2019_2020

Annual Report

Increasing Productivity of Rice–based Cropping Systems and Farmers' Income in Odisha

Department of Agriculture and Farmers' Empowerment, Odisha
in collaboration with the
International Rice Research Institute

Increasing Productivity of Rice-based Cropping Systems and Farmers' Income in Odisha

(IRRI Ref. Nos. A-2016-48 and A-2018-181)

Annual Report 2019-20

submitted to the

Department of Agriculture and Farmers' Empowerment,
Government of Odisha
March 2020

Contact:
Alvin Poncin
Head, Portfolio Management Office
Telephone: +63 (2) 8580-5600; Fax: +63 (2) 8580-5699
E-mail address: ipmo@irri.org; Mailing address: DAPO Box 7777, Metro Manila, Philippines
Courier address: 10th Floor, Suite 1009, Security Bank Center, 6776 Ayala Avenue, Makati City 1226, Philippines

Rice Science for a Better World

The International Rice Research Institute (IRRI) was established in 1960 by the Ford and Rockefeller Foundations with the help and approval of the Government of the Philippines. It is supported by government funding agencies, foundations, the private sector, and nongovernment organizations. Today, IRRI is one of 15 nonprofit international research centers that is a member of the CGIAR Consortium (www.cgiar.org). CGIAR is a global agricultural research partnership for a food-secure future. The work described here was undertaken as part of the ongoing Government of Odisha–funded project **Increasing Productivity of Rice-based Systems and Farmers' Income in Odisha.** The responsibility for this publication rests with the International Rice Research Institute.

Mailing address:
International Rice Research Institute
Odisha Project Office: 340/C. Sahidnagar, Bhubaneswar, Odisha, India.
IRRI-India Office: 1st floor, Office Block, NASC Complex, DPS Marg, Pusa New Delhi 110012, India. Telephone: +91-11-66763000.

Headquarters: DAPO Box 7777, Metro Manila, Philippines
Telephone: +63 (2) 580-5600; Fax: +63 (2) 580-5699
Email: info@irri.org; Web: www.irri.org

Courier address: Suite 1009, Security Bank Center, 6776 Ayala Avenue, Makati City, Philippines
Telephone: +63 (2) 891-1236, 891-1174, 891-1258, 891-1303

Suggested citation: Annual Progress Report. **Increasing Productivity of Rice-based Systems and Farmers' Income in Odisha (2019)**. India Office, International Rice Research Institute.

Contents **Page**

Preface…………………………………………………………………………………………… 1

Acknowledgments………………………………………………………………………………… 3

Introduction…………………………………………………………………………………… 5

Executive summary……………………………………………………………………………… 15

Subproject 1: Strengthening Seed Systems of Stress-tolerant Rice Varieties
through Innovative Demonstrations and Extension Approaches in Odisha………..….. 21

Subproject 2: Targeting Rice-Fallows: A Cropping System-based Extrapolation
Domain Approach…………………………………………………………………………….... 55

Subproject 3: Raising the Productivity and Profitability of Rice-based
Cropping Systems in Odisha through Rice Crop Manager (RCM)……………………….. 75

Subproject 4: Inclusive Development through Knowledge, Innovative
Extension Methods, Networks, and Capacity Building in Odisha……………………..…. 87

Subproject 5: Science-based Crop Insurance
5a. Remote Sensing-based Rice Monitoring and Yield Estimation………………………..... 113
5b. Delivering a Science-based Crop Insurance for Increasing Farmer Resilience.……... 136

Workplan, 2020-21………………………………………………………………………………... 162

References………………………………………………………………………………………..… 168

Annexures…………………………………………………………………………………..….... 170

Preface

All countries and states endeavor to ensure that their people have access to adequate quantities of nutritious food to address the challenges of hunger and malnutrition. One hopes that the women and men farmers who feed these people have sustainable and remunerative livelihoods and are themselves well-nourished and lead healthy lives. Farming households in Odisha depend predominantly on rice for their food security and income. Odisha has adequate land and water resources to grow rice in most of its districts, but the varieties grown, management practices followed, yield obtained, and income generated vary widely, leading to inequitable benefits for its people. Although cereal production in the state is marginally surplus, pulses and oilseed production are below the requirement. The research for development efforts of the International Rice Research Institute (IRRI) are therefore aimed at reducing the disparities in production and income from rice-based systems by promoting appropriate crop production technology while addressing the environmental, economic, and social aspects of sustainability. This report of the project on Increasing Productivity of Rice-based Cropping Systems and Farmers' Income in Odisha, supported by the Department of Agriculture and Farmers’ Empowerment, covers the activities undertaken during 2019-20 under five subprojects. The work plan designed and executed covered a wide array of interventions with an intentional bias toward smallholder farms in stressed environments. IRRI led a convergent effort by researchers from several institutions, extension specialists, NGOs, social enterprises, agri-input dealers, and farmer groups to create an enabling environment for farmers to optimize crop yield, derive higher income from a diversified portfolio of crops, and seek additional revenue through women-led enterprises.

Seeds of new and improved crop varieties developed for different conditions by multiple agencies need to reach farmers in sufficient quantities within a couple of years after their release and notification. The subproject on seed systems examined the avenues for testing and demonstrating the new varieties, helping farmers make informed choices about the most suitable ones and making available high-quality seeds of preferred improved cultivars. Actors in the seed value chain and cooperating farmers also received training on good-quality seed production so that they could gain access to the seed themselves, and also be able to serve the needs of their communities. The subproject on rice-fallows focused on characterizing the areas having potential for double cropping but left uncultivated for various reasons. It assessed the feasibility of various cropping systems in rabi, executed in collaboration with other CGIAR institutions and national agricultural research and extension systems. Subproject 3 promotes site-specific, balanced, ICT-assisted nutrient management, with emphasis on the responsible use of fertilizer that, while sustaining yield, also limits the effect of abiotic/biotic stresses, reduces input costs, and decreases the carbon footprint. Subproject 4 supports knowledge management and capacity building of extension service providers so that diverse stakeholder groups have access to updated knowledge, science, technologies, and skills to support agricultural transformation. It also assesses diverse models for catalyzing entrepreneurship of women farmer collectives. Satellite-based crop monitoring, crop loss assessment, and assessment of the socioeconomic and psychological factors that affect crop insurance uptake among farmers are the thematic areas under subproject 5.

Regional disparities in productivity, with Coastal Plains and Central Table Lands exhibiting relatively better land, water, and labor productivity than the Eastern Ghat and Northern Plateau regions, require special focus on the latter two to bring them up to par with the former. Although crop diversification with a mix of high-value crops has good potential, this may not happen soon as most of the small farmers cultivate rice in rainfed districts for food security. Relatively low input intensity, especially of agro-chemicals, in the Northern Plateau and Eastern Ghat regions suggests that it is possible to achieve environmentally responsible production targets with appropriate combinations of stress-tolerant rice, pulses, and oilseeds; site-specific crop management; and risk management interventions. Better access to new technologies, extension services, and collectivization to realize economies of scale for inputs as well as sale of produce can improve farm income, contributing to the desired goal of improved productivity with profitability.

Mukund Variar

Ranjitha Puskur

Acknowledgments

The International Rice Research Institute (IRRI) began the project Increasing Productivity of Rice-based Cropping Systems and Farmers' Income in Odisha in 2016, with support from the Department of Agriculture and Farmers' Empowerment (DAFE) of the Government of Odisha. IRRI would like to express its sincere gratitude to all the government officials, ICAR institutions, OUAT, other R&D partner organizations, NGOs, seed agencies, dealers, and farmers for their tremendous support to the project activities, thus contributing to the goal of strengthened rice-based cropping systems in the state.

Dr. Saurabh Garg, principal secretary, DAFE, provided strong and constant support to plan and carry out the project activities across the state and guided the team to work with the Directorate of Agriculture (DoA) to implement the activities as envisaged in the four-year plan. Without his constant encouragement and inspiration, the project objectives would not have been achieved. Dr. M. Muthu Kumar, director of the Directorate of Agriculture & Food Production, along with senior officials of DAFE, ably facilitated the implementation of the project activities by providing necessary support and linkages with various stakeholders. Their patronage is gratefully acknowledged.

Shri Mahesh Prasad Rath, joint director of agriculture (Special Programs& Crops), was instrumental in establishing the linkages that ensured a seamless information flow between IRRI and the DoA for various operations. His valuable suggestions and feedback were helpful in implementing the activities smoothly. Steady support from Shri Saroj Kant Chand, deputy director of agriculture-coordination, and Shri Tarun Chotoray, block agriculture officer, DAFE, was very helpful in the timely and smooth reporting of the project activities.

The active participation of Chief District Agriculture Officers, Assistant Agriculture Officers, and other staff in training programs, meetings, and workshops greatly helped IRRI in organizing awareness programs and implementing various trials and demonstrations in farmers' fields spread across the state.

IRRI would like to mention here the support provided by the Odisha State Seed Corporation (OSSC), Odisha State Seed Organic Products Certification Agency (OSSOPCA), Orissa Space Applications Centre (ORSAC), Institute on Management of Agricultural Extension (IMAGE), and district functionaries. The dynamic role played by the director of OSSC for actively engaging in varietal evaluation programs and seed supply and the director of OSSOPCA for prioritizing the production and certification of stress-tolerant rice varieties is highly appreciated. The support from the director of IMAGE in holding numerous meetings and workshops throughout the year is also thankfully acknowledged.

Many institutions provided enormous support for the implementation of this project. Odisha University of Agriculture and Technology (OUAT), Krishi Vigyan Kendras in different districts, National Rice Research Institute (ICAR-NRRI), Central Institution for Women in Agriculture (ICAR-CIWA), and Odisha Livelihood Mission (OLM) provided much-needed support in collaborative research, technology demonstrations, organizing farmers' field days, and conducting training programs on different aspects. Valuable support by Dr. Pawan Kumar Agarwal, vice-chancellor, OUAT; Dr. Himanshu Pathak, director, NRRI; and Mr. Smruti Ranjan Pradhan, CEO-cum-director, OLM, in facilitating these activities is gratefully acknowledged.

Last but not least, IRRI is grateful for the enthusiastic support and partnership of thousands of women and men farmers, field functionaries of DoA, seed and input dealers, NGO representatives, many self-help groups, and members of Farmer Producer Company who made it possible for IRRI to reach out effortlessly to the rice farming community in the state. Their contributions and efforts are thankfully acknowledged.

Introduction

Rice is a food staple for more than 3.5 billion people worldwide, particularly in Asia. It provides a significant proportion of both human and animal diets and helps poor and vulnerable socioeconomic groups meet their calorific requirements. Rice-based cropping systems, especially those involving pulses and oilseeds, complement the dietary requirements to meet nutrition requirements while maintaining soil health, and thus are indispensable to people, directly or indirectly, for balanced nutrition, food security, and poverty alleviation.

Rice has shown incredible capacity to adapt itself to a great variety of soil and climatic conditions, having been grown in diverse environments over several millennia. Global/regional research efforts have also substantially contributed to improved yields in different environments with ecosystem-specific varieties and management technologies. Although overall productivity has improved, the benefits have not percolated to small farms with poor resource endowments and those in remote localities. Many socioeconomic constraints, including timely access to information, credit, farm inputs, and markets; gender gaps; and an equal number of technical constraints, including those exacerbated by climate-induced changes, suppress attainable yields. Enhancing the sustainability and productivity of rice-based production systems, while protecting and conserving the environment, will therefore require the commitment of many parts of civil society as well as government and intergovernmental action (IYR 2004).

Several countries in Asia, where most rice is grown and consumed, have placed "climate-smart" rice farming practices at the center of their impact investment strategies. The objective is to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a timeframe sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner (Biennial Update Report, UNFCC 2015). About 18% of total GHG emissions from India for 2010 were attributed to agriculture (390 million tons CO_2 eq), with rice cultivation being one of the major contributors (71.4 million tons) along with livestock rearing (enteric fermentation and manure management: 229 million tons), fertilizer/soil (81 million tons), and field burning of crop residue (0.8 million tons). GHG inventory mapping for Odisha done in 2014 indicated that agriculture contributed 25 million tons of CO_2 eq emissions in the state.

Odisha was one of the first states to begin work on a Climate Change Action Plan in 2009. The state's vulnerability stems from its high poverty level (43%) and higher-than-national average (21%) of natural resource dependency, particularly by its large population of indigenous communities. Odisha is also the first state in the country to monitor and report the progress made by its various departments in the areas of adaptation and mitigation. The State Action Plan on Climate Change (SAPCC), prepared for 2015-20, delineated a state-level assessment of the likely consequences of the changing global climate on Odisha's agriculture, industry, forest resources, environmental priorities, energy requirements, fisheries resources, freshwater supply, aquatic and terrestrial ecosystems, and human health. Notwithstanding the climatic threat, poverty levels, and resource limitations, the state pushed for a robust agriculture policy focusing on the economic well-being of the farmers rather than just productivity. This has helped the state to achieve consistent growth during the past ten years.

Status reports on agriculture in Odisha indicate that Odisha’s agricultural GDP nearly doubled in real terms from 2000-01 to 2016-17, clocking an average annual growth rate of about 4.5%, higher than the India average of 3.1%. Diversification to high-value agriculture including oilseeds, pulses, and vegetables; improvements in the value of output generated from cereals from higher production and higher prices realized by farmers; and higher value generated from livestock are reported to be the drivers for income growth, calculated from the gross value of agricultural output. Although Odisha’s productivity in major crops such as rice, groundnut, gram, lentils, etc., has improved over time, it is still lower than that of some other states in India. There is also a large yield gap among the state’s different districts, indicating a gap in resources, technology diffusion and adoption, and knowledge sharing. Further, Odisha’s growth rate is more volatile than the all-India rate. This high volatility is partially explained by the impact of weather and climatic variability on agricultural growth in Odisha (State Agricultural Policy, Odisha, 2019). The policy paper notes that the state is placed on a high growth path in agriculture and it is important that the Odisha government build on these successes, recognize the constraints, and formulate a policy to overcome the challenges and harness the potential and opportunities that the fast-emerging markets within the state and outside provide while keeping the policy focus steadfast on farmers’ well-being.

The Department of Agriculture and Farmers’ Empowerment (DAFE) in Odisha supported several projects for Development of Agriculture in Collaboration with International Agricultural Research Institutions during the past 5 years. The Odisha government signed an MoU with the International Rice Research Institute (IRRI) on 3 October 2015 to promote and accelerate the expansion and dissemination of improved research technologies and packages of practices to enhance the livelihood of poor farmers in a missionmode approach. Subsequently, the project Improving Productivity of Rice-based Farming Systems and Farmers’ Income in Odisha was launched (2016-17) to promote cooperation in the fields of rice research, development and training, and improvement of production technologies and extension thereof, through the following:

- Promoting new high-yielding stress-tolerant and climate-resilient rice varieties in the state through seed multiplication–linked demonstrations and targeted dissemination, thus strengthening the seed supply system of the state
- Developing and promoting appropriate management practices for both rainfed and irrigated systems, resulting in improved rice-based cropping systems to ensure food and nutritional security and profit to farmers
- Collaboratingin developing and promoting IRRl's Rice Crop Manager and other digital tools that leverage modern information and communication technologies in the state, and extending these programs to rainfed farming areas

- Collaborating with the state to strengthen the capacity of rice scientists and agriculture officials and progressive farmers to build strong and vibrant research, extension, and advisory services
- Collaborating in the development of policies and programs that promote the empowerment of women in agriculture
- Exploring the development of a science-based crop insurance system at a reasonable cost in collaboration with IRRI's RIICE project

These objectives were molded into a set of subprojects and implemented in collaboration with the Department of Agriculture and Farmers' Empowerment, national agricultural research systems (ICAR institutes: NRRI, CIWA), the state agricultural university (OUAT), KVKs, other line departments (OLM), R4D organizations (CRISP), social enterprises (ALCI), NGOs, and farmers of the state of Odisha. As the project progressed, annual work plans were streamlined and integrated across subprojects for better technology targeting and product delivery, addressing the increasingly complex environmental and social challenges. Climate-resilient rice varieties with stable performance in farmers' fields, improved seed systems with stakeholder engagement across the value chain for better inventory management, women entrepreneurship to promote decentralized production and marketing of seeds and value addition, resource characterization of rice fallows to convert them into productive patches, regenerative crop and nutrient management practices that sustain soil and crop health, risk management with satellite-based crop monitoring systems, bundling of insurance products, and informed choices for farmers to adapt to the challenges were the elements that IRRI focused on during the year under report. Experiential learning by women and men farmers by testing new technologies was the core of on-farm interventions. Supporting the extension and advisory service providers of the state to realign their roles in a climate-smart regime, building their capacity to position themselves as gender-inclusive facilitators rather than mere information givers, and helping the farming community to move out of a subsistence mode to a market-oriented enterprise were also part of the work plan for 2019-20.

Seed systems

The diversity of rice-growing environments in Odisha is a reflection of the ten agro-climatic zones into which the state is subdivided based on physiography, soils, climate, and length of growing period. Rice is the major crop in all the agro-climatic zones, with very short-duration (80–100 days) photo-insensitive varieties grown in the plateau uplands, medium-duration (120–135 days) photo-insensitive varieties grown in the irrigated areas, and long-duration (150–165 days) photo-sensitive varieties grown in the semi-deep waters in the coastal zone. This is an oversimplification of the topology in which rice is grown, considering that 50–60 different rice varieties are grown in different districts. Although the preponderance of varieties of different duration groups, traditional as well as modern, contributes to stable but low yields in a subsistence environment, the demand for higher and sustained yields requires that varieties tolerant of prevailing stresses be developed with higher yield and more acceptable grain quality, and seed provisioning be ensured on a large scale through public-private partnership. Fast-paced varietal development spurred by climate change effects, biotic and abiotic stress factors, and the need to replace old varieties with newer ones dictate a slew of measures to maintain varietal identity and purity, develop delivery and marketing strategies, and develop information systems to create demand, raise awareness, and enhance their diffusion and adoption.

Odisha has several hundred publicly bred, formally released, and notified rice varieties, but their adoption and diffusion have been slow and limited. On the other hand, some popular varieties continue to be grown even decades after their release, potentially blocking yield improvement/genetic gain that is possible with newer, better performing varieties. Farmers, especially smallholders, continue to access a large part of their seed requirement through farm-saved seeds. Loss of seed purity and quality by unprotected cultivation (limited isolation from other varieties, exposure to biotic and abiotic stresses, etc.), threshing (admixtures), and storage of seed under less-than-ideal conditions by farmers lead to an erosion of seed quality and consequently poor crop production. Breeding programs may not realize their investments if varieties cannot be delivered quickly and at scale. Farmers also need to be dynamic to use new varieties and discard old ones when better options become available. This calls for sustained efforts to (a) create awareness about the characteristics and advantages of new varieties through appropriate demonstrations and information dissemination and (b) produce and supply a sufficient quantity of good-quality seeds to replace older ones with ease of access/proximity to smallholder farmers.

