increased since the beginning of the 21st century, with the Ganges basin showing a clear signal of changes. The high rainfall areas of southern Ganga, Mahanadi, Brahmani and Subernarekha have experienced the maximum drop in moderate rain events. The arid northern part of the Ganga basin, where the groundwater-fed rice-wheat cropping system rely mostly on rainfall to recharge its aquifer, has witnessed maximum stress. Consistently, a drop of 1.48 m groundwater level was estimated during 2011-2015, compared to the pre-2000 mean water table.

Studies on water and nitrogen dynamics in paddy fields for assessing groundwater pollution initiated

Three nitrogen doses (90, 120 and 150 kg N ha^{-1}) in rice was imposed and result shows that with the increase of N dose, there was slight increase of grain yield and decrease in harvest index.

Evaluation of drip irrigated multi-tier cropping systems

A study has been initiated to evaluate drip irrigated multi-tier cropping systems at ICAR-IIWM research farm. Different cropping systems viz., ridge gourd + okra, cucumber + cowpea, and bottle gourd + greengram were intercropped between two rows of banana using solar powered drip irrigation system.

***In-situ* phytoremediation of Cr (VI) from water in Chromite mine areas for irrigation**

An *in-situ* storage facility has been created for supplying aquatic macrophytes for phytoremediating Cr (VI); Cr (mg l^{-1}) varied from 0.348 to 0.112 and 0.09 to non-detectable in WHS-1 and WHS-2 respectively. Irrigation with Cr-enriched water (0.3 – 0.37 mg l^{-1}) has however found no-impact on fruit yield of tomato (KSG1201) growing under net-house condition.

Development of biological filter for safe wastewater irrigation

Bacterial incompatibility issue was resolved with immobilized axenic hydrogel-beads. Axenic hydrogel-beads gave promising results in removing pollutants, but the consortia of axenic hydrogel-beads of different strains performed far better. Four biofilters have been designed, namely, i) Biobed, ii) Tunnel, iii) Gabion and iv) Column. Three new strains were 16s-rRNA sequenced.

Study on the functioning of water user association in different irrigation command

Aspects of irrigation services and management through water user association were studied in medium irrigation command of Nayagarh district and farmer's perception was found satisfactory in terms of water supplied, point of delivery, stream size of water, duration, timeliness and frequency and equitability during kharif season, however majority expressed concern about irregular water supply and non-availability during rabi season, and tail end farmers being the worst affected. Paddy is the main crop in *kharif* season and vegetables, pulses, maize are the main crops during *rabi* season.

Piloting water management technologies for enhancing productivity and income (under SCSP)

Training program and farmer-scientist interaction meetings were organized to discuss the problems and scope of agriculture in the Dangariguda village of Bhwanipatna block in Kalahandi district of Odisha. Saplings of mango, lime, drumstick and papaya and seedlings of brinjal and tomato were distributed among farm families for homestead agriculture and livelihood improvement. Demonstration of pulse crop (mung) has been taken up on 0.2 ha land to study the prospect of crop diversification in direct-seeded rice fallow lands.

Farmer's FIRST project

Interventions like sprinkler irrigation, line transplanting of paddy, SRI demonstrations, polythene mulching in vegetable cultivation for moisture conservation, popularization of short-duration hybrid paddy varieties, scientific irrigation scheduling for drought proofing and improving water productivity were taken up in the project implementation villages. Several farmers adopted SRI method and reported significant yield increase. Banana and pineapple planting materials, vegetable seedlings and fish fingerlings were distributed. Three one-day farmer-training programs were organized. WhatsApp group was used to identify and solve diseases and pests in crops/vegetables.

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:** 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, 24% in green-gram, and 28-46% in vegetables. The four years average annual groundwater recharge was estimated as 3630 m^3. Due to construction of rubber dam, water harvesting structure and recharge well in the Khamara village, an increase of 25 mm of groundwater level was observed. The rubber dam along with the water harvesting structure provided supplementary irrigation to 24 ha of paddy land.

- **Enhancing water productivity in canal command:** 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.

- **Automated drip irrigation and fertigation in banana:** Soil water sensor-based irrigation scheduling could save 20% water with 16% higher yield compared with manually operated drip irrigation in banana (cv. G-9). The available N, P and K in soil under sensor based irrigation were higher than those under manual irrigation. Similarly, both soil available N, K and leaf N and K under drip-fertigation at 60% of crop evapotranspiration (ET_C) at pre-flowering, 80% ET_C at flowering and fruit setting, and 60% ET_C at fruit development stages integrated with fertilizer application at 80% RDF (recommended dose of fertigation) at pre-flowering, 100% RDF at flowering and fruit setting, and 80% RDF at fruit development were higher than irrigation at 100% ET_C with 100% recommended dose of fertigation (RDF) in the crop. The plants with plant density of 3,333 plants ha^{-1} (1 plant per pit) under drip system had higher vegetative growth and leaf N and K compared with 5,000 plants ha^{-1} in banana.

- **Wastewater re-use in aquaculture and its impact of fish body parts:** The heavy metal accumulation in fish-body parts decreased in treated wastewater and further with dilution. Heavy metal concentrations were the lowest in the mostly consumed muscles. Accumulation of heavy metals were in the order as Cr>Pb>Ni>Cd for liver, then Cr>Ni>Cd~Pb for muscle, then Cr>Ni>Cd~Pb for gills and Cr>Ni>Cd>Pb for kidney.

- **Developed water-use efficient integrated farming system (IFS) model with carp polyculture:** A water-use efficient IFS model has been developed integrating aquaculture, agriculture, on-dyke horticulture and poultry, resulting in the net income of ₹111,020 ha^{-1} yr^{-1} and net consumptive water productivity of ₹16.08 m^{-3}. Further, water requirement of different freshwater polyculture systems indicates that multi-stock and multi- harvest system (MSMH) is more efficient, productive and profitable in terms of water use efficiency (0.57 kg m^{-3}), productivity (4.6 t ha^{-1}), feed conversion ratio (1.51), total water footprint (998 m^3 t^{-1}) and net consumptive water productivity (₹9.2 m^{-3}).

- **Water markets in Nayagarh district of Odisha:** In Odisha, water market is informal and location-specific, and the price decision is mostly based on the convenience of the buyer and seller. The survey was conducted on groundwater use and its marketing in two blocks viz. Khandpara and Ranpur in Nayagarh district of Odisha. The price of water was ₹150 per hour during *kharif* season, and ₹200 per hour during *rabi* season in Ranpur block. However, in Khandapada block, pricing was based on land area basis, and it varied between ₹11250 ha^{-1} in *kharif* to ₹15000 ha^{-1} in *rabi* season It was found that the maximum net profit was accrued to the water sellers in the Nayagarh district among the surveyed farmers

Publication, awards and recognitions

During 2020, scientists of ICAR-IIWM published 34 peer reviewed research papers, 9 bulletins / folders / training manuals / book chapters and 7 popular articles. Our Scientists have received several awards, along with many others honours and recognitions.

Research projects

Scientists of ICAR-IIWM working on 18 in-house and 15 externally-funded research projects.

HRD, training & capacity building

Our staff received 12 trainings on various topics from different organizations; ICAR-IIWM conducted several virtual meetings / programs; seven farmers' training programs / interaction meetings; and two exhibitions to showcase ICAR-IIWM technologies.

Swachh Bharat Abhiyan

ICAR-IIWM participated actively in *Swachh Bharat Abhiyan* and 82 number of cleanliness drive and *Swachhta* Awareness Campaigns were conducted during 2020 in the Institute main campus, public places and tourist spots; motivated students for cleanliness; organized debate, seminars and trainings.

CONTENTS

Introduction

Introduction

The ICAR-Indian Institute of Water Management 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 9.5 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 above mean sea level. The research farm of the Institute (63.71 ha of farm land) is located at Deras, Mendhasal (20°17′ N and 85°41′ E at 61 m above mean sea level) and is 25 km away from main institute complex.

MANDATE

- Strategies for efficient management of on-farm water resources for sustainable agricultural productivity.
- Co-ordinate research for generating location-specific technologies for efficient use of water resources.
- Center 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 is bestowed with experienced multi-disciplinary team of scientists.

Significant research achievements for the year 2020 have been included in this annual report under four programs of the Institute. Our scientists are actively involved in development of irrigation plans; studies on impacts of land-atmosphere interactions on dry-hot episodes in India and land modification/shaping technique for enhancing productivity; Impact of land use and land cover changes on groundwater storage, 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, basic studies on water stress, 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 phytoremediation of Cr (VI) from water in chromite mine areas for irrigation and development and evaluation of mini-pan evaporimeter for irrigation scheduling. Our Institute has also initiated site suitability analysis for crop planning and aquaculture development using geo-informatics, studies on water and nitrogen dynamics in paddy field, evaluation of drip irrigated multistoried cropping systems and preparation of yield gap atlas for pulses and oilseeds. A substantial work has been done for livelihood improvement of scheduled tribe and tribal farmers through water management interventions, in Farmers FIRST project and revival of village ponds through scientific intervention.

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 farmers on various aspects of water management, and participated in exhibitions to showcase technologies developed by the institute.

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 NASF, ICAR, New Delhi, IWMI, Colombo and DST. The institute is coordinating center for AICRP on Irrigation Water Management and ICAR- Agri-Consortia Research Platform on Water, ICAR, New Delhi.

Finances

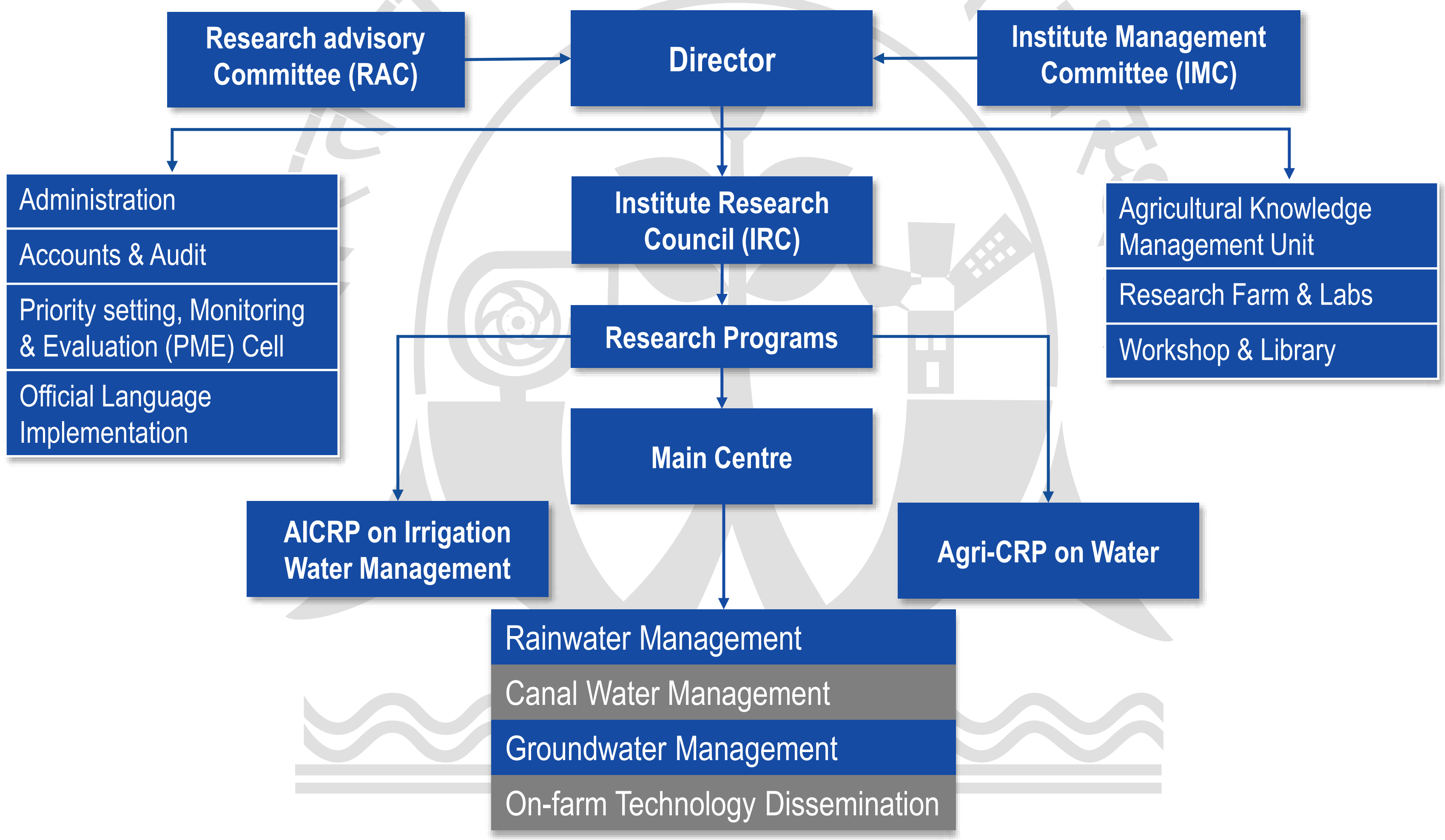
Summary of income & expenditure account and balance sheet of the institute during the year 2020 is presented at the end of this report.

Staff

As on December 31, 2020, ICAR-IIWM had 80 sanctioned posts (including AICRP-IWM coordinating center), out of which 62 are in position. Details of the personnel are given below:

Cadre	Sanctioned	In Position	Vacant
RMP	01	00	01
Scientific	40	32	08
Technical	17	15	02
Administrative	16	10	06
Supporting	06	05	01
Total	**80**	**62**	**18**

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
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

Development and Evaluation of Mini-pan Evaporimeter for On-farm Irrigation Scheduling

Project Code: NRMA/IIWM/SIL/2017/001/00183

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

To evaluate the performance of GI mini pan evaporimeters (30 and 20 cm diameter) against USWB Class A Open Pan evaporimeter for on-farm irrigation scheduling, field experiments were conducted during *rabi* (2019-20), summer (2020) and *kharif* (2020) seasons at the ICAR-IIWM research farm, Mendhasal, Bhubaneswar, Odisha.

During *rabi* 2019-2020 season, experiment was conducted with tomato with three treatments viz. T1-irrigation scheduling based on 30 cm mini pan, T2 - irrigation scheduling based on 20 cm mini pan, T3-irrigation scheduling based on USWB Class-A pan, and seven replications in a randomized complete block design. Irrigation scheduling was carried out using IW/CPE ratio where IW was 50 mm. All the three treatments T1 to T3 were irrigated equally during January 2020 based on the evaporation data. It was observed that plant height, number of branches and yield (ranged between 16.93 to 19.95 t ha^{-1}) (Fig. 1) of tomato showed no significant difference among the three treatments.

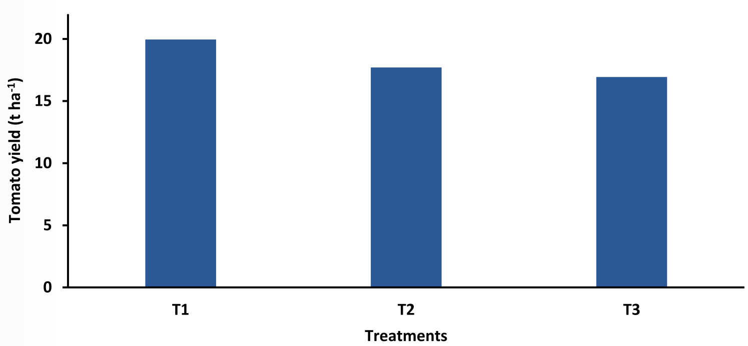


Fig. 1. Tomato yield as affected by different treatments

Rainwater Management

In summer 2019-2020, an experiment was conducted using maize crop with three treatments [T1-irrigation scheduling based on 30 cm mini pan. T2 - irrigation scheduling based on 20 cm mini pan, T3- irrigation scheduling based on USWB Class-A pan] and seven replications in a randomized complete block design. Irrigation was applied to experimental fields based on IW/CPE ratio of 1, where IW was 50 mm. All the three treatments T1 to T3 were irrigated four times during crop growing period. The maize leaf area index (2.49 to 2.55), aboveground biomass (6.93 to 7.35 t ha^{-1}) and cob yield (4.06 to 4.07 t ha^{-1}) were not affected significantly due to treatments (Fig. 2).

Maize experiment field view

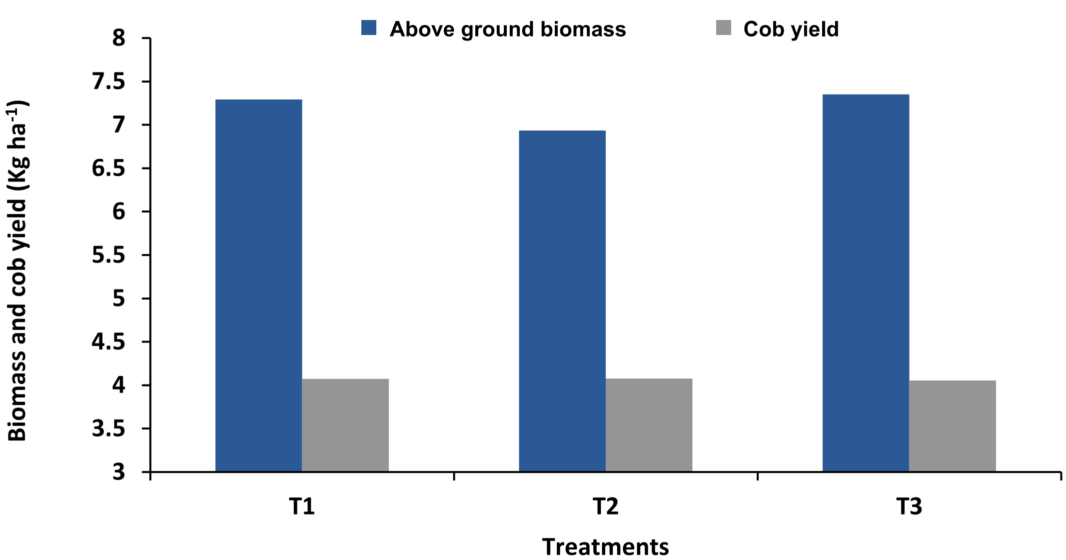


Fig. 2. Above ground biomass and cob yield of maize under different treatments

During *kharif* 2020, an experiment was conducted in rice with five treatments [T1: irrigation scheduling based on 30 cm mini pan; T2: irrigation scheduling based on 20 cm mini pan; T3: irrigation scheduling based on USWB Class A pan; T4: irrigation scheduling based on 3 days after disappearance (DAD) of ponded water and T5: control (i.e. rainfed) with four replications in a randomized complete block design, with two varieties viz., 'Pooja' and 'Swarna'. Irrigation scheduling was done based on IW/CPE (IW/CPE = 3, where IW was 60 mm). 'Swarna' and 'Pooja' were irrigated with 7 and 6 number of irrigation, respectively. 'Swarna' and 'Pooja' under treatment T4 (3 DAD) were also irrigated with 7 and 6 number of irrigation, respectively, with 7 cm depth of water. The total amount of water used in 'Swarna' and 'Pooja' were 508–998, and 508–928 mm, respectively. The grain and straw yield of 'Swarna' and 'Pooja' were not significantly ($P \leq 0.05$) different among T1 to T4 treatments (Table 1). From this study it can be summarized that the crop performance under mini pan evaporimeters and USWB Class A pan did not vary significantly.

Table 1. Grain and straw yield of rice (Swarna and Pooja) in *kharif* season

Treatments	Swarna			Pooja		
	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Water use (mm)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Water use (mm)
T_1: Irrigation based on 30 cm diameter mini pan	5.35a	8.80a	928	4.83a	7.95a	868
T_2: Irrigation based on 20 cm diameter mini pan	5.20a	8.68a	928	4.73a	7.93a	868
T_3: Irrigation based on USWB Class A pan	5.28a	8.90a	928	4.78a	8.03a	868
T_4: Irrigation based on 3 DAD of ponded water	5.05a	8.33a	998	4.55a	7.48a	928
T_5: Control (rainfed)	2.93b	5.73b	508	2.70b	5.40b	508

Field experimental view of rice (var. Swarna) during *kharif*, 2020

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

Project code: NRMA/IIWM/SIL/2017/002/00184

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

Land shaping option of converting coastal waterlogged area from lowland rice-fallow system to “Alternate raised and furrow bed and aquaculture in an agroforestry system” was attempted at Baghadi village in Ersama Block of Jagatsingpur District. There were 7 broad beds each having 5.5 m at base (ground level) and 5.0 m at top. There were 6 furrows alternated with broad beds. Furrows were 3 m wide at ground level and 2 m at base with a depth of 1 m from surface level. At the downside of the beds and furrows, all the 6 furrows were connected to a lateral furrow of 45.5 m length and 5 m width. The lateral furrow was connected to a water harvesting farm pond which served as refuge pond for fishes grown in the system. Thus, the total water surface area for growing fish was 1427.5 m^2 (refuge pond 300 m^2+furrows 900 m^2+ lateral furrow 227.5m^2).

Fish yield harvested from the system was 329.5 kg. It includes 123 kg catla, 62 kg rohu, 48 kg mrigal, 49 kg magur and 47.5 kg *kau* (*Anabaes*). Catla, rohu and mrigal were sold at ₹120 kg^{-1}, while kau at ₹150 kg^{-1} and magur at ₹200 kg^{-1}. Gross return, expenditure and net return from the water area of the system were ₹44885, ₹19246 and ₹25639, respectively. This on hectare basis works out as ₹367910, ₹157754 and ₹179608, respectively.

Vegetables were grown on the raised bed in *kharif* and *rabi* seasons. Gross return, expenditure and net return from the system for *kharif* vegetables on hectare basis were ₹198693, ₹62754 and ₹135939, respectively, with a B: C ratio as 3:2. Similarly, for *rabi* vegetables the values were ₹124486, ₹58571 and ₹65915, respectively. Thus, more returns were obtained for *kharif* vegetables as compared to *rabi* vegetables. The bed system with well drainage and good capillary supply might be more useful in *kharif* season. Also, there was faster decline of salinity from the bed system in *kharif* season. Combining the returns from both from *kharif* and *rabi* season; gross return, expenditure and net return on hectare basis were ₹323179, ₹121325 and ₹201854, respectively, with 2.7 as B: C ratio.

Brinjal on raised bed (alternate bed system)

Tomato on raised bed (alternate bed system)

Comparison of "Alternate raised and furrow bed and aquaculture in an agroforestry system" vs "Land shaping option of converting 1/3rd area for farm pond and 1/3rd area for raised bed"

Land shaping option of converting 1/3rd area for farm pond, 1/3rd area for raised bed and the remaining area for lowland rice without land modification was experimented at two locations (Baghadi and Hatiapal) in Ersama block, Jagatsinghpur District. Vegetables were grown on raised beds while pisciculture was practised in farm pond. The mean returns from the two sites are presented in Table below. Highest net return (₹ 170875 ha^{-1}) and B:C ratio (2.66) was accrued from fish component closely followed by vegetable component while prominently the lowest with the lowland rice cultivation in the undisturbed 1/3rd area. The system as a whole provided ₹ 121908 ha^{-1} as net return and 2.38 as B: C ratio (Table 2).

Table 2. Gross return, expenditure and net return (₹ ha^{-1}) from the system with 1/3rd area for farm pond and 1/3rd area for raised bed

	Vegetables	Fish	Rice	Total
Gross return	300708	273750	55725	210061
Expenditure	134583	102875	27000	88153
Net return	166125	170875	28725	121908
B: C ratio	2.23	2.66	2.06	2.38

Okra on raised bed (1/3rd bed system)

Green Amaranth (1/3rd bed system)

Gross return, expenditure and net return from the system with Alternate raised and furrow bed and aquaculture in an agroforestry system are presented in Table 3. Alternate raised and furrow bed and aquaculture was beneficial with higher net return ₹192381 ha^{-1} and B: C ratio 2.51 as compared to the system with 1/3rd area for farm pond and 1/3rd area for raised bed (₹121908 ha^{-1} and 2.38, respectively). This was due to higher return from vegetable component followed by fish component. Also, the low productive of lowland rice system was absent in this system. Faster rate of salinity removal and higher root length density might be beneficial for bed crops with 'Alternate raised and furrow bed and aquaculture in an agroforestry system'. Inclusion of air breathing fish (kau and magur) with higher market price could be grown profitably with shallow water depth condition with higher net return on unit area basis. Also, the beds alternated with furrows was beneficial for bed crops for solar energy harvest, especially in *kharif* season.

Table 3. Gross return, expenditure and net return (₹ ha^{-1}) from the system with alternate raised and furrow bed and aquaculture in an agroforestry system

	Vegetables	Fish	Total
Gross return	323179	367910	340531
Expenditure	121325	102875	135456
Net return	201854	179608	192381
B: C ratio	2.66	2.33	2.51

Another experiment was conducted at ICAR-IIWM Research farm in a drought prone area with land shaping of narrow raised bed (2 to 5 m) alternated with wide furrow (3 to 5 m) system. Unlike coastal waterlogged ecosystem, the furrows were made wider to harvest more rain water to overcome moisture stress during dry spell. Four intercropping systems viz. rice+ maize, rice + ladies finger, rice + cowpea and rice + chilli were evaluated for yield performance. These four intercropping systems were compared with sole rice grown in flat land. In addition, high value horticultural crops (Banana, papaya and cucumber) were grown on pond embankment to make this an integrated farming system for enhancing income. Results revealed that rice yield during *kharif* season varied from 4.45 -5.27 t ha^{-1} in furrows while in flat land it was lower (3.97 t ha^{-1}) (Table 4). From different size of beds, cob yield of maize varied from 6.22 to 7.48 t ha^{-1}, while pod yield of ladies finger from 6.40 to 7.82 t ha^{-1}, cowpea from 1.32 to 2.51 t ha^{-1} and green chilli from 4.5 to 8.12 t ha^{-1}. Optimum size of raised bed and furrow were 4 m and 5 m, respectively. From pond embankment, horticultural crops like banana, papaya and cucumbers yielded at 35 t ha^{-1}, 40 t ha^{-1} and 5.5 t ha^{-1}, respectively.

Table 4. Performance different crops in sunken bed and furrow land modification

Raised bed x furrow size	Yield (t ha^{-1})				
	Rice	Maize	Ladies finger	Cowpea	Chilli
2m x 3 m	4.45	6.22	6.40	1.32	4.5
3m x 4 m	4.68	6.98	6.86	1.58	6.34
4m x 5 m	5.27	7.48	7.82	2.51	8.12

Maize and okra on raised bed and rice in sunken bed

Water Management Using Artificial Substrate Induced Periphyton Biomass in Zero-water Exchange Shrimp Culture System

Project code: NRMA/IIWM/SIL/2018/001/00188

Investigators: R.K. Mohanty, S. Raychaudhuri and P. Deb Roy

An attempt is being made by ICAR-IIWM to study (1) The effect of artificial substrate induced periphyton biomass on the consumptive and total water requirement in monoculture of Pacific white shrimp *(Litopenaeus vannamei)* in zero-water exchange earthen pond, (2) The impact of periphyton biomass / biofilm on water quality, sediment load, water productivity, water footprint, zoo-technical and production performance of *L. vannamei* and (3) To develop protocols for best water management practices in zero-water exchange shrimp culture system.

We quantified the total water requirement and consumptive water use in monoculture of Pacific white shrimp, *L. vannamei*. Treatment-wise estimated total water use was 2.68, 2.63 and 3.78 ha-m, while the computed consumptive water use index, (m^3 kg^{-1} biomass) was 1.23, 1.05 and 2.24 in T_1 (ZE-NS, Zero-water exchange ponds without substrate), T_2 (ZE-WS, Zero-water exchange ponds with substrate; aquamats H” 50% bottom area only) and T_3 (E-NS, Periodic water exchange ponds without substrate), respectively. Treatment-wise estimated total water footprint was 699.3, 615.8 and 1751.4 m^3 t^{-1}, while the computed consumptive water use efficiency was 814, 953 and 446 g m^{-3} in T_1, T_2 and T_3, respectively. Similarly the net total water productivity (₹ m^3) was 59.0, 73.1 and 43.1 in T_1, T_2 and T_3, respectively.

The shrimp pond water quality suitability index (WQSI)/ Hydrological index that expresses the overall water quality in a given place and time infers that substrate induced periphyton biomass in zero-water exchange condition (T_2) improves the overall suitability of water quality for shrimp culture. WQSI up to 70, 98 and 84 days of culture range between 7.5-9.0 (very good) in T_1, T_2 and T_3, respectively and needs little management while it was good (5.5-7.5) thereafter with moderate management requirements (Fig. 3).

Substrate induced periphyton biomass in zero-water exchange condition (T_2) gives significantly higher yield (11.53 t ha^{-1} $120d^{-1}$), economic benefit (Output Value:Cost of Cultivation, 2.3), net total water productivity (₹ 73.1 m^{-3}) and lesser sediment load (28.6 m^3 t^{-1} biomass). This treatment (T_2) has also significantly improved water quality, minimized the total water requirement (43.7%) and enhanced yield by 8.6-15.2%.

Periphyton biomass developed on the aquamats (T_2) helped in reducing the Total Vibrio Count (1.18 x 10^3 CFU ml^{-1}) in water while increased the Total Heterotrophic Bacteria count (3.6 x 10^5CFU ml^{-1}) in comparison to T_1 and T_3 (Fig. 4). Addition of the substrate along with the carbon source supplementation significantly increased the THB count in the water column. Lowest percentage of TVC/THB (0.33) in T_2, suggesting competitive approach of heterotrophic bacteria for space and nutrients. AI (autotrophic index) in T_2 (197.1 - 243.2) indicates no organically polluted conditions (<400) (Fig. 5). Feed & nutrition management infers that at desirable rearing density (50 PL m^{-2}) and in best production practice (T_2), 0.5 kg crude protein in feed is required to produce 1 kg shrimp (PCR), while 5.1 kg of dry matter in feed is required to produce 1 kg dry mater of shrimp. Similarly 1.04 kg waste is produced per 1 kg shrimp production.

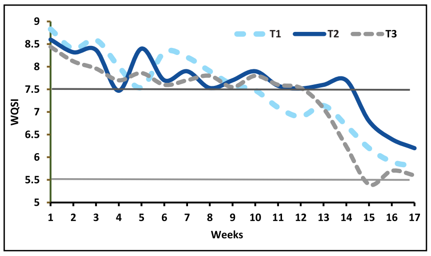


Fig. 3 Treatment-wise water quality suitability index (WQSI).

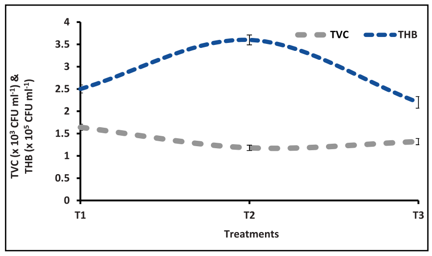


Fig. 4 Total vibrio and heterotrophic bacteria count in T_2 (ZE-WS).

