वार्षिक प्रतिवेदन

ANNUAL REPORT 2023

भाकृअनुप - भारतीय जल प्रबंधन संस्थान
भुवनेश्वर, ओड़िशा-७५१०२३

ICAR-Indian Institute of Water Management
Bhubaneswar, Odisha-751023

ANNUAL REPORT

2023

ICAR-INDIAN INSTITUTE OF WATER MANAGEMENT

(INDIAN COUNCIL OF AGRICULTURAL RESEARCH)

Bhubaneswar-751023, India

https://iiwm.icar.gov.in

ICAR-IIWM Annual Report 2023

Published by
Director

Editors
Dr. Ranu Rani Sethi
Dr. Rajeeb K. Mohanty
Dr. Ashok K. Nayak
Dr. Om Prakash Verma
Dr. Sanatan Pradhan
Dr. Ankita Jha

Hindi Translation
Mr. K.K. Sharma

Citation: ICAR-IIWM 2023, Annual Report 2023. ICAR Indian Institute of Water Management, Bhubaneswar, India 96 p.

Layout & Printing
Print-Tech Offset Pvt. Ltd.
Chandaka I.E, Bhubaneswar-24, Odisha

PREFACE

Water is the messenger of peace and prosperity and can spark conflict if not managed properly. About 2.2 billion people globally live without safely managed drinking water, including 115 million people who drink surface water. In India, water was surplus in 1951 with per capita water availability of 5177 m3, which has now declined to about 1450 m3 per year and is projected to be a water-stressed Country by 2030. Moreover, water-related problems can be ameliorated if different sectors implement water-saving technologies. According to the World Bank, India has 18% of the world's population but only has enough water resources for 4% of its people. In India, after Chennai, recently, Bengaluru is witnessing water scarcity. These problems are aggravated by the changing climate, as well as the lack of infrastructure for storage and water supply. When water is scarce or polluted, or people have unequal or no access, tensions can rise between communities and countries. Roughly half of the world's population is experiencing severe water scarcity for at least some part of the year. Out of 193 member countries of the UN, 153 countries share trans-boundary basins, and only 24 countries report that their trans-boundary catchments are covered by cooperation. So, as nations manage climate change, citizen migration, and political unrest, it becomes imperative to put water cooperation-related issues into the country's policies. To ensure water availability to all citizens of the country and its sustainable use, the Government of India (GoI) has implemented several schemes (*viz.* National Water Mission (NWM), PMKSY, ABY (*Atal Bhujal Yojana*), *Amrit Sarovar* Mission, *Jal Sakti Abhiyan* (JSA)-catch the rain (CTR) initiative, National Rural Drinking water programme, *Jal Jivan Mission* (JJM), *Sahi Fasal*, MGNREGS, *Namami Ganga,* National Hydrology Projects etc.). Besides this, the Bureau of Water Use Efficiency (BWUE) has also been set up by GoI to prepare guidelines for enhancing the water use efficiency from present level of 40% to 60%.

Under such scenarios, ICAR-IIWM intensified activities to reach out to different stakeholders during 2023 and disseminated agricultural water management technologies developed by ICAR-IIWM to improve agricultural water productivity. Stakeholder feedback proforma was prepared to acquire feedback from stakeholder and used in different outreach programmes of the Institute. Efforts were made this year pertaining to installation of the requisite hardware for automation of canal commands in one of the minor Irrigation projects of Govt. of Odisha, water budgeting studies at command and catchment scales, spatiotemporal availability and variability of water resources, groundwater recharge, redesigning and renovation of WHS, recycling and re-use of wastewater, management of coastal ecosystem and groundwater quality, capacity building programmes on agricultural water management technologies, ecosystem services, construction of tube wells in hard rock aquifers for irrigation and increasing the livelihood of tribal farming community besides dissemination of the GoI schemes to the stakeholders. Such activities will be continued in subsequent years to achieve sustainability in natural resources management. Moreover, two national level training programmes on water footprint estimation and use of modern tools in saving water use in agriculture were conducted by the Institute. Besides this, 120 Assistant Horticulture Officers and 120 progressive farmers were trained at ICAR-IIWM on use of tools and techniques for water management in Horticulture. Students from different Agricultural Universities were guided by the faculty and under ICAR-IARI Mega University.

On technology development front, the Institute developed and tested ICT-enabled digital devices pertaining to acquisition of real time soil moisture for judicious irrigation scheduling, Alternate Wetting Drying (AWD) enabled sensing system for irrigation scheduling in rice, IoT enabled device for measurement of flow in open channel and switching on and off the pumps for delivery of water to fields. Technology was standardized for enhancing water productivity of baby corn-maize-tomato cropping sequence under subsurface drip irrigation. Flood susceptible zones in *Baitarani* River Basin using geospatial tools and AHP techniques and the sea water intrusion in coastal areas of Puri District, Odisha was simulated. To ensure integration and linkage with different departments for implementation of technologies developed by the Institute, efforts were made to have frequent interface meetings with line departments and Water User Associations besides field visits. IIWM technologies were disseminated through participation and demonstration in conferences, farmers' fairs besides different training and capacity building programmes under TSP, SCSP, Farmer FIRST, MGMG, NICRA etc. ICAR-IIWM coordinated twenty six AICRP Centers pan India on Irrigation Water Management to carry out basic and applied studies on soil, water, and plant relationships and their interactions for enhancing irrigation water productivity besides serving as coordinating unit of Agri-CRP on water (Phase II). Externally funded, consultancy and foreign aided projects were awarded to the Institute; fifteen technologies developed by ICAR-IIWM were certified by ICAR besides the copyright of the mobile app pertaining to the ICAR-IIWM research farm. During this year, six flexi rubber dams in four locations in Kerala State were constructed under technical supervision from ICAR-IIWM.

During 2023, scientists of ICAR-IIWM published 45 research papers, 9 book chapters, 8 technical bulletins and 18 popular articles and received several awards and recognitions. Institute was adjudged with 2nd rank amongst ICAR Institutes under *Swachhta* campaign initiatives. Seven MoUs were signed and one MoU was renewed with different universities and Govt. of Odisha (GoO) departments. Moreover, scientists and staff of the Institute could expand their knowledge by attending different workshops, conferences and brainstorming sessions and invited as lead speakers. Further, staffs of the Institute were motivated by the visit of eminent personalities and academicians, including Hon'ble Secretary DARE and DG, ICAR, DDG (NRM), ICAR, Principal Secretary, MoA & FW, GoO, Engineer-in-Chief, Govt of Odisha, Director, OPIICRA, CAD-PIM, GoO and Director (HR), NALCO and Commissioner of BMC, Govt of Odisha. Several programmes as desired by the Council and GoI from time to time in the form of awareness initiatives and *Swachhta Pakhwada* were also organized.

I sincerely acknowledge the valuable guidance, suggestion and support of Dr Himanshu Pathak, Secretary, DARE and Director General, ICAR; Dr S.K.Chaudhari, Deputy Director General (NRM), ICAR, New Delhi; Dr A. Velmurugan, ADG (Soil and Water Management) and Dr Rajvir Singh, ADG (Agronomy, Agroforestry and Climate Change) and other concerned officials of the Council. I sincerely thank the esteemeed Chairman and members of RAC and IMC for their valuable guidance, input and support. I thank all members of IRC, program leaders, members of different Institute committees, staff of administration and the internal finance section of the Institute for their active help and unwavering cooperation for smooth functioing of the Institute. This document is the testimony of focused, dedicated, committed service and creativity of all staff of the Institute. The publication committee also deserves appreciation for their efforts to compile and edit the annual report. I hope that the annual report will immensely benefit stakeholders, *i.e.* policymakers, academicians, researchers, development functionaries and farmers in enhancing agricultural water productivity.

April 18, 2024
Bhubaneswar

(Arjamadutta Sarangi)
Director, ICAR-IIWM

कार्यकारी सारांश

वर्षा जल प्रबंधन

आय और जल उत्पादकता में वृद्धि के लिए इन-सीटू वर्षा जल का प्रबंधन

भाकृअनुप-भारतीय जल प्रबंधन संस्थान, भुवनेश्वर के अनुसंधान फार्म पर ऊँची भूमि के क्षेत्रों में कृषि आय और जल की उत्पादकता में वृद्धि के लिए इन-सीटू वर्षा जल प्रबंधन का अनुसंधान किया गया। इन-सीटू वर्षा जल प्रबंधन के उपचार संयोजन यानि बॉटम लेस मृदा के गड्ढे में रोपण + पुआल मल्चिंग + तीन चौथाई भरा हुआ सिलेंडर + परकोलेशन गड्ढा के तहत अदरक, गेंदा और परवल की अधिकतम उपज क्रमशः 16 टन/हेक्टर, 15.82 टन/हेक्टर और 18.52 टन/हेक्टर तक प्राप्त हुई।

बाढ़ के बाद प्रबंधन योजनाओं की तैयारी

सेंटिनल -1 उपग्रह के आंकड़ों का उपयोग करके ओड़िशा राज्य के पुरी जिले के कनास ब्लॉक के लोकपाल गाँव में बाढ़ प्रभावित और जलभराव वाले क्षेत्रों की वर्षवार (2017-2022) तुलना को मानचित्रित किया गया। वर्ष 2018 के दौरान बाढ़ से सबसे अधिक प्रभावित क्षेत्र (405.6 हेक्टेयर) की गणना की गई जो वर्ष 2017 के दौरान सबसे कम (9.1 हेक्टेयर) पाई गई। जबकि, वर्ष 2022 के दौरान जलभराव क्षेत्र की गणना सबसे अधिक (458.5 हेक्टेयर) की गई जो कि वर्ष 2018 के दौरान जल भराव क्षेत्र (448.2 हेक्टेयर) के बराबर थी। वर्ष 2017 के दौरान सबसे कम जलभराव क्षेत्र (73.1 हेक्टेयर) प्राप्त हुआ। इसके अलावा बाढ़ प्रभावित क्षेत्र 9.1 हेक्टेयर (वर्ष 2017) से 405.6 हेक्टेयर (वर्ष 2018) के बीच प्राप्त हुआ।

धान की वृद्धि और उपज के लिए नीम लेपित यूरिया (NCU) और एग्रोटैन समाविष्ट यूरिया (AIU) का प्रयोग

खरीफ मौसम में रोपाई वाले धान (किस्म स्वर्णा) में यूरिया, सिंगल सुपर फॉस्फेट और म्यूरेट ऑफ पोटाश का उपयोग करके 100 किलोग्राम नाइट्रोजन और 50 किलोग्राम फॉस्फोरस और पोटेशियम/हेक्टेयर की दर से उर्वरकों का प्रयोग किया गया। इस अनुसंधान में धान की फसल में नीम लेपित यूरिया और एग्रोटैन समाविष्ट यूरिया के माध्यम से यूरिया उर्वरक (नाइट्रोजन की पूर्ति के लिए) का प्रयोग किया गया। यूरिया के दोनों स्रोतों ने समान मात्रा में अपना प्रभाव दिखाया और सबसे अधिक उपज तब प्राप्त हुई, जब बुवाई के समय और जुताई के बाद नाइट्रोजन के उर्वरकों को मृदा में समावेश करके अच्छी तरह से प्रबंधित किया गया।

रोपित धान के लिए सेंसर आधारित एकांतर नम एवं सुखी सिंचाई विधि का विकास

रोपित धान में एकांतर नम एवं सुखी सिंचाई द्वारा शेड्यूल के लिए सेंसर आधारित स्वचालन सिंचाई विधि को विकसित किया गया। प्रयोगशाला स्केल के लिए प्रोटोटाइप मॉडल और फील्ड स्तर पर उपयोग के लिए मुख्य मॉडल, दोनों विकसित किए गए और इनका परीक्षण भी किया गया। यह प्रणाली अल्ट्रासोनिक सेंसर के उपयोग के माध्यम से डीजाइंड पानीपाइप के अंदर उपस्थित जल के स्तर का पता लगाती है। माइक्रोकंट्रोलर लगातार जल स्तर के प्रत्येक आंकड़ों की तुलना थ्रेसहोल्ड लिमिट से करता है। जब पाइप के अंदर उपस्थित जल का स्तर मिट्टी की सतह से 10 सेमी नीचे चला जाता है तो सिंचाई पंप को चालू करने का संकेत मिलता है। इसी प्रकार, जब जल का स्तर मिट्टी की सतह से 5 सेमी ऊपर हो जाता है तो पंप को बंद करने का संकेत प्राप्त होता है। जल स्तर के आंकड़ों और पंप की स्थिति के आंकड़ों को डाटालॉगर में डाले गए मेमोरी कार्ड में संग्रहीत किया जाता है। अत: इससे खेत में प्रयोग किए जाने वाले सिंचाई जल की मात्रा को निर्धारित करने में मदद मिलती है।

भारत में कृषि आपदा जोखिम प्रबंधन रणनीति के माध्यम से जलवायु अनुकूलन कृषि में वृद्धि करना

ओड़िशा राज्य में सेंटिनल-1 उपग्रह के आंकड़ों का उपयोग करके वर्ष 2023 में मानसून के मौसम के दौरान गूगल अर्थ इंजन एल्गोरिदम में विभिन्न थ्रेसहोल्ड मानों के माध्यम से बाढ़ प्रभावित क्षेत्रों को अंकित किया गया। ओड़िशा राज्य में वर्ष 2023 के दौरान थ्रेसहोल्ड मान को 1.10 मानकर क्रमशः जुलाई में 583938 हेक्टेयर, अगस्त में 902425 हेक्टेयर और सितंबर में 381332 हेक्टेयर जल भराव क्षेत्र पाया गया। इसी प्रकार, वर्ष 2023 के दौरान थ्रेसहोल्ड मान को 1.50 मान लेने पर जुलाई में 30522 हेक्टेयर, अगस्त में 40484 हेक्टेयर और सितंबर में 32393 हेक्टेयर बाढ़ प्रभावित क्षेत्र का पता लगाया गया।

मशीन लर्निंग मॉडल का उपयोग करके वर्षा का पूर्वानुमान लगाना

ओड़िशा राज्य के 30 विभिन्न स्टेशनों/जिलों में वर्षा का पूर्वानुमान लगाने के लिए वर्ष 1901 से 2019 तक के मासिक वर्षा के आंकड़ों का उपयोग किया गया। मॉडलों को विभिन्न मशीन लर्निंग मॉडल के साथ ट्रेंड किया गया। इससे यह पता चला कि DEM टेस्ट के आधार पर शैलो लर्निंग मॉडल, डीप लर्निंग मॉडल से बेहतर प्रदर्शन करता है। सर्वोत्तम मॉडल के आधार पर वर्ष 2030 तक मासिक वर्षा का पूर्वानुमान लगाया गया। प्रेक्षित और अनुमानित मानों के बीच चेक लिमिट्स ऑफ एग्रीमेंट (LoA) की सहायता से मॉडल के सत्यापन हेतु ब्लैंड-अल्टमैन प्लॉट लेयर को जोड़ा गया। इससे यह पाया गया कि 95% से अधिक पूर्वानुमान प्रेक्षित आंकड़ों के समान ही हैं।

नहरी जल प्रबंधन

बेबी कॉर्न और मक्का में उपसतही ड्रिप सिंचाई (एसडीआई) प्रणाली का मूल्यांकन

लेटरल के विभिन्न दबाव (75 kPa, 100 kPa, 125 kPa एवं 150 kPa) और गहराई (10, 15 एवं 20 सेमी) के साथ उपसतही ड्रिप सिंचाई (SDI) के प्रदर्शन का अध्ययन किया गया। ओड़िशा राज्य में खुर्दा जिले के मेंढ़ासल गाँव में स्थित भाकृअनुप – भारतीय जल प्रबंधन संस्थान, भुवनेश्वर के अनुसंधान फार्म पर मक्का-टमाटर-बेबी कॉर्न फसल चक्र में उपसतही ड्रिप सिंचाई प्रणाली की तुलना, सतही ड्रिप सिंचाई (DI) और सतही सिंचाई (SI) प्रणालियों के साथ की गई। रबी के मौसम के दौरान टमाटर (किस्म - सम्राट) की फसल में ड्रिप सिंचाई प्रणाली एवं सतही सिंचाई विधि की तुलना में 15 सेमी गहराई के साथ 125 kPa पर उपसतही ड्रिप सिंचाई प्रणाली से सिंचाई करने 18% और 42% सिंचाई जल की बचत प्राप्त होती है। इसके अलावा, 15% और 33% फल उपज में वृद्धि के कारण जल उत्पादकता में 34% (ड्रिप सिंचाई) और 108% (सतही सिंचाई) तक वृद्धि हुई। बेबी कॉर्न (किस्म : G-5414) जो टमाटर के बाद ग्रीष्मकालीन मौसम के दौरान उगाई जाती है। इस फसल में उपसतही ड्रिप सिंचाई प्रणाली का उपयोग करने पर ड्रिप सिंचाई और सतही सिंचाई की तुलना में क्रमशः 15% और 39% कम सिंचाई जल उपयोग हुआ। बेबी कॉर्न उपज में 12% और 34% की वृद्धि हुई जबकि, ड्रिप सिंचाई और सतही सिंचाई की तुलना में उपसतही ड्रिप सिंचाई प्रणाली से सिंचाई के कारण जल उत्पादकता में 32% और 122% की वृद्धि हुई। खरीफ मौसम के दौरान मक्का (किस्म: शुगर 75) की फसल में उपसतही ड्रिप प्रणाली के तहत लेटरल की 15 सेमी गहराई पर सिंचाई करने से सांख्यिकीय रूप से समान उपज प्राप्त हुई। लेटरल की 10 सेमी गहराई पर उपसतही ड्रिप सिंचाई एवं ड्रिप सिंचाई से प्राप्त उपज भी समान ही प्राप्त हुई। लेकिन, उपसतही ड्रिप सिंचाई के तहत उपज सतही सिंचाई की तुलना में 7% अधिक प्राप्त हुई। उपसतही ड्रिप सिंचाई प्रणाली के तहत मक्का में जल उत्पादकता ड्रिप सिंचाई और सतही सिंचाई की तुलना में क्रमशः 7% और 18% अधिक प्राप्त हुई।

प्राकृतिक खेती: फसल और जल उत्पादकता पर इसके प्रभाव

भाकृअनुप-भारतीय जल प्रबंधन संस्थान, भुवनेश्वर के अनुसंधान फार्म पर धान-टमाटर- मूंग की फसल पद्धति में इन फसलों की उपज पर पारंपरिक (रासायनिक) खेती, जैविक खेती और प्राकृतिक खेती जैसे विभिन्न तरीकों के प्रभाव को समझने के लिए अनुसंधान किया गया। सभी फसलों में सबसे अधिक उपज पारंपरिक खेती के बाद जैविक/प्राकृतिक खेती के तहत प्राप्त हुई। रासायनिक खेती की तुलना में जैविक/प्राकृतिक खेती में धान की उपज में 16-18% की कमी, टमाटर के फल की उपज में 9-18% की कमी और मूंग की उपज में 6-9% की कमी प्राप्त हुई।

संरक्षित कृषि में सटीक सिंचाई प्रबंधन

पूर्वी भारत की धान आधारित गहन फसल पद्धति में संरक्षित कृषि के तहत सटीक सिंचाई के प्रदर्शन का अध्ययन करने के लिए अनुसंधान किया गया। इस अनुसंधान में सटीक सिंचाई के साथ पारंपरिक जुताई (CT) करने पर मक्का की दाना उपज में अधिकतम वृद्धि प्राप्त हुई, जो सांख्यिकीय रूप से सटीक सिंचाई करने के साथ शून्य जुताई (ZT) करने से प्राप्त उपज के बराबर थी। सटीक सिंचाई के साथ शून्य जुताई के तहत मक्का की अधिकतम जल उत्पादकता (14.43 किग्रा/हेक्टेयर-मिमी) प्राप्त हुई। मूंग की फसल में सटीक सिंचाई के साथ शून्य जुताई के तहत अधिकतम उपज (870 किग्रा/हेक्टेयर) प्राप्त हुई। इसी प्रकार सटीक सिंचाई के साथ शून्य जुताई के तहत मूंग की जल उत्पादकता (2.86 किग्रा/हेक्टेयर-मिमी) अधिकतम प्राप्त हुई। सटीक सिंचाई के साथ शून्य जुताई वाले सीधे बुआई के धान में सबसे अधिक जल उत्पादकता (6.46 किग्रा/हेक्टेयर-मिमी) प्राप्त हुई। सीधे बीज बुवाई विधि में धान की उपज नम जुताई

वाले रोपित धान की तुलना में 8% कम प्राप्त हुई, लेकिन जल उत्पादकता 17% अधिक प्राप्त हुई।

मक्का-सूरजमुखी फसल पद्धति में संसाधन संरक्षण प्रौद्योगिकियाँ

उप-सतह ड्रिप सिंचाई प्रणाली (शून्य जुताई एवं फसल अवशेष को सीधे मृदा में मिलाने, ZTSDI + R) से सिंचाई के कारण सबसे अधिक मक्का की पैदावार (12.54 टन/हे प्राप्त हुई और सबसे कम उपज (10.78 t/ha) पारंपरिक रूप से समतल भूमि में नाली सिंचाई विधि (CTFBF) से प्राप्त हुई। ड्रिप सिंचाई प्रणाली में कम सिंचाई जल के उपयोग के कारण अधिकतम मक्का के भुट्टा की उपज और जल उत्पादकता (22.23 किग्रा/हेक्टेयर-मिमी) प्राप्त हुई जो पारंपरिक विधि की तुलना में 35% अधिक थी। उप-सतह ड्रिप सिंचाई प्रणाली (फसल अवशेष को सीधे मृदा में मिलाने एवं शून्य जुताई) के कारण रबी के मौसम में सूरजमुखी के बीज की उपज (2.04 टन/हेक्टेयर) अधिक प्राप्त हुई। उप-सतह ड्रिप सिंचाई प्रणाली (फसल अवशेष को सीधे मृदा में मिलाने) से प्राप्त बीज उपज सांख्यिकीय रूप से शून्य-जुताई के साथ उप-सतही ड्रिप सिंचाई (ZTSDI), अवशेषों के साथ शून्य जुताई व ड्रिप सिंचाई (ZTDI +R) और शून्य जुताई के साथ ड्रिप सिंचाई (ZTDI) के बराबर थी। पारंपरिक रूप से समतल भूमि में नाली सिंचाई विधि (1.42 टन/हेक्टेयर) में बीज की उपज सबसे कम प्राप्त हुई। उप-सतह ड्रिप सिंचाई प्रणाली (शून्य जुताई एवं फसल अवशेष को सीधे मृदा में मिलाने) के कारण अधिकतम जल उत्पादकता (6.97 किग्रा/हेक्टेयर-मिमी) प्राप्त हुई क्योंकि, इसमें सबसे कम सिंचाई जल का उपयोग हुआ।

सिंचित नहरी कमांड में आर्थिक जल उत्पादकता

इस अनुसंधान में जल अकाउटिंग और आर्थिक जल उत्पादकता की गणना की गई और कुकड़ी लेफ्ट बैंक नहरी कमांड में दो फसल सिनेरियो विकसित किए गए। जियोस्पेसियल पद्धति का उपयोग करके बड़े क्षेत्र के अनुमान के अनुसार प्राप्त जल उपयोग दक्षता को आधिकारिक रूप से रिकॉर्ड किए गए डाटा से 100% अधिक पाया गया। अधिक मूल्य वाली (नगदी) फसलों की खेती के माध्यम से आर्थिक जल उत्पादकता में वृद्धि की संभावना है। मुख्य रूप से जल-गहन फसलों जैसे गन्ना के बजाय जल का पुनः आवंटन कम जल मांग वाली बारहमासी फसल जैसे अनार या मौसमी फसलों जैसे सब्जियों में किया जा सकता है। विभिन्न जल उपयोगकर्ता संस्थाओं की उत्पादकता फसल तीव्रता के साथ सकारात्मक रूप से जुड़ी हुई है और फसल विविधीकरण के साथ नकारात्मक रूप से जुड़ी हुई है। फसल पद्धतियों के वैकल्पिक परिदृश्यों के विकास से उत्पादन के शुद्ध मूल्य (NVOUP) वृद्धि प्राप्त होती है।

भूजल प्रबंधन

जलवायु परिवर्तन का प्रभाव भूजल संसाधनों पर पड़ना जलवायु आंकड़ों के विश्लेषण से पता चला कि वर्ष 2002, 2004, 2008, 2009, 2012, 2015 के दौरान पड़े गए सूखों का गंगा नदी बेसिन की भूजल-सिंचित जलोढ़ जलवाही पर उल्लेखनीय प्रभाव पड़ा। वर्ष 2000 से पहले (1985-2000) और वर्ष 2000 के बाद (2001-2017) के बीच भूजल के स्तर में औसतन 1 मीटर तक की गिरावट दर्ज हुई है। जनवरी और मई के महीनों में क्रमशः 1.5 मीटर और 1.2 मीटर की गिरावट हुई है। वर्ष 2000 से पहले की अवधि के दौरान वर्ष 1995 के आसपास तीन साल के सूखे के समय भूजल स्तर की गिरावट में सुधार देखा गया है जिसके परिणामस्वरूप एक नॉन सिगनिफिकेंट स्थिर उप-सतह प्रणाली विकसित हुई है। वर्ष 1996-2000 और वर्ष 2011-2015 के बीच स्पेसियल कोंट्रास्ट आगे और कोहिरेंट गिरावट के सबूत प्रदान करता है जो बेसिन के उत्तरी और उत्तर-पश्चिमी भागों के अत्यधिक सिंचित बेल्ट से मेल खाता है।

नीची भूमि में धान की खेती के तहत फास्फोरस की उपलब्धता को कम करने के लिए वैकल्पिक वेटिंग एंड ड्राइंग जल प्रबंधन

दो जल प्रबंधन विधियों जैसे लगातार जल भराव (CF) और वैकल्पिक वेटिंग एंड ड्राइंग (AWD) के साथ-साथ विभिन्न नाइट्रोजन उर्वरक के प्रयोग की दरों (नाइट्रोजन की 0, 100%, 133% और 166% अनुशंसित मात्रा) का धान की मिट्टी में फॉस्फोरस की उपलब्धता पर मूल्यांकन हेतु दो वर्षों तक अनुसंधान किया गया। इसके परिणामों से यह पता चला कि फेरस आयरन, माइक्रोबियल बायोमास फॉस्फोरस और मिट्टी में उपलब्ध फॉस्फोरस पर जल प्रबंधन का महत्वपूर्ण प्रभाव पड़ा। हालाँकि, मिट्टी में नाइट्रोजन के प्रयोग से फॉस्फोरस की उपलब्धता पर कोई प्रभाव नहीं पड़ा। लेकिन जब नाइट्रोजन की विभिन्न दरों का प्रयोग किया गया तो खेत में लगातार जल भराव की तुलना में वैकल्पिक वेटिंग एंड ड्राइंग विधि ने मिट्टी में उपलब्ध फॉस्फोरस की मात्रा को कम कर दिया। इसका मुख्य कारण यह था कि वैकल्पिक वेटिंग एंड ड्राइंग विधि ने माइक्रोबियल

बायोमास फॉस्फोरस में वृद्धि की जिससे फॉस्फोरस स्थिर हो गया और फेरस आयरन की मात्रा कम हो गई। इस कारण मिट्टी की फॉस्फोरस को अवशोषित करने की क्षमता बढ़ गई, जिससे उपलब्ध फॉस्फोरस की मात्रा में कमी आई। इस प्रकार वैकल्पिक वेटिंग एंड ड्राइंग विधि खेत में लगातार जल भराव की तुलना में धान की मिट्टी में उपलब्ध फॉस्फोरस की मात्रा को कम कर देती है।

बैतरिनी नदी बेसिन में भूजल के भंडारण की प्रवृत्ति

भारत की बैतरणी नदी बेसिन के लिए जल बजट के विभिन्न मापदंडों (वर्षा, सतही अपवाह, वाष्पीकरण-उत्सर्जन और भूजल भंडारण) की मात्रा का निर्धारण किया गया। इनोवेटिव ट्रेंड अनालिसिस (ITA) का उपयोग करके मौसमवार ट्रेंड विश्लेषण से पता चला कि सभी गेजिंग स्टेशनों (चंपुआ, केंदुझर, स्वमपटना, ठाकुरमुण्डा, आनंदपुर, बेलबहाली, अखुआपाड़ा एवं भद्रक) के लिए सर्दियों के मौसम में वर्षा और सतही अपवाह ने नॉन-मोनोटोनिक नेगेटीव (-) ट्रेंड और अन्य सभी मौसमों में मोनोटोनिक पॉजीटिव (+) ट्रेंड का अनुसरण किया है। भूजल भंडारण पर स्पेसियल विश्लेषण से पता चला कि इस नदी बेसिन का ऊपरी जलग्रहण क्षेत्र भूजल में गिरावट के प्रति अधिक संवेदनशील हैं।

कुशभद्रा-भार्गवी दोआब में भूजल की लवणता का ट्रेंड

ट्रेंड विश्लेषण से ओड़िशा राज्य के पूरी जिले के गोप ब्लॉक में पिछले कुछ वर्षों से भूजल की लवणता में बढ़ता ट्रेंड पाया गया है। ड्यूरोव के डायग्राम को बनाकर मानसून पूर्व और मानसून के बाद के मौसम के लिए भूजल की गुणवत्ता की तुलना की गई। मानसून के बाद के मौसम में भूजल की गुणवत्ता थोड़ी अच्छी रहती है। यह इसलिए हो सकता है कि वर्षा जल से पुन:भरण के कारण भूजल की लवणता में कमी आ गई हो। वर्टीकल इलेक्ट्रिकल साउंडीग का उपयोग करके 6 स्थानों पर रजिस्टीविटी सर्वेक्षण किया गया। इनमें से दो स्थानों पर लवणता का प्रभाव देखा गया। दोनों मौसम यानि मानसून और मानसून के बाद के लिए नदी के तल और नदी के स्तर के सर्वेक्षण हेतु डीजीपीएस सर्वेक्षण आयोजित किया गया।

ड्रैगन फ्रूट के उत्पादन के लिए जल का प्रबंधन

ड्रैगन फ्रूट की अधिकतम औसत उपज (8.6 किग्रा/पॉट) कोकोपीट और पर्लाइट मीडिया के संयोजन से उगाए गए पौधे से प्राप्त हुई। इसके बाद अकेले कोकोपीट (6 किग्रा/पॉट), कोकोफाइबर (4 किग्रा/पॉट) और सबसे कम केवल मृदा में उगाए गए पौधे (3.5 किग्रा/पॉट) से प्राप्त हुई। मिट्टी में उगाए गए पौधों का लाभ:लागत अनुपात 1.68 प्राप्त हुआ जबकि, कोकोपीट-3.31 है: कोकोफाइबर-1.65 प्राप्त हुआ और कोकोपीट और पर्लाइट के संयोजन में उगाए गए पौधे से यह 2.19 प्राप्त हुआ। मिट्टी में उगाए गए ड्रैगन फ्रूट की तुलना में कोकोपीट और पर्लाइट के तहत उगाए गए ड्रैगन फ्रूट में कुल कार्बोहाइड्रेट, प्रोटीन, बीटासायनिन और कुल फ्लेवोनोइड जैसे जैव रासायनिक मापदंडों में वृद्धि हुई।

ऑन-फार्म जल प्रबंधन एवं तकनीकों का प्रसार

जल गुणवत्ता में जोखिम प्रबंधन के लिए तकनीकी विकल्प और पॉलिसी दिशा निर्देश

कृषि और मत्स्य पालन में जोखिम का आकलन करने हेतु सीडब्ल्यूसी, सीजीडब्ल्यूबी, सीपीसीबी, एसपीसीबी से सतही जल और भूजल गुणवत्ता के आंकड़ों को एकत्रित किया गया। इसके बाद मशीन लर्निंग का उपयोग करके जल की गुणवत्ता की उपयुक्तता का आकलन करने के लिए वर्गीकरण मॉडल को (डिसीजन ट्री, रैंडम फॉरेस्ट) विकसित करने हेतु प्राथमिक डाटाबेस बनाया गया। डिसीजन ट्री मॉडल में ट्रेन्ड डाटा का सटीकता स्तर 1.0 प्राप्त हुआ और परीक्षण डाटा का सटीकता स्तर 0.97 प्राप्त हुआ। Mn > Fe > Mg जैसे तत्वों से संबंधित जोखिम पर ध्यान देने की आवश्यकता है। कृषि और मत्स्य पालन में जल के सुरक्षित उपयोग के लिए इसकी गुणवत्ता पर आधारित तकनीकी विकल्पों को प्राथमिकता दी गई।

क्या जैविक संशोधन और बीज प्राइमिंग से धान में क्रोमियम (VI) विषाक्तता कम हो सकती है?

क्रोमियम के एलिवेटेड स्तर ने पौधों की वृद्धि को काफी कम कर दिया जिससे फूल आने में देरी हुई और धान और टमाटर की उपज कम प्राप्त हुई। वर्मीकम्पोस्ट और बीज प्राइमिंग तकनीक को शामिल करने से पौधों में क्रोमियम के स्थानांतरण को सीमित करके उपज में वृद्धि प्राप्त हुई और अंततः अधिक मात्रा में उत्पादन प्राप्त करने में सफलता मिली।

फसल योजना और जलीय जीव पालन के विकास के लिए स्थान की उपयुक्तता का विश्लेषण

स्थान-विशिष्ट जल गुणवत्ता, मिट्टी की गुणवत्ता, बुनियादी सुविधाओं आदि के आधार पर अनालिटिकल हिरारची प्रोसेस

का उपयोग करके ओड़िशा राज्य के तटीय क्षेत्र और भारत के पश्चिमी तट (केरल) में जलीय जीव पालन के लिए उपयुक्त स्थलों की पहचान की गई।

आउटरीच गतिविधियां

एकीकृत कृषि प्रणाली के माध्यम से भूमि और जल उत्पादकता में वृद्धि करना (जनजातीय उपयोजना परियोजना- अब अनुसूचित जनजाति घटक, STC)

ओड़िशा राज्य के रायगड़ा और गजपति जिलों (Aspirational Districts) में स्थित दो आदिवासी गांवों में पाइप आधारित सिंचाई और फसल विविधीकरण में बदलाव के लिए कृषि इनपुट्स की सुविधा उपलब्ध करवाई गई। इसके अलावा, राज्य के कृषि विश्वविद्यालय के दो कृषि विज्ञान केन्द्रों के सहयोग से किसानों के खेतों पर विभिन्न आउटरीच गतिविधियों जैसे कि क्षमता निर्माण उपाय/कौशल विकास, कृषि परीक्षणों और फ्रंट लाइन प्रदर्शनों पर सुविधा प्रदान की गई। इस अवधि के दौरान गजपति जिले के फटाचंचड़ा गांव सूक्ष्म सिंचाई-आधारित कृषि प्रणाली मॉडल को शुरू किया गया।

उत्पादकता और आय में वृद्धि बढ़ाने के लिए जल प्रबंधन तकनीकों का संचालन (SCSP परियोजना)

ओड़िशा राज्य के पुरी जिले के नीमापड़ा ब्लॉक में अनुसूचित जाति के 350 किसानों द्वारा फसल विविधीकरण अपनाने और इनकी आय में वृद्धि के लिए नगदी फसलों के बीज, पौध संरक्षण रसायन, जैव उर्वरक, यूरिया और पानी में घुलनशील उर्वरक, पौधे, मछली फिंगरलिंग्स, वर्मीकम्पोस्ट, डीकंपोजर आदि किसानों को वितरित किए गए। इसके अलावा, इस ब्लॉक के हंसपड़ा और विलीग्राम गांवों के किसानों को मिनी पावर वीडर, बिग पावर वीडर, शेड नेट, संरक्षित खेती संरचना के लिए प्लास्टिक क्लैडिंग फिल्म, एचडीपीई स्प्रिंकलर पाइप, एचडीपीई कन्वेन्स पाइप, कांटेदार तार, गैल्वेनाइज्ड शीट आदि को वितरित किया गया। प्राकृतिक संसाधन प्रबंधन, बागवानी, खेत में फसलों की खेती, मत्स्य पालन, उद्यम और सोशल मीडिया हस्तक्षेप आदि पर विभिन्न जागरूकता मॉड्यूल अभियान चलाए गए। इस परियोजना के तहत छह प्रशिक्षण और पांच क्षमता निर्माण कार्यक्रम भी आयोजित किए गए।

फारमर्स फर्स्ट परियोजना

खुर्दा जिले के तीन गांवों अर्थात हरिड़ामाड़ा, जामुझरी और गिरिंगापुट में फारमर्स फर्स्ट परियोजना को क्रियान्वित किया गया है। प्राकृतिक संसाधन प्रबंधन, बागवानी, खेत में फसलों की खेती, मत्स्य पालन, उद्यम और सोशल मीडिया हस्तक्षेप आदि पर विभिन्न जागरूकता मॉड्यूल अभियान चलाए गए। पांच क्षेत्रीय स्तर के प्रशिक्षण और प्रदर्शन कार्यक्रम भी आयोजित किए गए जिनमें 800 से अधिक किसान और कृषक महिलाएं लाभान्वित हुईं। वर्ष 2023 के खरीफ के मौसम के दौरान अधिक पैदावार देने वाली धान की किस्मों (स्वर्णा सब-1, बिना धान-11, मृणालिनी और एमटीयू 1001) और रागी (किस्म - अर्जुन) के क्रॉप कटिंग प्रयोगों (CCE) के साथ दस धान और मिलेट दिवसों का आयोजन किया गया।

मेरा गांव - मेरा गौरव कार्यक्रम से संबंधित गतिविधियाँ

यह संस्थान 7 समूहों में ओड़िशा राज्य के 4 जिलों (खुर्दा, पुरी, नयागढ़ और कटक) के कुल 33 गांवों में मेरा गांव - मेरा गौरव कार्यक्रम से संबंधित गतिविधियों का आयोजन कर रहा है। इस संस्थान के द्वारा अपनाए गए गांवों से करीब 322 किसानों को शामिल करके कृषि जल प्रबंधन प्रौद्योगिकियों पर 7 प्रशिक्षण कार्यक्रम आयोजित किए गए। नेशनल होर्टीकल्चरण रिसर्च एंड डेवलपमेंट फाउंडेसन (NHRDF) से प्राप्त बीज किट के साथ ग्रीष्मकालीन सब्जियों की खेती, अच्छी गुणवत्ता वाली सब्जियों की पौध तैयार करना और रबी में सब्जियों के उत्पादन के लिए ऊंची क्यारी पर नर्सरी लगाना जैसे प्रदर्शन कार्यक्रम आयोजित किए गए। वर्ष 2023 के दौरान इस प्रदर्शन कार्यक्रम में लगभग 200 किसानों ने भाग लिया। इसके अलावा इन अपनाए गए गांवों में लगभग 15 किसान-वैज्ञानिक संवाद बैठकें आयोजित की गई और एक स्वच्छता जागरूकता कार्यक्रम और एक सतर्कता जागरूकता कार्यक्रम आयोजित किया गया।

स्वच्छ भारत अभियान

भाकृअनुप-भारतीय जल प्रबंधन संस्थान, भुवनेश्वर ने वर्ष 2023 के दौरान इस संस्थान के मुख्य परिसर, मेरा गाँव - मेरा गौरव कार्यक्रम के गांवों, सार्वजनिक स्थानों और पर्यटन स्थलों पर स्वच्छ भारत अभियान, स्वच्छता अभियान और स्वच्छता जागरूकता अभियानों में सक्रिय रूप से भाग लिया। इसके अलावा, इस अभियान के दौरान विभिन्न छात्रों को स्वच्छता के लिए प्रेरित किया गया। इस वर्ष के दौरान स्वच्छता के विभिन्न विषयों पर वाद-विवाद, व्याख्यान, सेमिनार और प्रशिक्षण कार्यक्रम भी

आयोजित किए गए।

किसान संपर्क सूत्र (KSS)

इस संस्थान द्वारा 15 दिन के अंतराल पर (शाम 7 बजे से) भारत के विभिन्न राज्यों के किसानों से वर्चुअल मोड से जुड़ने और बातचीत करने के लिए 'किसान संपर्क सूत्र' आयोजित किए गए हैं। देश भर के किसानों और ओड़िशा राज्य के किसानों के लिए क्रमशः हिंदी और ओड़िया भाषा में ग्यारह-ग्यारह कार्यक्रम आयोजित किए गए। कृषि जल प्रबंधन के विभिन्न विषयों और मिलेट फसलों को लोकप्रिय बनाने सहित कुल 40 विषयों पर चर्चा की गई जिसमें 638 किसानों ने भाग लिया।

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

भाकृअनुप-भारतीय जल प्रबंधन संस्थान, भुवनेश्वर द्वारा संचालित देश के विभिन्न कृषि उप पारिस्थितिकी सब क्षेत्रों में स्थित सिंचाई जल प्रबंधन पर अखिल भारतीय समन्वित अनुसंधान परियोजना के कुल 26 केन्द्रों के द्वारा मृदा-जल पौधे संबंध पर बुनियादी अध्ययन एवं इनकी प्रतिक्रिया पर अनुसंधान किया जाता है तथा अधिक वर्षा वाले क्षेत्रों में वर्षा जल प्रबंधन, जल के बहुआयामी उपयोगों से उत्पादकता में वृद्धि, क्षेत्रीय स्तर पर भूजल का उपयोग, भूजल का मूल्यांकन और पुन:भरण, दबाव सिंचाई पद्धतियों (ड्रिप एवं स्प्रिंकलर) 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 Phase II)

भाकृअनुप - भारतीय जल प्रबंधन संस्थान, भुवनेश्वर जल पर कृषि भागीदारी अनुसंधान मंच (एग्री-सीआरपी ऑन वाटर -फेज-II) परियोजना के प्रमुख केंद्र के रूप में अनुसंधान कार्य कर रहा है। इस परियोजना के तहत चार विषयों पर अनुसंधान आयोजित किया जा रहा है। भारत के विभिन्न कृषि-पारिस्थितिक क्षेत्रों में भूसूचना एवं नैनों तकनीक के उपयोग से सतही जल संसाधनों का विकास एवं मृदा में नमी का प्रबंधन, कुशल एवं स्मार्टसिंचाई जल प्रबंधन के लिए स्वचालित नहरी सिंचाई पद्धति का विकास एवं भूजल-ऊर्जा नेक्सस का विश्लेषण करके भूजल की स्थिरता में सुधार, इंटरनेट ऑफ थिंग्स युक्त सेंसर आधारित स्मार्ट सिंचाई प्रबंधन पद्धति का विकास आदि पर अनुसंधान हो रहा है।

प्रकाशन, पुरस्कार और सम्मान

भाकृअनुप - भारतीय जल-प्रबंधन संस्थान, भुवनेश्वर के वैज्ञानिकों द्वारा वर्ष 2023 के दौरान कुल 45 शोध पेपरों के अलावा 9 पुस्तक अध्याय, 8 तकनीकी बुलेटिनों और 18 लोकप्रिय लेखों को प्रकाशित किया गया है। इसके अलावा, इस 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 संस्थान में 19 घरेलू, 13 बाह्य वित्त पोषित, 1 परामर्श अनुसंधान परियोजना और एक प्रायोजित प्रशिक्षण कार्यक्रम पर काम कर रहे हैं। यह सभी परियोजनाएं कृषि में जल प्रबंधन से संबंधित हैं।

मानव संसाधन विकास, प्रशिक्षण और क्षमता निर्माण

इस संस्थान के कर्मचारियों ने अलग-अलग संगठनों से विभिन्न विषयों पर प्रशिक्षण प्राप्त किया है। भाकृअनुप-भारतीय जल प्रबंधन संस्थान, भुवनेश्वर ने ऑनलाइन के माध्यम से कई बैठकों/कार्यक्रमों को आयोजित किया है तथा किसानों के लिए भी प्रशिक्षण कार्यक्रमों को आयोजित किया है। इस संस्थान द्वारा किसानों के लिए अन्य महत्त्वपूर्ण प्रशिक्षण कार्यक्रमों/विचार विमर्श बैठकों का भी आयोजन किया गया।

EXECUTIVE SUMMARY

Rainwater Management

In-situ **rainwater management for enhancing income and water productivity**

In-situ rainwater management practices for enhancing farm income and water productivity of uplands resulted in highest yield of ginger, marigold and pointed gourd as 16 t/ha, 15.82 t/ha and 18.52 t/ha, respectively by the treatment combination comprising of planting in bottomless earthen cylinder + straw mulching + three fourth filled cylinder + percolation pit experiment conducted at ICAR-IIWM Research farm, Bhubaneswar.