A robust seed system is pivotal in bringing about accelerated adoption of new varieties by farmers. Essential to such a system is the production of seeds of proper physical and physiological quality and their marketing through outlets spread over the state, thus ensuring proximity to farmers located away from production and processing centers. Such a formal system needs to co-exist with and complement farmer-managed systems so that farmers have access to certified seeds periodically and at the same time are able to produce and use good-quality seeds to maintain a healthy seed replacement rate of 33%.

IRRI started a series of varietal evaluations and capacity-building activities in partnership with district-level officials of the DoA, OSSC, and NGOs to identify stable, high-yielding stress-tolerant varieties and their fit in the different agro-climatic zones, and to create awareness among the different stakeholders, including officials of other line departments, seed producers, agri-input dealers, and farmers themselves. During 2016-19, IRRI organized (a) crop varietal cafeterias in different districts, (b) dyadic and triadic comparison of stress-tolerant rice varieties (STRVs) with existing farmer-used varieties, (c) cluster demonstrations of selected varieties linked with seed production, (d) awareness campaigns about new STRVs, (e) training on good-quality seed production (training of trainers as well as farmers) and storage, and (f) breeder-seed provisioning and preferential multiplication of STRVs through OSSC and private seed producers. Nearly 20,000 ha were covered under various trials involving approximately 60,000 women and men farmers in 28 districts during 2016-19. A digital tool (SeedCast) to estimate demand to help manage inventories and facilitate indenting and provisioning of seed as per demand was also developed, field-tested, and launched during this period.

Rice-based cropping systems and fallow management

Rice-based cropping systems with rice as the first crop during the monsoon season are the major cropping system in Odisha. Although Odisha has high species diversity with manycereal, leguminous, oilseed, vegetable, and fiber crops grown, the state has recently witnessed a sharp decline in crop diversification. By 2014-15, 80% of the cropped area was under rice, around 10% under other pulses, and around 4% under other food crops (Table 1).

The Odisha government started several schemes in the last couple of years (Odisha Millet Mission, Targeting Rice Fallows in Eastern India, etc.) realizing that crop diversification needs to be encouraged to improve soil health, productivity, and thereby profitability of cultivation.

Table 1. Crop diversification index* (adapted from Economic Survey 2018, GOI).

Year	Odisha	India
1994-95	0.740	0.905
2005-06	0.703	0.907
2010-11	0.380	0.907
2014-15	0.340	0.899

**Index of crop diversification =*
$1 - [\Sigma x^2/(\Sigma x^2)]$, where x is the percentage of total cropped area under an individual crop.

Legume crops in rotation with a cereal-based system and their crop residue incorporation in soil sustain C and N dynamics in soil. Recent research shows that only 32% of the N taken up by the crop is from current-year N fertilizer while the majority of nonfertilizer N comes from turnover of soil and crop residue N (Yan et al 2020). Nitrogen from legumes remains in the soil longer than the nitrogen in synthetic fertilizers. The adoption of green manures/pulses/leguminous crops in a nutrient-exhaustive rice-based cropping system can therefore save N fertilizer for successive crops, increase grain yield, and increase profitability.

IRRI began a two-pronged approach to examine crop diversification and intensification (a) focusing on resource characterization of rice fallows in Odisha and (b) agronomic interventions to bring in fallow areas under double cropping based on resource endowments, best-fit technologies, and addressing the socioeconomic constraints that prevent the conversion of cultivable rice fallows into productive farms. IRRI estimated the extent of ricefallows using Sentinel 1 and 2 and Landsat data, and validated the map with ground truthing during 2016-19. The average area under fallows was estimated at 2.0 million ha, with yearly variations of 0.1 million ha, mostly due to variations in the onset/withdrawal of monsoons. Based on the suitability maps prepared, it was assessed that potential exists to bring about 1.1 million ha under cultivation. Based on the GP-level, remote-sensing-based estimates of potential area, IRRI is evaluating and demonstrating the potential of recently released, early-duration, high-yielding, and disease-resistant pulse varieties (green gram and black gram) in rice fallows during rabi 2019-20, covering approximately 2,500 ha in 23 districts. A multi-institutional (IRRI, ICARDA, ICRISAT, CIP, NRRI, OUAT) program to identify potential crops for rice fallows has also been taken up in villages in 23 districts.

Rice nutrient management

Nutrient needs of rice are not constant and can vary with seasons and years, varieties grown, inherent soil fertility, and because of differences in crop-growing conditions and management. Fertilizer consumption in Odisha was 68.67 kg/ha in 2017-18. Although consumption steadily increased from 2001-02 to 2017-18 with minor year-to-year variations, total fertilizer consumption still remains well below the national average of 128.02 kg/ha during the corresponding period (Odisha Economic Survey, 2018-19). Lower consumption of inorganic fertilizer may no longer be considered a highly negative trend if the state can improve and sustain productivity with organic sources. In fact, Niti Ayog (2015) suggested that farming, being organic by default, in tribal-dominated regions (including Odisha) has good scope for expanding organic farming. Data on district-wise consumption of fertilizer for 2013-14 show that the range is wide, with some districts using as low as 10 kg/ha (Kandhamal) and some as high as 154 kg /ha (Nabarangpur). Rice farmers under the Hirakud, Indravati, and Rishikulya river basins are the major consumers of fertilizer in the state (Bargarh, Sambalpur, Balasore, Ganjam, Kalahandi). Nabarangpur has a more diversified system, with maize and sugarcane occupying relatively larger area, and hence higher fertilizer consumption than other districts.

Ecological intensification of production in less arable land, and still meeting acceptable standards of environmental quality, requires along with genetically improved varieties and seeds balanced fertilization to avoid depletion of soil nutrients and sustain soil quality. It is difficult to determine the contribution of commercial fertilizers alone in crop productivity, as inherent soil fertility, climate, crop rotations, and management also contribute to the overall production. Long-term fertilizer experiments and omission plot techniques estimate that 30–50% of crop yield can be attributed to commercial fertilizer inputs (Roberts 2007). In order to ensure that fertilizer is used responsibly and efficiently, 4 Rs—right source (or product), right rate, right time, and right place—are considered the foundation of fertilizer best management practices (BMPs). This essentially means applying the correct nutrient in the amount needed, timed, and placed to meet crop demand. Although fertilizer management is broadly described by the four "rights," determining which practice is right for a given farm depends on the local soil and climatic conditions, crop, management conditions, and other site-specific factors.

Site-specific nutrient management (SSNM) is an approach of supplying plants with nutrients to optimally match their inherent spatial and temporal needs for supplemental nutrients (Buresh and Witt 2007). Optimally supplying rice with essential nutrients as and when needed to achieve high yield and high efficiency of input use involves three steps. The first step is to establish an attainable yield target, which is location- and season-specific depending upon climate, rice cultivar, and crop management. This yield target or goal reflects the total amount of nutrients that must be taken up by the crop. The second step is to ensure effective use of existing indigenous nutrients such as from soil, organic amendments, crop residue, manure, and irrigation water. The third step is to apply fertilizer to dynamically fill the deficit between crop needs and indigenous supply and to maintain soil fertility. The SSNM approach does not specifically aim to either reduce or increase fertilizer use. Instead, it aims to apply nutrients at optimal rates and times to achieve high profit for farmers, with high efficiency of nutrient use by crops across spatial and temporal scales, thereby preventing leakage of excess nutrients into the environment.

Rice Crop Manager and other digital tools

Rice Crop Manger (RCM), built on the principles of SSNM, is used to calculate field-specific requirements for fertilizer nitrogen, phosphorus, potassium, and zinc based on scientific principles with the aim to increase nutrient-use efficiency. RCM has been promoted extensively in Odisha in the past four years to enable farmers to balance fertilizer inputs based on the inherent fertility of their specific parcels evidenced from previous yields and the targeted yield based on the varieties grown. IRRI, with support from district officials (RCM Kendras), NGO partners, agri-input dealers, and Common Service Centers, distributed more than 100,000 RCM recommendations during 2016-19 to rice farmers spread over 16 districts. IRRI also helped a subset of the farmers who received recommendations to compare the yield obtained under RCM and the fertilizer practices followed by them using STRVs and farmer-owned varieties. These demonstrations empower farmers with greater decision-making skills for their specific rice-growing conditions. IRRI also evaluated several RCM disseminationchannels to identify the most effective ones to scale and find ways to overcome the problems of low adoption due to low literacy/poor ICT skills among the farmers, and the lack of trust in the robustness of RCM.

The project has collaborated with OUAT and NRRI to generate information on crop performance under rainfed vs. irrigated conditions, under different crop establishment methods, crop rotations, rate of Zn application, and weed management practices. The database would be helpful in fine-tuning RCM for rainfed conditions in the different districts.

Another important aspect of efficient crop management is early detection and prophylaxis to prevent losses from field problems of the crop caused by diseases and insect pests and correction of imbalances caused by deficiencies or toxicities of macro- and micronutrient elements. Farmers often face difficulty in correctly diagnosing the problem to take appropriate corrective action. With higher smartphone access among rural communities, including Odisha, it has become possible to provide smart solutions to farmers to help them diagnose problems and use suggested action plans to manage them efficiently. **Rice Doctor Odisha** is an Android-based mobile app, developed by IRRI and modified and field-tested in Odisha, to address locally important problems. The app was launched for use by farmers and field-level workers of the DoA of Odisha on 23 January 2020, along with the **Rice-based cropping systems Knowledge Bank,** which is a web- and mobile-based tool serving as a one-stop information source for farmers growing rice, pulses, and oilseeds in Odisha.

Extension and advisory services

The provision of effective extension and advisory services (EAS) is critical for disseminating and upscaling new knowledge needed for enhancing farm productivity and income. Although Odisha has a pluralistic extension system, it faces several challenges in extension delivery. Although several new approaches to strengthen extension have been tried in Odisha, the range of services and the quality of service delivery offer immense scope for taking them to a higher level.

IRRI worked with the Government of Odisha to strengthen the capacity of EAS providers in the state so that they could contribute more effectively to Odisha's agricultural transformation. A status paper on "Enhancing Innovation and Impact in Odisha Agriculture: Analysis of Key Extension Stakeholders, Capacity Gaps, and Ways Forward" was the first step, followed by a Capacity Needs Assessment Workshop on Extension and Advisory Service Providers in Odisha. The workshop identified key capacity gaps at different levels. Based on the findings from capacity needs assessment, IRRI and CRISP developed training modules that can support trainers to organize effective training activities on (a) value chain extension, (b) enabling EAS for climate-smart agriculture, (c) facilitation for development, and (d) designing and delivering gender-responsive EAS.

These modules were pilot-tested as Training of Trainers (ToT) with IMAGE faculty and other trainers from interested organizations in the state.

Women-led entrepreneurship

The FAO estimates that women comprise, on average, 43% of the agricultural labor force in developing countries. If they had equal access to productive resources, they could increase yields on their farms by 20–30% (FAO 2011). Nearly 48% of all laborers are female in Odisha, heavily involved in all farming activities, but most lack land ownership or have limited landholding, and continue to face many constraints and inequities. Overcoming gender inequalities and empowering women through knowledge provision; access to technologies, services, and resources; and enhanced participation at various levels will bring significant improvements to farm productivity, food security, and nutrition (Ching 2018).

The gender gap in access to productive assets, resources, and inputs is well established. Because of a multitude of societal and structural barriers, women farmers tend to face serious challenges in accessing good-quality agricultural inputs at the right time and place and at an affordable price. Women's access to markets tends to be limited, as they are not often recognized as farmers. This also limits their ability to obtain inputs from formal governmental sources or cooperatives. IRRI therefore began a series of capacity-building and entrepreneurship development programs involving women groups in the districts of Puri, Koraput, and Kalahandi during the past couple of years. A women's Farmer Producer Company was established in Kalahandi in 2019. FPC members were trained on seed production techniques, helped to procure agri-inputs to achieve economies of scale, and linked to state agencies for seed certification.

Satellite-based rice monitoring system

Remote sensing has the capacity to assist the adaptive evolution of agricultural practices in order to face the challenge of environmental sustainability and climate change by providing repetitive information on crop status throughout the season at different scales and for different stakeholders (farmers, governments, insurers, etc.). Remote sensing offers nondestructive measurements and estimations providing recurrent information from local to global scale in a systematic way to help characterize the spatio-temporal variability with a given area, monitor land use, and forecastwithin-season crop production.

IRRI started satellite-based monitoring of the rice ecosystem in Odisha to provide timely and accurate information on rice area and crop yield. This work is based on data acquired from the Sentinel satellite system of the European Space Agency (ESA). Sentinel 1 and 2 use radar sensors (synthetic aperture radar) with a spatial resolution of 20 meters and a temporal resolution of 6/12 days. Unlike optical systems, radar sensors can generate reliable datasets even at night and in cloudy conditions, thus making the tool perfect for rice crop monitoring, especially during the monsoon season. RS-based real-time monitoring and ground data collection occur during the beginning and at different phenological stages of the crop run simultaneously. This helps in the calibration and validation of the datasets, before integrating the SAR data with ORYZA crop growth model (Rice-Yield Estimation System) for yield estimation. A rice monitoring platform was also used to assess the extent of rice area affected by cyclonic events during the season. IRRI also estimated GP-level yield in two districts (Jagatsinghpur and Puri) to help the state in accurately assessing crop performance and validating RS data with crop-cut data and other modes (picture-based, etc.) of yield estimation.

Socioeconomics of crop insurance

Adoption of a robust crop insurance system can mitigate the effects of agricultural risks emanating from the occurrence of calamitous events such as droughts, floods, cyclones, etc. PMBFY has been implemented in India since 2016 and is currently operational in most states, including Odisha. There are several issues related to the scheme, including meagre payouts to farmers on the one hand and high claim ratios affecting the profits of insurance companies on the other. Extreme weather events and moral hazards/political interference contribute to high crop loss estimation. The number of farmers covered under the scheme has also declined since the inception of PMFBY in the country. In 2016-17, more than 58 million farmers were covered under the scheme, which dropped to around 56 million in 2018-19. This has increased the scheme's premium, which is shared by farmers, the Center, and states. Although a farmer in 2016-17 paid on average a premium of INR 725 under the scheme, this increased to INR 860 in 2018.

Although efforts are being made to use remote-sensing technology to assess crop damage and thereby timely settle claims in a transparent manner, it is important to understand farmers' perception of risk, adaptive capacity, and resilience to ensure the development of efficient measures for farmers to cope with climatic risks. Several socioeconomic constraints tend to limit insurance uptake by farmers. IRRI studied insurance literacy levels, awareness, and risk aversion among farmers, validated key indicators of a comprehensive insurance scheme from multiple stakeholders, and designed educational interventions to increase farmers' awareness and acceptability of crop insurance. IRRI also examined the possibility of coupling insurance with alternative risk mitigation strategies such as the use of STRVs.

The overall objective of the activities undertaken aimed to improve productivity without negative environmental impacts. Special focus was given to using technology to elevate the system productivity of smallholder farms to the level achieved on farms with better resource endowments such as irrigation and nutrient use, and to enhance the farmers' capacity to deal with, adapt to, and respond to changes in the physical environment in which farming is done. In addition to building this resilience, IRRI strived to disrupt the social deficits, especially those related to gender, by promoting farmers' active involvement in farming-related activities. The outputs, outcomes, and potential impacts from the interventions are discussed in this report.

Executive summary

A series of small improvements can add up to larger, measurable impacts. This project is tailored to support farmers to benefit from climate-resilient varieties suitable for different rice-growing environments, higher production with lower costs, decreased year-to-year yield variations, risk mitigation, intensified cropping opportunities, and capacity development for livelihood resilience with a pro-smallholder bias. Interdisciplinary approaches with multi-sectoral collaboration and improved organizational capacity are needed to tackle multiple constraints, thus leading to improved development outcomes. Collaborative research for development communities have the ability to fast-track diffusion of knowledge-intensive technologies effectively as different actors contribute their institutional specialities to organize and execute work plans with stakeholder participation. IRRI, with support from DAFE, chartered this course to integrate the activities working with several national (OUAT, ICAR institutes, KVKs, MNCFC, Space Application Centre, Odisha) and international research institutions (CGIAR and AIRCA institutes active in Odisha), R4D/management institutions (CRISP, ISB, Hyderabad), other public and private institutions and service providers (Odisha Livelihood Mission, Seed corporations/certifying agencies, common service centers, PAD-IF, CSR wing of Reliance Foundation), social enterprises (ALCI Ltd.), NGOs, local business entities (agri-input dealers), and the farming community, especially women farmers. Following is a summary of the activities taken up during 2019-20 under five subprojects:(1) seed system improvement, (2) fallow management, (3) crop and nutrient management, (4) knowledge management, capacity building, and entrepreneurship development, and (5) risk management (remote-sensing-based crop monitoring and socially acceptable crop insurance).

Seed system

Exposure to newly released climate-resilient rice varieties befitting the duration requirement in uplands, medium lands, and lowlands through farmer-managed comparative evaluations vis-à-vis their existing varieties, larger demonstrations of selected varieties in clusters, and their seed supply in different districts were the direct interventions that contributed to farmer awareness and demand creation for seeds of drought- and submergence-tolerant rice varieties across the state.

Seventeen STRVs were grown on about 20,000 ha by 82,000 farmers through head-to-head trials, cluster demonstrations, and dealer-linked minikits during 2016-19. Triadic comparisons with 25 new releases and pipeline varieties in 80 blocks involving nearly 1,000 farmers were also organized (kharif 2019). The introduction of new varieties among farmers through NGOs and village-level agri-input dealers ensured better outreach, with potential for accelerated adoption by a larger number of farmers in a short period.

Awareness programs and training on good-quality seed production helped famers save seeds from the demonstrations for themselves and fellow farmers, thus increasing local availability of newly released varieties. The linkage of seedgrowers to OSSC for varieties that were in short supply (Sahbhagi dhan) helped to balance the requirement of certified seeds.

IRRI has so far organized 67 crop varietal cafeterias, 17 of them this year, across Odisha engaging and linking nearly 1,500 stakeholders from the farming community, private seed suppliers, state seed corporations, input dealers, extension agencies, NGOs, and government as well as researchers. Selection of suitable varieties by seed value chain actors ensured that the formal seed indenting systems are skewed in favor of recently released varieties. Training of trainers for good-quality seed production at ISARC and NRRI further contributed to building capacity, which could help in scaling out these interventions.

IRRI trained more than 3,000 agri-input dealers to use SeedCast Odisha, which is an app-based digital decision support system to reliably estimate demand, rationalize production, and ensure better supply chain management for rice seeds in the state. Generating seed indent from the largely village-based agri-input sellers directly, quickly, and digitally will help in matching demand and supply more efficiently and reliably.