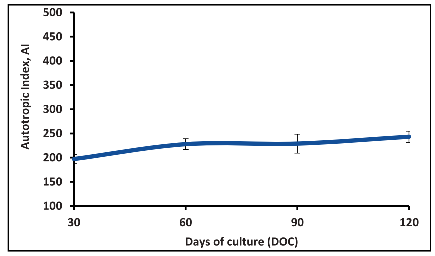


Fig. 5 Monthly autotrophic index in T_2 (ZE-WS).

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.K. Jena, S.K. Ambast, A. Ahmed, A.K. Singh, B.P. Bhatt, G. Amarnath and A.K. Sikka

The objectives of this project are 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 promote agricultural resilience.

The agro-economic analysis was done for the post-flood management plan implemented in operational area viz., flood affected areas of Gaighat and Katra blocks, Muzaffarpur district of Bihar and Kanas block, Puri district of Odisha during 2019-2020. In Muzafarpur, the post-flood management plan (cultivation of maize, wheat, mustard, lentil, brinjal, tomato, cucumber and cauliflower) resulted in higher crop resilience and crop productivity thereby resulting in additional net economic returns up to ₹29,800/- ha^{-1} compared to flood damaged field without intervention. Overall, the post-flood management interventions resulted in enhancement of benefit: cost ratio from 1.55 to 2.79. In Puri, the performance of sunflower was superior in terms of its productivity (1.22 t ha^{-1}) and net returns (₹25,200/-) compared to other alternate crops viz., greengram, brinjal, ridge gourd, pumpkin, okra and cowpea.

View of overaged seedlings of rice and mustard field under post-flood management plan in flood affected areas of Bihar and Odisha

About 150 farmers under IBFI project were paid crop insurance during 2019-2020 by Hon'ble Union Minister of Animal Husbandry, Dairying & Fisheries, Shri Giriraj Singh at ICAR-RCER, Patna, Bihar on 22nd February 2020. Stage wise yield loss curves were developed for flash flood tolerant rice variety Swarna Sub-1 under different depths (5 – 120 cm) and durations of submergence (1-12 days duration) compared to potential yield (5.5 t ha^{-1}) and control plot yield (4.7 t ha^{-1}) which will help in refining the flood damage index for crop insurance. The yield loss of rice crop under submergence/flood was highest in early vegetative stage followed by reproductive stage (Fig. 6a-d). During vegetative stage of rice crop, the highest loss of grain yield was 34.5 and 23.4% compared to potential yield (5.5 t ha^{-1}) and control plot yield (4.7 t ha^{-1}), respectively (Table 5).

Table 5. Maximum yield loss (%) of Swarna Sub-1 variety of rice under submergence (5 – 120 cm and 1-12 days duration) compared to potential yield and control plot yield

Growth stage of rice	Maximum yield loss (%)	
	With reference to potential yield (5.5 t ha^{-1})	With reference to control plot yield (4.7 t ha^{-1})
Early vegetative stage	34.5	23.4
Late vegetative stage	25.5	12.8
Reproductive stage	30.9	19.1
Maturity stage	21.8	8.5

The rainfall pattern and flood damage during *kharif* season of 2020 was assessed and dynamic post-flood crop management plans was prepared for flood affected areas of Muzaffarpur and Darbhanga districts of Bihar and Malkangiri district of Odisha. Twelve blocks (including Hanumannagar and Bahadurpur) of Darbhanga district, and Podia, Mathili and Kalimela blocks of Malkangiri district were identified as severely flood affected areas. Advancing sowing time of maize (variety : Shatkiman-3) and toria (variety: RAUTS-17) in areas with probability of early withdrawal of flood water, and cultivation of cabbage /cauliflower / sponge gourd / brinjal with zero tillage in areas with probability of late withdrawal of flood water is suggested as post-flood management measures in Darbanga district.

IBFI project work was recognized with International Award 2020 GEO Sustainable Development Goals (SDG) Award which was presented to International Water Management Institute, Colombo.

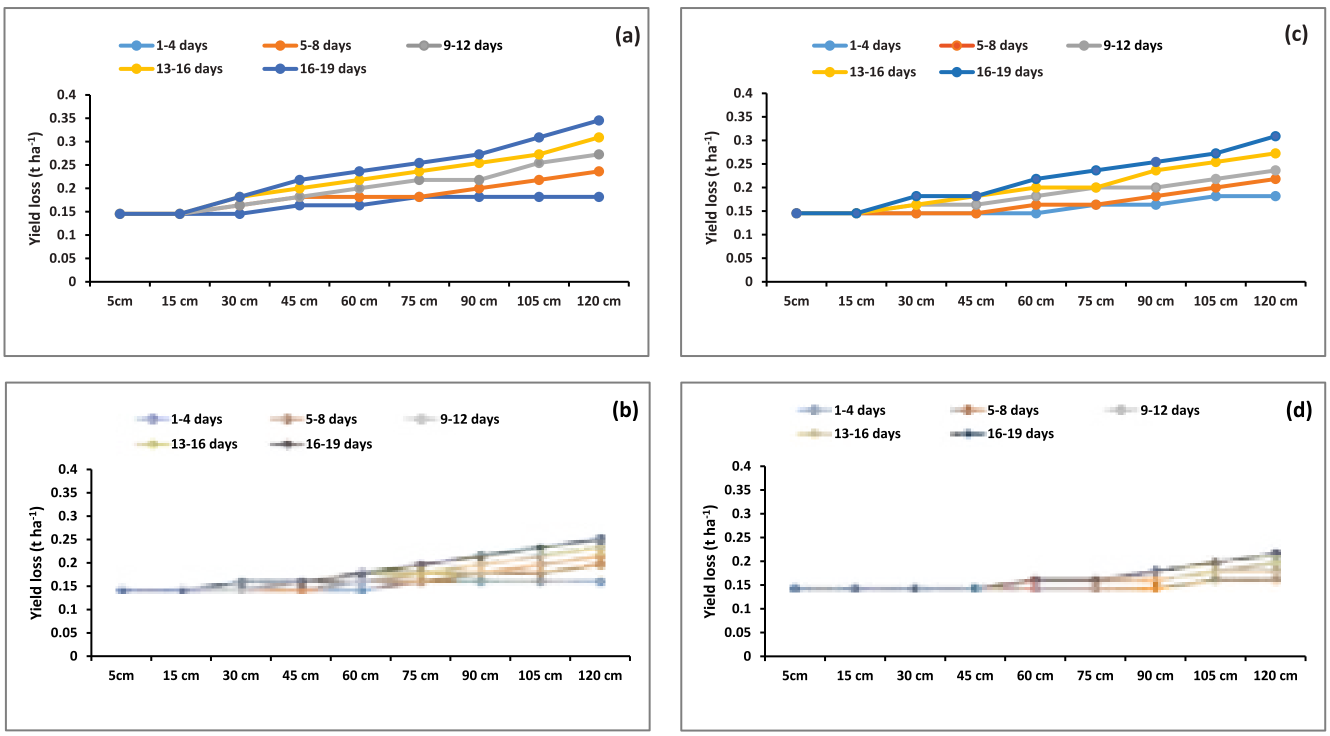


Fig. 6. Stage wise yield loss curves of rice (Var: Swarna Sub-1) with reference to potential yield (5.5 t ha^{-1}) at different depth and duration of submergence (a) Early vegetative stage, (b) Late vegetative stage, (c) Reproductive stage, and (d) Maturity stage

In-situ Rainwater Management Practices for Enhancing Farm Income and Water Productivity of Uplands

Project Code: NRMA/IIWM/SIL/2020/006/00201

Investigators: P. K. Panda, S. Pradhan and P. Sahu

One field trial was conducted at Research Farm of ICAR-Indian Institute of Water Management, Bhubaneswar with an objective to enhance the income and water productivity of upland through combined use of various *in-situ* rainwater management practices. The experiment was laid out in split-plot design with three replications. Three intercropping systems such as drumstick + ginger, drumstick + marigold (*kharif*) and drumstick + pointed gourd were assigned to main plots. Four rain water management practices such as normal planting + straw mulching + full filled pit+ percolation pit (S_1), normal planting + straw mulching + three fourth filled pit+ percolation pit (S_2), planting in bottomless earthen cylinder + straw mulching + full filled pit+ percolation pit (S_3) and planting in bottomless earthen cylinder + straw mulching + three fourth filled pit+ percolation pit (S_4) were assigned to sub-plots. Mulching was provided with use of paddy straw @ 5 t ha^{-1}. Two percolation pits with a dimension of each having 45 cm length, 45 cm width and 45 cm depth were dug on outer side of each plot. Drumstick variety PKM-2 were planted in the field with row to row and plant to plant distance of 2.5 m. Marigold variety 'African Giant' tall orange, ginger variety 'Suprabha' and pointed gourd variety 'Swarna' Alaukik were grown with recommended package of practices. The initial soil sample before starting the experiment was analyzed for getting soil properties (Table 6). Observations on Drumstick plant height and girth were recoded, and soil moisture of the plots at different days after planting are given in the Table 7. Plant height and girth of drumstick indicated an increase with the treatment planting in bottomless earthen cylinder + straw mulching + three fourth filled pit+ percolation pit compared to other treatments. Soil moisture contents were similar with different treatments.

Table 6. Initial soil properties of experimental site

Soil depth (cm)	Sand (%)	Silt (%)	Clay (%)	Texture	pH (1:2.5)	E C (1:2.5) dsm^{-1}	Organic Carbon (%)	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
0-15	49.5	14	36.5	Sandy clay	5.2	0.051	0.28	221.14	3.26	130.36
15-30	49.5	12	38.5	Sandy clay	5.1	0.037	0.22	180.23	3.04	119.23
30-60	47.5	12	40.5	Sandy clay	5.4	0.031	0.17	155.14	1.74	119.23
60-90	53.5	8	38.5	Sandy clay	5.7	0.028	0.10	126.34	1.30	108.09
90-120	51.5	10	38.5	Sandy clay	5.8	0.03	0.10	118.47	1.09	108.09

Table 7. Soil moisture content of the plots on weight basis (%)

Treatments	30 DAP	60 DAP	90 DAP	120 DAP
Main plot treatments				
Drumstick + ginger	17.00	18.00	15.80	14.80
Drumstick + marigold	17.20	18.20	16.30	15.30
Drumstick + pointed gourd	17.50	18.40	16.80	16.00
Sub plot treatments				
Normal planting + straw mulching + full filled pit+ percolation pit (S_1)	17.10	17.70	16.00	15.00
Normal planting + straw mulching + three fourth filled pit+ percolation pit (S_2)	17.60	18.20	16.40	15.60
Planting in bottomless earthen cylinder + straw mulching + Full filled pit+ percolation pit (S_3)	17.20	18.00	16.30	15.30
Planting in bottomless earthen cylinder + straw mulching + three fourth filled pit+ percolation pit (S_4)	17.62	18.20	17.00	16.00

Canal Water Managment

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: NRMA/ IIWM/SIL/2015/009/00174

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

Rice is the most important food crop in the world, especially in Asia. It accounts for 88% of the world's area and 90.5% of world's production in Asia. Rice farming is the livelihood of millions of farmers in India and other Asian countries. Water requirement of rice depends upon growing season, climatic conditions, soil type and hydrological conditions etc. and it is very high in puddled rice. Therefore, with the objective to reduce irrigation water application and to assess the performance of rice with sprinkler irrigation and increasing water productivity, field experiments were conducted for both aerobic and puddled rice with selected three varieties of rice ('Sahabhagi', 'CR-202' and 'NPH-150') having different duration, 105, 115 and 120 days, respectively i.e. one variety was early, two medium duration. 'NPH-150' was a hybrid variety and other two was high yielding. The experiment was conducted at the Institute research farm during summer season (January- May, 2020) under Deras minor irrigation command in Odisha. In every treatment, crop was grown with recommended rate of N, P_2O_5 & K_2O at 80, 40 & 40 kg ha^{-1}. Before land preparation, one flood irrigation was provided to aerobic plots as a pre-sowing irrigation. Direct seeding was followed for aerobic and nursery raising on the same day for transplanting. Transplanting was carried out on the puddled soil. Standard practices were carried out for manual weeding and plant protection measures against inset-pests and diseases.

A view of the aerobic-sprinkler rice experimental plots having three varieties

A view of the transplanted-flood rice experimental plots having three varieties

Experimental findings from both aerobic and puddled conditions show that average rice yield was 2.95 and 4.07 t/ha in aerobic-sprinkler and transplanted-flooded conditions, respectively i.e., grain yield in aerobic-sprinkler was about 28% less than puddled transplanting. Among the three varieties, average grain yield was the highest with NPH 150 i.e. 3.17 and 4.74 t ha^{-1} in aerobic-sprinkler and transplanted-flooded conditions, respectively (Fig. 7). The performance of other two variety was similar (2.83 and 2.88 t ha^{-1} in ‘Sahabhagi’ and ‘CR-202’, respectively) under aerobic-sprinkler irrigation condition, and it was 3.48 t ha^{-1} in ‘CR-202’ and 4.20 t ha^{-1} in ‘Sahabhagi’ under transplanted-flooded conditions. The physiological parameters of rice crop were measured as leaf area index, which varied from 2.35 to 2.77, SPAD chlorophyll meter reading (37.5-40.8) and interception of PAR (69-81%) in maximum tillering stage; yield components viz. number of spikelet per panicle in three varieties under aerobic and transplanted conditions. Irrigation water saving was about 43% in sprinkler irrigation compared to transplanted-flood irrigation. Physical water productivity (WP) was 0.45 and 0.35 kg m^{-3} in aerobic-sprinkler and transplanted-flooded conditions, respectively i.e. there was increase in water productivity by 28% in sprinkler irrigation compared to flood irrigation. Among three varieties, WP was the highest (0.47 kg m^{-3}) in ‘NPH-150’, and the order was ‘NPH-150’>‘CR-202’ Sahabhagi’ in aerobic-sprinkler, and under transplanted-flooded conditions, almost similar trend was obtained (Fig. 8). Our results show a trend of increased water productivity in sprinkler irrigation but with less yield compared transplanted-flooded conditions due to more weed population in aerobic conditions.

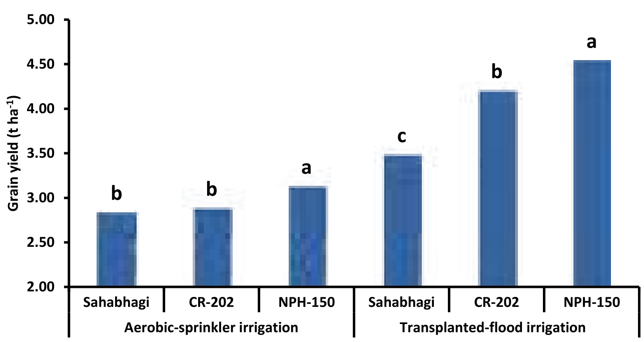


Fig. 7. Grain yield (t ha^{-1}) of rice for three selected varieties under aerobic-sprinkler irrigation and transplanted-flood conditions; different letters above bars indicate significant difference at $p < 0.05$ according to Duncan's multiple range test for aerobic-sprinkler and transplanted- flood separately.

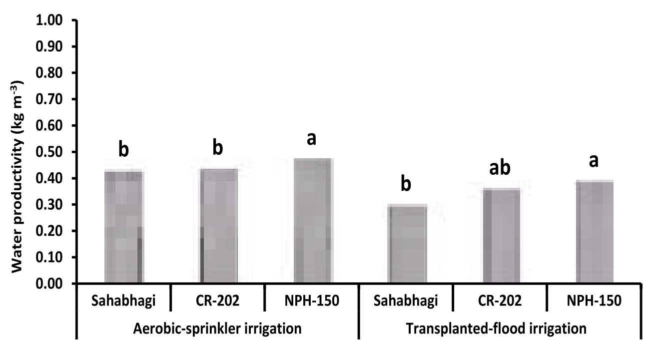


Fig. 8. Rice water productivity for three selected varieties under aerobic-sprinkler irrigation and transplanted-flood conditions; different letters above bars indicate significant difference at $p < 0.05$ according to Duncan's multiple range test for aerobic-sprinkler and transplanted-flood separately.

Impact of Water Stress on Growth and Physiology of Rice under Different Crop Management Practices

Project Code: NRMA/IIWM/SIL/2018/002/00189

Investigators: A.K. Thakur, K.G. Mandal and S. Pradhan

Rice (*Oryza sativa* L.) is both a staple food for much of the world's population and the largest consumer of water in the agricultural sector. In spite of looming water shortage, climate change and occurrence of abiotic stresses regularly, we need to enhance the productivity of rice through an alternative option that should lead to tolerance of abiotic stresses viz. drought stress.

To improve the productivity and the production of drought-prone areas, a combination of improved varieties and crop management is necessary. Optimal use of rice varieties will require the combination with adequate and, if possible, improved management techniques. For rice cultivation, three principal methods of rice establishment are used: direct seeding (DS), conventional transplanting system (CTS) and system of rice intensification (SRI). Each method has its own advantages and disadvantages. Thereby, combining the new/existing varieties with established and new management options and opportunities to address water stress could transform rice-based systems, make them more productive, and increase and stabilize farmers' income.

With this background, a field experiment was conducted on rice during *rabi*/ summer season 2020 to evaluate rice crop performance under different durations of water stress at the Institute research farm, under Deras minor irrigation command. The rice was grown adopting methods, viz. direct seeding, SRI and transplanting during summer season. Four water stress treatments were imposed on rice viz. (i) water stress started during late vegetative stage (VegL), (ii) water stress started during early reproductive stage (RepE), (iii) water stress started during late reproductive stage (RepL), (iv) water stress started during early ripening stage (RipL), and these treatments were compared with control i.e. without any water stress. In every treatment, recommended dose of fertilizers: N, P_2O_5 & K_2O at 80, 40 & 40 kg ha^{-1} were applied. Standard management practices were carried out for weeding and plant protection measures against inset-pests and diseases.

Experimental results revealed that the highest grain yield was obtained under SRI cultivation methods for all the treatments followed by CTS method and least under direct-seeding method (Fig. 9). Averaged over the different water stress treatments, 57 and 39% higher grain yield was obtained in SRI than direct seeding and CTS, respectively. Also, CTS out-yielded DS by 13%. Amongst, different water stress treatments, lowest grain yield was found when water stress treatment started during late vegetative crop growth stage under all the methods. There was no significant grain yield differences between control and water stress treatment applied during early ripening stage.

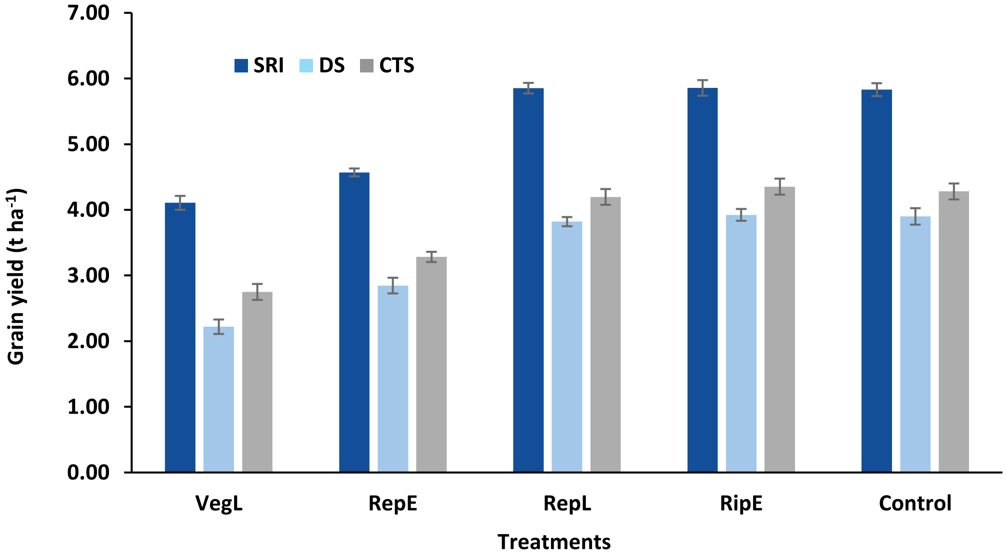


Fig. 9. Effects of crop management practices and water stress for different durations on rice grain yield (DS: direct seeding, CTS: conventional transplanting system, SRI: system of rice intensification)

A field views of the experimental plots

Another field experiment was conducted on rice during *kharif* season 2020 to evaluate rice crop performance grown by different crop management practices under rainfed condition and compared with irrigated condition, at the Institute research farm, under Deras minor irrigation command. The rice was grown adopting three methods, viz. direct seeding (DS), SRI and conventional transplanting system (CTS) during rainy season. In every treatment, recommended dose of fertilizers: N, P_2O_5 & K_2O at 80, 40 & 40 kg ha^{-1} were applied. Standard management practices were carried out for weeding and plant protection measures against inset-pests and diseases. Experimental results revealed that the highest grain yield was obtained under SRI cultivation methods followed by CTS method and least under direct-seeding method (Fig. 10). Averaged over the different treatments, 66 and 39% higher grain yield was obtained in SRI than direct seeding and CTS, respectively. Significant higher grain yield obtained under irrigated condition than rainfed condition in all the crop establishment methods (Fig. 10).

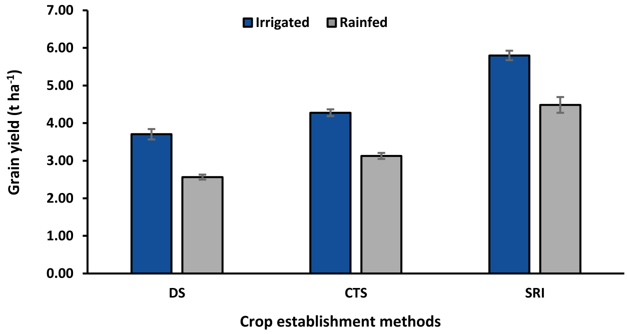


Fig. 10. Effects of crop management practices under rainfed and irrigated conditions on rice grain yield (DS: direct seeding, CTS: conventional transplanting system, SRI: system of rice intensification)

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

In India, the general perception of canal irrigation systems is that of massive physical infrastructure with low irrigation performance. The low water productivity (WP), and the widening gap between the irrigation potential utilized (IPU) and irrigation potential created (IPC) are of particular concerns. The national and state Governments allocate huge investments annually to bridge the perceived gap between IPU and IPC and enhance WP. In canal irrigation systems, often the geographical unit of management focus is the designed canal command area (CCA). However, the CCA is usually much smaller than the water influence zone (WIZ) through direct use of canal irrigation supply, and indirect use of return flows through groundwater. Therefore, accurate estimates of land and water use patterns in the WIZ are imperative for a precise assessment of IPU/IPC and WP.

Under the above backdrop, this ICAR-IWMI collaborative study in research partner with MPKV, Rahuri (Maharashtra) introduced a new analytical framework for performance assessment in the WIZ, which included the CCA and a 1 km buffer zone that benefit through recharges from canal irrigation return flows and reservoir lift irrigated area (RLIA) in Sina irrigation system, a water-scarce medium irrigation project in Maharashtra. The designed irrigation potential of project is 8,444 ha. The annual rainfall is 640 mm in the command, receives primarily between June and October in the monsoon season with the potential annual evaporation of 1,445 mm.

The information management system primarily includes land and water use and agricultural production information, climatic, and socio-economic data. The performance analysis system comprises water and energy accounting, benchmark indicators, and the economic water productivity cost curve. The performance analysis supports the decision support system for identifying financially viable strategies, including cropping patterns and technologies for enhancing water productivity in the WIZ.

The RS/GIS analysis showed a substantial under-estimation of IPU in official records. The actual ratio of IPU/IPC based on RS/GIS estimates is close to one in the CCA and substantially higher than one if water use accounts groundwater irrigation in the whole WIZ. There is hardly any gap between IPU and IPC in the Sina Irrigation system. Farmers capture return flows either within the CCA or in the buffer zone through private investments on pumps. Groundwater irrigation generates many social benefits in the WIZ. Therefore, any investments for the increasing of irrigated area in the CCA can have far-reaching implications outside the CCA. Policy interventions only focusing the command area cannot ignore the impacts on groundwater irrigation and social benefits in the whole WIZ.

The water accounting analysis of the irrigation system showed similar under-estimation trends for the consumptive fraction (CF) of irrigation supply and the total depletion fraction (DF) of the reservoir storage. However, the CF based on RS/GIS data shows a completely different picture. The differences of the consumptive water use (CWUs) between the official and RS/GIS-based irrigated area are more than seven times within the CCA in 2010-11 and more than two and half times in 2010-11, and four times in 2016-17 in the CCA and RLIA. The comparison shows that the actual WUE of irrigation supply in Sina is significantly higher than the official records. The water use efficiency (WUE) in the WIZ could be close to one. The CWU in the whole WIZ is larger than the available water supply. This disparity could be due to the under-estimation of groundwater recharge, or over-estimation of CWU due to deficit irrigation. However, the EWP in WIZ is significantly low. The low-value crops, such as sorghum, oilseeds, and pulses, which dominate the cropping patterns contributed to this low EWP.

Strategies for improving EWP

As the irrigation system is a physically water-scarce irrigation system, any improvement of CWU and WP in one region in the WIZ can impair the water supply and agricultural production in other areas within the WIZ. For physically water-scarce irrigation systems, increasing EWP of irrigation CWU is the most viable alternative. These systems will have to reallocate the beneficial CWU to high-value less-water intensive crops. The crops with the highest EWP are fruits (pomegranate), vegetables (onions), and fodder (lucerne). The groundwater availability under low rainfall conditions determines the extent of permanent crops (fruits or fodder). In moderate to high rainfall years, in addition to the fruits and fodder area in low rainfall years, cropping patterns can have a larger share of high-value crops such as vegetables and pulses. These cropping patterns can generate more value output with the scarce irrigation CWU. The EWP cost curve indicating the net value of production versus economic water productivity per unit of irrigation CWU paves the way for selecting the potential cropping patterns and technology. A combination of different crops with fruits generate substantially higher output than now in both moderate to high rainfall conditions.

Thereby, the policy recommendations are: 1. Accurate estimates of actual irrigated area (IPU) in the CCA using RS/GIS methods are necessary before further investments for bridging the gap between IPU and IPC in canal irrigation systems. The annual IPU/IPC could be over one of many water-scarce irrigation systems. 2. The estimation of water accounts needs to consider the irrigated area in the whole WIZ. The cropping outside the CCA in the WIZ would not have been possible without the groundwater recharged from the reservoir and surface irrigation in the CCA. 3. It is necessary to reassess WUE estimation methods in canal irrigation systems. The current approach of estimating beneficial CWU focuses only the surface irrigation in the CCA. However, groundwater and conjunctive irrigation are prevalent in the WIZ. Much of the beneficial CWU from groundwater irrigation within and outside the CCA in the WIZ would not be possible without the groundwater recharged from the reservoir storage and canal irrigation supply. 4. In scarce water systems, the allocation of CWU for agricultural production patterns that increases EWP is the way forward. 5. All water-scarce irrigation systems should assess the groundwater recharge zones and the volume that can support crop production in the WIZ at times when there are no releases for irrigation from the reservoir.

Groundwater Mangement

Groundwater Management

This program includes research projects on groundwater management & related issues

Impacts of Land-atmosphere Interactions on Dry-hot Episodes in India

Project Code: NRMA/IIWM/SIL/2019/001/00193

Investigators: D.K. Panda and S. Pradhan

In a significant part of the country the temperature rises is mainly because of the drying monsoon rainfall, both of which are coupled in a feedback loop driving the intensity, translating even moderate droughts into major ones. So, the increasing tendency of hotter droughts will enhance the irrigating requirements, especially in the agriculturally productive regions sustained by groundwater irrigation.

The process of land-atmosphere coupling in India starts fundamentally with the monsoon rainfall in June that dissipates the reigning high summer temperatures. Whereas, the subsequent rainfalls during the peak months of July and August strengthens the interaction between evaporation and soil moisture to drive the rainfall variability, particularly over the monsoon-dominated transitional regime of central India. This coupling between soil moisture and rainfall ensures the evaporative cooling, failure of which amplifies temperatures because of reduction in latent heat flux. Particularly, in the dry summer season, since rainfall is scanty and sporadic and *in-situ* soil moisture measurements are scarce, land evaporation that is closely related to soil moisture, is found to express well the coupling process. It is well known that the drying phase began since the mid-1980s, as a result of which the rainfall-dependent canal irrigated area decreased that initiated the groundwater revolution in India. However, national average monsoon rainfall hardly exhibits any conspicuous pattern, obvious from the contrasting regional tendency depicted in the spatially interpolated trends (Fig. 11a). Noteworthy, however, is the drop in rainfall in the agriculturally productive Indo-Gangetic Plain of northern and central India. In turn, the summer is warming at a faster rate, covering about 92% of the landmass (Fig. 11b). About 35% of the geographical area has witnessed statistically significant ($p<=0.05$) rises in maximum temperature.

The strength of the land-atmosphere coupling has been assessed using the correlation analysis, which supports the hypothesized mechanism as 76% of the country has shown inverse relationship between rainfall and temperatures (Fig. 12). Globally, both the mean and extreme matrices of temperatures have experienced profound increases in recent years. Consistently, India has also most of the record hot years since then. Although it is widely believed that global warming is the main reason, relatively stronger coupling during 2002-2016 is indicative of the feedback mechanism in amplifying the temperatures and thus imposing additional stresses on water resources.