Post-flood management plans

Year wise (2017-2022) comparison of flood affected and waterlogged areas in the Lokapala of Kanas block in Puri district of Odisha were delineated using the Sentinel-1 satellite data. The area under flood inundation was calculated to be the highest (405.6 ha) during 2018 and the lowest (9.1 ha) during 2017. Whereas, the area under waterlogging was calculated to be highest (458.5 ha) during 2022, which is at par with the year 2018 (448.2 ha) and the lowest (73.1 ha) during 2017. Moreover, the flood affected area ranged within 9.1 ha (2017) to 405.6 ha (2018).

Neem coated urea (NCU) and AGROTAIN incorporated urea (AIU) on rice growth and yield

Fertilizer was applied to *Kharif* transplanted rice (variety *Swarna*) at 100 kg N, and 50 kg each of P_2O_5 and K_2O ha^{-1} using urea, SSP and MOP. Urea was provided using neem coated urea (NCU) and AGROTAIN incorporated urea (AIU). Both the sources of urea performed similarly and yielded highest when the best management practice of incorporating the fertilizer at basal application and tillering was adopted.

Development of sensor based alternate wetting and drying (AWD) in transplanted rice

Sensor based irrigation automation in transplanted rice for alternate wetting and drying schedule was developed. Both the proto type model for laboratory scale and main model for field scale use were developed and tested. The system detects water level inside the designated *Panipipe* using ultrasonic sensor. The microcontroller continuously compares each water level data to the threshold. When the water level inside pipe falls below 10 cm from surface, one interrupt is generated to switch on the water lifting pump. Similarly, when the water level reaches 5 cm above the soil surface, signal is generated to switch off the water lifting pump. The water level data and pump status data is stored in the memory card inserted in the datalogger. This helps in quantifying the irrigation water volume supplied to the field.

Increasing agriculture resilience through agricultural disaster risk management strategy in India

Flood affected areas in Odisha during the monsoon 2023 by taking different threshold values used in Google earth engine algorithm were delineated using the Sentinel-1 satellite data. The waterlogged area in Odisha was found to be 583938 ha in July, 902425 ha in August and 381332 ha in September during 2023, by taking threshold value as 1.10. The area under inundation in Odisha was found to be 30522 ha in July, 40484 ha in August and 32393 ha in September during 2023, by taking threshold value as 1.50.

Rainfall prediction using machine learning models

The monthly rainfall data from 1901 to 2019 were considered for rainfall prediction in 30 different stations/ districts. Models were trained with different machine learning models. It was found that shallow learning models outperformed the deep learning models based on the DM-test. Based on the best model, monthly rainfall upto 2030 was forecasted. Bland-Altman plot layer was added for validation to check Limits of Agreement (LoA) between the observed and predicted value. It was found that more than 95% of prediction agreed with the observed data.

Canal water management

Evaluation of subsurface drip irrigation (SDI) system in baby corn and maize

The performance of subsurface drip irrigation (SDI) with different lateral pressures (75 kPa, 100 kPa, 125 kPa, 150 kPa) and depths (10 cm, 15 cm and 20 cm) was studied and compared with surface drip irrigation (DI) and surface irrigation (SI) in maize-tomato-baby corn cropping sequence at ICAR-IIWM research farm, Mendhasal. The subsurface drip irrigation (SDI) at 125 kPa with 15 cm depth saved 18% and 42% irrigation water compared to DI and SI, respectively in tomato (*cv. Samrat*) during *rabi* season. Yield enhancement of 15% and 33% resulted in 34% and 108% improvement in water productivity (WP) under SDI compared to DI and SI in the crop. In baby corn (cv. G-5414) which was grown as a summer crop after tomato, the water use in

SDI was 15% and 39% less than DI and SI, respectively. Yield under SDI was 12% and 34% higher than DI and SI, respectively; whereas WP in SDI increased by 32% and 122% compared with DI and SI, respectively in baby corn. Moreover, during *kharif* season, the yield under SDI at 15 cm lateral depth was statistically at par ($P < 0.05$) with that in SDI at 10 cm lateral depth and DI in maize (sweet corn cv. *Sugar 75*). The yield under SDI was 7% higher than that under SI. The water productivity under SDI was 7% and 18% higher than DI and SI, respectively in maize.

Natural farming: Impact on crop and water productivity

To understand the impact of different farming methods viz. conventional (chemical) farming, organic farming and natural farming on yield in a cropping system of the rice-tomato-green gram, field experiments were conducted at ICAR-IIWM Research farm. In all the crops, the highest yield was obtained under conventional farming followed by organic/natural farming. A 16-18% decline in rice grain yield, a 9-18% decline in tomato fruit yields, and a 6-9% decline in the yield of green gram were observed in organic/natural farming than in conventional chemical farming.

Precision irrigation management in conservation agriculture

The field experiment to study the performance of precise irrigation under conservation agriculture in intensive rice-based cropping system of Eastern India resulted highest grain yield of maize under conventional tillage with precise irrigation (PI) which was statistically at par with zero tillage (ZT) with precise irrigation. The highest water productivity (14.43 kg/ha-mm) of maize was observed under zero tillage with precise irrigation. The highest green gram seed yield (870 kg/ha) was obtained from ZT with PI. Similarly, the water productivity of green gram was the highest (2.86 kg/ha-mm) under ZT with PI. The highest water productivity (6.46 kg/ha-mm) of rice was obtained in zero tillage direct seeded rice (ZTDSR) with PI. The rice grain yield in DSR was 8% lower than puddled transplanted rice (PTR). However, the water productivity of DSR was 17% higher than the PTR.

Resource conservation technologies in maize-sunflower cropping system

The highest maize cob yield was observed under zero-till sub-surface drip irrigation with residue (ZTSDI+R, 12.54 t/ha) and the lowest in conventional till flatbed furrow irrigation (CTFBF, 10.78 t/ha). The highest cob yield and lowest water use resulted in the highest water productivity (22.23 kg/ha-mm) in ZTSDI+R which was 35% higher than that in CTFBF. During *rabi* season, the sunflower seed yield was the highest under ZTSDI+R (2.04 t/ha). The seed yield of ZTSDI+R was statistically at par with zero-till sub-surface drip irrigation (ZTSDI), zero tillage drip irrigation with residue (ZTDI+R) and zero tillage drip irrigation (ZTDI). The seed yield was the lowest in CTFBF (1.42 t/ha). The highest seed yield and the lowest water use under the ZTSDI + R led to highest water productivity (6.97 kg/ha-mm).

Economic water productivity in irrigation canal commands

Water accounting and economic water productivity were computed and two crop scenarios were developed in Kukadi Left Bank Canal Command. With larger area estimates using geospatial method, the WUE is found 100% higher than the official recorded data. Scope exists for improvement of EWP through introduction of high value crops, mainly by reallocating water from water-intensive crops such as sugarcane to low water-intensive perennial crops such as pomegranate or seasonal crops such as vegetables. The productivity of various WUAs is positively associated with cropping intensity and negatively with crop diversification. Developed alternative scenario of cropping patterns result in net value of output (NVOUP) gains.

Groundwater Management

Climate change impacts on groundwater resources

Climatic data analysis showed that droughts of 2002, 2004, 2008, 2009, 2012, 2015 had notable impacts on groundwater-irrigated alluvial aquifer of Ganga basin. Between pre-2000 (1985-2000) and post-2000 (2001-2017), there was an average decline of groundwater table upto 1 m, with the January and May experiencing 1.5 m and 1.2 m decline, respectively. During pre-2000 period, the falling water table during the three-year drought around 1995 witnessed a recovery thereafter resulting in a non-significant stable sub-surface system. The spatial contrast between 1996-2000 and 2011-2015 provides further evidence regarding the coherent pattern of decline, matching the intensely irrigated belt of northern and north-western parts of the basin.

Alternate wetting and drying water management to reduce phosphorus availability under lowland rice cultivation

Performance evaluation of two water management strategies that is continuous flooding (CF) and alternate wetting and drying (AWD) irrigation along with various nitrogenous fertilizer addition rates (equivalent to 0, 100%, 133%, and 166% recommended dose of N addition) on P availability in paddy soil was carried out over the course of a 2-year field experiment. The results showed that water management had a significant influence on ferrous iron, microbial biomass P, and soil-available P. However, the addition of N did not affect the availability of P in the soil. When N was added at various rates, AWD consistently reduced the amount of soil-available P compared to CF. This was primarily because AWD increased microbial biomass, which immobilized P and decreased the content of ferrous iron. As a result, the soil's ability to absorb P increased, leading to a decrease in the amount of P available. In conclusion, AWD decreases the amount of available P in paddy soil compared to CF.

Groundwater storage trend in Baitarini river basin

Quantification of the water budget parameters (precipitation, surface runoff, evapotranspiration and groundwater storage) and season wise trend analysis by using Innovative Trend Analysis (ITA) for Baitarani River Basin of India showed that precipitation and surface runoff followed a non-monotonic negative (–*ve*) trend in winter season and monotonic positive (+ve) trend in all other season for all gauging stations (Champua, Keonjhar, Swampatna, Thakurmunda, Anandpur, Belbahali, Akhuapada and Bhadrak). The spatial analysis on groundwater storage showed that the upper catchment areas of the river basin is more vulnerable to groundwater decline.

Groundwater salinity trend in Kushabhadra-Bhargavi doab

Groundwater-salinity trend analysis showed the increasing trend over the years in Gop block. Groundwater quality for the pre-monsoon and post-monsoon season were compared by plotting Durov's diagram. The groundwater quality is marginally better in post-monsoon season. This can be attributed to dilution of groundwater salinity in post-monsoon season due to recharge from rainfall. Resistivity survey was done at 6 sites using vertical electrical sounding. Salinity intrusion was observed at two sites. DGPS survey was conducted for river bed and river level survey for both monsoon and post-monsoon season.

Water management in dragon fruit

The highest average yield of dragon fruit (8.6 kg/pot) was obtained in combination of cocopeat and perlite media followed by cocopeat alone (6kg/pot), cocofibre (4 kg/pot) and lowest was in soil (3.5kg/pot). The B:C ratio is found to be 1.68 for plants grown with soil while, for cocopeat it is 3.31, for cocofibre 1.65 and for combination of cocopeat and perlite it is 2.19. Dragon fruit grown under cocopeat and perlite has enhanced biochemical parameters like total carbohydrate, protein, betacyanin and total flavonoids than the dragon fruit grown in soil.

On-Farm Technology Dissemination

Technological options and policy guidelines for risk management in water quality

Surface water and groundwater quality data were collected from CWC, CGWB, CPCB, SPCB, to assess the risk to agriculture and aquaculture. Accordingly primary database was considered to develop a classification models (Decision Tree, Random Forest) to assess the suitability of water quality using machine learning. The accuracy level of train data was 1.0 and for test data was 0.97 in decision tree models. The risk associated variables were Mn > Fe > Mg that needs to be addressed. The technological options based on the water quality for its safe use in agriculture and aquaculture were prioritized.

Can organic amendment and seed priming alleviate the chromium (VI) toxicity in rice?

Elevated level of Cr significantly reduced plant growth, delayed flowering, and produced a lower yield of rice and tomato. The addition of vermicompost and seed priming technique enhanced the plant growth by limiting the Cr translocation in plant ultimately leading to a larger yield.

Site suitability analysis for crop planning and aquaculture development

Identification of suitable sites for aquaculture in the coastal region of Odisha and Western coast of India (Kerala) were carried out by using Analytical Hierarchy Process based upon the site-specific water quality, soil quality, infrastructure facilities etc.

Outreach activities

Enhancing land and water productivity through integrated farming system (Tribal Sub Plan Project-Now STC)

Facilitated with farm inputs and organization of outreach field day activities like capacity building measures/skill development, on farm trials and frontline demonstrations to bring changes in pipe-based irrigation and crop diversification in two tribal villages located in aspirational districts of Rayagada and Gajapati in Odisha (Left Wing Extremism affected - Priority 1 districts >=50% STs) in association with two KVKs of State Agricultural University. During the period, a micro irrigation-based farming system model was initiated in Phatachanchada village (Gajapati).

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

In order to bring in crop diversification and improve income of farmers, seeds of high value crops, plant protection chemicals, biofertilizers, urea and water-soluble fertilizers, saplings, fish feed, vermicompost, decomposer etc. were distributed to 350 farmers of SC farmers in Nimapada. Apart from this mini power weeders, large power weeders, shade net, plastic cladding film for protected cultivation structure, HDPE sprinkler pipes, HDPE conveyance pipes, barbed wire, galvanized sheets were distributed to farmers of Hansapada and Villigram villages of Nimapara block. Different modules like NRM, horticulture, crop, fishery, enterprise and social media interventions were carried out. Six training and five capacity building programs were also conducted under the project.

Farmer FIRST Project

The Farmer FIRST project has been implemented in three villages i.e., Haridamada, Jamujhari and Giringaput in Khordha district. Different modules like NRM, horticulture, crop, livestock, fishery, enterprise and social media interventions were carried out. Seven field level training and demonstration programmes were conducted, in which more than 800 farmers and farm women were benefited. Ten rice and millet field days along with crop cutting experiments (CCEs) of demonstrated high yielding rice varieties (var. *Swarna sub-1, Binadhan 11, Mrunalini and MTU 1001*) and finger millet (*var. Arjun*) were conducted during *kharif* 2023.

MGMG activities

Institute is organizing *Mera Gaon Mera Gaurav* Activities in 33 villages in 4 Districts (Khordha, Puri, Nayagarh and Cuttack) of Odisha under 7 clusters. Nearly 7 training programs on Water management technologies were conducted in the adopted villages involving 322 farmers. Demonstration program on summer vegetables with NHRDF seed kit, raised bed nursery for production of healthy vegetable seedlings and *rabi* vegetables were conducted. Nearly 200 farmers were participated in the demonstration program during 2023. Apart from this, nearly 15 numbers of Farmer-Scientist interaction meeting and one *Swachhata* awareness program and one vigilance programme was organized in these adopted villages.

Swachh Bharat Abhiyan

ICAR-IIWM participated actively in *Swachh Bharat Abhiyan,* cleanliness drives and *Swachata* Awareness Campaigns during 2023 in the Institute's main campus, MGMG villages, public places and tourist spots; motivated students, organized debate, lectures, seminars and training.

Kisan Sampark Sutra (KSS)

Institute is organizing *'KISAN SAMPARK SUTRA'* to connect and interact with farmers in virtual mode from different States of India on fortnight basis (7.00 PM onwards). Eleven programs each were conducted in hindi and odia language for the farmers across the country and for the farmers of Odisha, respectively. A total of 40 topics on water management aspects and popularization of millet crops were discussed in which a total of about 638 farmers participated.

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 and their interaction, and extension work in the field of assessment of water availability, rainwater management in high rainfall areas, enhancing productivity by multiple uses of water, groundwater use at the 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.

Agri-Consortia Research Platform on Water

ICAR-IIWM acts as a coordinating unit of Agri-CRP on water (Phase-II) and research work is being conducted under four themes. Development and management of surface water resources and soil moisture in different agro-ecological regions of India using Geoinformatics and Nano Technology, automated canal irrigation system for efficient and smart irrigation water management, improving groundwater sustainability through analyzing groundwater-energy nexus, IoT enabled sensor based smart irrigation management system.

Publication, awards and recognitions

In 2023, scientists of ICAR-IIWM published 45 research papers, 9 book chapters, 8 technical bulletins and 18 popular articles. Scientists have received several awards along with many honors and recognitions.

Research projects

Scientists of ICAR-IIWM are working on 19 in-house, 13 externally funded, 1 consultancy research project and one sponsored training program.

HRD, training and capacity building

Our staff received training on various topics from different organizations; ICAR-IIWM conducted several virtual meetings/programs and farmers training program/interaction meetings.

CONTENTS

INTRODUCTION

The ICAR-Indian Institute of Water Management was established on May 12, 1988, to cater to the research and development needs of agricultural water management at the national level. The institute is located at Chandrasekharpur, Bhubaneswar on 15.71 ha of land along with its main office-cum-laboratory building, guest house and residential complex. It is situated about 8 km north of railway station and at about 9.5 km away from Biju Patanaik International Airport, Bhubaneswar. The location of the Institute is at 200 15' N and 85052'E at 23 m above mean sea level. The research farm of the Institute (63.71 ha of farmland) is located at Deras, Mendhasal (20017' N and 850 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.
- Coordinate research for generating location-specific technologies for efficient use of water resources.
- Centre for training in agricultural water management.

Research Achievements

Core research activities of the institute are carried out under four programs, viz., rainwater management (including waterlogged area management), canal water management, groundwater management and on -farm technology dissemination (including wastewater management, water policy & governance) to solve the agricultural water management related problems. The institute is bestowed with an experienced multi-disciplinary team of scientists. Significant research achievements for the year 2023 have been included in this annual report under four programs of the Institute. Our scientists are actively involved in the *In-situ* rainwater management for enhancing income and water productivity, Post-flood management plans, cropped area mapping through remote sensed high-resolution data, periphyton-based Carp-SIS Polyculture System, development of sensor based alternate wetting and drying (AWD) in transplanted rice, rainfall prediction using machine learning models for crop planning, evaluation of subsurface drip irrigation systemin baby corn and maize, natural farming, precision irrigation management in conservation agriculture, climate change impacts on groundwater resources, alternate wetting and drying water management to reduce phosphorus availability under lowland rice cultivation, groundwater storage trend in Baitarini River Basin, seawater intrusion dynamics in Kushabhadra-Bhargavi etc.

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 centers under 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 uses of water, groundwater use at the 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.

ICAR-IIWM acts as a coordinating unit of Agri-CRP on water (Phase-II) and research work is being conducted under four themes i.e., development and management of surface water resources and soil moisture in different Agro-ecological regions of India using geoinformatics and nano technology, automated canal irrigation system for efficient and smart irrigation water management, improving groundwater sustainability through analyzing groundwater-energy nexus and IoT enabled sensor based smart irrigation management system.

ICAR-IIWM is one of the technical partners for World Bank funded project on Rejuvenating Watersheds for Agricultural Resilience through Innovative Development (REWARD) Project for Odisha. Centre has taken up Odagaon and Daspalla block in Nayagarh district of Odisha as model and monitoring watershed, respectively. Many outreach activities livelihood improvement of the farmers were conducted during 2023. Scheduled caste community through SCSP projects in of Hansapada and Villigram villages of Nimapara block in Puri district of Odisha were provided with agricultural inputs to improve the livelihood status of farmers. Scheduled Tribe farmers are being addressed through Tribal Sub Plan Project (Now STC) in Gunupaur Block in Rayagada and R.Udaigiri block in Gajapati district of Odisha. The Farmer FIRST project has been implemented in three villages i.e., Haridamada, Jamujhari and

Giringaput in Khordha district. Different modules like NRM, horticulture, crop, livestock, fishery and social media interventions were carried out. Twelve field level training and demonstration programmes were conducted, in which more than 900 farmers and farm women were benefited. Institute is organized Mera Gaon Mera Gaurav Activities in 33 villages in 4 Districts (Khordha, Puri, Nayagarh and Cuttack) of Odisha under 7 clusters. Nearly 7 training programs on Water management technologies were conducted in the adopted villages involving 322 farmers. Demonstration program on summer vegetables with NHRDF seed kit, raised bed nursery for production of healthy vegetable seedlings and *rabi* vegetables have been conducted. Nearly 200 farmers participated in the demonstration program during 2023. Apart from this, nearly 15 numbers of Farmer-Scientist interaction meeting and one *Swachhata* awareness program and one vigilance programme was organized in these adopted villages. Several training programs on various aspects of water management, enhancement in water productivity is being conducted through offline and evening online programs like *Kisan Sampark Sutra* (KSS). ICAR-IIWM participated actively in *Swachh Bharat Abhiyan,* cleanliness drives and *Swachata* Awareness Campaigns were conducted during 2023 in the Institute's main campus, public places and tourist spots; motivated students, organized debate, lectures, seminars and training.

Infrastructure facilities and organization

The Institute has state-of-art infrastructure facilities and has four well equipped laboratories, vi., soil-water-plant relationship, irrigation & drainage, hydraulic, geoinformatics, plant science with all the latest equipment for research activities. An engineering workshop also caters to the needs of the institute. The institute has its web server and regularly updated website (https://iiwm.icar.gov.in). The entire network administration of the computers, internet, and website management is looked after by the Agricultural Knowledge Management Unit (AKMU) cell. The AKMU cell also accommodates a fully developed GIS laboratory. The air-conditioned library of the institute has more than 20000 reference books and subscribes to 14 international and 6 national journals. It has a CD-ROM Server with a 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 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 Groundwater 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 has been awarded with many sponsored collaborative projects by various organizations like NASF, ICAR, New Delhi, IWMI, Colombo, DST and REWARD with World Bank and DST. The institute is the coordinating center for AICRP on Irrigation Water Management and ICAR-Agri-consortia Research Platform on Water, ICAR, New Delhi.

Finances

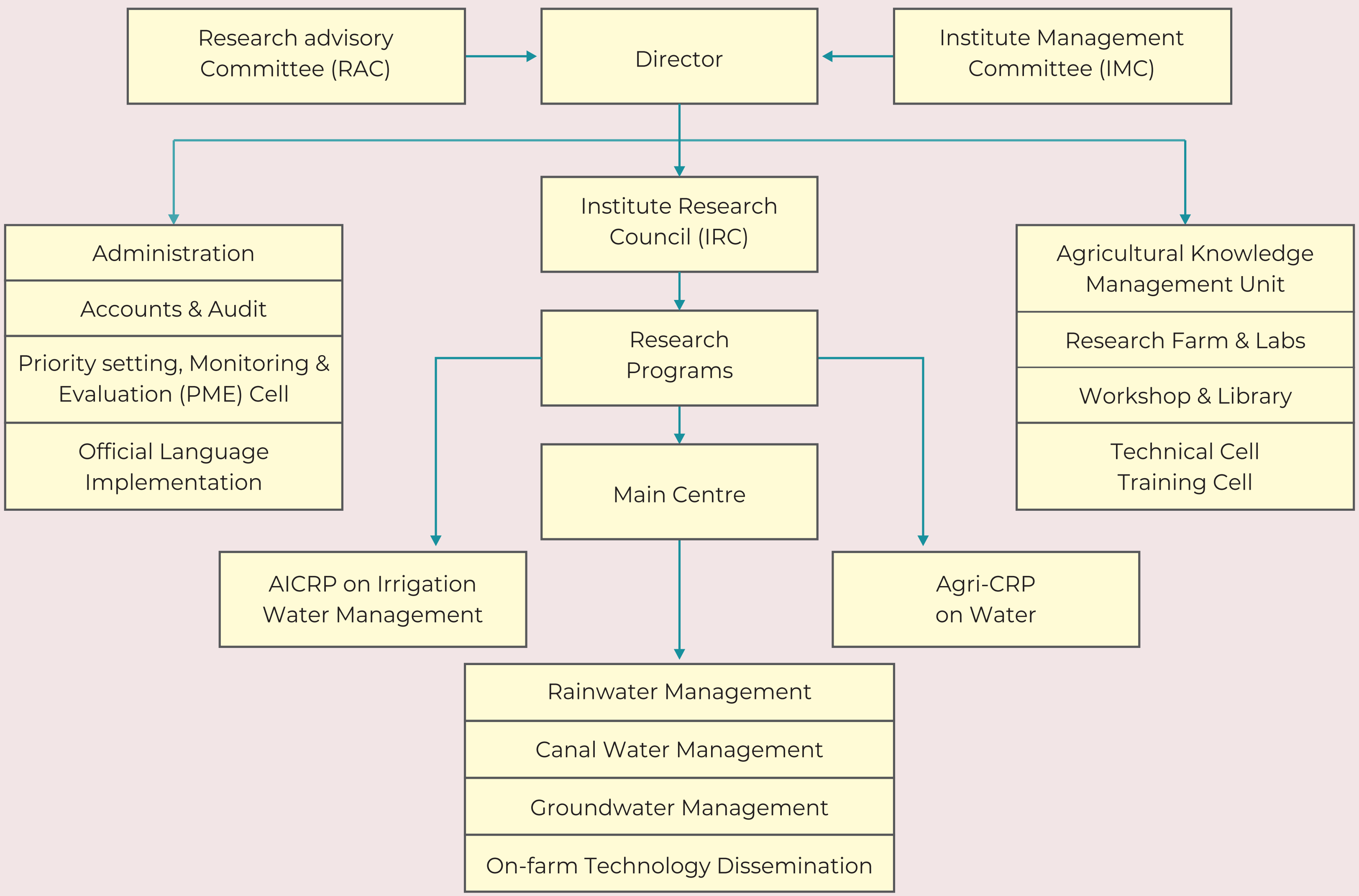
Summary of the income & expenditure account and balance sheet of the Institute during the year 2023 is presented at the end of this report.

Staff

As of December 31, 2023, ICAR-IIWM had 88 sanctioned posts (including AICRP-IWM coordinating center), out of which 60 are in position. Details of the personnel are given below:

Cadre	Sanctioned	In position	Vacant
RMP	01	01	-
Scientific	40	32	08
Technical	17	10	07
Administrative	24	12	12
Supporting	06	05	01
Total	88	60	28

ORGANOGRAM


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

RESEARCH ACHIEVEMENTS
RAINWATER MANAGEMENT

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

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

Three profitable agro-forestry systems with in-situ runoff conservation measures were under taken in a project at ICAR IIWM research farm, Mendhasal, Khurda. The field experiment was conducted in split plot design with four replications. The main plot treatments are drumstick + ginger, drumstick+ marigold and drumstick+ pointed gourd. The sub plot treatments are 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). Mulching was provided with use of paddy straw @ 5t/ha. Two percolation pits with a dimension of each having 45cm length, 45 cm breadth 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 2.25 m. Marigold variety *African Giant tall orange,* ginger variety *Suprabha* and pointed gourd variety *Swarna Alaukik* were grown with recommended package of practices. The soil profile moisture and various crop yields were given in Table 1, 2 and 3. With reference to monthly soil moisture content, the intercrops didn't exhibit significantly different values with each other and Drumstick + pointed gourd exhibited higher moisture content in most months may be due to complete coverage of ground with its foliage. Among the sub plot treatments, normal planting recorded lower moisture content compared to planting in bottomless earthen pipes and large differences were not observed among various treatments. With respect to various intercrops, maximum ginger yield of 16.00 t/ha was recorded with S_4 treatment, which was found to be significantly superior to S_1, S_2 and at par with S_3. Similarly, highest marigold flower yield of 15.82 t/ha was recorded in S_4 treatment combination which was found to be significant to S_1, S_2 and at par with S_3. Pointed gourd yield also exhibited similar trend and highest yield of 18.52 t/ha was recorded in S_4. Highest water productivity was observed by S_4, among all the treatment combinations. The average drumstick pod length was measured to be 74.2 cm and pod girth was found to be 1.84 cm. The drumstick pod yield was not influenced by different intercrops and maximum pod yield of 12.48 t/ha was recorded in S_4 which was found to be superior to both S_1, S_2 and at par with S_3. Net amount of rainwater harvested in each pit was 1.18 m^3. Average soil erosion from the experimental plot was measured and found to be 8.97 t/


Ginger *'Suprabha'*


Marigold *'African GT'*


Pointed gourd *'Swarna Alaukik'*


Drumstick *'PKM-2'*

ha in Drumstick + Ginger plots followed by 8.10 t/ha from Drumstick + Marigold and 7.90 t/ha from Drumstick + Pointed gourd plots.

Table 1. Soil moisture content of the treatment plots on weight basis (%)

Treatment	Jun, 23	Jul, 23	Aug, 23	Sept, 23	Oct, 23	Nov, 23	Dec, 23
Main plot treatments							
Drumstick+ Marigold	16	18	19	21	20	17	16
Drumstick+ Ginger	16	18	19	20	19	17	16
Drumstick+ Pointed gourd	17	19	20	21	20	18	17
Subplot treatments							
S_1	16	18	20	20	19	17	16
S_2	16	18	21	21	20	18	17
S_3	17	18	20	20	20	17	17
S_4	17	19	21	21	20	18	17

Table 2. Yield and water productivity of various crops influenced by treatments

Treatment	Ginger		Marigold		Pointed gourd	
	Rhizome yield (t/ha)	WP (kg/m^3)	Flower yield (t/ha)	WP (kg/m^3)	Yield (t/ha)	WP (kg/m^3)
S_1	13.86	1.31	14.62	1.52	17.36	1.64
S_2	14.26	1.34	14.84	1.54	17.52	1.65
S_3	15.76	1.48	15.64	1.63	18.38	1.73
S_4	16.00	1.51	15.82	1.65	18.52	1.75
CD (0.05)	0.42		0.38		0.48	

Table 3. Green pod yield of drumstick as influence by treatments

Treatment	Pod yield (t/ha)
Main plot treatments	
Drumstick+ Marigold	10.34
Drumstick+ Ginger	10.48
Drumstick+ Pointed gourd	10.60
CD (0.05)	NS
Sub-plot treatments	
S_1	9.62
S_2	10.00
S_3	12.10
S_4	12.48
CD (0.05)	0.60
Interaction (MXS)	NS

Estimation of water footprint for sustainable water management

Project code: NRMA/IIWM/CIL/2021/005/00207

Investigators: R.K. Jena, R. R. Sethi, N. Kumar, U.K. Pradhan and S. Khedikar

Rainfall prediction is pivotal for agricultural planning, influencing crop cycles, and aiding farmers in making informed decisions regarding planting, harvesting, and irrigation. Accurate forecasts contribute to water-efficient practices and sustainable crop management. Also, rainfall data contributes significantly to climate change research by providing insights into shifting weather patterns. Understanding these changes is crucial for developing strategies to adapt and mitigate the impacts of climate change. During this period an attempt has been made to develop machine learning based forecast model for rainfall prediction in all 30 stations of Odisha. To develop the forecast model for rainfall prediction in 30 different stations/districts were carried out by using monthly rainfall data from 1901 to 2019. Model was trained with different machine learning models such as Classification and Regression Trees (CART); Gaussian Process, Support vector machine (SVR), Random Forest (RF), Xtreme gradient boosting (XGBoost), k-Nearest Neighbours (KNN), Recurrent Neural Network (RNN), Gated Recurrent Unit (GRU), Long Short-Term Memory (LSTM), Bidirectional Long Short-Term Memory (Bi-LSTM) and Deep Long Short-Term Memory (Deep-LSTM). To train the model monthly rainfall data from 1901 to 2010 and for testing purpose 2011 to 2019 are considered. To evaluate the performance of the models, different statistical measures such as RMSE (Root Mean Squared Error), MAE (Mean Absolute Error), and MASE (Mean Absolute Scaled Error) were used. Based on the best model monthly rainfall was forecasted up to 2030. It was found that shallow learning models outperformed the Deep learning models based on the DM-test. The best six machine learning models' performance as presented in Table 4. By using the best model, the prediction performance was tested based on the test dataset. The results are encouraging and models could be to capture the rainfall pattern in the test data which indicates the best fit of the model (Fig. 1).

Table 4. Performance metrics of best six ML algorithms for nine districts of Odisha

	Angul			Balangir			Balasore		
Algorithm	RMSE	MAE	MASE	RMSE	MAE	MASE	RMSE	MAE	MASE
CART	90.06	62.5	0.77	98.91	55.44	0.63	163.74	82.36	0.89
Gaussian Process	65.57	44.16	0.55	71.22	48.03	0.55	90.63	59.40	0.64
KNN	**63.90**	41.30	0.51	**67.98**	43.02	0.49	**90.09**	58.88	0.63
RF	67.29	43.99	0.54	71.87	45.45	0.52	96.87	58.14	0.63
SVR	83.93	48.76	0.60	92.01	51.75	0.59	108.1	70.69	0.76
XGBoost	77.84	47.64	0.59	85.19	52.54	0.60	101.67	61.46	0.66
	Bargarh			Bhadrak			Boudh		
	RMSE	MAE	MASE	RMSE	MAE	MASE	RMSE	MAE	MASE
Algorithm	129.74	78.72	0.93	107.31	73.49	0.88	117.75	78.78	1.10
CART	80.72	49.98	0.59	84.16	57.29	0.69	**79.82**	50.13	0.70
Gaussian Process	**72.80**	45.57	0.54	83.04	54.66	0.66	81.36	54.19	0.76
KNN	83.54	51.98	0.62	**82.10**	54.51	0.65	90.61	64.17	0.89
RF	109.70	60.50	0.72	101.40	63.39	0.76	112.68	71.88	1.00
SVR	82.30	50.69	0.6	81.17	54.54	0.66	90.88	61.03	0.85
XGBoost									
	Cuttack			Debagarh			Dhenkanal		
Algorithm	119.61	79.03	0.92	101.5	67.16	0.75	91.45	57.75	0.75
CART	81.92	54.01	0.63	68.87	44.69	0.50	74.33	49.66	0.64
Gaussian Process									
KNN	**81.25**	52.07	0.61	**63.19**	39.10	0.44	68.89	47.52	0.61
RF	82.63	55.42	0.64	67.10	41.95	0.47	71.92	47.43	0.61
SVR	113.05	73.23	0.85	94.91	59.37	0.66	87.56	56.82	0.73
XGBoost	94.56	61.47	0.71	73.71	47.44	0.53	**68.44**	44.90	0.58

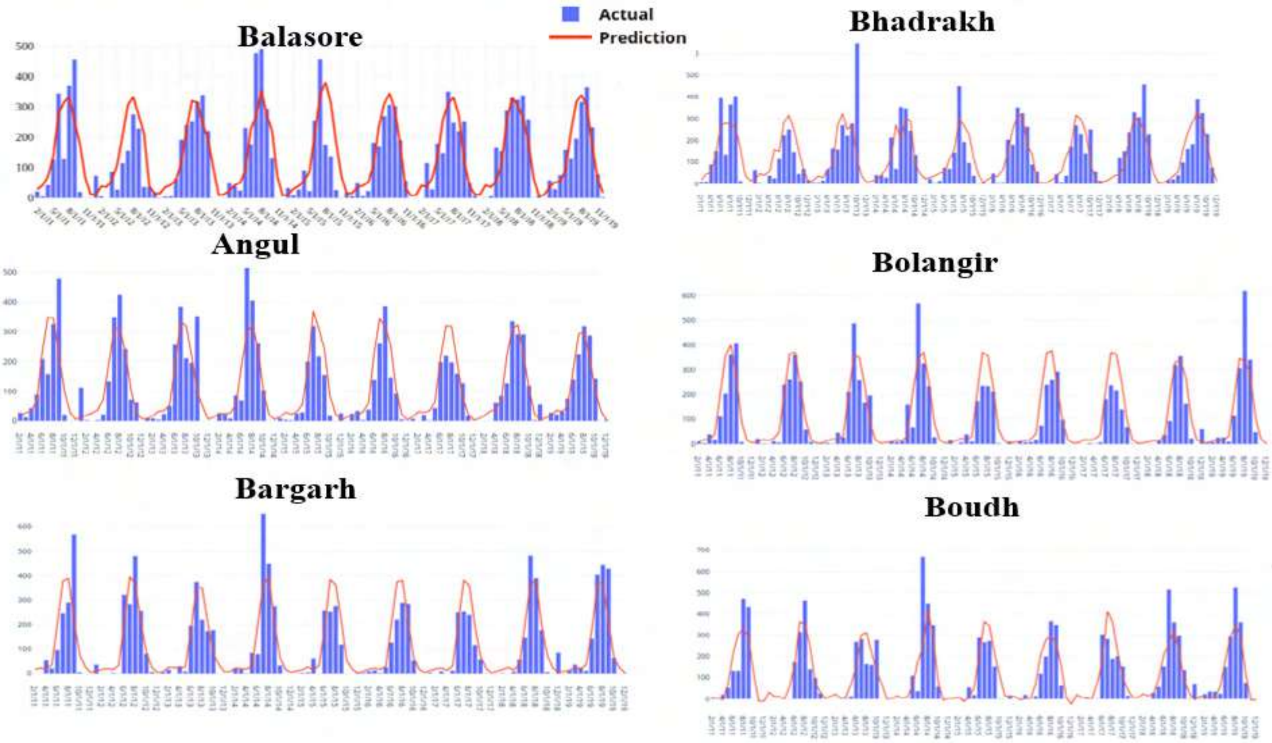


Fig. 1. Observed vs. predicted rainfall in best ML model for six districts of Odisha

Further another layer was added for validation using the Bland-Altman plot to check Limits of Agreement (LoA) between the observed and predicted value (Fig. 2). The primary purpose is to identify any systematic bias or trends between the two measurements and to assess the agreement between them. The Bland-Altman plot provides a straight forward way to assess the agreement between two measurement methods by visualizing the distribution of the differences and highlighting any patterns or discrepancies It was found that > 95% of our predicted agreed with the observed data.

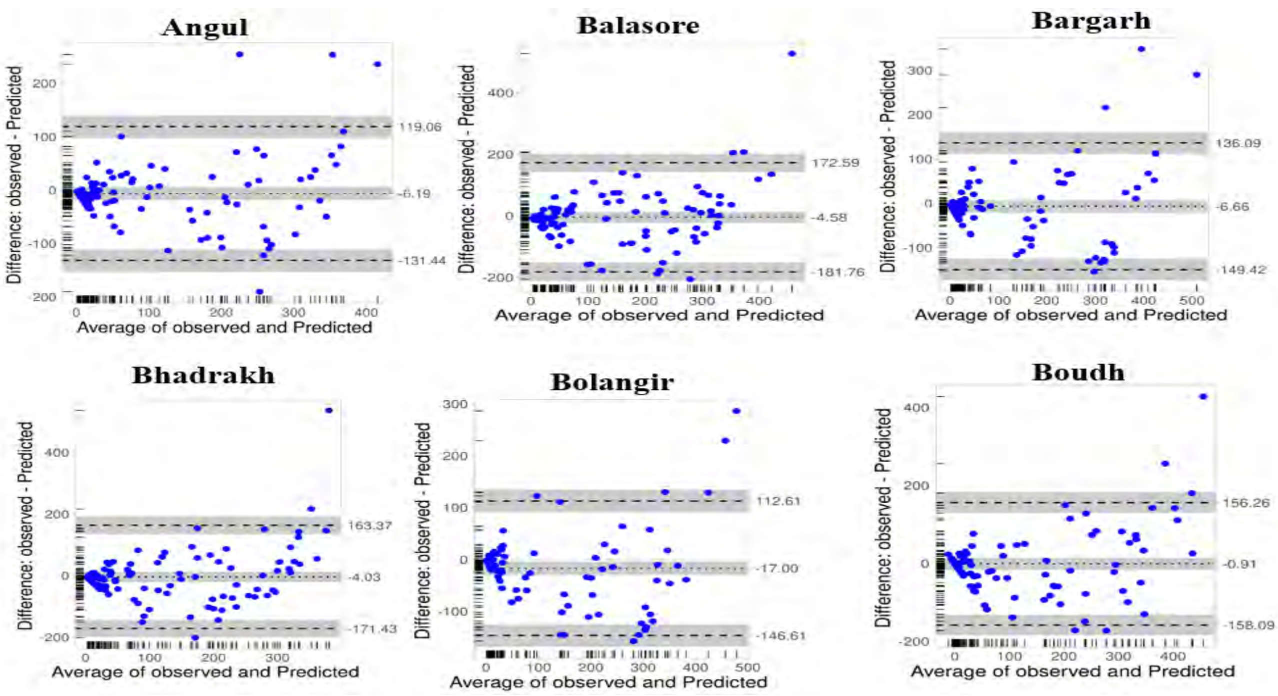


Fig. 2. Bland-Altman plot and limit of agreement

Crop planning under climate change scenario in Mahanadi and Godavari Basin

Project Code: NRMA/IIWM/SIL/ 2022/003/00215

Investigators: A. Jha, D. Ghosh, D. K. Panda and A.K. Misra

Projected weather data of 18 blocks of Balangir district, 13 blocks of Kalahandi district of Odisha and 23 blocks of Bhadradi Kothagudem district of Telangana were downloaded from MarkSim (http://gisweb.ciat.cgiar.org/marksimgcm/) weather generator website, which is an ensemble of all 17 GCMs to analyze trends of climatic parameters. Out of 17 GCMs, projected data of HadGEM2-ES was used for the study. The weather data has been generated for 2030, 2040 and 2050. The weather parameters viz., rainfall, maximum and minimum temperature have been used for the trend analysis. As per all the RCP, monthly maximum, minimum, mean temperature and rainfall showed an increasing trend for the year 2030, 2040 and 2050. For Balangir, the decadal trend of maximum temperature increases at the rate of 0.019°C, 0.046°C/ decade, 0.033°C/ decade and 0.053°C/ decade for the scenario RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5 respectively, whereas minimum temperature increases at the rate of 0.021°C/ decade, 0.043°C/ decade, 0.038°C/ decade and 0.065°C/ decade for the scenario RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5 respectively. Rainfall showed increasing trend at the rate of 0.11 mm/decade, 1.52 mm/decade and 3.3 mm/decade for the entire scenario except RCP 4.5 which showed decreasing trend @ 0.88mm/decade. For Kalahandi, the decadal trend of maximum temperature increases at the rate of 0.017°C/decade, 0.045°C/ decade, 0.031°C/ decade and 0.05°C/ decade for the scenario RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5 respectively, whereas minimum temperature increases at the rate of 0.02°C/decade, 0.04°C/decade, 0.03°C/decade and 0.06°C/decade for the scenario RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5, respectively. Rainfall showed an increasing trend at the rate of 0.25 mm/decade, 0.48 mm/decade and 2.95 mm/decade for the entire scenario except RCP 4.5 which show decreasing trend @ 0.71 mm/decade.