CR 1009-Sub1 is steadily establishing its place in coastal districts, with average yields exceeding 6 t/ha in kharif 2019, while Swarna-Sub 1 is fast replacing its parent Swarna. The versatility of Bina dhan 11 in diverse environments is well-proven not only by its production potential but also by the opportunities it provides to farmers for crop intensification. DRR 44 is finding acceptance among farmers for its yield and grain type and it can withstand drought-induced shocks reasonably well on medium lands.

The absence of fresh variety infusions in marginal ecosystems, especially in drought-prone uplands and stagnant flood-prone lowlands, is a pointer for breeding programs. Although Sahbhagi dhan has proved its worth, there are no new introductions in the 100–110 days' duration group. On the other hand, old varieties such as Pooja continue to occupy large tracts with persistent demand for seed as better varieties matching its characteristics are not yet available.

Although a few biofortified varieties (CGZR-1, Zinco Rice, CR 310, CR 311) evaluated during kharif 2019 gave a wider choice to the farming community, these varieties need to compete for yield and other desired characteristics with existing varieties to scale up their adoption in specific ecosystems.

Fallow management

Integrated analysis of time series remote-sensing satellite data of Sentinel1 (SAR) microwave and Landsat OLI (optical) imageries for the period 2015 to 2019 revealed that rice fallow area ranged from 1.97 to 2.20 million ha in Odisha (40–45% of the net cropped area), out of which about 1.33 million ha would be considered as permanent rice fallow.

Geo-spatial modeling and the decision tree approach were used to identify rice fallow areas in Mayurbhanj District using soil moisture, texture, slope, soil depth, and surface water resources. The district has the largest rice fallow area of 1.86 lakh ha in the state, 46.7% of which was found suitable and 38% moderately suitable for rabi cropping.

Based on fallow area estimation, agronomic evaluations of suitable crops were taken up in rabi 2019-20. Demonstration of pulses (green gram and black gram) with short-duration disease-resistant varieties covering approximately 2,500 ha in 81 blocks of 23 districts involving more than 6,000 farmers, adaptive trials on 125 ha of 6 districts with new pulse varieties and management practices, and trials on other suitable crops in 6 districts in collaboration with several CGIAR institutions are in progress.

A rice fallow atlas with spatial distribution maps of fallow area and crop suitability based on soil moisture availability at the gram panchayat level and district-wise soil moisture profiles indicating suitable rabi crop windows has been prepared. State-level spatial distribution maps of different stress-prone areas such as flood and drought maps, land use/land cover maps, and cropping intensity maps are included in the atlas.

An updated version of the Rice-Pulse Monitoring System (RPMS) has been developed. RPMS (V2) is a customized Android (phone/tablet)-based survey application system for rice, pulses, and oilseed crops that can be used to collect and store geo-referenced information, along with a suite of geo-spatial tools to visualize, analyze, and manipulate ground data for various needs of the Department of Agriculture in different projects.

District-level agriculture officers associated with schemes such as NFSM and RKVY were trained (ToT) to use RPMS. The trainers were expected to impart training to field functionaries to enable them to monitor area covered under different schemes using the RPMS app.

Crop and nutrient management

Rationalizing fertilizer use by providing information to farmers using Rice Crop Manager that computes the requirement based on defined yield targets was the major emphasis in crop and nutrient management interventions. Nearly 70,000 recommendations were given to farmers during kharif 2019. IRRI enlisted the support of several agencies to generate and distribute recommendations. Common Service Centers, NGO partners, and PAD-IF provided 94% of the recommendations during kharif 2019. The agencies were trained to use the tool.

Use of RCM was monitored at two levels: one, where nearly 10% of the farmers who received recommendations were monitored through the season, and two, where the farmers agreed to evaluate RCM in comparison with their existing fertilizer practices. This included government schemes such as BGREI, in which RCM was superimposed in a part of the demonstration for comparison. The yield advantage realized by farmers was in the range of 0.5 to 1.0 t/ha with varieties of different duration and yield potential.

Use of RCM under rainfed conditions with wet direct seeding and transplanting increased yield by 0.57 t/ha and 0.52 t/ha, respectively, over farmers' fertilizer practices. When STRVs were combined with RCM, the additional yield realized increased to 0.99t/ha, with a monetary gain of INR 17,325/ha.

Target yields under RCM are set based on farmer-reported yield in the previous year, among other parameters. Other parameters being constant, the yield targeted based on remote-sensing-based LAI/NDVI of the field plots was closer to actual yield, indicating that LAI/NDVI can substitute the reported yield, which is highly subjective.

Awareness creation about RCM through wall posters, newspaper advertisements, and audio-conferencing was taken up. Field days, crop cuts, awareness meetings, and on-the-spot generation of recommendations at farmers' fairs were other means adopted to reach out to farmers. Pro-bono student internships for management students (Indian School of Business, Hyderabad) on the efficacy of dissemination channels helped in the development of a priority matrix based on which further dissemination strategies would be developed.

Scalability, constraints associated with disseminating agencies, resources, literacy level, ICT skills, and trust issues for farmers were analyzed. Disseminating information about the economic benefits of using RCM, targeting women farmers and self-help groups (SHGs), and printing advertisements on fertilizer bags emerged as priorities.

Knowledge management, capacity building, and entrepreneurship

The Rice-Based Cropping Systems Knowledge Bank Odisha is a digital extension service that provides practical knowledge solutions tailored for smallholder farmers in Odisha. RKB Odisha was developed by IRRI as a web portal and mobile app and is available as a digital repository of a set of accessible and usable materials in the form of management practices, ICT tools, videos, fact sheets, awareness materials, etc.

Rice Doctor Odisha (RD) is a mobile app developed by IRRI that enables farmers to diagnose and manage rice crop problems better and it provides access to information about correct management and prevention options that include cultural, mechanical, biological, and chemical methods. Both RKB and RD have been released and are available for access and downloading. Several actors, including farmers, DoA officials, extension workers, NGOs, and students, have been extensively trained in using these tools.

Trichoderma strains can form endophytic associations and interact with other microbes in the rhizosphere, thereby influencing disease protection, plant growth, and yield. IRRI worked with NRRI to deploy a strain of this fungus through seed treatment in its IPM module. Farmers witnessed enhanced plant growth (early vigor, higher tiller number) and partial protection from sheath blight in variety Kalachampa in on-farm trials of IPM modules. Training programs were organized in collaboration with the National Institute of Plant Health Management in Hyderabad for women members of three FPOs to enable them to produce bioagents at the village level.

Following a capacity assessment workshop and policy dialogue on ways to strengthen extension and advisory services in Odisha, a series of training of trainers was organized for extension officials on value chain extension, climate-smart agriculture, facilitation for development, and designing and delivering gender-responsive extension. The pool of trainers is equipped to train the field-level extension workers. The training module for induction of assistant agriculture officers (AAOs) organized by IMAGE was reviewed and a new curriculum was designed. The organization andmanagement (O&M) review of DAFE highlighted the need for several actions to rejuvenate extension services in the state.

IRRI developed an all-women Farmer Producer Company named Adarsh Dharmagarh Women Farmers Services Producer Company (ADFSPC) Ltd.in Dharmagarh, Kalahandi. With a membership of more than 1,700, the FPC began seed production and sale of recently released rice and pulse varieties and procured and supplied inputs to its members. They obtained a license for seed production. A seed processing unitwas set up. Fifty women farmers started a Desi poultry business.

IRRI, together with ICAR-CIWA, NRRI, and IIRR and with support from DAFE, Government of Odisha, organized a series of activities with women-led farmer producer companies in Odisha to share their experiences, distill good practices, and help establish a network among women leaders of the women FPCs in the state. Workshops with selected FPCs in Odisha and exposure visits for selected women-members of several FPCs were organized.

Remote-sensing-based crop monitoring

A satellite-based rice monitoring system (SRMS) was used to capture reliable rice area map products in a near real-time manner. Estimated rice area data were consolidated at the state level after validating the rice area map for each district. SAR-based rice area estimates indicated that rice was planted on 3,325,024 ha during kharif 2019. Rice area map accuracy at the district level ranged from 87.6% to 99.0%.

A majority of the rice area (51.7%) was planted in August, with minimum year-to-year variation (48.1–51.7% during 2017-19). Rainfall-dependent variation was maximum in July (10.0–22.6%), followed by direct-seeded rice in the lowlands and autumn rice during June (22.7–31.4%).

Remote-sensing-based yield estimates at the gram panchayat (GP) level for the district of Jagatsinghpur had 84% agreement with crop-cut data. GP-level estimates for Puri District and validation with crop data are in progress.

SAR imagery was used to assess the extent of flooding as an aftermath of the cyclone Fani that lashed coastal Odisha (Puri District) on 3May 2019. A total of 33,380 ha were flooded, which included 3,435 ha of rabi rice that was at different stages of maturity. Damage to rabi pulses in the affected area was also detected.

Socially acceptable comprehensive insurance

Socioeconomic studies on crop insurance examined policy options for designing a comprehensive crop insurance scheme by aligning farmers' preference to various insurance attributes, developing and testing different options for insurance awareness and a literacy campaign, as well as ways of bundling technologies (stress-tolerant rice) with the insurance scheme and their acceptance among farmers.

Farmers' preference for various attributes of a crop insurance scheme was elicited in a choice experiment wherein approximately 3,000 farmers selected from 15 districts were queried about their willingness to pay for given options under each attribute. The farmers were divided into incentivized and non-incentivized groups in an effort to reduce hypothetical bias associated with choice experiments.

Willingness to pay (WTP) diminished but remained positive for a change from prevented sowing to full crop coverage and market risk but it was negative when insurance units (IUs) were changed from individual plots to GPs/blocks as such aggregation increased the basis risk.

The farmers preferred remote sensing to the CCE method of yield estimation but not self-reporting yield. The most preferred timeline for claim settlement was 3 to 6 months. Farmers were highly positive toward process transparency and are willing to bear the additional costs for transparency in the insurance process.

Depending on the complexity of the attributes and farmers' cognitive ability, the hypothetical bias varied among the second group of farmers, confirming the hypothesis that *hypothetical bias is large when the cognitive ability of individuals is low.*

Three types of awareness and literacy programs were developed and tested in a randomized control trial involving the same set of farmers. Among the three modules, (a) traditional classroom training, (b) mass training using educational videos, and (c) decision exercise using insurance simulations, the video film format would be the scalable one as it provided the opportunity to listen to and watch the experience of other farmers.

A randomized control trial on bundling insurance products revealed high demand for coupling STRVs with crop insurance as farmers perceived STRVs to be effective in mitigating the effects of low intensive flood/drought, complementing or substituting insurance. Obviously, crop loss as well as premium decrease to some extent when insurance is coupled with STRVs.

Subproject 1: Strengthening Seed Systems of Stress-tolerant Rice Varieties through Innovative Demonstrations and Extension Approaches in Odisha

Subproject 1: Strengthening Seed Systems of Stress-tolerant Rice Varieties through Innovative Demonstrations and ExtensionApproaches in Odisha

The importance of rice in the agrarian economy of Odisha doesn't need reiteration. Rice in the state constitutes 24.4% of the value of total agriculture and allied output (Odisha State Agriculture Policy 2019), besides employing a huge workforce. But frequent abiotic stresses such as flood, drought, and salinity coupled with the slow pace of varietal replacement and farmers' poor access to good-quality seeds impede both the production and productivity of rice. Faced with these recurring climatic and deep-seated institutional challenges, paddy cultivation has become hugely risk-prone, less remunerative, and hence not a robust livelihood option to lead to prosperity. This subproject addresses these critical challenges of enhancing varietal and seed replacement.

Stress-tolerant rice varieties (STRVs), which help farmers to mitigate the risk of abiotic stresses and assure a good harvest, hold immense potential. This subproject has successfully evaluated and diffused climate-resilient varieties as well as other high-yielding varieties in different rice ecosystems since 2016. In the reporting year of 2019-20, employing different approaches, a range of suitable varieties was tested across the state in close coordination with key stakeholders in the seed system. This subproject strove to promote both formal and farm-managed seed systems through multiple institutional linkages to fulfill the seed needs of farmers. This was accomplished through strategic engagement with local NGOs, input dealers, and various government departments, which facilitated the process of STRV and HYV popularization, seed production, and distribution. In addition, through various capacity-building programs, this subproject enhanced the adoption of good-quality seed production practices by farmers. Furthermore, this subproject has evaluated the acceptability of some of the recently bred protein- and zinc-rich varieties that could help overcome widespread malnutrition in the state.

The overall goal of this subproject is to improve the access to and availability of good-quality seed of stress-tolerant rice varieties in the risk-prone (flood and drought) areas of Odisha for improving and optimizing rice-based cropping system intensification and its productivity.

Objectives:

The major objectives of the five-year project are the following:

- Development of a contextuallyrelevant strategy for sustainable seed production, promotion, and delivery of stress-tolerant and high-yielding varieties to farmers through demonstrations
- Identification of best approaches for improving seed dissemination and adoption of stress-tolerant varieties
- Boosting the scope and efficiency of the farmer-managed seed system and seed storage methods through a well-formulated capacity-building program
- Strengthening of knowledge, capacity, and awareness for scaling up through participatory evaluation of stress-tolerant rice

- Promotion and awareness creation of the role of STRVs in rice-based cropping systems
- Impact evaluation of the adoption of stress-tolerant rice varieties

To achieve these objectives, this subproject has four strategic elements that together contribute to building an effective seed system. First, promoting widespread awareness of STRVs and HYVs at the farm level, which translates into accelerated demand for a range of suitable varieties. Second, engaging key stakeholders in the seed chain to engage and evaluate the performance of varieties. These seed chain actors select and recommend good-fit STRVs and can facilitate their introduction, multiplication, and dissemination via the national, commercial, and farmer-managed seed systems. This is important as seed of all the preferred STRVs may not be readily available for interested farmers because they are not in the seed chain.

Therefore, the third element of this strategy is to facilitate the provisioning of breeder seeds of STRVs to Odisha State Seed Corporation and private growers for conversion to foundation and certified seeds. Given the limitation of the current seed system to enhance farmers' access to good-quality seeds fully, promotion of farmer- and community-based good-quality seed production and storage is the fourth element in this subproject. All interventions during the reporting year were centered around these four areas.

Targeted evaluation of ten potential varieties was conducted in 81 blocks representative of different rice-growing ecosystems spread across 25 districts, in close coordination and with support from key officials of the DoA (CDAO, AAO, BAO, DAO, OSSC officials, and Odisha Livelihood Mission. A total of 22 NGOs were also engaged for wider and targeted reach to smallholder and vulnerable farmers. The activities taken up during kharif 2019 and the following rabi season are summarized in Tables 1.1 and 1.2.

Table 1.1. Summary of activities in 2019-20

S N	Activity		Unit	Physical targets		Area/	Achievement	Remarks
				Districts	Blocks	No.	Total	
Kharif 2019-20								
1	**Demonstrations**	Demonstrations (5–10 ha each)	ha	23	81	5,600	5,602	81 blocks from 24 districts covered for demonstration on 5,607 ha
		H2H demonstrations	no.	23	81	2,400	2,404	Against the target, 3,612 trials were established in 81 blocks of 24 districts.
		Demos through OSSC dealers	no.	12		3,600	3,606	This was a dealer-led demonstration with active participation of farmers.
		Crop cafeteria	no.	12	Dist. level	15	15	A range of 15–20 varieties were demonstrated.
		Client- oriented crop cafeteria	no.	2	2 in state	2	2	This was established in close collaboration with NRRI and I-concept—a grassroot-level NGO.
2	**Training**	QRSP training for farmers	no.	23	81	4,000	4,021	Farmers were trained in groups of 40–50, with support from DoA officials, NGOs, and farmers.
		TOT on QRSP and storage	no.		State level	2	2	Conducted at NRRI and ISARC, Varanasi
3	**Workshops and meetings**	District- level seed meetings	no.	30	Dist. level	30	30	DDAs, KVK, OSSC, AAOs, and dealers participated.

S N	Activity		Unit	Physical targets		Area/	Achievement	Remarks
				Districts	Blocks	No.	Total	
		Women-led seed/variety demonstration	no.	30	12	30	30	Women led the demonstration and varietal evaluation.
		Awareness creation meetings (2/season), 100 farmers each	no.	14	42	252	253	Project engaged AAOs, NGOs, and farmers for this activity.
4	**Research support**	Breeding program with NARES	no.			1	1	Breeding program at OUAT is underway for BLB resistance and varietal development for stagnant flooding.
		Pilot of SeedCast	no.			1	1	2,965 dealers covered in 24 districts.
		Research program to attain key outputs	no.			1	1	Research studies on STRV adoption; dealer-led demonstrations are underway.
Rabi 2019-20								
	Demonstration	Cluster demonstration	ha		5	5	1,000	Cluster demonstrations have been established on 1,000 ha in five districts. Bina dhan 11 is being evaluated in this dry season.
		Tricot trials	no.		5	5	300	10 varieties are being evaluated against farmers' checks.