(a) (b)

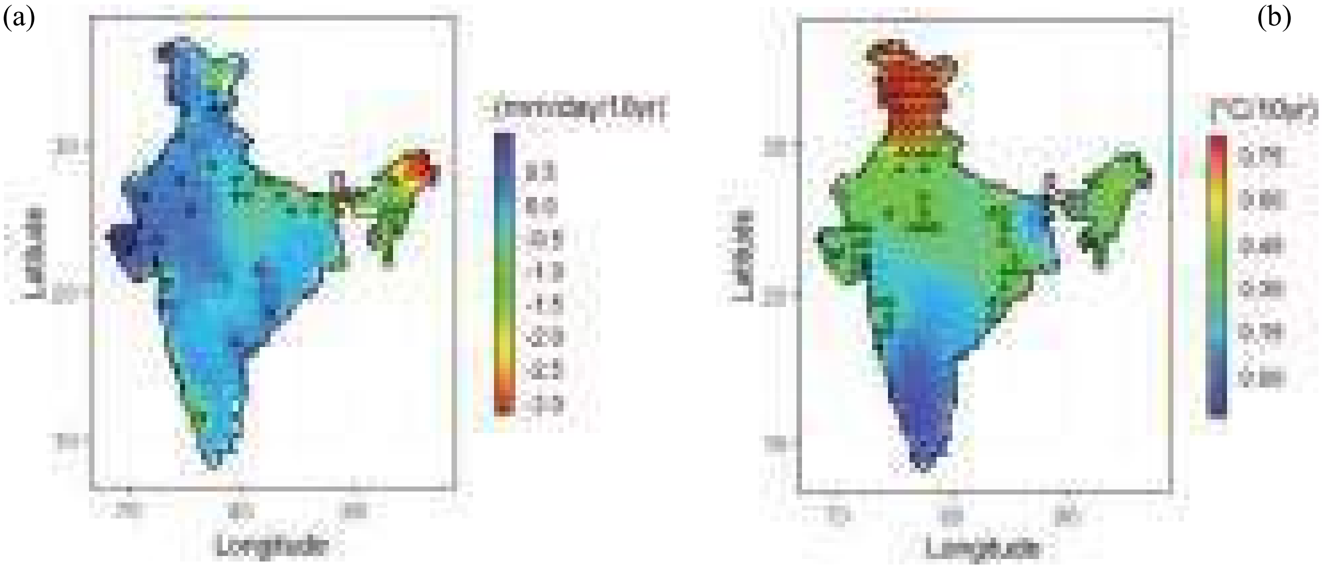


Fig. 11. Spatial depiction of the monsoon rainfall (%) trends (a) and its correspondence with the summer maximum temperatures (b).

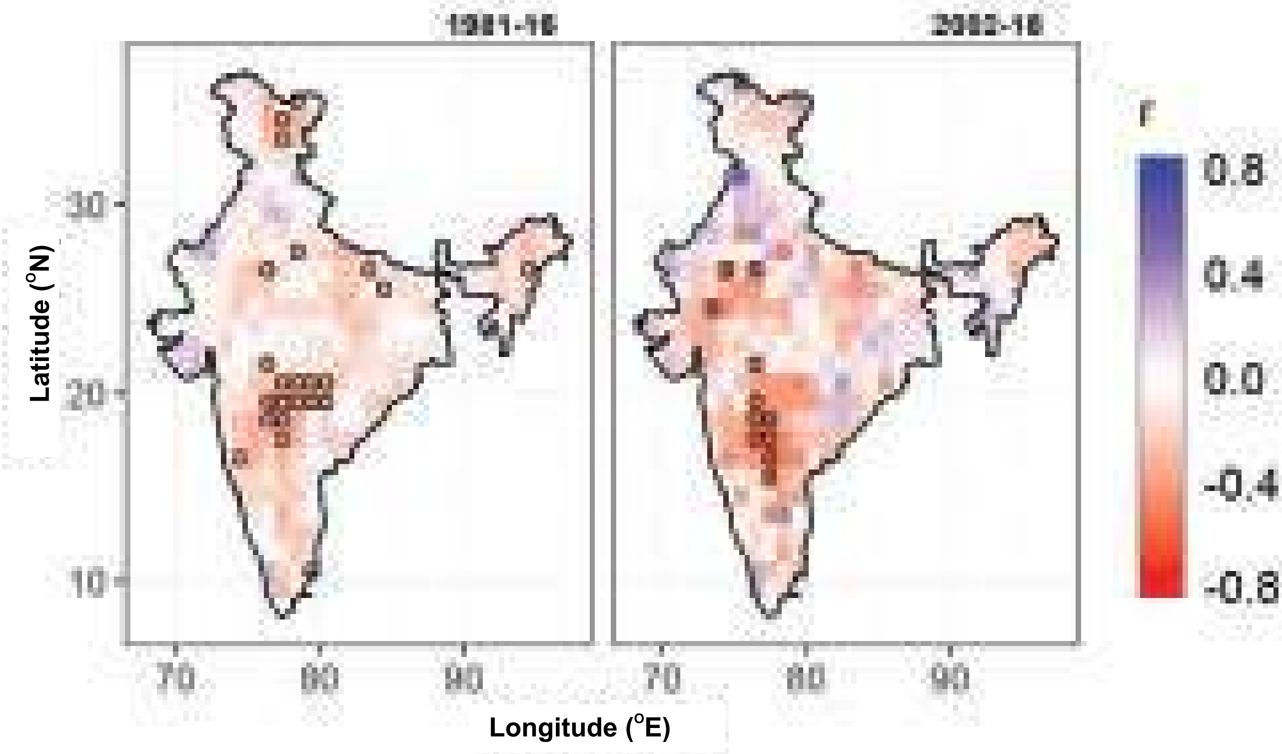


Fig. 12. Map of correlation coefficient (*r*) between rainfall and temperature during 1981-2016 and 2002-2016 delineating the strength of coupling.

Impact of Land Use and Land Cover Changes on Groundwater Storage in Baitarani River Basin

Project Code: NRMA/IIWM/SIL/2020/005/00200

Investigators: R.R. Sethi, D.K. Panda and S.K. Jena

Baitarini River is one of the east flowing rivers of India. It has total drainage area of 14,218 km^2, of which 13,482 km^2 lies in Odisha covering 42 blocks of 8 districts i.e., Balasore, Bhadrak, Jajpur, Kendrapada, Angul, Keonjhar, Mayurbhanj and Sundergarh (Fig. 13). The basin has both issues of water scarcity problem in upper part and water logging or problem of flooding in the deltaic region. It has been reported that contribution of groundwater to baseflow is increasing in recent years indicating risk of waterlogging in lower part of the basin. Hence, hydrological analysis is being carried out for the basin.

Hydrological analysis

Hydrological analysis was carried out taking into consideration the digital elevation model (DEM), slope, fill, flow direction, flow accumulation, stream network and stream order for Baitarini river basin. Stream net of Baitarini river basin is shown in Fig. 14. This basin is of 6^{th} order drainage basin. Drainage patterns are mainly dendritic pattern which indicates that the rock formations are impervious and the permeability is low. This can act as guidelines to locate vulnerable areas requiring different kinds and degrees of soil conservation measures. Stream originating in the upper reaches are first order streams; when two first order stream unites, a segment is designated as a second order stream; when two second order segments join a channel, segment is a third order stream, and so on. The trunk stream or the main stream through which all the discharge of the water is carried out is the stream of the highest order. Stream analysis was carried out based on stream order and bifurcation ratio (Table 8). Streams are classified into different orders according to the number of bifurcations. The mean bifurcation ratio is 1.79. The stream lengths play a significant role in generating surface run off and the volume of water flow through the channel. The stream length ratio has been calculated for all orders of streams in the basin. It was observed that each stream order has characteristic number of channels, length and drainage area. The 1^{st} order streams have the highest total length of 3446.33 km with a mean length 1.18 km. Similarly, for 6^{th} order stream has the lowest length of 138.27 km with a mean length 0.78 km. It has been found that the mean length of all streams decreased with increase in order. The drainage density was worked out as 0.527 km km^{-2} which is inadequate to meet the drainage requirement of the basin.

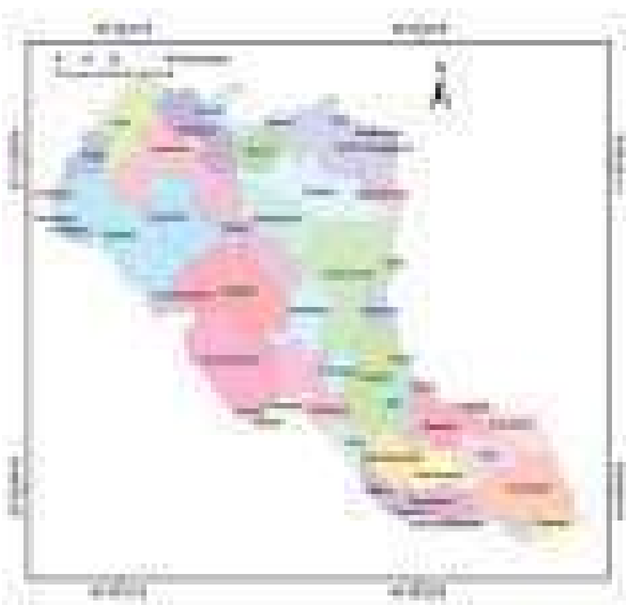


Fig. 13. Baitarini river basin with block boundary

Fig. 14. Stream net and stream order of Baitarini river basin

Table 8. Stream order with bifurcation ratio of Baitarini river basin

River basin	Stream order	Stream segment (Nos)	Stream length (km)	Mean stream length (km)	Stream length ratio	Bifurcation ratio	Length of overland flow
	1st	2926	3446.3	1.18		1.87	
	2nd	1567	1652.0	1.05	0.48	1.93	
	3rd	812	866.5	1.07	0.52	1.17	
	4th	694	553.6	0.80	0.64	1.85	
	5th	375	270.7	0.72	0.49	2.12	
	6th	177	138.3	0.78	0.51		
Mean						1.79	0.95
Total		6551	6927.2	5.59	0.53		

Monthly rainfall data (1901-2019) of 8 blocks of Baitarini river basin were analyzed. The average annual, monsoon, post monsoon, winter and summer season rainfall were 1417, 1094, 153, 38 and 132 mm, respectively (Fig. 15). Daily rainfall and stream discharge at two gauging stations i.e. Akhuapada in Bhadrak district and Belbahali in Keonjhar district during 2000 to 2019 were collected and time series analysis is being carried out. Depth of groundwater table (1994-2019) from 111 dug wells, 108 tube wells, and 43 bore wells within Baitarini river basin was collected. Depth of dug wells, tube wells and bore wells varies from 4.1 to 18 m, 5 to 373 m and 15.4 to 51.83 m, respectively.

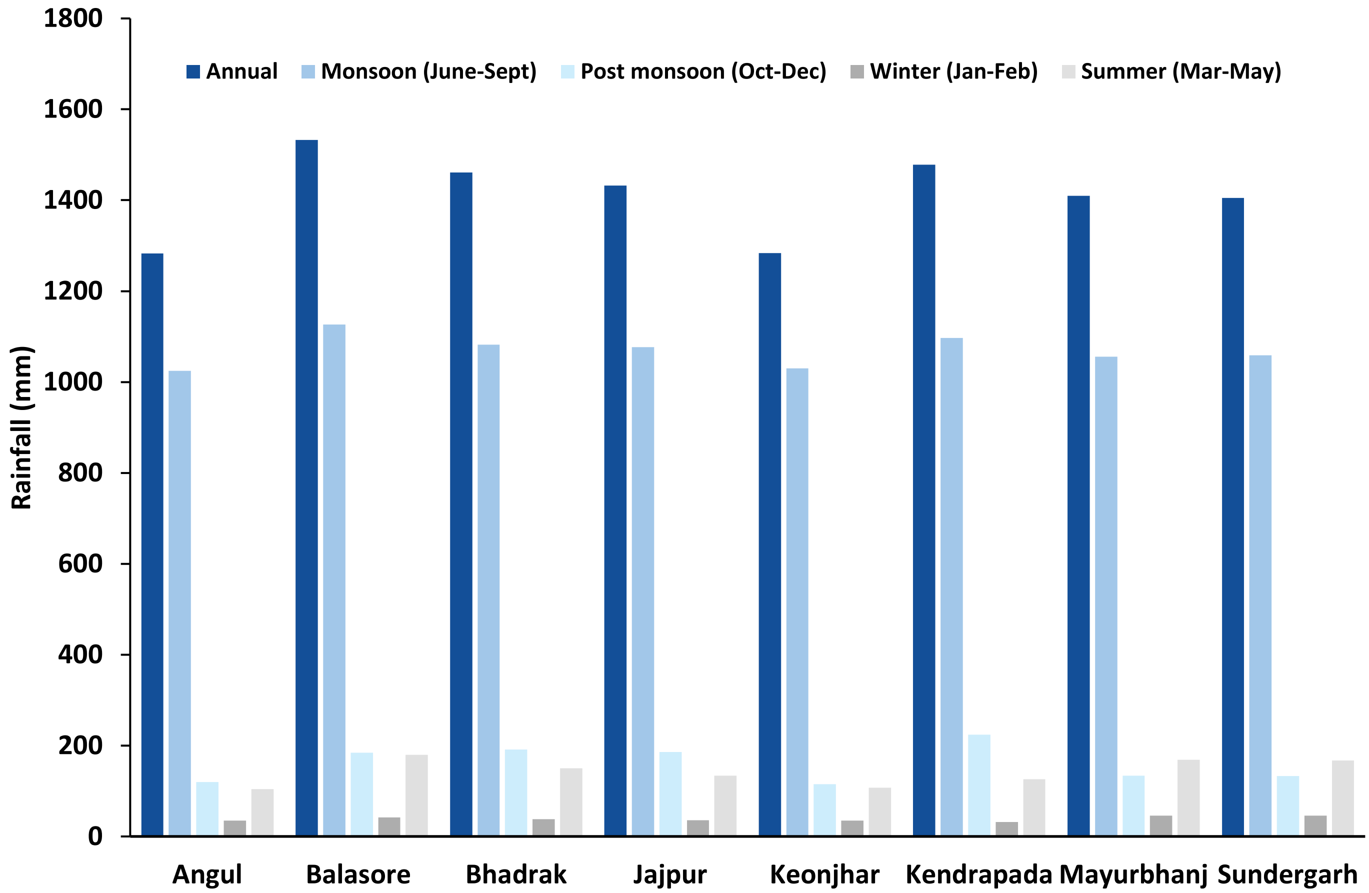


Fig. 15 Rainfall variation (1901-2019) in Baitarini river basin

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

Project code: NRMA/IIWM/SIL/2017/003/00185

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

Groundwater samples were collected, from different depths in lower Godavari basin during pre-monsoon season in 2019, to assess different chemical parameters. pH of the groundwater samples varied from 6.5 to 8.8 with a mean of 7.2. Most of the groundwater samples are suitable for irrigation (pH<8.4). Electrical conductivity ranged from 0.07 to 3.04 dSm^{-1}. About 25% of the sample have EC less than 0.7 dSm^{-1}, it means there is no restriction on use of groundwater, whereas 72% of samples having EC value comparatively higher (0.7-3.0 dSm^{-1}). About 75% of the groundwater samples have SAR values less than 3 and have no restriction to be used as a source of surface irrigation to sensitive crops for sodium hazard. However, rest of the samples has Sodium Adsorption Ratio (SAR) value between 3-9, with slight to moderate restriction could be used for irrigation. Groundwater samples collected from Srirangapatanam had the highest SAR of 7.5 followed by samples from Draksharamam SAR 7.1 of majority of the groundwater samples (69%) have chloride less than 4 me/L and could be used for irrigation with no restriction. Whereas, two samples collected from Draksharamam and Koti have chloride content above critical value of 10 me/L. Bicarbonate hazard of irrigation water determined from residual sodium carbonate revealed that all the groundwater samples from Draksharam and Talapudi in the study area were found safe i.e. within safe limit of <1.25, except two samples collected. Nitrate-nitrogen in the samples varied from 0.2 to 8.9 mg L^{-1}. None of the samples were found to have higher nitrate-nitrogen content then the maximum contaminant level of 10 mg L^{-1} for drinking purpose. Piper plot of the groundwater samples revealed that among cations, majority of the samples have no dominant cation type, followed by samples with calcium type and a few samples with sodium and potassium type. Whereas in case of anions majority of the groundwater samples are of bicarbonate type followed by samples with no dominant type and a few samples with chloride type. Higher nitrate-nitrogen content was found in ground water samples where cropping systems, rice-maize (2.7 mg L^{-1}) and banana plantation (4.4 mgL^{-1}) are prevailed as compared to rice-rice (0.8 mg L^{-1}) and Oil palm plantation (0.3 mg L^{-1}) (Fig. 16). Increased loss of nitrate through denitrification under the anaerobic conditions prevailing in the lowland rice–rice system and prevention of leaching due to puddling causes low nitrate in groundwater where rice-rice cropping system prevails.

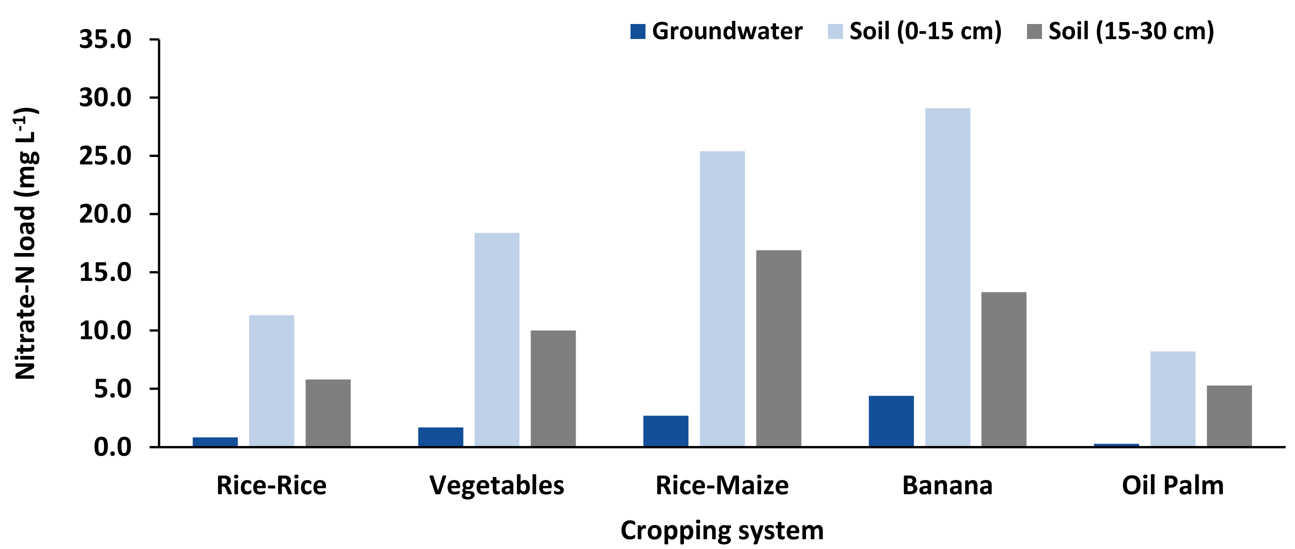


Fig. 16. Effect of cropping system on NO_3^--N load in soil & groundwater ecosystem

Use of groundwater for irrigation in lower Godavari basin

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

Project code: NRMA/IIWM/SIL/2018/003/00190

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

A net house experiment was conducted to study arsenic contamination in rice and possibility of mitigation through organic and chemical amendments, during the *rabi* season of 2019 at the IIWM research farm, Mendhasala. Seeds of 'Satabdi' variety were collected from West Bengal. Soils were spiked with arsenic @ 30 mg kg^{-1} and different organic and chemical amendments were applied at two water regimes viz. continuous flooding (M1) and flooding at 3 day after disappearance (DAD) of ponded water; up to Panicle initiation (PI) stage (M2) to evaluate their ability to mitigate arsenic accumulation in rice straw and grain. Phosphorus (P) enriched FYM was applied at the rate 0.5 (T1L1) and 1L/ha (T1L2). Among chemical amendments, gypsum was applied @ 276 (T2L1) and 552 kg ha^{-1} (T2L2), ferrous sulphate @ 112 (T3L1) and 223 (T3L2) kg ha^{-1}, ferrous sulphate and lime @ 112 (T4L1) and 223 (T4L2) kg ha^{-1} and boron (B) as borax @ 10.5 kg ha^{-1} (T5). Significant treatment effect was observed in number of tillers, panicle number, straw and grain yield of rice (Table 9). Plant height was found in the range of 87.9 to 93.8 cm and no significant difference was observed among treatments. Highest tiller number per hill was recorded in T1L2M1 (20.6) followed by T1L2M2 (19.8), T2L2M1 (19.8) and T2L2M2 (19.7). Number of panicles per hill varied from 9.3 to 12.0 and found to be increased significantly over control in T1L2M1 (12.0) followed by T2L2M1 (11.9), T2L2M2 (11.7), T1L2M2 (11.7) and in T2L1M2 (10.9). Straw yield was found in the range of 85.3 to 96.6 g pot^{-1}. Straw weight increased significantly over control in the treatments T1L2M2 (96.6 g pot^{-1}) followed by T1L2M1 (95.7 g pot^{-1}), T2L2M2 (95.1 g pot^{-1}). Test weight was ranged between 17.4 to 21.0 g. Grain yield increased significantly in treatments viz. T1L2M1; T1L2M2, T2L2M1, T2L2M2, T4L2M2, T4L2M1. Arsenic content in straw varied from 3.1 to 5.4 mg Kg^{-1} whereas, in whole grain it varied from 0.68 to 0.96 mg Kg^{-1}. In case of continuous flooding arsenic content was found 5.4 and 0.95 mg Kg^{-1} whereas, in case of irrigation at 3DAD arsenic (As) was measured as 5.1 and 0.85 mg Kg^{-1} respectively, in straw and whole grain. Among organic amendments, in T1L2M1 arsenic (As) content was found 3.1 and 0.75 mg Kg^{-1} respectively, in straw and whole grain. In case of inorganic amendments in T4L1M1 arsenic content was measured 4.0 and 0.69 mg Kg^{-1} whereas, in T5M1 arsenic (As) content was found 3.7 and 0.70 mg Kg^{-1} respectively, in straw and whole grain. In the next *kharif* season rice was grown in the same pot to evaluate the residual effect of the previously applied treatments. No significant difference among treatments in growth and yield attribute of rice was observed.

Table 9. Effect of organic and chemical amendments on growth and yield attributes of rice (*Rabi*, 2019)

Treatment	Plant height (cm)		Tiller no./hill		No. of panicles/ hill		Straw weight (g pot⁻¹)		Test weight (g)		Grain yield (g pot⁻¹)	
	M1	M2	M1	M2	M1	M2	M1	M2	M1	M2	M1	M2
T1L1	91.1	88.0	18.3	17.7	11.0	10.2	89.0	90.2	18.2	18.4	41.2	40.8
T1L2	92.1	92.4	20.6	19.8	12.0	11.7	95.7	96.6	19.0	19.8	43.5	42.7
T2L1	92.2	89.1	19.2	19.1	10.6	10.9	92.1	92.5	18.6	20.8	40.9	41.5
T2L2	93.0	91.2	19.8	19.7	11.9	11.7	94.8	95.1	18.8	21.0	42.9	42.7
T3L1	92.9	87.9	18.2	17.9	10.1	9.7	89.4	89.6	18.6	19.6	40.1	40.4
T3L2	93.8	91.9	17.2	18.2	9.7	10.5	87.1	89.8	17.4	19.0	39.0	40.5
T4L1	91.2	89.2	18.4	18.1	10.3	10.1	89.5	89.7	18.2	19.0	40.0	40.2
T4L2	90.4	91.6	19.0	19.0	11.0	10.8	91.1	92.9	18.4	18.8	41.1	41.5
T5	89.7	88.0	18.8	18.4	10.0	10.0	90.1	89.7	18.6	18.2	39.7	39.3
Control	88.9	88.6	16.8	16.6	9.5	9.3	85.3	85.4	18.4	18.2	38.2	38.4
CD at 5%	T= NS M=NS		T= 1.5 M=NS		T= 1.4 M=NS		T= 4.5 M=NS		T= NS M=NS		T= 2.1 M=NS	

Net house experiment with organic and chemical amendments

Drought and Hot-spell Assessment using Gravity Records in Major River Basins of India (DST Project)

Investigators: D.K. Panda and S. Pradhan

The spatial and temporal distribution of drought and extreme temperatures are evaluated at the basin scale. The water stress has markedly increased since the beginning of the 21st century, with the Ganges basin showing a clear signal of changes. The high rainfall areas of southern Ganga, Mahanadi, Brahmani and Subernarekha have experienced the maximum drop in moderate rain events. The arid northern part of the Ganga basin, where the groundwater-fed rice-wheat cropping system rely mostly on rainfall to recharge its aquifer, has witnessed maximum stress. Consistently, a drop of 1.48 m groundwater level was estimated during 2011-2015, compared to the pre-2000 mean water table.

The broad objective is to assess drought and hot-spell severity using observation and satellite products in India's major river basins (Ganga, Mahanadi, Godavari and Krishna basins). The drought conditions are assessed by computing the monsoon season moderate rainfall (MDR) days for each grids, for exploring the point-to-point correspondence with the heat stress indices. It is worth mentioning that MDR, ranging from 5 to 100 mm, contributes to recharge by raising the opportunity time for percolation over the extreme events (above 100 mm) that generate more runoff. Results indicate about 48% of 149 grids covering the considered basins have experienced decrease in MDR days (Fig. 17), which is more than double of the rises. It is noted that 10% of the grids decline significantly ($p<=0.05$), so the basin averages time series of MDR has undergone a rapid decline, particularly since the beginning of the 21st century.

A critical look of the map suggests the high rainfall areas of southern Ganga, Mahanadi, Brahmani and Subernarekha have experienced the maximum drop in MWD. But its drop in the northern part of the Ganga basin has affected the groundwater resources, as we find a drop of 1.48 m groundwater level during 2011-2015, compared to the pre-2000 mean water table. These results are consistent with the aridity index (i.e., ratio of rainfall to PET) and the standardized precipitation evapotranspiration index (SPEI), modelled by water demands through evapotranspiration and rainfall supply. Moreover, the applicability of GRACE TWS for basin-scale assessment of drought has been ascertained.

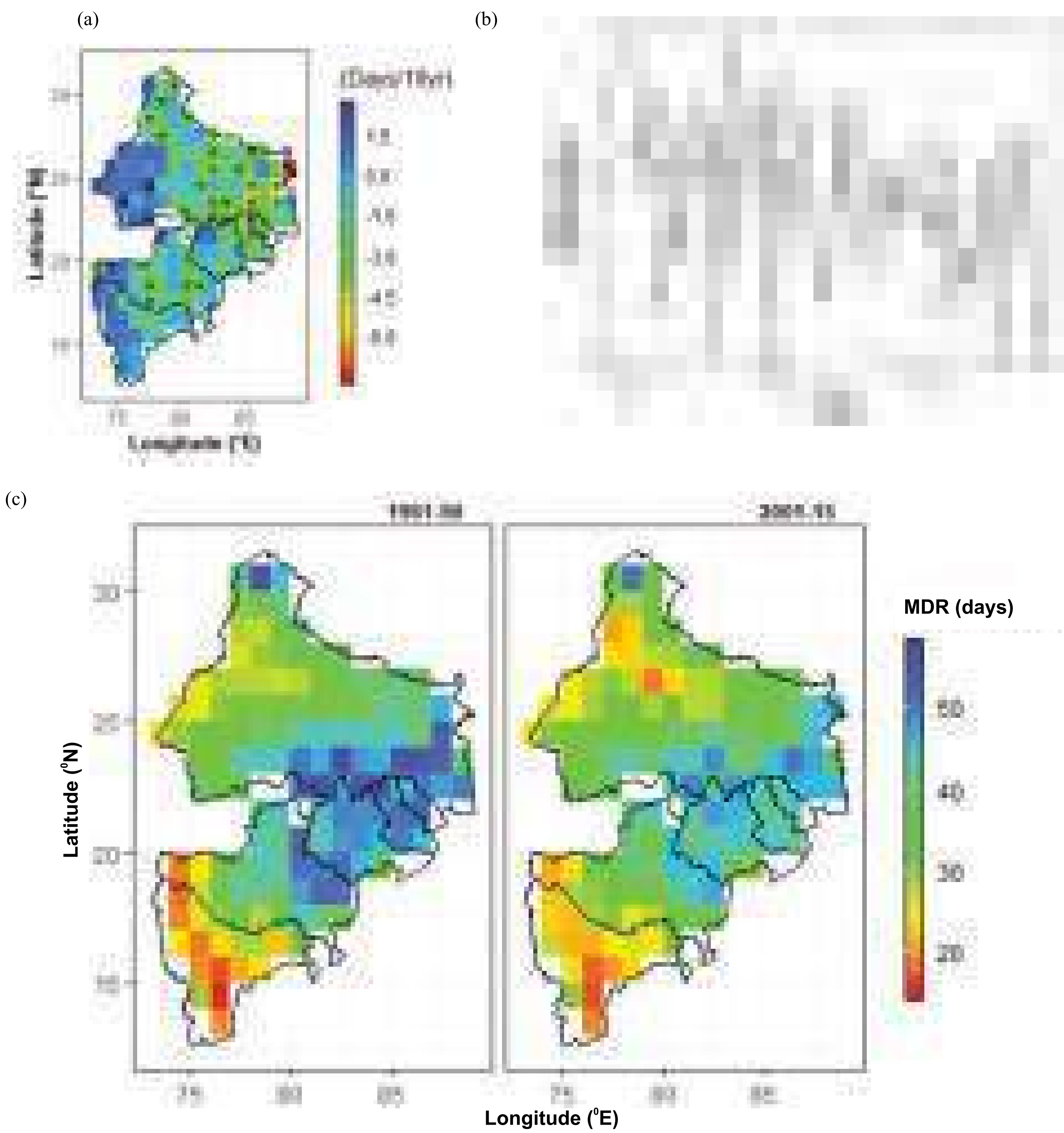


Fig. 17. (a) Distribution of statistically significant ($p<=0.1$) trends in moderate rainfall (MDR) days, (b) basin-averaged time series and (c) difference between the recent changes (2001-2015) from the base period (1961-1990)

Modelling of Water and Nitrogen Dynamics in Paddy Fields for Assessment of Groundwater Pollution in Shallow Water Table Regions

Project code: NRMA/IIWM/SIL/2020/003/00198

Investigators: P.P. Adhikary, S. Mohanty, S.K. Rautaray and A. Mishra

Continuous flooding and alternate wetting and drying are widely adopted irrigation techniques under low land paddy cultivation. But evaluation of the water and nitrogen (N) fate under these irrigation techniques in lowland paddy fields is complicated because of many pathways of water losses and N transformation processes that occur in flooded or non-flooded conditions. Field condition of alternate wetting and drying increases the complexity of water movement and N transformation in paddy fields, compared to the condition of continuously flooded or continuously non-flooded conditions. The presence of plough pan at the sub-surface and existence of bunds in the paddy field make the process very complicated. In this context modeling of water and N dynamics in low land paddy cultivation with the presence of shallow water table under sub-tropical humid condition was undertaken using HYDRUS model.

The study is being undertaken in the field of the experimental farm, Medhasal, ICAR Indian Institute of Water Management, Bhubaneswar, Odisha (20°17′ N latitude and 85°41′ E longitude). Medium duration rice variety MTU 1001 was transplanted during the month of August, 2020 in the plots having dimension of 15 X 10 m.