For Bhadradri Kothagudem, the decadal trend of maximum temperature increases at the rate of 0.017°C/decade, 0.039°C/decade, 0.029°C/decade and 0.045°C/decade for the scenario RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5 respectively, whereas minimum temperature increases at the rate of 0.019°C/decade, 0.045°C/decade, 0.358°C/decade and 0.05°C/decade for the scenario RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5 respectively. Rainfall showed an increasing trend at the rate of 0.22 mm/decade, 0.12 mm/decade and 1.74 mm/decade for the entire scenario except RCP 4.5 which shows decreasing trend @ 0.89 mm/decade.

Periphyton-based Carp-SIS Polyculture System: Effects on Zootechnical and Production Performance

Project Code: NRMA/IIWM/SIL/ 2022/004/00216

Investigators: R. K. Mohanty, R. K. Panda and A. Jha

A study was initiated in 2023 to study the effect of artificial substrate induced periphyton biomass on the consumptive and total water requirement in carp-SIS (Small Indigenous Species) polyculture system in zero-water exchange earthen ponds. Field study for grow-out operation is carried out at ICAR-IIWM research farm. All total there will be 3-crop cycles (1-crop/year). Zero- water exchange with and without artificial substrate (aqua mat for periphyton development) is taken as treatment. Stocking density of Indian Major Carp (IMC) fingerlings is maintained at 5000 ha^{-1} in all the treatments. Stocking composition of IMCs is maintained at 30:30:40: SF:CF:BF. Stocking density of Mola seed is maintained at 15000, 25000 and 35000 ha^{-1} in T_1 (no aqua mat), T_2 (aqua mat equivalent to 50% of WSA) and T_3 (aqua mat equivalent to 75% of WSA), respectively. Rearing duration will be of 300 days. Management practices and feeding programme are same for all treatments and replications. Periodic data on amount of water replenishment/ exchange, seepage & percolation loss, depth of water in the pond, rainfall, evaporation, hydrological index, water quality parameters (pH, DO, turbidity, TSS, TDS, total plankton count, total alkalinity, nitrite, nitrate, temperature, H_2S, NH_3, total bacterial load in each experimental pond, estimation of periphyton biomass, periphyton diversity, Autotrophic Index, etc.), growth parameters (absolute growth, PDI, performance index, production-size index, sustainable growth rate) are taken up at regular intervals. Periodic harvesting of A. mola is also carried out. Survivability (%), Feed efficiency (FE), AFCR, sediment load, biomass yield (t/ha), nutritional water productivity and economic water productivity (Rs/m^3). etc. will be estimated after final crop harvesting in the month of April.

Experimental pond with fixed bamboo mats for growth of periphyton biomass

Periodic harvest of Amblypharyngodon mola

Catchment-command characterization & Evaluation of Rainwater Harvesting Structures in a Treated Watershed

Project Code: NRMA/IIWM/SIL/2022/005/00217

Investigators: B. K. Sethy, P. K. Panda, S. K. Mishra and H. K. Dash

A study was initiated in a treated micro-watershed 'Unnakotiswar Dakhinakali' at Latadeipur in Gondia block of Dhenkanal. It is located at 20^{0}46'30" N to 20^{0}49'0" N latitude and 85^{0}39'30" E to 85^{0}41'0" E longitude. The watershed was developed during 2010-2015 under IWMP-II and PMKSY. The watershed (About 720.5 ha) covers one village Lata Deipur with 214 households. Land use and land cover of the watershed revealed that forest area (95.4 ha,) non-agriculture use 200.08 ha, permanent pasture 29.8 ha, temporary fallow (4.0 ha,) permanent fallow 52.98 ha and agriculture (337.74 ha) (Rainfed:329.14 ha and irrigated:8.6 ha) exist in the watershed. Single crop (paddy: *Swarna, Rani, Kalachampa,*1025 with yield range 2 to 5 t/ha) of 290 ha and double crop (Green gram, water melon, vegetable, etc.) of 26 ha is taken up the watershed. In the watershed, 8 check dams, 16 farm ponds, 10 loose boulder check dams were available. The average annual rainfall in the watershed was 1339.81 mm with very high runoff and soil loss from the watershed. Five numbers of rainwater harvesting structures were selected for the study and topographic survey was made for their catchment characterization. Minor repair and renovation work at the inlet and outlet of rainwater harvesting structures were carried out.

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: S.K. Jena, B.S Satpathy, A. Maity, G. Amarnath and A.K. Sikka

Year wise (2017-2022) comparison of flood affected areas and waterlogged areas in the Lokapala of Kanas block in Puri, Odisha and flood affected Dhemaji and Lakhimpur districts of Assam in 2023 were delineated using the Sentinel-1 satellite data. The area under flood inundation in Lokapala of Kanas block, Puri was calculated to be highest (405.6 ha) during 2018 and lowest (9.1 ha) during 2017. Whereas, the area under waterlogged in Lokapala of Kanas block, Puri was calculated to be highest (458.5 ha) during 2022, which is at par with the year 2018 (448.2 ha) and lowest (73.1 ha) during 2017. Moreover, flood affected area in Lokapala of Kanas block of Puri district ranged from a maximum of 405.6 ha in 2018 and a minimum of 9.1 ha during 2017. During the period of 6 years (2017-2022), the flood occurred during months of July and August. In this area, the flood inundation during August 2022 was one of the worst conditions, presented in Fig. 3. The area under inundation in Lakhimpur and Dhemaji districts in Assam were found to be 35647 and 20147 ha, respectively during June 2023 and are *shown in* Fig. 4 & Fig.5. The surging water breached the Narayanpur farm bund in Lakhimpur district and 24 villages in Lakhimpur district were affected. The composite soil samples from three reaches in the flood affected Lokapala village of Kanas block were analyze and spatial maps for different soil properties were prepared.

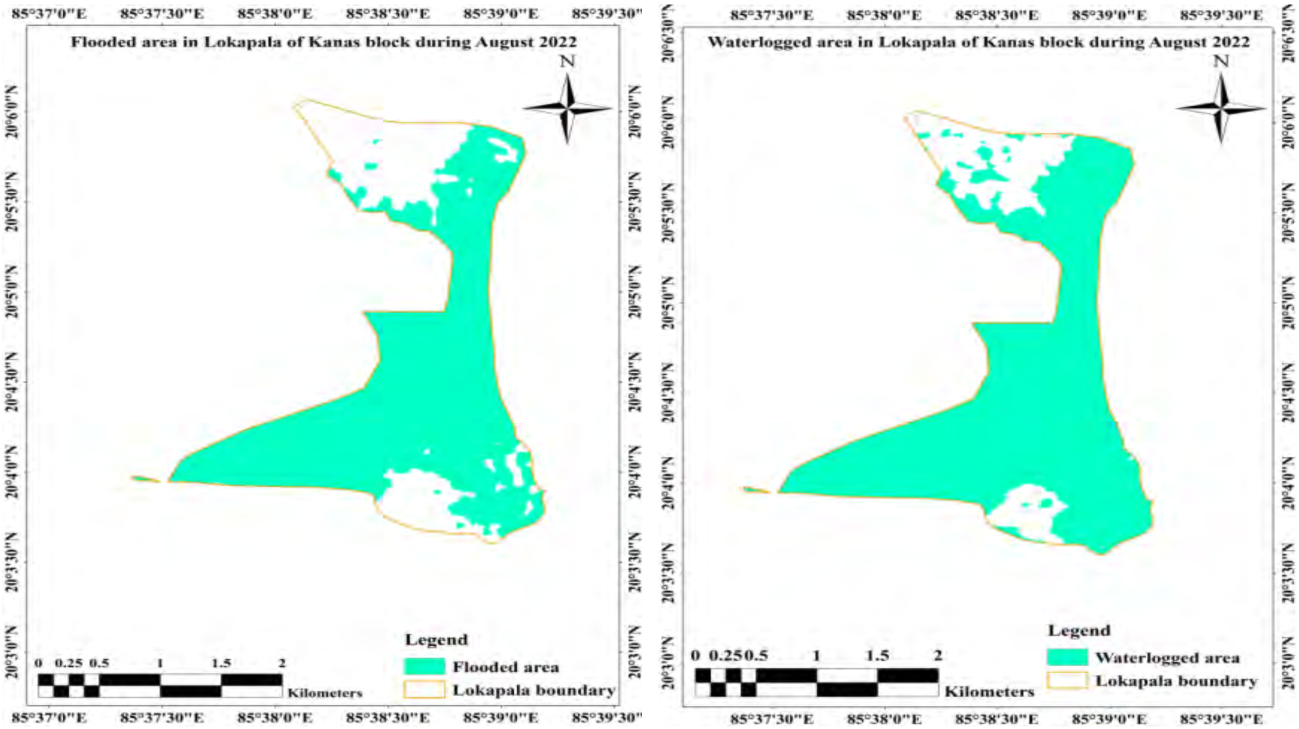


Fig. 3. Comparison of flooded and waterlogged area of Lokapala in Kanas (August, 2022)

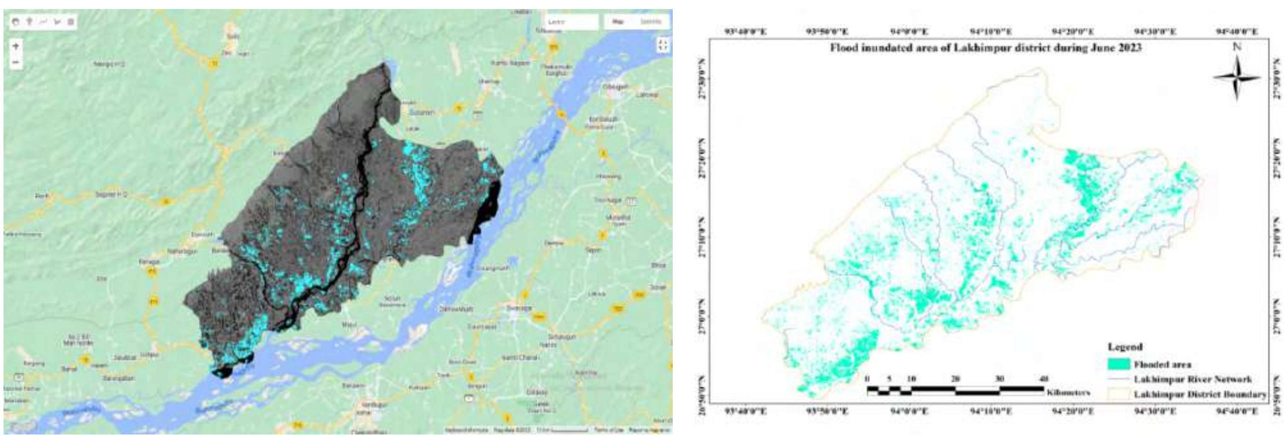


Fig. 4. Delineated flooded area of Lakhimpur in Assam (June, 2023)

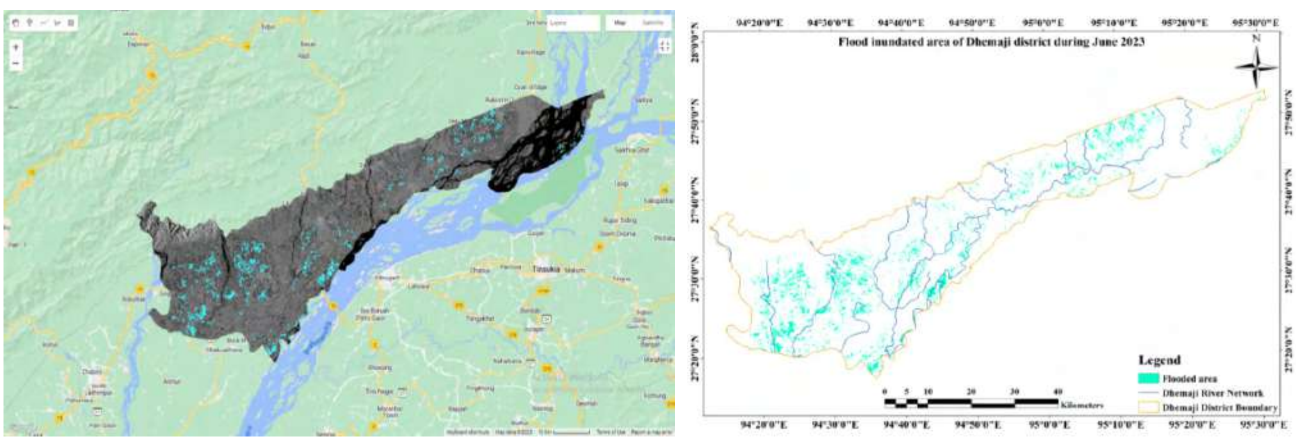


Fig. 5. Delineated flooded area of Dhemaji in Assam (June, 2023)

The post-flood crop management plans for post flood situation in Lokapala of Puri district of Odisha were prepared. Seed distribution programme was organized in Lokapala and Haladiapada villages of Kanas block in Puri district, Odisha after the flood water recedes in 2023. Based on the soil analysis it was recommended for addition of 1500 m^3 ha^{-1} of silty soil as soil amendments followed by disc ploughing and leveling for improvement of soil physical properties. The intervention of crop diversification with high value crops like groundnut as single crop or mixed crop (linseed, toria, amaranthus, field pea, carrot, sweet corn) with stored residual soil moisture with sowing period of 2nd fortnight of October to 2nd fortnight of November immediately after the receding of floodwater. Need based intercultural operation, pest and disease management should be recommended to compensate the loss of paddy crop due to floodwater. It was calculated that groundnut pod yield of 3.4 t ha^{-1} resulted in gross return of ₹225000 ha^{-1} and benefit-cost ratio of 2.38. Group of vegetables like pumpkin, pointed gourd, tomato, onion under residual soil moisture with one or two supplemental irrigations should be recommended for enhancing yield.

Studies on N-(n-butyl) Thiophosphoric Triamide (NBPT) as a Urease Inhibitor for Improving Nitrogen Use Efficiency in Rice-Rice cropping system

Collaborative Research Project: ICAR and CIMMYT

Investigators: S.K. Rautaray, A.K. Thakur, A. Maity and S. Mohanty

A field experiment was conducted at the ICAR- Indian Institute of Water Management (IIWM) Research Farm at Deras, Bhubaneshwar with rice (variety Swarna) in Kharif in 2023. The soil is sandy clay loam with acidic reaction (pH 5.40 in 1:2.5 soil: water) and medium in available organic carbon (0.51%) and low in available major nutrients. The experiment was laid out in a randomized complete block design with four replications and 5m x 4 m plot size. Fertilizer N was applied in 3 splits (50% as basal, 25% at tillering and 25% at panicle initiation stage). Treatments include T_1 (Control): No nitrogen (N), T_2 (100% N as NCU): N fertilizer applied at 100 kg/ha using Neem Coated Urea as surface broadcast at 7 days after transplanting, T_3 (100% N as AIU): Similar to T_2, but N fertilizer was AGROTAIN Incorporated Urea, T_4 (80% N as AIU): Similar to T_3 but N fertilizer rate was 80 kg/ha, T_5 (60% N as AIU): Similar to T_3 but N fertilizer rate was 60 kg/ha N. T_6 (100% N as NCU incorporation): Similar to T_2, but 50% N was incorporated in reduced zone at final land preparation and 25% N at tillering stage was incorporated with cono weeder and T_7 (100% N as AIU incorporation): Similar to T_3, but 50% N was incorporated in reduced zone at final land preparation and 25% N at tillering stage was incorporated with cono weeder like T_6.

Effect on plant growth

The highest plant heights (92.5 cm and 92.3 cm) were recorded with the treatment 100% N as NCU Incorporation (T_6) and 100% N as AIU Incorporation (T_7), respectively (Table 5). These two treatments were followed by surface broadcasting of 100% N using AIU or NCU. Thus, incorporation of N was superior to the surface broadcasting using either AIU or NCU. With the reduction of N dose by 20% (T_4), there was a reduction in plant height to 89.1 cm. Further reduction of fertilizer dose by 40% (T_5), reduced the plant height further to 88.3 cm. Regarding SPAD chlorophyll meter value, 100% N as AIU incorporation (T_7) showed the highest SPAD value of 38.4, and 39.2 at 60 and 80 DAT, respectively. Similar values (38.2 and 38.8 for respective DATs) were recorded for T_6 (100% N as NCU incorporation). A higher SPAD value under incorporation as compared to surface broadcasting indicates the benefits of N fertilizer incorporation, irrespective of source on SPAD values. There was distinct decrease in SPAD value with the reduction of N-fertilizer dose by 20% and a further lowered value when the N dose was reduced by 40%. Lowest SPAD value was recorded with no N control. Normalized Difference Vegetation Index (NDVI) was highest with the 100% N as AIU Incorporation (T_7) closely followed by 100% N as NCU Incorporation (T_6). These two treatments were followed by surface broadcasting. Reduced N fertilizer dose resulted in lower NDVI values. Prominently lowest NDVI value was recorded with the control (No N fertilizer).

Yield attributes and yield

Number of panicles/m^2 was highest (242.4) with the T_7 (100% N as AIU incorporation) and similar number of panicles were recorded with T_6 (100% N as NCU incorporation). These were followed by T_3 and T_2 where urea sources at the same rate were broadcasted instead of incorporation. Significantly panicles numbers were lowered with decrease in fertilizer dose by 20% and further lowered when the fertilizer dose was reduced by 40%. The lowest number of panicles were noted in the control where no N was applied. Number of grains per panicle under different treatments were similar to panicle number.

Table 5 Growth and yield of rice as influenced by different sources, method of application and doses of N

Treatments	Plant height at harvest (cm)	SPAD Value 60 DAT	SPAD Value 80 DAT	NDVI 60 DAT	NDVI 80 DAT	Panicles/ m^2	Grains/ panicle	Grain Yield (t/ha)	Straw Yield (t/ha)
T_1: Control	80.2	30.3	29.6	0.32	0.33	164.8	108.4	2.87	3.91
T_2: 100% N as NCU (*SB)	90.4	37.3	38.4	0.52	0.54	228.8	128.4	4.59	5.84
T_3:100% N as AIU (SB)	90.7	37.9	38.5	0.54	0.57	233.0	129.7	4.76	5.87
T_4: 80% N as AIU (SB)	89.1	36.3	37.4	0.50	0.53	223.0	127.2	4.39	5.41
T_5: 60% N as AIU (SB)	88.3	35.9	36.9	0.46	0.50	209.3	121.5	3.70	5.18
T_6: 100% N as NCU (**Incorp.)	92.5	38.2	38.8	0.54	0.58	241.8	135.4	5.07	6.16
T_7: 100% N as AIU (Incorp.)	92.3	38.4	39.2	0.55	0.58	242.4	135.1	5.04	6.19
CD (P=0.05)	1.39	0.87	0.91	0.02	0.03	9.6	3.3	0.23	0.29

*SB means surface broadcasting, **Incorp. means Incorporation

The rice grain and straw yield was recorded at 14 and 15% moisture content, respectively. Net plot of 15.66 m^2 was used for calculating grain and straw yield (t/ha) after discarding the border row. Treatment T_6 (100% N as NCU Incorporation) and T_7 (100% N as AIU Incorporation) recorded the highest grain yields of 5.07 t/ha and 5.04 t/ha, respectively. With the incorporation, both the sources of urea were superior in grain yield as compared to surface broadcasting. There was a decrease in yield (4.39 t/ha) with the reduction in fertilizer dose by 20% as observed in AIU. Rice yield was further reduced to 3.7 t/ha when the fertilizer dose was reduced by 40%. Similar results were observed for straw yield.

On-farm evaluation

Agrotain incorporated urea (AIU) was tested with the conventional NCU in eight farmer field in Puri, Khordha and Cuttack districts. The five treatments include T1: Control, T2: 100% N as NCU (*SB), T3:100% N as AIU (SB), T4: 80% N as AIU (SB) and the Farmer Practice. The results revealed that grain yields were similar with NCU (4.26 t/ha) and AIU (4.33 t/ha). There was a reduction in grain yield (3.82 t/ha) by reducing fertilizer dose by 20% (80% AIU). Lowest grain yield was recorded with the control. (Table 6)

Table 6 Yield of rice as influenced by different sources, method and doses of N application

Treatments	Farmer 1	Farmer 2	Farmer 3	Farmer 4	Farmer 5	Farmer 6	Farmer 7	Farmer 8	Mean
T_1: Control	2.49	2.48	3.1	2.83	3.05	3.1	2.95	3.13	2.89
T_2: 100% N as NCU (*SB)	4.00	3.97	4.2	4.37	4.15	4.5	4.38	4.53	4.26
T_3:100% N as AIU (SB)	4.09	4.07	4.3	4.41	4.20	4.58	4.46	4.54	4.33
T_4: 80% N as AIU (SB)	3.56	3.52	3.65	4.07	3.6	38.5	4.05	4.22	3.82
Farmers Practice	3.91	4.02	4.3	4.46	4.2	4.5	4.42	4.51	4.29

Precision water and nutrient application in selected crops for enhancing input use efficiency and profitability

Collaborative Research Project: ICAR -Network Project on Precision Agriculture

Investigators: S.K. Rautaray, A. Sarangi, D. Sethi, S. Pradhan, Ajit K. Nayak, S.K. Jena and Ashok K. Nayak

Development of sensor based alternate wetting and drying (AWD) in transplanted rice

Sensor based irrigation automation in transplanted rice for alternate wetting and drying schedule was developed. Both the Proto type model for laboratory scale and main model for field scale use were developed and tested. The system detects water level inside the designated panipipe using ultrasonic sensor. The microcontroller continuously compares each water level data to the threshold. When the water level inside pipe falls below 10 cm from surface, one interrupt is generated to switch on the water lifting pump. Similarly, when the water level reaches 5 cm above the soil surface, signal is generated to switch off the water lifting pump. The water level data and pump status data is stored in the memory card inserted in the datalogger. This helps in quantifying the irrigation water volume supplied to the field.

Field testing of sensor based automated AWD

Field testing of developed automated AWD module was conducted in dry season of 2023. The results revealed that rice grain yield was 4.43 t/ha with water use of 1340 mm and water productivity of 0.33 kg/m^3 under continuous flooding (common practice in farmers field). With the sensor based automated AWD, rice grain yield was similar (4.21 t/ha) with water use of 1100 mm and water productivity of 0.38 kg/m^3 under. Thus, the save in water use was 18% with enhanced water productivity by 15%. Volumetric soil moisture content determination using capacitance-based soil moisture sensor (VH 400) and data storing in cloud. The IoT enabled volumetric soil moisture measurement using capacitance based soil moisture sensor (VH 400) was calibrated and validated for different types of soil texture. This was installed at IIVR, Varanasi and NRT Banana at Trithy. Irrometer based automated irrigation in direct seeded rice revealed that grain yield was 4.29 t/ha with water use of 737.7 mm and water productivity of 0.58 kg/m^3.

Development and Management of Surface Water Resources and Soil Moisture in Different Agro-ecological Regions of India using Geoinformatics.

Project: Agri Consortia Research Platform on Water, Agri CRP on Water Theme-I

Investigators: S. K. Jena, D. Sethi, B. S. Satapathy and A. Sarangi

ARCSWAT hydrology model was set up for upper Mahanadi River basin. The model was calibrated for period (1980 to 1997) including 3 years as warm up (1980 to 1982), subsequently model was validated for 6 years from 1998 to 2003. SWAT-CUP (SWAT-Calibration and Uncertainty Programs) was used for model calibration, validation, sensitivity and uncertainty analysis, using the Sequential Uncertainty Fitting (SUFI-2) technique. The uncertainty in SWAT stream flow simulation is expressed based on ninety-five percent prediction uncertainty (95PPU). The uncertainty is determined by p-factor (percentage of observation covered by the 95PPU) and r-factor (average thickness of the 95PPU band divided by the standard deviation of the measured data). The p-factor varies from 0 to 1 and r-factor varies from 0 to ∞. When the P-factor is 1 and R-factor is 0, the simulated value perfectly matched with observed value. The results of NSE and R^2 indicated that the model performance was good (Fig. 6). The uncertainties in the model during calibration and validation are within permissible limits because most of the observed values are within the 95PPU.

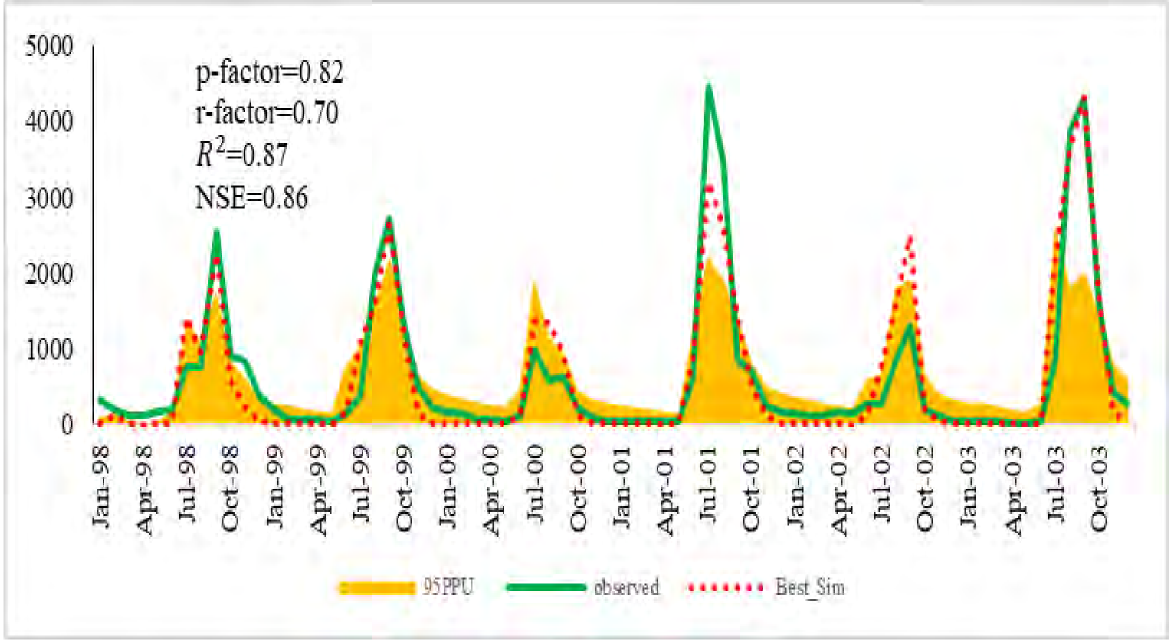


Fig. 6 Observed and simulated stream flow with 95ppu during validation

Catchment area threshold for Mahanadi basin (upper) was determined by experiment for river network extraction through the statistical method. For this purpose, initially river network density was estimated. After calculating the river network density under different threshold values, the relationship curve between river network density and the threshold value was obtained. The inflection point was found when the density of the river network was stable with the change in the catchment area thresholds (3.12, 6.25, 9.37, 12.50, 15.62, 18.75, 21.87, 25.00, 28.12, 31.25, 34.37 km^2) and catchment area threshold was obtained 10.94 km^2 (Fig. 7). The discharge calculated by ARCSWAT hydrology model showed that discharge and water yield increased for increment of catchment area threshold.

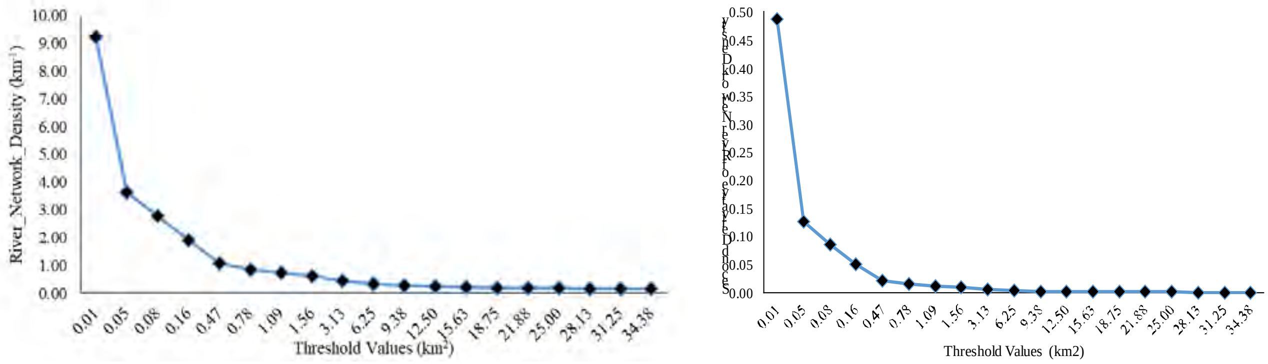


Fig. 7. Variation in river network density with catchment area threshold (ii) Variation in second order derivative of river network density with catchment area threshold

The water indices (NDWI, MNDWI and MNDWI2), machine learning algorithms and SAR satellite data have been evaluated to understand their ability to extract surface waterbodies for Nayagarh District. For this purpose, Sentinel-2A (Level-1A) and Sentinel-1 data was used to extract information of water indices for pre-monsoon and post-monsoon seasons. Ground truth information was collected through visual examination using a high-resolution image. Automatic water extraction was achieved for different water indices and SAR data by applying a threshold value using Otsu's algorithm. The kappa coefficient and overall accuracy was used to assess the accuracy of all water extraction techniques. Results indicate MNDWI2 performed better in extracting waterbodies and estimation of changes of water surface area (Fig. 8).

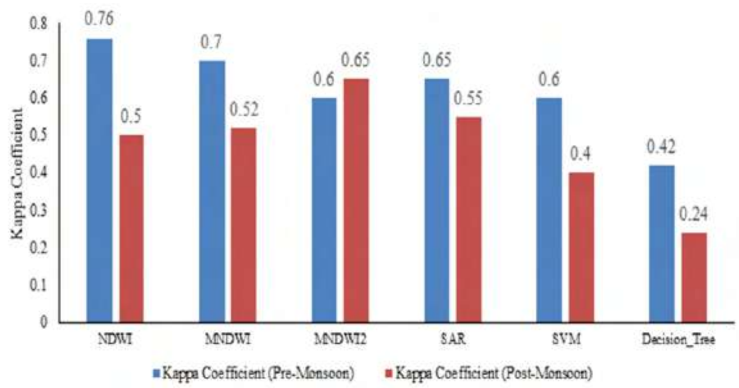


Fig.8. Kappa Coefficient for various waterbody extraction methods

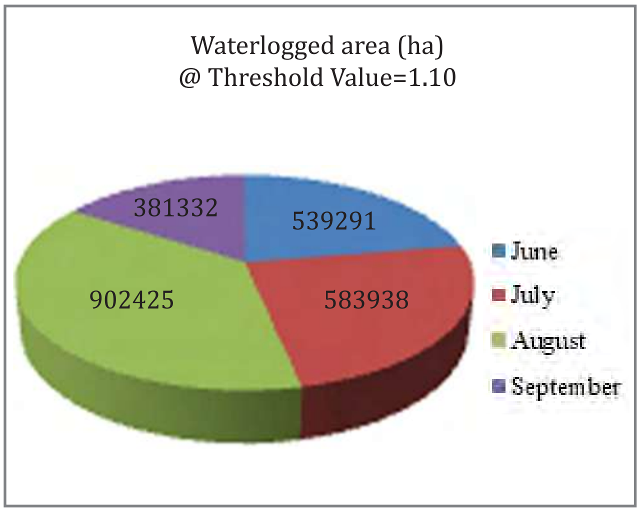
Development and impact evaluation of eco-friendly rubber material for the lining of water harvesting structures was initiated at IIWM campus and the system is working satisfactorily with no leakage and loss is only through evaporation which is being measured daily at 9.00 AM.

Increasing Agriculture resilience through Agricultural Disaster Risk Management Strategy in India

Project: (INTEGRATE) (ICAR-IWMI Collaborative projects)

Investigators: S. K. Jena and B.S. Satapathy

The different components of INTEGRATE solutions are risk assessment, mitigation, preparedness, risk transfer: response, recovery and monitoring and evaluation. In this study, flood affected areas during the monsoon season of 2023 by taking different threshold values used in Google earth engine algorithm for Odisha were delineated using the Sentinel-1 satellite data. The waterlogged area in Odisha was found to be 583938 ha, 902425 ha, 381332 ha in July, August and September, respectively during 2023, by taking threshold value as 1.10 (Fig.9). The severity of flood was observed in August 2023. Whereas, the area under inundation in Odisha was found to be 30522 ha, 32393 ha and 40484 ha in July, August and September, respectively during 2023, by taking threshold value as 1.50 (Fig. 10).



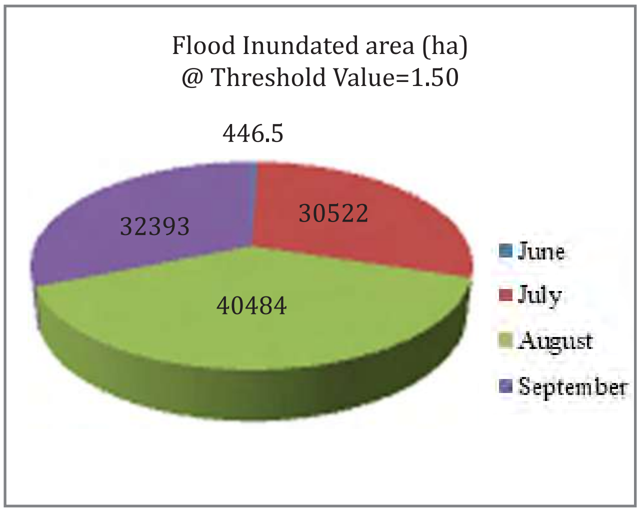


Fig. 9. Delineated flood inundated area during Monsoon 2023 in Odisha

Fig. 10. Delineated waterlogged area during Monsoon 2023 in Odisha

Out of the monsoon season flood delineated maps of Odisha during August month for different threshold values were prepared. From the map, area under inundation in Kendrapara district was 126606 ha in August 2023, by taking threshold value as 1.10 (Fig. 11), whereas, the area under inundation in Kendrapara district was 27329 ha in August 2023, by taking threshold value as 1.50 (Fig. 12).

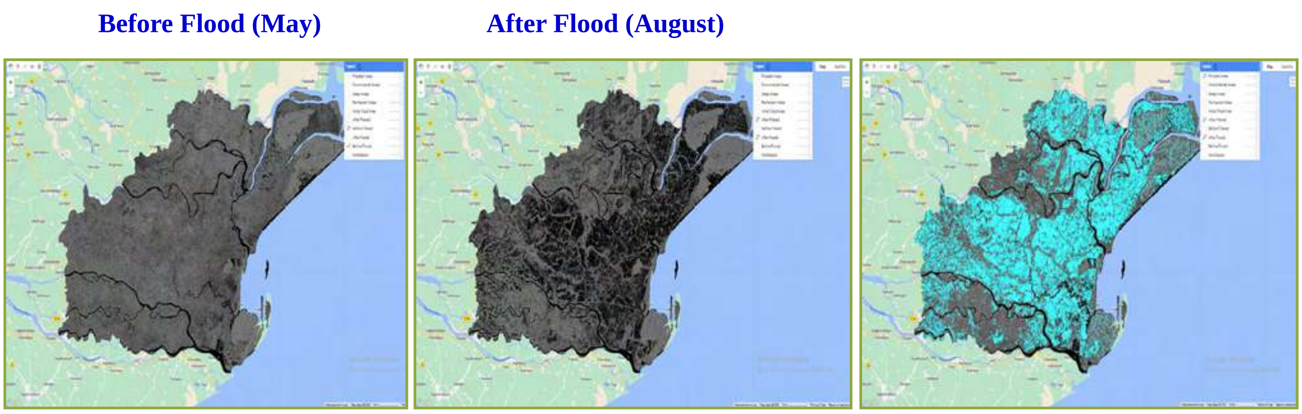


Fig. 11. Delineated Flooded area in Kendrapara (August, 2023) in GEE interface @ threshold value of 1.10

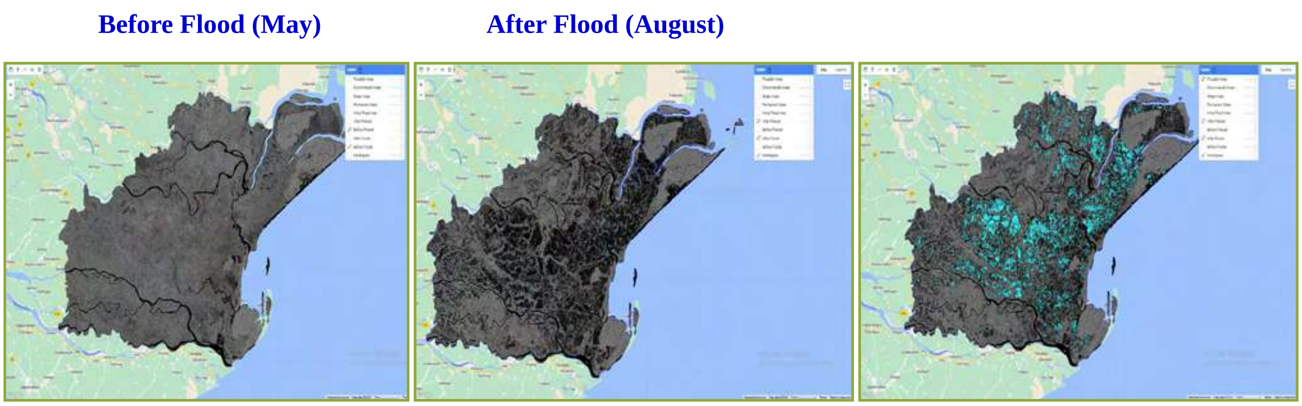


Fig. 12. Delineated Flooded area in Kendrapada (August, 2023) in GEE interface @ threshold value of 1.50

CANAL WATER MANAGEMENT

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

Developing Efficient Water Management Strategies Using Resource Conservation Technologies in Maize-sunflower Cropping System

Project code: NRMA/IIWM/SIL/2021/004/00206

Investigators: S. Pradhan, P. Panigrahi, Ankhila R.H. and K.K. Bandyopadhyay

A field experiment was conducted during *Kharif* - 2022 and *Rabi*- 2022-2023 to study the effect of resource conservation technologies involving different irrigation methods and preceding sunflower and maize residue, respectively, on maize (sweet corn) and sunflower crop growth, yield and water productivity. The experiment was laid out in a randomized block design with four replications involving ten treatments. The treatments include permanent broad-bed furrow irrigation (PBBF), permanent broad-bed furrow irrigation with residue (PBBF+R), permanent narrow-bed furrow irrigation (PNBF), permanent narrow-bed furrow irrigation with residue (PNBF+R), zero-till surface drip irrigation (ZTDI), zero-till surface drip irrigation with residue (ZTDI + R), zero-till sub-surface drip irrigation (ZTSDI), zero-till sub-surface drip irrigation with residue (ZTSDI+R), zero-till flatbed flood irrigation with residue (ZTFBF+R), conventional till flatbed furrow irrigation (CTFBF+R). The sweet corn variety 'Sugar 75' with the recommended package of practices was grown during kharif season. The maize cob yield was highest under ZTSDI+R (12.54 t/ha). The cob yield of ZTSDI+R was statistically at par in ZTSDI, ZTDI+R, ZTDI, PBBF+R, PBBF, PNBF+R and PNBF. The cob yield of ZTSDI+R was 15% and 16% higher than the ZTFBF+R and CTFBF treatments, respectively. The cob yield of ZTFBF+R and CTFBF treatments were statistically ($P<0.05$) at par. The retention of preceding sunflower residue didn't bring any changes in yield of maize under different treatments. The highest water use (656 mm) was observed in CTFBF. The highest cob yield and lowest water use resulted in the highest water productivity (22.23 kg/ha-mm) in ZTSDI+R which was 35% higher than that in CTFBF. The water productivity of ZTSDI+R was statistically at par with ZTSDI, ZTDI+R and ZTDI. There was no significant difference between the PNBF+R, PNBF, PBBF+R and PBBF, and ZTFBF+R and CTFBF with respect to water productivity.