Table 1.2. District-wise trials and demonstrations in kharif 2019

District	Cluster demonstrations			Head-to-head trials		Dealer-led demonstrations		Varieties demonstrated	Implementing partners
	Farmers	Seeds (q)	Area (ha)	No.	Area (ha)	No.	Area (ha)		
Anugul	342	65.1	130.2	23	4.6	154	15.4	Bina dhan 11, DRR 44, Sahbhagi, Swarna Shreya, MTU 1156, Bina 17, Zinco Rice, CGZR1, DRR 50, MTU 1001	Srijan
Balangir	454	105	210	144	28.8	133	13.3	Bina dhan 11, DRR 44, Sahbhagi, Swarna Shreya, MTU 1156, Bina 17, Zinco Rice, CGZR1, DRR 50, MTU 1002	Loksebak
Balasore	610	128.1	256.2	108	21.6	153	15.3	Bina dhan 11, Swarna-Sub1, CR 1009-Sub1, Ranjit-Sub1, Bahadur- Sub1, CR 801, MTU 1075	SPARSHA
Bargarh	608	128.7	257.4	76	15.2	103	10.3	Bina dhan 11, DRR 44, Sahbhagi, Swarna Shreya, MTU 1156, Bina 17, Zinco Rice, CGZR1, DRR 50, MTU 1001	AJKA and MASS
Bhadrak	367	80	160	79	15.8	107	10.7	Bina dhan 11, Swarna-Sub1, CR 1009-Sub1, Ranjit-Sub1, Bahadur-Sub1, CR 801, MTU 1075	Netaji Yuvak Sangha
Boudh	239	77	154	56	11.2	166	16.6	Bina dhan 11, DRR 44, Sahbhagi, Swarna Shreya, MTU 1156, Bina 17, Zinco Rice, CGZR1, DRR 50, MTU 1001	Palli Seva Sadan
Deogarh	323	74.57	149.14	56	11.2	135	13.5	Bina dhan 11, DRR 44, Sahbhagi, Swarna Shreya, MTU 1156, Bina 17, Zinco Rice, CGZR1, DRR 50, MTU 1001	CSDR
Dhenkanal	481	109.8	219.5	32	6.4	165	16.5	Bina dhan 11, DRR 44, Sahbhagi, Swarna Shreya, MTU 1156, Bina 17, Zinco Rice, CGZR1, DRR 50, MTU 1001	Direct implementation

District	Cluster demonstrations			Head-to-head trials		Dealer-led demonstrations		Varieties demonstrated	Implementing partners
	Farmers	Seeds (q)	Area (ha)	No.	Area (ha)	No.	Area (ha)		
Gajapati	527	104.9	209.8	89	17.8	165	16.5	Bina dhan 11, DRR 44, Sahbhagi, Swarna Shreya, MTU 1156, Bina 17, Zinco Rice, CGZR1, DRR 50, MTU 1001	Jana Kalyan Pratisthan
Ganjam	239	65.35	130.7	162	32.4	100	10	Bina dhan 11, Swarna-Sub1, CR 1009-Sub1, Ranjit-Sub1, Bahadur-Sub1, CR 801, MTU 1075	CHARM, Center for Dignity
Jagatsinghpur	898	142.5	285	120	24	118	11.8	Bina dhan 11, Swarna-Sub1, CR 1009-Sub1, Ranjit-Sub1, Bahadur-Sub1, CR 801, MTU 1075	Palli Vikash
Jajpur	1,216	141.3	282.64	98	19.6	165	16.5	Bina dhan 11, Swarna-Sub1, CR 1009-Sub1, Ranjit-Sub1, Bahadur-Sub1, CR 801, MTU 1075	Netaji
Kalahandi	347	107.4	214.7	90	18	180	18	Bina dhan 11, DRR 44, Sahbhagi, Swarna Shreya, MTU 1156, Bina 17, Zinco Rice, CGZR1, DRR 50, MTU 1001	Direct implementation
Kandhamal	525	108.7	217.4	122	24.4	85	8.5	Bina dhan 11, DRR 44, Sahbhagi, Swarna Shreya, MTU 1156, Bina 17, Zinco Rice, CGZR1, DRR 50, MTU 1001	CHARM and SWATI
Keonjhar	1,528	144.6	289.2	115	23	225	22.5	Bina dhan 11, DRR 44, Sahbhagi, Swarna Shreya, MTU 1156, Bina 17, Zinco Rice, CGZR1, DRR 50, MTU 1001	STARR
Koraput	1,331	184.4	368.7	152	30.4	310	31	Bina dhan 11, DRR 44, Sahbhagi, Swarna Shreya, MTU 1156, Bina 17, Zinco Rice, CGZR1, DRR 50, MTU 1001	Pragati

District	Cluster demonstrations			Head-to-head trials		Dealer-led demonstrations		Varieties demonstrated	Implementing partners
	Farmers	Seeds (q)	Area (ha)	No.	Area (ha)	No.	Area (ha)		
Mayurbhanj	1,254	196.8	393.66	70	14	165	16.5	Bina dhan 11, DRR 44, Sahbhagi, Swarna Shreya, MTU 1156, Bina 17, Zinco Rice, CGZR1, DRR 50, MTU 1001	ACM and SPARDA
Nabarangpur	305	81.9	163.8	143	28.6	165	16.5	Bina dhan 11, DRR 44, Sahabhagi, Swarna Shreya, MTU 1156, Bina 17, Zinco Rice, CGZR1, DRR 50, MTU 1001	Loksebak and Pragati
Nuapada	227	79.85	159.7	106	21.2	185	18.5	Bina dhan 11, DRR 44, Sahbhagi, Swarna Shreya, MTU 1156, Bina 17, Zinco Rice, CGZR1, DRR 50, MTU 1001	Loksebak
Puri	674	181	362.02	146	29.2	159	15.9	Bina dhan 11, Swarna-Sub1, CR 1009-Sub1, Ranjit-Sub1, Bahadur-Sub1, CR 801, MTU 1075	SWAD, WISDOM
Sambalpur	614	185.5	370.93	217	43.4	185	18.5	Bina dhan 11, DRR 44, Sahbhagi, Swarna Shreya, MTU 1156, Bina 17, Zinco Rice, CGZR1, DRR 50, MTU 1001	Direct implementation
Sonepur	411	113.8	227.6	126	25.2	175	17.5	Bina dhan 11, DRR 44, Sahbhagi, Swarna Shreya, MTU 1156, Bina 17, Zinco Rice, CGZR1, DRR 50, MTU 1001	Global Green and RARE
Sundargarh	906	195.2	390.43	74	14.8	108	10.8	Bina dhan 11, DRR 44, Sahbhagi, Swarna Shreya, MTU 1156, Bina 17, Zinco Rice, CGZR1, DRR 50, MTU 1001	Disha
Grand total	**14,426**	**2,801**	**5,602.7**	**2,404**	**481**	**3,606**	**360.6**		

Extension and demonstration approaches to strengthen the formal and informal seed systems for STRVs

i) Head-to-head trials

During the past four years, head-to-head trials conclusively proved to be an impactful method to showcase the comparative advantage of a variety. The efficacy and impact of this method have been observed to be high among farmers and other important stakeholders engaged in extension activities. This method is simple and allows targeting individual farmers intensively, thus enabling them to observe, compare, and decide on two demonstrated varieties in their own field conditions.

In a head-to-head trial, an STRV and a traditional variety are grown side by side in the same plot. This provides participating farmers with an opportunity to observe and compare the performance of these two varieties. Since the management practices for both varieties are the same, any advantage gained (yield, grain quality, etc.) can be attributed to the superiority of the STRV. Besides farmers, DoA employees (CDAOs, DAOs, AAOs) and implementing NGO partners endorsed this as an effective method for creating varietal awareness.

Against a target of 2,400 such trials for this reporting year, the project successfully established 2,404 in 81 blocks spread across 23 districts. Women farmers managed 32% of these trials. The varieties were carefully chosen to match with the environment of the trial sites. NGO partners and some farmer networks played a key role in identifying appropriate demonstration sites and selecting the farmers who would host the trials. The IRRI team monitored the trials at important stages of crop growth, after which crop-cutting experiments were undertaken with participation from farmers, VAWs, AAOs, and Krushak Sathis.

Yield was evaluated in medium, lowland, and upland environments. On medium land, Bina dhan 11, DRR 44, and in some cases Sahbhagi dhan were taken up for the trials. CR 1009-Sub 1 and Swarna-Sub 1 were demonstrated in low-lying areas, mainly in the coastal belt of Odisha. Uplands, which are underserved in terms of varietal choices available, had Sahbhagi dhan for comparative assessment against long-grown local checks.

As in the previous years, STRVs continued to record a significant yield advantage over existing varieties. A whopping yield gain of 0.57 t/ha was registered by these five varieties collectively in 2019-20. This brings forth the need of a coherent effort in speeding up these varieties for widespread adoption. When studied further, the yield advantage created by varieties individually revealed that the yield gains generated by CR 1009-Sub 1 and Swarna-Sub 1 in the lowland environment are 0.70 and 0.59 t/ha, respectively (Table 1.3). Likewise, Bina dhan 11, DRR 44, and Sahbhagi dhan, when evaluated on medium lands against adjacent varieties, gave an additional yield of 0.65 and 0.50 t/ha, respectively. Sahbhagi dhan, the best available variety for uplands, gave a 0.46 t/ha yield advantage.

It is to be noted that these varieties are grown in comparison with many other varieties, including their parents, and are exposed to stresses occurring in farmers' fields. The difference in yield therefore represents the advantages due to their tolerance of stresses as well as better fitness of these STRVs in comparison with farmer-grown varieties.

The onset of monsoon was delayed in the 2019 kharif season andrain occurred during crop maturity. Some pockets in Balasore, Puri, and Bhadrak reported preventive sowing. This was the reason many photosensitive varieties such as Pooja and Kalachampa registered a good yield because of their special advantage of aged seedlings. Nevertheless, the latter part of the season saw a reasonably fair distribution of rain as June-September received a rainfall of 1,109 mm (*http://rainfall.nic.in/PubRainChart.asp*).

This helped farmers avert any major drought-induced stress in this season. But, untimely rain triggered by cyclone Bulbul caused substantial damage to the crop just before harvest in coastal districts and this affected all varieties equally.

Table 1.3. Average yield of STRVs across different environments in head-to-head trials

Environment/ variety	No. of observations	Av. STRV yield (t/ha)	Av.adjacent variety yield (t/ha)	Yield gain (t/ha)
Lowland				
CR 1009-Sub1	43	6.22	5.52	0.70
Swarna-Sub1	43	6.34	5.76	0.59
Medium land				
Bina dhan 11	197	5.17	4.52	0.65
DRR 44	112	4.55	4.05	0.50
Upland				
Sahbhagi dhan	110	4.77	4.31	0.46
Grand total	**505**	**5.13**	**4.56**	**0.57**

The distinct advantages of an assured yield gain and resilience in the face of abiotic stresses using STRVs have been observed over the past three years. When the yield data of all STRVs are compared with the data of all existing varieties from 2017 to 2019, a 0.39 to 0.67 t/ha yield advantage is visible. The year 2017 was a relatively rain-deficit year (at least at the trial locations), which affected the rice crop considerably, yet a 0.39 t/ha yield gain was possible with STRVs (Fig. 1.2). Both 2018 and 2019, which experienced normal seasonal rainfall distribution, had a higher yield reward from STRVs of 0.67 and 0.55 t/ha, respectively. These findings reinforce the need for diffusion and adoption of STRVs at a faster pace.

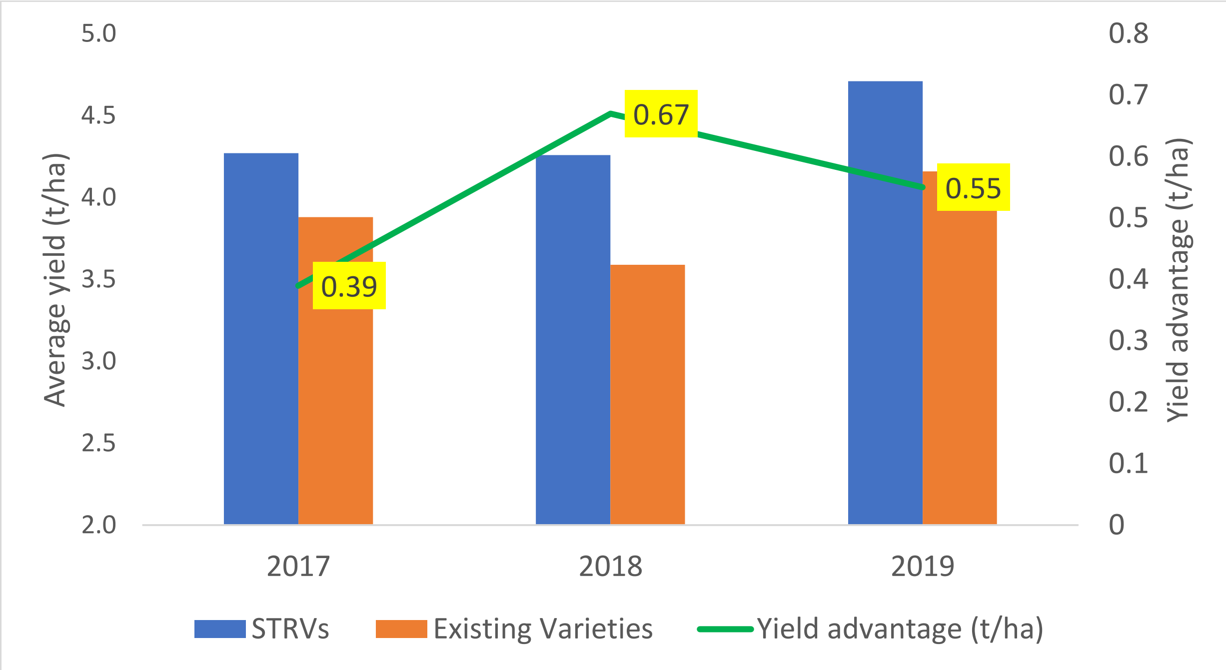


Figure 1.1. Yield gain trend with STRVs vis-à-vis traditionally grown varieties (all environments)

In kharif season, rainfall during June to September is critically important for crop growth and yield. STRVs with drought tolerance capability were compared with their checks over the past three years. Although the yield gain from STRVs in the event of lesser rainfall is reduced (2017), it still offers 0.42 t/ha additional yield over traditionally grown varieties (Figure 1.3). This further corroborates the superiority of STRVs and the need for rapid dissemination.

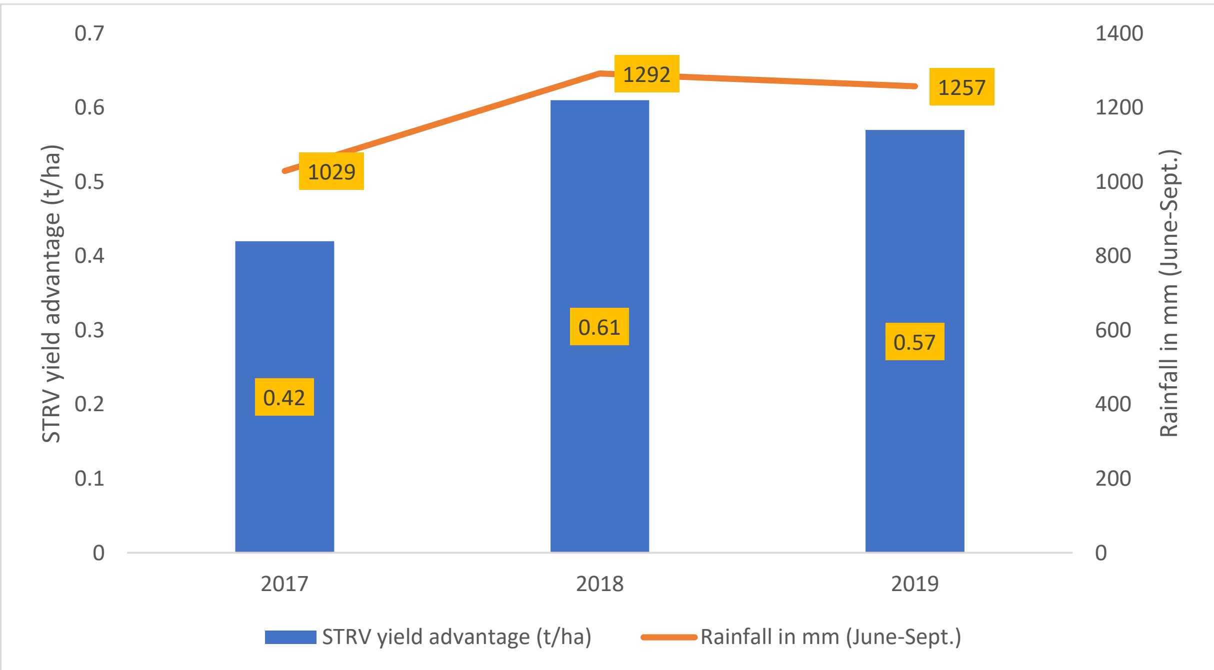


Figure 1.2. Yield gain from drought-tolerant STRVs in different rainfall regimes (2017-19)

A total of 74 varieties were grown against five STRVs in head-to-head trials. In the upland environment, 24 varieties were compared with Sahbhagi dhan. Notably, many of these varieties are not ideally recommended in upland areas, yet they have been adopted. This indicates the few varietal choices that farmers have for this environment. For medium lands, the number of local varieties was 45, where STRVs such as Bina dhan 11, DRR 44, and, in a few cases, Sahbhagi dhan were demonstrated. The coastal belt, characterized by low-lying environment, has seen 14 varieties against Swarna-Sub1 and CR 1009-Sub1. Table 1.4 summarizes the comparative yield of STRVs vis-à-vis the major adjacent varieties in different environments.