The design of experiment was split plot where two irrigation techniques (continuous flooding and alternate wetting and drying) were imposed in main plots and three nitrogen management treatments (90, 120 and 150 kg N ha^{-1}) were imposed in the sub plots. During *kharif* season, only one irrigation treatment (continuous flooding) was imposed and during *rabi* season both the irrigation treatments were imposed. Fully decomposed farmyard manure (FYM) was applied @ 5 t ha^{-1} along with chemical fertilizers using urea, diammonium phosphate, and muriate of potash as sources. The entire amount of phosphorus and potash and half of N was applied at the time of final land preparation, while rest 50% N was applied in two splits, i.e., 25% at tillering stage, and 25% at panicle initiation stage.

Before the start of the experiment the soil samples were collected from the experimental plots and analyzed for their properties. The soil was sandy clay loam with 61.6, 16.2 and 22.2% sand, silt and clay, respectively. Soil pH was 5.57, EC 0.36 dS m^{-1}, organic carbon 0.47%, available N 206 kg ha^{-1}, P 13.71 kg ha^{-1} and K 178 kg ha^{-1}, bulk density 1454 kg m^{-3} (Table 10). Soil moisture regime was Ustic and soil temperature regime was Hyperthermic.

Soil sample collection by auger

View of experimental field

Table 10. Initial soil properties of the experimental field

Parameters	pH	EC (dSm^{-1})	OC (%)	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Sand (%)	Silt (%)	Clay (%)	BD (kg m^{-3})
Mean	5.57	0.36	0.47	206.1	13.7	178.4	61.6	16.2	22.2	1454
Minimum	5.52	0.27	0.42	197.7	11.5	169.4	54.1	13.5	17.6	1369
Maximum	5.64	0.44	0.53	217.1	16.9	185.3	66.5	19.2	29.2	1524
SD	0.03	0.06	0.04	6.42	1.66	4.77	3.32	1.56	3.28	40.44
CV (%)	0.63	15.76	7.46	3.11	12.14	2.67	5.39	9.62	14.76	2.78
SE	0.01	0.01	0.01	1.51	0.39	1.12	0.78	0.37	0.77	9.53
Skewness	0.38	-0.43	0.22	0.32	0.62	-0.06	-0.37	0.08	0.70	-0.41
Kurtosis	-0.56	-1.16	-1.19	-1.27	-0.60	-1.12	-0.07	-0.73	-0.34	-0.30

Paddy crop was harvested at maturity and yield of grain and straw were measured. From this the harvest index was calculated. The grain yield varied between 3705 and 4274 kg ha^{-1} with average yield of 4040 kg ha^{-1} (Table 11). With the increase of N dose, there was slight increase in grain yield. Harvest index decreased with increase in N level in soil.

Table 11. Yield and harvest index of rice crop under various nitrogen level grown during *kharif* season

Parameters	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Harvest Index (%)		
N dose (kg ha^{-1})	150	120	90	150	120	90	150	120	90
Mean	4140	4096	3884	8173	7666	6977	33.63	34.83	35.76
Minimum	3954	3974	3705	7812	7365	6807	32.51	33.59	34.59
Maximum	4274	4215	4012	8457	7917	7148	35.36	35.37	37.08
SD	122.97	101.90	131.02	271.78	226.62	134.59	0.99	0.68	0.90
CV (%)	2.97	2.49	3.37	3.33	2.96	1.93	2.94	1.94	2.50
SE	50.20	41.60	53.49	110.95	92.52	54.95	0.40	0.28	0.37
Skewness	-0.43	0.10	-0.57	-0.21	-0.56	0.02	1.14	-1.55	0.29
Kurtosis	-0.72	-2.09	-1.90	-2.37	-1.75	-1.63	1.58	2.21	-0.60

Evaluation of Drip Irrigated Multi-tier Cropping Systems for Enhancing Land and Water Productivity

Project Code : NRMA / IIWM / SIL / 2020 / 007 / 00202

Investigations : O.P. Verma, P.P. Adhikary, Ankhila, R. Handral and S. Mohanty

Multi-tier cropping is a system of growing crops of different heights at the same time on the same piece of land and thus using land, water, and space more efficiently and economically by crop intensification. It is a labour-intensive cropping system and provides employment to more people. Thus, a field experiment was conducted during the *kharif* season of 2020 at ICAR-IIWM research farm to assess the profitability and carbon sequestration potential of banana-based drip-irrigated multi-tier cropping systems. Initial soil samples from two different depths (0-15 cm and 15-30 cm) were collected from the experimental plots and analyzed for their properties. Soil texture was sandy clay loam with 62.8, 19.7, and 17.5 % sand, silt, and clay in the top layer and 58.1, 17.4, and 24.5 % sand, silt and clay in the bottom layer, respectively. Top soil pH was 5.34, EC 0.74 dS m^{-1}, organic carbon 0.52 %, available N 218.6 kg ha^{-1}, P 15.8 kg ha^{-1} and K 174.5 kg ha^{-1} and bulk density was1452 kg m^{-3}.

The treatments were laid out in randomized block design where three multi-tier cropping systems (Banana + Okra + Cowpea, Banana + Cucumber + Chilli, Banana + Ridge gourd + Cabbage) were compared with sole banana during the *kharif* season. The banana (first tier crop) suckers/seedlings (cv-Amrutpani) were transplanted during monsoon at the spacing of 3 × 3 m in a square planting pattern. Within two rows of banana plants, second-tier crops (Okra, cucumber, and bitter gourd) with a spacing of 50 × 50 cm in a paired row were planted. Similarly, third-tier crops (cowpea, chilli, and cabbage) were grown, respectively. The average yield of cabbage, chili, cowpea, cucumber, okra, and ridge gourd were 6.20, 3.20, 5.43, 6.30, 5.06, and 2.59 t ha^{-1}, respectively. Banana has not attained its reproductive stage because it is a perennial crop.

Multi-tier cropping systems in the field

On-farm Technology Dissemination

भाकृ अनुप
ICAR

On-farm Technology Dissemination

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

In-situ Phytoremediation of Cr (VI) from Water in Chromite Mine Areas for Irrigation

Project Code: NRMA/IIWM/SIL/2019/002/00194

Investigators: Madhumita Das, P.S. Brahmanand and R.R. Sethi

Variation of water level and Cr (VI) concentration in chromite mining areas, Sukinda

Two water harvesting structures viz. WHS- 1 at village Majisahi and WHS-2 at village Barkathia were selected for reducing hexavalent Cr prior to supplying irrigation to the nearby fields, at chromite mining areas, Sukinda. A storage facility (2 x 3 x 1.5 m^3) for rearing the aquatic macrophytes has been created at Majisahi village.

Annual rainfall received during 2019 and 2020 in Sukinda block were 1933.5 mm and 1668.65 mm respectively. Out of the total rainfall, 1448.2 mm (75% of annual rainfall) was received during 2019 monsoon and 1116.1 mm (67% of annual rainfall) was received during 2020 monsoon. Total number of rainy days were 73 and 83 during 2019 and 2020, respectively. Capacity of two WHSs were 1376 m^3 (0.13 ha m) and 362 m^3 (0.04 ha m) with depth of 3 m and 2 m, respectively. In case of WHS-1, on an average, 1 m of water (270 m^3) is available throughout the year. During monsoon season, water level increased up to 1.8 m with 918 m^3 of water is available in the structure (Fig.18) and in WHS-2, water level varied within 1.5 to 2.0 m during 2019-2020.

In the study location, canal operates during June to November and flow in unlined field channel varied within 0.4 to 0.6 m^3 s^{-1}. Inflow to the selected water harvesting structures were measured from 1m concrete pipe of 30 cm diameter. During canal flow period the inflow to the structures varied from 0.15 to 0.2 m^3 s^{-1}.

Cr (VI) concentration (mg L^{-1}) in the Damshal minor irrigation project, WHS-1 and WHS-2 varied from 0.424 to 0.036, 0.348 to 0.112 and 0.09 to ND (non-detectable) during June to December, 2020.

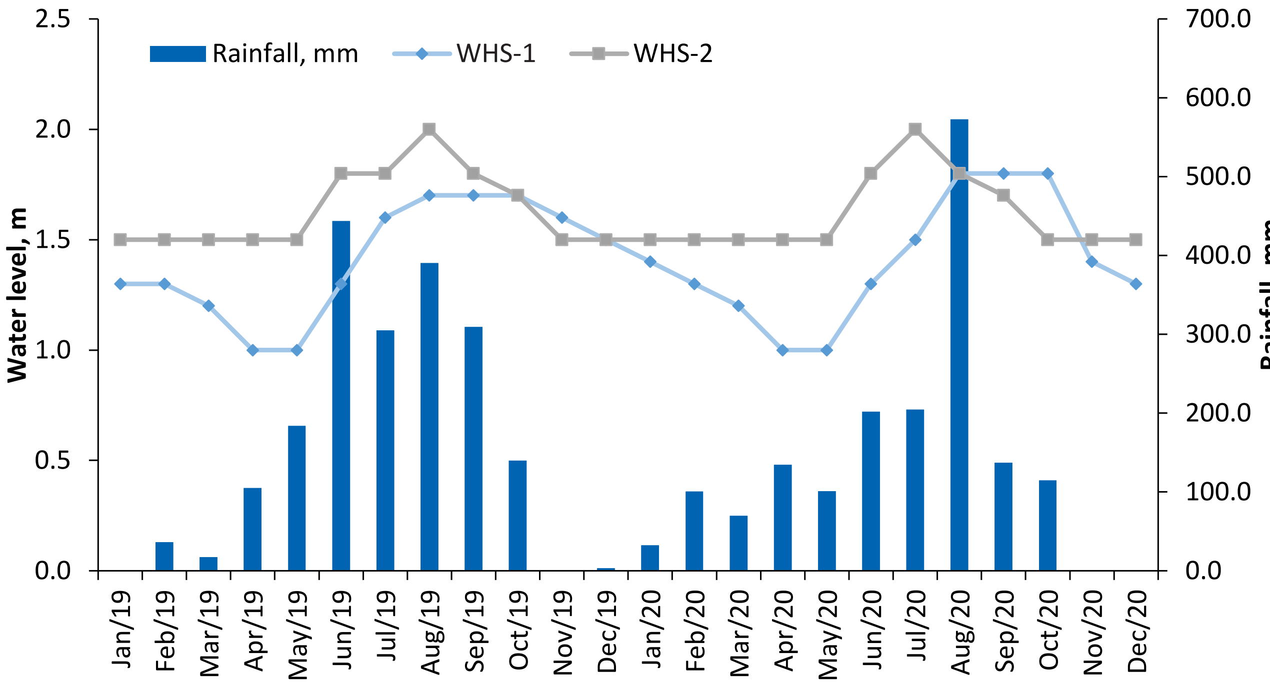


Fig. 18. Hydrographs of water level in two water harvesting structures in Sukinda block

Response of tomato (*Solanum lycopersicum*) to Cr (VI) polluted water irrigation under net-house environment

Tomato (var. KSG1201) seedlings of four weeks old were planted on January 16, 2020 at a spacing of 60 x 45 cm of 1 m^2 plot size under net house condition. Four Cr laden (mg L^{-1}) water viz. normal water (0), damsal canal water (0.37), *Pistia stratiotes* (0.30) and *Salvinia minima* (0.24) treated damsal canal water were used for irrigation. Irrigation was applied on an average of five days interval to all the plots. Fruit yield varied from 16.44 to 27.3 t ha^{-1} with lowest value obtained under damsal canal water containing highest amount of Cr. No significant yield difference was however vivid across the treatments (Fig. 19).

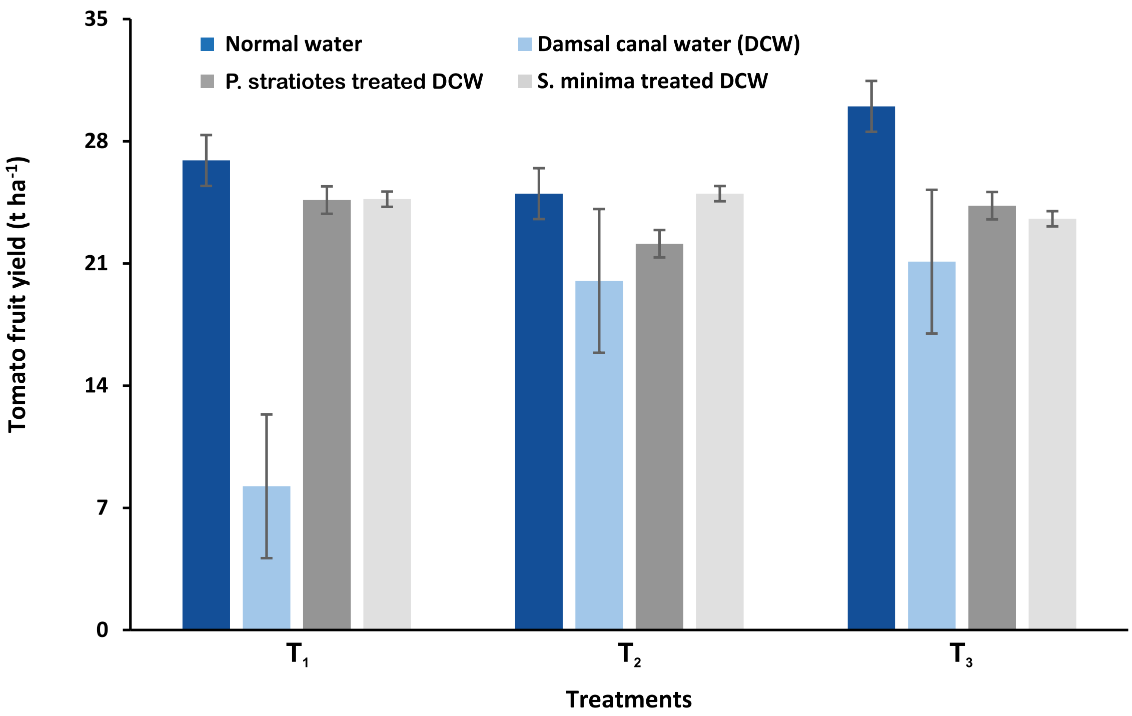


Fig. 19. Tomato yield under varied levels of hexavalent Cr in irrigation water
(Error bar represents standard error of n = 3, F-statistics is NS)

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

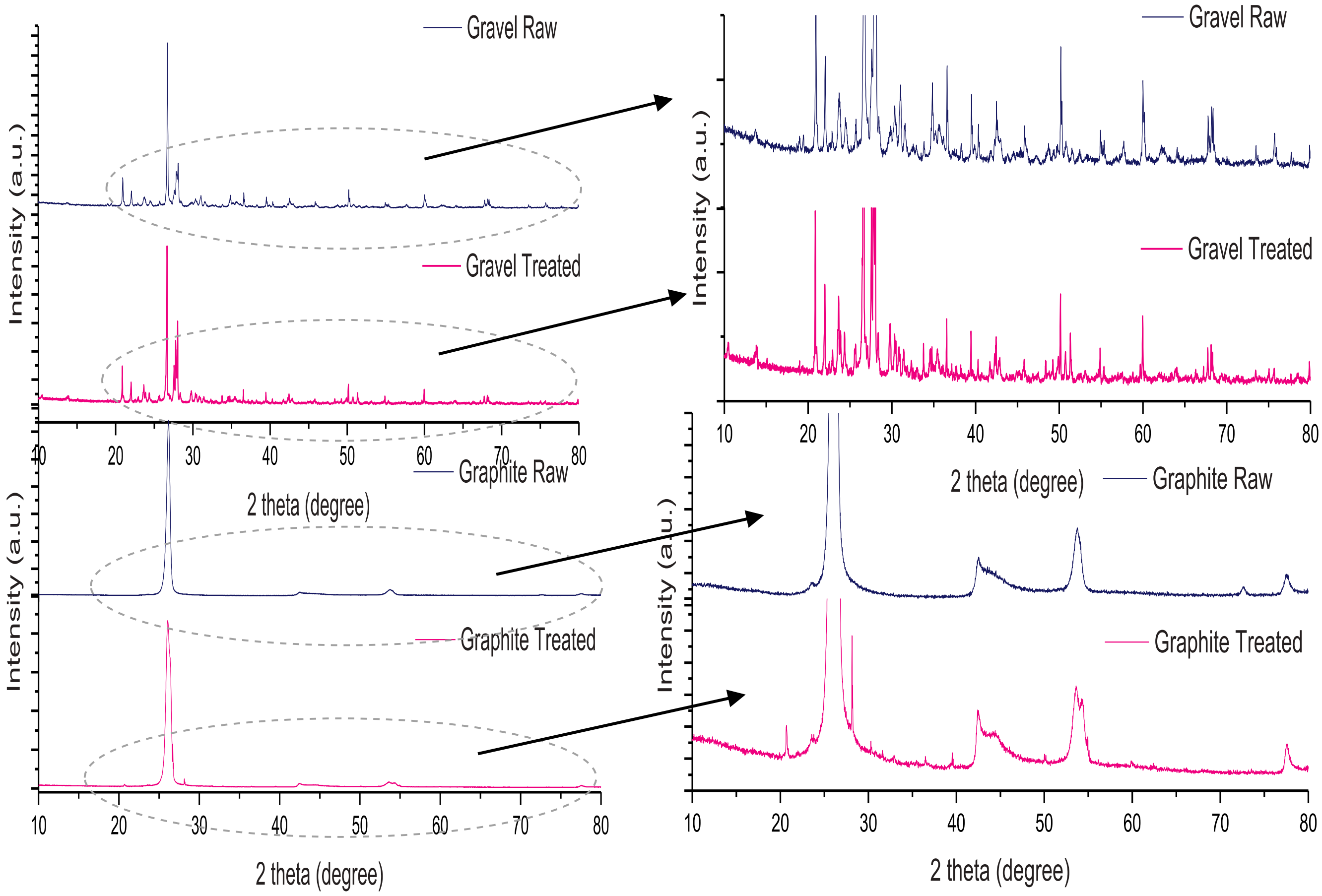
Externally funded project: National Agricultural Science Fund, New Delhi

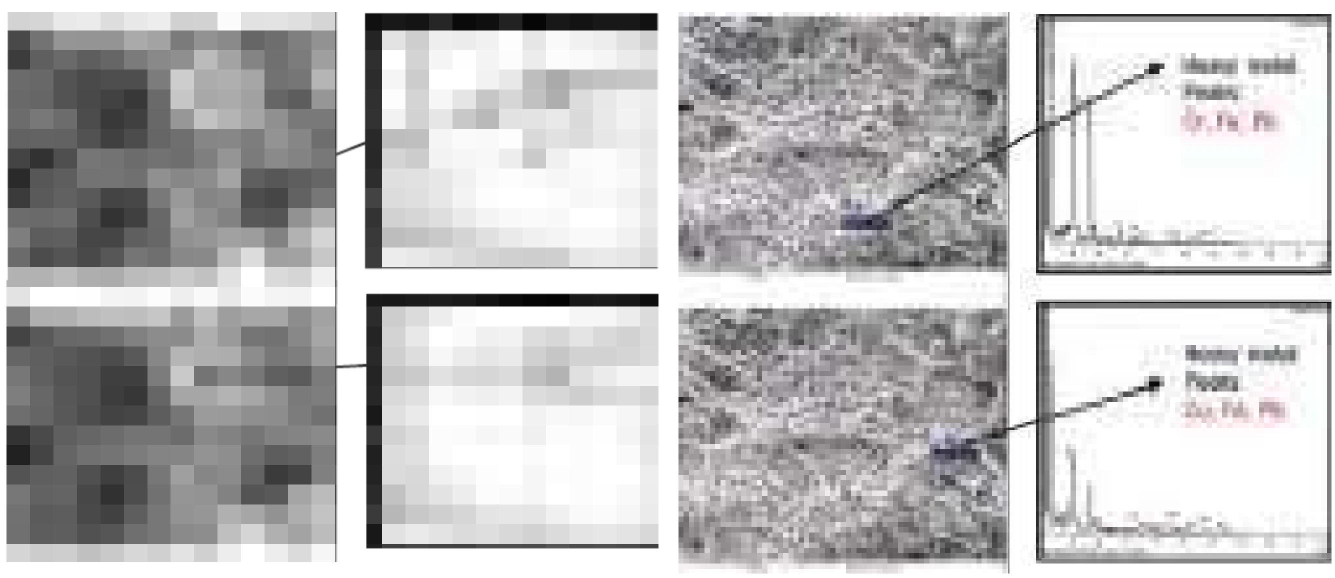
Investigators: S. Raychaudhuri, M. Raychaudhuri, Asheesh Yadav, Sony Pandey and Manish Kumar

All the three isolated strains E (*Pseudomonas aeruginosa*), O (*Acinetobater baumannii*) and H (*Bacillus cereus*) were effective in removing heavy metals and pharmaceutical products like paracetamol and ibuprofen present in wastewater. Isolate E had the maximum potential of removing such impurities. Due to incompatibility among the potential bacterial strains a novel consortium of immobilized axenic microbial hydrogel beads were used to house the bacterial isolates minimizing the antagonism. The microbial embedded hydrogel beads individually gave promising results in removing heavy metals and pharmaceutical products whereas the formulated consortia by administering equal number of hydrogel beads of strains E, O and H performed much better than those did individually. The consortium was used along with other primary water purification agents to design four different novel biofilters, namely, i) Biobed, ii) Tunnel, iii) Gabion, and iv) Column biofilter.

Three more novel bacterial isolates having potential in absorbing heavy metals and degrading paracetamol were identified and their RNA sequences are submitted in NCBI: *Bacillus megaterium* IIWM-DW-09I, *Enterobacter asburiae* IIWM-JS-07L and *Bacillus cereus* IIWM-OMS-06N.

The performance of graphite, gravel and fibre reinforced polymer (FRP) biofilters was investigated at the cooperating center (IMMT) for metal removal from synthetic municipal wastewater. The packing materials were characterized to demonstrate the adsorption pattern and other removal processes. X-Ray Diffraction peaks suggested the accumulation of several metal precipitates as crystals over the material surface. The field emission scanning electron microscopy (FESEM) showed surface morphology of material. It revealed the unevenly distributed presence of various elements. Toxicity studies of treated wastewater will be helpful to analyze its suitability for reusability.





Field Emission Scanning Electron Microscopy of biofilter materials

Refinement of Small Scale Online Wastewater Filter for Safe Irrigation Practice

Project Code: NRMA/IIWM/SIL/2018/004/00191

Investigators: M. Raychaudhuri, S. Raychaudhuri, D. Sethi, M. Das, S.K. Jain, P.K. Singh, Rajan Agarwal and Tarini Mohanty

The use of urban waste water is of increasing global importance, particularly in urban and peri-urban agriculture. Only 24% of the urban effluent in India is treated due to lack of infrastructural facilities and rest is discharged into river or land that contaminates the natural resources. The effluents contain heavy metals like lead, chromium, cadmium, zinc and mercury. Besides, the sewage effluents are rich in organic matter and sediments that nourishes pathogens which are harmful to human health. Farmers are more inclined towards using urban wastewater as they found it as a cheap nutritional resource unaware of the poor water quality that contaminates soil, crop and groundwater. To address this problem a small-scale online hybrid filter has been devised under the project entitled 'Design and Development of Small Filters for Reducing Contaminants in Poor Quality Water at Farmers' Level for Safe Irrigation in Periurban Areas'. The filter was demonstrated to the farmers of peri-urban areas using municipal wastewater for cultivation of horticultural crops. The technology was also demonstrated to the line departments for safe use of municipal wastewater in agriculture.

Further, six filters have been devised and four filters have been sent to four locations for evaluation. Three AICRP centres viz., Pusa, Udaipur and Ludhiana, and one Cr mining area at Sukinda were selected for treatment of domestic/municipal effluent and industrial effluent respectively. The AICRP centres were selected because of their distinct feature. Due to less rainfall and over exploitation of groundwater at Udaipur the farmers are using the wastewater extensively. Whereas in Bihar, with abundance of surface water and groundwater, municipal wastewater is being used by the farmers in this region for its nutritional value, which is dominant at Patna bypass area. It is planned to use ICAR-IIWM filter for filtration of grey water available in the drain of premises of girl's hostel, RPCAU, Pusa.

For further upscaling of the technology industrial effluent of Sukinda mines area was targeted. The Sukinda chromites valley in Jajpur district of Odisha is well known for its extensive chromite ore deposits. This valley is considered as one of the richest chromites and nickel producing areas and supplies 90% of India's demand. Presently 14 chromite mines are operating in Sukinda mines for extraction of chromites through open cast methods. One of such prominent mining company is Balasor Alloys. One filtration unit has been installed at discharge point of mine effluent for performance evaluation of the developed IIWM filter.

Demonstration of ICAR-IIWM filter to treat industrial effluent at Sukinda mines area

Geoinformatics Application in Site Suitability Analysis for Crop Planning and Aquaculture Development in Eastern and Western Coast of India

Project Code: NRMA/IIWM/SIL/2020/004/00199

Investigators: A.K. Nayak, S.K. Jena, R. K. Mohanty, S.K. Rautaray and M. Das

The open series Sentinel-2B satellite data were collected and analysed for Jagatsinghpur district in coastal Odisha. The land use and land cover map (Fig. 20) of the district was prepared based on the satellite data for the period November-December 2020.

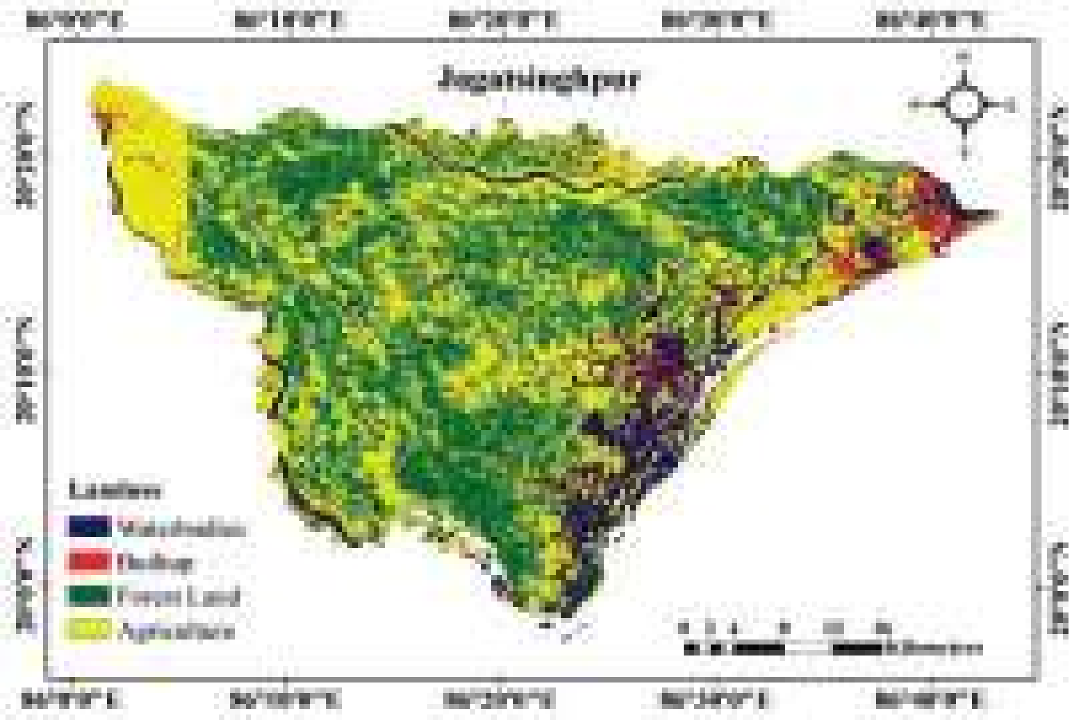


Fig. 20. Land use and land cover map of Jagatsinghpur district based on Sentinel -2B data

For water quality appraisal at the unused cultivable pasture of coastal Odisha, nine water samples, five from surface water and four from groundwater sources, were collected along with GPS readings during post-monsoon period (December 2020) from Jagatsinghpur district. Water quality appraisal that has been presented in Table 12, revealed that there was no variation in pH and electrical conductivity, while Na, K, Ca and Mg were 1.3, 1.2, 2.1 and 1.1 times more in groundwater than surface water sources. Considering 10 mmol L^{-1} as threshold level of sodium adsorption ratio (SAR), 11% of water samples were found not suitable for use in irrigation. The ratio of Ca and Mg varied from 0.21 to 4.25. Calcium is beneficial to crop, consequently 22% of water samples (containing Ca/Mg ratio >1.0) were found beneficial for agriculture.

Table 12. Appraisal of water quality during post monsoon period in coastal Odisha

Source type	pH	E C (dSm^{-1})	Na (me L^{-1})	K (me L^{-1})	Ca (me L^{-1})	Mg (me L^{-1})	SAR (m mol L^{-1})	Ca/Mg	Cl (me L^{-1})
Surface	6.88±0.086	0.9±0.03	6.81±0.95	0.41±0.05	3.2±0.43	3.96±1.63	5.41±0.87	1.68±0.71	14.24±1.62
Groundwater	7.02± 0.19	0.93± 0.14	8.93± 4.29	0.50± 0.12	6.6± 0.68	4.2± 0.61	5.14± 2.27	1.68± 0.30	19.2± 7.97

Mean values ± SEm

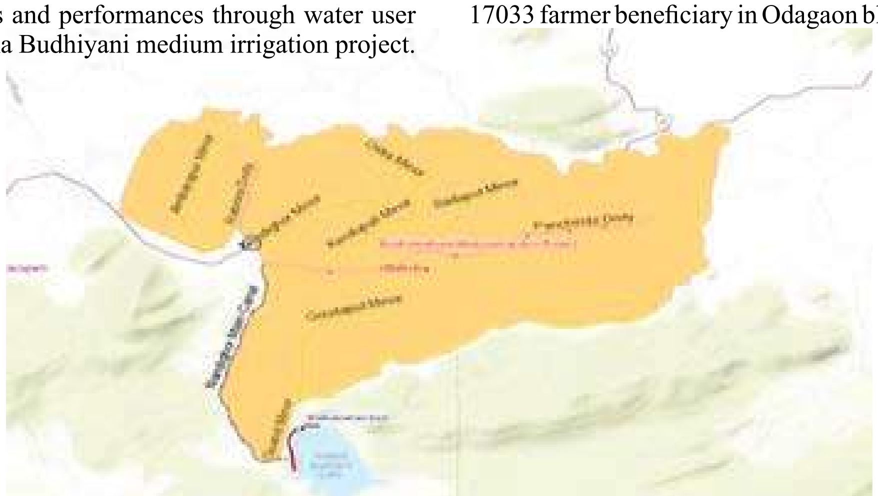
During interaction with farmers, it has been revealed that there was a large tract surrounded by Hansua river having the problem of acid sulfate soil in subsoil. Locally farmers name those soils as *'Fitikiri mati'*. The depth at which acid sulfate soil was present varied from 1.5 to 5 m. Construction of farm pond in such soils exposed the acid sulfate soil with pond water. This has created the problems for fish growth. The sites where pond dyke was exposed to acid sulfate soils, suitable crops like pineapple, sugarcane, banana, citrus and mango may be grown. In lieu of farm ponds, alternate raised and sunken beds system may be adopted for such areas having acid sulfate soil in subsoil. The depth of sunken bed should be limited to one meter.