After sweet corn, sunflower (DRSH-1) was grown with recommended package practices during *Rabi* 2022-2023. The sunflower seed yield was the highest under ZTSDI+R (2.04 t/ha) (Fig. 13). The seed yield of ZTSDI+R was statistically at par with ZTSDI, ZTDI+R and ZTDI. The seed yield was the lowest in CTFBF (1.42 t/ha). There was no significant yield difference between PNBF+R, PNBF, PBBF+R, PBBF, ZTFBF+R and CTFBF treatments. The ZTSDI+R provided 44% higher yield as compared to CTFBF. The water use varied between 293-498 mm under various treatments. The lowest water use (293 mm) was in ZTSDI+R and the highest water use (498 mm) was in ZTFBF+R and CTFBF treatments. The highest seed yield and the lowest water use under the ZTSDI + R led to the highest water productivity (6.97 kg/ha-mm) (Fig. 14). The ZTSDI + R resulted in 26%, 38%, 39%, 73%, 74%, 83%, 113% and 144% higher crop water productivity as compared to the ZTDI + R, ZTDI, PBBF + R, PBBF, PNBF+R, PNBF, ZTFBF and CTFBF, respectively.

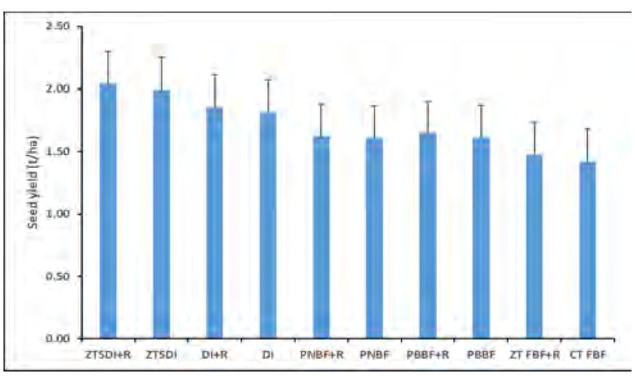


Fig. 13. Sunflower seed yield during *rabi* 2022-23. Error bars indicate CD value at $P<0.05$.

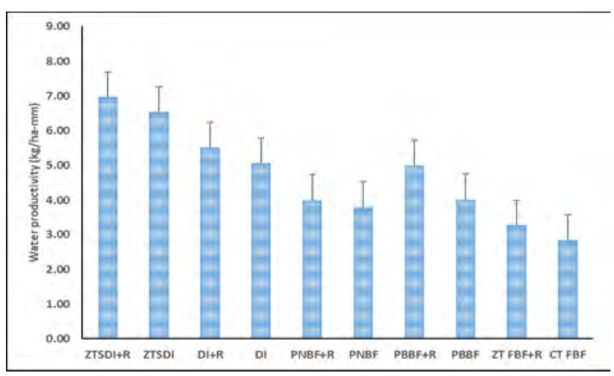


Fig. 14. Water productivity of sunflower during *rabi* 2022-23. Error bars indicate CD value at $P<0.05$.

Evaluating Sub-surface Drip Irrigation in Maize Based Cropping Sequence

Project Code: NRMA/IIWM/SIL/2021/007/00209

Investigators: P. Panigrahi and S. Pradhan

The study was conducted to evaluate the response of maize-based cropping sequence (maize-tomato-baby corn) to sub-surface drip irrigation (SDI), surface drip irrigation (DI) and surface irrigation (SI) at ICAR-IIWM research farm, Mendhasal, Khurdha, Odisha. The SDI at different operating pressure (75 kPa, 100 kPa, 125 kPa, 150 kPa) and lateral depths (10 cm, 15 cm and 20 cm) was evaluated in the crops. The SDI and DI were laid out at 0.8 m lateral spacing. The hydraulics of drip irrigation was studied from time to time and found satisfactory with mean distribution uniformity of 95%, coefficient of variation of 5% and mean emitter flow rate variation (Q_v) of 4%.

In tomato (cv. *Samrat*), SDI operated at pressure of 125 kPa and lateral depth of 15 cm saved 18% and 42% of irrigation water compared to DI and SI (420 mm), respectively. The soil water content in top 15 cm soil under SDI was 16–22% lower than DI and 8–12% higher than SI. However, water content at 15–30 cm and 30–45 cm soil under SDI was 13% and 28% higher than DI, respectively. The soil water content at 15–30 cm and 30–45 cm depths in SI was lower compared with DI. The soil water content at 45–60 cm depth in SI was 11% and 35% higher than SDI and DI, respectively. Higher vegetative growth (14–26%) of the plants was observed in SDI and DI compared with SI. However, the growth parameters in SDI and DI were statistically at par ($P<0.05$). Yield under SDI (47.82 t ha^{-1}) was 15% and 33% higher than DI and SI, respectively; whereas WP in SDI (14.99 kg m^{-3}) increased by 34% and 108% compared with DI and SI, respectively (Fig. 15). The fruit qualities viz., pulp content, juice percentage, total soluble solids (TSS), titratable acidity (TA) and ascorbic acid content in SDI and DI were statistically at par ($P < 0.05$). However, under SI, lower TSS and juice percentage with higher TA were observed in comparison to SDI and DI. The radiation use efficiency under DI and SDI were 7% and 16% higher than SI, respectively. Similarly, SPAD was 11% and 23% higher under DI and SDI, respectively in comparison to SI.

After tomato, baby corn (cv. G-5414) was grown in the experimental field with different treatments of SDI, DI and SI during summer season. The SDI at 125 kPa lateral pressure with 15 cm lateral depth was found best in relation to water saving under which 15% and 39% of water could be saved in comparison to DI and SI (361 mm), respectively, in baby corn. The soil water content in top 15 cm soil under SDI was 14–18% lower than DI, but 6–11% higher than SI. However, the water content at 15–30 cm and 30–45 cm soil under SDI was 12–15% and 25–29% higher than DI and SI, respectively. The soil water content at 45–60 cm depth in SI was 14–17% and 38–41% higher than SDI and DI, respectively. Higher vegetative growth (16–24%) was observed in SDI compared to SI. However, the growth parameters in SDI and DI were at par ($P < 0.05$). Yield under SDI (2.02 t ha^{-1}) was 12% and 34% higher than DI and SI, respectively; whereas WP in SDI (0.91 kg m^{-3}) increased by 32% and 122% compared with DI and SI, respectively (Fig. 16). Under SDI, RUE was 6% and 11% higher than DI and SI, respectively. Similarly, SPAD under SDI was 5% and 11% higher than DI and SI, respectively. Available nutrients (N, P and K) and organic carbon content in 0–15 cm soil marginally (5–11%) increased over the initial values in different treatments. The higher increase in nutrients and organic carbon was observed under SDI and DI than SI.

In maize (Sweet corn, cv. *Sugar 75*) which was grown as post-baby corn crop during *kharif* season (August–December), the SDI at 15 cm lateral depth produced the yield of 12.81 t ha^{-1} which was statistically at par ($P < 0.05$) with that in SDI at 10 cm lateral depth (12.59 t ha^{-1}). However, the DI and SI produced the yield of 12.32 t ha^{-1} and 11.74 t ha^{-1}, respectively which were statistically at par with SDI. The water productivity under SDI (2.23 kg/m^3) was 7% and 18% higher than DI and SI, respectively.

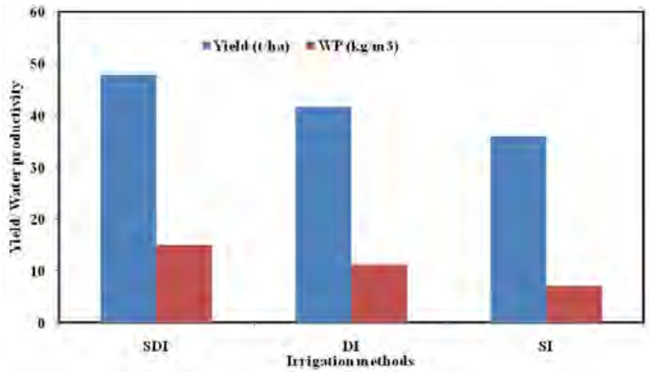


Fig. 15. Yield and water productivity of tomato under subsurface drip irrigation (SDI), surface drip irrigation (DI) and surface irrigation (SI)

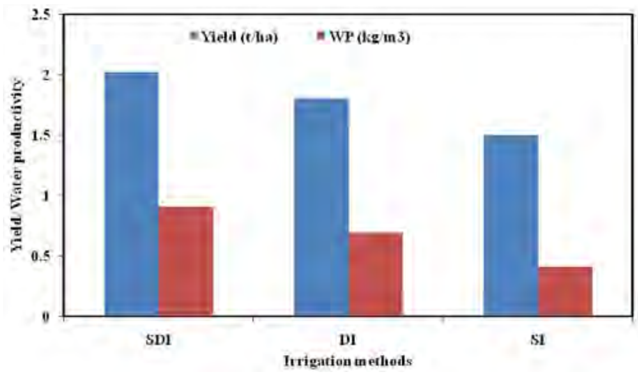


Fig. 16. Yield and water productivity of baby corn under subsurface drip irrigation (SDI), surface drip irrigation (DI) and surface irrigation (SI)

Tomato under sub-surface drip irrigation (SDI)

Baby corn under sub-surface drip irrigation (SDI)

Precise Irrigation under Conservation Agriculture for Improving Water Productivity in Intensive Rice Based Cropping System of Eastern India

Project Code : NRMA/IIWM/SIL/2021/008/00210

Investigators : S. Pradhan, P. Panigrahi, B. Behera and K.K. Bandyopadhyay

A study was conducted for evaluating the performance of precise irrigation under conservation agriculture in an intensive rice-based cropping system of Eastern India. The treatments of the experiment are as follows: TPR-CTM-CTG with CI (T1), TPR-CTM-CTG with PI (T2), (TPR+GR)-(ZTM+RR)-(ZTG+MR) with CI (T3), (TPR+GR)-(ZTM+RR)-(ZTG+MR) with PI (T4), (ZTDSR+GR)-(ZTM+RR)-(ZTG+MR) with CI (T5), (ZTDSR+GR)-(ZTM+RR)-(ZTG+MR) with PI (T6) and TPR-F (Farmers' practice) (T7). ZTDSR: zero tillage direct seeded rice, GR: green gram residue, ZTM: zero tillage maize, RR: rice residue, ZTG: Zero tillage green gram, MR: Maize residue, TPR: transplanted rice, CTM: conventionally tilled maize, CTG: conventionally tilled green gram, CI (Conventional irrigation) and PI (Precise irrigation based on SMP). The experiment comprising 7 treatments was executed in RBD with 3 replications.

Field experiments were conducted in maize (cv. *Nilesh*) during *rabi* season, in green gram (cv. *Virat*) during summer and in rice (cv. MTU 1010) during *kharif* season. The maize crop was sown with a spacing of 60 cm×30 cm and fertilizer dose of 150:60:60. The highest grain yield of maize was observed under CT with PI in T2 (Fig. 17). The grain yield of T2 was statistically ($P<0.05$) at par with T4 and T6. The lowest grain yield was observed in T5 (4545 kg/ha). The grain yield of T5 was statistically at par with T3 (4613 kg/ha) and T1 (4642 kg/ha). The grain yield of maize under PI was 13-14% higher compared to CI. The water use varied from 363 to 417 mm across various treatments. Precise irrigation saved 12% of water use compared to conventional irrigation. The highest water productivity (14.43 kg/ha-mm) of maize was observed under ZT with PI in T4 (Fig. 18). The water productivity of T2 was statistically (P<0.05) non-significant with T2 and T6. The lowest water productivity of maize was observed in T5 (11.06 kg/ha-mm) which was statistically at par with T1 and T3. The water productivity of maize under PI was 28-29% higher compared to CI.

After maize, green gram (cv. Virat) was grown on the same plots. The highest green gram seed yield (870 kg/ha) was obtained from ZT with PI in T4. The seed yield of T2 and T6 were statistically at par with it. The T1 registered the lowest seed yield which was statistically at par with T3 and T5 treatments. However, the highest stover yield (2878 kg/ha) was observed in ZT with PI in T6 which was statistically at par with T2, T3 and T4. The PI registered 17-23% and 11-16% higher seed and stover yield, respectively, compared to CI. The water productivity of green gram was the highest (2.86 kg/ha-mm) under ZT with PI in T4 which was statistically at par with T2 and T6. The PI registered 42-49% higher water productivity compared to CI.

After green gram, rice was grown on the same plots. The highest grain yield of rice (5665 kg/ha) was obtained from ZT with PI in T4 which was statistically at par with T2, T3 and T6. The lowest grain yield (4928 kg/ha) was obtained from TPR-Farmers practice in T7 which was statistically non-significant with T1, T2, T5 and T6. The water use under different treatments of rice varied from 810 mm to 1220 mm. The highest water productivity (6.46 kg/ha-mm) of rice was obtained in ZTDSR with PI in T6. The rice grain yield in DSR was 8% lower than PTR. However, the water productivity of DSR was 17% higher than the PTR.

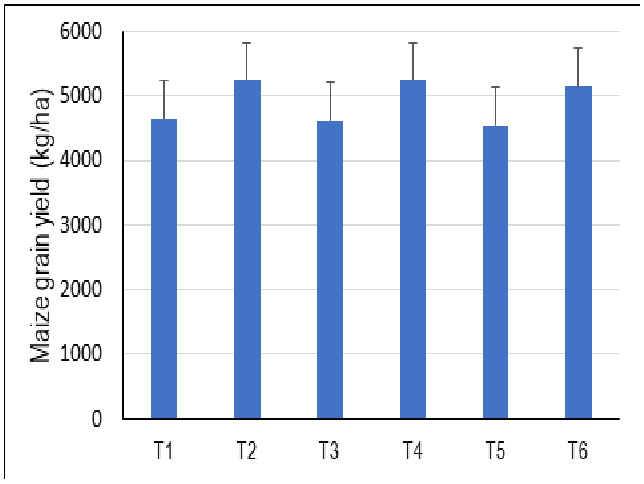


Fig. 17: Maize grain yield under different conventional and zero tillage treatments. Error bars indicate CD value at P<0.05.

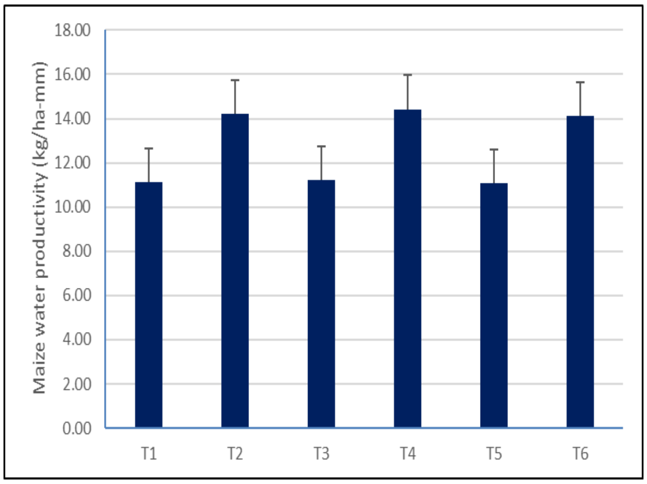


Fig. 18. Maize water productivity under different conventional and zero tillage treatments. Error bars indicate CD value at P<0.05.

Maize crop under ZT with PI

Green gram crop with ZT and PI

Paddy with ZTDSR and PI

Natural Farming: Impact on Crop and Water Productivity under Different Irrigation Methods

Project Code: NRMA/IIWM/SIL/2021/010/00213

Investigators: A.K. Thakur, P. Panigrahi, A. Maity and O.P. Verma

Natural Farming (NF) is a unique chemical-free farming method and it has resulted in widespread adoption at varying levels in many states, especially, Andhra Pradesh, Karnataka, Maharashtra, and Himachal Pradesh. It is considered to drastically cut down production costs by replacing chemical fertilizers and pesticides with home-grown products like Jeevamritha, Beejamritha, Neemastra, etc., and adopting intercropping and mulching. It is also contemplated to promote soil health and improve soil organic carbon even without the need of adding a huge quantity of FYM (farmyard manure) as in the case of organic farming and thus help in attaining sustainable agriculture with a reduced carbon footprint. The NITI Ayog of the Government of India emphasized the importance of Natural Farming as one of the alternative farming practices for improving the farmers' income, in the backdrop of declining fertilizer response and farm income. With this background, field experiments were conducted at ICAR-IIWM Deras research farm during 2022-23. During the *Kharif* season, rice was grown following the cultivation methods, viz., chemical (conventional) farming, organic farming and natural farming systems. Under a conventional/ chemical farming system, 5 t/ha FYM and N: P_2O_5:K_2O were added @ 80:40:40 kg/ha. While for organic farming 25-tonne FYM /ha was applied and under natural farming, Jeevaamrit were added 500 litre/ha every month. A significantly higher grain yield in rice (var. *Lalat*) was obtained under conventional farming (4.28 t/ha) than in organic and natural farming. A 16-18% decline in grain yield was observed in organic/ natural farming than in conventional chemical farming. This decline in grain yield was mainly due to a significant reduction in panicle number and grain filling under organic and natural farming systems (Table 7).

Table 7. Yield attributes of rice under different systems of production

Yield attributes	Conventional (Chemical) Farming	Organic Farming	Natural Farming
Panicle/m^2	396.4a	300.4b	302.8b
Grains/panicle	120.0a	115.0a	121.2a
Filled grains/panicle	97.8a	87.4b	84.6b

Grain filling (%)	81.6a	76.7b	69.9c
1000-grain weight	24.0a	24.2a	24.1a

After the rice harvest, tomatoes (var. *VNR-3348*) were grown in the same plots under similar three systems during the *Rabi* season. A significantly higher yield was obtained under conventional farming (25.5 t/ha) than organic farming and natural farming. A 9% and 18% decline in fruit yields were observed under organic and natural farming, respectively. After the tomato harvest, green gram (var. *Virat*) was grown under these systems between April and July 2023, where also highest yield was recorded under conventional farming (564 kg/ha). Under organic and natural farming, a significantly lower yield (6-9%) in green gram was recorded than in conventional farming systems. In all the farming methods, 180 mm of supplemental irrigation water was applied. The water productivity (WP) in conventional farming was 19-23% higher than in organic and NF. The soil moisture content at 0-45 cm was not affected significantly under different farming methods in tomatoes. WP in conventional farming was 10-23% higher compared with organic and NF in tomatoes.

Experimental view of green gram grown under different farming systems during the summer

Water Demand Estimation in Part of a Canal Command Area Using Machine Learning

Project Code: NRMA/IIWM/SIL/2021/010/00212

Investigators: Ajit K. Nayak, D. Sethi and R.K. Panda

The study has been initiated with the objective of assessment of reference evapotranspiration using conventional methods vis-à-vis ML algorithms in the Phulnakhra Canal Command area. Six machine learning (ML) techniques namely Linear Regression (LR), XG Boost (XGB), Random Forest (RF), Support Vector Regression (SVR), XGBoost (XGB) and KNN (k nearest neighbor) was used to estimate ET0 with four combinations of meteorological data for the study area. The performance of each machine learning model was compared and observed that SVM model accomplished excellent performance (R^2=0.98, RMSE=0.14, MSE=0.04, and MAE=0.21) among the evaluated models, trailed by XGB, RF, ANN, KNN and LR for all input parameter. For input parameters of temperature, windspeed, relative humidity, SVM (R^2=0.88, RMSE=0.36, MSE=0.24, and MAE=0.49) is followed by ANN, XGB, RF, ANN, LR and KNN for performance.

A methodology has been developed to extract information on crop growth stages for rice at the distributary level from high-resolution satellite imagery using SAR data. The Sentinel 1 SAR data was acquired with both VV and VH polarization for Phulnakhara command area from the Google Earth Engine image collection. Preprocessing was done by applying a speckle filter to reduce the noise in the backscattering coefficient value. The temporal analysis of the pattern of backscattering values for different growth stages of rice were carried out. The thresholds for backscatter values corresponding to different stages of rice growth, such as early, mid, and late stages were defined for the canal command area. While the backscatter reaction of flooded fields during the rice transplanting season is distinctive for delineating rice areas, the backscatter response from other land features is also important. Furthermore, mixing may occur due to various non-rice land features such as natural vegetation (forest) and built-up areas, which may exhibit temporal dynamics comparable to those of rice. Before classifying rice, threshold-based masks for non-rice areas such as settlements, water bodies, and forests were created in Google Earth Engine (GEE) to prevent the mixing of classes.

After transplanting, there is a discernible shift in the temporal signature of the backscattering coefficients (Fig. 19). The backscattering coefficient analysis followed by random forest-based classification that was performed fortnightly (FN) from June to October makes it evident that the transplantation is carried out in five stages between June to August in the canal command area.

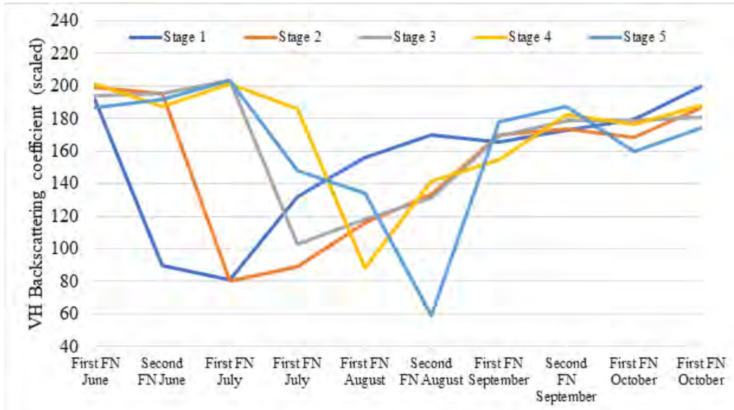


Fig. 19. Temporal signature for different stages of rice in Phulnakhara distributary

Enhancing Economic Water Productivity in Irrigation Canal Commands

Externally Funded Project: IWMI, Colombo, Sri Lanka

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

Water Accounting and Economic Water Productivity

Water accounting in Kukadi Left Bank Canal (KLBC), Maharashtra shows that the water use efficiency (WUE) based on geospatial estimates is substantially higher than the official estimates. The total water supply is the sum of irrigation released from the reservoir and groundwater recharged from rainfall, assumed to be 11% of the total rainfall in the command area. Considering the year 2019-20, the WUE, i.e., the ratio of irrigation CWU to total water supply is reported about 50% as per the official data. However, with larger area estimates using geospatial tools, the WUE is found 100% higher. Increasing evapotranspiration or irrigation CWU to increase WUE would be extremely difficult. Given that 2019-2020 is above-average rainfall year, it will be even more challenging to increase irrigation CWU to increase WUE in low to moderate rainfall years.

Substantial variation of economic water productivity (EWP) exists among crops. Orchard crops have higher land and water productivity. Sugarcane, an annual crop has higher land productivity; but substantially lower water productivity. Tomatoes grown in the hot- weather season have higher land and water productivity than Kharif or Rabi seasons. Thus, there is scope for improvement of EWP through higher-value crops, mainly by reallocating water from water-intensive crops such as Sugarcane to low water-intensive perennial crops such as pomegranate or seasonal crops such as vegetables.

The cost curve for EWP shows the potential to combine crops with technologies to increase EWP, the net production value, or reduce the irrigation CWU. It also shows the water and financial trade-off of allocating irrigation CWU of one crop with the other. The ordinate of the cost curve shows the net value of output, i.e., (value of production – total cost of production) per unit of irrigation CWU of different crops with conventional production or combined with advanced technologies and agronomic practices. Similarly, the abscissa shows the EWP per irrigation CWU. It is seen that tomatoes with drip irrigation have the highest net value of output per unit of irrigation CWU. Even with advanced technologies or agronomic practices, sugarcane has lower EWP and net output value than many annual crops (orchards) or vegetables such as tomatoes. EWP is generally higher in WUAs with larger annual crop areas, and the EWP is even larger without sugarcane in annual cropping patterns. The productivity of WUAs is positively associated with cropping intensity and negatively with crop diversification. Theil's inequality index shows the extent of crop diversification. The lowest level of Theil's index or lowest crop diversification means that the cropped area has only one crop and that mostly is a high-value fruit crop, which generally has the highest productivity.

Crop Scenarios

Based on the trade off among various crops with diversified technologies and agronomic practices, an alternative scenario was developed. The alternative pattern resulted in net value of output (NVOUP) gains with irrigation CWU savings. The base scenario is taken considering the cropping pattern of the year 2019-20. The result shows that there is need of 1105 Mm^3 total IRCWU (Mm^3) with 38 Billion USD of NVOUP. However, the alternative scenario-1 is taken considering the existing cropping patterns of year 2019-20 with adoption of advanced technologies or agronomic practices. This scenario resulted in increase of the NVOUP by 80% over the BAU (Table 8).

Table 8. Alternate scenario versus Business As Usual (BAU) scenario

Crops	BAU scenario			Scenario-1 Technology and agronomic practices		
	NVOUP/IRCWU (USD/m^3)	Total IRCWU (Mm^3)	Total NVOUP (B USD)	Crop and Technology	NVOUP/IRCWU (USD/m^3)	Change in total VOUP (B USD)
Wheat	0	27	0.0	Wheat+IPM	7	+0.2
Maize	15	35	0.5	Maize+IPM	32	+0.6
Sorghum	0	79	0.0	Sorghum+Bf	16	+1.6
Soybean	1	11	0.0	Soybean+HYV	19	+0.2
Onion	5	50	0.3	Onion+MI	46	+2.0
Tomato	116	21	2.5	Tomato+MI	131	+0.3
Sugarcane	21	450	9.6	Sugarcane+Bf	33	+5.1
Grapes+Drip	211	41	8.6	Grapes+Drip	211	+0.0
Pomegranate	43	234	10.1	Pomegranate+MI	128	+19.8
Other crops (Pulses)	36	61	2.2	Other crops (Pulses)	36	+0.0
Other vegetables	47	96	4.5	Other vegetables	47	+0.0
Total		1105	37.9			+29.8

IPM=Integrated Pest Management, MI=Micro Irrigation, Bf=Broad furrow, USD is considered @ 2019 INR base price.

Automated Canal Irrigation System for Efficient and Smart Irrigation Water Management

Project: Agri Consortia Research Platform on Water, Agri CRP on Water Theme-II

Investigators: R. K. Panda, Ajit K. Nayak, Ashok K. Nayak, S. Pradhan and D. Sethi

The project is aimed at designing an improved irrigation delivery mechanism using automated head regulator and outlet gates for improved physical and economic water productivity. During the period under report, 1D HD Canal model has been set up and the results are displayed.

Canal automation framework

Development for Real Time Decision Support System (RTDSS) for Canal Automation

RTDSS for canal automation is a desktop application developed in C# .NET. This system is designed having interfaces with SCADA and other data sets, which includes data discovery, download, visualization, editing and integration with other analysis and modelling tools. The layout of RTDSS-CA has three main components viz. Tasks, Explorers and Display of Maps and Graphs. The modules of RTDSS-CA include Hydraulic Module (HEC-RAS); Hydrology Module (HEC-HMS), Irrigation Module and Reservoir Balancing Module. Fig. 20 shows the Hydraulic Module, in which HEC-RAS adopter is developed and HEC-RAS base canal model is integrated. Fig. 21 shows results of the HEC-RAS base canal model within the domain of RTDSS-CA. Presently, prior to installation of the canal automation gates etc., the canal release data and additional canal geometry data are being collected for model calibration. Peripheral activities like entering into MoU among ICAR-IIWM; Dept. of Water Resources, Govt. of Odisha; Water

User Association (WUA); and Mechatronics Systems Pvt. Ltd., Pune, frequent meetings of the Executive Committee of WUA for smooth operationalization of the canal automation system, restoration of stable electricity connection to the designated automation server room, watch and ward provision etc. are being mobilized.

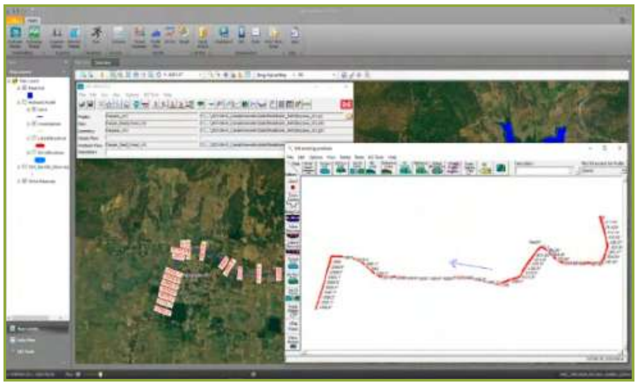


Fig.20. Hydraulic Module - Integration of HEC-RAS Base Canal Model

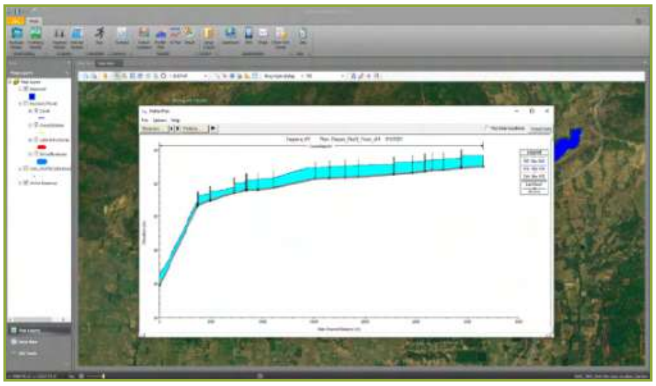


Fig.21. Hydraulic Module -Results of HEC-RAS Base Canal Model

IoT Enabled Sensor Based Smart Irrigation Management System

Project: Agri Consortia Research Platform on Water, Agri CRP on Water Theme-IV

Investigators: Ajit K.Nayak, D. Sethi, S. Pradhan and P. Sahu

The research activities were carried out in One farmer's field in Bhakarsahi, Balipatna Tehsil, Khurda District, Odisha, as well as at ICAR-IIWM research farm, Mendhasal, Khurdha for evaluating the existing IoT-based smart irrigation system. Two emitters of 8 lph per plant emitters fixed on 16 mm lateral at 25 cm from the plant with distribution uniformity of 95% were used for irrigation. The value of Kc of Banana crop varies from 0.5-1.1. The ET0 is calculated from Automatic Weather Station (AWS) and irrigation was scheduled accordingly. The layout for the banana plantation is done for three treatments. T1: IoT-based drip fertigation, T2: Timer-based drip fertigation based on ETc, and T3: farmers' practice of ring basin irrigation with seven replication each. The irrigation water saving of 22% was observed under automatic system vis-à-vis surface irrigation system.

Solar operated electronic solenoid valve and manual solenoid valve

GROUNDWATER MANAGEMENT

This program includes research projects on groundwater management & related issues

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

This study was aimed to quantify the water budget parameters (precipitation, surface runoff, evapotranspiration and groundwater storage) for Baitarani River Basin of India and to analyze the season-wise trend by using Innovative Trend Analysis (ITA). The analysis showed that precipitation and surface runoff followed a non-monotonic negative (–ve) trend in winter season and monotonic positive (+ve) trend in all other season for all gauging stations (Champua, Keonjhar, Swampatna, Thakurmunda, Anandpur, Belbahali, Akhuapada and Bhadrak). Season-wise analysis of all the water budget parameters is presented below;

Winter season

Precipitation is comparatively less in winter season hence the magnitude of precipitation slope is low, which varied between 0.134 to 15.86 mm/year with an average of 3.87 mm/year. In case of surface runoff, which is dependent on precipitation varied between 0.4-4.8 mm/year with an average of 0.743 mm/year. Groundwater storage is generally dependent on geological factors as well as both precipitation and surface runoff. In Baitarini River Basin, groundwater storage varied between 15.73-37.95 mm/year with average of 27.34 mm/year. In Champua, located in higher elevation, average groundwater storage is only 270.02 mm/year and in Akhuapada, located in middle of the basin, groundwater storage was estimated as 298.8 mm/year. Maximum groundwater storage was observed at Bhadrak station, located at the lower part of the basin, is 295.66 mm/year (Fig. 22). Both precipitation and surface runoff during winter season represents non monotonic negative (–ve) trend, whereas groundwater storage showed increasing positive (+ve) trend for all stations. It was observed that in most of the gauging station, data points fall within the 5% variations range from no-trend (1:1) line but generally insignificant at 95% confidence interval. There was sharp increase in groundwater storage trends in winter season ($p < 0.01$) during 1981 to 2022.

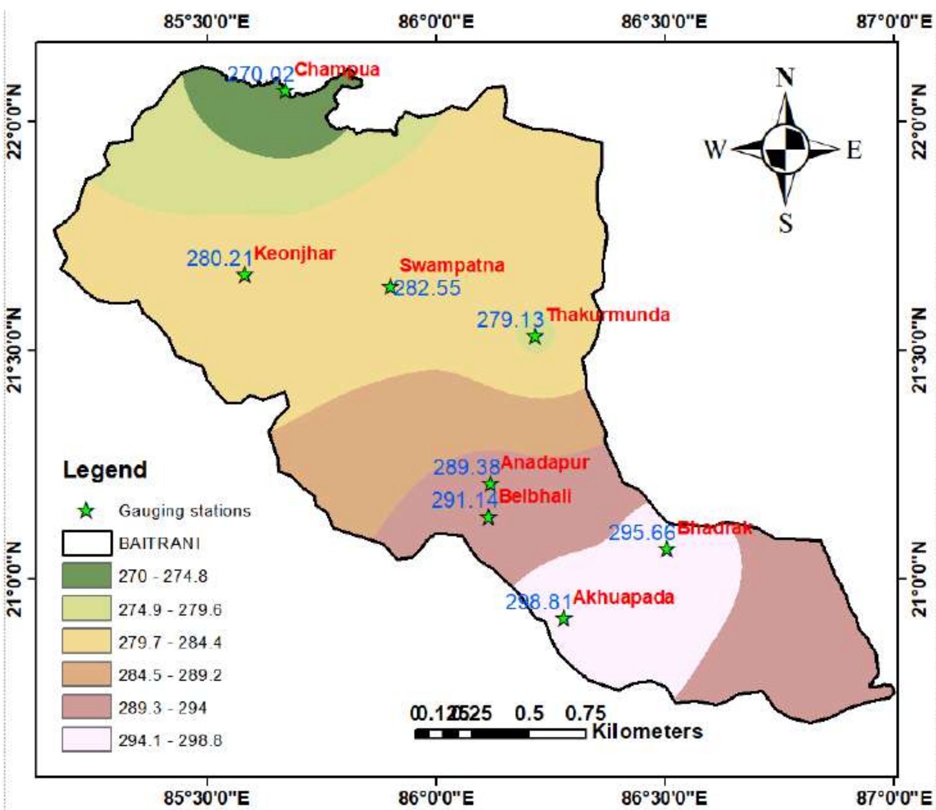


Fig.22. Spatial variation of winter average groundwater storage (mm/year) in different gauging station

Pre-monsoon

In pre monsoon season, magnitude of precipitation slopes varied between 0.158 - 72.28 mm/year with an average of 12.91 mm/year; surface runoff varied between 0.039 – 53.03 mm/year with average of 5.167 mm/year. The average groundwater storage varied between 12.53 -53.46 mm/year with mean of 39.03 mm/year. Trend analysis showed that in low pattern group- the precipitation and runoff data points accumulated in the upper triangular area of the 1:1 line which demonstrates increasing trends whereas groundwater storage indicated 0 trend in lower pattern. In middle, precipitation and surface runoff data points are in the upper triangular area of the ITA line (Increased trend) while groundwater storage data points in lower triangular area indicates decreasing trend. Although groundwater storage has a monotonic negative (-ve) trend, rainfall and surface runoff both exhibit monotonic positive (+ve) trends.

South West Monsoon

The magnitude of precipitation ranged between 16.05 -289.98 mm/year with average of 56.26 mm/year and surface runoff varied between 4.66 – 267.29 mm/year with average of 38.52 mm/year. The average groundwater storage in monsoon season varied between 5.43 -35.58 mm/year with average of 12.83 mm/year. Trend analysis showed that in low and medium class group, rainfall and surface runoff is increased while in high group category both have no trends. But groundwater storage showed decreasing trend which represented decreased trend for all stations. All stations have non monotonic –ve trend for GW storage, but rainfall and surface runoff both exhibit monotonic + ve trends.

Post-monsoon

Post monsoon trend analysis showed that the magnitude of precipitation slopes varied between 0.13-1733.85 mm/year with an average of 27.38 mm/year; similarly, magnitude of surface runoff varied between 0.05 - 2999.413 mm/year with an average of 7.76 mm/year. However, the groundwater storage slope varied between 4.95 - 28.27 mm/year. In Thakurmunda station, due to more elevation, groundwater storage is too less 271.89 mm/year and the maximum storage in plain area at Bhadrak 310.14 mm/year. For all 8 stations rainfall is moderate and it was found that in low pattern zone, the rainfall and surface runoff data points accumulated in the upper triangular area of the 1:1 line, it demonstrates upward trends, while GW storage indicates no trend, but in medium to high zone, it was represented as no trend for rainfall and overland flow and trend for storage is decreased. Although storage has a monotonic - ve trend, rainfall and surface runoff both exhibit monotonic + ve trends. Eight (08) sites displayed a mix of rising and falling trends for annual rainfall, stream flow, and GWS.

The spatial analysis on groundwater storage showed that the upper catchment areas of the river basin is more vulnerable to groundwater decline. The groundwater availability and abstraction could be enhanced in middle catchment areas. However, groundwater extraction pattern needs to be monitored quantitatively and qualitatively in both middle and lower catchment areas of the basin. The outcomes for the lower reach indicated that groundwater availability is more, which can be exploited through appropriate measures. Groundwater withdrawal should be restricted in coastal areas even though water availability is more still it can aggravate the situation like saline water intrusion.

Study of Seawater Intrusion Dynamics and Development of Management Strategy in a Coastal Aquifer of Eastern India

Project Code: NRMA/IIWM/SIL/2021/001/00203

Investigators: S. Mohanty, P. P. Adhikary, Atulya Mohanty and M.K. Jha

Groundwater-salinity trend analysis

The trend analysis of salinity parameters of groundwater collected from GWSI was done by Mann-Kendall test. Analysis was done for EC, TDS, Na^+ and Cl^- for the Gop and Puri Sadar block, the results of which are presented in Table 9. The analysis showed that groundwater salinity is increasing over the years in Gop block. This can be attributed to excessive groundwater pumping for irrigation and saltwater intrusion from the Kushabhadra River in the Gop block. Due to the connection of Kushabhadra river with sea, the river water near to the coast is saline and it is transmitted to the aquifer due to river-aquifer interaction.

Table 9. Groundwater - salinity trend analysis in 'Gop' and 'Puri Sadar' blocks

Salinity Parameter	Time Period	Block	Mann–Kendall Test		Trend	Sen's Slope Magnitude (parameter unit/year)
			Z_{CAL}	p–Value		
EC (µS/cm)	Pre–Monsoon	Gop	2.265	0.024	↑ 5%	11.908
		Puri Sadar	–0.151	0.880	No	–1.724
	Post–Monsoon	Gop	4.499	6.816E–06	↑ 1%	14.767
		Puri Sadar	0.997	0.319	No	21.306
TDS (mg/L)	Pre–Monsoon	Gop	2.748	0.006	↑ 1%	9.519
		Puri Sadar	–0.453	0.651	No	–2.907
	Post–Monsoon	Gop	4.258	2.065E–05	↑ 1%	10.532
		Puri Sadar	0.967	0.334	No	12.608
Na^+ (mg/L)	Pre–Monsoon	Gop	2.567	0.010	↑ 5%	1.962
		Puri Sadar	–0.211	0.833	No	–0.407
	Post–Monsoon	Gop	4.077	4.570E–05	↑ 1%	1.964
		Puri Sadar	0.997	0.319	No	2.450
Cl^- (mg/L)	Pre–Monsoon	Gop	0.907	0.365	No	1.238
		Puri Sadar	–1.390	0.165	No	–3.437
	Post–Monsoon	Gop	4.016	5.915E–05	↑ 1%	2.184
		Puri Sadar	1.420	0.156	No	5.060

Seasonal analysis of groundwater quality

The groundwater quality of the water samples collected in the pre-monsoon and post-monsoon season were compared by plotting different diagrams like Durov diagram, Gibb's diagram, USSL diagram, Chadha's diagram and Schoeller's diagram. AquaChem software was used for the analysis and identification of dominant groundwater type. Fig.23 and Fig. 24 shows the Durov diagram of the study area for the pre-monsoon and post-monsoon season respectively. In both pre-monsoon and post-monsoon season, most of the points (water samples) lie near the center and bottom left corner of the upper triangle, which reveals that chloride is more dominant anion there. However, in the left triangle, points move further towards sodium/potassium zone than Calcium, indicating alkali metals are dominant there. In the right rectangle box, points mainly lie between EC = 1000 to 3000 µS/cm range. In the pre-monsoon and post-monsoon season, samples exceeding the EC = 3000 µS/cm limit are 16 and 12 respectively. This is attributed to the saline nature of above samples. In the lower rectangle box, major points lie between pH = 6.5 to 8.0. Only 10 and 9 samples are below pH = 6.5 limit for pre-monsoon and post-monsoon season respectively. These samples are unsuitable for drinking. The groundwater quality is marginally better in post-monsoon season. This can be attributed to dilution of groundwater salinity in post-monsoon season due to recharge from rainfall.

Resistivity survey

Resistivity survey was conducted at 6 sites in the study area. Resistivity meter was used for vertical electrical sounding using Schlumberger arrangement. The sites are (1) Mainpur, (2) Bhuan, (3) Alatunga, (4) Balighai, (5) Chhaitana, and (6) Samangara village. Based on the resistivity survey, lithologic interpretations were made. At Mainpur, the first layer was generalized as top soil with a thickness of 2.13 m. The 2nd layer was generalized as alluvium deposit with a thickness of 14.8 m. The 3rd layer was recent formation aquifer zones of sand, silt and gravel and with thickness of 16.9 m to 133 m. At Bhuan, the 1st layer was generalized as top soil with a thickness of 0.47 m. The 2nd layer was generalized as alluvium deposit with a thickness of 0.84 m. The 3rd layer was recent aquifer patch with sand and silt having a thickness of 1.84 m. The 4th layer was aquifer zones of sand, silt and gravel having a thickness of 19.1 m. 5th layer upto a thickness of 22.3 -200 m was found to have good aquifer potential. At Alatunga, the 1st layer was generalized as top soil with a thickness of 0.9 m. The 2nd layer was alluvium deposit with a thickness of 15.9 m. The 3rd layer was generalized as aquifer patch with sand and silt having thickness of 18.03 m. The 4th layer was good aquifer zones of sand, silt and gravel having a thickness of 115.5m. The 5th layer upto a thickness of 150.3- 200 m was having a resistivity of 20.04 Ωm. At Balighai, the 1st layer was generalized as top soil with a thickness of 1.31 m. The 2nd layer was generalized as younger alluvium deposit with a thickness of 25.93 m. The 3rd layer was recent formation aquifer zones of sand, silt and gravel having a thickness of 92.76 m. The fourth layer indicated some saline water intrusion in the aquifer and have a thickness of 120 m to 200 m. At Chhaitana, the 1st layer was generalized as top soil with a thickness of 2.42 m. The 2nd layer was generalized as alluvium deposit with a thickness of 9.34 m. The 3rd layer was aquifer patch with sand and silt having a thickness of 21.1 m. The 4th layer was good aquifer zones of sand, silt and gravel having a thickness of 57.2 m. The very low resistivity value indicated the saline water intrusion in the aquifer (32 m to 90 m). At Samangara, the 1st layer was generalized as top soil with a thickness of 0.64 m. The 2nd layer was alluvium deposit with a thickness of 11.8 m. The 3rd layer was generalized as recent formation of good aquifer zones of sand, silt and gravel with thickness of 19.1 m.