Table 1.4. Environment-wise yield comparison between STRVs and adjacent varieties *

STRV	Adjacent variety	STRV yield (t/ha)	Adjacent variety yield (t/ha)	Difference (t/ha)
Bina dhan 11	**Other varieties**	**5.17**	**4.52**	**0.65**
Bina dhan 11	Agnisal	3.84	3.00	0.84
Bina dhan 11	Bhuban	4.03	3.40	0.63
Bina dhan 11	Budha Dhana	5.14	4.12	1.02
Bina dhan 11	Chinamali	4.80	5.60	–0.80
Bina dhan 11	Desi Jira	4.28	3.56	0.72
Bina dhan 11	Dhani	2.19	2.08	0.11
Bina dhan 11	Dhania	4.16	3.56	0.60
Bina dhan 11	Hardil	4.38	4.55	–0.17
Bina dhan 11	Hybrid	4.56	3.87	0.69
Bina dhan 11	Jajati	6.25	4.92	1.33
Bina dhan 11	Jamuna	4.56	4.32	0.24
Bina dhan 11	Kanak Plus	4.40	5.20	–0.80
Bina dhan 11	Khandagiri	3.20	2.80	0.40
Bina dhan 11	Lalat	5.50	4.72	0.78
Bina dhan 11	Lal Kuber	6.64	6.40	0.24
Bina dhan 11	Laxmi	4.26	4.53	–0.27
Bina dhan 11	Lochai	3.20	2.40	0.80
Bina dhan 11	Mamata	4.12	3.90	0.22
Bina dhan 11	Manaswini	4.32	4.12	0.20
Bina dhan 11	MTU 1001	4.48	4.34	0.14
Bina dhan 11	MTU 1010	5.42	4.87	0.55
Bina dhan 11	MTU 1156	4.74	4.01	0.73
Bina dhan 11	Mugei	4.48	3.30	1.18
Bina dhan 11	Naveen	6.61	5.83	0.78
Bina dhan 11	Otara	6.87	5.06	1.81
Bina dhan 11	Punia	7.34	6.04	1.30
Bina dhan 11	Ratnachuda	7.17	5.12	2.05
Bina dhan 11	RGL 2537	6.08	5.92	0.16

STRV	Adjacent variety	STRV yield (t/ha)	Adjacent variety yield (t/ha)	Difference (t/ha)
Bina dhan 11	Sahbhagi	2.36	2.03	0.33
Bina dhan 11	Silky	5.05	4.76	0.29
Bina dhan 11	Sindhu	4.14	4.74	–0.60
Bina dhan 11	Tej gold	4.40	4.00	0.40
CR 1009-Sub1	**Other varieties**	**6.22**	**5.52**	**0.70**
CR 1009-Sub1	CR 1009	6.37	6.31	0.06
CR 1009-Sub1	CR 1018	4.68	4.76	–0.08
CR 1009-Sub1	Kalachampa	6.06	5.92	0.14
CR 1009-Sub1	Masuri	5.90	5.45	0.45
CR 1009-Sub1	MTU 1001	7.16	6.68	0.48
CR 1009-Sub1	Pooja	6.54	5.47	1.07
CR 1009-Sub1	RGL 2537	4.78	4.70	0.08
CR 1009-Sub1	Sadhana	4.78	4.92	–0.14
CR 1009-Sub1	Sarala	6.37	5.04	1.33
DRR 44	**Other varieties**	**4.55**	**4.05**	**0.50**
DRR 44	Agnisal	5.28	3.92	1.36
DRR 44	Badhashree	4.40	4.00	0.40
DRR 44	Bhuban	4.29	3.66	0.63
DRR 44	Dasamati	6.00	5.20	0.80
DRR 44	Dhani	2.16	1.28	0.88
DRR 44	Hardil	4.48	4.12	0.36
DRR 44	Hirakhandi	4.10	3.80	0.30
DRR 44	Jira	3.88	3.00	0.88
DRR 44	Khandagiri	2.14	1.97	0.17
DRR 44	Kranti	3.44	2.84	0.60
DRR 44	Kuja	3.87	3.25	0.62
DRR 44	Lalat	5.34	4.52	0.82
DRR 44	Laxmi	4.12	3.80	0.32
DRR 44	M.C.13	4.08	3.26	0.82
DRR 44	Mamata	4.67	4.00	0.67
DRR 44	MTU 1001	3.71	3.70	0.01
DRR 44	MTU 1010	5.34	5.07	0.28
DRR 44	MTU 1156	5.08	5.16	–0.08
DRR 44	Mugei	4.60	3.60	1.00
DRR 44	Naveen	4.63	4.43	0.20
DRR 44	Pratikhya	4.99	4.32	0.67
DRR 44	Ratnachuda	6.90	5.78	1.12
DRR 44	Silki	4.61	4.10	0.51

STRV	Adjacent variety	STRV yield (t/ha)	Adjacent variety yield (t/ha)	Difference (t/ha)
DRR 44	Sindhu	4.96	4.68	0.28
Sahbhagi dhan	**Other varieties**	**4.77**	**4.31**	**0.46**
Sahbhagi dhan	Bahubali	4.20	3.88	0.32
Sahbhagi dhan	Bhuban	4.11	3.91	0.20
Sahbhagi dhan	Dhanalaxmi	4.80	6.00	–1.20
Sahbhagi dhan	Dhani	4.00	3.20	0.80
Sahbhagi dhan	Jajati	6.56	5.93	0.63
Sahbhagi dhan	Jira	3.48	3.00	0.48
Sahbhagi dhan	Kanak Plus	4.24	3.92	0.32
Sahbhagi dhan	Khandagiri	4.46	4.25	0.21
Sahbhagi dhan	Kranti	4.31	4.61	–0.30
Sahbhagi dhan	Kuja	3.87	3.47	0.40
Sahbhagi dhan	Lalat	4.28	3.74	0.54
Sahbhagi dhan	M.C.13	3.96	3.44	0.52
Sahbhagi dhan	Mamata	4.80	4.00	0.80
Sahbhagi dhan	MTU 1010	4.60	3.80	0.80
Sahbhagi dhan	MTU 1156	3.68	3.84	–0.16
Sahbhagi dhan	Naveen	4.65	4.30	0.35
Sahbhagi dhan	Parijat	4.14	4.60	–0.46
Sahbhagi dhan	Pratikhya	4.54	4.17	0.37
Sahbhagi dhan	Punam	4.26	4.42	–0.16
Sahbhagi dhan	Ragini	4.16	2.84	1.32
Sahbhagi dhan	Sarathi	3.36	2.52	0.84
Sahbhagi dhan	Silky	3.68	5.00	–1.32
Sahbhagi dhan	Sinari	5.32	4.44	0.88
Swarna-Sub1	**Other varieties**	**6.34**	**5.76**	**0.58**
Swarna-Sub1	Deradun	7.00	6.80	0.20
Swarna-Sub1	Kalachampa	8.80	8.60	0.20
Swarna-Sub1	MTU 1001	5.68	5.23	0.45
Swarna-Sub1	Pooja	6.17	5.06	1.11
Swarna-Sub1	Pratikhya	6.56	6.76	–0.20
Swarna-Sub1	Rani	4.29	4.46	–0.17
Swarna-Sub1	Swarna	6.61	6.62	–0.01
Total yield gain		**5.13**	**4.56**	**0.57**

These yields are the average of the same varieties in different farmers' fields. Yields are obtained from crop-cutting experiments in 5 × 5 m² plots.

Photo 1.1: A farmer from Sonepur at his H2H plot

Photo 1.2: Bina dhan 11 in H2H trial against MTU 1156 at Sambalpur

ii) Cluster demonstrations

Cluster demonstrations provide opportunities for farmers and other stakeholders for varietal selection and are an important method that targets both varietal diffusion and seed multiplication. Contiguous patches of 5–10 ha belonging to 25–30 farmers are used for these demonstrations and an environment-specific STRV is demonstrated under common management of participating farmers. Participating and nonparticipating farmers can observe varietal outcomes comparing their adjacent fields. These plots are also used for seed production for subsequent cropping seasons and many of these farmers were trained in good-quality seed production techniques. These demonstrations are designed to achieve the twin purposes of varietal diffusion and farmer-managed seed multiplication at a rapid and large scale.

Photo 1.3: Cluster demo for Bina dhan 11 at Bargarh

In the 2019-20 kharif season, cluster demonstrations were conducted in 81 blocks of 24 districts, engaging 14,426 farmers. Five varieties (CR 1009-Sub1, Swarna-Sub1, DRR44, Sahbhagi dhan, and Bina dhan 11) were deployed in suitable environments. As observed in past years, these STRVs continue to result in good yield, thus triggering their uptake. CR 1009-Sub1, which is steadily finding its place in coastal districts, produced 6.04 t/ha yield in the reporting season. Swarna-Sub 1, another mega-variety, included in the state's seed chain a few years ago, is fast replacing its national check Swarna as evidenced by the change in the ratio of seed sales by OSSC. The growing seed demand for Bina dhan 11is testimony to its stable performance across environments. This variety yielded 4.96 t/ha when grown on submergence-prone medium land. DRR 44, another potential variety that can absorb drought-induced shock

Photo 1.4: Farmers at a CCE of cluster demo at Dhenkanal

reasonably on medium land, was harvested with an average yield of 4.58 t/ha. This suggests that this variety can be recommended for medium land subject to frequent drought of varying levels.

Photo 1.5: Swarna Sub-1 in a cluster demo at Bhadrak

The biggest challenge to growing rice in uplands is the limited varietal choice, particularly in the uplands of Sundergarh, Bargar, Boudh, and Sonepur. Farmers in these areas are left with only two choices—to grow or not grow rice. Since a majority of them are marginal and small farmers and rice is their staple cereal, growing it even in constrained conditions is an imperative for them. Sahbhagi dhan, a 105-day variety, is the best available varietal choice as evident from demonstrations. This year, Sahbhagi dhan was demonstrated mainly in uplands and in some midland areas of southwestern districts. The results are encouraging since the average yield of this variety reached 4.35 and 4.22 t/ha from medium lands and uplands, respectively. Like Swarna-Sub1, Sahbhagi dhan has been in the seed system for the past few years and has been doing remarkably well against the best alternatives. The level of acceptance and diffusion of the varieties are on the rise as revealed by their sale trend by Odisha State Seed Corporation (OSSC). The scale of these demonstrations and yield performance are presented in Tables 1.5 and 1.6, respectively. Figure 1.4 depicts the average STRV yield observed from cluster demonstrations and head-to-head trials together in different environments.

Photo 1.6: Farmers weighing yield of STRVs at Dhenkanal

Table 1.5. Variety-wise area (ha) covered by different varieties under cluster demonstrations

District/ variety	CR 1009 Sub-1	DRR44	Sahbhagi dhan	Swarna Sub-1	Bina dhan 11	Total area (ha)
Anugul		4.4	50.2		75.6	130.2
Balangir		22.2			187.8	210.0
Balasore	78.8			147.2	30.2	256.2
Bargarh		7.2	60.6		189.6	257.4
Bhadrak	70.0			90.0		160.0
Boudh		24.0	55.0		70.0	149.0
Deogarh		21.0	52.0		76.2	149.2
Dhenkanal		7.0	54.5	60.0	98.0	219.5
Gajapati		74.8	30.0		105.0	209.8

District/ variety	CR 1009 Sub-1	DRR44	Sahbhagi dhan	Swarna Sub-1	Bina dhan 11	Total area (ha)
Ganjuam	15.7			28.1	86.9	130.7
Jagatsinghpur	90.0			165.0	30.0	285.0
Jajpur		8.6	0.4	80.0	193.6	282.6
Kalahandi		1.2			213.5	214.7
Kandhamal		2.8	77.0		137.6	217.4
Keonjhar			101.2		188.0	289.2
Koraput			140.3		228.4	368.7
Mayurbhanj		132.4	147.6		113.7	393.7
Nabarangpur		25.0	8.5		130.3	163.8
Nuapada		50.8			108.9	159.7
Puri	141.1			183.1	42.8	367.0
Sambalpur		10.7	137.2		223.1	371.0
Sonepur		7.2	95.2		125.2	227.6
Sundargarh		11.6	152.5		226.3	390.4
Grand total	**395.6**	**411.0**	**1,162.0**	**753.4**	**2,880.7**	**5,602.7**

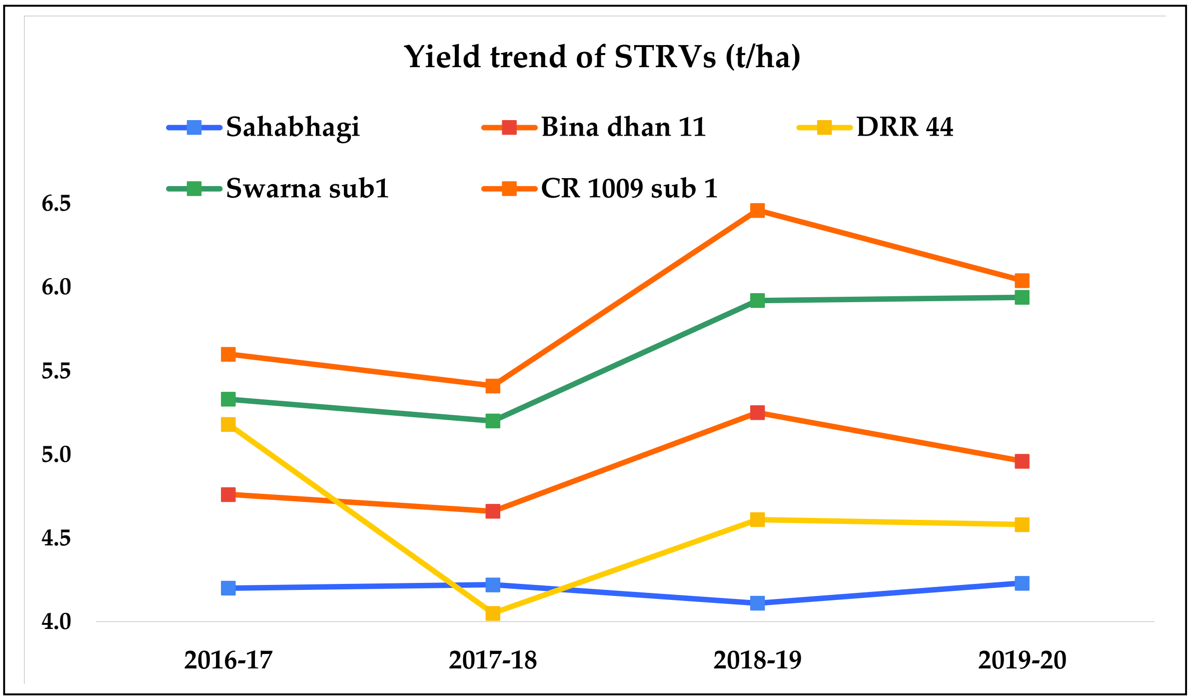


Figure 1.3. Average yield of different STRVs in different environments as observed in all trials combined

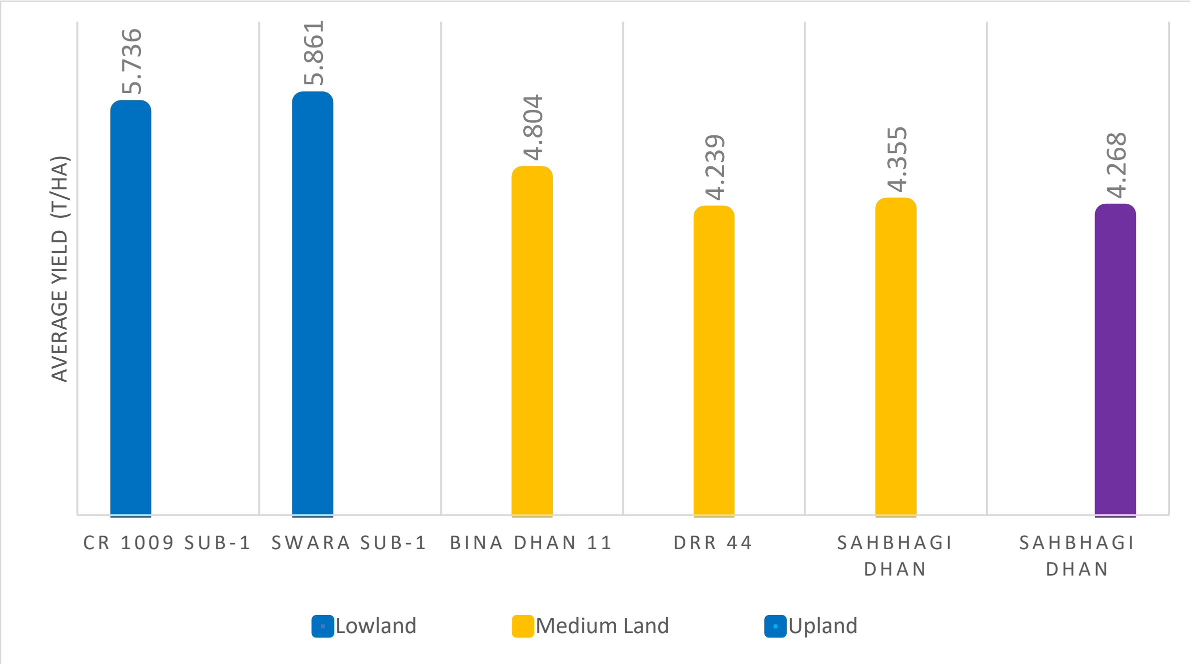


Figure 1.4. Yield potential of different STRVs as observed in past four years

Table 1.6. Average STRV yield in cluster demonstrations (environment-wise)

Variety	No. of observation	Average yield (t/ha)	Min.yield (t/ha)	Max.yield (t/ha)
Lowland				
CR 1009-Sub 1	30	6.04	4.68	7.68
Swarna-Sub 1	55	5.94	4.20	8.05
Medium land				
Bina dhan 11	373	4.96	3.00	8.36
DRR 44	62	4.58	3.68	5.76
Sahbhagi dhan	70	4.35	3.24	6.36
Upland				
Sahbhagi dhan	94	4.22	2.76	5.60
Grand total	**684**	**4.89**	**2.76**	**8.36**

iv) Demonstrations through dealers' engagement

Another approach IRRI has employed for varietal awareness and demand creation is dealer-led demonstrations. In this method, seed dealers/agro vets are supplied with seed minikits of agro-ecologically suitable varieties to be cultivated in the fields of their customers/farmers. Seed dealers are oriented and encouraged to evaluate these minikits in association with their customers.

Seed dealers are important stakeholders in the seed chain and can play a major role in faster dissemination of seed/varieties. However, input dealers have never been engaged strategically. This is also in the interest of the dealers as the demand created translates into growth of their business. Such demonstrations can also reduce the cost of reaching huge numbers of farmers directly. A study to analyze the efficacy of this method is underway. The steady increase in the seed indent for Bina dhan 11, DRR 44, Swarna-Sub1, and CR 1009-Sub1 by dealers reflects the impact of these demonstrations.

Presently, OSSC has a network of 3,500 active dealers (PACS and private), and 240 dealers from different districts were chosen and provided with 15 minikits of two to three STRVs for each dealer.

Varietal cafeteria

Photos 1.7: A bird's eye view of a CC in Puri

A varietal cafeteria is a replicated trial to assess the performance of suitable varieties (STRVs and HYVs) in a particular agro-climatic region where a range of varieties are grown and assessed in comparison with local checks. A set of 20 varieties was evaluated during the year in different subsets. At maturity but before harvest, different groups of stakeholders (government officials, seed growers, farmers) are invited to observe and evaluate the demonstrated varieties. Subsequently, the most preferred varieties, which are adjudged as having potential for the state, are recommended for inclusion in the seed chain.

In 2019-20, 17 such cafeterias were established at several sites representative of different rice-growing environments. The participating stakeholders rated the demonstrated varieties on a five-point scale on important phenotypic parameters—duration suitability, stress-tolerance traits, grain size and quality, resistance to major pests and diseases, and expected yield. Following this collective evaluation process, actual yield was obtained through a crop-cutting exercise. A perceptual mapping was generated through a scatter plot in which an overall phenotypic rating for a particular variety is compared to actual yield). This substantiates the selection of those varieties that need to be included and multiplied in seed system activities of the state (particularly OSSC). In upland districts, DRR 44, BINA 11, Swarna Shreya, and MTU 1156 are most preferred because of their superior phenotypic characters and observed yield (Fig. 1.6). Therefore, these varieties need further promotion, multiplication, and dissemination in

Photo 1.8: CDAO, Bargarh scoring varieties in CC

Photo 1.9: Knowledge dissemination through a CC in Bargarh

the state. On the other hand, Sahbhagi dhan, DRR 39, and MTU 1001 are rated good phenotypically but they offer slightly less yield, which could be a deterrent to further adoption by farmers. Some varieties such as Anjali and Lalat, which are quite old, are less preferred because of both their low yield and lower phenotypic rating.

In the lowland environment, Swarna-Sub1, CR 1009-Sub1, and MTU 1075 are rated higher (Fig. 1.7). IR85086-Sub33-3-2-1—an advanced line for replacement of CR 1009-Sub1—and Mahanadi earned impressive ratings for both parameters. For a substitute of Swarna-Sub1 and Pratikshya, the line IR88230-60-1-2-2 was well rated by stakeholders. Surprisingly, Swarna, despite being an older variety, continues to be one of the preferred varieties. Some of the new varieties such as CR 801, DRR 50, and Samba Mahsuri-Sub1 did not score well because of their shortcomings in yield as well as phenotypic appearance.