Analysing the Functioning of Water User Association in Different Irrigation Command

Project Code: NRMA/IIWM/SIL/2018/005/00192

Investigators: M.K. Sinha, P. Panigrahi, S. Rautaray, D. Sethi and R.K. Panda

Participatory irrigation through water user's association is an important water governance policy. To understand participatory process in irrigation and the factors associated with, the study zeroed on farmer's perceptions towards utility in irrigation services and performances through water user associations in Budha Budhiyani medium irrigation project. The project is of Chute spillway masonry gravity type with 5 nos vertical lift gate of size 6.00 x 3.28 m, covers 4290 ha ayacut area in *kharif* and 1250 ha of *rabi* crops spread across 39 villages and 9 water user associations, having sum of 17033 farmer beneficiary in Odagaon block of Nayagarh.



Schematic map of BB medium irrigation project

An analysis considering farmer's perception towards irrigation water distribution was carried out through survey schedule from 5 out of 9 water user association's farmer, across head, mid and tail regions. Five point continuum scale of different parameters of manageability, convenience, predictability and equity considered includes quantity of water supplied, point of delivery, stream size of water, duration, timeliness and frequency and equitable water supply having better off in *kharif* season, however, majority expressed concern about irregular water supply and non-availability during *rabi* season. There is not much difference in perception regarding sufficiency of irrigation water during *kharif* season, whereas, not sufficient during *rabi* season and tail end farmers being worst hit having lowest availability. Paddy is the main crop in the study area in *kharif* season, transplanted paddy area is higher in the head region, where direct sown paddy area is higher in both middle and tail region. Almost 50 percent area covered by transplanted rice, as noted by farmers. The average productivity of paddy ranges from 1.4 to 1.6 t ha^{-1}. Vegetables like brinjal, tomato, cauliflower, pulses-greengram, blackgram and maize are the main crop of *rabi* season fetching higher income to the farmers.

Piloting Water Management Technologies for Enhancing Farm Productivity and Income (under SCSP)

Investigators: H.K. Dash, P.K. Panda, P. Panigrahi, S. Pradhan and D. Sethi

Onion yield and water productivity under sprinkler irrigation

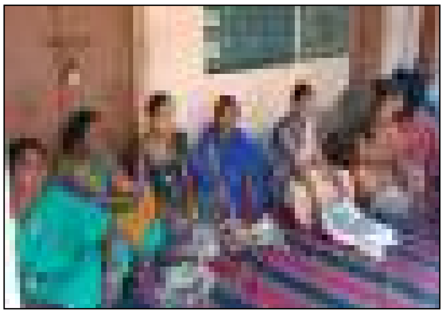
At the project site in Dangariguda village, sprinkler irrigation was demonstrated on 0.8 ha area in onion crop to study the effect of water management practice on yield and water saving under SCSP project in Bhawanipatna block of Odisha. Total of 400 mm water was used as against 480 mm in surface flood irrigation. It was found that sprinkler irrigation could save 17% water and produced 10% higher yield resulting in 32% higher water productivity (Table 13).

Table 13. Effect of sprinkler irrigation on onion yield and water productivity

Method of irrigation	Water used (mm)	Yield (t ha^{-1})	Water productivity (kg m^{-3})
Sprinkler irrigation	400	20.3	5.07
Surface irrigation (flooding)	480	18.5	3.85

Seven new villages i.e. Pandigaon in Bhawanipatna block of Kalahandi district, Nathipada in Banapur block of Khordha district, Kadampur in Dhenkanal sadar block of Dhenkanal district and Ranga, Chitra, Nijogkasoti and Budhei villages in Nimapara block of Puri district were added to the SCSP project. Under the project, about 250 kg of vegetable seeds, 36 kg of onion seeds, bio-pesticides and 100 kg sulphur were distributed to the farmers in newly adopted SCSP villages. Farmers were given orientation on the use of inputs viz. seeds, bio-pesticides and sulphur.

As a part of institute's efforts towards strengthening livelihood of scheduled caste families, 10,000 fish fingerlings were stocked in three ponds of about 1.08 ha area in Chitra and Nijogkasoti villages of Nimapara block and 105 kg of fish feed were distributed to participating groups for aquaculture. The activity would benefit about 100 families. Similarly, 500 numbers of 21-days chicks of Kuroiler variety were distributed to the 100 farmers of Dangariguda and Pandigaon villages of Bhawanipatna block. Apart from supporting individual farmers, group farming has been also initiated in village 'Ranga' in Nimapara block on a 4-acre patch of land near river 'Kushabhadra'. In *rabi* season, crops such as leafy vegetables, green pea, raddish, coriander, gourds, beans,


Distribution of sulphur and bio-pesticides, vegetable seeds, chicks and fish feed to farmers

Training conducted

A training program on 'Scientific water management for enhancing water use efficiency and farmers' income' was organized on March 12-13, 2020 at RRTTS, OUAT, Bhawanipatna, for farmers of SCSP project village of Dangariguda, Bhawanipatna block. Thirty farmers attended the training program.

Exposure visit

Thirty farmers of SCSP project village of Dangariguda in Bawanipatna block were taken on exposure visit to the farm of a progressive farmer named Dhananjay Sahu in Bhwanipatna block. They got an opportunity to experience the working of drip irrigation and interacted with the farm owner on benefits of micro-irrigation, government schemes and management of farm. Project farmers were also taken to RRTTS farm of OUAT and interacted with scientists on different demonstrations and new technological know-how on onion cultivation.

Exposure visit to the micro-irrigation (drip) site

Visit to RRTTS, OUAT farm, Bhawanipatna

Enhancing Land and Water Productivity through Integrated Farming System [Schedule Tribe Component (Formerly TSP Project)]

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

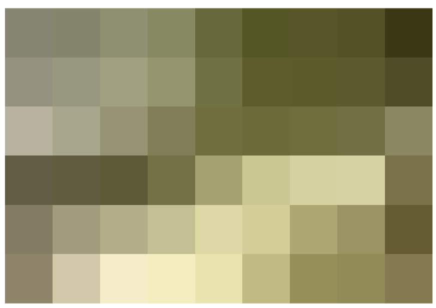
Two tribal villages in Sundargarh district and one tribal village in Rayagada district (aspirational district) of Odisha were considered under Scheduled Tribe Component Project (formerly Tribal Sub Plan Project) and the farmers were strengthened with various farm inputs during 2020.

Distribution of planting materials / fish feed

During the year, Krishi Vigyan Kendras (KVK) under Odisha University of Agriculture & Technology located in Sundargarh district and Rayagada district were mobilized for facilitating various planting materials in the adopted tribal villages. Accordingly, total 4350 nos. each of various planting material like papaya, *baula*, guava and drumstick were collected from KVK, Sundargarh (Odisha) and the farmers were advised to go for back yard planting for meeting their daya to day need. Similarly, total 3065 nos. of various planting materials like papaya, drumstick, pomegranate, lemon, mango, coconut, bamboo and aonla were collected from KVK, Rayagada (Odisha) and the farmers were encouraged to plant in their back yards.

In order to enhance the economic conditions of the farmers, pisciculture activities were taken up in Sundargarh district and accordingly the farmers were facilitated with fish feed and fish net in two tribal villages. In order to facilitate the farmers with farm implements to ease the farming operations, further farm implements like back carrying power sprayer and self-propelled weeders are planned for distribution in the villages.

Mohuljhore village (Sundargarh)



Birjaberna village (Sundargarh)

Purtiguda village, Rayagada

Distribution of planting materials

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 2020, interventions were made through poultry and use of farm machineries, use of community ponds for pisciculture etc for increasing water use efficiency in different crops and cropping sequences, and increasing farmer's income. The methods viz. pipe irrigation, line transplanting, SRI method of rice cultivation increased water use efficiency in transplanted rice. The impact evaluation of farmers FIRST project was conducted. It indicates that, during 2017-20, different interventions increased the average farm income of beneficiary farmers from ₹ 31,900 to 68,700 in Malharpada, ₹ 93,467 to ₹ 2,74,322 in Jamda and ₹ 40,289 to ₹ 1,02,556 in Khuntapingu in comparison to the year 2016-17 due to adoption of improved technologies under the project. The improvement in cropping intensity was analyzed during the same period and was found that, it increased from 125 to 170%, 125 to 173% and 130 to 177% in Malharpada, Jamda and Khuntapingu village, respectively during the same period. The land utilization index was calculated, it increased from from 0.46 to 0.65 in Malharpada, 0.46 to 0.66 in Jamda and 0.48 to 0.68 in Khuntapingu.

The farm income of two successful lady farmers were analysed. Mrs. Meena Mahanta of Khuntapingu village earned a net income of ₹ 3.40 lakh during the year 2019-20 as against ₹1.65 lakh in 2016-17, and Mrs. Ranjita Mahanta of the same village earned a net income of ₹ 1.96 lakh in 2019-20 against ₹ 0.2 lakh in 2016-17.

Line transplanted paddy field under the farmer FIRST Project

Farm-based Science and Technology Interventions for Socio-economic Development of Nabaragapur District (RKVY)

Investigators: P.K. Panda, P. Panigrahi and P. Debroy

One demonstrative project has been initiated at Kutiguda village of Kosagumunda block of Nabaragapur. The aim of this project was rainwater harvesting and its multiple use for production and profit enhancement through land modification in rainfed areas. Soil samples were collected from surface soil (0-15 cm depth) from the study area and analyzed. Soils are sandy loam in texture and mostly acidic with pH varies from 5.4 to 5.7 and non-saline in nature (EC: 0.04-0.07 mS cm^{-1}). Organic carbon status was found medium to high (0.45 to 0.96%). Available P was low to medium (6.3 to 54.06 kg ha^{-1}), whereas, available K was medium to high and varied from 162.5 to 339.5 kg ha^{-1}. A water harvesting structure has been constructed having dimension of 20 x 20 x 3 m^3. The excavated soil was used for construction of pond dyke and leftover soil was used for construction of heap with 2 m radius and 1m height having gradual slope. The heaps were constructed at a distance of 7.m x 7.5 m. On the pond dyke, papaya (var. Red Lady) was planted at a distance of 2 m. In harvested water, 800 IMC (Indian Major Carp) fingerlings were released and recommended feeding schedule was followed. During *kharif*, high yielding variety of paddy (var. Maudamani) of ICAR-NRRI, Cuttack gave 7.5 t ha^{-1} grain yield. On the mounds, cowpea was grown and from each mound, a pod yield of 6 kg was harvested. During *rabi* and summer season, onion, okra, bottle gourd, coriander, radish, bitter gourd, tomato, pumpkin, tomato, cucumber and ridge gourd have been grown.

WHS constructed at Kutiguda

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

Revival of village ponds through scientific interventions were taken up in eastern coastal plain zone of Odisha covering one site in Garadpur of Kendrapada district and another site in Kapileswarpur, Brahmagiri block of Puri district. In both the locations, pond is the major source of water for domestic as well as agriculture and fishery activities besides river water. The groundwater is saline and can't be used for domestic as well as irrigation purpose. For planning, and execution of different activities, discussions were made with the gram panchayat office bearers along with farmers and other stake holders. For convergence of different developmental schemes of Government of Odisha, officials from different government agencies were consulted and so many developmental activities were implemented in and around the ponds during the project period.

Historical satellite images were studied to find out the status of the pond in the past till the implementation of the project. All waterbodies, ponds present in the block were delineated and causes of their dysfunction were assessed. Indigenous knowledge of construction, management and use of village ponds were documented. The contour map and catchment of the pond was delineated from the ASTER and SRTM digital elevation models. It was found that for a small pond and its catchment of the order of 25 ha or less, the above method is approximation only. For accurate generation of contour map and catchment of the pond, dumpy level survey was done and maps were generated.

For design of different structures required for the pond and also to find out different components of hydrological balance of the pond, historical rainfall, evaporation and other parameters were analyzed for a period of 44 years (1975-2018). From the historical hydrologic data analysis, it is concluded that around 80,000 m^3 of water can be contributed by the catchment to the pond during monsoon. Since all the losses such as evaporation, percolation, deep percolation etc. happens continuously throughout the year, the excess water stored during July to October can be used for irrigating the crop if required without affecting the water filling up to the maximum capacity. The pond holds water to its full capacity till mid of October and reduces to 1.5 m in the peak summer (May-June). Fishery can be undertaken throughout the year as sufficient depth of water remains in the pond. The design which has been proposed in this study for trapping mesh would suitably remove the trashes and garbage. The design dimensions of the sediment basin with 40 m length, 1.5 m deep below the channel bottom with a trapezoidal shape of 4 m top width at the bottom of channel which gradually reduce to a width of 2 m with 1 horizontal: 1.5 vertical slope is recommended. The cross section of the existing channel for the sediment basin section has been modified to rectangular cross section of 4 m width and 1 m depth. All these prescribed design dimensions would be of help in reducing the velocity of flow in the sediment basin section and settling of the sediment or silt in the basin. Desilting of the sediment basin is required to be done once in two years or beyond. The designed dimensions of the gabion filter are suitable to the location to further filter the smaller floating materials and sediments. Design of emergency spillway for safe disposal of excess runoff during peak rainy season from the pond was also recommended. Hydrologic analysis for finding out the percentage area of a land to be converted to pond for holding water optimally was recommended. The catchment to pond area ratio should be around 5:1 to 6:1 in the coastal plain zone of Odisha. These design prescriptions of different structures required in a pond located in eastern coastal plain zone of Odisha, would allow good quality water free from trashes, garbage and sediment to enter into the pond. These pond water can be used for multiple use including domestic, irrigation and fishery activities.

The ponds at both sites were cleaned to remove all weeds and water hyacinths and the pond at Kapileswarpur was desilted. Bathing ghats, changing rooms, strengthening of one side of the bund by laying concrete road and keeping a provision of culvert for easy movement of farm equipment and machineries were made. Catchment planning was done demarcating area for paddy, horticulture, agroforestry and aquaculture activities for Garadpur pond. This planning was based on water availability in the pond, water requirement for different activities, soil type, topography and preference of farmers. Aquaculture (Indian major carp) was taken up in both ponds for getting additional revenue from the pond. Net profit varying from ₹50,000 to more than ₹1,00,000 per ha was obtained from fishery activities. Regular monitoring of soil and water quality was made and it was observed that pond water quality is within permissible limit throughout the year. De-siltation, construction of bathing ghats, changing room, concrete road on one side of the pond, bund plantation, pumping cum recharge pit, Children Park on the bund etc, was completed through convergence of other Government schemes. The damages caused due to severe cyclone Fani on May 3, 2019 were also revived by new plantation around the pond as well as developing the children park at Garadpur.

To create awareness among farmers and other stake holders and also to disseminate knowledge to the stakeholders, farmers' training program cum workshops were arranged at both the sites. Several discussion meetings were also organized with the gram panchayat officials, farmers, villagers, along with government officials.

Farmers' training cum workshop at Kapileswarpur, Puri on March 11, 2020

Bathing ghat at Garadpur pond

Groundwater pumping cum recharge unit at Garadpur pond

AICRP on Irrigation Water Management

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

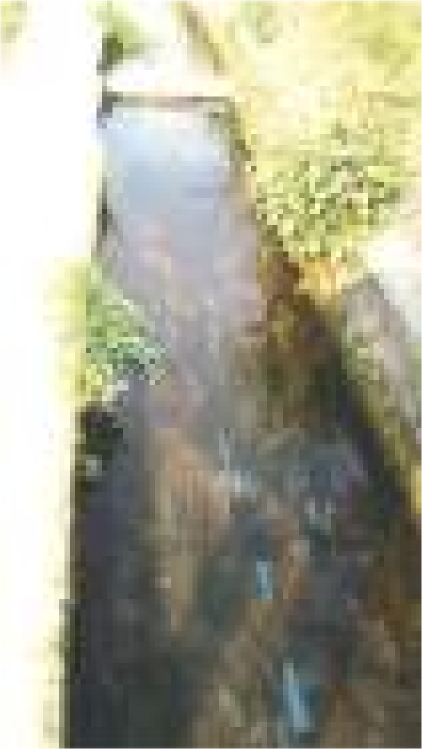
Assessment of availability and quality of surface water and groundwater

A study was conducted at Pantnagar to identify potential recharge or water harvesting zones in Gagas river basin of Uttarakhand using drainage basin morphometry, so that water harvesting or recharge structures can be constructed. The potential zones were identified by superimposing stream network map over basin slope map. As per the superimposed map, there are four zones that have slope in the range of 0-10% and have straight runoff channels most suited for construction of water recharging/ water harvesting structures. These zones are available in sub-basin 2 (Gagas- origin), 3 (Khaur), 9 (Gagas- main course in between sub-basin 8 (Riskan) & 15 (Jam)) and 14 (Navrar). Since the sub-basin 9 is 5th order stream, it should not be included in selected zone because of the quantum of discharge. Only sub-basins up to 4th order streams should be considered for check dam constructions; hence sub-basin 2, 3 and 14 are the only sub-basins that qualify the criteria of Integrated Mission for Sustainable Development (1995).

At Palampur, periodical water availability in *kuhl* (perennial gravity streams) command area was studied for estimating irrigation requirements under different cropping systems. Four *kuhl* covering about 5000 ha in Panchrukhi, Baijnath, Nagrota Bagwan and Kangra blocks of Kangra district were selected and periodical flow rate and flow velocity was recorded from July 2020. Observations showed average discharge rates of 1.86 and 2.32 $m^3 s^{-1}$ and water depths of 0.54 and 0.91 m during July and August, respectively. Thus sufficient irrigation water was available in *kuhl* command area for storage during monsoon period and utilization thereafter if auxiliary tanks are constructed adjacent to *kuhl* pathway. However, from September to

December 2020, average discharge rates of 3.8, 1.6 and 2.6 m^3s^{-1} and water depths of 0.80, 0.40 and 0.60 m were recorded at Kuwari (Nagrota), Pathiar (Malan) and Matour (Kangra) points, respectively. These low discharge rates were primarily due to non-availability of sufficient snowfall on Dhauladhar range.

Kawari point in Nagrota



Pathiar point in Malan

Mataur point in Kangra

Perennial gravity streams (*kuhl*) Himachal Pradesh

Design, development and refinement of surface and pressurized irrigation systems

At Rahuri, N, NP, NK and NPK fertigation along with varying sub surface drip irrigation levels were evaluated to study their effect on productivity of *suru* sugarcane (Com-265), soil properties and cost economics. Four irrigation levels were 40 (I_1), 60 (I_2), 80 (I_3), 100% ET_c (I_4). Fertigation levels were F_1- 80% N through weekly fertigation (30 splits) with P & K applied as basal, F_2- 80% N & P through weekly fertigation (30 splits) with K applied as basal, F_3- 80% N & K through weekly fertigation (30 splits) with P applied as basal, F_4- 80% NPK through weekly fertigation (30 splits) with no basal application, F_5- 80% NPK through fertigation (26 splits) with application of basal dose, F_6- RDF (band placement + surface application) (Control) and F_7: No fertilizer (Control). Results showed that treatment combination of 80% ET_c (I_3) and 80% NPK through weekly 30 splits with no basal application (F_4) produced significantly higher yield of 132.48 t ha^{-1}, highest monetary return of ₹214637 ha^{-1} and B:C ratio of 2.13 among the treatment combinations and control. There was a water saving of 16.8% with I_3F_4 compared to the control. There was no significant effect of the fertigation treatments on soil properties. Thus it was recommended to plant two-eye bud *suru* sugarcane at a spacing of 30 cm in furrows having length of 5 feet and irrigated with sub surface drip irrigation scheduled at 80% ET_c every alternate day with 80% RDF (200:136:136, $N:P_2O_5:K_2O$ kg ha^{-1}) through water soluble fertilizers in 30 weekly splits in medium deep black soil of western Maharashtra for obtaining higher yield, monetary returns and water saving.

A low cost bamboo drip irrigation technology for tomato was developed to enhance economic water productivity (EWP), yield and income in hilly upland condition at Shillong, Meghalaya. Treatments on different methods of irrigation with *in situ* moisture conservation techniques were bamboo drip, bamboo drip + straw mulch @ 5 t ha^{-1}, conventional drip, conventional drip + straw mulch @ 5 t ha^{-1}, straw mulch @ 5 t ha^{-1} + mini-sprinkler, control (life saving irrigation through mini-sprinkler). Results showed significantly higher yield in all the treatments compared to the control. But there was no significant difference in yield among the treatments. However, bamboo drip + straw mulch @ 5 t ha^{-1} resulted in highest tomato yield of 24.9 t ha^{-1} among the treatments, with water productivity (WP) of 9.4 kg m^{-3}, EWP of ₹282 m^{-3} and benefit-cost ratio (B:C) of 2.8. The control showed lowest yield (12.9 t ha^{-1}), WP (5.5 kg m^{-3}), EWP (₹165 m^{-3}) and B:C (1.2). It was concluded that bamboo drip irrigation along with straw mulching @ 5 t ha^{-1} is an ecofriendly and economic system that is not dependent on market inputs. It has potential to enhance yield and water productivity of tomato crop in the hills.

Bamboo based drip irrigation system

Drip fertigation schedule for sweet potato-sweet corn cropping system was optimized at Dapoli for Konkan region. It is recommended to grow sweet potato followed by sweet corn in lateritic soils of Konkan region with drip irrigation scheduled on alternate days at 100% ET_c and fertigation with 100% RDF through water soluble fertilizers (FYM @ 10 t ha^{-1} + 75:50:75 kg $N:P_2O_5:K_2O$ ha^{-1} for sweet potato / FYM @ 10 t ha^{-1} + 200:60:60 kg $N:P_2O_5:K_2O$ ha^{-1} for sweet corn) for obtaining higher system yield and economic return.

Fertigation scheduling in sweet potato-sweet corn cropping system

At Sriganganagar, optimization of surface irrigation schedule for cotton crop (var. RCH-776 BG II) was done for North West Plain Zone of Rajasthan. Treatments on irrigation schedule were I_1- Two irrigations at 35 days after sowing (DAS) & boll development stage, I_2- Two irrigations at 35 DAS & square formation stage, I_3- Three irrigations at 35 DAS, square formation & boll development stages, I_4- Three irrigations at 35 DAS, boll initiation & boll development stages, I_5- Four irrigations at 35 DAS, square formation, boll initiation & boll development stages. Treatment on depth of irrigation was D_1- 50 mm, D_2- 60 mm and D_3- 70 mm. Results showed that interaction effect of irrigation schedule i.e. four irrigations at 35 DAS, square formation, boll initiation & boll development stages (I_5) and 60 mm depth of irrigation (D_2) showed significantly higher seed cotton yield of 2.80 t ha^{-1} that was statistically similar to yield of 2.76 t ha^{-1} obtained with I_3D_2. The later treatment combination (I_3D_2) also led to 20% water saving. Thus it was recommended to grow cotton with three border strip irrigations at 35 DAS, square formation & boll development stages and 60 mm depth of irrigation to get higher yield and save water in the North West Plain Zone of Rajasthan.

Cotton crop grown with border strip irrigation

Rainwater harvesting and utilization

At Dapoli centre, *Konkan Vijay Bandhara* and *Konkan jalkund* have been developed for rainwater harvesting and utilization. From October to December 2020, total 10 plastic lined check dams (*bandhara*) named as '*Konkan Vijay Bhandara*' were constructed through peoples' participation and in collaboration with a voluntary organization BAIF-MITTRA, Jawhar in tribal areas of Konkan region. During 2020, about 40 tribal farmers were benefitted due to *bandhara* and provided irrigation to a command area of 11.9 ha to grow vegetables, watermelon, cashew, mango and jasmine in Vikramgad taluka. Total 100 *jalkund* was constructed during 2019-20, due to which 100 tribal farmers provided irrigation to 10 ha land under mango and cashew plantations in Jawhar taluka. The farmers cultivated seasonal vegetables such as chilli, cucumber, tomato, brinjal, onion and leafy vegetables using *jalkund* water. Assessment of *jalkund* technology indicted higher survival rates of mango and cashew grafts by 28.9% and 41.5%, respectively. Implementation of *jalkund* technology in north Konkan region resulted in increase in cultivated land utilization index from 0.25 to 0.45 and saved ₹ 1,30,334 ha^{-1} against the conventional method. An amount of ₹ 1,29,324 ha^{-1} was fetched by cultivating jasmine as an intercrop in mango and cashew fields irrigated with *jalkund* water. Jalkund technology was found economically viable as the drudgery and time loss in water transport was reduced due to rainwater harvesting, thereby reducing costs of operation and cultivation. During 2020-21, tribal farmers of Vikramgad taluka were trained on construction of *jalkund* in their fields. *Bandhara* was also constructed in Kongale village, Welawi village and tribal areas of Vikramgad taluka.

Training on construction of *jalkund* on tribal farmers' field in Vikramgad taluka

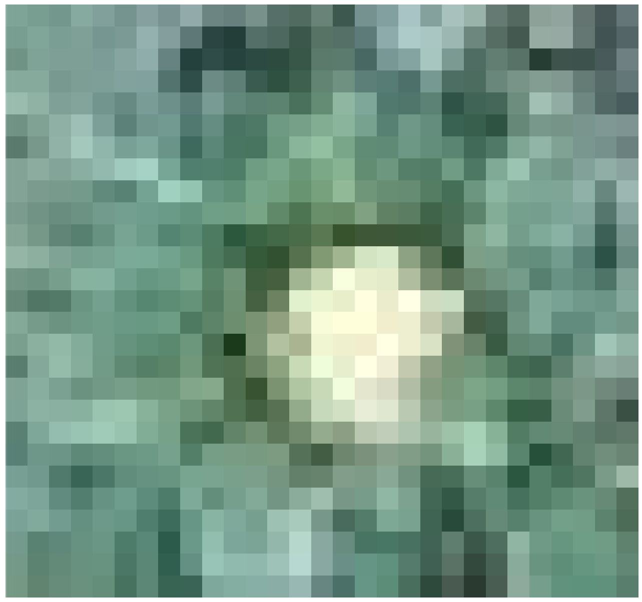
***Konkan Vijay Bandhara* constructed in tribal areas of Vikramgad taluk**

Vegetables cultivation on one acre using *bandhara* water

***Konkan Vijay Bandhara* at Kongale village was inaugurated by Director of Research, DBSKKV and sub-divisional Agricultural Officer, Dapoli**

Basic studies on soil-plant-water-environment relationship

Effect of drip irrigation and weed management practices on cauliflower crop was studied from *rabi* 2018-19 to 2020-21 at Palampur,. Irrigation schedules were 0.9, 0.7 and 0.5 PE. Weed management treatments included use of black polythene mulch, pendimethalin @ 1.5 kg ha^{-1} followed by one hand weeding at 40-45 days after transplanting (DAT), pendimethalin @ 1.5 kg ha^{-1} followed by straw mulching, and control (weedy check). Results showed significantly higher marketable curd yield of 17.65 t ha^{-1} and net return of ₹ 123816 ha^{-1} with application of irrigation at 0.9 PE and use of black polythene mulch, with water productivity of 3.13 kg m^{-3}. However, as water productivity (3.51 kg m^{-3}) was highest under treatment combination of irrigation at 0.7 PE and black polythene mulch, this combination may be applied in case of limited availability of irrigation water.

Cauliflower grown with drip irrigation and black polythene mulch

Operational Research Project (ORP)

Improved water management practices developed by Jorhat centre was demonstrated on summer (*boro*) rice, hybrid tomato and brinjal (var. *Sangro* 33) on 0.8 ha of farmers' fields in Bokakhat and Golaghat and Jorhat districts, Assam. Recommended irrigation management in rice i.e. 5 cm irrigation at 3 days after disappearance of ponded water, resulted in 29.4% higher yield, 90.3% more water use efficiency and 32% water saving compared to farmers' practice of continuous submergence. In brinjal and tomato crops, improved irrigation management of applying 4 cm irrigation at 15-18 days interval in both the crops resulted in 19.5 and 32.4% higher yield and 33.3 and 23.8% water saving, respectively compared to farmers' practice of applying irrigation at 10 days interval.

AGRI-CRP on Water

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 entitled "Development and Management of Integrated Water Resources in Different Agro-ecological regions of India", installation and evaluation of innovative water harvesting structures such as rubber dams in different agro-ecological regions were taken up. The impact of installed ICAR-flexi rubber check dams has been studied for different locations of India and the data is presented for two agro-climatic zones i.e., Chandeswar, Khordha district of Odisha (ACZ-XI i.e., East Coast Plains and Hills Region) and Jogiput, Korapur district of Odisha and Kadalipatraguda, Nabarangpur district of Odisha (ACZ-VII i.e., Eastern Plateau and Hills Region).

The impact of installed rubber dams on agricultural performance in Chandeswar-1 and Chandeswar-2 sites of Khordha district of Odisha was evaluated. During *kharif* season of 2020, the rice grain yield was found to be increased from 4.14 t ha^{-1} during pre-installation period to 4.85 t ha^{-1} during post-installation of rubber dam resulting in a jump by 17% due to optimum time of transplanting and assured irrigation during mid-season dry spells (Table 13). During *rabi* season of 2019-20, the pod yield of greengram was found to be enhanced by 24% from 0.72 t ha^{-1} to 0.89 t ha^{-1}. At the same time, the yield of brinjal was enhanced by 28% from 7.4 t ha^{-1} during pre-installation period to 9.5 t ha^{-1} during post-installation of rubber dam due to assured irrigation (Table 13). The farmers could irrigate *rabi* crops using water from rubber dam at critical crop growth stages (flowering and pod formation) which minimized water limiting factors for growth, development and the economic yield. The rubber dam has also resulted in positive impact on productivity of summer season vegetable crops in the year 2020 such as watermelon (40%), cowpea (46%) and ridgegourd (25%). The fruit yield of watermelon and cowpea has been increased from 9.2 and 5.2 t ha^{-1} to 12.9 and 7.6 t ha^{-1}, respectively, during corresponding period due to available water after installation of rubber dam at Chandeswar. Similarly, the fruit yield of ridgegourd was enhanced from 5.5 t ha^{-1} during pre-installation stage to 6.9 t ha^{-1} during post-installation of rubber dam.

Table 13. Productivity of *kharif*, *rabi* and summer crops pre-installation and post-installation period in rubber dam command area at Chandeswar, Khordha district, Odisha

Crop	Yield (t ha^{-1})		Percent increase in yield
	Pre-installation stage	Post-installation stage	
	kharif season		
Rice	4.14	4.72	17
	rabi season		
Greengram	0.72	0.89	24
Brinjal	7.4	9.5	28
	summer season		
Watermelon	9.2	12.9	40
Cowpea	5.2	7.6	46
Ridgegourd	5.5	6.9	25

The farmers in Jogiput of Odisha could cultivate vegetable crops like brinjal (32% additional yield from 12.6 to 16.6 t ha^{-1}) and tomato (26% additional yield from 14.5 to 18.3 t ha^{-1}) during *rabi* season of 2019-20 due to assured irrigation from rubber dam. Similarly, the rice grain yield during *kharif* 2020 was found to be increased from 3.4 t ha^{-1} during pre-installation period to 4.2 t ha^{-1} during post-installation of rubber dam resulting in a jump by 23% due to timely transplanting and assured irrigation during mid-season dry spells.