River bed survey

River water level survey was done using DGPS for the monsoon and post-monsoon season. The survey was carried out at 8 sites on rivers distributed over the study area in the month of August and December 2023. The survey was done at two profiles in Kushabhadra River, two profiles in Nuanai river, two profiles in Dhaudia river, one profile in Bhargabi river and one profile in Dhanua river. Boats were used for the survey wherever it was required. During the monsoon season, the river water level varied form 3.7 m to 12.4 m at the survey sites. In the post-monsoon season, the river water level varied from 1.5 m to 10.6 m.

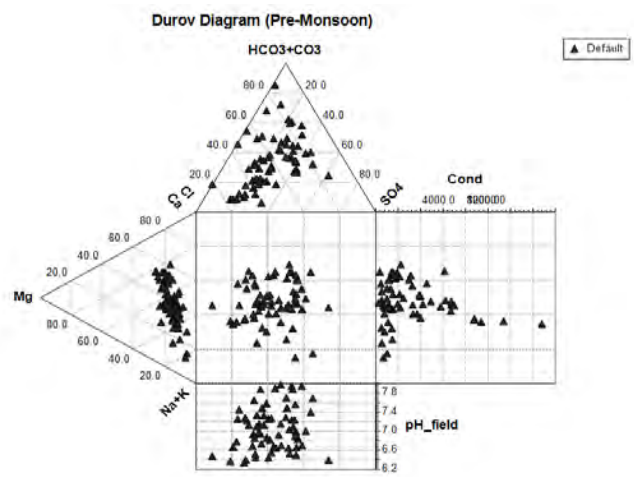


Fig. 23. Durov diagram of the study area for pre-monsoon season

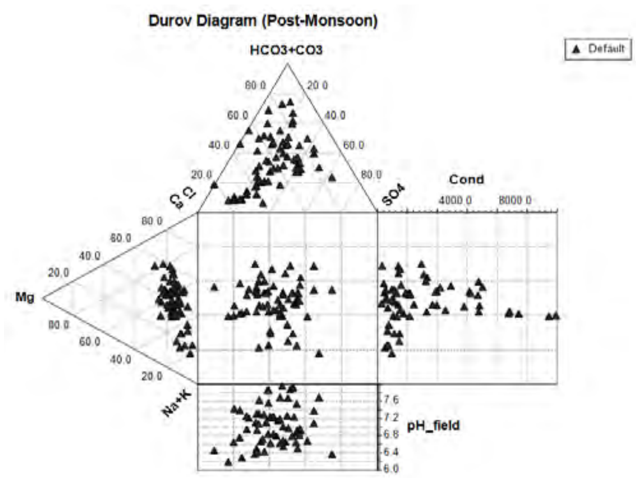


Fig. 24. Durov diagram of the study area for post-monsoon season

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 and S.K. Rautaray

Water and N regime on paddy water productivity

The comparison between continuous flooding (CF) and alternate wetting and drying (AWD) irrigation methods in paddy cultivation reveals significant impacts on yield, water productivity, and resource utilization. AWD demonstrates a wider range of yield variation (4036 to 4738 kg/ha) compared to CF (4138 to 4622 kg/ha), potentially indicating higher yield potential or variability. AWD exhibits higher water productivity, ranging from 3.60 to 4.42 kg/ha-mm, compared to CF's range of 3.18 to 3.49 kg/ha-mm. High nitrogen levels correlate with yield increase, with AWD showing a 17% boost and CF showing a 12% increase. AWD reduces water usage by 17.22% compared to CF, consuming 1092 mm of water versus CF's 1322 mm. Transitioning to AWD may result in a 4.5% average yield decrease but leads to an 11.4% increase in water productivity, highlighting its efficiency in water utilization. This trade-off emphasizes the sustainability of AWD, aligning with water conservation goals while maintaining or potentially increasing yields.

Water management and soil water storage

In CF, water depth varied between 10 and 100 mm, while in AWD it ranged between -102- and 101-mm. Shallow groundwater depths varied from 90 to 280 cm below the surface until one week before harvest. AWD showed 42% of days without standing water compared to 31% in CF. AWD saved 17.4% more water than CF, with 1322.5 mm and 1092.5 mm applied, respectively. Moisture distribution in surface soil under both treatments remained similar at harvest, but AWD had 11.7% lower soil moisture in the rhizosphere throughout the growth period.

Water balance under HYDRUS simulation

In the Kharif season, water balance in HYDRUS showed 1195.2 mm of total water input, with evapotranspiration and percolation as major losses at 491.2 mm and 487.9 mm, respectively. Capillary rise from groundwater contributed 154.2 mm, lateral seepage from bunds was 131.5 mm, and soil storage was 61.6 mm. During the Rabi season, CF input was 1281.9 mm and AWD input was 1061.1 mm. Evapotranspiration, percolation, capillary rise, lateral seepage, and soil storage under CF were 517.2, 410.2, 274.5, 144.4, and 80 mm respectively. AWD values were 412.9, 275.9, 284.7, 85.3, and 87.6 mm respectively. AWD conserved 17.2% more water than CF.

Simulation of nitrate balance using HYDRUS

The comparison between nitrate leaching under alternate wetting and drying (AWD) versus continuous flooding (CF) reveals significant differences in nitrogen balance components. Simulations using HYDRUS-2D illustrate that under AWD, NH4+ and NO3− loads converged at 120 cm below the surface, consistently lower than CF across various N fertilization levels. AWD showed lower nitrogen loads (e.g., at 120 kg ha−1: AWD 22.2 kg ha−1 vs. CF 23.6 kg ha−1). Percentages of N leaching losses concerning applied N were notably lower for AWD (14.8% to 17.1%) than CF (15.7% to 19.2%). AWD effectively mitigates nitrate leaching, offering a more environmentally sustainable irrigation approach compared to CF. Additionally, soil water movement to the bund from the paddy field primarily occurred in the upper bund layer, influencing lateral seepage and percolation.

N leaching under different fertilizer application scenario

The HYDRUS simulations examine nitrogen (N) uptake dynamics under different fertilizer application and irrigation methods (CF and AWD). Results showed that crop N uptake increases with N fertilizer up to 150 kg/ha, beyond which additional N doesn't significantly enhance uptake. Excessive N (>150 kg/ha) can lead to negative environmental impacts, including increased soil NO3−-N concentration and leaching, especially pronounced under CF. These findings stress the importance of strategic N management to mitigate leaching, highlighting the role of irrigation methods like AWD in sustainable agriculture. Balancing N application and irrigation strategies is crucial for environmental and economic sustainability in farming.

Evaluation of climate change impacts on groundwater resources and development of management strategies for resilient agriculture in India

Project Code: ICAR, New Delhi under NICRA

Investigators: D. K. Panda, B. Satapathy, Ajit K. Nayak and R. K. Jena

In order to compare and validate the results of GRACE-derived terrestrial water storage (TWS), we investigated the groundwater storage changes under erratic climate and anthropogenic pressure in the alluvial aquifer of Ganga basin, using in-situ groundwater level data from 8600 monitoring wells recorded in four seasons during 1995-2017. Consistent with the GRACE results, the in-situ observations reflect that the resilience of the Ganga basin started to weaken during the post-2009 drought period. The major concern is the groundwater level drop of more than 2 m and 1.5m in the non-monsoon and monsoon months, respectively. Despite the world-wide use of the Gravity Recovery And Climate Experiment (GRACE) based terrestrial water storage (TWS) to assess the groundwater storage changes, its low spatial resolution warrants validation using in-situ groundwater levels. To this end, we collated a large dataset from 8600 monitoring wells of CGWB, recorded in four seasons August (monsoon), November (post-monsoon), January (irrigation winter) and May (pre-monsoon summer) during 1995-2017. The mean groundwater level over the Ganga basin is presented in Fig. 25. The response of the mean groundwater level (m, below surface) reflects both the seasonality and long-term declines. The summer drawdown is 8.87m, dropping from the monsoon season groundwater level of 5.85m, thus indicating about 3m difference between the driest and wettest cycle. Over the study period, the groundwater level has dropped significantly ($p<0.05$) irrespective of seasons: August (1.5 m), November (2.19 m), January (2.31m) and May (2.02m).

Since the beginning of the 21st century, the monsoon rainfall that replenish the groundwater resources on an annual cycle behaves more erratically. Particularly, the droughts of 2002, 2004, 2008, 2009, 2012 and 2015 had notable impacts. Although the groundwater-irrigated alluvial aquifer of Ganga basin exhibited resilience to the initial years of rainfall deficits, an apparent irreversible kind of falling water table can very well be noticed from the monthly time series data. The response of the mean groundwater level (m, below surface) derived from 8600 monitoring wells over the Ganga River basin in the month of August (monsoon), November (post-monsoon), January (irrigation winter) and May (pre-monsoon summer) during 1985-2017 is shown in Fig. 25. A perceptible decline can be seen in recent years because of excess groundwater withdrawal to adapt a dry-hot climate.

Between the pre-2000 (1985-2000) and post-2000 (2001-2017) periods, an average decline of 1 m has occurred, with the January and May experiencing 1.5 m and 1.2 m decline, respectively. Interestingly, during the pre-2000 period, the falling water table during the three-year drought around 1995 witnessed a recovery thereafter resulting in a non-significant stable sub-surface system. The spatial contrast between 1996-2000 and 2011-2015 (Fig. 26) provides further evidence regarding the coherent pattern of decline, matching the intensively irrigated belt of northern and northwestern parts of the basin.

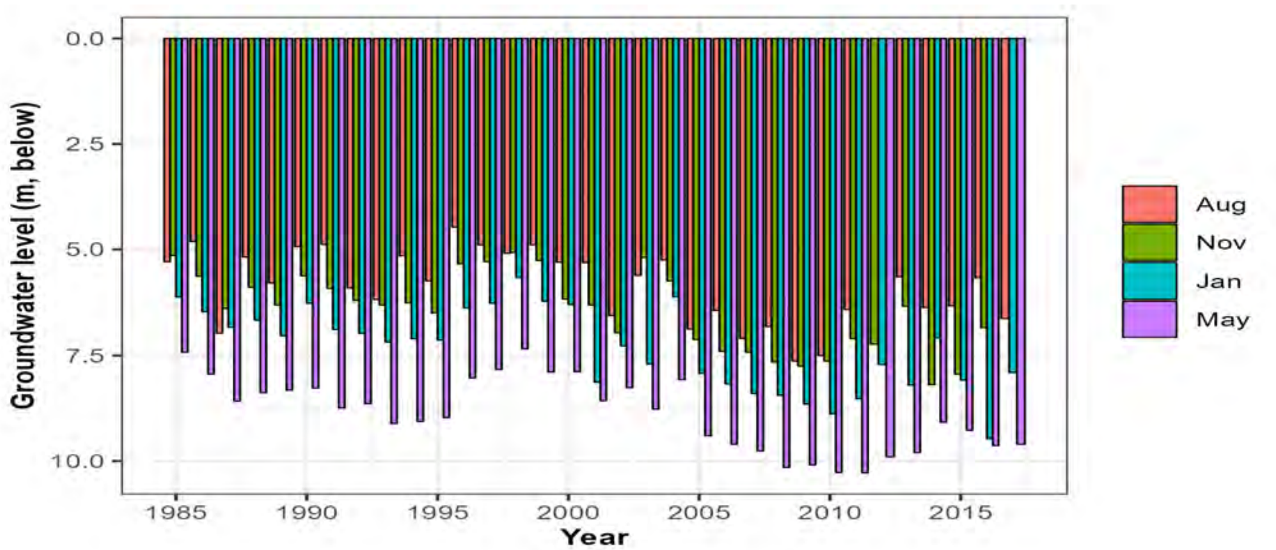


Fig. 25. Response of the mean groundwater level (m, below surface) derived from 8600 monitoring wells over the Ganga River basin

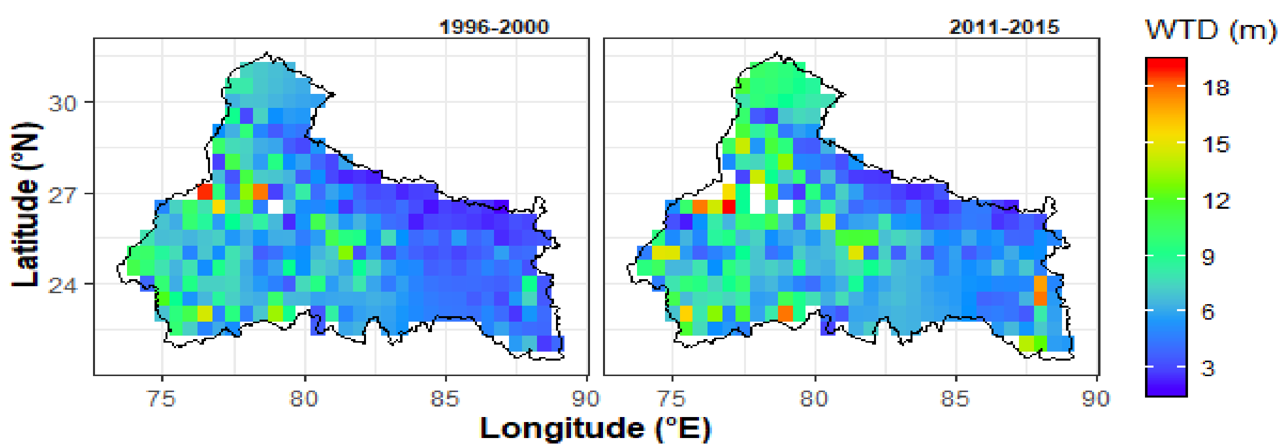


Fig. 26. Spatial difference of water table depth (WTD, m) between 1996-2000 and 2011-2015 across the Ganga River basin, indicating widespread declines over the western and north western parts of the basin.

Water Management and Production Practices of Dragon Fruit Under Protected Cultivation

Project Code: NRMA/IIWM/SIL/2021/002/00204

Investigators: P. Sahu, Ajit K. Nayak, Kundan Kishor and R.K. Jena

An attempt was made to test the feasibility of the dragon fruit cultivation under aggregate hydroponic based system in open field conditions inside ICAR-IIWM main campus. To accomplish the above-mentioned objective, two varieties of dragon fruit (pink pulp type & white pulp type) were planted in HDPE pot (height: 448 mm, dia: 590 mm, weight: 4.7 kg) with four different growing media (Cocopeat, Coco fibre, Cocopeat+ perlite & soil) in four planting systems (1 plant/pit, 2 plants/pit, 3 plants/pit and 4 plants/pit) in CRD design with three replications under open field condition.

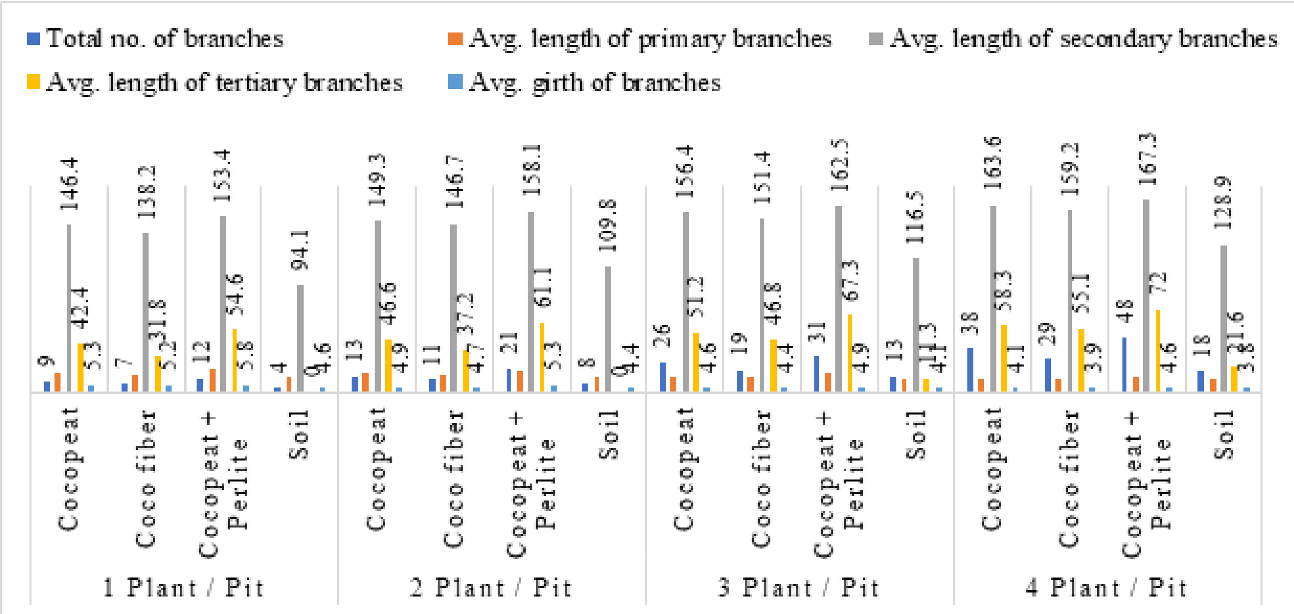


Fig. 27. Effect of planting system and media on vegetative growth of dragon figure

Cocopeat+ Perlite in 1 plant/pit planting system has highest length of primary branches (20.2cm) while cocopeat + perlite in 4 plants/pit planting system has highest length of secondary branches (167.3 cm) and highest length of tertiary branches (72 cm) (Fig. 27). Dragon fruit plant generally start yielding after 12-15 months from the date of planting. However, under soilless media cultivation we could able to get the 1st yield at 9 months of planting. After 1st year of planting, highest average yield (8.6 kg/pot) was obtained in combination of cocopeat and perlite media followed by Cocopeat alone (6kg/pot), Cocofibre (4 kg/pot) and lowest was in soil (3.5kg/pot). Fruits were harvested 30–40 days after flowering which is considered as an appropriate maturity stage and the samples were used for physio-chemical and biochemical analysis. Wide variability was observed for fruit size and shape in different soilless media studied. The average fruit weight varied between 152 g to 404 g, Peel weight varied between 60 g to 154 g, Pulp weight varied between 92 g and 250 g. Both the peel weight and pulp weight showed a positive correlation with fruit weight (r = 0.886 and 0.987, respectively at 5% level of significance). Average peel and pulp percent was about 27 and 72.8% respectively. The pulp percent is comparatively high (70–78%) in the cocopeat media as compared to soil (57.3%). Pulp to peel ratio varied between 2.69 and 4.81. Among different soilless media grown fruits analyzed, cocopeat + perlite recorded the highest pulp to peel ratio (4.81), and the lowest pulp to peel ratio (2.69) in the soil. Overall, red pulp fruits recorded the highest pulp to peel ratio (3.60) than white pulp fruits (2.85), indicating their high recovery. Pulp to peel ratio negatively correlated with peel percent (r = -0.960) and positively correlated with pulp percent (r = 0.960). Fruits harvested from cocopeat recorded highest no. of seeds/100g pulp (3927.88), seed test weight (1.21g), TSS (16.15^0 Brix), reducing sugar (13.17% glucose) and lowest acidity (0.43%). Approximately 2-4 litres of water (weekly) twice per plant is sufficient during the summer/ dry days in dragon fruit. However, we found 2-4lits of water is sufficient for 15 days in dragon fruit when planted in different soilless media. We observed the phenological growth stages of dragon fruit under circular apex canopy i.e., vegetative bud development (90 days), shoot development (60 days), development of vegetative propagated organ (45 days), reproductive bud development (45 days), flowering (21 days), fruit development (2days), fruit maturation (28days).

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

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

Investigators : O.P. Verma, P.P. Adhikary, Ankhila R.H and S. Mohanty

A field experiment was conducted at ICAR-IIWM research farm to assess the productivity and profitability of banana based solar powered drip irrigated multi-tier cropping systems during rabi season 2022-23. The treatments were: four multi-tier cropping systems (Banana + ridge gourd + groundnut, Banana + okra + cowpea, Banana+ cucumber + pea and Banana + bittergourd + beans), compared with sole cropping of banana. All the intercrops in association with banana presented higher values of LER than the sole banana. During this season, Banana + okra + cowpea multi-tier cropping system recorded maximum LER value of 1.51 with drip irrigation system (Table 10), It Indicates that the yield advantage was more in intercropping as compared to mono cropping of banana. Banana + okra + cowpea multi-tier cropping system produced the maximum banana equivalent yield which is 45% higher than the sole banana. With respect to water productivity, WP and EWP, maximum was recorded with the above said cropping system. The highest equivalent water productivity, EWP (Rs 68.6 m^3) was obtained when banana intercropped with okra and cowpea. Least EWP was registered with mono cropping of banana. In 90 cm soil profile total carbon storage was found as 72.83 t/ha from the total multi-tier cropping systems. In top soil layer up to 0-5 cm soil depth 7% more carbon storage was observed as compared to initial value.

Table 10. Banana equivalent yield, WP and EWP of different multitier cropping systems during *rabi*

	LER	BEY (t/ha)	WP (kg/m^3)	EWP (Rs/m^3)
Banana	-	9.10	2.20	28.4
Banana+ Ridge gourd +Groundnut	1.36	15.05	4.16	64.3
Banana + Okra + Cowpea	1.51	15.43	4.33	68.6
Banana + Cucumber + Pea	1.22	13.83	3.10	54.0
Banana + Bitter gourd + Beans	1.11	14.23	3.75	52.1

Improving Groundwater Sustainability Through Analyzing Groundwater-Energy Nexus

Project: Agri Consortia Research Platform on Water, Agri CRP on Water Theme-IV

Investigators: R. R. Sethi and Ankhila R. H

Groundwater use in different sectors across India

The groundwater use in different sectors of India showed that 18 states out of 28 states, namely, Andhra Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Telangana, Uttar Pradesh, Uttarakhand, West Bengal and Puducherry, groundwater extraction for irrigation purposes is more than 60% of total groundwater draft.

Groundwater status in Odisha

In Odisha, mostly hard rock dominating areas falls under safe groundwater use zone, whereas coastal districts like Kendrapada, Jagatsinghpur, Bhadrak, Balasore and few areas of Puri districts falls under saline categories. Initial primary survey was carried out in Bhadrak, Balasore, Jajpur, Keonjhar, Puri, Dhenkanal and Mayurbhanj districts. It was observed that majority of sample survey falls under small land holding category (1-2 ha) (Table 11). Details of irrigation infrastructures (Table 12) showed that electric pump is predominant in the survey location. However, diesel pumps were also used in most of the location due to irregular electricity supply for irrigation in post monsoon and summer season. Solar pumps were used in Keonjhar district through different government schemes.

Table 11. Distribution of sample households in surveyed location

District	Distribution of sample households (%)					
	Marginal (<1 ha)	Small (1-2 ha)	Semi-median (2-4 ha)	Medium (4-10 ha)	Large (>10 ha)	Total area, ha
Operational land holding (%)						
Bhadrak (Bhandaripokhari)	15.38	26.92	42.31	15.38	0.00	59.79
Balasore (Jalewsar)	6.00	22.00	22.00	50.00	0.00	182.41
Jajpur (Korei)	27.27	63.64	9.09	0.00	0.00	17.17
Keonjhar (Sadar-Jhumpura)	18.18	9.09	72.73	0.00	0.00	22.22
Puri (Nimapada)	20.00	60.00	10.00	10.00	0.00	19.19
Dhenkanala (Sadar)	9.38	28.13	18.75	43.75	0.00	93.00
Dhenkanala (Gandia)	0.00	16.67	46.67	36.67	0.00	8.90
Mayurbhanj (Bahalda)	0.00	75.00	25.00	0.00	0.00	79.69
Mayurbhanj (Badasahi)	53.85	30.77	7.69	7.69	0.00	22.44
Mayurbhanj (Betonoti)	33.33	33.33	33.33	0.00	0.00	8.69
Mayurbhanj (Khunta)	33.33	60.00	6.67	0.00	0.00	19.10
Mayurbhanj (Kuliana)	14.29	71.43	14.29	0.00	0.00	7.07
Mayurbhanj (Udala)	28.57	57.14	14.29	0.00	0.00	11.12

Table 12. Details of irrigation infrastructures

District	Percent of households owing (%)				Depth of boring (m)	Horse power of Pump		
	Boring	Pumpsets (diesel)	Submersible (electric)	Pump set (Solar)		Pumpsets (diesel)	Submersible (electric)	Pump set (Solar)
Bhadrak	20	13	15	0	51	10	5	0
Balasore	25	17	32	0	58	5	7.5	0
Jajpur	5	0	6	0	74	0	5	0
Keonjhar	5	0	1	11	69	0	5	5
Puri	4	1	6	0	34	2	2.5	0
Dhenkanal	17	11	33	0	81	2.5	5	0
Mayurbhanj	30	8	35	0	52	2.5	1.5	0

Paddy-green gram was dominating cropping system in most of the districts. It was observed that kharif paddy is mainly dependent on rainfall, however supplemental irrigation was provided during long dry spell in most of the area. But over irrigation was provided in Bhadhak and Balasore farmers due to shallow water table depth. In all the areas, *Rabi* and *zaid* crops are mainly dependent on irrigation. Volume of groundwater pumped and energy used in groundwater pumping were presented in Fig. 28 and 29.

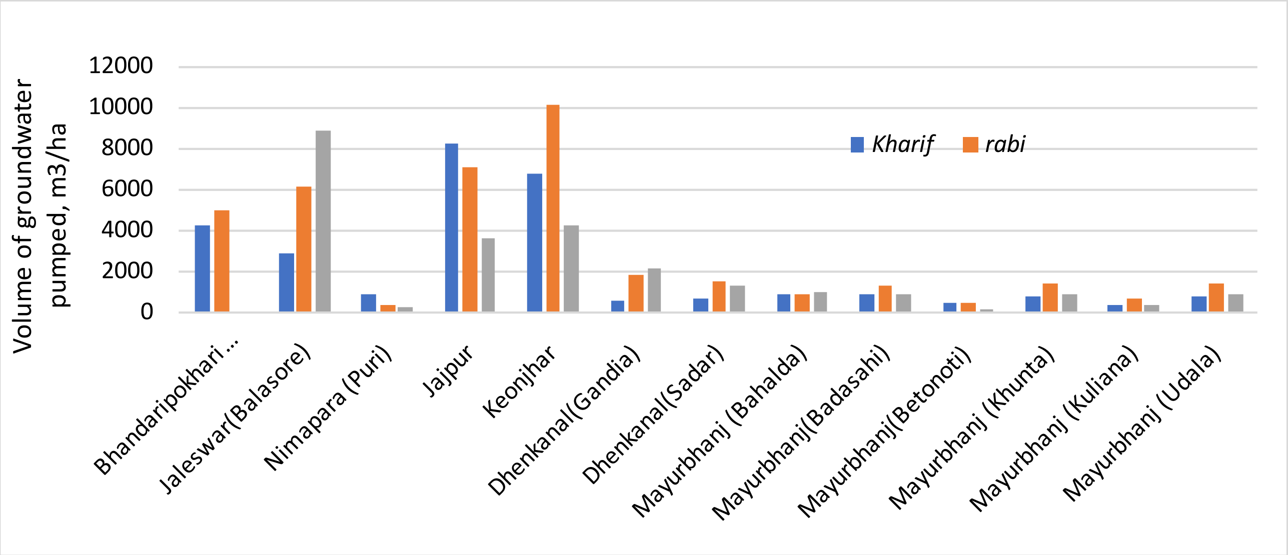


Fig.28. Volume of groundwater pumped in different locations (based on questionnaire survey)

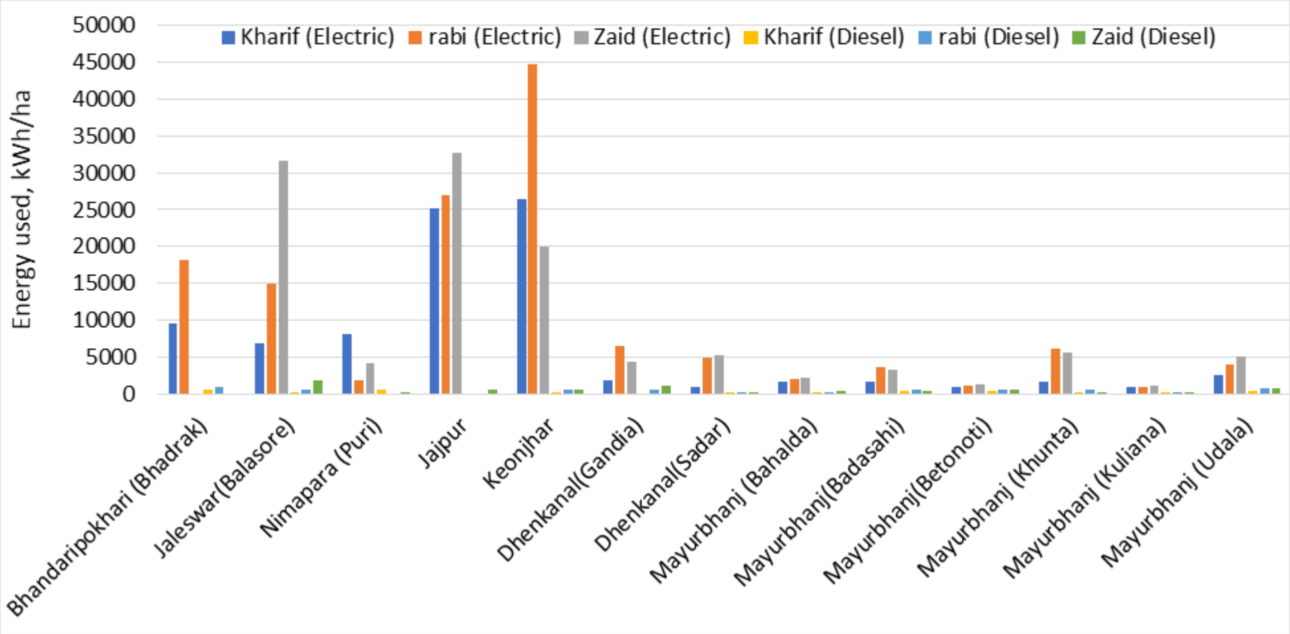


Fig. 29. Energy used for groundwater pumping in different locations

Comprehensive Hydrologic Assessment and Monitoring for Science-Based Watershed Planning and Management

Project: Rejuvenating Watersheds for Agricultural Resilience through Innovative Development (REWARD)

Investigators: S. K. Jena, D. C. Sahoo, R. R. Sethi, S. K. Rautaray, A. Sarangi and P.P. Adhikary

This project is functioning at the ICAR- Indian Institute of Water Management, Bhubaneswar under the aid of World Bank and Directorate of Soil Conservation and Watershed Development (DSCWD), Government of Odisha since June-2022. The project development objective (PDO) of REWARD is to improve land and water conservation and climate resilience in selected watersheds, and strengthen capacities of national and state institutions to deliver more effective science-based watershed development program. The specific task undertaken by ICAR-IIWM is to provide comprehensive hydrologic assessment and monitoring for science-based watershed planning and management in two MWS clusters viz, Odagaon and Daspalla of Nayagarh district in Odisha covering the area of 18,739.15 ha.

Establishment of bench marking sites and measurement of hydrometeorological parameters

One model micro watershed and six monitoring micro watersheds was selected in the Odagaon and Daspalla clusters for the establishment of benchmarking sites. Total 13 and 11 benchmarking sites has been established to install the different hydrometeorological instruments to measure the various climatic parameters and hydrological fluxes in the Odagaon and Daspalla cluster respectively.

One Automatic Weather Station (AWS), two Telemetric digital automatic rain gauges, three Pan Evaporimeters, one Double ring Infiltrometer, two Theta Probe with data loggers, twenty-seven TDR access tubes, two Current meters, four Groundwater level indicators (Reel type), two Digital water Level Recorders (DWLR), and four Stage Level Recorders (SLR) were installed at various locations of Odagaon and Daspalla. A daily monitoring and observation of data from all these field equipment is continuing.

Rainfall and temperature analysis of Odagaon cluster

The grided data (0.25°x0.25° and 1°x1°) of IMD from 1980 to 2022 was used to analyze rainfall and temperature, respectively, in Odagaon SWS cluster. The normal annual rainfall of Odagaon SWS is 1343 mm, which varied within 606 mm in 1985 to 2109 mm in 1986. The rainfall is highest in the month of August (314mm) and lowest (6.97 mm) in the month of December. It remains low from November to April (26 to 47 mm) and then increases gradually from May onwards, reaching the highest in August and then gradually decreases to 158 mm in October. The average number of rainy days of the SWS is 82, which ranges from a maximum of 111 days during the years 1990, and a minimum of 59 days in 1985. During the period from 1980 to 2022 (43 years), total of 40 extreme rainfall events (> 100 mm/day) occurred indicating that such events are likely to happen in 57 years out of 100. The South-West monsoon onsets in the region during 2nd to 3rd week of June every year and withdraws during 2nd or 3rd week of October. Of late the date of onset is found to be gradually moving towards the 3rd week of June. The hottest month in the SWS is June and the coldest months are December and January. The maximum temperature between July and February is observed to be less than 36°C, which indicates a favourable weather for growing crops. The monthly analysis of rainfall and 50% of PET showed that the Length of growing period (LGP) in the Odagaon SWS starts from 4th week of May and ends in 4th week of October (148 days). The water balance of all the 12 MWS under Odagaon SWS was simulated on a daily basis for a period of 10 years from 2013 – 2022 using Soil and Water Assessment Tool (SWAT). The depth of runoff generated from the MWSs of Odagaon SWS is found to vary from a minimum of 349.7 mm in Bhandar to a maximum of 479.7 mm in Badagorada MWS.

Delineation of groundwater recharge potential map of Odagaon SWS cluster using GIS-AHP technique

Total 9 thematic layers such as geomorphology, lineament density, slope, stream network, land use/land cover, soil, rainfall and elevation were used to delineate the groundwater recharge potential zone by using AHP method. The study revealed that about 5% of the cluster is covered under moderate groundwater recharge potential zone. The low and high groundwater potential zones are observed in 15% and 0.15% respectively (Fig. 30).

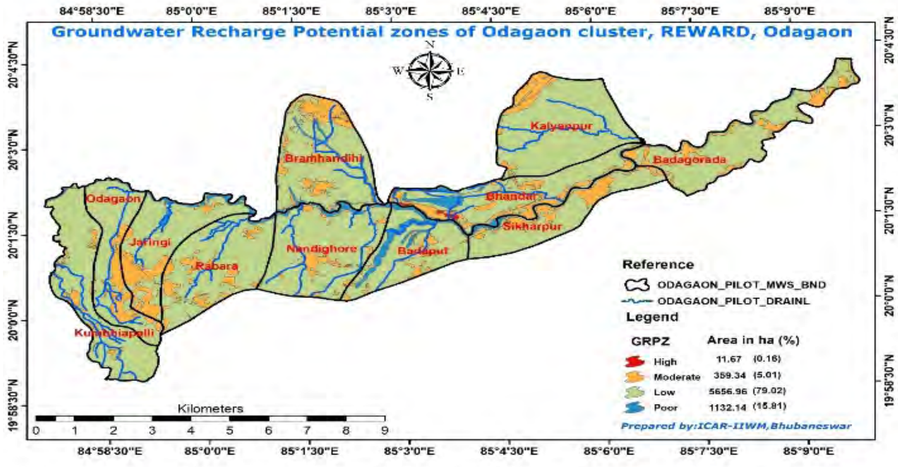


Fig. 30. Delineation of groundwater recharge potential zone in Odagaon cluster

Preparation of soil conservation, drainage line treatment and water storage plan of Odagaon cluster

The design of the structures under soil & water conservation (SWC) plan, drainage line treatment (DLT) and water storage (WS) plans are based on some assumptions with respect to retention of runoff in them (Fig. 31). However, the Loose Boulder Check Dams (LBCD), Percolation ponds and Masonry Check Dams (MCD) have been suggested under the DLT plan. Masonry Stone Wall (MSW) is also suggested for the impounding the water to irrigate the surrounding areas.

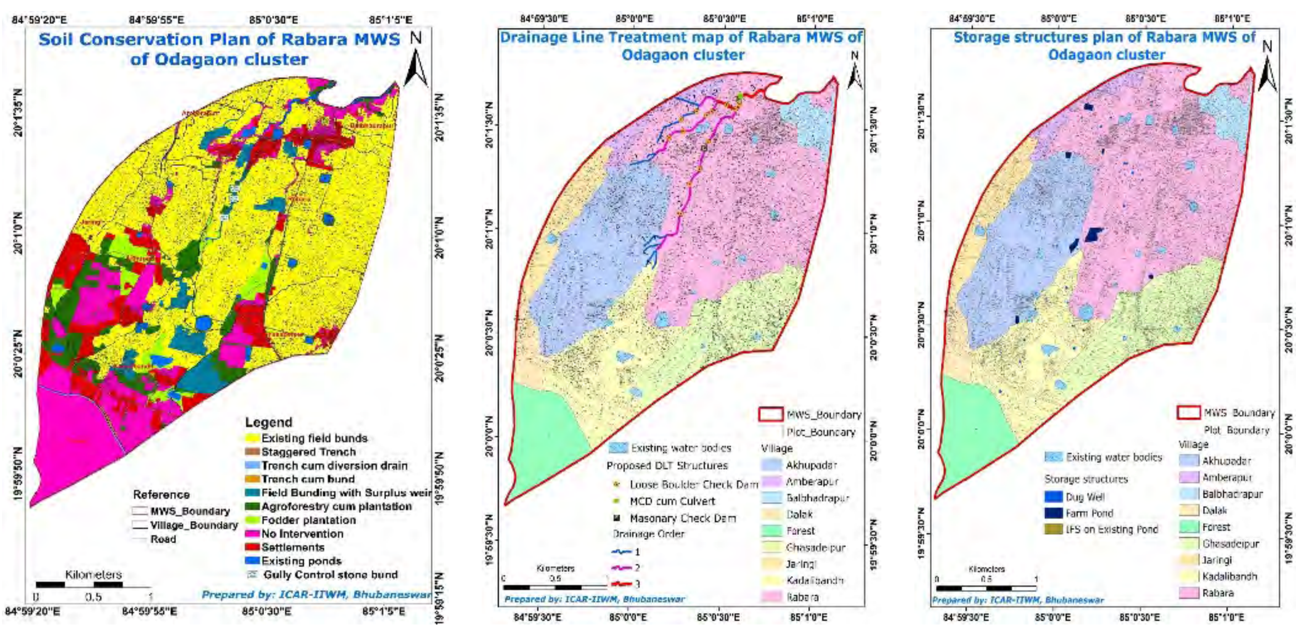


Fig. 31. Soil conservation, DLT and water storage plan for Odagaon

The water storage (WS) plan includes farm ponds of different sizes, WHS and IFS ponds. Ponds are suggested for arable lands where the soil texture is mostly sandy loam. Similarly, the IFS ponds have been recommended for the arable lands in valley region of the MWS. However, to ensure the irrigation water available in the rabi season and subsequent seasons the dug wells are suggested.

ON-FARM TECHNOLOGY DISSEMINATION

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

Development of Package and Practices for Reducing Hexavalent Chromium in Soil Plant Continuum

Project Code: NRMA/IIWM/SIL/2021/003/00205

Investigators: D. Ghosh, P. Deb Roy, A. Maity and K. Laxminarayana

Two field experiments were conducted during kharif 2023 at ICAR-IIWM, Bhubaneswar. In experiment-I, treatments comprised two levels of chromium (Cr) stress [natural and elevated (20 mg/kg soil)], three levels of organic amendment [without amendment, biochar (5 t/ha) and vermicompost (10 t/ha)] and two methods of irrigation practice [irrigation applied at 3 days after disappearance of ponded water (DADPW) and continuous flooding]. Experiments were conducted in completely randomized design and replicated thrice. The addition of organic amendments, especially vermicompost enhanced the plant height by 26 and 15% at tillering and flowering stages, respectively over control. Vermicompost improved the growth and yield attributes of rice. Organic amendments significantly reduced the Cr content in plant parts and enhanced the grain yield of rice (Fig. 32). Vermicompost performed better compared to biochar in restricting Cr translocation from root to shoot and Cr content in plants. Among the irrigation practices, continuous flooding significantly reduced the Cr content in rice roots. In experiment-II, treatments comprised of two levels of chromium (Cr) stress [natural and elevated (20 mg/kg soil)], three levels of seed priming [without priming, Fe primed (250 ppm) and Zn primed (1000 ppm)] and two methods of irrigation practice [3 DADPW and continuous flooding]. The seed priming with Fe enhanced the tiller number per hill by 22% and also improved the growth and yield attributes of rice. The rice plant grown in controlled condition (without seed priming) produced a less number of panicles and grains per panicle with shorter panicle length, and more chaffy grains. It ultimately yielded lower grain in comparison to seed priming (Fig. 33). The seed priming with Fe significantly reduced the Cr content in plant parts. The performance of Fe was better compared to Zn in restricting the Cr translocation from root to shoot and Cr content in plant.