Photo 1.10: Women evaluating varieties at a CC in Puri

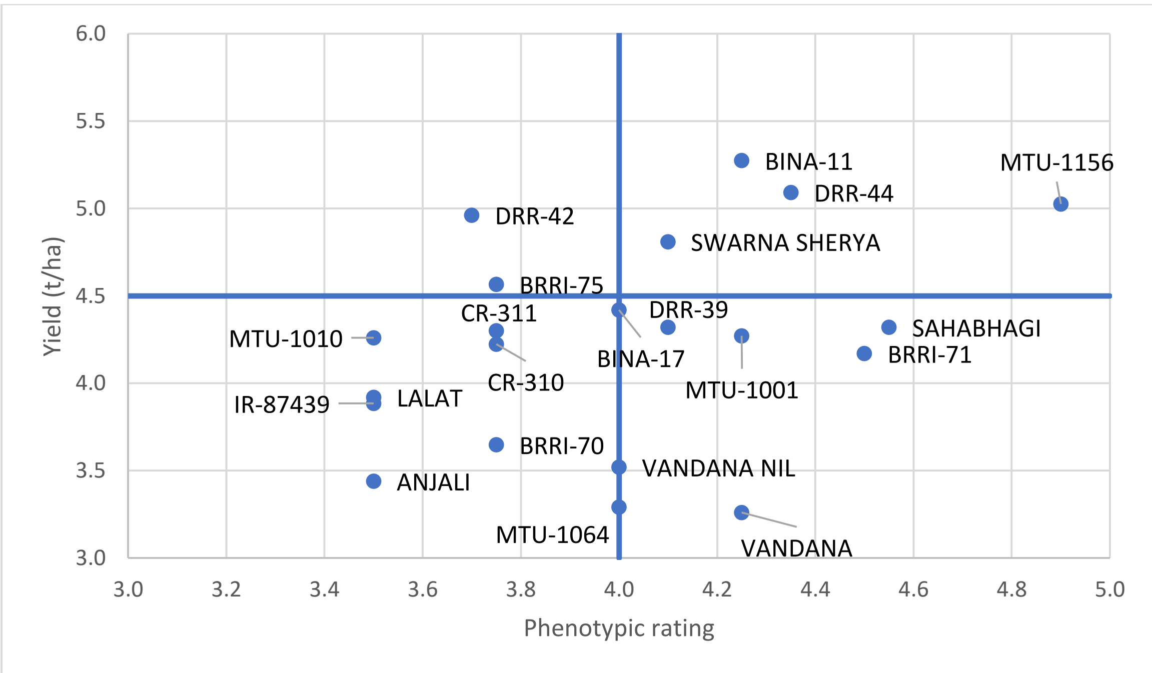


Figure 1.5. Perceptual mapping of demonstrated varieties in a crop cafeteria of upland districts

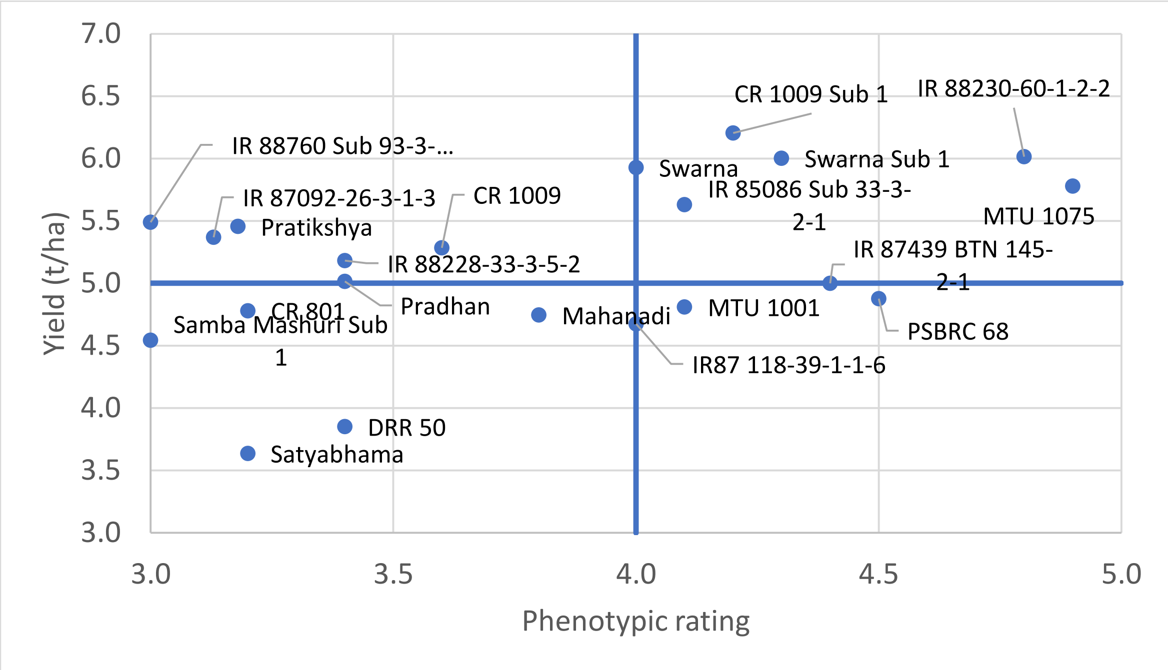


Figure 1.6. Perceptual mapping of different varieties demonstrated in a crop cafeteria of coastal districts

vi) Triadic trials for assessing genetic gain

This year, the project introduced another tool to evaluate genetic gain through tricot trials. This trial is an on-farm comparison of three improved varieties and a traditionally grown variety. This form of trial is essentially an upgraded version of the proven head-to-head trial and it involves many farmers in the testing and/or validation of new and promising rice varieties. A set of 25–30 newly released varieties, advanced breeding lines, and local checks constitute the experimental material. Each farmer is given a subset of three varieties randomly selected from the parent set, which is evaluated in comparison with a farmer-grown variety. The fourth one (farmers' variety) ideally will be the one being grown by farmers for some time and researchers have the option to replace it with an improved one. This trial, when conducted widely in different environments, will provide researchers with scope to assess and validate varietal performance, which in turn can facilitate the process of selecting the most suitable variety for the region. On the other hand, farmers, being the main drivers of this trial, obtain first-hand experience on and exposure to the performance of the varieties evaluated. This can play a critical role in both assisting researchers in participatory varietal development and popularizing promising varieties in their communities.

During kharif 2019, 936 tricot trials were implemented in 80 blocks of 23 districts of Odisha. Selection of subsets was based on the environment of the trial locations. In low-lying districts where long-duration varieties were tested, there was a yield advantage of 0.39 t/ha, whereas, in medium and upland locations, the advantagewas 0.22 t/ha (Table 1.7).

Table 1.7. Yield gain from different STRVs and HYVs as observed in tricot trials

Variety (medium land)	Average grain yield (t/ha)	Variety (lowland)	Average grain yield (t/ha)
Bina dhan 11	4.95	Rani Dhan	5.42
MTU 1001	4.86	Swarna-Sub1	5.83
Swarna Shreya	4.80	CR 1009-Sub1	6.07
MTU 1156	4.79	Ranjeet-Sub1	5.77
Bina dhan 17	4.69	MTU 1140	5.48
DRR 44	4.58	MTU 1172	5.38
DRR 50	4.54	Samba Mahsuri-Sub1	4.69
Sahbhagi dhan	4.28	MTU 1075	5.53
CGZR1	4.17	CR 801	5.12
Zinco Rice	3.96	Bahadur-Sub1	5.59
All other varieties	4.56	All other varieties	5.49
Farmers' varieties	4.34	Farmers' varieties	5.10
Yield gain (t/ha)	**0.22**	**Yield gain (t/ha)**	**0.39**
***P* value**	**0.00**		**0.00**

Photo 1.11: A tricot trial in Keonjhar

Photo 1.12: CCE in tricot trial in Balangir

Photos 1.13: Yield comparison in a tricot trial in Balangir and Puri

ix) Capacity building on good-quality seed production (QSP)

Photo 1.14: QSP ToT participants at NRRI, Cuttack

Currently, OSSC supplies approximately 30,000 metric tons of certified seeds of paddy each year through its network of more than 3,000 dealers. The Department of Agriculture, through its different development schemes, pumps another 1,500 metric tons into the system. Unfortunately, this is not sufficient to cover the 3.5 million ha under rice in the wet season. With an ideal SRR of 33% for rice, at least 60,000 metric tons of seeds are required every year. Infrastructure constraints and poor production and distribution networks would not allow realizing this target through state channels alone. Thus, encouraging and capacitating farmers to produce good-quality seeds can enhance farmers' seed security. The project, since 2016, has been training farmers through a team of master trainers at research institutes. In 2019, ToT activities were organized at NRRI, Cuttack, and the IRRI-South Asia Regional Center (ISARC), Varanasi. A total of 132 master trainers were trained (Table 1.8), who further facilitated field-level good-quality seed production training programs to cover 4,007 farmers. Notably, 1,427farmers (35%) were women. Other details appear in Table 1.8.

Photo 1.15: Practical session at NRRI farm, Cuttack

Table 1.8. Details of ToT activities organized for participants from different organizations

Batch no.	Date	Agriculture department (no.)	NGO partner (no.)	OLM (no.)	OSSC seed growers (no.)	IRRI field staff (no.)	Total (no.)
1	9-10 December 2019	12	19	4	19	6	60
2	12-13 December 2019	14	21	0	12	0	47
3	17-19 December 2019	0	15	0	0	10	25
Total		**26**	**55**	**4**	**31**	**16**	**132**

Apart from the training programs for farmers and other value chain actors, IRRI commenced a three-tier capacity-building program targeting (a) rural youth who could act as trainers, (b) farmers obtaining hands-on training while implementing demonstrations, and (c) district-level officials of line departments who would orient and support youth and farmers beyond the project period.

Photo 1.16: Women learning QSP techniques at Kalahandi

Photo 1.17: Participants receive field knowledge at Mayurbhanj

An orientation was held centrally on 9 July 2019, with 15 representatives of key collaborators to appraise two key staff members of the basics and support required for conducting a rice seed production training program at their respective locations. After the orientation, IRRI trained lead farmers and selected staff of Odisha Livelihoods Mission, I-Concept, and Adarsh Dharmagarh Women Farmers Services Producer Company Ltd. (ADWFSPCL) during kharif 2019 in Puri, Kalahandi, and Sambalpur districts of Odisha. A total of 141 women and men were trained on technologies and management practices for rice seed production, including classroom and practical sessions spread throughout the kharif season (Table 1.9). A demonstration site was set up at each location for providing hands-on training.

Photos: 1.18: Women farmers learning different QSP methods and techniques at Sambalpur

Table 1.9. Details of training on good-quality seed production undertaken with key collaborators

Collaborator	Location	Total no. oftrainees	Women	Men	Type of participant
I-Concept	Dandamakundpur (Puri)	18	4	14	Lead farmers and staff
OLM	Jujumara (Sambalpur)	45	45	0	Krushi Mitra, ELSP, farmers
ALCI	Dharmagarh and Koksara (Kalahandi)	78	78	0	Women farmers
Total		**141**	**127**	**14**	

vii) Seed production of recommended STRVs by OSSC

Popularization of well-performing varieties through different extension approaches is important but at the same time availability of breeder seeds is critically important to support the seed system of the state. Therefore, IRRI has been supporting OSSC in procuring breeder seeds of suitable varieties. Some of those are STRVs rated well in different evaluations; a few were very newly notified (BRRI 75, Swarna Shreya). Details are presented in Table 1.10.

Table 1.10. Breeder seed supply to OSSC for multiplication

SN	Variety	Sourced from	Quantity supplied (kg)	Multiplication (q)
1	CR 1009-Sub1	TNAU	200	160
2	DRR 44	IIRR	510	408
3	DRR 42	IIRR	1,000	800
4	BRRI 75	IIRR	5	4
5	Swarna Shreya	ICAR-Patna	300	240
6	DRR 46	IIRR	90	72
7	DRR 43	IIRR	30	24
Total			**2,135**	**1,708**

viiii) Farmers' participation in seed production

Experience proves that good-quality seed produced by well-trained farmers using provided foundation seeds may not be procured by formal channels such as OSSC. This is because OSSC has its own seed production plan and seed growers' network. These growers are producing seeds as per the OSSC requirement and this is sufficient to support OSSC's annual seed requirement. Identifying and supporting seed entrepreneurs in local communities to produce and market branded seed either individually or collectively can be a way around this.

In 2019-20, Sahbhagi dhan was chosen in consultation with OSSC, as they needed only this variety from these new growers. A total of 155 farmers (34 women) produced 226 tons of Sahbhagi seeds on 75.4 ha (Table 1.11). The project facilitated registration of these producers and certification through OSSOPCA.

Table 1.11. Seed production of farmers with OSSC

District	Area(ha)	Total production (t)	No. of farmers	STRV
Bargarh	29.0	87.0	36	Sahbhagi dhan
Boudh	4.8	14.4	13	Sahbhagi dhan
Keonjhar	20.0	60.0	69	Sahbhagi dhan
Sonepur	21.6	64.8	37	Sahbhagi dhan
Grand total	**75.4**	**226.2**	**155**	

ix) IRRI super bag: a low-cost high-impact option for seed storage

Photo 1.19: Farmers of Sambalpur showing grains stored in IRRI super bag

The IRRI super bag is a hermetic plastic storage material with very low oxygen permeability and this airtight enclosure reduces biological activity inside the bag, lowers moisture content, and kills insects. An ordinary plastic or gunny bag lets too much air pass through and cannot control insects. The super bag comes with 50-kg capacity in two variants—sealing by twisting or zip lock. A study undertaken in 2019 revealed that 81% of the farmers who received this bagwere keen to buy it from the market if available. They preferred this bag mainly for its ability to keep pest infestation at a minimum level and maintain an impressive germination rate even after six months of storage. This super bag has been promoted in conjunction with the good-quality seed production (QSP) initiative since 2017.

To date, 10,000 farmers (41% women) have been oriented on this storage method, while 7,000 IRRI super bags were distributed among farmers covering around 200 blocks in 30 districts. In the reporting year, 4,000 farmers have been oriented on QSP and provided with these super bags. The frequent inquiry about this bag from farmers, NGO partners, input dealers, and seed growers is indicative of the acceptability and demand for this product.

Research collaboration with OUAT: Bacterial blight and stagnant flooding are the two major constraints in the rainfed lowland environment, not just for Odisha but for all of eastern India. In view of this research gap, IRRI in collaboration with OUAT is implementing a breeding program that aims to develop new varieties that can mitigate the impact of stagnant flooding and bacterial blight in rice. Although development of advanced lines against bacterial blight is still underway, some promising stagnant flooding lines better than their national checks have been identified. These new lines have been evaluated in lowland environments in coastal geographies. IR85086-Sub33-3-2-1, a check against CR 1009-Sub1, produced better results. In efforts to develop a substitute for Swarna-Sub1, IR88230-60-1-2-2 was found to have potential. IR87439 BTN 145-2-1, another advanced line, was evaluated against established and popular variety Bina dhan 11 and the results are convincing.

However, these lines need further wide and intensive multi-location trials for assessing and conclusively establishing their worth against the best checks. This will be pursued in the coming season. The basic agronomic outcomes of these new lines are provided in Table 1.12.

Table 1.12. Performance of different advanced lines

Name of variety	Checks	Plant height (cm)	No. of tillers /hill	No. of grains/ panicle	Grain yield of test line (t/ha)	Grain yield of check (t/ha)
IR85086-Sub33-3-2-1	CR 1009-Sub1	128.75	16.2	183.0	6.32	6.20
IR87092-26-3-1-3	CR 1009-Sub1	103.70	15.7	148.5	5.36	6.20
IR88228-33-3-5-2	Swarna-Sub1	115.80	18.1	135.0	6.12	6.00
IR88230-60-1-2-2	Swarna-Sub1	108.10	21.0	220.4	6.24	6.00
IR88760-Sub 93-3-3-3	CR 1009-Sub1	133.00	19.1	217.0	5.60	6.20
IR87118-39-1-1-6	CR 1009-Sub1	105.50	19.0	182.6	4.80	6.20
IR87439 BTN 145-2-1	Bina 11	111.40	15.0	186.0	5.60	4.94

Nutrient-dense varieties

Malnutrition in Odisha is a complex health crisis that largely affects women, children, and adolescents. Biofortified rice can provide higher content of zinc, protein, and vitamin A. In exploring rice-focused solutions for better nutrition, four varieties were evaluated in different parts of the state. CGZR-1 and Zinco Rice, developed by IGKV, Raipur, are known for higher than normal zinc content (22–26 ppm). The quantity of protein in CR 310 and CR 311 is reported to be higher than that of other rice varieties. Normal milled rice contains 6–7% protein while these two varieties are reported to have at least 10%. It is prudent to consider biofortification along with essential attributes such as yield, duration, grain size, disease/pest resistance, etc. Just a focus on nutrient quality might not make such varieties popular, given the calorific needs of large numbers of poor and marginal households that depend on rice. Observations generated from this year's trials will help in developing a research agenda for the future. Nutrient content analysis of these varieties is being conducted at ISARC. Table 1.13 summarizes results for these four varieties.

Table 1.13. Results for biofortified varieties and their yield

Variety	Duration	Micronutrient	Claimed micronutrient content	Yield (t/ha)
CR 310	125	Protein	10.30%	4.45
CR 311	123	Protein	10.10%	4.41
CGZR1	118	Zinc	23 ppm	4.16
Zinco Rice	123	Zinc	22 ppm	3.97

xiii) SeedCast

Seed security of farmers depends on seed availability, quality, access, and use and control. With approximately 3.6 million ha under rice cultivation in the wet season annually in Odisha, 18 lakh quintals of good-quality seeds are needed each kharif season. The state government with its several well-planned schemes and programs is relentless in its efforts to ensure the availability of the required quantity of preferred rice varieties to farmers well before the sowing season. Odisha

State Seed Corporation (OSSC), the nodal agency for seed production, marketing and distribution, has a vast network of around 3,500 dealers (PACS and dealers), who supply 28,000–30,000 tons of rice seeds of different varieties to farmers.

To support OSSC in generating reliable demand estimates for rice seed, IRRI, in collaboration with GoO and other stakeholders, developed SeedCast Odisha, an app-based digital tool. This app also includes varietal information, recommendations, and management practices on major HYVs and availability of HYV seed with different dealers. This app can foster an efficient connection between dealers, farmers, and officials that will contribute immensely to planning seed production and supply to meet farmers' demand in Odisha.