The farmers in Kadalipatraguda watershed, Nabarangpur district of Odisha could cultivate different types of crops like maize (33% additional yield from 12.6 to 16.8 t ha^{-1}) and sesamum (27% additional yield from 0.48 to 0.61 t ha^{-1}) during *rabi* season of 2019-20 due to assured irrigation from 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 for irrigating maize, vegetables, and also drinking purposes, washing milch animals, rabbits as well as pigs and poultry.

The water storage capacity created at different locations were measured. At Dapoli it was 20,000 m^3 with a command of 30 ha; at Ootty a command of 5 ha was created; at Palampur-1 it was 4,200 m^3, at Plampur -2 it was 3,600 m^3; at other locations it varied between 4000 m^3 and 10000 m^3 depending upon the slope and cross section of the stream.

Groundwater recharge in hard rock regions of Dhenkanal

The water in the water harvesting structure at Khamara and Khallibandha village, Dhenkanal district of Odisha was used for fish culture, on-dyke horticulture and supplementary irrigation during *kharif* season. In the water harvesting structures, fish yield of 1.9 quintal and 1.5 quintal, was recorded from Khamara and Khallibandha villages, respectively. The rubber dam along with the water harvesting structure constructed in the Khamara village provided supplementary irrigation to 60 acre of paddy land. Regular monitoring of water level in the water harvesting structures, observation wells and recharge well was continued. Due to combined effect of construction of rubber dam, water harvesting structure and recharge well in the Khamara village, an average increase of 25 cm of groundwater level was observed over four year period.

Water balance analysis in the water harvesting structure (WHS) in Khallibandha village was continued. The water balance components were rainfall, runoff into the WHS, 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 during the no rainfall and no runoff period. A relationship was developed between the water level in the pond and the potential groundwater recharge per day. Using the relation, the day-wise potential groundwater recharge from the water harvesting structure was estimated. The four years average annual groundwater recharge was estimated as 3630 m^3. The month-wise average groundwater recharge estimated in the water harvesting structure is shown in Fig. 21.

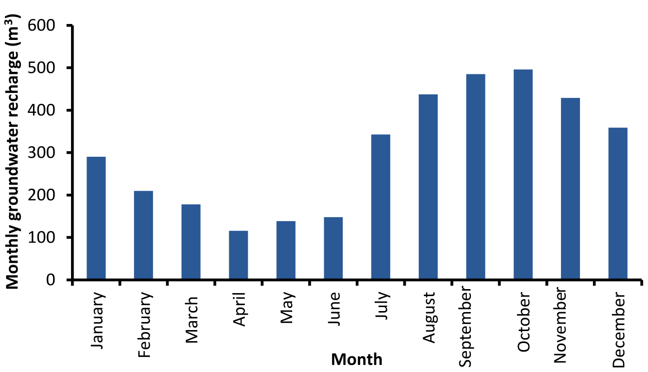


Fig. 21. Average monthly groundwater recharge in the water harvesting structure

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

Nagpur minor canal directly off taking from Puri main canal system, in coastal Puri district of Odisha is deficient in its functioning due to non-demand based water supply in the canal. It mostly runs during monsoon season months. Thus, there was need of provision of auxiliary water storage structures for creating an assured irrigation source in the command. Keeping this in view, three existing farm ponds were linked with canal system and irrigation provision having PVC pipe conveyance system, PVC pipe conveyance along with sprinkler irrigation system and PVC pipe conveyance along with drip irrigation system were laid out in head, middle and tail reaches during 2017-18. Four major crops were grown in *rabi* season 2018-20 in the command i.e. groundnut, sesamum, pointed gourd, and bitter gourd and performance study was made for the developed irrigation system.

Pressurized irrigation systems operational in the canal command

Crop yield, physical and economic water productivity under pressurized irrigation systems

Supply of canal water through farm-pond fed drip irrigation system during 2017-18 to 2019-2020 resulted in enhancement of yield of groundnut, pointed gourd and bitter gourd to the tune of 32-50% and water productivity of 118-136%, while there was less irrigation water use by 37-43%, when compared with channel conveyance system. The crop yield, water use and water productivity in case of channel conveyance system resulted in crop yield in the range of 1.4-12.5 t ha^{-1}, water use of 260-307 mm and water productivity of 0.5-5.2 kgm^3. Similarly, drip irrigation system resulted net economic water productivity of 310 and 199 ₹ m^3 for the vegetable crops like pointed gourd and bitter gourd, respectively, whereas channel conveyance system resulted in 129 and 91 ₹ m^3 (Table 14).

Similar trend was also observed in case of supply of canal water through farm-pond fed sprinkler irrigation system, when compared with channel conveyance system. However, farmers' preference remained with sprinkler irrigation system than drip irrigation system due to requirement of frequent maintenance in drip irrigation system.

Table 14. Average yield and physical water productivity during 2017-18 to 2019-20

Location		Crops	Yield (t ha^{-1})	Water applied (mm)	Physical water productivity (kg m^{-3})
Upper reach	Groundnut	Pipe conveyance	1.5	260.0	0.6
		Channel conveyance	1.2	313.3	0.4
	Sesamum	Pipe conveyance	0.9	116.7	0.7
		Channel conveyance	0.7	150.0	0.4
Middle reach	Groundnut	Pipe conveyance	1.6	260.0	0.6
		Sprinkler	2.1	226.7	0.9
		Channel conveyance	1.4	313.3	0.4
	Sesamum	Pipe conveyance	0.8	110.0	0.8
		Sprinkler	1.0	83.3	1.4
		Channel conveyance	0.8	133.3	0.6
Lower reach	Groundnut	Pipe conveyance	1.7	246.7	0.7
		Drip	2.1	193.3	1.1
		Channel conveyance	1.4	306.7	0.5
	Pointed gourd	Pipe conveyance	13.6	246.7	5.5
		Drip	16.6	170.0	9.9
		Channel conveyance	12.5	296.7	4.2
	Bitter gourd	Pipe conveyance	11.4	216.7	5.2
		Drip	13.9	160.0	8.7
		Channel conveyance	10.5	260.0	4.0
Traditional	Groundnut		1.1	360	0.31
	Sesamum		0.7	120	0.58
	Pointed gourd		12.5	300	4.17
	Bitter gourd		11.0	300	3.67

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

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

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

Studies were carried out to evaluate the responses of banana to automatic irrigation, growth stage specific drip-fertigation and different plant number per pit under drip system at ICAR-IIWM research farm, Mendhasal, Khordha. In the first experiment, the effects of soil water sensor based and timer based irrigation (1 hour interval 3 times daily at 80% ET_C, 2 hour interval 2 times daily at 80% ET_C, 1 hour interval 3 times daily at 60% ET_C, 2 hour interval 2 times daily at 60% ET_C) were compared with manual irrigation in the crop. At the end of experiment in 2020, final vegetative growth parameters, soil water content, available soil nutrients, plant nutrients and hydraulics of the drip irrigation system were studied. In the second experiment, drip irrigation scheduled at different growth stages (60 and 80% ET_C at pre flowering, PF; 80 and 100% ET_C at flowering and fruit setting, F and FS; 60 and 80% ET_C at fruit development, FD) and fertigation levels (60 and 80% recommended dose of fertigation, RDF at pre flowering; 80 and 100% of RDF at flowering and fruit setting; 40 and 60% RDF at fruit development) were compared with drip irrigation at 100% ET_C with fertigation at 100% RDF in the crop. In the third experiment, 1 plants per pit (3,333 plants ha^{-1}), 2 plants per pit (5,000 plants ha^{-1}) and 3 plants per pit (6,000 plants ha^{-1}) with different soil wetted volume (SWV: 20, 40, 60 and 80%) under drip irrigation were compared in the crop. In second and third experiments also, the final vegetative growth parameters, soil water content in crop root zone, available N, P and K in soil, leaf N, P and K and hydraulics of drip irrigation were observed.

The hydraulic performance of the drip irrigation system indicated that the emitter flow rate variation (Q_V) was 7–8% with coefficient of variation (CV) of 6–7% and distribution uniformity (DU) of 90–92%. Under manually operated drip system, the soil water content was 16-25% higher than that in automatic irrigation systems. The available N and K in soil and leaf N and K were higher under sensor based irrigation compared with other treatments, whereas P was not affected significantly due to differential irrigation. Final plant height, canopy diameter, number of leaves, stem girth and leaf area index of the plants under manual drip irrigation were 8-15%

higher than that in automated irrigation schedules. Similarly, under different growth stage specific drip-fertigation treatments, irrigation at 60% ET_C during pre-flowering along with 80% ET_C at flowering and fruit setting and 60% ET_C at fruit development stages integrated with fertilizer application at 80% RDF at pre-flowering with 100% RDF at flowering and fruit setting and 80% RDF at fruit development, the leaf N and K were at par with that under normal drip-fertigation practice. The soil water content in crop root zone and vegetative growth of plants under 100% ET_C with RDF was higher than that in other treatments. Among different plant densities and SWV, the 3,333 plants ha^{-1} with 80% WV resulted in higher final plant growth parameters, soil available N and K and leaf N and K compared with other treatments. However, soil water content was at par in different treatments.

Automated drip irrigation system in Banana

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

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

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

Growth of fishes (IMC) in different combinations, wastewater and treated wastewater with fresh water, suggested higher growth rate due to the higher availability of nutrients from treated wastewater. Even in raw wastewater, the survivability of IMC was not affected. With treated wastewater, even no discernible disease due to wastewater was observed. While growth of fishes in wastewater is much appreciated in terms of food and water security, however, the health risks associated with the wastewater produce is an area of concern. There are two main perceived health hazards associated with the culture of fish in wastewater: i) accumulation of heavy metals in the fishes and its effect on human health, and ii) pathogenic load in wastewater fishes.

The concentration of Cd, Cr, Pb and Ni varied between 0.125 - 0.39, 0.26 - 0.875, 0.12 - 0.465 and 0.135 - 0.41 mg kg^{-1}, respectively in different tissues of fishes grown in untreated wastewater. In wastewater total maximum accumulation of heavy metals were in the order of Cr (0.539) > Ni (0.305) > Pb (0.268) > Cd (0.253) in different tissues of fish which were within the permissible limit. The accumulation of heavy metals in different fish parts decreased significantly ($P<0.01$), in treated wastewater and on further diluted treatments. In untreated wastewater maximum accumulation of Cd was in kidney (0.325 mg kg^{-1}) at par with liver (0.320 mg kg^{-1}) followed by gills (0.232 mg kg^{-1}) and muscle (0.135 mg kg^{-1}). The accumulation of Cr was in the order of liver > kidney > gills > muscle with minimum significant difference of 0.0836 mg kg^{-1}. Accumulation of Pb was in the order of liver > kidney > gills > muscle with minimum significant difference of 0.0327 mg kg^{-1}. The results of the present study revealed that the concentration of all the heavy metals viz., Cd, Cr, Pb and Ni was the lowest in muscles, the part which is mostly consumed and was within the permissible FAO limits (1983). In different organs accumulation of heavy metals were in the order as Cr>Pb>Ni>Cd for liver, then Cr> Ni> Cd ~Pb for muscle, then Cr> Ni> Cd ~Pb for gills, and then Cr> Ni> Cd >Pb for kidney. The accumulation of heavy metals in fish lowered significantly in treated wastewater and in diluted wastewater. There was no heavy metal found in the fish grown in fresh water.

Human health risk assessment

The potential health risk in human (male and female) due to prolonged exposure to chemical has been estimated as estimated daily intake (EDI), target hazard quotient (THQ), hazard index (HI) as introduced by EPA in the United States, USEPA (United States Environmental Protection Agency), 1989. The results reveal that female has higher risk due to their lower body weight. Maximum daily intake of Cr is 0.0957 and 0.081 mg kg^{-1} bodyweight day^{-1} for female and male respectively followed by Ni > Cd > Pb from fish grown in wastewater. EDIs were many fold higher than their respective reference doses. The daily intake of Cd, Cr, Pb and Ni reduced by 62.96, 54.07, 80.77 and 89.51% respectively in male and female from fish grown in treated wastewater. On further dilution of treated wastewater by fresh water (FW) i.e. (TWW) at 1:3, daily intake of Cd, Cr, Pb and Ni reduced maximum by 100, 90, 100, 98% respectively in both male and female. THQ for heavy metals was in the order of Cd > Cr > Pb > Ni for both male and female. Maximum HI was 0.095477 and 0.080788 for wastewater grown fish intake, which was lowered, to 0.03518 and 0.029768 for females and males respectively when the intake was treated wastewater grown fish. HI was reduced to the minimum of 0.003126 and 0.002645 for female and male on further dilution of treated wastewater (TWW: FW at 1:3). THQ for all the heavy metals studied has not exceed 1 even for fish grown in untreated wastewater, which indicates less potential non-carcinogenic risks to exposed population. The level of concern increases as THQ approaches 1 or greater than 1.

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 P. Sahu

Collaborating Institutes: ICAR-CIFA, Bhubaneswar

A water-use efficient integrated farming system (IFS) model has been developed at ICAR-IIWM research farm integrating aquaculture, agriculture, on-dyke horticulture and poultry. In this system, a pond of 700 m^2 had been stocked with Indian Major Carps @ 5000 fingerlings ha^{-1}. On-dyke horticulture with 120 plants of banana (G-9) in two rows and 60 papaya plants (Red Lady) in single row planting were carried out. Adjacent 0.3 ha was under *kharif* rice, followed by greengram while, 0.1 ha area was also under ladies finger, followed by pumpkin. Ducks (White Pekins, 20 numbers) and poultry birds (*vanaraja*, 80 numbers) had also been introduced as an integrated component. Lifesaving irrigation to on-dyke crops & agriculture crops was provided using the nutrient rich pond water. 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 crop harvesting.

Out of system's total crop water use (3.24×10^4 m^3 240 d^{-1}), the estimated total water use (TWU) and consumptive water use index (CWUI) in carp polyculture was 2.42×10^4 m^3, 240 d^{-1} and 2.54 m^3 kg^{-1} fish production, respectively. The estimated evaporation and seepage loss was 2.8 and 2.3 m^4 water kg^{-1} fish production respectively and contributed significantly to consumptive water use (CWU). In aquaculture alone, 1 m^3 of water produced 196 g of carp biomass while, output value - cost of cultivation ratio (2.64), net consumptive water productivity (₹8.62 m^{-3}) and lower apparent feed conversion ratio (AFCR) (1.58) resulted in net profit of ₹79,617 ha^{-1} 240 d^{-1}. Along with aquaculture (2.9 t ha^{-1}) and on-dyke horticulture, adjacent 0.3 ha was under *kharif* rice (3.28 t ha^{-1}), followed by greengram (0.92 t ha^{-1}) while, 0.1 ha area was also under ladies finger (18.1 t ha^{-1}), followed by pumpkin (27.8 t ha^{-1}). System as a whole, resulted in gross and net income of ₹1,72,336 and ₹111,020 ha^{-1} respectively with anoutput value - cost of cultivation ratio of 2.6 and net consumptive water productivity of ₹16.08 m^{-3}. This integrated farming not only accommodates crop diversification, enhance productivity, generate employment opportunity, increase income and provide nutritional security to resource poor farming community but also distribute the risk (both biological and economic), since two or more subsystems are involved instead of a single-commodity farming system.

In an another study, out of four different production systems such as (1) IMC grow-out culture : single stock-single harvest system, (2) IMC grow-out culture : single stock-multi harvest system, (3) IMC grow-out culture : multi stock-multi harvest system, (4) intercropping of IMC-Minor carp; Multi Stock-Multi Harvest system (MSMH) was found to be more efficient, productive and profitable (Table 15) in terms of water use efficiency (0.57 kg m^{-3}), productivity (4.6 t ha^{-1}), FCR (1.51), total water footprint (998 m^3 t^{-1}) and net consumptive water productivity (₹ 9.2 m^{-3}). Next to Multi Stock-Multi Harvest system, intercropping system of IMC-Minor carp was considered efficient, productive and profitable.

Table 15. Water-use in different carp production systems (average of three year's data)

Water management parameters	Single stock-single harvest	Single stock-multi harvest	Multi stock-multi harvest	Intercropping of IMC-Minor carp
Stocking density, ha^{-1}	10,000 IMC fingerlings	10,000 IMC fingerlings	4,000 IMC fingerlings**	8,000 fingerlings Including 50% IMC
Culture duration	360 days	360 days	360 days	360 days
Water depth (m)	1.2 up to 180 DOC 1.5 up to 360 DOC	1.2 up to 180 DOC 1.5 up to 360 DOC	1.2 up to 180 DOC 1.5 up to 360 DOC	1.2 up to 180 DOC 1.5 up to 360 DOC
TWU, ($\times 10^4$, m^3)	2.40	2.53	2.5	2.43
CWU, ($\times 10^4$, m^3)	0.73	0.84	0.82	0.76
CWUI, $m^3 kg^{-1}$	1.97	1.95	1.78	1.77
Productivity, t ha^{-1}	3.7	4.3	4.6	4.3
WUE_C (kg m^{-3})	0.50	0.51	0.57	0.56
FCR	1.76	1.63	1.51	1.72
NCWP, ₹m^{-3}	7.7	8.1	9.2	8.3
Wf_t, m^3 t^{-1}	1122	1093	998	1026

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

The survey was conducted on groundwater use and its marketing, by collecting data from 50 farmers, in two blocks viz. Khandpara and Ranpur in Nayagarh district of Odisha. The well owners and sellers had total 84.8 ha owned land and 3 ha of leased out land. Usually the farmers grow rice during *kharif* season, vegetables and pulses during *rabi* season. It was found that rice was grown in an area of 76.8 ha and vegetables in 22 ha by the 50 surveyed farmers. Water trading was done in both the blocks by small group of farmers. The price of water was decided based on the acreage and hours of pump operation in a season. The capacity of pump was selected according to the area to be irrigated and water requirement. Generally 2.5- 5.0 hp pump was installed by the water sellers and self-users. The installation cost was about ₹ 1.4 lakh for government sponsored subsidized pumps, in which ₹ 20,000 was deposited by beneficiary farmers on their own, whereas ₹ 90,000 to ₹ 1.5 lakh was invested by the farmers with non-subsidized own project depending upon the depth of water groundwater table and pump capacity. The price of water was ₹ 150 per hour during *kharif* season, and ₹ 200 per hour during *rabi* season in Ranpur block. In Khandapada block, pricing was based on land area basis, and it varied between ₹ 11250 ha^{-1} in *kharif* to ₹ 15000 ha^{-1} in *rabi* season It was found that the maximum net profit was accrued to the water sellers in the Nayagarh district among the surveyed farmers (Table 16).

Table 16. Average economic return to sellers and buyers in two blocks of Nayagarh district (50 surveyed farmers)

Particulars	Cost of production for all farm enterprises (*kharif*+*rabi*) (₹ ha^{-1})	Average gross income (₹ ha^{-1})	Average net return (₹ ha^{-1})
Water sellers	293563	450645	157083
Water buyers	320813	390613	69800
Self-users	197320	296030	98710
Govt. well users	140185	174390	34205
Non users (rainfed)	90695	103895	13200

Weather Report of Research Farm

The weekly rainfall and open pan evaporation data was recorded during 2020 at ICAR-IIWM Research Farm, Deras Mendhasal, Khordha and were analysed, presented in presented Fig. 22. The total rainfall between January 1, 2020 and December 31, 2020 was 1622.4 mm and standard meteorological week (SMW) 32 received the highest rainfall of 184.9 mm due to cyclon-Fani. Total evaporation was 1186.7 mm and highest evaporation was observed during SMW 20 (44.8 mm) and thereafter it declined during monsoon period.

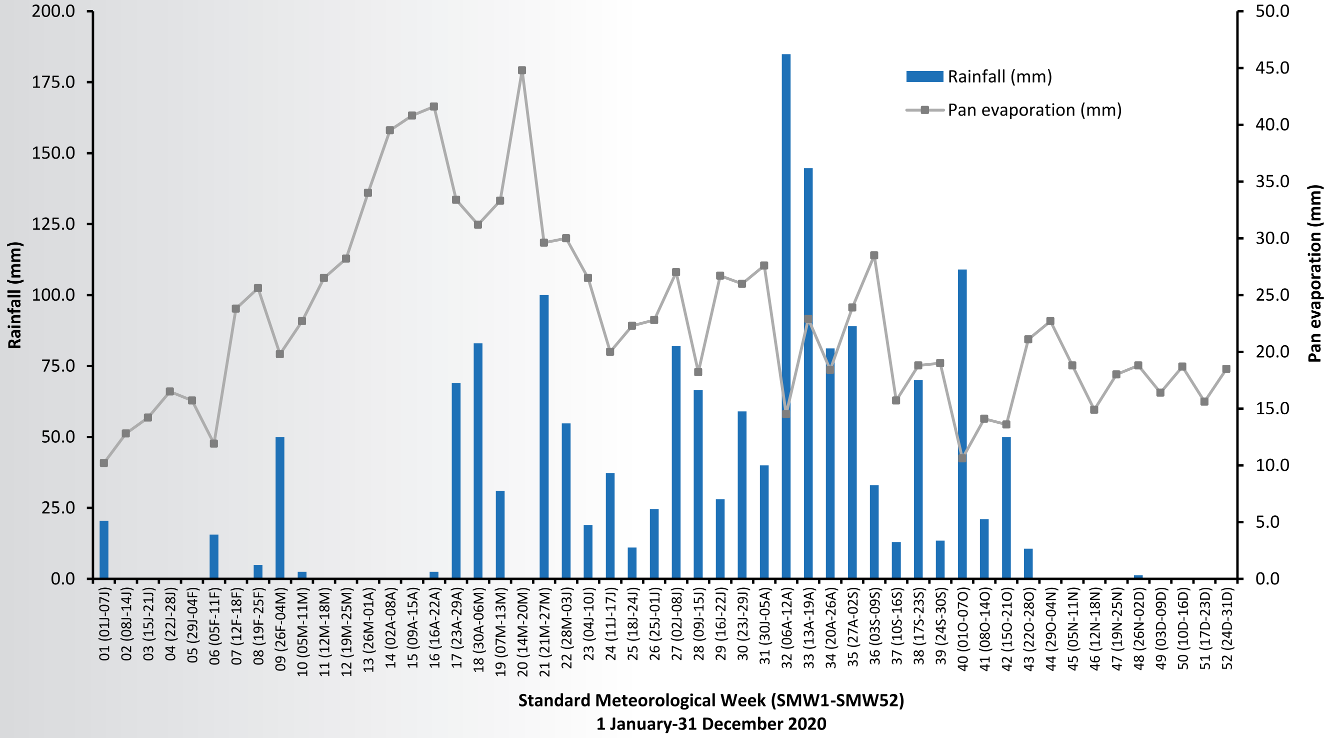


Fig. 22. Weekly rainfall and pan evaporation during January-December, 2020 at ICAR-IIWM research farm

Publications 2020

Publications 2020

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Folders

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Book chapter

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Research Projects

IN-HOUSE PROJECTS (2020)

Completed Research Projects

Sl. No.	Project Code	Project Title	PI Name
1.	NRMA/IIWM/SIL/ 2015/009/00174	Enhancing water productivity through water management in transplanted and aerobic rice in canal command area	Dr. K.G. Mandal
2.	NRMA/IIWM/SIL/ 2015/011/00176	Enhancing water productivity through intensive horticultural system in degraded land	Dr. S. Pradhan
3.	NRMA/IIWM/SIL/ 2016/003/00179	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
4.	NRMA/IIWM/SIL/ 2016/004/00180	Design and field evaluation of groundwater recharge structures for hard rock region	Dr. R.R. Sethi
5.	NRMA/IIWM/SIL/ 2016/005/00181	Development of web-based expert system on agricultural water management	Dr. A.K. Nayak
6.	NRMA/IIWM/SIL/ 2016/006/00182	Enhancing yield and water productivity of Rice-fallow areas of eastern India through Super Absorbent Polymers (SAP)	Dr. S. Pradhan

Ongoing Research Projects

Sl. No.	Project Code	Project Title	PI Name
1.	NRMA/IIWM/SIL/ 2017/001/00183	Development and evaluation of mini pan evaporimeter for on-farm irrigation scheduling	Dr. S. Pradhan/ Mr. N. Manikandan
2.	NRMA/IIWM/SIL/ 2017/002/00184	Evaluation of land shaping options for increasing farm income in coastal waterlogged area	Dr. S.K Rautaray
3.	NRMA/IIWM/SIL/ 2017/003/00185	Assessment of groundwater contamination due to excess fertilizer and pesticide uses and its management in lower Godavari basin	Mr. P. Deb Roy
4.	NRMA/IIWM/SIL/ 2018/001/00188	Water management using artificial substrate induced periphyton biomass in zero-water exchange shrimp culture system	Dr. R.K. Mohanty
5.	NRMA/IIWM/SIL/ 2018/002/00189	Impact of water stress on growth and physiology of rice under different crop management practices	Dr. A.K. Thakur
6.	NRMA/IIWM/SIL/ 2018/003/00190	Arsenic contamination in rice and possibility of mitigation through organic and chemical amendments	Mr. P. Deb Roy
7.	NRMA/IIWM/SIL/ 2018/004/00191	Refinement of small scale online wastewater filter for safe irrigation practice	Dr. M. Raychaudhuri
8.	NRMA/IIWM/SIL/ 2018/005/00192	Analyzing the functioning of water user association in different irrigation command	Dr. M.K. Sinha
9.	NRMA/IIWM/SIL/ 2019/001/00193	Impacts of land-atmosphere interactions on dry-hot episodes in India	Dr. D.K. Panda
10.	NRMA/IIWM/SIL/ 2019/002/00194	*In-situ* phytoremediation of Cr (VI) from water in chromite mine areas for irrigation	Dr. M. Das
11.	NRMA/IIWM/SIL/ 2019/003/00195	Piloting water management technologies for enhancing farm productivity and income	Dr. H.K. Dash

New Research Projects

Sl. No.	Project Code	Project Title	PI Name
1.	NRMA/IIWM/SIL/ 2020/001/00196	Evaluation of micro-irrigation for enhancing water use efficiency of selected rice varieties	Dr. K.G. Mandal
2.	NRMA/IIWM/SIL/ 2020/002/00197	Yield gap and water productivity atlas of pulse and oilseed crops in India	Dr. P.S. Brahmanand
3.	NRMA/IIWM/SIL/ 2020/003/00198	Modelling of water and nitrogen dynamics in paddy fields for assessment of groundwater pollution in shallow water table regions	Dr. P.P. Adhikary
4.	NRMA/IIWM/SIL/ 2020/004/00199	Geo-informatics application in site suitability analysis for crop planning and aquaculture development in eastern and western coast of India	Dr. A.K. Nayak
5.	NRMA/IIWM/SIL/ 2020/005/00200	Impact of land use and land cover changes on groundwater storage in Baitarani river basin	Dr. R.R. Sethi
6.	NRMA/IIWM/SIL/ 2020/006/00201	*In-situ* rainwater management practices for enhancing farm income and water productivity of uplands	Dr. P.K. Panda
7.	NRMA/IIWM/SIL/ 2020/007/00202	Evaluation of drip irrigated multistoried cropping systems for enhancing land and water productivity	Dr. O.P. Verma

Research Projects

EXTERNALLY FUNDED (2020)

Title	Budget (₹ in lakh)	Duration	PC / NO / PI / CCPI	Sponsored by
All India Co-ordinated Research Project on Irrigation Water Management	319.90	2020-21	Dr. A. Mishra, PC	ICAR, New Delhi
Agri-Consortia Research Platform on Water	384.91	2020-21	Dr. A. Mishra, LCPC Dr. P. Panigrahi, Dy LCPC	ICAR, New Delhi
I. Development and Management of Integrated Water Resources in Different Agro-ecological regions of India	–	2015-21	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	–	2015-21	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	–	2015-21	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	–	2015-21	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	–	2015-21	Dr. R.K. Mohanty	Agri-Consortia Research Platform on Water, ICAR, New Delhi
VI. Institutional and Marketing Innovations Governing Use of Agriculture Water	–	2016-21	Dr. P. Nanda	Agri-Consortia Research Platform on Water, ICAR, New Delhi
Index Based Flood Insurance (IBFI) and Post-Disaster Management to Promote Agriculture Resilience in Selected States in India	(USD 73920)	2017-2022	Dr. P.S. Brahmanand	International Water Management Institute (IWMI), Colombo
Enhancing Economic Water Productivity in Irrigation Canal Commands (Sina command)	(USD 62294)	2017-2020	Dr. R.K. Panda	International Water Management Institute (IWMI), Colombo
Enhancing Economic Water Productivity in Irrigation Canal Commands (Kukadi Command)	(USD 40479)	2020-2022	Dr. R.K. Panda	International Water Management Institute (IWMI), Colombo
Drought and Hot-spell Assessment using the GRACE Gravity Records Delhi	20.68	2019-2022	Dr. D.K. Panda	DST, Ministry of Science & Technology, New

Title	Budget (₹ in lakh)	Duration	PC / NO / PI / CCPI	Sponsored by
In Situ Phytoremediation of Chromium VI from Polluted Water Sources for Safe Use of Water for Irrigation in Chromite Mining Areas at Sukinda, Odisha	49.03	2020-2022	Dr. M. Das	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
Piloting Water management Technologies for Enhancing Farm Productivity and Income (SCSP)	31.34	2020-21	Dr. H.K. Dash	ICAR, New Delhi
Enhancing Land and Water Productivity through Integrated Farming System (Scheduled Tribe Component Project)	15.00	2020-21	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	2018-21	Dr. P. Nanda	ICAR, New Delhi
Farm-based Science and Technology Interventions for Socio-economic Development of Nabaragapur district (RKVY)	10.25	2019-22	Dr. P.K. Panda	Govt. of Odisha

Awards, Honours & Recognitions

- ICAR-IIWM was bestowed with 'Public Appreciation Award' and Dr. P. Nanda, Principal Scientist and Dr. P.S. Brahmanand, Principal Scientist & Nodal Officer, *Swachh Bharat Abhiyan* were honoured with '*Swachhta* Visionary Leadership Award' for their extraordinary contribution towards *Swachha Bharat* Mission activities during five year period of 2014-19 in a function organized by Pipli Samskrutika Parishad at Pili, Odisha on January 14, 2020. The award was presented by His Excellency Prof. Ganeshi Lal, Governor of Odisha.