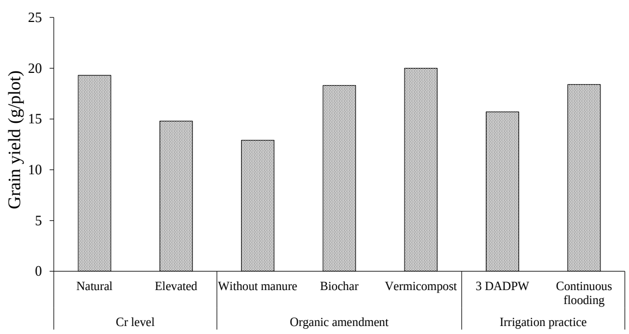


Fig. 32. Effect of organic amendment and irrigation practices on grain yield of rice under varied Cr level

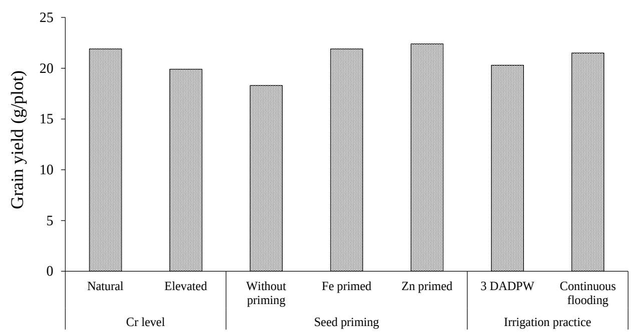


Fig. 33. Effect of seed priming and irrigation practices on grain yield of rice under varied Cr level

During *rabi* season two experiments were conducted on tomato. In experiment-I, treatments comprised of two levels of chromium (Cr) stress [natural and elevated (20 mg/kg soil)], three levels of organic amendment [without amendment, biochar (5 t/ha) and vermicompost (10 t/ha)] and two methods of irrigation practice [0.8 ET_C and 1.0 ET_C]. The enhanced level of Cr stress delayed the flowering of tomato plants, which ultimately reduced the tomato yield (Fig. 34). The addition of organic amendments, especially vermicompost enhanced the plant height and number of branches/plant over control and also improved the growth, yield attributes and yield of tomato. The tomato plant grown in controlled condition (without organic amendment) required more days for flowering and did not produce fruit in comparison to organic amendment addition. The irrigation practice with 1.0 ET_C yielded higher as compared to 0.8 ET_C. In experiment-II, treatments comprised two levels of chromium (Cr) stress [natural and elevated (20 mg/kg soil)], three levels of seed priming [without priming, Fe primed (1000 ppm) and Zn primed (1000 ppm)] and two methods of irrigation practice [irrigation applied at 0.8 ET_C and 1.0 ET_C]. Seed priming with Fe improved the plant's height and branch count compared to control. The plant growth, yield characteristics, and yield of tomato increased with seed priming technique (Fig. 35). The tomato plant grown under controlled condition (without priming) required more days for flowering and did not produce fruit in comparison to seed priming. The irrigation practice with 1.0 ET_C yielded higher as compared to 0.8 ET_C.

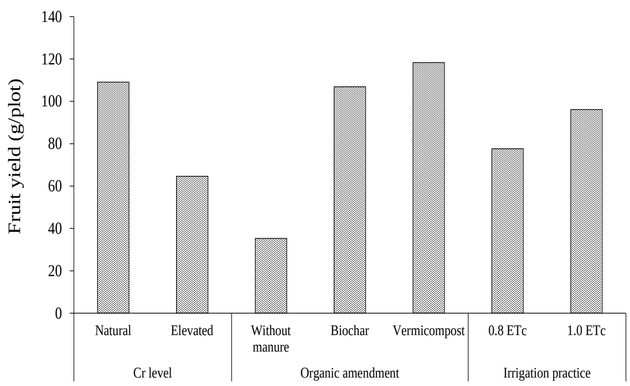


Fig. 34. Effect of organic amendment and irrigation practices on fruit yield of tomato under varied Cr level

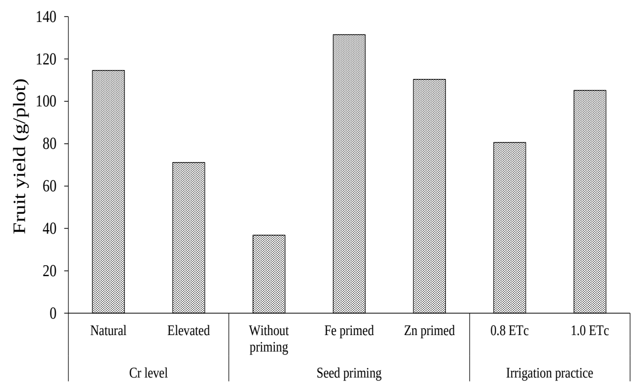


Fig. 35. Effect of seed priming and irrigation practices on fruit yield of tomato under varied Cr level

The best treatment combination i.e. seed priming coupled with vermicompost was demonstrated at three farmer's fields of Kaliapani, Sukinda, located in Odisha's chromium-mining areas. The tested approach enhanced the rice grain yield upto 12% at farmers' field.

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: Ashok K. Nayak, S.K. Jena, R. K. Mohanty and S.K. Rautaray

An attempt was made in this study to identify suitable sites for aquaculture in the coastal region of Eastern and Western coast of India. Land use and land cover maps of Western coast i.e. Ernakulum and Thrissur districts of Kerala, and three coastal districts of Odisha, i.e. Puri, Jagatsinghpur, and Kendrapara in the Eastern coast were prepared by using Sentinel-2 data. The georeferenced water samples were collected from these regions and analyzed using point feature class in ArcGIS 10.3 platform. Water quality parameters viz. pH, CO_2, dissolved oxygen, TDS, Transparency, Alkalinity, and Salinity were estimated. Further, soil, water, and infrastructure facilities were assessed by the analytical hierarchy process (AHP). Based on the point data of water quality parameters of different stations, the geo-statistical interpolation was done to generate the spatio-temporal variability map. Raster maps thus generated have been reclassified as per the suitability rating and thematic maps for these seven water quality parameters have been prepared. Moreover, for soil quality analysis, different soil parameters were considered for mapping viz. soil pH, soil texture, organic carbon, soil depth (cm) and slope (%). The soil suitability map was prepared by assigning weightage to the parameters based on the published protocols & AHP model. For infrastructure facilities, the distance to water sources (km), distance to the hatchery (km), and distance to the market (km) were considered in the study. Sixteen thematic layers were prepared using ArcGIS. In this process, the region was categorized into different suitable locations for developing aquaculture activities in Jagatsinghpur district. Out of the entire land cover area of Jagatsinghpur district, the most suitable areas comprise 35%, moderately suitable areas (41%), and other unsuitable and restricted areas (24%), which is the extent for the development of aquaculture. Based on this information, thematic maps were created using geospatial analysis tool (raster calculator) as shown in Fig. 36. This study will assist in delineation of aquaculture development zone for enhancing production and income of stakeholders.

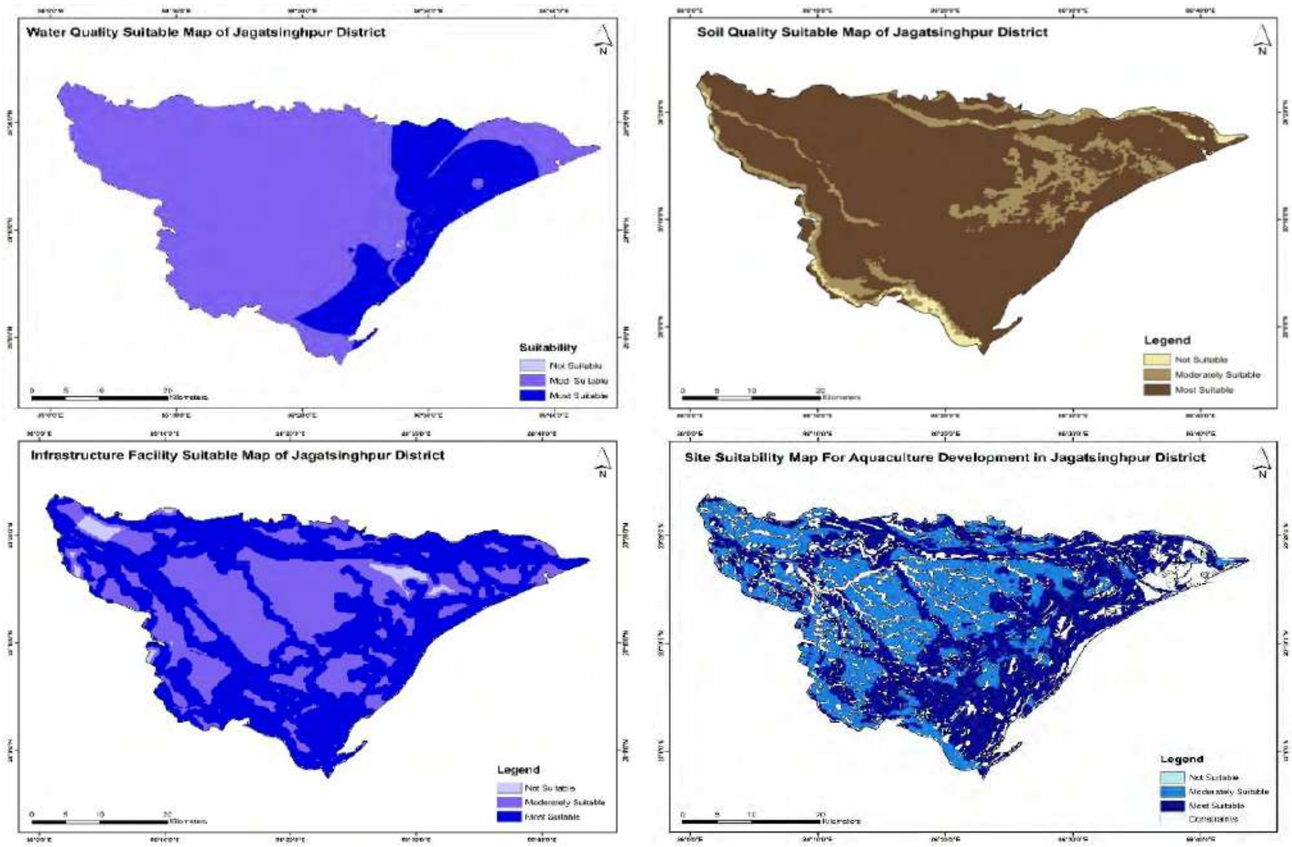


Fig.36. Thematic map for soil quality, water quality & infrastructure facilities and site suitability map of Jagatsinghpur district respectively

Socio-Economic Evaluation of Solar Irrigation and Its Impact on Farmers Livelihood in Eastern India

Project Code: NRMA/IIWM/SIL/2021/009/00211

Investigators: Ankhila R.H., R.R. Sethi, D. Sethi and O. P. Verma

The project's goal was to assess how well the PM-KUSUM programme and solar irrigation work together to support farmers in using solar irrigation. The study was conducted in Odisha, Chhattisgarh and Andhra Pradesh. Primary survey of 120 respondent farmers from Odisha, 50 from Chattisgarh and 30 from Andhra Pradesh were collected. The data was analyzed for the factors influencing the adoption of solar irrigation by the farmers, the total sample size was 200. The results of the analysis are represented in the Table 13.

Table 13. Factors influencing farm households' adoption of solar irrigation analyzed using binary logistic regression

Variables	Coefficient	Marginal Effects (dy/dx)
Farming experience	0.309	0.061
Education	0.253**	0.05
Land Ownership	-0.083	-0.017
Age	-0.031**	-0.006
Farm size	0.127 **	1.013
Household size	-0.364	-0.072

** Indicates significance at 5% level of significance

Six most important factors were considered to see the adoption of solar irrigation by the respondent farmers, i.e. age, education, land ownership, farming experience, farm size and household size. The results of the factor analysis showed that education and farm size are the two most important factors affecting the adoption of solar irrigation positively and found to be significant at 5% level of significance. Educated farmers and the farmers having large farm sizes are better in adopting the solar irrigation and *PM-KUSUSM* scheme. While it was observed that age factor is negatively affecting the adoption of solar irrigation with coefficient of -0.031, farmers with more experience or aged farmers are not ready to easily adopt the new scheme of solar irrigation.

Table 14. Farmers' perception about the solar irrigation among the sampled farmers (in percentages of the responses)

	High	Moderate	Low	No change	Negative
Economic direct benefits					
Enhanced yield with solar irrigation	81.3	17.2	1.6	0.0	0.0
Improved quality of produce	60.3	33.3	4.8	1.6	0.0
Electricity saving/diesel saving	86.4	13.6	0.0	0.0	0.0
Increased irrigation area	87.3	7.9	4.8	0.0	0.0
Environmental benefits					
Reduction in pest and diseases	24.4	39	9.8	17.1	9.8
Reduction in weed infestation	18.2	45.5	9.1	15.2	12.1
Social benefits					
Saving of energy consumption	55.9	35.3	5.9	2.9	0.0
Efficient allocation of water among farmer	-	38.5	15.4	46.2	0.0

Perception of the farmers was captured in terms of economic, environmental and social benefits. Nearly 81% of the farmers agreed that solar irrigation greatly enhanced yield to a high degree. About 86.4% of the farmers highly agreed on electricity saving/diesel saving, while 87.3% of the farmers agreed upon increased irrigation area and 4.8% agreed with a low increase in irrigation area. In terms of environmental benefits, pest and disease reduction was not agreed upon by majority of the farmers. Only 18% of the farmers highly agreed on reduced weed infestation and 12% of the farmers opined negatively saying more weeds after solar. In social benefits, 55% of the farmers highly agreed on saving of energy/ fuel with solar and none had a negative opinion about it. About 38% of the farmers moderately agreed on efficient allocation of water after the adoption of solar irrigation. Perception of the farmers regarding the training needs was captured, and the results are represented in the Table 14. Nearly 75% expressed high need for training to learn about repair and maintenance of the solar panels. 50% of respondents said they needed training on which crops to use with solar-powered irrigation. Training regarding knowledge about the number of times to irrigate was felt by 65% of the farmers while 64.7% of the farmers expressed need for training in plant protection and 53.8% expressed the need to create awareness about the scheme, which is lacking among majority of the areas (Table 15).

Table 15. Training need for promoting adoption of solar irrigation system

Respondents (%)	High-need	Need	No need
Repair and maintenance	75.0	20.8	4.2
Suitability of crops to solar powered irrigation	42.9	50.0	7.1
Irrigation management	64.5	29.0	6.5
Plant protection	64.7	32.4	2.9
Creating awareness of the scheme	53.8	46.2	-

Technological Options and Policy Guidelines for Risk Management in Water Quality

Project Code: NRMA/IIWM/SIL/2022/002/00214

Investigators: M. Raychaudhuri, D. Ghosh and R.K. Mohanty

Surface and groundwater quality data was collected from CWC, CGWB, CPCB and SPCB to assess the risk to agriculture and aquaculture on the basis of available standards from BIS, FAO and other agencies. To assess the risk, primary database was considered and a classification model was developed to assess the suitability of water quality using machine learning. Several classification models were tried viz, Decision Tree Models, Random Forest, XG Boost, and lightGBM. All the models performed well. The accuracy level of train data was 1.0 and for test data was 0.97 in decision tree models (Fig. 37). The risk associated variables as categorized by Random Forest Model were Mn > Fe > Mg those needs to be addressed accordingly.

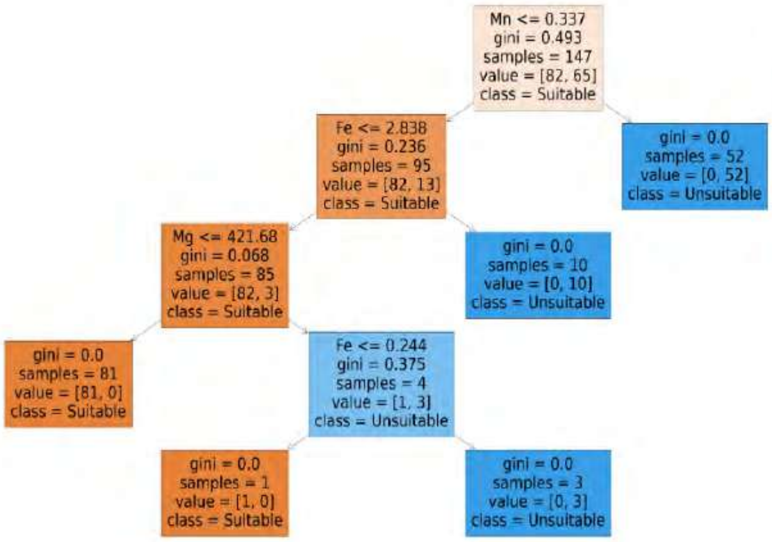
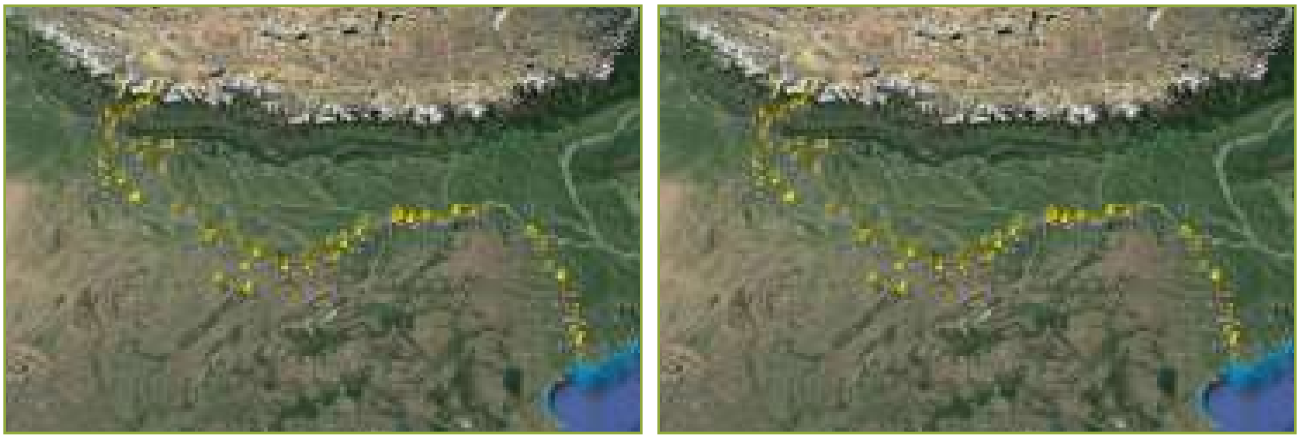


Fig. 37. Decision Tree Model to assess the risk associated with water quality

The Ganga River and its tributaries gets untreated discharge of about 13320.44 MLD, from the states of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal, largely due to the misspent installed STPs, as well as untapped drains (Fig.38). The data on biological oxygen demand (BOD) of 637 drain water flowing to the Ganga River and its tributaries were collected from National Water Quality Monitoring Programme (NWMP) Dataset. It is estimated based on post monsoon period of 2021 the river receives BOD load of 605.01 TPD. The pollution sources are mainly domestic but mixing of other effluents like industrial, hospital and other sources are also prevalent. The river water carries chemicals and other effluents, which is used to irrigate agricultural fields. The vegetables are cultivated with contaminated water. There is skin disease due to contact with the polluted water.



Post-monsoon 2021 | Pre-monsoon 2022

Fig. 38. Municipal drains being discharged in Ganga River and its tributaries

The water quality of inland ponds of ten states and coastal ponds of 5 States were analyzed for different parameters as listed in table 16 and 17 using data collected from SPCB's/PCC's under NWMP. Based on the water quality, different aquaculture options were prioritized and recommended.

Table 16. State-wise minimum-maximum average inland pond water quality parameters and suggested aquaculture options.

	Temp. (^{0}C)	Water pH	DO (ppm)	Salinity (ppt)	Total Alkalinity (ppm)	BOD (ppm)	Aquaculture options*
Assam n = 170	20.1- 31.6	6.9- 7.8	4.4- 7.3	0.09- 0.13	77.6- 87.4	3.2- 4.9	1,2,3,8,9,11
Bihar n = 20	16.2- 31.8	7.3- 8.7	4.7- 14.8	0.27- 0.53	81.8- 97.4	2.1- 10.9	1,2,9,11
Goa n = 23	26.4- 31.3	6.1- 7.3	4.4- 6.8	0.04- 0.46	68.3- 81.5	0.8- 4.22	1,2,3,8,9
Gujarat n = 50	23.6- 30.4	7.0- 7.6	4.4- 6.6	0.32- 0.54	78.6- 85.1	2.3- 11.2	1,2,9,11,12
Karnataka N = 500	24.6- 27.9	6.8- 7.9	3.7- 6.3	0.22-0.46	76.2- 88.2	3,85- 22.39	1,2,11,12
Rajasthan n = 75	19.1- 29.7	7.4- 8.5	4.5- 6.6	0.32- 0.66	83.4- 95.6	1.48-3.92	1,2,3,8,9
Tamil Nadu n = 20	21.9- 30.0	6.4- 7.8	4.9- 6.8	0.35- 0.80	71.6- 87.4	1.31- 2.12	1,2,3,8,9
Telangana n = 466	23.8- 29.3	7.0- 8.0	1.7- 4.0	0.60- 1.20	78.8- 88.2	6.0- 20.8	2,11
Tripura n = 69	20.1- 29.3	5.5- 6.7	6.8- 7.5	0.08- 0.13	62.0- 75.4	0.96- 2.25	1,2,3,8,9,11
West Bengal n = 41	14.6- 28.8	6.1- 9.2	6.7- 7.9	0.13- 0.21	68.3- 103.1	1.3- 2.8	1,2,3,8,9,11
Odisha n = 44	19.8- 31.6	7.1- 8.4	4.6-10.1	0.12 0.26	80.0- 94.4	1.7- 3.62	1,2,3,8,9,11

* 1-Carp poly culture, 2- freshwater cat fish/murrel /climbing perch culture, 3-freshwater prawn culture, 4- brackish water shrimp-fish (Penaeus monodon, Mugil cephalus, Chanos chanos, Liza parsia) polyculture, 5-brackish water crab-fish poly culture, 6- crab (Scylla serrata, S. tranquebarica) culture, 7-monoculture of Litopenaeus vannamei, 8-freshwater pearl culture, 9-carp-SIS polyculture, 10- brackish fish (Mugil cephalus, Chanos chanos, Liza parsia) polyculture, 11- culture of locally preferred freshwater fish, 12-waste water aquaculture (bheri culture).

Table 17. State-wise minimum-maximum average coastal pond water quality parameters and suggested aquaculture options.

	Temp. (^{0}C)	Water pH	DO (ppm)	Salinity (ppt)	Total Alkalinity (ppm)	BOD (ppm)	Aquaculture options*
Goa n = 14	28.0- 33.0	6.62- 7.88	4.9- 7.6	3.8- 8.0	74.2- 88.2	0.7- 3.68	4,5,6,7,10
Gujarat n = 32	24.6- 30.8	6.68- 8.04	4.6- 6.2	1.7- 6.1	74.8- 90.0	7.3- 12.2	7,10,12
Karnataka n = 135	24.6- 28.9	6.72- 7.44	4.4- 6.1	0.62- 4.18	75.2- 83.4	3.8- 17.2	4,5,6,10
Tamil Nadu n = 15	25.4- 32.1	6.78- 7.84	4.7- 6.5	3.25- 14.2	76.0- 88.0	1.4- 5.16	4,5,6,7,10
West Bengal n = 12	21.9- 34.0	5.3- 11.2	7.4- 8.6	1.38- 6.48	60.0- 125.4	3.3- 9.4	4,5,6,10,12
Odisha n = 16	20.8- 32.2	6.8- 8.22	5.1- 8.8	2.4- 12.4	76.2- 92.0	1.8- 4.86	4,5,6,7,10

* 1-Carp poly culture, 2-freshwater cat fish/murrel /climbing perch culture, 3-freshwater prawn culture, 4- brackish water shrimp-fish (Penaeus monodon/L. vannamei, Mugil cephalus, Chanos chanos, Liza parsia) polyculture, 5-brackish water crab-fish poly culture, 6- crab (Scylla serrata, S. tranquebarica) culture, 7-monoculture of Litopenaeus vannamei, 8-freshwater pearl culture, 9-carp-SIS polyculture, 10- brackish fish (Mugil cephalus, Chanos chanos, Liza parsia) polyculture, 11- culture of locally preferred freshwater fish, 12-waste water aquaculture (bheri culture).

OUTREACH ACTIVITIES

Enhancing Land and Water Productivity through Integrated Farming System (Tribal Sub Plan Project)

Project Code: Tribal Sub Plan

Investigators: R.K. Panda, R.R. Sethi, R.K. Mohanty, Ashok K. Nayak, R.K. Jena and O.P. Verma

Outreach capacity building programme

Total eight nos. of Capacity building measures/skill development (02 nos.), On farm trials (02 nos.) and Frontline demonstrations (04 nos.) were organized in two villages in presence of officials from KVK, Gunupur, and KVK, Gajapati. Institute developed technology on 'Adoption of SRI technique in paddy crop' was introduced in both the villages. In spite of inhibition not to adopt a new practice of paddy cultivation, few progressive tribal farmers tried the practice in a small area. Front line demonstrations on 'Paired row bed planting of Maize/vegetables and mushroom cultivation' were exhibited in Khaira village (Gunupur, Rayagada) under the aegis of *'Viksit Bharat Sankalp Yatra'* in association with KVK, Gunupur. Crop production was given priority in Agricultural water management in order to increase productivity, profitability, and usage efficiency. The live demonstrations involved active participation and interaction of 186 tribal farmers on various aspects from both the villages. A micro irrigation-based farming system model was initiated in Phatachanchada village (Gajapati). Additionally, 64 samples of surface and sub-surface soil were collected to assess the effect of land use on different pools of soil organic carbon and forms of Nitrogen in the Khaira village project site.

Facilitation with farm input material

Farmers were facilitated with 1000 packets of back yard seed kits, 200 nos. of chicklings, 100 nos. of 6m each HDPE pipe conveyance systems along with sprinkler systems, 04 nos. of petrol operated water pumps, 30 nos. of threshing mats and 50 nos. of water storage tanks to promote low-cost drip irrigation system during the period under report.

Distribution of farm input

Viksit Bharat Sankalp Yatra programme

Adoption of modified SRI technique

Promotion of sprinkler irrigation system

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

Project: ICAR Project (Under SCSP)

Investigators: H.K. Dash, S.K. Mishra, B.K. Sethy, S. Pradhan and B.S. Satpathy, D.Ghosh and A.Jha

Support for Crop diversification, income enhancement and nutrition security

In order to bring in crop diversification and improve income of farmers more than 510kg of seeds of high value crops and 4.2q of HYV of paddy were distributed among 350 farmers under SCSP. Similarly, 90 kg of plant protection chemicals, 65kg of biofertilizers, 33.2q of urea and water-soluble fertilizers, 650 saplings, 6.0q of fish feed, 10.0q of vermicompost, 150 litres of decomposer, etc. were also distributed among famers. Further, to improve access of farm families to vegetables, kitchen garden vegetable seed kits containing 12 vegetable seeds were distributed to 430 women during the period.

Support for mechanization and irrigation

In order to ease the burden of land preparation, intercultural operation, eight (8) power mini weeders of 2.5hp capacity, six(6) power weeders of 7.0hp capacity, 2000 sq.mt of shade net, 1500sq.mt of plastic cladding film for protected cultivation structure, 540mt (90 number of 6mt each) of HDPE sprinkler pipes, 450mt of HDPE conveyance pipes, fittings of sprinkler irrigation (including riser and sprinkler, end caps, Qc bend, Tee, pump connectors, etc.), 38 bundles of barbed wire of 30kg each, 20 pieces of 3mt long galvanized sheets, 20 pieces of 4mt long galvanized sheets were distributed to farmers of Hansapada and Villigram villages of Nimapara block.

Distribution of Vegetable seeds in Sarbapada village of Nimapara block, Puri district

Capacity Development programme

Under SCSP, a two-day orientation workshop cum training programme on 'Crop and water management strategies for enhancing higher yield and income from rabi season crops' was organized in Goradapal village of Karimula GP of Gondia block in Dhenkanal district, Odisha on 20-21 Sept.2023. 150 mango saplings of variety Amrapalli and Dusheri were distributed for planting in homestead land, and about 80kg of vegetable seeds including tomato, chilli, French, cow pea, yard long bean, okra was distributed to farmers for growing in rabi season. About 145 farmers attended the programme

Demonstration of mulching in vegetable crops, Hansapada village, Nimapada

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

Project: ICAR Project (Farmer FIRST Project)

Investigators: S.K. Mishra, D. Sethi, B.S. Satapathy, S. Mohanty, P. Sahu, P.P. Adhikary and Ankhila R.H.

The Farmer FIRST Project (FFP) has been implemented in three newly adopted villages, namely, Haridamada and Barapita of Bhubaneswar block and Jamujhari of Jatani block of Khordha district, in addition to old clusters comprising Jamuda, Mallarpada and Khuntapingu villages in Saharapada block of Keonjhar district. In order to achieve doubling farmer income, capacity building, women's empowerment and livelihood improvement, seven field level training and demonstration programmes were conducted, in which more than 800 farmers and farm women were benefited. Ten rice and millet field days along with crop cutting experiments (CCEs) of demonstrated high yielding rice varieties (var. *Swarna sub-1, Binadhan 11, Mrunalini & MTU 1001*) and finger millet (var. *Arjun*) were conducted during *kharif* 2023 at both the clusters. For conducting field demonstrations, critical inputs like quality paddy, finger millet, dhanicha, vegetable seeds and seedlings, fruit saplings, polythene mulch, pro-trays, coco peats, fertilizers, paddy straw & oyster mushroom spawns, polythene for mushroom farming, vermi-beds with earthworm, *Trichoderma viridi* bio-agent and pesticides etc. were provided to the farmers under the project. Various farm implements, viz., 5 HP pump set (2 nos.), 3.2 HP pump sets (3 nos.), cono weeders (10 nos.), power weeders (2 nos.) and power sprayers (12 nos.) were distributed to the beneficiary farmers in groups for facilitating the farm operations at the new adopted cluster.

Farmers field day and feedback sharing in the Keonjhar

Rice field day cum CCE in Khordha

Kisan Sampark Sutra (KSS)

ICAR-Indian Institute of Water Management, Bhubaneswar, Odisha organized *"KISAN SAMPARK SUTRA"* to connect and interact with farmers in virtual mode from different States of India on fortnight basis (7.00 PM onwards). The program includes lectures of eminent Scientists/Experts from different disciplines, audio visuals, success stories, Scientist-Farmer interaction, etc. relevant to advance agricultural water management technologies; besides fisheries and animal sciences. Dr. Mausumi Raychaudhuri, Principal Scientist and Program Leader (OFTD) coordinated the programme. During this period, eleven programs was conducted in *hindi* language for the farmers across the country and eleven programs in *odiya* language for the farmers of Odisha. A total of 40 topics on water management aspects and popularization of millet crops were discussed and about 638 farmers participated. Major topics discussed is given below.

Date	Topic
April 12, 2023	Pressurized irrigation in crop production
April 26, 2023	Role of FPOs' in economic empowerment of farmers
May 17, 2023	Summer ploughing to conserve in-situ moisture
May 31, 2023	Water management in direct seeded rice and nursery preparation for transplanted rice
June 21, 2023	Organic farming to maintain soil health and ecosystem
July 12, 2023	Scientific paddy cultivation for higher yield
July 26, 2023	Watershed management strategies for soil and water conservation
Aug. 09, 2023	Management of fruit crops in rainy season
Aug. 23, 2023	Crop diversification under climate change scenario
Sept.13, 2023	Veterinary health issues
Sept. 27, 2023	Agricultural schemes for sustainable agriculture
Oct.01, 2023	Groundwater management for sustainable agriculture
Nov. 01, 2023	Soil health monitoring and improvement is a must for sustainable agriculture
Nov. 15, 2023	Digital agriculture for farmers' welfare
Nov. 29, 2023	Increasing water productivity of winter season crops with the use of drip irrigation

Mera Gaon Mera Gaurav

ICAR-IIWM has is organizing *Mera Gaon Mera Gaurav* Activities in 33 villages in 4 Districts (Khordha, Puri, Nayagarh and Cuttack) of Odisha under 7 clusters. Nearly 7 training programs on Water management technologies were conducted in the adopted villages involving 322 farmers. Demonstration program on summer vegetables with NHRDF seed kit, raised bed nursery for production of healthy vegetable seedlings and rabi vegetables were conducted. Nearly 200 farmers were participated in the demonstration program during 2023. Apart from this, nearly 15 numbers of Farmer-Scientist interaction meeting and one Swachhata awareness program and one vigilance programme was organized in these adopted villages. The details of adopted cluster village is given below;

Sl. No	Cluster-wise Adopted Villages	No. of farm families
I.	Beleswar Patana and Beladala in Puri Sadar; Balanga in Nimapada, Puri (3 nos.)	110
II.	Majana, Angarapada, Madhupur and Palaspur villages of Jatani, Khordha (4 nos.)	100
III	Taralapada, Fakirpada, Pampalo, Nuapada, Denga and Sahanisai of Balipatna, Khorda (6 nos.)	280
IV	Rabara, Nandighar, Akhupada, Ghasadeipur, Balabhdrapur of Nayagada (5 nos.)	300
V	Brahmadabati, Badabili, Sanamulai, Salei and Maujpur of Kantapada, Cuttack (5 nos.)	250
VI	Bhatabandha, Murudi, Dhamantira Niagorada, Chatahar and Parichanrapada of Nimapara, Puri (5 nos.)	200
VII	Benakera, Narendrapur and Ghasi Bhawanipur of Satyabadi; Arihan and Antikera of Puri Sadar, Puri (5 nos.)	280
Total	7 clusters, 33 villages, 4 districts	1520


VIGILANCE AWARENESS WEEK 2023

AICRP ON IRRIGATION WATER MANAGEMENT

Assessment of surface water and groundwater availability

Groundwater potential zoning in all river basins of Madhya Pradesh using geoinformatics technique (Jabalpur centre)

The study was done to delineate groundwater potential zones of 12 river basins (Betwa, Chambal, Dhasan, Ken, Mahanadi, Mahi, Narmada, Sindh, Sone, Tapi, Tons, and Wainganga) covering total 3.28 lakh km^2 in Madhya Pradesh (Fig. 39). A combination of geographic information system and analytical hierarchical process techniques (AHP) was used for delineation of groundwater potential zones. Eight thematic maps including geology, geomorphology, land use/land cover, lineament density, drainage density, rainfall, soil, and slope were prepared and analysed. The AHP method was utilized to assign weights to each class in all the thematic maps. Output accuracy was cross validated with data on the region's groundwater prospects. The maps were classified into five different groundwater potential zones such as Very good, Good, Moderate, Poor and Very poor. As a whole in the State, different groundwater potential zones were categorized into very good, good, moderate, poor, and very poor covering 6.20%, 28.73%, 51.43%, 13.05%, and 0.59%, respectively (Fig. 40).

Evaluation of surface and groundwater quality across the state of Kerala and its effect on vegetation (Chalakudy centre)

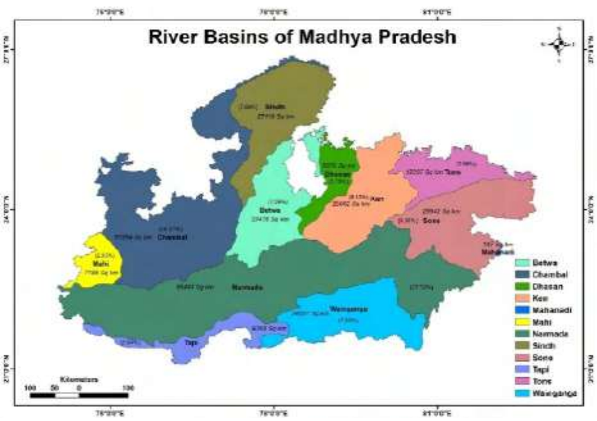


Fig. 39. Major river basins in Madhya Pradesh

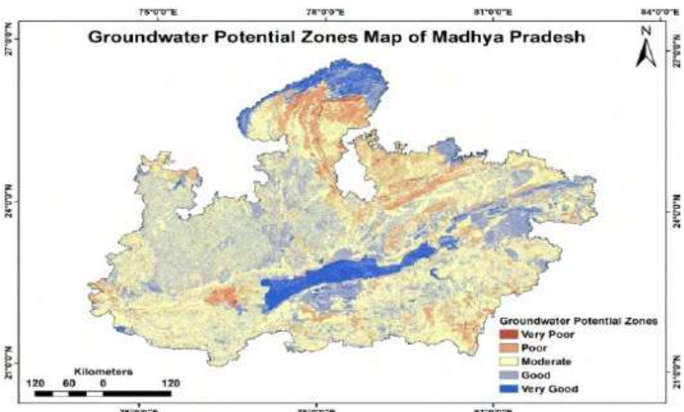


Fig. 40. Groundwater potential zone map of MP

Water samples were collected from different locations of three major rivers of Kerala viz. Periyar, Chalakudy and Karuvannur River in Kerala. Then samples were analysed for various water quality parameters viz., dissolved Oxygen, pH, EC, BOD, carbonate, bicarbonate, SAR, RSC, Mg/Ca ion ratio, sodium, potassium, chloride, sulphate, calcium, magnesium, copper, zinc, iron, manganese and boron to find out the suitability of the river water for irrigation purpose.

Chalakudy river: Chalakudy river water is heavily utilized in Kerala. Water samples and sediment samples were collected from 14 different locations in the river. Only one location i.e. Elanthikara has saline water due to seawater intrusion after monsoon. Majority of the paddy fields are left fallow due to unavailability of good quality irrigation water. Field demonstrations with salt tolerant rice varieties Vytilla and Ezhom showed that performance of Vytilla 9 was better. Well water can be utilized for irrigating crops in Elanthikara. Presence of heavy metal Nickel was found in four locations viz. Elenthikara, Parakadavu, Kaathikudam and Peringalkuthu reservoirs along Chalakudy river. Presence of E. coli was observed in six locations viz. Valparai, Athirappilly, Sree Sakthi Paper Mills, Chalakudy and Parakadavu.

Karuvannur river: Water samples were collected from 22 locations. Water Quality Index (WQI) of Karuvannur river in 17 regions were found to be <150. So, water from these areas is good for irrigation. WQI in five regions viz., Munayam bund, Thriprayar, Chemmapilly hanging bridge, Muthichur bridge, Chettuva bridge was >150 indicating poor quality for irrigation. Salinity (EC) was higher towards downstream side of the river. The adjoining area is famous for paddy cultivation and is known as Kole lands of Thrissur district. Waterlogging is a major constraint for paddy cultivation in these areas.

Periyar river: Twenty water samples were collected along the length of the river at an interval of 10-13 km along the stretch of 244 km of the river during pre-monsoon season. Water Quality Index ranged from 8.56 to 802.17. WQI in locations Gothuruthu, Maliankara, Kottappuram, Kothadu, Vaduthala, Goshree and Mulavukad were >150 indicating that irrigation water is not safe.

Irrigation and Fertigation Scheduling

Coordinated fertigation on cabbage crop in open field (Palampur)

Coordinated fertigation trial with cabbage crop was conducted from rabi 2020-21 to 2022-23 in silty clay loam soil of Palampur to evaluate effects of N, NP, NK and NPK fertigation on crop productivity. Ten treatments (T_1 to T_{10}) i.e. eight fertigation treatments, one control and one absolute control were applied. The Control treatment involved 100% NPK through conventional fertilizers, where half of recommended N and entire PK were applied as basal and remaining N was applied in two equal splits. No fertilizer application was done in the Absolute Control. Urea, SSP and MOP were used as conventional fertilizers for the Control treatment. Results for three consecutive seasons showed that the nutrient management treatments had significant effect on cabbage yield. Significantly higher yield of 28.9 t ha^{-1} and benefit-cost ratio of 1.65 was obtained with application of 25% NPK as basal and 75% NPK through fertigation among the fertigation treatments.

Coordinated fertigation on Marigold under protected condition (Palampur centre)

Marigold crop was grown in silty clay loam soil under protected condition of polyhouse during summer seasons of 2021 to 2023. Objective was to study the effects of surface and subsurface drip fertigation using inorganic and liquid organic (vermiwash) fertilizers under varying irrigation schedules on crop performance. Twelve fertigation treatment combinations were employed, with six under surface drip irrigation at 0.8 PE and remaining six under sub surface drip irrigation at 0.6 PE. Marketable flower yield (19.94 t ha^{-1}) was significantly higher and water use efficiency (54.90 kg ha-mm^{-1}) was maximum with application of 25% NPK as basal and weekly fertigation of 75% NPK in 10 splits along with sub-surface drip irrigation at 0.6 PE. Average WUE (44.3 kg ha-mm^{-1}) with subsurface irrigation was higher compared to surface irrigation (32.8 kg ha-mm^{-1}).

Response of high-density guava plantations to drip fertigation under semi-arid condition (Rahuri centre)

Fertigation scheduling was done for guava variety Sardar (Lucknow 49) grown with high density planting (3 m × 2 m) accommodating 1667 plants per hectare. Drip irrigation treatments viz., 120, 100, 80 and 60% ET_c and fertigation treatments viz., 120, 100, 80 and 60% RDF were applied. Results showed that interaction effect of drip irrigation at 80% ET_c and 120% RDF led to significantly higher fruit yield of 12.91 t/ha compared to all the treatment combinations. However, the fruit yield was statistically at par with yield obtained under drip fertigation at 80% ET_c and 100% RDF. Water use efficiency was also maximum (1990 kg/ha-mm) under drip irrigation at 80% ET_c. Net return of ₹ 197496/ha and benefit-cost ratio of 2.12 was highest under drip irrigation at 80% ET_c and 120% RDF, followed by irrigation at 80% ET_c and 100% RDF. Thus, it was recommended to plant high density guava at a spacing of 3 m × 2 m under drip irrigation scheduled at 80% ET_c every day and fertigation with 120% RDF through water soluble fertilizers (900:300:300 N, P_2O_5 and K_2O g per plant) through weekly 20 splits in medium deep soils of north-western Maharashtra for obtaining higher yield, monetary returns and resource use efficiency.