Kharif 2019 was the first season for SeedCast implementation. Several consultations with seed system experts from OSSC and the DoA helped fine-tune the application. A plan was developed to orient all 2,963 active dealers of OSSC from 26 districts on the functionality, benefits, and application of SeedCast (Table 1.14). Simultaneously, dealers using this application were encouraged to use SeedCast to place their varietal indent for kharif 2020. It was observed that some dealers are no longer part of OSSC after their licenses expired and some of the active dealers could not be reached as well. The number of dealers trained is therefore less than the total number of listed dealers. Even after orientation, 276 dealers did not register their seed demand, saying that more deliberation is required. Some did not seem comfortable using digital platforms. Several dealers in districts such as Ganjam and Puri couldn't attend the orientation program, but registered their demand through SeedCast after being briefed by phone.

Table 1.14. Details of Seed Cast orientation program for dealers

No.	District	No. of OSSC listed dealers	No. of dealers trained on SeedCast	No. of dealers indented
1	Angul	108	112	44
2	Balasore	280	230	318
3	Bargarh	197	108	47
4	Bhadrak	149	127	144
5	Bolangir	462	341	272
6	Boudh	72	80	56
7	Cuttack	259	150	77
8	Deoghar	32	32	27
9	Dhenkanal	103	110	56
10	Gajpati	95	45	29
11	Ganjam	560	365	600
12	Jagatsinghpur	136	60	55
13	Jajpur	174	148	129
14	Kalahandi	302	263	186
15	Kandhmal	31	48	24
16	Keonjhar	86	78	63
17	Khurdha	161	120	103

No.	District	No. of OSSC listed dealers	No. of dealers trained on SeedCast	No. of dealers indented
18	Koraput	103	73	54
19	Mayurbhanj	93	82	77
20	Nabrangpur	87	56	23
21	Nayagarh	157	120	78
22	Nuapada	101	97	51
23	Puri	246	60	246
24	Sambalpur	91	105	91
25	Sonepur	135	120	27
26	Sundargarh	110	109	86
Total		**4,330**	**3,239**	**2,963**

As many as 166 varieties were demanded by participating dealers, constituting a total demand of 58,862 tons for kharif 2020. This is approximately twice the quantity of seeds that OSSC distributed annually from 2016 to 2018. Of the 166 varieties, 58 accounted for 99% of the total quantity demanded (Table 1.15). OSSC, on average, produces and sells 45–50 varieties in the wet season.

Table 1.15. Share of different varieties indented for kharif 2020

Varieties	Share in total demand	Average age(years)	No. of varieties <10 years
Top 58 varieties	99%	17	18
Top 10 varieties	80%	19	3
Top 5 varieties	65%	24	1

A variety older than 10 years from the date of notification is ideally discouraged for cultivation as genetic purity and other quality parameters deteriorate over time. Table 1.15 reveals that 40 out of 58 varieties indented for 2020 kharif are older than 10 years. Varieties such as Pooja, Swarna, MTU 1001, MTU 1010, Lalat, etc., are 20 years old or more. Swarna (MTU 7029) is a 35-year-old variety, but still accounts for 20% of total demand in the state.

Seven varieties make up 72% of the total demand: Pooja (21.22%), MTU 7029 (19.78%), MTU 1001 (13.04%), Swarna-Sub 1 (6.3%), Lalat (4.31%), and Bina dhan 11 (4.26%) (Figure 1.8). Bina dhan 11, a medium-duration variety notified in 2015, was recently introduced into the seed chain. In a short span, this variety has gained wider acceptance in Odisha as reflected in the indented quantities from dealers of all districts (Table 1.16).

Table 1.16. District-wise total demand and share of top ten varieties

District	Total demand (t)	Pooja (%)	MTU 7029 (%)	MTU 1001 (%)	Swarna-Sub1 (%)	Lalat (%)	MTU 1010 (%)	Bina dhan 11 (%)	Khandagiri (%)	Sahbhagi (%)	Pratikshya (%)
Anugul	583.8	32.13	12.97	3.73	6.31	2.66	1.46	4.02	0.14	2.24	0.49
Balasore	2,641.23	5.33	43.22	6.12	10.21	0.2	3.69	0.72	0.28	0	2.72
Bargarh	620.9	21.11	24.05	12.76	8.02	0	4.9	5.23	0	2.91	0.16
Bhadrak	1,318.83	1.87	28.39	10.24	16.34	2.99	0	0.85	0.77	0	1.83
Bolangir	9,953.10	22.68	19.4	16.45	2.26	5.9	8.73	4.08	6.37	2.66	0.94
Boudh	1,466.32	31.98	10.81	21.95	10.03	3.21	3.67	0.34	3.43	2.05	0.38
Cuttack	1,102.70	35.15	10.86	3.44	10.25	0.18	0.14	0.13	0.28	0.03	0.07
Deogarh	581.9	29.64	17.27	15.42	0.6	2.41	6.44	3.7	1.8	7.13	1.03
Dhenkanal	1,996.20	19.5	19.41	7.21	9.03	0.44	0	0.06	0.46	0.97	0.91
Gajapati	882.6	35.29	10.42	8.36	9.22	0.06	1.02	0.73	0	0	2.15
Ganjam	8,166.60	32.47	28.61	6.62	10.74	0.02	0.02	0.46	0.05	1.33	0.09
Jagatsinghpur	581.23	28.1	2.75	0	6.99	0	0	0.52	0	0	0.69
Jajpur	934.68	9.62	26.66	0.61	14.23	0.82	0	3.13	4.34	0.53	1.08
Kalahandi	10,701.00	18.15	17.65	21.62	4.45	8.05	5	5.72	4.45	1.05	0.24
Kandhamal	139.9	15.15	6.08	18.58	0	1.43	0	0	0	10.72	7.86
Keonjhar	1,968.50	4.95	11.99	6.56	12.74	11.57	5	4.11	1.42	11.44	10.89
Khurda	1,137.30	37.7	23.18	3.23	7.14	0.27	0.13	0.94	0.01	0	0.16
Koraput	1,249.40	18.43	1.08	31.78	0.12	17.17	10.46	4.36	5.97	0.64	4.24
Mayurbhanj	1,821.10	19.53	26.82	4.46	6.73	5.13	0.95	3.53	1.34	4.05	7.88
Nayagargh	635	26.74	14.24	29.01	4.74	0.16	0.44	1.06	0	0	0
Nuapada	2,138.50	6.06	25.65	18	3.83	9.26	10.83	6.57	7.81	4.02	0
Puri	2,486.45	32.4	18.13	0.55	8.91	0.76	1.21	1.61	0.06	0.08	0.26
Sonepur	866.5	32.31	21.81	12.58	3.92	1.67	6.98	2.77	0.98	0.35	0.12
Sundargargh	3,187.36	10.21	6.65	10.34	0.97	3.4	4.85	4.92	5.22	10.53	18.02
Sambalpur	849.7	30.18	13.24	6.53	0	0.47	3.51	2.67	0	2.61	7.64
Nabarangpur	851.6	8.38	1.06	42.88	0.53	7.2	12.59	9.32	1.35	7.66	2.11
Grand total	**58,862.39**	**21.22**	**19.78**	**13.04**	**6.3**	**4.31**	**4.26**	**3.21**	**2.94**	**2.46**	**2.34**

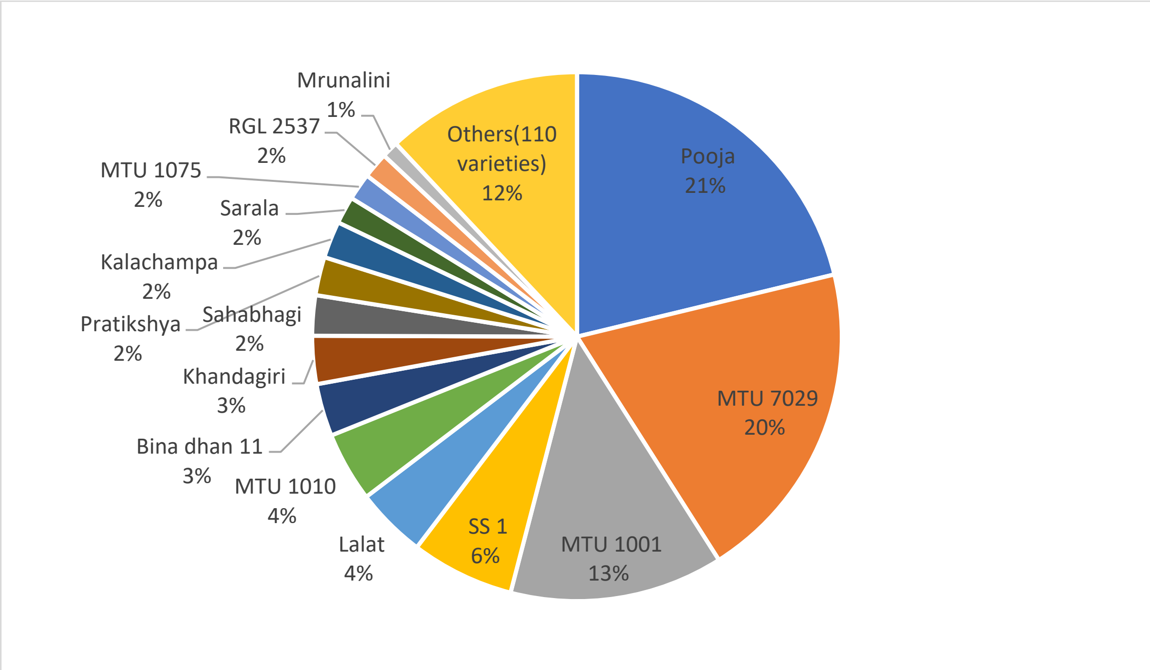


Figure 1.7. Share of different varieties in total demand

MTU 1156, which is a replacement of MTU 1001, has demonstrated higher acceptance as evident from the substantial demand for it. Other varieties such as DRR 42 and DRR 44, recommended for rainfed drought-prone areas, are also in demand by dealers. CR 307, popularly known as Moudamani, notified in 2014, and preferred for its high yield, is gaining in popularity. In 2019, a total of 285.3 tonswere indented (Table 1.17). The initial level of acceptance of CR 310 and CR 311 (notified in 2015), two high-protein varieties, is also encouraging. CR 1009-Sub1, a long-duration variety introduced in recent years, is in high demand in low-lying coastal belt districts.

Table 1.17. Indent of new varieties placed by dealers

District	Total demand (t)	MTU 1156	DRR 44	DRR 42	CR 307	CR 310	CR 311	CR 1009-Sub1
Anugul	583.8	1	0	3	3	0	0	3
Balasore	2,641.23	0	0	0	1	0	0	11
Bargargh	620.9	56.2	0	0	0	4.6	0	0
Bhadrak	1,318.83	0	0	0	0	0	0	219.1
Bolangir	9,953.10	125	19.3	33	36	0	0	0
Boudh	1,466.32	1	0	2	0	0	0	0
Cuttack	1,102.70	0	0	0	0	0	0	18.8
Deogargh	581.9	0	0	0	0	0	0	0
Dhenkanal	1,996.20	0	0	0.5	11.3	0	0	1.3
Gajapati	882.6	0	0	0	0	0	0	0
Ganjam	8,166.60	0	2.7	0	6	0	0	17.5
Jagatsinghpur	581.23	0	0	0	0	0	0	17.5
Jajpur	934.68	0.7	0.6	0.5	11.9	0	0	17.5
Kalahandi	10,701.00	118.5	1	0	161	1	1	39
Kandhamal	139.9	0	0	0	0	0	0	0

District	Total demand (t)	MTU 1156	DRR 44	DRR 42	CR 307	CR 310	CR 311	CR 1009-Sub1
Keonjhar	1,968.50	1.7	0.2	0	18.9	0	0	32.3
Khurda	1,137.30	0.5	1	0	12.5	0	0	18
Koraput	1,249.40	4	7.4	0	0	0	0	0
Mayurbhanj	1,821.10	0	2.5	6	3	0	0	0
Nabarangpur	851.6	0	0	0	0	1	0	0
Nayagargh	635	0	0	0	0	0	0	0
Nuapada	2,138.50	0	0	0	0	0	0	0
Puri	2,486.45	0	0	0	20.7	0	0	112.3
Sonepur	866.5	46	0	0	0	0	0	0
Sundargargh	3,187.36	51	1	21	0	0	0	0
Sambalpur	849.7	146.6	3	1	0	0	0	0
Grand total	**58,862.39**	**552.2**	**38.7**	**67**	**285.3**	**6.6**	**1**	**507.3**

Photo 1.20: SeedCast orientation for dealers at CDAO, Balangir

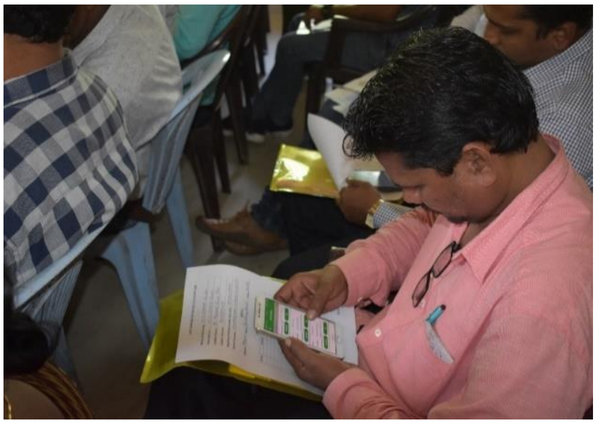


Photo 1.21: A dealer from Koraput learning about SeedCast

xiii) Activities during rabi 2019-20

Only 3.5 lakh ha (10% of kharif area) are cultivated with rice during the rabi season. Mainly short-duration varieties such as MTU 1001, MTU 1010, Lalat, MTU 1156, and Khandagiri are grown in irrigation-assured areas. In order to understand seasonal variance and season adaptation, the project is evaluating Bina dhan 11 in 12 blocks from five districts where irrigation facilities are available. A total of 300 tricot trials with a combination of other varieties and 1,000 ha of cluster demonstrations have been rolled out in this season (Table 1.18). A total of 55 tons of seed has been distributed among farmers through five NGO partners.

Table 1.18. Rabi plan for 2020

NGO	District	Blocks	Cluster demonstrations	Tricot trials
			Area under CDs (ha)	No. of tricot trials
AJKA	Bargarh	Bargarh, Barpali	200	60
Adarsa	Sambalpur	Maneswar, Dhankauda	200	60
LOKSEBAK	Kalahandi	Jeypatna, Junagarh	200	60
Netaji	Bhadrak	Tihidi, Dhamnagar	200	60
Swad	Puri	Brahmagiri, Delang	100	30
Wisdom	Puri	Pipili, Nimapada	100	30
Total			**1,000**	**300**

The key learnings

Before we summarize the key learnings from the past 4 years of implementing this suite of interventions to support rice seed sector development in Odisha, we highlight the major outputs. STRVs have been demonstrated on more than 20,000 ha and more than 80,000 tons of rice has been produced to be used as grain or seed. Cluster demonstrations covered 18,000 ha, combined with seed production training. A conservative estimate of 10% of the rice produced from these demos is being used/reused as seed, indicating that 7,000 tons of seed has been shared or used in farmer-managed systems. More than 10 new, released, or pipeline STRVs have been tested through 12,800 on-farm trials organized across diverse environments. A total of 67 varietal cafeterias hosted across Odisha engaged and linked nearly 1,500 key stakeholders, including farmers, private seed suppliers, the state seed corporation, input dealers, extension agencies, NGOs, and government as well as researchers. STRV awareness programs were organized for 82,000 farmers. The formal seed system has been strengthened by advancing several new varieties and infusing 74 quintals of breeder seed for further multiplication. A total of 398 master trainers and 11,230 farmers have been trained in good-quality seed production. A total of 32,880 minikits were provided through dealer networks to create demand for new products.

Key learning emerging from this experience highlights the following:

The demand for wider product choice: Although some new STRVs have been introduced into the seed chain and varietal awareness created, data from SeedCast, seed sales in the state, and field interactions reveal that the varietal choices available to farmers do not meet their preferences and needs. The top five varieties (in terms of volumes demanded) have an average age of more than 25 years. Many varieties in use are more than four decades old. These varieties persist in the seed chain due to a lack of suitable alternatives. This calls for innovation in product range and including potential new HYVs to replace the old varieties, especially in areas subject to lesser frequency or intensity of stresses.

Bina dhan 11, a variety fast growing in the seed chain: Within a short period of 3 years of demonstrations and institutional linkage for breeder and foundation seed multiplication, Binadhan 11 is claiming 2–3% of market demand for STRVs, competing with about 100 varieties available in the seed chain. This number could be much higher if estimates from seed exchange and use of own saved seed in farmer-managed systems were included. With superior grain quality and a yield advantage of 0.5 t/ ha under flood conditions, this variety has emerged as a good choice for farmers seeking to intensify cultivation as its early harvest permits them to grow a sequence crop, thus saving irrigation in the early stages of the second crop.

Need for establishing genetic/yield gain: The yield advantage of STRVs is realized only in stress conditions. Data show that STRVs such as Sahbhagi dhan and DRR 44 have an average yield advantage of 0.43 to 0.50 t/ha against local checks under stress (11–15 days of drought spells). Bina dhan 11, a flood-tolerant variety, has an average yield advantage of 0.5 t/ha under 14 days of submergence. These varieties have been evaluated and found to have no yield penalty under nonstress conditions. However, the significance of these varieties goes unnoticed under nonstress conditions. Experience with varietal cafeterias shows that farmers and other stakeholders value yield or yield-contributing traits higher than others. Therefore, it is important to undertake demonstrations/trials that showcase genetic gain under both stress and nonstress conditions using a wider pool of varieties.

SeedCast as a decision support tool: SeedCast has generated significant opportunity and ambition among stakeholders. To make it a more effective tool for state employees and seed suppliers, it could include seeds of all important crops in the indenting process. This can also encompass multiple user groups involved in demand aggregation beyond dealers, for example, farmers, community groups, local extension workers, etc.

Promoting small seed entrepreneurs: Odisha hosts several **s**mall-scale seed entrepreneurial firms that work closely with the local community for provisioning good-quality seeds. Although OSSC remains a predominant supplier for the region, these small firms could be critical for enhancing the availability of and access to good-quality seed for smallholder, poor, and women farmers and those in remote areas. Seed production training needs to go beyond technical aspects and include business dimensions, so that interested women and men can establish small or medium-sized enterprises individually or collectively. This needs to be bolstered by linkages with government schemes to access machinery and equipment for seed production and processing to make it more remunerative. Efforts to promote and include these enterprises systematically can help reach the unreached.