- Drs. P.K. Panda, P. Panigrahi and P. Debroy of the institute involved in a project- Farm based Scientific & Technological Interventions for Socio-economic Development of Aspirational District Nabarangapur, which received Skoch Platinum Award for the 2019-20.

- Dr. S. Pradhan, Scientist received the 'Outstanding Scientist Award 2020' presented by 'The Society of Tropical Agriculture', New Delhi.

- Drs. S.K. Rautaray, S. Mohanty and S. Pradhan received the 'Gannet Memorial Award 2020' by Institute of Engineers, Odisha State Centre in the category of Environmental Science for the paper 'Environmental benefits from organic nutrition in rice crop'.

- Dr. O.P. Verma received Appreciation Award 2018-19 from Bhubaneswar Official Language Implementation Committee for his significant contributions in organizing and conducting various Hindi language competetions.

- Dr. S.K. Jena, Principal Scientist has received 'Appreciation Award' for successful completion of DST-RVPS project, presented by WTC, ICAR-IARI, New Delhi.
- Dr. S. Raychaudhuri, Principal Scientist received 'Certificate of Appreciation' from Atal Incubation Centre, sponsored by NITI Aayog/ Atal Innovation Mission for contribution in the field of Organic Agriculture.
- Dr. P.S.B. Anand, Principal Scientist has been nominated by the ICAR as Member, IMC of ICAR-Directorate of Weed Research, Jabalpur, Madhya Pradesh and ICAR-Research Complex for Eastern Region, Patna, Bihar.
- Dr. S.K. Jena Principal Scientist has been nominated by the ICAR as Member, IMC of ICAR Research Complex for Eastern Region, Patna, Bihar.
- Dr. P.P. Adhikary, Senior Scientist has been recognized as Impactful Peer Reviewer 2020 of PLOS ONE journal by Public Library of Science.
- Dr. S.K. Rautaray received compliment letter for Lead Paper presentation on 'Water Saving Techniques for Agriculture under Climate Change' at National Seminar on 'Climate Smart Agriculture for Enhancing Farm Profitability' organized by Indian Society of Agronomy (Odisha Chapter) held at OUAT, Bhubaneswar during January 28-29, 2020.
- Dr. S. K. Jena, Principal Scientist was invited as key note speaker in the 29th Swadeshi Science Congress and National conference on 'Science and Technology for Sustainable Development' at ICAR-CPCRI, Kasaragod, Kerala during February 27-29, 2020.
- Dr. S. K. Jena, Principal Scientist attended 54th ISAE Convention and International symposium on 'Artificial Intelligence Based Future Technologies in Agriculture' during January 7-9, 2020 at Pune, Maharashtra; and was Chairman of the selection committee for best poster presentation in the field of Soil & Water Conservation Engineering; and co-chairman of the technical session on 'Groundwater and Drainage'.
- Dr. S.K. Jena, Principal Scientist has been invited for Dr. A.P.J. Abdul Kalam Endowment Lecture on 'Advanced rainwater harvesting technologies in watersheds' by Andhra Pradesh Akademi of Science on December 24, 2020.
- Dr. P.S.B. Anand, Principal Scientist has been invited as member, National level Technical Sub-Committee on Flood constituted by Credit Division, Ministry of Agriculture & Farmers Welfare, Government of India.
- Dr. M. Raychaudhuri, Principal Scientist was invited for special lecture on World Soil Day (December 5, 2020) on 'Keep soil alive, protect soil biodiversity' organized by Kumaraguru Institute of Agriculture, TNAU, Tamil Nadu.
- Dr. M. Das, Principal Scientist has been invited for lecture on 'ETP water quality and probability of use in mainstream agriculture' by HINDALCO, Muri on July 7, 2020.
- Dr. S. Raychaudhuri, Principal Scientist was invited for lecture on 'Principles of organic farming and recycling as the mainstay of organic agriculture" on July 7, 2020 during training program on 'Organic Farming' organized by Regional Centre of Organic Farming, GOI, Bhubaneswar.
- Dr. M. Das, Principal Scientist has been invited for lecture on 'Water quality issues, wastewater use preamble and outlook of use especially in farming' in the Brainstorming Session on Utilization of Wastewaters in Urban and Peri-urban Agriculture on November 17, 2020.
- Dr. S. Raychaudhuri, Principal Scientist was invited for lecture on 'Safe wastewater irrigation - policy perspective' in the Brainstorming Session on Utilization of Wastewaters in Urban and Peri-Urban Agriculture organized by NAAS, New Delhi.
- Dr. M. Raychaudhuri, Principal Scientist evaluated Doctoral degree thesis of Agricultural Chemistry and Soil Science of Post-graduate studies, BCKV, West Bengal.
- Dr. P.P. Adhikary, Senior Scientist has been nominated as adjudicator of a Ph.D. thesis submitted to Sidho-Kanho-Birsha University, Purulia, West Bengal, India.
- Dr. M. Raychaudhuri, Principal Scientist has been nominated as an external expert in Viva-Voce examination of Ph.D. Thesis on Agricultural Chemistry and Soil Science, Post-Graduate Studies, BCKV, Nadia, West Bengal on August 14, 2020.

- Dr. P.P. Adhikary, Senior Scientist has been nominated as adjudicator of a Ph.D. thesis submitted to Academy of Scientific and Innovative Research (AcSIR), CSIR-IMMT, Bhubaneswar during December, 2020.

- Dr. P.K. Panda, Principal Scientist acted as external examiner and conducted thesis viva of students of Department of Agronomy, OUAT, Bhubaneswar.

- Dr. S.K. Jena, Principal Scientist has been nominated as member of the assessment committee for promotion of Technical personnel of ICAR-National Rice Research Institute, Cuttack.

- Dr. S.K. Rautaray, Principal Scientist has been invited for the panel discussion in the Technical session IV - Case studies on conservation of biodiversity in Odisha Environment Congress 2020 (11th Edition) held during December 20-22, 2020.

- Dr. P.K. Panda, Principal Scientist has been invited for the panel discussion on Research, Policy and Action Plan for Alternatives to Plastics in the National Webinar on 'Alternative to Plastics for Sustainable Soil and Environmental Health' organized by ICAR-IISS, Bhopal on December 30, 2020.

- Dr. S.K. Rautaray, Principal Scientist has been invited as resource person for the training program on 'Irrigation Management & Income Augmentation Farming in Command Areas' organized by WALMI, Odisha for the officers from Agriculture and Farmers' Empowerment Department and Water Resources Department, Govt. of Odisha.

Doordarshan / Radio Talk

- Dr. P.K. Panda participated as an expert in the panel discussion on '*Pradhana Mantrinka carona jana andolana ebam janasadharananka sahabhagita'* (PM's corona jana andolan and people's participation) on December 26, 2020 on Doordarshan.

- Dr. P.K. Panda, Principal Scientist participated as an expert in 'Live phone in' program on '*Adinia Barsaru Fasalaku Surakhya Kariba Kipari'* (How to save crops from untimely rain) at All India Radio, Cuttack on January 4, 2020.

- Dr. P.K. Panda, Principal Scientist delivered a radio talk on '*Agami Sankata: Tusarta Bharat'* (Future Challenge: Thirsty India) at All India Radio, Cuttack on March 19, 2020.

- Dr. P.K. Panda, Principal Scientist participated as an expert in the discussion on 'Agro-advisory services for the farmers in the context of spread of Covid-19 for improving village economy' at All India Radio, Cuttack on April 19, 2020.

- Dr. P.K. Panda, Principal Scientist participated as an expert in the discussion on 'Agro-advisory services for the farmers in the context of spread of Covid-19'at All India Radio, Bhawanipatna, Kalahandi, Odisha on April 21, 2020.

- Dr. P.K. Panda, Principal Scientist, participated as an expert in program on '*Jalasurakhyara abasyakata'* (Need of water conservation) at All India Radio, Cuttack on September 8, 2020.

- Dr. P.K. Panda, Principal Scientist, participated as an expert in program on '*Agua rabi fasalare jala parichalana'* (Water management in early *rabi* crops) at All India Radio, Cuttack on September 28, 2020.

- Dr. P.K. Panda, Principal Scientist, participated as an expert in program on '*Krusaka sabuthu bada karona jodhha'* (Farmers are greatest corona warriors) at All India Radio, Cuttack on October 4, 2020.

- Dr. P.K. Panda, Principal Scientist, participated as an expert in program on ''*COVID talabandi hatiba pare krushaka manaka pain satarka suchana*' (Guidelines for the farmers during COVID unlock) at All India Radio, Bhawanipatna on October 9, 2020.

- Dr. P.K. Panda, Principal Scientist, participated as an expert in program on '*Corona pain pradhan mantrinka jana andolana'* at All India Radio, Cuttack on November 15, 2020.

- Dr. P.K. Panda, Principal Scientist, participated as an expert in program on '*Corona sahasangram'* (*Jan Andolan* of PM for COVID) at All India Radio, Cuttack on December 26, 2020.

Research Management Meetings

Research Advisory Committee (RAC) Meetings

Members Eighth RAC of ICAR-IIWM, Bhubaneswar

1	Dr. P.K. Sharma, Former Vice Chancellor, Sher-e-Kashmir University of Agricultural Science & Technology of Jammu, Jammu	Chairman
2	Dr. R. Singh, Professor, Dept. of Agricultural & Food Engineering, IIT, Kharagpur	Member
3	Dr. B.J. Pandian, Former Director, Water Technology Center, TNAU, Coimbatore	Member
4	Dr. G.G.S.N. Rao, Former Project Coordinator, ICAR – AICRP on Agro-Meteorology, ICAR-CRIDA, Hyderabad	Member
5	Dr. A.K. Sarkar, Ex-Dean, Birsa Agricultural University, Ranchi	Member
6	Dr. Adlul Islam, Asst. Director General (S&WM), ICAR, New Delhi	Member
7	Dr. A. Mishra, Director, ICAR-IIWM, Bhubaneswar	Member
8	Dr. R.K. Panda, Principal Scientist, ICAR-IIWM, Bhubaneswar	Member-Secretary

The second meeting of 8th Research Advisory Committee (RAC) of ICAR-IIWM, Bhubaneswar was organized on September 8, 2020 through virtual mode. Dr. P.K. Sharma, Former VC, Sher-e-Kashmir University of Agricultural Science & Technology of Jammu and the Chairman of the Committee presided over the meeting. Among other members of the Committee, Dr. B. J. Pandian, Former Director, Water Technology Center, TNAU, Tamil Nadu; Dr. A.K. Sarkar, Ex-Dean, Birsa Agriculture University, Ranchi; Dr. G.G.S. N. Rao, Ex-Project Coordinator, ICAR-AICRP on Agro-Meteorology, ICAR-CRIDA, Hyderabad; and Dr. Adlul Islam, ADG (S&WM), NRM, ICAR, New Delhi attended the meeting. During the meeting the Annual Report of the Institute for 2019 was released by the Chairman. Dr. R.K. Panda, Principal Scientist and Member-Secretary, RAC presented the Action taken report (ATR). Dr. A. Mishra, Director of the institute presented an activities of the institute and Program Leaders presented their significant research findings during the last year, which were appreciated by the Committee. Chairman and members of RAC emphasized to use time tested efficient water management technologies for the benefits of farmers. They also mentioned that as we received sufficient monsoon water, thereby, we must reap bumper crop production while using scientific agricultural water management for greater productivity. They emphasized for more research on use of micro-irrigation for cash crops, addressing problematic soils, robust agro-advisory service, and priority on use of ICT / DSS / automation. At the end of the meeting, Chairman and members expected to achieve the mandate of the institute, and hoped for continuance of farmer-oriented inter-institutional collaborative water management research activities by the institute.

Recommendations:

1. A status report on canal automation may be prepared and collaborative research project on "Canal Automation" may be taken up.

2. Before commercialization and large scale field application of the mini pan-evaporimeter being developed by the institute, comments on its design and accuracy may be obtained from Instruments Division of IMD, Pune.

3. Information on the ITKs on water management available across the states covering sectors of agriculture, viz. crop production, horticulture, animal husbandry, fisheries and their combinations may be compiled, which would help to refine/develop water management technologies.

4. Recommendations/Guidelines/Status reports/Policy papers may be prepared/compiled on the following issues:

    - Free water and power supply to farmers
    - Management of Coastal waterlogged areas and flood affected areas (Bihar, Assam, Odisha, West Bengal, etc.).
    - State water management plans, guidelines for irrigation practices based on ground reality, ground water recharge, waste water management etc.

5. Success stories in local languages and case studies from farmer's field should be documented.

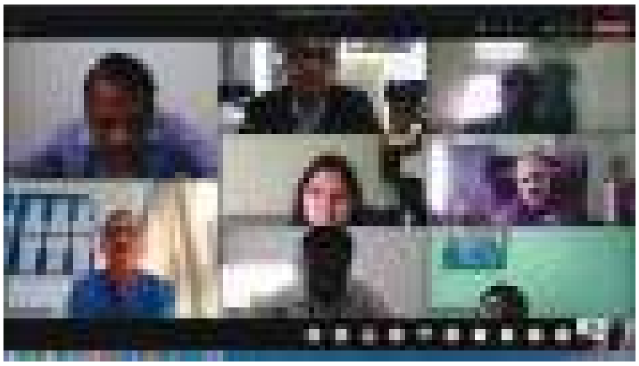
6. Young scientists with engineering/soil physics background may be trained in application of advanced technologies like simulation modeling, RS and GIS to cater the researchable issues on current water management problems of different agro-systems.

Institute Research Council (IRC) Meeting

Institute's Research Council (IRC) meeting was organized during March 3-4, 2020 at ICAR-IIWM under the Chairmanship of Dr. A. Mishra, Director of the institute. Six new project proposals were presented initially. Thereafter, progress and achievements of the fourteen externally-funded projects were presented and deliberated in the meeting. The progress of two ongoing and one completed institute projects were also presented and discussed. The Chairman, IRC concluded with positive remarks and encouraged scientists to continue good work, timely reporting and systematic record keeping. He also emphasized to take research projects at our institute farm and experiments should be always kept in the presentable form to the visitors.

The first meeting of the Institute Research Council for the year 2020-21 was held during June 2-4, 2020 with the welcome address by Dr. S.K. Jena, Principal Scientist & Member Secretary, IRC. The program was conducted through video conferencing. The inaugural session was graced by Dr. S.K. Chaudhari, DDG (NRM) and Dr. Adlul Islam, ADG (S&WM), and chaired by Dr. Atmaram Mishra, Director, ICAR-IIWM & Chairman, IRC. DDG (NRM) emphasized to have state specific water management plan for the country. Ten new project proposals were presented and discussed in IRC meeting, out of which, two were pan-India level, two were basin level, two were state level and four were field level studies. The progress, achievements and recommendation from five concluding projects and nine ongoing projects were also discussed. The Director and Chairman, IRC in his concluding remark emphasized for good research publication, efforts for getting externally-funded project and development of institute museum.

The 2nd meeting of the IRC for the year 2020-21 was held during December 15-16 and 21, 2020 with the welcome address by Dr. S.K. Jena, Principal Scientist & Member Secretary, IRC. Thereafter, Dr. Atmaram Mishra, Director, ICAR-IIWM & Chairman, IRC delivered introductory remarks. There was presentation of 10 new project proposals during December 15-16, 2020. The progress of two ongoing institute projects were also presented. Results of 14 number of externally funded projects were presented on December 21, 2020. Chairman, IRC made the concluding remarks with encouraging notes to continue good research work, timely reporting and systematic record keeping. He also emphasized for the improvement of IIWM research farm at Deras, Mendhasal and main campus.



Virtual Biennial Scientists Meet of AICRP-IWM

A virtual biennial scientists' meet of AICRP on Irrigation Water Management was organized at ICAR-IIWM during June 24-26, 2020 through video conferencing. Hon'ble DG, ICAR and Secretary, DARE, Dr. Trilochan Mohapatra graced inaugural session of the meet as Chief-Guest and addressed the delegates. Dr. Mohapatra suggested researchable issues on various aspects of water management and stressed the need to focus on 'more crop per drop'. Dr. S.K. Chaudhari, DDG (NRM) graced the occasion as Guest-of-Honor and addressed the delegates. Dr. Atmaram Mishra, Director, ICAR-IIWM welcomed the dignitaries and briefed about the history of AICRP on IWM and its present themes of research. Dr. P. Nanda, Principal Scientist introduced about the activities of the AICRP on IWM. The Chief Scientists of the 26 AICRP centers presented the achievements during 2019-20 in six technical sessions and new research proposals were discussed. To improve the research proposals and outputs, six prominent expert members in the field of irrigation water management *viz*., Dr. P.K. Sharma, Former VC, SKUST, Jammu; Dr. P.S. Minhas, Former Director, ICAR-NIASM, Baramati; Dr. D.K. Sharma, Former Director, ICAR-CSSRI, Karnal; Dr. S.K. Gupta, Former Head, ICAR-CSSRI, Karnal; Dr. R.B. Singhandhupe, Former Head, ICAR-CICR, Nagpur; and Dr. S.D. Gorantiwar, Prof. and Head, MPKV, Rahuri were invited to the biennial meet. Each one of them chaired a technical session and gave their technical inputs and suggestions. Dr. S.K. Chaudhari, DDG (NRM), the Chief-Guest of plenary session addressed the delegates and emphasized on digitization of the old reports, development of state-specific water management plan, need for opening of new centres, development of regional-scale studies and recasting of the present research themes. Dr. S. Bhaskar and Dr. Adlul Islam ADGs, NRM Division, ICAR, New Delhi also graced the occasion as Guests of Honour. Dr. Atmaram Mishra, Director, ICAR-IIWM delivered the concluding remarks. Dr. P. Nanda and Dr. S. Mohanty, Principal Scientists, ICAR-IIWM organized this meet.

Virtual Review Meeting by DDG (NRM), ICAR

Dr. S.K. Chaudhari, Hon'ble Deputy Director General (Natural Resource Management), ICAR reviewed the progress of Standing Finance Committee (SFC) document with regard to research achievements (2017-2020) and future research plan for the plan period (2020-2025) of ICAR-IIWM, the research achievements and future research plans of AICRP on IWM and CRP on water during May 9-11, 2020. Directors of NRM institutes, Dr. S. Bhaskar, ADG (AAF&CC), Dr. Adlul Islam, ADG (S&WM), Heads and scientists from various institutes participated in the meeting. Dr. Atmaram Mishra, Director, ICAR-IIWM presented the research achievements and future research plan of the institute. Dr. Chaudhari appreciated the efforts of ICAR-IIWM and suggested to develop field scale water management solutions for the nation, use of ICT/artificial intelligence in agricultural water management including canal automation, development of state specific water management plans and policy papers on energy saving and groundwater-energy nexus. He also suggested to study water management strategies for Bundelkhand region, rejuvenation of defunct bore wells, groundwater modelling under AICRP on IWM and impact analysis of rubber dams installed through CRP on Water.

Agri-Consortia Research Platform on Water Project Meeting

ICAR-IIWM organized two days concept note presentation meeting for Agri-CRP on Water for the period 2021-2026 on December 1-2, 2020. On first day, some of the ICAR, SAU, and other institutes, who were partners during the first phase of Agri-CRP on Water (2015-21) presented their concept notes. On December 2, 2020, some of the ICAR, SAU, and other institutes, presented their new concept notes. Dr. S.K. Jena, Principal Scientist coordinated this meeting.

Training and Capacity Building

Training and Capacity Building of ICAR Employees

Official & Designation	Subject	Organization	Period
Mrs. Ankhila R. Handral, Scientist Mr. Biswaranjan Behera, Scientist	110th FOCARS foundation training	ICAR-NAARM, Hyderabad	January 7- March 20, 2020
Mrs. Ankhila R. Handral, Scientist Mr. Biswaranjan Behera, Scientist	Orientation Training Program	ICAR-IIWM, Bhubaneswar	April 5-May 4, 2020
Mrs. Ankhila R. Handral, Scientist	Professional Attachment Training	ICAR-IIHR, Bangalore	May 5-August 4, 2020
Mr. Biswaranjan Behera, Scientist	Professional Attachment Training	ICAR-NRRI, Cuttack	May 5-August 4, 2020
Dr. A.K. Nayak, Principal Scientist Dr. S. Pradhan, Scientist	E-Office - Online training	ICAR – IASRI, New Delhi	June 17, 2020
Mr. Ajit K. Nayak, Scientist	Introduction to Machine Learning using Python	NIT, Jalandhar	July 11-20, 2020
Dr. R.K. Panda, Principal Scientist Dr. Dibakar Ghosh, Scientist	Training Programme on Agriculture 4.0: Precision & Automated Agricultural Technologies	CAAST-CSAWM, MPKV, Rahuri	September 28-October 2, 2020
Dr. A.K. Nayak, Principal Scientist	Generic Online Training in Cyber Security	Ministry of Electronics and Information Technology, Govt. of India	December 16, 2020

Webinar / Programs / Virtual Meetings Attended by Employees

Officials	Name of the Conference / Meeting / Workshop / Symposium / Seminar	Organized by	Period
Dr. P.S. Brahmanand	Training Program on 'Tuber crops and Allied Agricultural Technologies for Livelihood and Nutritional Security' (Invited Talk)	Regional Centre of ICAR-CTCRI, Bhubaneswar	January 7, 2020

Officials	Name of the Conference / Meeting / Workshop / Symposium / Seminar	Organized by	Period
Dr. S.K. Jena	54th Annual Convention of ISAE and International symposium on 'Artificial Intelligence Based Future Technologies in Agriculture'	ISAE, Pune and MKPV, Rahuri	January 7- 9, 2020
All Scientists of ICAR-IIWM	Institute Seminar on 'Cleaning of Urban Waste Water- Nanobubbles based Aeration'	ICAR-IIWM, Bhubaneswar	January 11, 2020
Dr. P.K. Panda	National Seminar on 'Climate Smart Agriculture for Enhancing Farm Profitability'	OUAT, Bhubaneswar	January 28-29, 2020
Dr. P.S. Brahmanand	Divisional Review Meeting of Foreign-aided Projects	NRM Division, ICAR, New Delhi	January 29, 2020
Dr. A. Mishra	Expenditure Review Meeting	ICAR, New Delhi	February 5, 2020
Dr. P.S. Brahmanand	International Convention on 'Perspectives to Face Contemporary Challenges of Agricultural Development' (Invited Talk)	Bharatiya Kisan Sangh and ICAR at National Agricultural Science Complex (NASC), New Delhi.	February 19, 2020
Dr. O.P. Verma Mr. K.K. Sharma	*Nagar Rajbhasha karyanvayan samiti, Bhubaneswar ki 64 vi ardhvarshik baithak*	O/O The Principal Accounts General (A&E)	February 21, 2020
Dr. P. K. Panda Dr. P.P. Adhikary Dr. O.P. Verma	National Conclave on 'Science and Technology Interventions for the Welfare of Tribal Populations'	Institute of Life Sciences, Bhubaneswar	February 24-25, 2020
Dr. R.R. Sethi	Roorkee Water Conclave (RWC) 2020	IIT, Roorkee and NIH, Roorkee	February 26-28, 2020
Dr. S.K. Jena	29th Swadeshi Science Congress and National Conference on 'Science and Technology for Sustainable Development'	ICAR-CPCRI, Kasaragod, Kerala	February 27-29, 2020
Dr. S.K. Jena	National seminar on 'Sustainable Agriculture'	ICAR-NIAP, New Delhi	March 6, 2020
Dr. A. Mishra	ICAR-CWC Joint Panel Meeting	NASC Complex, ICAR, New Delhi	March 13, 2020
Dr. R.K. Panda	Webinar on 'Enhancing Outreach of Research for Empowering Farmers'	ICAR, New Delhi	April 27, 2020
Dr. R.K. Panda	Virtual CGIAR Meeting	ICAR, New Delhi	May 4, 2020
Dr. A. Mishra	CG Review Meeting	ICAR, New Delhi	May 4, 2020
Dr. M. Das	HRM Workshop on 'Training Management Information System (TMIS)' for HRD Nodal officers in Virtual Mode	HRM unit of ICAR, New Delhi	May 8, 2020
Dr. A. Mishra	Institute Progress Review Meeting	NRM Division, ICAR, New Delhi	May 9-11, 2020

Officials	Name of the Conference / Meeting / Workshop / Symposium / Seminar	Organized by	Period
Dr. R.K. Panda	Review Meeting of ICAR-NIASM, Baramati (Maharashtra)	ICAR, New Delhi	May 23, 2020
Dr. K.G. Mandal	Video-Conferencing Meeting on Precision Farming	ADG (ICT), ICAR, New Delhi and IARI, New Delhi	June 1, 2020
Dr. P.S. Brahmanand	2nd Meeting (Through Video link) of Core-Committee on Preparation of Policy Document on Futuristic Crop Planning for 2030/2050	ICAR-IIFSR, Modipuram	June 10, 2020
Dr. S.K. Rautaray	State-level Executive Committee Meeting for Rainfed Area Development (RAD) under NMSA (National Mission on Sustainable Agriculture)	Department of Agriculture and Farmer Empowerment, Odisha	June 10, 2020
Dr. K.G. Mandal	Video-Conferencing Meeting on Precision Farming	ADG (ICT), ICAR, New Delhi and IARI, New Delhi	June 12, 2020
Dr. A. Mishra Dr. K.G. Mandal Dr. A.K. Thakur Dr. O.P. Verma Dr. S. Pradhan Mr. P. Deb Roy	Biochar: Potential Availability, Usefulness and Limitations - National Webinar	ICAR – IISS, Bhopal	June 19, 2020
Dr. S.K. Rautaray	61st Technical Annual Session of The Institution of Engineers (India)	Institution of Engineers (India), Bhubaneswar	June 23, 2020
Dr. K.G. Mandal	Video-Conferencing Meeting on Precision Farming	ADG (ICT), ICAR, New Delhi and IARI, New Delhi	June 27, 2020
Dr. A. Mishra	NAABARD ICAR Workshop	ICAR, New Delhi	July 6, 2020
Dr. P.S. Brahmanand	Divisional Review Meeting of Foreign-aided Projects	NRM Division, ICAR, New Delhi at ICAR-CSSRI, Karnal	July 13, 2020
All Scientists of ICAR-IIWM	92nd Foundation Day and Award Ceremony of the ICAR through Video- Conferencing	ICAR, New Delhi	July 16, 2020
Dr. K.G. Mandal	Web-Lecture on 'Soil Science in Sustainable Food Systems Beyond COVID-19'	ICAR-IISS, Bhopal, NAAS Bhopal Chapter and ISSS Bhopal Chapter	July 21, 2020
Dr. K.G. Mandal Dr. P.P. Adhikary Mr. P. Deb Roy	Achieving Land Degradation Neutrality- International Webinar	ICAR-IASWC, Dehradun	July 22-24, 2020
Dr. A. Mishra	Meeting on World Bank Funded Reward Project	OUAT, Bhubaneswar	August 6, 2020
Dr. K.G. Mandal Dr. P.K. Panda Dr. A.K. Thakur	National Webinar on 'Underutilized Crops for Augmenting Farmer's Income in Abiotic Stress Regions'	Society for Abiotic Stress Research in Agricultural Sciences (SARAS) and ICAR-NIASM, Baramati	August 10, 2020

Officials	Name of the Conference / Meeting / Workshop / Symposium / Seminar	Organized by	Period
Dr. R.R. Sethi	National Web-Conference on 'Technological Approaches for Resource Conservation and Management for Environmental Sustainability'	Academy of Natural Resource Conservation and Management (ANRCM), Lucknow	August 16-17, 2020
Dr. S.K. Rautaray	Towards Self-reliance in Coastal Agriculture: Challenges and Way Forward	Indian Society of Coastal Agricultural Research, Canning Town	August 22, 2020
Dr. S.K. Jena	Online review meeting of DST Network Project on Revival of Village Ponds through Scientific Interventions	Director, NRDMS, DST, Govt. of India, New Delhi	August 27, 2020
All Scientist of ICAR-IIWM	Inauguration of Academic and Administrative Building of Rani Lakshmi Bai Central Agricultural University, Jhansi by Hon'ble Prime Minister of India	ICAR, New Delhi & Rani Lakshmi Bai CAU, Jhansi	August 29, 2020
Dr. K.G. Mandal	Video-Conferencing Meeting on Precision Farming	ADG (ICT), ICAR, New Delhi and IARI, New Delhi	September 7, 2020
Dr. R. K. Panda	Online 7th Dr. B. P. Ghildyal Memorial Lecture on 'Transforming Indian Agriculture in New Normals'	Indian Society of Agrophysics and Division of Agricultural Physics, ICAR-IARI, New Delhi	September 10, 2020
All Scientist of ICAR-IIWM	Inauguration of School of Agri-Business and Rural Development of Dr. RPCAU, Pusa, Bihar by Hon'ble Prime Minister of India	ICAR, New Delhi & Dr. RPCAU, Pusa, Bihar	September 10, 2020
Dr. H.K. Dash	Intellectual Property Rights in Agricultural Research and Education in India	NAHEP and IP&TM unit of ICAR Headquarters	September 12-28, 2020
Dr. P. K. Panda	Webinar on Farm Bills 2020 : Understanding the implications	ICAR- IARI, New Delhi	September 26, 2020
Dr. K.G. Mandal Dr. A.K. Thakur	Webinar on *Vaishwik Bhartiya Vaigyanik* (VAIBHAV) Summit- a Global Virtual Summit of Overseas Indian Researchers and Academicians	NITI Aayog, Govt. of India, New Delhi	October 2-5, 2020
Dr. K.G. Mandal	International Webinar on 'A New Measure: The Reform of the International System of Units'	The NASI Delhi Chapter & MHRD Institution Innovation Council (IIC), University of Delhi under the aegis of DBT Star College Program	October 6, 2020
Dr. A. Mishra	Regional Committee II Meeting	ICAR, New Delhi	October 8, 2020
Dr. R. K. Panda	CII Webinar on 'Evaluation of Science Indicators of Public Funded R&D Institutions'	Office of the Principal Scientific Adviser to the Government of India	October 14, 2020