Rainwater harvesting and groundwater recharge

Assessment of influence of groundwater recharge on groundwater quality and fluctuations (Arabhavi centre)

A study is being conducted with goal to explore and construct indigenous groundwater recharge (GWR) technique/ structure for existing tubewell in IWMRC Belavatagi, and to assess the influence of the GWR structure/technique on groundwater quality and fluctuations. Double ring technique for borewell/ tubewell recharge was applied. Rainwater harvesting was done by diverting and storing excess runoff water from the adjoining field to the existing tubewell for point recharge. Total cost of construction of groundwater recharge unit including farm pond and silt trap was ₹83633. Monthly/ seasonal variations in tubewell water level, quality and discharge were observed. Total point recharge during 2020-21 to 2023-24 was 12.38 lakh litre. The groundwater level data revealed that there is considerable rise in the water table from more than 100 feet below ground level to around 33 feet below ground level. There is drastic reduction in electrical conductivity (EC) of groundwater from more than 10 dS/m to an average of 1.80 dS/m; and bore well yield has significantly increased from 0.4 lps to around 2.33 lps.

Harvesting of rainwater and collection in farm pond for groundwater recharge during 12 to 14th May 2023

Groundwater point recharge (in progress) during 12 to 14th May 2023

Identification of suitable sites for artificial groundwater recharge structures in different river basins under the jurisdiction of JNKVV Jabalpur (Jabalpur centre)

Identification of suitable sites for construction of artificial groundwater recharge structures was done using RS&GIS technique in Betwa, Dhasan, Ken, Mahanadi, Narmada, Sone, and Tons River basins. In this study, four major different thematic layers slope, soil permeability, stream order, and lineaments were used for site selection. All the thematic maps were reclassified and exported in 10 m spatial resolution. Different guidelines were analysed like IMSD (1995), CGWB (2007), NRSA (2011), and SAKSHAM (2017) for suitable site selection of various groundwater recharge structures. Suitable sites were identified using a GIS-based site suitability model created with the Model Builder in ArcGIS 10.8. Suitable artificial groundwater recharge structures like Check Dams (CD), Percolation Tanks (PT), Nala Bunds (NB) and Staggered Contour Trenches (SCT) and their possible sites were identified for each river basin.

Basic studies on soil-plant-water-environment relation

Mitigating heat stress in spring sweetcorn through irrigation optimization, mulch and companion cropping (Pantnagar centre)

A study was conducted to mitigate heat stress in sweetcorn crop during spring season i.e., February to June during anthesis and grain filling stages in Tarai region of Uttarakhand. Irrigation scheduling, cropping pattern and mulching treatments were applied in Factorial RBD design. Irrigation schedules of IW/CPE 1.2 and 1.0 were applied with irrigation depth of 6 cm. Crops were irrigated when cumulative pan evaporation (CPE) values reached 50 and 60 mm with total six and four irrigations under IW: CPE 1.2 and 1.0, respectively. Cropping patterns were Sweetcorn + Mentha (1:1) (between two rows of sweetcorn at 75 cm, one row of mentha), Sweetcorn + Mentha (2:2) (2 rows of sweetcorn at 50/100 cm and 2 rows of mentha between two pairs of maize), Sole sweetcorn (75 cm × 20 cm), and Sole mentha (50 cm) on flat bed. Mulching treatments were no mulch and rice straw mulching @ 6.0 t/ha at knee high stage of sweet corn. Results showed that highest green cob equivalent yield of 20.49 t/ha, WUE of 55.27 kg/ha-mm, net return of ₹281326/ha and benefit-cost ratio of 2.99 was observed in paired row planting i.e. sweetcorn + mentha (2:2) compared to single row planting of sweetcorn + mentha (1:1) and monocrops. Rice straw mulch application @ 6 t/ha at knee high stage of sweetcorn improved green cob equivalent yield and WUE by 10% over no mulch treatment. Rice straw mulch application also led to enhanced net income by ₹ 21399/ha over no mulching.

Paired row planting of Sweetcorn + Mentha intercrop (2:2)

Effect of irrigation schedule and soil amendments on surface cracks, water and yield in soybean-wheat cropping system in Vertisol (Kota centre)

The study was conducted from *rabi* season of 2020-21 to 2022-23 revealed that application of irrigation to wheat at IW/CPE 1.0 recorded significantly higher grain yield of 5.18 t/ha, water use efficiency of 13.04 kg/ha-mm, net return of ₹ 72193 and benefit-cost ratio of 1.53 among the irrigation treatments. Application of compost @ 5.0 t/ha recorded significantly higher grain yield of 4.63 t/ha and water use efficiency of 13.78 kg/ha-mm over other soil amendments. Positive trend in available nutrients status in soil were also observed in balance nutrient supplementing treatments. It was recommended to apply compost @ 5.0 t/ha as soil amendment (25-30 days before sowing) and irrigation at IW/CPE 1.0 (4-5 irrigations at critical stages) to enhance grain yield and water use efficiency of wheat and improve physicochemical properties of soil.

WEATHER REPORT

The weekly rainfall and open pan evaporation data during 2023 of Bhubaneswar was analyzed, and has been presented in Fig. 41 & Fig. 42. The average maximum and minimum temperatures were 33.4°C and 22.7°C, respectively, with the highest and lowest temperatures were 41.1°C in SMW 24 and 12.8°C in SMW 51. Average maximum and minimum relative humidity were 89.3% & 57.8% respectively. The highest and lowest relative humidity has been observed in SMW 13 (94.3%) and SMW 5 (33.3), respectively. The average wind speed was 1.7 km/h and the maximum speed recorded were 6.9 km/h in 20 & 21 SMW. The average BSS was 4.1 hours, with the highest value of 7.6 hours recorded in 15 and 50 SMW, respectively. The total number of rainy days was 66, with maximum 5 rainy days were observed in 29, 30, and 36 SMW. The total rainfall between January 1, 2023, and December 31, 2023, was 1629.9 mm and standard meteorological week (SMW) 31 received the highest rainfall of 301.7 mm. Total evaporation was 1588.1 mm and the highest evaporation was observed during SMW 21 (63.7 mm) and thereafter it declined during the monsoon period.

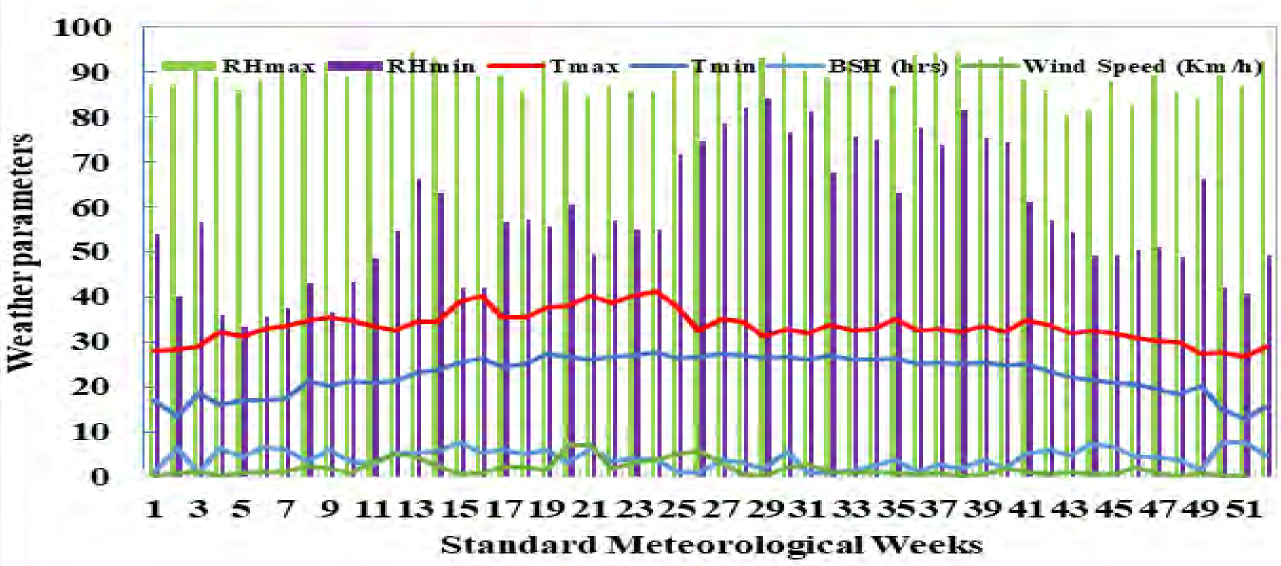


Fig. 41. Weekly weather parameters during 2023

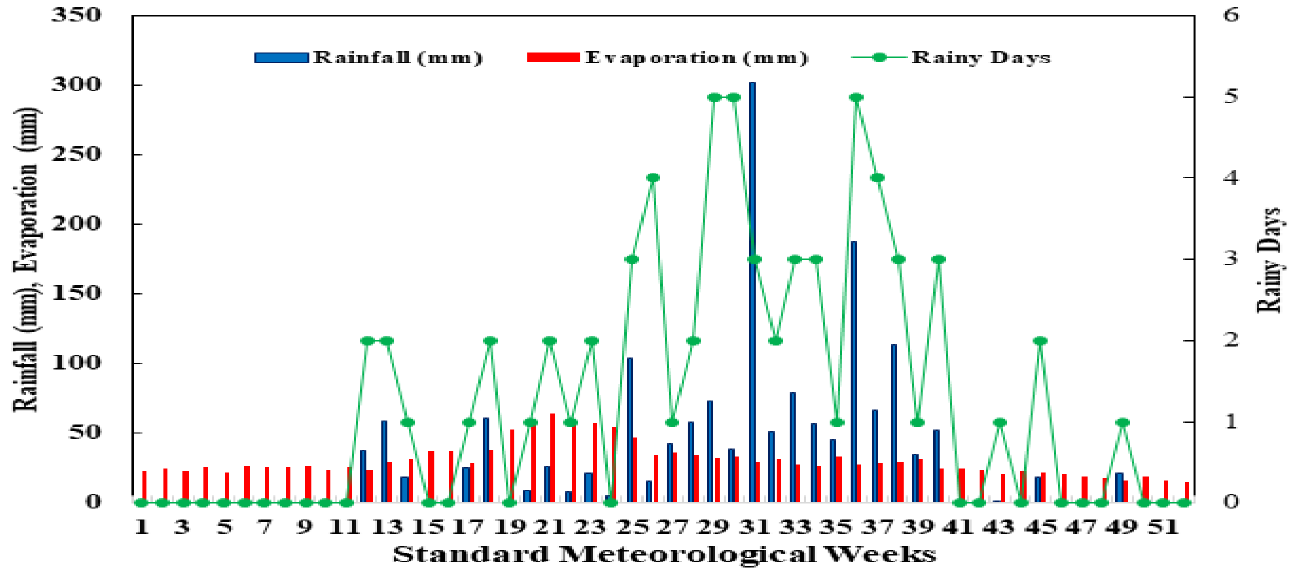


Fig. 42. Weekly evaporation and rainfall during 2023

PUBLICATIONS 2023

Peer reviewed research articles

- Adak, S., Bandyopadhyay, K., Purakayastha, T.J., Sen, S., Sahoo, R.N., Shrivastava, M. and Krishnan, P. 2023. Impact of contrasting tillage, residue mulch and nitrogen management on soil quality and system productivity under maize-wheat rotation in the north-western Indo-Gangetic Plains. *Front. Sustain. Food Syst.,* 7:1230207.
- Adhikary, P.P., Mohanty, S., Rautaray, S.K., Manikandan, N. and Mishra, A. 2023. Alternate wetting and drying water management can reduce phosphorus availability under lowland rice cultivation irrespective of nitrogen level. *Environ Monit Assess,* 195, (12) 1420.
- Ampee Tasung, Nayan Ahmed, Ruma Das, Ranjan Bhattacharyya, K.K. Bandyopadhyay, Neera Singh, Debarup Das, Bishal Gurung & S.C. Datta .2023. Effect of land use system and altitude on carbon stability in naturally occurring clay-organic complex in soils of Arunachal Pradesh in the Eastern Himalaya, India. *Archives of Agronomy and Soil Science*, 69:15, 3405-3421.
- H, A. R., Singh, A., Kumar, P., Kumar, S., Meena, M. C., Singh, R., Sunani, S. K., Adhikary, P. P., Kumar, D., Pradhan, S., and H, S. B.2023. Socio-economic impact of Soil Health Card scheme in the state of Andhra Pradesh. *The Indian Journal of Agricultural Sciences, 93(6), 683–686.*
- Bagwan, W.A., Gavali, R.S., Maity, A. 2023. Quantifying soil organic carbon (SOC) density and stock in the Urmodi River watershed of Maharashtra, India: implications for sustainable land management. *Journal of Umm Al-Qura University for Applied Sciences,*9,548-564.
- Basak, B.B., Sarkar, B., Maity, A., Chari, M.S., Banerjee, A., Biswas, D.R. 2023. Low-grade silicate minerals as value added natural potash fertilizer in deeply weathered tropical soil. *Geoderma,* 433, 116433.
- Bhattacharya, P, Bandyopadhyay, K.K., Krishnan, P., Maity, P.P., Purakayastha, T.J., Bhatia, A., Chakrabarti, B. and Adak, S. 2023. Effect of tillage, residue and nitrogen management onyield, water and nitrogen use efficiency of wheat (Triticum aestivum). *Indian Journal of Agricultural Sciences,* 93: 1191-1196.
- Bhattacharya, P., Bandyopadhyay, K.K., Krishnan, P., Maity, P., Purakayastha, T., Bhatia, A., Chakraborty, B., Kumar, S., Adak, S., Tomer, R. and Meenakshi. 2023. Impact of tillage and residue management on greenhouse gases emissions and global warming potential of winter wheat in a semi-arid climate. *Journal of Agrometeorology,* 25(4), 503–509.
- Chander, S., Ghosh, D., Tyagi, V.C., Chethan, C.R., Pawar, D., Gharde, Y., Kumar, b. and Singh, P.K. 2023. Imazethapyr-resistant jungle rice (Echinochloa colona) in Soybean growing belt of central India: A case study. A*gricultural Research,* 12(3): 298-307.
- Choudhary, C.S., Behera, B., Raza, M.B., Mrunalini, K., Bhoi, T.K., Lal, M.K., Nongmaithem, D., Pradhan, S., Song, B. and Das, T.K. 2023. Mechanisms of allelopathic interactions for sustainable weed management, *Rhizosphere.* 25: 100667.
- Das, Madhumita, Nayak, A.K., Verma, O.P. and Sethi R.R. 2023. Assessment and processing of groundwater quality from various land uses - a case study in Odisha, *Indian Journal of Soil Conservation,* 51(1): pp 1-10.
- Debnath, M., Sena, D. R., Sarangi, A., Singh, D. K. 2023. Simulating the effect of increased area under direct seeded rice and canal water supply on ground water table under climate change in five selected central Punjab districts, India. *Scientist,* USA. 2023; 2(1):274-280.
- Didawat, R. K., Sharma, V. K., Nath, D. J., Patra, Abhik, Kumar, Sarvendra, Biswas, D. R., Chobhe, K. A., Bandyopadhyay, K. K., Trivedi, Ankita. Indu Chopra, Dutta, Asik, Mohapatra, K.K. & Ajin S. Anil. 2023. Soil biochemical properties and nutritional quality of rice cultivated in acidic Inceptisols using long-term organic farming practices, *Archives of Agronomy and Soil Science,* 69:8, 1282-1297.
- Dinesh, G.K., Sharma, D.K., Jat, S.L., Bandyopadhyay,K.K., Shrinivasa Rao, C., Venkataramanan, V., Basant Kadam,

V., Sinduja, M., Sathya, V., Sethupathi, N., Bhatia, N., Kumar, P., Purakayastha, T.J., Anand, A. and Boomiraj, K. 2023. Effect of conservation agriculture practices on carbon pools in a sandy loam soil of Indo-Gangetic Plains. *Communications in Soil Science and Plant Analysis, 54(20), 2845-2862.*

- Gaddikeri, Venkatesh, Sarangi, A., Singh, D. K., Bandyopadhyay, K. K., Chakrabarti, Bidishaand Sarkar, S. K. 2023. Comparative evaluation of reference evapotranspiration estimation models in New Bhupania Minor Command, Jhajjar, Haryana, India. *Current Science, 124(10), 1181-1185.*
- Gavhane, K.P., Mishra, A.K., Sarangi, A., Singh, D.K. and Sudhishri, S.2023. Estimation of surface runoff potential of an ungauged watershed in semi-arid region using geospatial techniques. *Arab J Geosci*, 16, 402.
- Gavhane, K.P., Mishra, A.K., Sarangi, A., Singh, D.K., Sudhishree, S. 2023. Targeting of rainwater harvesting structures using geospatial tools and analytical hierarchy process (AHP) in the semi-arid region of Rajasthan (India). *Environ Sci Pollut Res.,* 30, 61682–61709.
- Ghosh D., Brahmachari K., Das A., Sarkar S., Dinda N.K., Moulick D., Datta M.K. and Bandyopadhyay S. 2023. Residual effect of organic manure on weed population and nitrogen uptake in greengram under rice-maize-greengram system. *Indian Journal of Weed Science,* 55(4): 374–379.
- Ghosh, S., Das, T.K., Nath,C.P., Bhatia, A., Biswas, D.R., Bandyopadhyay, K.K., Yasin, Md and Raj, Rishi.2023. Weed seedbank, above-ground weed community and crop yields under conventional and conservation agriculture practices in maize–wheat–mungbean rotation. *Weed Research, 63:270–281.*
- Kaledhonkar, M.J., Sethi, Ranu Rani and Rout, Pradeep Kumar. 2023. Delineation and prioritization of groundwater recharge areas in the state of Tamil Nadu using geographical information system, *Journal of Agricultural Engineering (India),* 60 (2): 218-238.
- Keerthana M., Ramakrishnan R.S., Kumar A., Pathak N., Pawar P.S. and Ghosh D. 2022. Seed rate and sowing method induced variation in phenology, seed yield and seed quality of soybean [Glycine max (L.) Merill]. *Biological Forum,* 14(4a): 541-547.
- Kiruthiga B., Singh M., Khanna M., Singh S., Parihar C.M., Bandyopadhyay K.K., Naresh Kumar S., Rajput J. and Kishor N. .2023. Crop yield, water use efficiency and economic assessment of purple broccoli (Brassica oleracea) across varied water and nitrogen management practices. *Indian Journal of Agricultural Sciences,* 93: 1202-1207.
- Kumar, A., Sarangi, A., Singh D.K., Dash, S., Mani, I. 2023. Evaluation of ultrasonic sensors for flow measurement in open channel, *Journal of Scientific and Industrial Research,* 82: 1091-1099
- Kundu R., Poddar R., Sen A., Sarkar A. and Ghosh D. 2023. Effect of varietal selection and nutrient management on productivity, soil fertility and economics of summer groundnut (*Arachis hypogaea*). *Indian Journal of Agronomy* 68 (4): 392-397.
- L. Ramalingappa, P., Shrivastava, M., Dhar, S., Bandyopadhyay, K., Prasad, S., Langyan, S., Tomer, R., Khandelwal, A., Darjee, S., Singh, R. 2023. Reducing options of ammonia volatilization and improving nitrogen use efficiency via organic and inorganic amendments in wheat (*Triticum aestivum L.*), *Peer J,* 11: e14965.
- Mahapatra, A., Saha, S., Munda, S., Satapathy, B.S., Meher,S. and Jangde, H.K.2023. Bio efficacy of herbicide mixture on weed dynamics in wet direct seeded rice, *Indian Journal of weed Science* 55, (I):18-23.
- Manu, S.M., Singh, Y.V., Shivay, Y.S., Shukla, L., Sharma, V.K., Das Saha, N., Shekhawat,K., Bandyopadhyay, K.K. and Gouda, H.S. (2023) Nitrogen budgeting under the influence of in situ rice residue management options in rice (Oryza sativa)–wheat (Triticum aestivum)cropping system. Indian Journal of Agricultural Sciences, 93:151-156.
- Mishra, R., Datta, Siba Prasad, Golui, Debasis, Meena, Mahesh Chand, Dwivedi, Bramha Swaroop, Rahman Mohammad Mahmudur, Bandyopadhyay, K.K. and Bhatia, Arti and Pandey, Punyavrat S. 2023. Evaluation of different extractants to estimate bioavailable arsenic in soil, *Communications in Soil Science and Plant Analysis,* 54:17, 2459-2474.
- Moulick, D., Ghosh, D., Mandal, J., Bhowmick, S., Mondal, D., Choudhury, S., Santra, S.C., Vithanage, M. and Biswas, J.K. 2023. A cumulative assessment of plant growth stages and selenium supplementation on arsenic and micronutrients accumulation in rice grains. *Journal of Cleaner Production, 386: 135764.*

- Nayak, A. K, Tripathi, R., Dhal, B., Nayak, A. D, Vijayakumar, S., Satapathy, B. S., Chatterjee, D., Swain, C. K, Moharana, K. C, Nayak, P.K., Poonam, A., Mohanty, S., Shahid, M., Kumar, A., Mondal, B., Panda, B. B., Patra, A.K., Swain, S.K. and Pathak, H. 2023. Eco-efficiency and technical efficiency of different integrated farming systems in Eastern India, *International Journal of Agricultural sustainability, 21:1,2270250.*
- Panda, D.K., Pradhan, S. and Aghakouchak, A. 2023. Surface drying impacts hot extremes in India: unravelling the exceptional 2010 and 2016 hot events. *Climate Dynamics.* 60:3785-3800.
- Panigrahi, P. 2023. Scheduling irrigation for improving water productivity and fruit quality in citrus (cv. Nagpur mandarin) under a dry tropical climate. *Irrigation Science,* 41: 511-520.
- Patra, S., Parihar, C.M., Mahala, D.M., Singh, D., Nayak, H.S., Patra, K., Reddy K.S., Pradhan, S. and Sena, D.R. 2023. Influence of long-term tillage and diversified cropping systems on hydro-physical properties in a sandy loam soil of North-Western India. *Soil and Tillage Research.* 229: 105655.
- Poddar, R., Kundu, R., Bera, S. and Ghosh, D. 2023. Complex weed flora managing efficacy of herbicides in soybean and their effect on soil properties, microorganisms and productivity of succeeding mustard. *Indian Journal of Weed Science,* 55(2): 181–186.
- Rajput, J., Singh, M., Lal, K. Khanna, M, Sarangi, A., Mukherjee, J, Singh, S. 2023. Selection of alternate reference evapotranspiration models based on multi-criteria decision ranking for semiarid climate. *Environ Dev Sustain.*
- Rajput, J., Singh, Man, Lal, K., Khanna, M., Sarangi, A., Mukherjee, J. and Singh, S. 2023. Assessment of data intelligence algorithms in modeling daily reference evapotranspiration under input data limitation scenarios in semi-arid climatic condition. *Water Sci Technol,* 87 (10): 2504–2528.
- Rajput, Jitendra, Singh, Man, Lal, K., Khanna, M., Sarangi, A., Mukherjee, J., and Singh, S. 2023. Performance evaluation of soft computing techniques for forecasting daily reference evapotranspiration. *Journal of Water and Climate Change,* 14 (1): 350–368.
- Rasal, A., Patnaik, M., Murmu, K., Mohanty, R.K., Sundaray, J.K., Swain, J.K., Mahapatra, K.D. 2023. Climate smart carp hatchery: Bringing resilience to sustainable fish seed production. *Aquaculture,* 571, 739476.
- Sethi, Ranu Rani, Dandapat, Asit Kumar, Sankalp, Sovan Sankalp, Jena, S. K., Panda, D. K. and Sahoo, D. C. 2023. Innovative trend analysis for evaluation of groundwater storage in Baitarani River Basin, *Environmental Earth Sciences,* 82:605.
- Thakur, A.K., Mandal, K.G., Verma, O.P., Mohanty, R.K. 2023. Do system of rice Intensification practices produce rice plants phenotypically and physiologically superior to conventional practice? *Agronomy,* 13, 1098.
- Verma, O.P., Sethi, R.R., Nayak, A.K., Manikandan, N., Pradhan, S., Jha, A., Jena, S.K. and Patra, P.K. 2023. Markov chain rainfall probability model and rainy season length in Kendrapara District, Odisha for efficient crop management strategies. *Current World Environment,* 18 (1): 133-144.
- Waghaye, A.M., Singh, D.K., Sarangi, A. Sena, D.R., Sahoo, R.N. and Sarkar. S.K. 2023. Identification of suitable zones and sites for rainwater harvesting using GIS and multicriteria decision analysis. *Environ Monit Assess,* 195, 279.
- Yadav, R., Sudhishri, S., Khanna, M., Lal, K., Dass, A., Kuswaha, H.L., Bandyopadhyay,K.K., Dey, A., Kuswaha,, A. and Nag, R.H. 2023. Temporal characterization of biogasslurry: a pre-requisite for sustainable nutrigation in crop production. *Front. Sustain. Food Syst, 7:1234472.*

Book chapter

- Adhikary, P.P., Dash, C.J., Behera, B., Mohanty, S. and Shit, P. K. 2023. Indicator kriging and its usefulness in assessing spatial suitability of groundwater for drinking. In case studies in geospatial applications to groundwater resources, pp. 11-26, Elsevier.
- Bandyopadhyay, K.K., Acharya, C.L. and Hati, K.M. 2023. Mulches and cover crops. part I: Types. In: Goss, Michael and Oliver, Margaret (eds.) Encyclopedia of soils in the environment. second Edition. vol. 3, pp. 392-400. UK: Elsevier.dx.
- Bandyopadhyay, K.K., Acharya, C.L. and Hati, K.M. 2023. Mulches and cover crops. part II: Role in soil health and

climate resilient agriculture. In: Goss, Michael and Oliver, Margaret (eds.) Encyclopedia of soils in the environment second edition. vol. 3, pp. 401-413. UK: Elsevier.dx.

- Deb, P., Mandal, A., Harendra, Roychoudhury, S., Das, A., Hazra, S., Mukherjee, A., Ghosh, D., Choudhury, S., Santra, S.C. and Moulick, D. 2023. Improving plant nutrient use efficiency for climate-resilient agriculture. Springer Nature M. Hasanuzzaman (ed.), Climate-Resilient Agriculture, Vol 2, 209-243.
- Dubey, Rachana, Raychaudhuri, M., Brahmanand, P.S., Kumar, Sanjeev, Singh, A. K. Upadhyaya, A. 2023. Impact of wastewater irrigation on growth, yield, and water productivity of Toria and sunflower crops. Journal of Agri Search, 10 (3): 158-162.
- Pradhan, S., Panigrahi, P., Mandal, K.G., Sahu, P., Sethi, D. and Nayak,A.K. 2023. Enhancing water productivity of drip irrigated pre-bearing mango orchard in degraded land of eastern India. In abstract book International conference on new generation horticulture for prosperity 20th & 21st January 2023, pp: 36-37.
- Roy, D., Ghosh, S., Datta, D., Sreekanth, D., Pawar, D., Mukherjee, P.K. and Ghosh, D., Santra, S.C. and Moulick, D. 2023. Chapter 7 Climate resilient weed management for crop production. Springer Nature M. Hasanuzzaman (ed.), Climate-Resilient Agriculture, Vol 2, 125-156.
- Roy, D., Pawar, D.V., Dasari, S., Mahawar, H. and Ghosh, D. 2023. Salinity and osmotic stress in field crops: effects and way out. In Choudhury, S. and Moulick, D. Response of field crops to abiotic stress current status and future prospects. CRC Press, Taylor & Francis Group 123-138.
- Satapathy, B. S., Sarangi, A., Raychaudhuri, M. Jena, S. K. and Mishra, S. K. Water management options for higher production and profitability of millet production system. In harvesting prosperity: rice, millets and beyond-cultivation, value addition and marketing. ICAR-National Rice Research Institute, Cuttack, Odisha, India, pp 89-100

Technical bulletin

- Jena, S.K. and Sethi, R.R. 2023. Annual report-2022, Agri-consortia Research Platform on water, ICAR-IIWM, Bhubaneswar, 70pp.
- Mohanty, R.K. and Sarangi, A. 2023.Water budgeting and cutback approach in aquaculture. Technical Bulletin-85, ICAR-IIWM, Bhubaneswar, India, 22p.
- Mohanty, S., Nanda, P., Ghosh, D., Dasgupta, P. and Sarangi, A. 2023. AICRP on IWM: A Profile, ICAR-IIWM Publication.
- Mohanty, S., Nanda, P., Ghosh, D., Satapathy, B. S. and Dasgupta, P. 2023. Annual Report 2022, AICRP on Irrigation Water Management, 84 pp.
- Mohanty, S., Sarangi, A., Nanda, P. and Dasgupta, P. 2023. Success Stories: AICRP on Irrigation Water Management. Technical Bulletin No. 86. ICAR-IIWM Publication, 48 pp.
- Raychaudhuri, Mausumi, Sarangi, A., Raychaudhuri, S., Ghosh, D. and Mohanty, R. K. 2023. Recommendations of Brainstorming Workshop on Water Quality Issues and Policy Guidelines in Agriculture and Aquaculture, Technical Bulletin No. 87, ICAR - Indian Institute of Water Management, Bhubaneswar, Odisha, India, 1-26 p.
- Sahu, Prativa. 2023. Role of conservation agriculture in horticultural crop production; In Training Manual on 'Conservation Agriculture'. Published by College of Agriculture, OUAT, Chiplima, pp: 59-63.
- Sahu, Prativa.2023. Protected cultivation for high value horticultural crops: In Training manual on 'Protected Agriculture'. Published by College of Agriculture, OUAT, Chiplima, pp: 48-50.

Popular articles

- Ghosh, D., Jha, A., Maity, A. and Jena, R.K. 2023. Weed management: Role in augmenting crop productivity and water use efficiency. KRISHI SCIENCE – e Magazine for Agricultural Sciences, 4(1):35-38.
- Ghosh D., Jha A., Maity A. and Roy D. 2023. Enhancing crop productivity and nutrient use efficiency through integrated weed management weed management. KRISHI SCIENCE – e Magazine for Agricultural Sciences, 4(7) : 26-29.
- Lenka J., Dash Ch. J.P. and Sahu P. 2023. Overview of artificial intelligence in horticulture. Agriculture & Food E-Newsletter, 5 (12) : 223-226.

- Panda, P. K. and Sarangi, A. 2023. Accelerating the change to solve water & sanitation crisis. Editorial page of Dharitri Newspaper 49(116): p. 6
- Panda, P. K. 2023. How to prevent sky rocketing of vegetable prices. Editorial page of Dharitri Newspaper 49(237): p. 4
- Panda, P. K. 2023. How to reduce rice import in Odisha. Editorial page of Prameya Newspaper 13(169): p. 10
- Panda, P. K. 2023. Integrated Farming can increase Farmers' income in Odisha. Editorial page of Samaj Newspaper 94(218): p. 6
- Panda, P. K. 2023. Odisha Agriculture needs Irrigation, Cold store and Marketing Mission. Editorial page of Samaj Newspaper 94(304): p. 6
- Panda, P. K. 2023. Odisha needs Irrigation Mission. Editorial page of Samaj Newspaper 94(254): p. 6
- Panda, P. K. 2023. We have to export agri-commodities from Odisha. Editorial page of Prameya Newspaper 12(300): p. 8
- Panda, P. K., Samantarai, R. K., Panda, D. and Das, T. R. 2023. Drip irrigation technology originated from Odisha province of India: A review. E-Planet 21(1): 1-9.
- Panigrahi, P., Dash, H.K., Pradhan, S., and Nayak, A.K. 2023. Rainwater management for improving yield, water productivity and profit in fruit orchards. Sabujeema. 3(7): 20-27.
- Panigrahi P., Jena R.K., Nayak A.K. and Pradhan, S. 2023. Efficient water management in fruit crops in water scarce regions. Sabujeema. 3(3): 18-24.
- Satapathy, B.S, Pradhan, S., Panigrahi, P., Mishra, S.K. and Rautaray, S.K. 2023. Dry direct seeded rice: A viable alternate crop establishment method for sustainable crop production in Odisha. Sabujeema. 3(6): 1-6.
- Satapathy, B.S, Pradhan, S., Rautaray, S.K. and Jena, S.K. 2023. Finger millet (Eleusine coracana L. Gaertn) a climate resilient food crop for livelihood security of small and marginal farmers of Odisha. Sabujeema. 3(3): 1-8.
- Satapathy, B.S., Jena, S.K., Mishra, S.K. and Pradhan, S. 2023. Little millet: A climate resilient crop for sustainable millet production in Odisha. Sabujeema. 3(10): 36-41.
- Satapathy, B.S., Panda, D.K., Rautaray, S.K. and Pradhan, S. 2023. Quinoa: A climate resilient crop for sustainable livelihood security of small and marginal farmers of Odisha. Indian Farming. 73(5): 22-24.
- Sulochana K.H., Ankhila R.H. and Sahu, P. 2023. Microgreens: A Food for Nutritional Security. Food & Scientific Report, 4 (Article-5).

IN-HOUSE RESEARCH PROJECTS (2023)

COMPLETED PROJECTS

Sl. No.	Project Code	Project Title	PI Name
1	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
2	NRMA/IIWM/CIL/ 2018/004/00191	Refinement of small-scale online wastewater filter for safe irrigation practice	Dr. M. Raychaudhuri
3	NRMA/IIWM/ SIL/2019/003/00195	Piloting water management technologies for enhancing farm productivity and income	Dr. H.K. Dash
4	NRMA/IIWM/ SIL/2020/002/00197	Yield gap and water productivity atlas of pulse and oilseeds crops in India	Dr. P.S. Brahmanand/ Mr. B. Behera/ Dr. S.K. Jena
5	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
6	NRMA/IIWM/SIL/ 2020/004/00199	Geoinformatics application in site suitability analysis for crop planning and aquaculture development in eastern and western coast of India	Dr. Ashok K. Nayak
7	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
8	NRMA/IIWM/SIL/ 2020/007/00202	Evaluation of drip irrigated multi-tier cropping systems for enhancing land and water productivity.	Dr. O.P. Verma

ONGOING RESEARCH PROJECTS

Sl. No.	Project code	Project Title	PI Name
1	NRMA/IIWM/SIL/ 2020/006/00201	In-situ rainwater management practices for enhancing farm income and water productivity of uplands through crop diversification and water conservation measures	Dr. P. K. Panda
2	NRMA/IIWM/SIL/ 2021/001/00203	Study of seawater intrusion dynamics and development of management strategy in a coastal aquifer of eastern India	Dr. S. Mohanty
3	NRMA/IIWM/SIL/ 2021/002/00204	Water management and production practices of dragon fruit under protected cultivation	Dr. P. Sahu
4	NRMA/IIWM/SIL/ 2021/003/00205	Development of package and practices for reducing hexavalent chromium in soil plant continuum	Dr. D. Ghosh
5	NRMA/IIWM/SIL/ 2021/004/00206	Developing efficient water management strategies using resource conservation technologies in maize-sunflower cropping system	Dr. S. Pradhan
6	NRMA/IIWM/CIL/ 2021/005/00207	Estimation of water footprint at regional scale for sustainable water management	Dr. R.K. Jena
7	NRMA/IIWM/SIL/ 2021/006/00208	Adoption and impact assessment of micro-irrigation in India with emphasis on community scale micro irrigation	Dr. D. Sethi
8	NRMA/IIWM/SIL/ 2021/007/00209	Evaluating sub surface drip irrigation in maize-based cropping sequence	Dr. P. Panigrahi

9	NRMA/IIWM/SIL/ 2021/008/00210	Precise irrigation under conservation agriculture for improving water productivity in intensive rice-based cropping system of Eastern India	Dr. S. Pradhan
10	NRMA/IIWM/SIL/ 2021/009/00211	Socio-economic evaluation of solar irrigation and its impact on farmers livelihood in Eastern India	Dr. Ankhila R.H.
11	NRMA/IIWM/SIL/ 2021/010/00212	Water demand estimation in a canal command area using machine Learning	Er. Ajit Kr. Nayak
12	NRMA/IIWM/SIL/ 2022/001/00213	Natural Farming: Impact on Crop and Water Productivity under different Irrigation Systems	Dr. A.K. Thakur
13	NRMA/IIWM/SIL/ 2022/002/00214	Technological options and policy guidelines for risk management in water quality	Dr. M. Raychaudhuri
14	NRMA/IIWM/CIL/ 2022/003/00215	Crop planning under climate change scenario in Mahanadi and Godavari basin	Dr. A. Jha
15	NRMA/IIWM/SIL/ 2022/004/00216	Periphyton-based Carp-SIS Polyculture system: Effects on Zoo technical and production Performance	Dr. R.K. Mohanty
16	NRMA/IIWM/SIL/ 2022/005/00217	Catchment command characterization and Evaluation of Rainwater Harvesting Structures in a Treated Watershed	Dr. B.K. Sethy
17	NRMA/IIWM/SIL/ 2022/006/00218	Water Productivity and Economic efficiency of groundwater use in different geo-hydrologic regions of Eastern India	Dr. H.K. Dash
18	NRMA/IIWM/SIL/ 2023/001/00219	Efficient water management strategies for higher water productivity and crop yield of millet production system	Dr. B.S. Satapathy
19	NRMA/IIWM/SIL/ 2023/002/00220	Development of semi-interpenetrating Polymer Network (Semi-IPN) based product/ slow-release fertilizer for enhancing water productivity and nutrient use efficiency	Dr. A. Maity

Externally Funded Research Projects

Title	Budget (Rs. in lakh)	Duration	PC/PI/CCPI	Sponsored by
All India Coordinated Research Project on Irrigation Water Management	2119.75	2023-2024	Dr. A. Sarangi, PC	ICAR, New Delhi
Agri-Consortia Research Platform on Water	914.48	2021-2026	Dr. S.K. Jena, PC	ICAR, New Delhi
Theme-1: Development and management of surface water resources and soil moisture in different agro-ecological regions of India using geoinformatics and nano technology	225.00	2021-2026	Dr. S.K. Jena, PI	Agri-CRP on Water, ICAR, New Delhi
Theme-2: Automated canal irrigation system for efficient and smart irrigation water management	271.79	2021-2026	Dr. R.K. Panda, PI	Agri-CRP on Water, ICAR, New Delhi

Theme-3: Improving groundwater sustainability through analyzing groundwater-energy nexus	36.70	2021-2026	Dr. R.R. Sethi, PI	Agri-CRP on Water, ICAR, New Delhi
Theme-4: IoT enabled sensor based smart irrigation management system	57.88	2021-2026	Er. Ajit Kr. Nayak, PI	Agri-CRP 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)	2017-2024	Dr. S.K. Jena, PI	International Water Management Institute (IWMI), Colombo
Enhancing economic water productivity in irrigation canal commands (Kukadi command)	(USD 40430)	2020-2024	Dr. R.K. Panda, PI	International Water Management Institute (IWMI), Colombo
Increasing agricultural resilience through agricultural disaster risk management strategy in India (INTEGRATE)	72.00	2023-2026	Dr. S.K. Jena, PI	International Water Management Institute (IWMI), Colombo
Studies on N-(n-butyl) Thiophosphoric Triamide (NBPT) as a urease inhibitor for improving nitrogen use efficiency in major cropping systems in India	(USD 36850)	2021-2024 (Extended upto April, 2024)	Dr. S.K. Rautaray, CCPI	CYMMIT, Nepal
Drought and hot spell assessment using GRACE gravity records	20.68	2019-2022 (Extended up to March, 2023)	Dr. D.K. Panda, PI	DST, Ministry of Science & Technology, New Delhi
ICAR network project on precision agriculture: Precision water and nutrient use in mandate crops for improving the input use efficiency and profitability (NePPA)	236.00	01.10.2021 to 31.03.2026	Dr. S.K. Rautaray, PI	ICAR, New Delhi
Sensor based integrated vertical farming for horticultural crops and aquaponic system	39.39851	June 2023 to May 2026	Dr. P. Sahu, CCPI	NASF, ICAR, New Delhi
Rejuvenating watersheds for agricultural resilience through innovative development (REWARD)	605.34	2022-2026	Dr. S.K. Jena, PI	Govt. of Odisha
Evaluation of climate change impacts on groundwater resources and development of management strategies for resilient agriculture in India	66.00	2022-2024	Dr. D.K. Panda, PI	ICAR, New Delhi under NICRA
Enhancing water and livelihoods security and improving water productivity in tribal dominated paddy rainfed agro-ecosystem of Odisha (Farmer FIRST Program)	22.50	2023-2024	Dr. S.K. Mishra, PI	ICAR, New Delhi
Piloting water management technologies for enhancing farm productivity and income (SCSP)	30.50	2023-2024	Dr. H.K. Dash, PI	ICAR, New Delhi

Enhancing land and water productivity through integrated farming system (Scheduled tribe component Project) (STC/TSP)	12.27	2023-2024	Dr. R.K. Panda, PI	ICAR, New Delhi

Consultancy Research Projects

Title	Budget (Rs. in lakh)	Duration	PC/PI/CCPI	Sponsored by
Study on assessment of water yield ecosystem services affecting agriculture practices and on-farm livelihoods in Similipal Tiger Landscape, Odisha	3.60	12 months (18.9.2023 to 17.9.2024)	Dr. S.K. Jena	Director, IMAGE, Govt. of Odisha

Sponsored Training

Title	Budget (Rs. in lakh)	Duration	PC/PI/CCPI	Sponsored by
To conduct training & exposure visit for the Officers/ Extension functionaries of Directorate of Horticulture & farmers in the following area: i) Enhancing productivity in horticultural crops through water management technologies- For Officers/ Extension Functionaries (08 batches) ii) Efficient water management and production practices of Horticultural Crops- for Farmers (08 batches)	76.16		Dr. A. Sarangi Dr. D.C. Sahoo Dr. P. Sahu	Directorate of Horticulture, Govt. of Odisha




AWARDS, HONOURS, RECOGNITIONS

- Dr. A. K. Thakur, Principal Scientist awarded with 'NABS Fellow 2020' for outstanding contribution to the field of Agriculture by the National Academy of Biological Sciences (NABS), Chennai on January 25, 2023.
- Dr. R. K. Mohanty, Principal Scientist awarded with 'NABS Fellow 2020' for outstanding contribution to the field of Aquaculture by the National Academy of Biological Sciences (NABS), Chennai on January 25, 2023.
- Dr. O. P. Verma, Senior Scientist has received 'Appreciation Certificate' 2023 from Ministry of Home Affairs, Department of official language for significant contribution as active member of subcommittee of town official language implementation committee, Bhubaneswar on January 6, 2023.
- Dr. A. K. Thakur, Principal Scientist acted as expert member of selection committee of assistant professor of plant physiology, OUAT, Bhubaneswar during January 9-10, 2023.
- Dr. R. K. Mohanty, Principal Scientist acted as expert member of scrutinization committee for Dean, Fisheries, OUAT, Bhubaneswar on January 17, 2023.
- Dr. A. K. Thakur, Principal Scientist acted as expert member for the promotion of teachers/scientist under the Career Advancement Scheme at Dr RPCAU, Pusa during February 13-14, 2023
- Dr. P. Sahu, Scientist has been awarded with 'Best oral presentation award' for the presentation on 'Enhancing water productivity of drip irrigated pre-bearing mango orchard in degraded land of Eastern India' in the International conference organized by Odisha Horticultural Society in association with College of Agriculture, OUAT, Bhubaneswar during January 20-21, 2023.
- Dr. P. Sahu, Scientist has been awarded with 'Young Scientist Award' in the International conference organized by Odisha Horticultural Society in association with College of Agriculture, OUAT, Bhubaneswar during January 20-21, 2023.
- ICAR-IIWM adopted farmer Sri Radhashyam Biswal of Lokapala vaillage in Kanas block of Puri received the prestigious 'IARI-Innovative Farmer Award 2023' in Pusa Krishi Vigyan Mela organized at ICAR-IARI, New Delhi on February 4, 2023.
- Dr. S.K. Mishra, Principal Scientist acted as Judge for evaluating poster presentations of 'Social Science Theme: Socio-extension approaches in rice farming to address global food security issues' during the '2nd Indian Rice Congress' organized by the 'Association of Rice Research Workers (ARRW), Cuttack at ICAR-NRRI, Cuttack on February 12, 2023.
- Dr. R. K. Panda, Principal Scientist was honored as a key speaker in Session on 'Natural resources management for agricultural resilience through innovative development" in Krushi Odisha 2023 organized by Department of Agriculture & Farmers' Empowerment, Govt. of Odisha on February 18, 2023.
- Dr. S. Mohanty, Principal Scientist was part of the Expert team which visited Raipur to study the technical capability, experience, capacity of the factory of 2 Micro-irrigation companies during February 20-21, 2023.
- Dr. S.K. Jena has presented Lead paper in the 13th National symposium on fostering resilient costal agro-ecosystem conducted by ISCAR, ICAR-CSSRI, Canning town, WB at Tirupati during February 22-25, 2023.
- Dr. P. Sahu, Scientist has been awarded with 'Best oral presentation Award' for the presentation on 'Gamma radio sensitivity study on papaya cv. Ranchi Local & Arka Surya' in 13th National Symposium of ISCAR organized by ISCAR at Acharya N. G. Ranga Agricultural University, Tirupati, Andhra Pradesh during February 22 – 25, 2023.
- Dr. S.K. Jena, Principal Scientist has provided technical guidance and installed eight rubber dams in Kasaragod districts of Kerala in collaboration with Engineers of Water resources department and Kasaragod Development agency, Government of Kerala during April 2023.
- Dr. R. K. Mohanty, Principal Scientist acted as Expert member of selection committee for inter-institutional transfer of Technical Officers at ICAR-CIFA, Bhubaneswar on April 5, 2023
- Dr. S.K. Mishra, Principal Scientist has evaluated one start-up *'E-panipuri Katrz',* Bhubaneswar for release of 2nd

installment of fund by the a-IDEA Incubation Centre of ICAR-NAARM, Hyderabad on April 26, 2023.