Officials	Name of the Conference / Meeting / Workshop / Symposium / Seminar	Organized by	Period
All Scientists of ICAR-IIWM	World Food Day program through Virtual Mode & Digital Release of Commemorative Coin on the Occasion of 75 Years of FAO	ICAR, New Delhi	October 16, 2020
Dr. S.K. Jena	National Webinar on 'Hydro-informatics for Smart Water Management in Agriculture'	DRPCAU, Pusa in collaboration with NIH, Roorkee; IIT, Roorkee and DAE, IARI, New Delhi	October 20, 2020
Dr. P.P. Adhikary	National Webinar on 'Quality Improvement and Proficiency Testing of Soil Laboratories in India – Towards Improving the Quality of Analytical Data and Harmonization of Soil Test Methods'	ICAR – IISS, Bhopal	October 31, 2020
Dr. R. K. Panda	Discussion on 'Planning for Water Harvesting in North Bengal and NE region	Uttar Banga Krishi Viswavidyalaya, West Bengal	November 6, 2020
Dr. R. K. Panda	19th Water Talk on 'Conserving Ecology & Biodiversity and Securing Livelihoods through Rainwater Harvesting' (Online)	National Water Mission, Ministry Resources, RD & GR, GoI	November 20, 2020
Dr. H.K. Dash	Virtual Workshop cum Annual Review Meeting of ZTMCc/ITMUs/ABIs under ICAR institutes of NRM, Education and Engineering Divisions under NAIF	IP&TM unit of ICAR	November 23-24, 2020
Dr. A. Mishra	Regional Committee IV Meeting	ICAR, New Delhi	November 27, 2020
Dr. H.K. Dash	Intellectual Property Management in Agriculture	ICAR-IIAB, Ranchi	November 28, 2020
All Scientists of ICAR-IIWM	Online World Soil Day-2020 Meeting	Soil Conservation Society of India, New Delhi & International Soil Conservation Organization, New Delhi	December 5, 2020
Dr. A. Mishra	Regional Committee V Meeting	ICAR, New Delhi	December 7, 2020
Dr. S.K. Rautaray	Environment and Biodiversity	Odisha Environment Congress 2020 (11th Edition)	December 20-22, 2020
All Scientists of ICAR-IIWM	*Pradhan Mantri Kisan Samman Nidhi* (PM-KISAN) programme	PMO, Government of India	December 25, 2020
Dr. P. K. Panda	National Web Conference on 'Sustainable Soil and Water Management for Biodiversity Conservation, Food Security & Climate Resilience'	Soil Conservation Society of India, New Delhi	December 29-30, 2020
Dr. R.K. Panda Dr. P.K. Panda Dr. P.P. Adhikary	National Webinar on 'Alternatives to Plastics for Sustainable Environmental Health'	ICAR-IISS, Bhopal	December 30, 2020

Trainings/Program Organized & Exhibitions Participated

Training / Program organized by ICAR-IIWM

Subject	Place	Period
Virtual Review Meeting with DDG, NRM, ICAR for Evaluation of Progress of ICAR-IIWM, Bhubaneswar	ICAR-IIWM, Bhubaneswar	May 9, 2020
Virtual Review Meeting with DDG, NRM, ICAR for Evaluation of Progress of Agri-CRP on Water and AICRP on Irrigation Water Management	ICAR-IIWM, Bhubaneswar	May 11, 2020
Virtual Biennial Scientists Meet of AICRP-IWM	ICAR-IIWM, Bhubaneswar	June 24-26, 2020
Webinar on "Rubber Dam"	ICAR-IIWM, Bhubaneswar	July 29, 2020
Agri-Consortia Research Platform on Water Project Virtual Meeting	ICAR-IIWM, Bhubaneswar	December 1-2, 2020

Farmers' / Officers Training Programs Organized by ICAR-IIWM

Subject	Place	Period	Participants
Farmers' Awareness Campaign	Srimakundpur village, Puri	January 4, 2020	35
Training on 'Doubling Farm Income by Rainwater Harvesting, Land Shaping and Use of Micro-irrigation (Drip and Sprinkler)' for Farmers	Kutiguda village, Nabarangapur	January 7, 2020	200
Training on 'Doubling Farm Income by Rainwater Harvesting, Land Shaping and Use of Micro-irrigation (Drip and Sprinkler)' for Officers	Nabarangapur	January 9, 2020	100
Farmers-Scientists Interaction Meet	Deras Research farm, Khordha	March 8, 2020	57
Workshop-cum-Farmers' Training on 'Revival of Village Ponds Through Scientific Interventions'	Kapileswarpur, Puri	March 11, 2020	78
Training program on 'Enhancing Water Use Efficiency in Canal Commands'	Bhakarsahi village, Khordha	March 12-14, 2020	74
Training Program on 'Scientific Water Management for Enhancing Water Use Efficiency and Farmers' Income'	Dangariguda village, Kalahandi	March 13-14, 2020	30
Farmers-Scientists Interaction Meet	Alisha, Puri district, Odisha	December 22, 2020	139

Exhibitions

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

Events	Place	Date / Period
National Workshop on 'Rice Research and Development: Doubling Farmers Income'	ICAR-NRRI, Cuttack	February 28, 2020
Farmers' Fair	OUAT, Bhubaneswar	March 7, 2020






Trainings/Programmes and Exhibitions organised by ICAR-IIWM

Women Empowerment

Women Empowerment

International Women's Day Celebrated

ICAR-IIWM celebrated International Women's Day by organizing a farmers-scientists interaction meet at research farm, Deras on March 8, 2020. Theme of this meet was 'Importance of Women in the Field of Agricultural Water Management'. During interaction, women education, involvement of farm women in agricultural activities, water conservation methods, soil management options, horticultural activities, animal husbandry and possibilities of woman empowerment through agricultural entrepreneurship, and government schemes for self-help groups (SHGs) were discussed. The meeting was attended by 57 farm women from Haridamada, Chatabara, Jamujhari villages of Khurda district of Odisha. Dr. P.K. Panda, Dr. R.R. Sethi, Dr. D. Sethi, Mrs. Prativa Sahoo and Mr. Partha Deb Roy organized the event.

Interaction with farm women during International Women's Day

Celebration of *Mahila Kisan Divas*

ICAR-IIWM celebrated '*Mahila Kisan Divas'* on October 15, 2020 and organized a *Mahila Kisan Gosthi* at Hansapada village, Nimapada block, Puri with the theme 'Empowerment of Women for Doubling Farm Income'. Nearly thirty seven women farmers participated this program by following the prescribed COVID norms. Dr. H.K. Dash, Dr. D. Sethi, Dr. S. Pradhan and Mr. B. Behera of the institute organised the program.

ICAR-IIWM Observed '*Mahila Kisan Diwas*' on October 15, 2020

Major Events 2020

Major Events 2020

Republic Day Celebration at ICAR-IIWM on January 26, 2020

Visit of Additional Secretary (DARE) & Secretary, ICAR at ICAR-IIWM on February 20 – 21, 2020

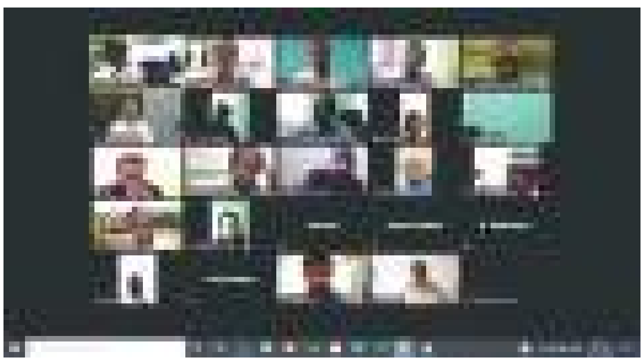
ICAR-IIWM Celebrated 'International Women's Day' on March 8, 2020

ICAR-IIWM Organized Farmer’s Training Program on March 11, 2020

ICAR-IIWM Organized Webinar on Rubber Dam on July 19, 2020

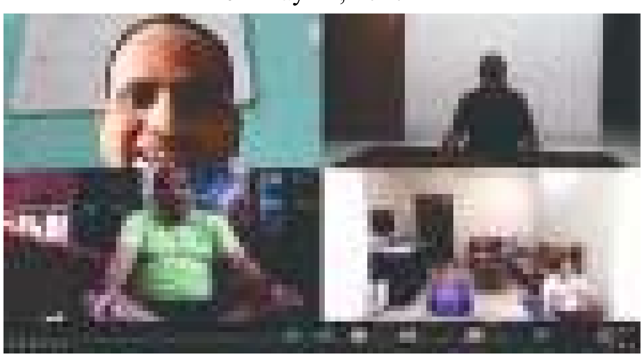
ICAR-IIWM Staff Distributed Food Packets on May 1, 2020

Independence Day Celebration at ICAR-IIWM on August 15, 2020



ICAR-IIWM Celebrated Foundation Day Virtually on May 12, 2020

ICAR-IIWM Celebrated *Hindi Pakhwada* during September 14-28, 2020



Celebration of International Day of Yoga June 21, 2020 in virtual mode

Celebration of 150^{th} birthday of the ‘Father of Nation’ Mahatma Gandhi during September 26 – October 2, 2020

Celebration of *Mahila Kisan Divas* on October 15, 2020

ICAR-IIWM Celebrated Constitution Day on November 26, 2020

ICAR-IIWM Observed Vigilance Awareness Week-2020

ICAR-IIWM Observed Farmer-Scientist Interactions Meet on December 22, 2020

PM Kisan Samman Nidhi Yojna Program Celebrated on December 23, 2020

Swachha Bharat Abhiyan

The Director and staff of ICAR-IIWM actively participated in the *Sharmdan*, sanitation drive and *swachhata* awareness programs under *Swachh Bharat Abhiyan*. Several cleanliness drive and *swachhta* awareness programs were conducted in the institute's main campus, research farm, guest house area, Sailashree Vihar area, Maitree Vihar area, schools and SCSP villages. Five sanitation drives against COVID-19 were organized inside the institute main building, Mendasal research farm and also in residential quarters. Scientists of the institute make them aware about domestic wastes and their management in daily life, ill effect of *Parthenium* weed, single used polythene. Jute bags were distributed to the participants to motivate them to curb use of polythene bags. Government e-Market (GeM) and ICAR-ERP has been fully implemented at the institute during this period. Beautification, landscaping and pruning old tress and mowing the lawn were done in the institute main campus. The Director, ICAR-IIWM administered *Swachhta Sapath* to all the staff of the institute during the celebration of *Swachhta Hi Sewa* (September 11 to October 02, 2020) and *Swachhta Pakhwada* (December 16-31, 2020). During *Swachhta pakhwada*, several cleaning and sanitation drive were organized at main campus, research farm, residential area of staff, MGMG & SCSP villages. *Swachhta* drive was organised at Bindhapada village of Tirtol block, Jagatsinghpur. Siam weed (*Chromolaena odorata* L.) was cleaned from the front foot path of the Institute's main entrance. The swachhta campaigning was also organized at Shantali basti of Nalco Nagar, Bhubaneswar where around 20 households participated. Training on preparation of compost from household wastages and their use for kitchen garden was organized. A virtual talk on 'Importance of *Swachh Bharat Mission* (SBM) in ensuring human health' delivered by Mr. Anubhav Patnaik, Advisor, Electronics and Information Technology Department, Govt. of Odisha. On the closing day of *Swachhta Pakhwada*, Dr. P.K. Mishra, Former Director, ICAR-IISWC, Dehradun graced the occasion as Chief Guest in presence of Dr. Atmaram Mishra, Director, ICAR-IIWM, Bhubaneswar. ICAR-IIWM, Bhubaneswar was awarded with Public Appreciation Plaque from Pipili Sankrutika Parishad, Pipili, Puri, Odisha for sincere and exemplary execution of *Swachha Bharat Mission* in the institute campus, public places and adopted villages during 2014-19 and this was received from Hon'ble Governor of Odisha Prof. Ganeshi Lal during January 2020. Mr. N. Manikandan and Dr. Roomesh K. Jena, Scientists of the institute with the help of Dr. S.K. Karna, Mr. K.K. Sharma and Mr. B.N. Nayak coordinated all activities.

A brief account on *Swachha Bharat Abhiyan* at ICAR-IIWM (January-December, 2020)

S. No.	Nature of Activities	Number of Events	Number of Hours
1	Digitization of Office Records/ e-office	04	04
2	Basic Maintenance	12	24
3	Sanitation and SWM	16	16
4	Cleaning and Beautification of Surrounding Areas	04	08
5	Vermi-composting / Composting of Bio-degradable Waste Management & Other Activities on Generate of Wealth for Waste	03	03
6	*Swachhta* Awareness at Local Level	15	15
7	*Swachhta* Workshops	01	01
8	*Swachhta* Pledge	03	01
09	Display and Banner	16	-
10	Involvement of Print and Electronic Media	05	-
11	Involving and with the Help of the Farmers, Farmwomen and Village Youth in Their Adopted Villages (No. of Adopted Villages)	03	06
	Total Number of Staff Involved in the Activities	**1143 (Combined Number on All Basic Cleanliness Activities (82) with an Average of 13.9 Persons per Activity)**	

Activities in *Swachha Bharat Abhiyan* organized by ICAR-IIWM, Bhubaneswar during 2020

Personnel

As on 31.12.2020

Dr. Atmaram Mishra
Director (Acting)

SCIENTIFIC

Dr. M. Das	Principal Scientist (Soil Physics)
***Dr. S. Roy Chowdhury**	Principal Scientist (Plant Physiology)
Dr. P. Nanda	Principal Scientist (Agricultural Economics)
Dr. R.K. Panda	Principal Scientist (S&WC Engg.)
Dr. S.K. Rautaray	Principal Scientist (Agronomy)
Dr. S.K. Jena	Principal Scientist (S&WC Engg.)
Dr. M. Raychaudhuri	Principal Scientist (Soil Fert./Che./Microbio.)
Dr. S. Raychaudhuri	Principal Scientist (Soil Fert./Che./Microbio.)
Dr. R.K. Mohanty	Principal Scientist (Aquaculture)
Dr. M. K. Sinha	Principal Scientist (Agricultural Economics)
Dr. K.G. Mandal	Principal Scientist (Agronomy)
Dr. H.K. Dash	Principal Scientist (Agricultural Economics)
Dr. P.K. Panda	Principal Scientist (Agronomy)
Dr. A.K. Thakur	Principal Scientist (Plant Physiology)
Dr. P.S. Brahmanand	Principal Scientist (Agronomy)
Dr. S. Mohanty	Principal Scientist (S&WC Engg.)
Dr. D.K. Panda	Principal Scientist (Agricultural Statistics)
Dr. Ranu Rani Sethi	Principal Scientist (S&WC Engg.)
Dr. Ashok K. Nayak	Principal Scientist (Computer Applications)
Dr. P. Panigrahi	Principal Scientist (S&WC Engg.)
Dr. P.P. Adhikary	Senior Scientist (Soil Physics and S&WC)
Dr. O.P. Verma	Scientist (Agronomy)
Dr. Sanatan Pradhan	Senior Scientist (Soil Physics and S&WC)
Dr. Debabrata Sethi	Scientist (Veterinary Extension)
Dr. Dibakar Ghosh	Scientist (Agronomy)
Dr. Roomesh K. Jena	Scientist (Soil Science)
Mr. Ajit K. Nayak	Scientist (Land and Water Management Engg.)
Mrs. Prativa Sahu	Scientist (Fruit Science)
Mr. Partha Deb Roy	Scientist (Soil Science)
Mrs. Ankhila R. Handral	Scientist (Agricultural Economics)
Mr. Biswaranjan Behera	Scientist (Agronomy)

TECHNICAL

Mrs. Sunanda Naik	Asst. Chief Technical Officer
Mr. Chhote Lal	Senior Technical Officer
Mr. R.C. Jena	Technical Officer
Mr. P.C. Singh Tiyu	Technical Officer
Mr. S.K. Dash	Technical Officer
Mr. B.K. Acharya	Technical Officer
Mr. S. Lenka	Technical Officer
Mr. P. Barda	Senior Technical Assistant
Mr. A.K. Binakar	Senior Technical Assistant (Driver)
Mr. L. Singh Tiyu	Senior Technical Assistant (Driver)
Dr. Subodha Kumar Karna	Technical Assistant (Lab)
Mr. Kamlesh Kumar Sharma	Technical Assistant (Hindi Translator)
Mr. Sunanda Kumar Sahoo	Technical Assistant (Library)
Mr. Sitesh Kumar Mohapatra	Technical Assistant (Farm)
Mr. A. Parida	Senior Technician

ADMINISTRATION

Mr. Vinod K. Sahoo	Finance & Accounts Officer
Mr. J. Nayak	Asst. Administrative Officer
Mrs. M. Padhi	Private Secretary
Mr. Trilochan Raut	Personal Assistant
Mr. R.K. Dalai	Assistant
Mr. A.K. Pradhan	Upper Division Clerk
Mr. N.K. Mallick	Upper Division Clerk
Mr. C.R. Khuntia	Lower Division Clerk
****Mr. B.S. Upadhyaya**	Lower Division Clerk
Mr. S.C. Das	Lower Division Clerk

SUPPORTING

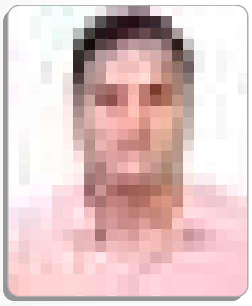
Mr. Sanatan Das	Skilled Support Staff
Mr. S.K. Panda	Skilled Support Staff
Mr. B.N. Nayak	Skilled Support Staff
Mr. B. Dutta	Skilled Support Staff
Mrs. Sanghamitra Singh	Skilled Support Staff

**On lien*
***On deputation*

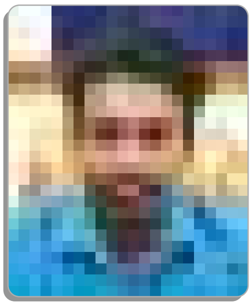
Joining, Promotion, Superannuation & Transfer

Mrs. Ankhila R. Handral
Scientist (Agricultural Economics)

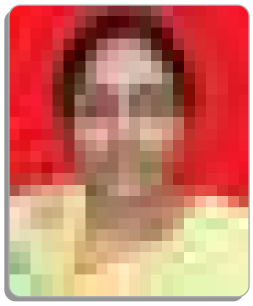
Mr. Biswaranjan Behera
Scientist (Agronomy)



Dr. Dibakar Ghosh
Scientist (Agronomy)



Dr. Roomesh K. Jena
Scientist (Soil Science)



Mrs. Sanghamitra Singh
Skilled Supporting Staff

- Dr. Atmaram Mishra joined as a Director (Acting) of the institute on February 4, 2020.
- Mrs. Ankhila R. Handral, Scientist (Agricultural Economics) joined ICAR-IIWM on April 4, 2020 (FN).
- Mr. Biswaranjan Behera, Scientist (Agronomy) joined ICAR-IIWM on April 4, 2020 (AN).
- Dr. Dibakar Ghosh, Scientist (Agronomy) joined this institute on August 26, 2020 after transfer from ICAR-Directorate of Weed Research, Jabalpur, Madhya Pradesh.
- Dr. Roomesh K. Jena, Scientist (Soil Science) joined this institute on August 27, 2020 after transfer from ICAR-NBSS&LUP, Regional Centre, Jorhat.
- Mrs. Sanghamitra Singh joined this institute as Skilled Supporting Staff on September 8, 2020 on compassionate ground.
- Dr. P. Panigrahi has been promoted to Principal Scientist through CAS of the ICAR w.e.f. September 11, 2018.
- Mr. J. Nayak, Assistant promoted to AAO of the institute w.e.f. May 1, 2020.
- Mr. A. Mallick, AAO of the institute superannuated on April 30, 2020.
- Dr. S.K. Ambast, Director of the institute transferred on February 4, 2020 and joined as Joint Director (Education) to ICAR-NIBSM, Raipur.
- Dr. G. Kar, Principal Scientist of the institute transferred on March 3, 2020 and joined as Director, ICAR-CRIJAF, Barrackpore, West Bengal.
- Mr. N. Manikandan, Scientist (Agricultural Meteorology) transferred to ICAR-Central Research Institute for Dryland Agriculture, Hyderabad on November 9, 2020.

Budget & Expenditure

The budget & expenditure for the financial year 2020-21 is presented below :

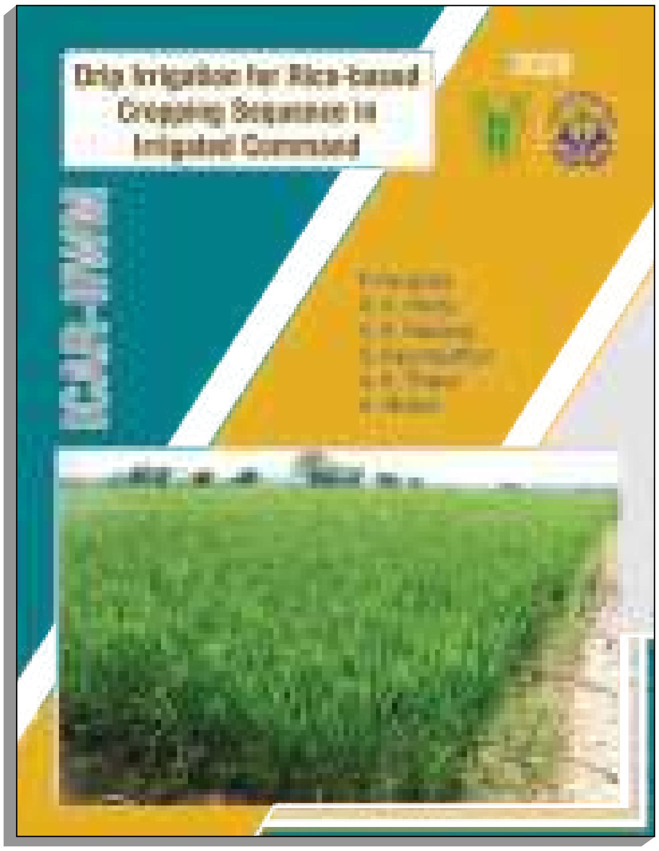
(Figures in ₹)

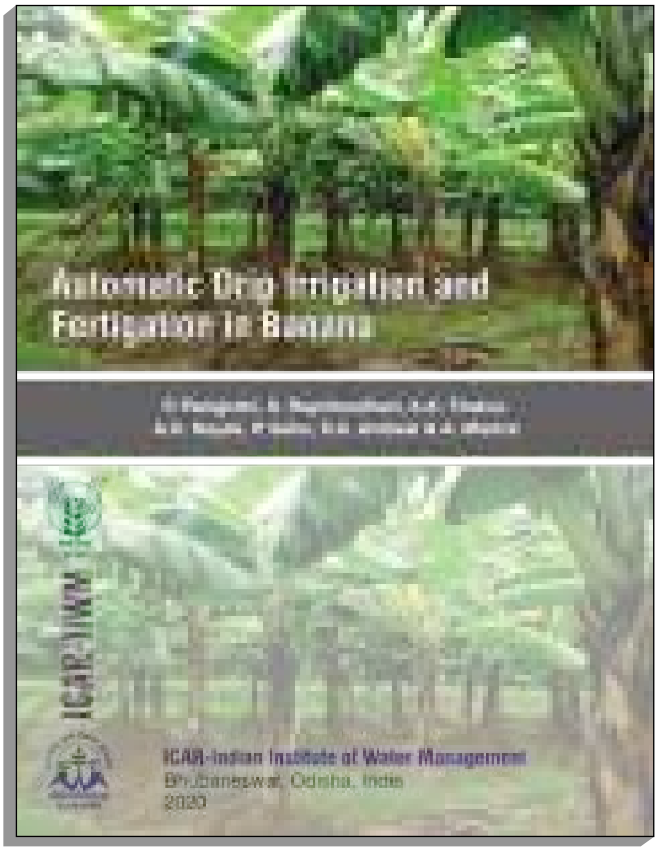
Sl. No.	Head of Account	R.E. 2020-21	Expenditure during the month (31.03.2021)	Progressive expenditure
1	2	3	4	5
	Grants for creation of Capital assets (CAPITAL)			
1	**Works**			
	A. Land			
	B. Building			
	i. Office Building	0	0	0
	ii. Residential Building	0	0	0
	iii. Minor Works	1500000	342842	1048334
2	Equipments	300000	1617218	1634978
3	Furniture & Fixture	400000	0	0
4	Library Books & Journal	0	0	0
5	Information Technology	600000	266144	299113
6	Vehicles & Vessels	0	0	0
7	Others	300000	0	117575
8	SCSP	954000	874393	940893
9	TSP	500000	296380	296380
	Total- CAPITAL	**4554000**	**3396977**	**4337273**
	Grants in Aid-Salaries (Revenue)			
1	**Establishment Expenses**			
	A. Salaries			
	i. Establishment charges	99400000	2417758	99400000
	ii. Wages			
	iii. O.T.A.			
	Total -Establishment Expenses	**99400000**	**2417758**	**99400000**
	Grants in Aid-General (Revenue)			
1	**Pension & Other Retirement Benefits**	3413000	5000	3412353
2	**Travelling Allowances**			
	A. Domestic TA/TTA	200000	249858	355224
	B. Foreign TA	0		0
	Total - Traveling Allownces	**200000**	**249858**	**355224**
3	**Research & Operational Expenses**			
	A. Research Expenses	3000000	382131	3113960
	B. Operational Expenses	1700000	428210	1535695
	C. SCSP Research and Operational Expenses	2180000	990815	2100837
	Total- Research & Operational Expenses	**6880000**	**1801156**	**6750492**
	TSP	**1000000**	128343	456110

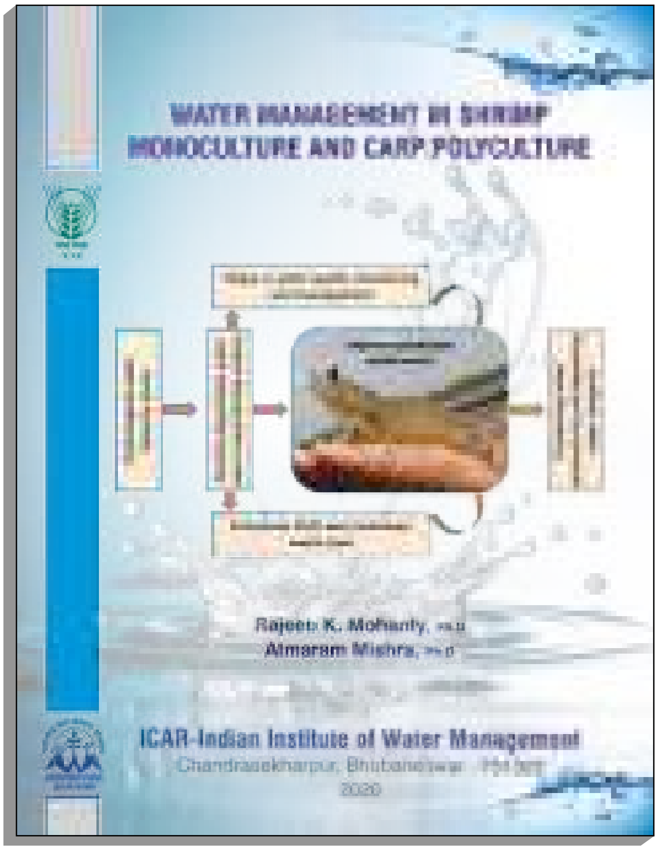
Sl. No.	Head of Account	R.E. 2020-21	Expenditure during the month (31.03.2021)	Progressive expenditure
1	2	3	4	5
4	**Administrative Expenses**			
	A. Infrastructure	8800000	2181558	9868530
	B. Communication	55000	36747	83138
	C. Repair & Maintenance			
	i. Equipment Vehicles & Others	400000	23578	323708
	ii. Office Building	725000	203947	556393
	iii. Residential Building	650000	22776	99352
	iv. Minor Works	0	0	0
	D. Others (excluding TA)	3600000	699726	3434736
	Total- Administrative Expenses	**14230000**	**3168332**	**14365857**
5	**Miscellaneous Expenses**			
	A. HRD	150000	5960	21006
	B. Other Items (Fellowship, Scholarships etc.)	0	0	0
	C. Publicity & Exhibitions	50000	0	0
	D. Guest House - Maintenance	54000	960	4980
	E. Other Miscellaneous	56000	0	12201
	Total- Miscellaneous Expenses	**310000**	**6920**	**38187**
	Total Grant-in-Aid-General	**26033000**	**5359609**	**25378223**
	Total Revenue (Grant-in-Aid-Salaries + Grant-in-Aid-General)	**125433000**	**7777367**	**124778223**
	G.TOTAL (Capital + Revenue)	**129987000**	**11174344**	**129115496**

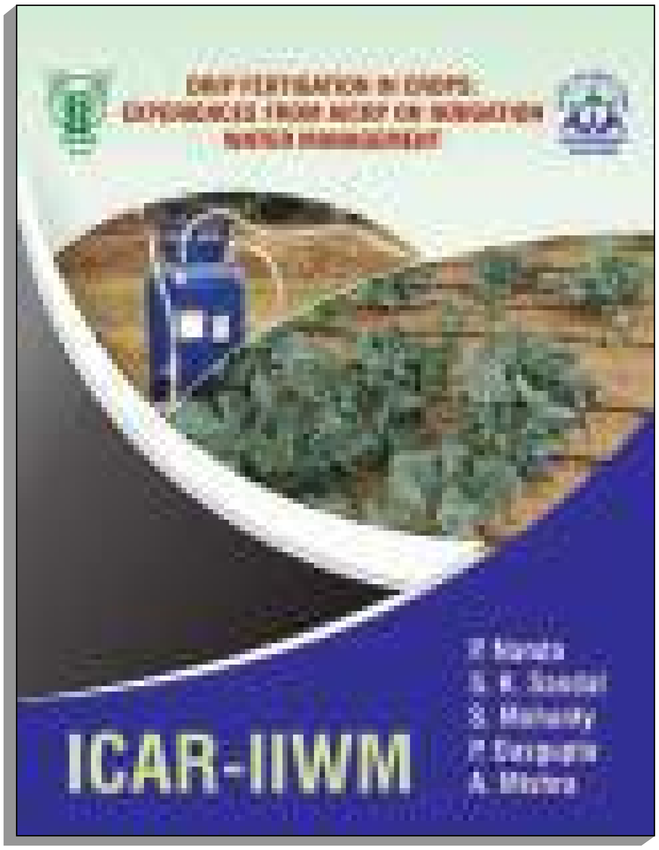
Sl. No.	Head of Account	R.E. 2020-21	Expenditure during the month (31.03.2021)	Progressive expenditure
1	2	3	4	5
1	**AICRP on IWM**			
	a) Other ICAR Instt.& SAU,s	210843000	68951780	210843000
	b) IIWM	1910000	569692	1398888
	TOTAL	**212753000**	**69521472**	**212241888**
2	**CRP on Water**			
	a) Other ICAR Instt. SAU,s & IIT	3069650	15520005	35512881
	b) IIWM	35421350	481292	1964470
	TOTAL	**38491000**	**16001297**	**37477351**
3	NAIF	345000	89094	274282
4	FARMER FIRST	1100000	324747	857534
5	NASF	1531700	93226	1203500

ICAR-IIWM Publications









ICAR-Indian Institute of Water Management
Bhubaneswar, Odisha - 751023
Phone : 91-674-2300060 (Director), 2300010/2300016/2301815
Fax : 91-674-2301651
E-mail : director.iiwm@icar.gov.in, director.dwm@icar.org.in
Web : http://www.iiwm.res.in