- Dr. R. K. Mohanty, Principal Scientist acted as Chief-de-Mission of ICAR-IIWM sports contingent for ICAR zonal sports meet (Eastern Zone) at ICAR-IVRI, Baraeli during April 24-27, 2023.
- Dr. S. Mohanty, Principal Scientist was part of the Expert team to study the technical capability, experience, capacity of the factory of a micro-irrigation company which visited Bangalore during April 29-30, 2023.
- Dr. P. K. Panda, Principal Scientist was awarded '*Utkal Prativa Ratna Samman'* on the occasion of Utkal Dibasa at Jayadev Bhawan by Happy Home Society.
- Dr. S.K. Jena, Principal Scientist was member of the committee for 'Periodic review of assessment and mapping of waterlogged area of major and medium irrigation projects in India', Nominated by Government of India, Ministry of *Jal Shakti*.
- Dr. S.K. Jena, Principal Scientist was member (Councilor) of Executive Council of Indian Society of Coastal Agricultural Research, Canning Town, West Bengal.
- Dr. S. K. Jena, Principal Scientist was member, Research Advisory committee of Centre for climate smart agriculture, SoA University, Bhubaneswar.
- Dr. R. K. Mohanty, Principal Scientist acted as Expert member for the promotion of scientists under the Career Advancement Scheme at ICAR-CIFA, Bhubaneswar on June 16, 2023
- Dr. P. K. Panda, Principal Scientist was Invited as Guest of Honour to delivered a talk on 'Impact of climate change on Odisha Agriculture' in Jayadev Bhawan during second Suban Khuntia Memorial Lecture on June 17, 2023.
- Dr. D. K. Panda, Principal Scientist was nominated as member of the NGP-DST 'Screening committee on shortlisting of proposals in geospatial science development' by DST.
- Dr. R. K. Mohanty, Principal Scientist acted as IMC member and attended 45th IMC at ICAR-CIFA on August 23, 2023.
- Dr. R. K. Panda Honoured as an IMC member for ICAR-CRIZAF, Barrack pore, West Bengal.
- Dr. A.K. Thakur, Principal Scientist visited on a foreign deputation to attend and present an oral paper at the 6th International Rice Congress (October 16-19, 2023) and to attend a consultation meeting and field trip October 20-21, 2023 at Manila, Philippines. His title of presentation was 'Rice physiology, yield and water productivity improvements through modifying cultivation practices and water Management'.
- Dr Dibakar Ghosh received ISA Associates Fellow Award at ICAR-CCARI, Goa during XXII Biennial National Symposium on Climate Smart Agronomy November 22-24, 2023.
- Er. Ajit K.Nayak was awarded with 'AI Aware' and 'AI Appreciate' in Odisha for AI which was organized by the E&IT Department, Government of Odisha in collaboration with intel.
- Dr. R.K. Mohanty, Principal Scientist acted as Chief-de-Mission of ICAR-IIWM sports contingent for ICAR zonal sports meet (Eastern Zone) at ICAR-NRRI, Cuttack during December 13-16, 2023.
- Dr. R. K.Panda Acted as Guest of Honour in *Krushi Sahayogi Mela* at Uparapathapur, Banki, Cuttack (Odisha) organized by Faculty of Agriculture, Sri Sri University, Bidyadharpur, Cuttack on December 15, 2023.
- List of awardees in ICAR-IIWM Foundation Day on May 12, 2023

Sl. No	Award	Name
1	Lifetime contribution Award-2022	Dr Atmaram Mishra, Retired Principal Scientist
		Dr Madhumita Das, Retd. Principal Scientist
		Dr Sachidulal Raychaudhuri, Retd. Principal Scientist
2	Progressive Farmer Award-2022	
		Smt. Basanti Naik, Badamba, Cuttack
		Shri Dhruba Charan Jena, Kendudhipi, Nayagarh

		Shri Kalandi Charan Behera, Haridamada, Khorda
		Shri Prakash Chandra Bhoi, Ranga Matha, Nimapara, Puri
		Shri Krushna Chandra Senapati, Rabara, Nayagarh
3	Award for Scientist	
	Outstanding Scientist Award-2022	Dr Amod Kumar Thakur, Principal Scientist
	Young Scientist Award-2022	Dr Prativa Sahu, Scientist
4	Best Employee Award-2022	
	Administrative Staff	Shri Rajib Kumar Dalai, Asst. Administrative Officer
	Technical Staff	Shri Basanta Kumar Acharya, Technical Officer
	Supporting Staff	Shri Bhaskar Dutta, Skilled Supporting Staff
5	Appreciation Award for Best Research paper publication	Dr Dileep Kumar Panda, Principal Scientist
6	Appreciation Award for Outstanding Performance in ICAR Zonal sports Tournament (Eastern Zone)	Mrs Subhashree Satapathy, Lower Division Clerk

Radio/TVTalk

- Dr. P. Sahu, Scientist has delivered a talk on 'Soilless dragon fruit farming' in 4 different regional news channels i.e. in Naxatra News Channel on May 30, 2023, Argus News on June 13, 2023, Reporters Today on June 22, 2023, Kanana News on June 24, 2023.
- Dr. A. Sarangi and Dr. P. K. Panda acted as resource person in the TV programme on 'Water productivity enhancement through use of digital agriculture' in DD Odia on August 10, 2023.
- Dr. P. K. Panda acted as resource person to discuss on 'Plastic pollution and water management' in Argus TV on the occasion of World Environment Day on June 5, 2023.
- Dr. P. K. Panda acted as resource person in the discussion on 'Jalabayu Paribartan Pariprekhire Dharanakhyama Krushi' at All India Radio, Puri on June 5, 2023.
- Dr. P. K. Panda acted as resource person in the discussion on 'Need for catch the rain programme of PM' at All India Radio, Cuttack on August 16, 2023.
- Dr. P. K. Panda, Principal Scientist of the institute acted as resource person in the discussion on 'Reduction of food wastage in India' on the occasion of World Food Wastage Day at All India Radio, Jeypore on Sept. 29, 2023

RESEARCH MANAGEMENT MEETINGS

Institute Research Council (IRC) Meeting

The Institute Research Council (IRC) meeting for 2022-23 was held on March 24, 2023. The annual IRC meeting for review of institute funded projects were held on June 7, 8, 9, 12, 30 and July 7, 20, 2023. The progress and achievements of institute ongoing and concluding projects were presented and discussed in all the IRCs.

Research Advisory Committee Meeting

The first meeting of 9th Research Advisory Committee (RAC) of ICAR-IIWM was held during January 27-28, 2023. Dr. Alok Kumar Sikka, IWMI Indian Country Representative and Former DDG (NRM) presided over the meeting as the Chairman, RAC. Dr. A. Velmurugan, ADG (SWM), ICAR, Dr. S. K. Pattanaik attended the meeting physically, whereas Dr. Amit Kar and Dr. B. S. Yadav attended the meeting in virtual mode. Program level presentation and discussion was held on significant research achievements of the Institute.

Institute Management Committee

The Institute Management Committee Meeting was held on June 28, 2023 under the Chairmanship of the Director, ICAR-IIWM, Bhubaneswar.

AICRP on Irrigation Water Management Scientists Meet

The Chief Scientists Meet of AICRP on Irrigation Water Management was organized at CSKHPKV, Palampur in collaboration with ICAR-Indian Institute of Water Management, Bhubaneswar during June 21-23, 2023. Deputy Director General (NRM), ICAR Dr. S. K. Chaudhari graced Inaugural Session of the Chief Scientists Meet as Chief Guest and Honorable Vice Chancellor, CSKHPKV, Dr. H. K. Chaudhary presided over the Inaugural Session. Respected Dr. C. L. Acharya, Former Director, IISS, Bhopal and Dr. A. Velmurugan, ADG (SWM), ICAR graced the occasion as Guests of Honour.

Agri-Consortia Research Platform on Water Annual review Meeting

The review and monitoring meeting of Agri-CRP on Water was held at MPKV, Rahuri during September 29-30, 2023 under the chairmanship of Dr. S. K. Chaudhuri, DDG (NRM). The detail theme wise and center wise presentation was carried out by respective PIs and CCPIs of ICAR-IIWM, Bhubaneswar; ICAR-IIHR, Bengaluru; ICAR-NAEP, New Delhi, ICAR-NRC Grapes, Pune; IIT, Kharagpur; MPKV, Rahuri; Forech India, New Delhi; Partha Infotech, Pune and RTI, New Delhi and other centres. During the meeting, field visit was carried out to IoT enabled smart irrigation management system in Rahuri district of Maharashtra.

Interface meetings with Government of Odisha

ICAR-IIWM organized Interface meeting of ICAR-IIWM and Water resource Department, Govt of Odisha on August 1, 2023. In this meeting discussion was held on possible future collaborative pilot research project as per the proceedings of the State Level monitoring committee on CAD& WM.

ICAR - IIWM Organized Interface meeting of ICAR-IIWM and Department of Extension Education, OUAT on August 11, 2023 at, Bhubaneswar for upscaling of the ICAR –IIWM technologies through KVKs. ICAR-IIWM technologies were presented in details and interacted with the University officials to identify suitable areas for upscaling of the technologies.

Review meeting of *Raj Bhasha* Hindi

ICAR - IIWM organized review meeting related to the implementation of official language in all ICAR Institutes located in Bhubaneswar on August 17, 2023 in the presence of Shri Sanjay Bokolia, Director, Official Language/GAC, Shri Girish Bhatt, Director, Crop Science and Shri Ram Dayal Sharma, Deputy Director, Official Language, ICAR, New Delhi. In this review meeting, Dr. Arjamadutta Sarangi, Director of the Institute welcomed the dignitaries on behalf of ICAR-IIWM. Whereas, officials nominated by their respective institutes were present on behalf of all the institutes of ICAR.

Online meeting of AICRP on IWM

ICAR-IIWM organized online AICRP on IWM meeting on 'Water resources budgeting of prioritized states' on July 24, 2023. Dr. P. K. Singh, Chief Scientist, AICRP on IWM Udaipur Centre discussed about the water resources budgeting in Rajasthan. 2nd Online AICRP on IWM meeting regarding new proposals on 'Use of Wastewater in Agriculture' and 'Use of AI/ML and Sensors in agriculture' was conducted on October 17, 2023. Three research projects were approved. 3rd Online AICRP on IWM meeting on 'Protocols of irrigation scheduling' was organized on November 13, 2023. Dr. S. D. Gorantiwar, Director of Research, MPKV, Rahuri delivered the expert talk. 4th online AICRP on IWM meeting on 'Sensor based automated irrigation' was conducted on November 16, 2023. Dr. S. D. Gorantiwar, Director of Research, MPKV, Rahuri delivered the expert talk.

ICAR-IIWM Showcased Technologies in the 95th Foundation Day of ICAR

The ICAR-IIWM, Bhubaneswar participated in the 95th Foundation Day and exhibited its technologies at National Agriculture Science Complex, Pusa, New Delhi from July 16-18, 2023. ICAR-IIWM, Bhubaneswar showcased two innovative technologies, i.e. 'IoT-enabled irrigation automation system for AWD in transplanted rice' and 'Solar tree-based micro-irrigation system'. Large number of farmers, students, industry representatives and start-up firms attended the event and interacted with scientists and staff of ICAR-IIWM.

ICAR - IIWM Organized Expert Lecture

An expert lecture on 'Hydrological analysis methods and techniques for Mahanadi basin' was organized on July 21, 2023 at ICAR-IIWM, Bhubaneswar. The lecture was delivered by Dr. Chandranath Chatterjee, Professor, Dept. of Agriculture and Food Engineering, IIT, Kharagpur and the PI of the CRP-Water theme of IIT, Kharagpur. He talked about sustainable surface water resources plan for Mahanadi and upper Krishna basins using high resolution geo-spatial database.

ICAR-IIWM Released the First Episode of ICAR-IIWM Krishi Jal Samachar

On the 36th Foundation Day of ICAR-IIWM, the institute released its first episode of ICAR-IIWM Krishi Jal Samachar (Bhag-01) in the Hindi language on May 11, 2023. It highlighted the news/activities/events/celebration of the institute along with some promising technologies such as enhancing water productivity in drip irrigated pre-bearing mango orchards in degraded land, canopy architecture and drip irrigation in guava, solar-based drip irrigation in multi-tier cropping system of horticultural crops, and levelling of land with laser leveller. It is available at the YouTube Channel (https://www.youtube.com/watch?v=qqeAjImCjPk).

Meeting for scientist of other ICAR organizations

ICAR-IIWM organized series of online meeting with scientists of other ICAR organization to develop synergy and avoid duplication of research.

Details	Date
Meeting with Scientists of ICAR-IIWM and ICAR-CCARI, Goa	August 7, 2023
Scientists of ICAR-IIWM and ICAR-IISWC, Dehradun	August 17, 2023
Scientists of ICAR-IIWM and ICAR Research Complex for NEH region, Barapani	August 25, 2023
Scientists of ICAR-IIWM and ICAR Research Complex Eastern Region, Patna	September 13, 2023

TRAINING AND CAPACITY BUILDING

Training and Capacity Building of ICAR Employees

Official & Designation	Subject	Organization	Period
Dr. A. K. Nayak Principal Scientist	Impactful ICT applications and technologies in agriculture (Online)	ICAR-NAARM, Hyderabad	February 6-10, 2023
Dr. D. Ghosh Scientist	Data Visualization using 'R' (Online)	ICAR-NAARM, Hyderabad	March 1-8, 2023
Dr. B. S. Satapathy Senior Scientist	Millets *(Shree Anna)* - Model crops for sustainable farming, value addition, entrepreneurship development and nutritional security	Society for Millet Research and ICAR-IIMR, Hyderabad	September 7-27, 2023
Dr. P. Sahu Scientist	Data science in agriculture	ICAR-IASRI, New Delhi	September 4-15, 2023

Webinar / Programs / Virtual Meetings Attended by Employees

Official	Name of the Conference/Meeting/ Workshop/Symposium/Seminar	Organized	Period
Dr. O. P. Verma	72nd half yearly meeting on 'Town official language implementation'	Institute of Physics, Bhubaneswar	January 6, 2023
All Scientists	Brainstorming session on 'Water quality issues and policy guidelines in agriculture and aquaculture'	ICAR-IIWM, Bhubaneswar	January 13, 2023
Dr. P. Sahu	International conference on 'New generation horticulture for prosperity'	Odisha Horticultural Society in association with College of Agriculture, OUAT, Bhubaneswar	January 20-21, 2023
Dr. R. K. Mohanty	National conference on 'Current perspective for sustainable development in life science, environment and agriculture'	Periyar University, Salem, Tamil Nadu	January 23-25, 2023
Dr. A. Sarangi Dr. S. K. Rautaray Dr. S. Mohanty Dr. R. K. Jena	Workshop on 'Systems approach to agriculture and pathways for action'	Department of Agriculture and Farmers Welfare, Govt. of Odisha	January 25, 2023
Dr. R. K. Panda	Inception workshop for the project 'Built water storage in South Asia'	IWMI, New Delhi	January 30, 2023
Dr. D.C. Sahoo Dr. S.K. Mishra Dr. B. K. Sethy Dr. R. R. Sethi	Three day off-campus training programme on 'Soil and water conservation measures for enhancing water productivity'	ICAR-IIWM and PRADAN-NGO, Bhubaneswar	February 1-3, 2023
Dr. B. K. Sethy	2nd Indian Rice Congress on 'Transforming rice research: Recent scientific developments and global food crisis'	National Rice Research Institute, Cuttack	February 11-14, 2023.

Dr. S. K. Jena Dr. P. Sahu Dr. Ankhila R.H	13th National Symposium of ISCAR on 'Fostering resilient coastal agro-ecosystems'	Acharya N. G. Ranga Agricultural University, Tirupati, Andhra Pradesh	February 22 – 25, 2023
All Scientists	World intellectual property day celebration and guest lecture on 'Women and IP: Accelerating innovation and creativity'	ICAR-IIWM, Bhubaneswar	April 26, 2023
Dr. S. K. Rautaray	State level consultation on 'Preparation of drought management plan'	Odisha State Disaster Management Authority	May 29, 2023
Dr. S. Mohanty	National workshop on 'Per drop more crop'	Department of Agriculture and Farmers Welfare, Govt. of India	May 31, 2023
Dr. S. K. Rautaray	National Training Conclave-2023	Capacity Building Commission (CBC), New Delhi	June 11, 2023
Dr. A. Sarangi Dr. D. Ghosh Dr. D. Sethi	95th ICAR Foundation cum Technology Day ceremony	ICAR, New Delhi	July 16-18, 2023
Dr. D. Ghosh Dr. A. Jha	Crop weather watch group committee meeting	Krushi Bhawan, Bhubaneswar	July 31, 2023
Dr. B. S. Satapathy	National seminar on 'Abiotic stress management for sustainable millet-based production system'	ICAR-NIASM, Baramati	August 22-23, 2023
Dr. S.K. Rautaray	Workshop on 'Agrotain incorporated urea produces with N-Tegration™ Technology for improving NUE in major cropping systems of India'	ICAR-IISS, Bhopal	August 26-27, 2023
Dr. K.K. Bandyopadhyay Dr. S. Pradhan	87th Annual convention of Indian Society of Soil Science	ICAR-Indian Institute of Soil Science, Bhopal	October 3-6, 2023
Dr. B. S. Satapathy	Millets: Science, Technology and Innovations	ICAR-National Rice Research Institute, Cuttack	October 6, 2023
Dr. R. K. Mohanty Dr. A. K. Nayak Dr. S.K. Rautaray Dr. D. Sethi	XVI Agricultural Science Congress & ASC Expo	CMFRI, Kochin	October 10-13, 2023
Dr. A. K. Thakur	6th International Rice Congress	Manila, Philippines	October 16-19, 2023
Dr. D. Ghosh	5th International conference on 'Sustainable natural resource management under global climate change'	Soil Conservation Society of India, New Delhi, India	November 07-10, 2023
Dr. S. Pradhan	Eighty-sixth Annual convention of Indian Society of Soil Science	Indian Society of Soil Science, New Delhi	November 15-18, 2022
Dr. S.K. Rautaray Dr. D. Ghosh Dr. P. K. Panda	XXII Biennial National symposium on 'Climate smart agronomy for resilient production systems and livelihood security'	ICAR-IARI, New Delhi, India	November 22-24, 2023
Dr. S. K. Mishra	National review workshop of Farmer FIRST Program	CSK HPKV, Palampur, H.P	November 28-30, 2023

TRAININGS PROGRAMS ORGANIZED

Farmers' / Officers Training Programs Organized by ICAR-IIWM

Subject	Place	Period	No. of Participants
Capacity building programme for entrepreneurship development in Agriculture and its allied sectors	Women's Junior College, Nabarangapur	March 16, 2023	150
Training on Seed treatment, nursery management and green manuring in *Kharif* paddy	Haridamada, Khordha	June 12, 2023	59
Training on Seed treatment, nursery management and green manuring in *Kharif* paddy	Giringaput, Khordha	June 13, 2023	59
Capacity building training program on 'SRI for tribal paddy farmers' under STC programme	Khaira, Rayagada and Phattachanchada, Gajapati	June 29-30, 2023	101
Training cum demonstration programme on 'Generating employment opportunities and enhancing farm income through horticultural enterprises'	Haridamada, Khordha	July 12-14, 2023	76
Training cum demonstration programme on 'Integrated crop and water management in *Kharif* paddy and rainy season vegetables'	Khuntapingu, Keonjhar	August 17, 2023	57
Training cum demonstration programme on 'Integrated crop and water management in *Kharif* paddy and rainy season vegetables' for farmers	Jamuda, Keonjhar	August 18, 2023	51
Orientation workshop cum training programme on 'Crop and water management strategies for enhancing yield and income from *rabi* season crops' under SCSP Project	Goradapal, Dhenkanal	September 20-21, 2023	110
Training cum demonstration programme on 'Integrated weed management in rice, finger millet and rainy season vegetables'	Haridamada, Khordha	September 29, 2023	45
Training on 'Pro-tray nursery raising for healthy seedling production'	Kantapad, Cuttack	November 15, 2023	20
Training on 'Mushroom cultivation and paired row bed planting'	Khaira, Rayagada	November 22, 2023	100
Training on 'Mushroom cultivation and paired row bed planting'	Phatachanchada, Gajapati	November 23, 2023	100
Training and capacity building programmes on 'Enhancing productivity in horticultural crops through water management technologies'	ICAR-IIWM, Bhubaneswar	December 4-11, 2023	29
Training on 'Efficient water management and production practices of horticultural crops'	ICAR-IIWM, Bhubaneswar	December 16-23, 2023	28
Training cum demonstration programme on 'Oyster mushroom farming for additional family income and nutritional security' for farmers'	Haridamada, Khordha	December 28, 2023	102

Programs Meetings Organized by ICAR-IIWM

Subject	Place	Date	No. of Participants
Soil and water conservation measures for enhancing water productivity	Adarsa Training Center, Sambalpur	February 1-3, 2023	45
Scientific backyard poultry farming for livelihood and nutritional security under SCSP programme	Viligram, Nimapara, Puri	March 10, 2023	68
Five '*Van Mahotsav*' programme cum distribution of 250 grated mango and guava fruit saplings to adopted farmers	Haridamada and Jamujhari, Khordha	July -August, 2023	182
Awareness programme on 'Mitigating chromium toxicity in rice'	Kaliapani, Sukinda	August 14, 2023	15
Farmers field day	Khuntapingu, Keonjhar	August 16, 2023	33
Agriculture water management for *Kharif* crop	Khaira, Rayagada	August 17, 2023	101
Agriculture water management for *Kharif* crop	Phatachanchada, Gajapati	August 18, 2023	100
Distribution of inputs for field demonstration under SCSP	Bolagarh, Khorda	September 6, 2023	41
Awareness programme on 'Agronomic practices for mitigating chromium toxicity in rice'	Kaliapani, Sukinda	September 12, 2023	20
Orientation workshop cum training programme on 'Crop and water management strategies for enhancing yield and income from *rabi* season crops' under SCSP Project	Goradapal, Dhenkanal	September 20-21, 2023	110
Swachhta awareness cum cleanliness drive under the 'Special campaign 3.0'	Barapita, Khordha	October 13, 2023	59
Ten 'Rice and millet field days, crop cutting experiments and feedback sharing' under Farmer FIRST Project	Keonjhar and Khordha FFP-adopted clusters	November -December, 2023	145
Swachhta awareness cum cleanliness drive under '*Swachhta Pakhwada*'	Jamujhari, Khordha	December 22, 2023	53
Scientific crop and water management practices in *rabi* season pulse crops	Nimapara	December 29, 2023.	20

WOMEN EMPOWERMENT

ICAR-IIWM, Bhubaneswar has organized several events under different projects/schemes to empower farm women in different districts of Odisha. Under the SCSP scheme, women-friendly farm implements like sickles, hand cultivators, and spades along with vegetable seed kits were distributed among 50 farm women each at different locations of Odisha like Budhei village of Nimapara block, Puri and Sampur and Srichandanpur villages of Kujanga block, Jagatsinghpur. This year National Farmers' Day (*Kisan Diwas*) was celebrated in Viligram village of Nimapara block of Puri district, Odisha on December 23, 2023, in which more than 150 farmers and farm women participated in the programme. Nearly 500 coconut saplings (var. *Chowghat orange dwarf*) were distributed to about 150 farmers in Nimapara block. Further, kitchen garden vegetable seed kits containing 12 vegetable seeds were distributed to 430 women during the period to improve access of farm families. Training cum demonstration program were organized under Farmers FIRST program to increase women's self-assurance in their ability to grow. Apart from this significant number of female students (B.Tech/M.Tech) were trained as part of various institute attachment programs and student internships. Community consultation program under REWARD project has been carried out to involve women farmers of the village about various soil and water conservation measures being taken up while preparation of DPR.

MAJOR EVENTS 2023

GeM Orientation training on January 10, 2023

Republic Day Celebration on 26 January, 2023

Training on Water harvesting on March 20-23, 2023

World Intellectual Property Day April 26, 2023

ICAR-IWMI steering committee meeting at IWMI, Colombo, Sri Lanka during April 21-23, 2023

Planning and management of watershed interventions with ICICI on April 17-19, 2023


IIWM Foundation Day on May 12, 2023


World Environmental day on June 5, 2023


International Day of Yoga on June 21, 2023


Showcased Technologies in the 95th Foundation Day of ICAR during July 16-18, 2023


Student Internship program

Interface meeting with Water Resource Department on August 1, 2023

Interface meeting with Department of Extension Education, OUAT on August 11, 2023

Signed MoA with a-IDEA on May 26, 2023

Signed MoU with C.V. Raman Global University, Bhubaneswar on June 26, 2023

Hindi Pakhwada on September 14-29, 2023

DG Visited ICAR-IIWM on November 9, 2023

Campaign on Micro Irrigation on July 11, 2023

Campaign on Conjunctive water use on August 8, 2023

Installation and demonstration of 'ICAR-IIWM developed IoT-enabled soil moisture sensor' at ICAR-IIVR Varanasi on October 18, 2023 under NePPA project

ICAR-IIWM participated in ICAR Tournament for Eastern Zone (TEZ) at ICAR-NRRI, Cuttack during December 13-16, 2023

Visit of Dr N.K,Tyagi and Dr S.K.Gupta on December 12

SWACHHA BHARAT ABHIYAN

Several *swachhata* activities like sanitation drives, awareness campaigns, *swachhta* pledge, *shramdan* and plantation drives were carried out by the Director, staff and scholars of the Institute during January to December 2023 under the *Swachh Bharat Abhiyan* (SBA). Major activities in *swachhata* drives included maintenance and cleaning of the office main building including laboratories, guest house, residential areas, campus roads, gardens, orchards, *sewage* channels and parking spaces of the Institute. Beautification through ornamental plantation, landscaping, pruning of old trees, anti-pest lime painting of trees, cutting of weeds, cleaning of roads, and mowing of lawns were done in the Institute and its research farm at Mendhasal. Three public auctions of old, obsolete, unserviceable and scrap items were done generating revenue of over two lakhs rupees. *'Swachhta Hi Sewa'* during September 15 - October 2, 'Special Campaign 3.0' during October 2-31 and *'Swachhta Pakhwada'* during December 16-31, 2023 were organized. Off-campus *swachhta* awareness campaign and sanitation drives were organized in eight villages involving over thousand farmers, farm women and village youths of Balanga, Hansapada, Viligram, Bhilideuli and Sana Nuaharakiri villages in Puri district, and Jamujhari, Haridamada and Barapita villages in Khordha district during October-December. On December 27, 2023, Shri Vijay Amruta Kulange, IAS, Commissioner, Bhubaneswar Municipal Corporation (BMC) delivered an Expert Talk on 'Making Bhubaneswar clean and green: Initiatives and activities. Ms. Pallavi Behera, Assistant Commissioner, BMC and Mr. Achyutananda Swain, Local Corporator (Ward-16) attended the inaugural programme of the 'Special Campaign 3.0' and planted saplings in the Institute campus on October 2 as a joint venture with the BMC. Gandhi Jayanti was celebrated with a special campaign to express our gratitude to the sanitary workers in the name of 'Thank You *Safai Mitra*' campaign. Ten '*Safai Mitras*' of the BMC and ICAR-IIWM were felicitated on the occasion. One Farmers' Day - '*Kisan Diwas* cum *Swachhta* Workshop' was organized at Viligram village, Nimapada block of Puri district on December 23. Nearly 150 farmers and farm women participated. An exposure visit was organized on December 29 for adopted farmers and staff to the BMC micro-composting centre of Hatiasuni, Bhubaneswar to learn the 'Waste-to-Wealth' management system.

During the year, several drawing and speech competitions on *swachhta* were organized, in which over two hundred staff, scholars and school children actively participated. Two drawing competitions were organized on the topic '*Swachh Gaon, Swachh Paribesa 'O' Aamara Swasthya*' for students of Government Ashram School, Haridamada, Khordha on Oct 17, 2023 and on the topic '*Swachh Bharat Abhiyan* for Clean and Green India' for students of Gopabandhu Sikshya Kendra, Chandrasekharpur, Bhubaneswar on Dec 28, 2023. Three speech competitions were organized on the topic '*Swachh Bharat Abhiyan:* Implications for health, environment and economy' for students of Saraswati Shishu Vidya Mandir, Adimata Colony, Mancheswar, Bhubaneswar and IIWM staff October 30, 2023. A topic on 'Importance of *Swachh Bharat* Mission on achieving Clean, Green and Healthy India' for students of Saraswati Shishu Vidya Mandir, Niladri Vihar, Bhubaneswar and St. Xavier's High School, Chandrasekharpur, Bhubaneswar was organized on December 29, 2022. The winners were awarded during the concluding function of each programme. In order to inculcate the habit of maintaining cleanliness, six special *swacchta* awards were also given to the staff for '*Swachh* room', '*Swachh* laboratory' and '*Swachh* quarters' (Type-I, II, III & IV quarters) during the *Swachhta Pakhwada* celebration. Shri Radhashyam Mahapatro, Director (HR), NALCO, Bhubaneswar graced as the Chief Guest during the special '*Swachhta* programme cum award giving Ceremony' on December 30, 2023 and distributed awards to all winners. Dr. S. K. Mishra, Chairman & Nodal Officer, Dr. H.K. Dash, Member, Dr. A.K. Nayak, Co-Nodal Officer, Dr. Prativa Sahu, Member and other members of the SBA Committee coordinated all *swachhta* activities during the year.

For its remarkable *swachhta* activities and initiatives, ICAR-IIWM bagged the 2nd Rank in the 'ICAR *Swachhta Pakhwada* Rank Award for the year 2022'.

Director administering *Swachhta* Pledge to staff and students of Institute

Plantation drive in the campus jointly by ICAR-IIWM and BMC, Bhubaneswar

Swachhta drive and *shramdaan* by staff in the IIWM Research Farm, Mendhasal

Screening of old files in administration and finance sections for weeding out

Swachhata awareness programme cum drawing competition at Govt. Ashram School, Haridamada, Khordha

Commissioner Sj. Vijay Amruta Kulange planting sapling in the campus

Chief Guest giving various *swachhta* awards to staff and family members

Activities during *swachhta* awareness cum cleanliness programs organized by ICAR-IIWM, Bhubaneswar under *Swachh Bharat Abhiyan* during 2023

PERSONNEL

As on 31-12-2023

SCIENTIFIC	
Dr. Arjamadutta Sarangi	Director
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. K.K Bandyopadhyay*	Principal Scientist (Soil Physics and S & WC)
Dr. M. Raychaudhuri	Principal Scientist (Soil Fert. /Che. /Microbio.)
Dr. R.K. Mohanty	Principal Scientist (Aquaculture)
Dr. S. K. Mishra	Principal Scientist (Agricultural Extension)
Dr. H.K. Dash	Principal Scientist (Agricultural Economics)
Dr. P.K. Panda	Principal Scientist (Agronomy)
Dr. A.K. Thakur	Principal Scientist (Plant Physiology)
Dr. S. Mohanty	Principal Scientist (S & WC Engg.)
Dr. D.K. Panda	Principal Scientist (Agricultural Statistics)
Dr. D. C. Sahoo	Principal Scientist (L & WME)
Dr. B. K. Sethy	Principal Scientist (L & WME)
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. Ashis Maity	Senior Scientist (Soil Science)
Dr. O.P. Verma	Senior Scientist (Agronomy)
Dr. Sanatan Pradhan	Senior Scientist (Soil Physics and S & WC)
Dr. B. S. Satapathy	Senior Scientist (Agronomy)
Dr. Dibakar Ghosh	Senior Scientist (Agronomy)
Dr. Roomesh K. Jena	Senior Scientist (Soil Science)
Dr. Debabrata Sethi	Scientist (Veterinary Extension)
Er. Ajit K. Nayak	Scientist (L & WME)
Dr. Prativa Sahu	Scientist (Fruit Science)
Dr. Ankita Jha	Scientist (Agricultural Meteorology)
Mr. Partha Deb Roy	Scientist (Soil Science)
Dr. Ankhila R. Handral	Scientist (Agricultural Economics)
Mr. Biswaranjan Behera	Scientist (Agronomy)
Mr. Ashish Madhukar Jadhav **	Scientist (Electronics & Instrumentation)

TECHNICAL	
Mrs. Sunanda Naik	Chief Technical Officer (Library)
Mr. Chhote Lal	Asst. Chief Technical Officer (Farm)
Mr. P.C. Singh Tiyu	Technical Officer (Estate)
Mr. S.K. Dash***	Technical Officer
Mr. B.K. Acharya	Technical Officer (Farm)
Mr. S. Lenka	Technical Officer (Lab)
Mr. P. Barda	Technical Officer (Estate)
Mr. A.K. Binakar	Technical Officer (Driver)
Mr. L. Singh Tiyu****	Technical Officer (Tractor Driver)
Dr. Subodha Kumar Karna	Technical Assistant (Lab)
Mr. Kamlesh Kumar Sharma	Technical Assistant (Hindi Translator)
Mr. A. Parida	Senior Technician (Farm)
ADMINISTRATION	
Mr Sanjay Kumar Jena	Administrative Officer
Mr. Janardan Biswal	Finance & Accounts Officer
Mr. J. Nayak	Asst. Administrative Officer
Mr. R.K. Dalai	Asst. Administrative Officer
Mrs. M. Padhi	Private Secretary
Mr. Trilochan Raut	Private Secretary
Mr. A. Pradhan	Assistant
Mr. N.K. Mallick	Assistant
Mr. C.R. Khuntia	Upper Division Clerk
Mr. B.S. Upadhyaya	Upper Division Clerk
Mr. S.C. Das	Upper Division Clerk
Mrs. Subhashree Satapathy	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

* Joined on June 30, 2023
** Joined on May 24, 2023
*** Retired on June 30, 2023
**** Retired under VRS on August 31, 2023

JOINING, PROMOTION, TRANSFER & SUPERANNUATION

Dr. K.K Bandyopadhyay, Principal Scientist has joined this Institute on June 30, 2023 after transferred from ICAR-IARI, New Delhi.

Dr. Om Prakash Verma, Sr. Scientist promoted to next higher scale RGP 9000 w.e.f. January 07, 2020.

Dr. Sanatan Pradhan, Sr. Scientist promoted to next higher scale RGP 9000 w.e.f. June 26, 2020.

Dr. Dibakar Ghosh, Scientist promoted to Senior Scientist w.e.f. September 15, 2021.

Dr. Roomesh Kumar Jena, Scientist promoted to Senior Scientist w.e.f. January 01, 2022.

Dr. Partha Deb Roy, Scientist promoted to next higher scale RGP 7000 w.e.f. January 01, 2020.

Mr. Ashish Madhukar Jadhav, Scientist has joined this Institute on May 24, 2023.

Shri Chhotelal was promoted to Assistant Chief Technical Officer on May 9, 2023.

Shri A. K. Binakar was promoted to Technical Officer on March 20, 2023.

Shri Laxman Singh Tiyu was promoted to Technical Officer on March 20, 2023.

Mr. S.K. Dash, Technical Officer retired from ICAR service on June 30, 2023.

Shri Laxman Singh Tiyu, Technical Officer retired from ICAR service on August 31, 2023 under VRS.

BUDGET & EXPENDITURE

The budget and progressive expenditure for the financial year 2023-24 in respect of ICAR-IIWM, Bhubaneswar, AICRP-IWM, CRP on Water and other projects:

Sl. No.	Head of Account	R.E. 2023-24	Expenditure during the month (March-24)	Progressive expenditure
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		0	0
2	Equipments	6890000	4512003	6889986
3	Furniture & Fixture	1520000	0	1519835
4	Library Books & Journal	0	0	0
5	Information Technology	1560000	0	1559829
6	Vehicles & Vessels	0	0	0
7	Others	0	0	0
8	SCSP	1050000	556159	1050000
9	TSP	201000	0	201000
	Total- CAPITAL	11221000	5068162	11220650
	Grants in Aid-Salaries (Revenue)			
1	Establishment Expenses			
	A. Salaries			
	i. Establishment charges	141099000	960502	141013593
	ii. Wages			
	iii. O.T.A.			
	Total -Establishment Expenses	141099000	960502	141013593
	Grants in Aid-General (Revenue)			
1	Pension & Other Retirement Benefits	5500000	0	5476019
2	Travelling Allowances			
	A. Domestic TA/TTA	2356000	218926	2354028
	B. Foreign TA	0		0
	Total - Traveling Allownces	2356000	218926	2354028
3	Research & Operational Expenses			
	A. Research Expenses	1896000	137169	1895405
	B. Operational Expenses	4375000	41277	4374696

	C. SCSP Research and Operational Expenses	2000000	581153	1999042
	Total- Research & Operational Expenses	8271000	759599	8269143
	TSP	1002000	132542	1000500
4	Administrative Expenses			
	A. Infrastructure	9587000	227936	9586690
	B. Communication	10100	870	10045
	C. Repair & Maintenance			
	i. Equipment Vehicles & Others	831000	96525	830485
	ii. Office Building	2078000	3160	2077268
	iii. Residential Building	512000	0	510061
	iv. Minor Works	469500	375626	469299
	D. Others (excluding TA)	7502600	432329	7502511
	Total- Administrative Expenses	20990200	1136446	20986359
5	Miscellaneous Expenses			
	A. HRD	44000	0	44000
	B. Other Items (Fellowship, Scholarships etc.)	0	0	0
	C. Publicity & Exhibitions	0	0	0
	D. Guest House - Maintenance	150000	13083	149075
	E. Other Miscellaneous	38800	3160	37664
	Total- Miscellaneous Expenses	232800	16243	230739
	Total Grant-in-Aid-General	38352000	2263756	38316788
	Total Revenue (Grant-in-Aid-Salaries + Grant-in-Aid-General)	179451000	3224258	179330381
	G. TOTAL (Capital + Revenue)	190672000	8292420	190551031

Sl. No.	SCHEMES	R.E. 2023-24	Expenditure during the month (March-24)	Progressive expenditure
1	AICRP on IWM			
a	Other ICAR Instt.& SAU,s	217385000	28570000	217385000
b	IIWM	1090000	173753	1090000
	TOTAL	218475000	28743753	218475000
2	CRP on Water			
a	Other ICAR Instt. SAU, s & IIT	5731000	144000	5731000
b	IIWM	8698000	5353724	8688283
	TOTAL	14429000	5497724	14419283
3	NAIF	95000	92990	92990
4	FARMER FIRST	1990000	709357	2049637
5	NASF	2210113	1644649	2152528
6	NICRA	5000000	1151865	5021993
7	NePPA	4500000	855659	2836083

ICAR-Indian Institute of Water Management
Bhubaneswar, Odisha - 751023
Phone : 91-674-2300060 (Director)
E-mail : director.iiwm@icar.gov.in
Web : https://iiwm.icar.gov.in