Making QSP training scalable and impactful: Although the project trained hundreds of farmers in good-quality seed production, there is a need to move to a training of trainers (ToT) mode to sustain the benefits and scale out the capacity beyond the project period. In addition to DoA officials, these trainers could be from among NGOs, CBOs, youth, and women who could provide such training to interested audiences at a nominal fee so that they also have incentives to engage in this.

Subproject 2: Targeting Rice Fallows: A Cropping System-based Extrapolation Domain Approach

Subproject 2: Targeting Rice Fallows: A Cropping System–based Extrapolation Domain Approach

Farmers rely on rainfall to produce crops during the monsoon (kharif) season, and droughts and floods often arise as a direct consequence of variations in monsoon rainfall. The state is plagued with the uncertainty of monsoon rainfall, which affects not only rainfed kharif rice but also succeeding crop productivity in the region. Therefore, system optimization using crop varieties of appropriate duration and management practices is important for cropping system diversification and intensification to enhance resilience, cropping intensity, and overall system productivity. In Odisha, substantial area of potentially productive land remains fallow during the winter (rabi) season after the monsoon (kharif) rice crop due to five major factors: (1) lack of irrigation, mostly in the plateaus and tablelands; (2) stagnant water causing waterlogging in coastal lowland areas; (3) high soil or water salinity in the coastal zone area; (4) late harvest of the kharif crop or excessive soil wetting after harvest leading to late planting and low productivity of rabi crops; and (5) other factors such as labor shortage, lack of awareness, credit market, and open grazing, among others. Increasing the productivity and profitability of these low-productive areas is a major challenge for the state. Bringing these fallow lands into cultivation could substantially improve food production and enhance the livelihoods of rural communities in this geography. With the availability of drought-, flood-, and salt-tolerant rice cultivars and short-duration pulse crops, along with improved agronomic practices such as water management, mechanization, and technology targeting using geospatial technology, these could significantly increase the potential of converting rice-fallow areas into cultivation.

To intensify cropping in rice-fallow areas, the spatial distribution and extent of the rice-fallow system area and soil moisture dynamics need to be mapped so that water-efficient crops such as pulses can be targeted. Using improved geospatial technologies, IRRI mapped rice fallows (current and permanent fallows) and their spatial-temporal change (by comparing the rice fallows in 2006, 2010, 2016, 2017, and 2018), major associated abiotic stresses (e.g., flood, drought, and salinity), and other drivers that instigate keeping productive lands under fallow (e.g., demarcating areas having long-duration rice cultivars). Residual soil moisture content after rice cultivation is often sufficient in most of the districts to raise short-duration pulses (55–75 days) and oilseed crops. However, the depletion rate of soil moisture varies in different areas. An analysis of spatio-temporal profiles of soil moisture availability and duration during the rabi season helps to precisely target and use the short residual soil moisture window, which varies from 10 to 30 days, depending upon land types. IRRI is developing extrapolation domain maps of fallows with potential for double cropping by integrating remote sensing (RS) and geographic information system (GIS) mapping with a logical decision tree approach and following this up with on-farm trials and demonstrations of pulses/oilseeds after rice in different locations in Odisha. Extrapolation domain mapping identifies the suitability of rice-based cropping systems for targeting improved stress-tolerant cultivars and sustainable agronomic and water management practices in underused stress-prone rice-fallow areas in Odisha.

The objectives of this subproject are the following:

- To develop, test, and validate appropriate and productive cropping systems to target rice fallows
- To identify the land-use requirements of tested cropping systems, and develop decision rules
- To develop extrapolation domain maps using geospatial modeling and the decision tree approach for targeting improved technologies (STRVs and relevant cropping systems) in rice fallows
- To demonstrate different tested technologies (STRVs and cropping systems) in extrapolation domain analysis (EDA)–guided farmers' fields for accelerated dissemination
- To disseminate project outputs to national partners, including research, extension, and policymakers through various means, including the open-access web-GIS system, mobile applications, atlases, and research papers

2.1 Rice-fallow characterization and management in Odisha

Integrated analysis of time-series remote-sensing satellite data of Sentinel1 (SAR) microwave and Landsat OLI (optical) imageries for the four years (2015 to 2019) revealed that rice-fallow area ranged from 1.97 to 2.20 million ha in Odisha (40% to 45% of the net cropped area), out of which about 1.33 million ha would be considered as permanent rice fallow as revealed by the analysis of frequency of common area for the four mapping years of 2015-16, 2016-17, 2017-18, and 2018-19. Multiple satellite RS datasets and associated parameters such as vegetation indices, cropping pattern and intensity, soil moisture, land use, land cover, and other stress parameters such as drought and flood conditions were used to develop a map depicting potential areas for crop intensification.

2.1.1 Spatial distribution mapping of rice fallows in Odisha

A standard methodological approach has been developed for processing and analyzing the time-series remote-sensing datasets of optical and microwave (SAR) imageries in different years to identify the rice-fallow area in Odisha. The multi-temporal RS data from Landsat OLI (optical) and Sentinel1 (microwave) sensors have been used to identify rice-fallow distribution in Odisha. The study area is covered under 14 Landsat and 12 Sentinel 1 tiles. The Landsat OLI and Sentinel1 SAR data were downloaded from NASA (https://search.earthdata.nasa.gov/) and ESA (https://scihub.copernicus.eu/) websites, respectively. The Landsat OLI data were downloaded covering the annual crop calendar (June to May) of Odisha during 2015-16, 2016-17, 2017-18, and 2018-19.

The spatial distribution of rice-fallow area in Odisha extracted using integrated analysis of Landsat OLI and Sentinel1 data for the 2015-16, 2016-17, 2017-18, and 2018-19 crop calendar is depicted in Figure 2.1 and the district-wise estimated area is provided in Table 2.1. The total rice-fallow area in Odisha during the 2015-16, 2016-17, 2017-18, and 2018-19 crop calendar is 2,206,364 ha or 45% of the net crop area (NCA), 1,970,301 ha or 40% of NCA, 2,122,161 ha or 43% of NCA, and 1,991,622 ha or 41% of NCA, respectively.

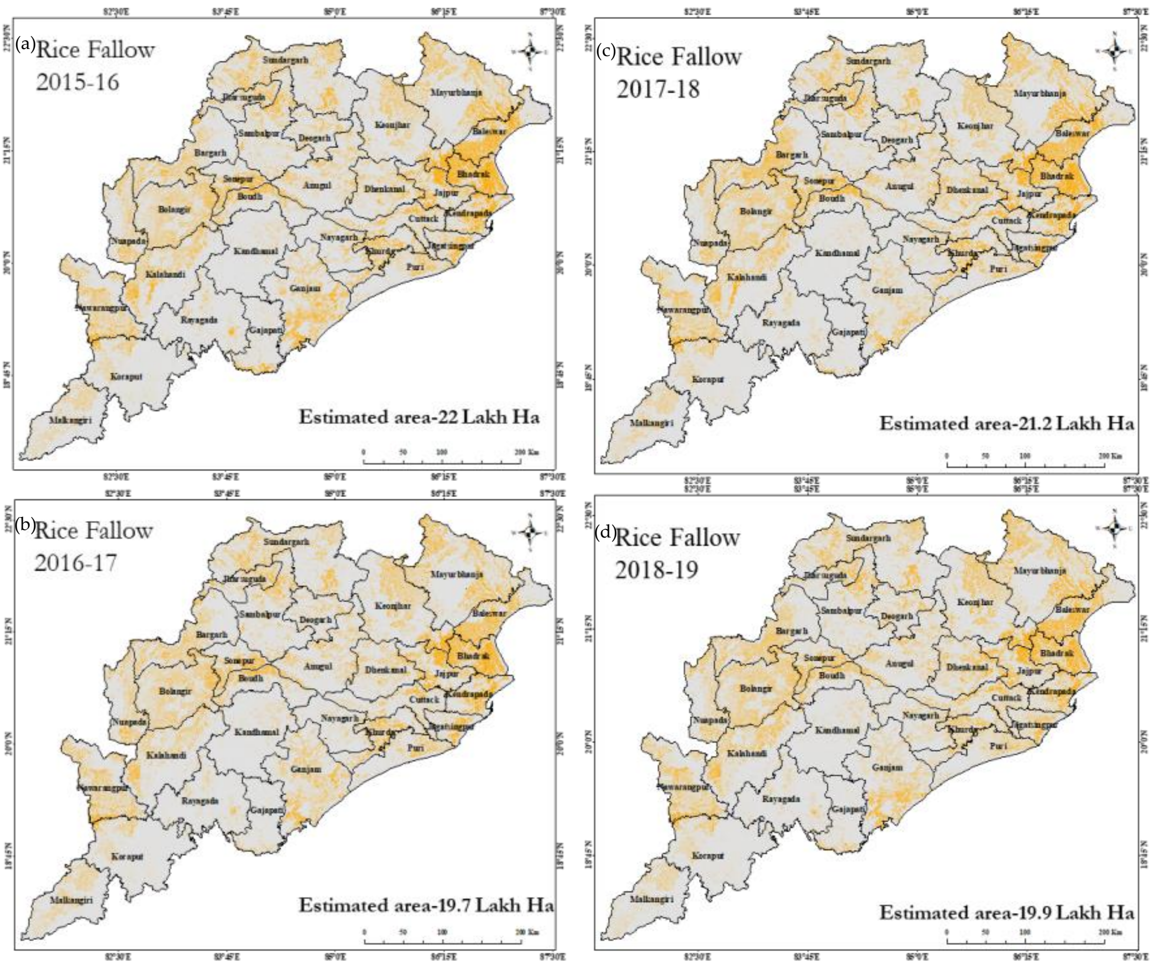


Figure 2.1. Spatial distribution of rice-fallow area extracted during (a) 2015-16, (b) 2016-17, (c) 2017-18, and (d) 2018-19 based on crop calendar of Odisha

Nine among the 30 districts (Mayurbhanj and Keonjhar districts in thenorth-central plateau, Bargarh and Bolangir districts in western-central table land, Baleswar and Bhadrak districts in the northeastern coastal plain, Sundargarh District in the northwestern plateau, Kalahandi District in the western undulating zone, and Nabarangpur District in eastern Ghat highland) account for about 50% of the total rice-fallow area. The rice-fallow area is considerably less in the districts situated in the southeastern coastal plain.

Table 2.1. District-wise distribution of rice-fallow area (in ha) during 2015-19

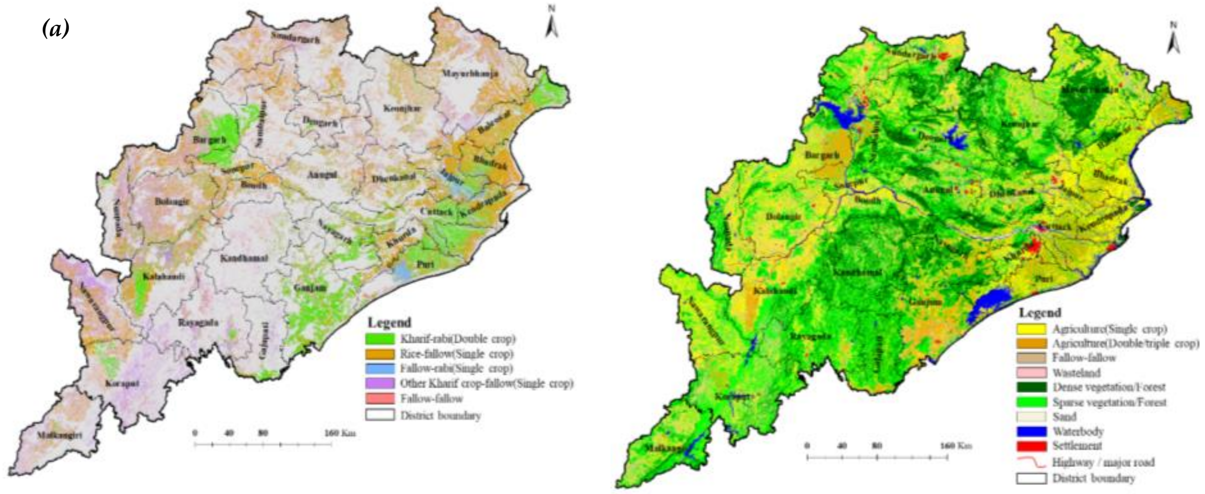
SN	District	2015-16	2016-17	2017-18	2018-19
1	Anugul	69,415	67,292	69,629	64,207
2	Baleswar	128,354	98,304	121,256	96,705
3	Bargarh	80,168	84,287	89,939	82,947
4	Bhadrak	138,152	121,705	125,401	120,602
5	Bolangir	132,779	133,711	135,828	132,648
6	Baudh	47,729	45,696	48,577	41,347
7	Cuttack	53,726	41,187	52,690	44,402
8	Debagarh	27,398	24,180	25,818	24,399
9	Dhenkanal	54,311	51,275	72,485	52,838
10	Gajapati	24,407	11,636	10,473	11,743
11	Ganjam	145,329	68,356	82,800	77,229
12	Jagatsinghpur	35,841	30,941	32,824	29,175
13	Jajpur	75,904	70,702	67,199	65,724
14	Jharsuguda	32,923	34,032	35,047	34,638
15	Kalahandi	112,412	86,937	111,827	89,540
16	Khandamal	19,040	20,596	17,240	23,017
17	Kendrapara	81,882	73,398	81,305	74,893
18	Keonjhar	111,562	127,777	119,902	127,020
19	Khorda	55,200	52,162	58,174	53,864
20	Koraput	46,636	41,125	48,091	41,709
21	Malkangiri	43,558	48,471	47,876	47,931
22	Mayurbhanj	179,241	172,680	187,473	179,240
23	Nabarangpur	97,105	96,141	100,421	97,310
24	Nayagarh	28,203	19,033	24,639	19,987
25	Nuapada	56,737	56,776	54,089	59,352
26	Puri	38,014	37,642	40,825	36,655
27	Rayagada	25,155	22,593	22,235	23,916
28	Sambalpur	75,993	65,025	68,060	64,221
29	Sonepur	49,976	48,885	49,692	50,295
30	Sundargarh	139,214	117,756	120,346	124,068
	Total	**2,206,364**	**1,970,301**	**2,122,161**	**1,991,622**

2.1.2 Cropping intensity extracted from multi-temporal Landsat OLI

In Odisha, two main cropping seasons, kharif (June to November or mid-December) and rabi (December to April), can be observed. In very few areas, crops are grown during the summer or zaid season (May to June), and those can be considered as late rabi crops. Therefore, the analysis aimed to extract three different levels of agricultural area information. In the first and second levels, overall agricultural area and seasonal agricultural area, respectively, are extracted. In the second-level classification, four different class combinations were defined: (a) kharif-rabi, (b) kharif-fallow, (c) fallow-rabi, and (d) fallow-fallow. The third-level classification mainly focuses on the rice crop and therefore four rice-based cropping system classes, (a) rice-rice (i.e., rice during both seasons), (b) rice-rabi (rice during kharif season and other crops during rabi season), (c) rice-fallow (i.e., rice during kharif season and fallow during rabi season), and (d) fallow-rice (i.e., fallow during kharif season and rice during rabi season), are extracted.

2.1.3 Land use and land cover extracted from multi-temporal Landsat OLI

The Landsat Normalized Difference Vegetation Index (NDVI) composite was used to extract the annual cropping system based on the temporal growth pattern of different seasons and also the Land Use/Land Cover (LULC) classification is extracted using the available ground truth information to separate the LULC major classes as agriculture (single crop and double crop area), fallow lands, wastelands, forest, sand, settlements, and waterbody. Therefore, the information redundancy of the original time-series images was analyzed to generate the LULC map. Figure 2.2(a) depicts the cropping intensity and Figure 2.2(b) shows the land cover and land use during 2018-19.



Figures 2.2. Spatial distribution of (a) cropping intensity extracted during 2018-19 and (b) land use and land cover extracted during 2018-19

2.1.4. Validation of maps

Two different data collection approaches were adopted to validate the cropping system maps. In the first approach, questionnaire-based (GPS tagged) direct field verification was carried out during kharif and rabi seasons in random locations across the study area. During the field verification, farmers were asked about the cropping system in the current as well as previous years in that location. In the second approach, first, stratified random samples were generated on each agricultural class and then each sample was verified with high-resolution Google Earth images corresponding to the mapping year. If the verified sample was labeled as agriculture, then it was further verified with a temporal profile extracted from the NDVI stack to determine the cropping system.

2.1.5 Inter-institutional collaboration on rice-fallow characterization and management in Odisha

Several CGIAR and ICAR institutions are active in Odisha working on their mandated crops and systems that include remote sensing to map the rice-based systems and testing and demonstrating various crop and management options for improved productivity from rice fallows. The Ministry of Agriculture, GoI, has also begun the project Targeting Rice-Fallow Area in Eastern India covering 50 districts, including districts in Odisha. An integrated planning process of national and international institutions would bring about the desired momentum to enhance farm income by selectively identifying and promoting the production of crops with good commercial potential and agronomic fitness to the prevailing climate in different districts of Odisha. IRRI organized a workshop on Rice-Fallow Mapping and Characterization for Crop Intensification in Odisha on 9 September 2019 in Krishi Bhawan, Bhubaneswar, with participation from CGIAR centers (IRRI, ICARDA, ICRISAT, CIP, CIMMYT, AVRDC, ICRAF), ICAR institutes (NRRI, IIPR), OUAT, remote-sensing agencies (MNCFC, NRSC, ORSAC), and the Department of Agriculture, Odisha.

Photo 2.1: Planning meeting for rice-fallow characterization with IRRI and CGIAR

The workshop was organized into two sessions: the first one focusing on resource characterization of rice fallows in the state of Odisha and the second one on agronomic interventions to bring fallow areas under double cropping based on the resource endowments, best-fit technologies, and addressing the socioeconomic constraints that prevent the conversion of cultivable rice fallows into productive farms.

Remote-sensing characterization has been done by different agencies in the past. The rice-fallow area estimation was done as a subset of rice area using optical imagery in the earlier years and a combination of optical and SAR (microwave) sensors in recent years. IRRI estimated the extent of rice fallows using Sentinel 1 and 2 and Landsat data, and validated the map with ground truthing during 2016-19. Average area under fallows was estimated at 1.9 million ha, with yearly variations of 0.1 million ha, mostly due to the variations in the onset/withdrawal of monsoons. ICRISAT, using 250-m resolution MODIS data, estimated the area to be 1.7 million ha, whereas MNCFC had a figure of 1.73 million ha. Based on datasets, spatial and temporal resolutions, methods used for analysis, and year-to-year fluctuations in cropped area, 2–3% variation is normally expected in dynamic estimates of area by different agencies. Based on suitability maps prepared by IRRI, potential exists to bring about 11 lakh ha under cultivation.

Many organizations are contributing technical support to the efforts in the state to diversify and intensify agriculture based on their respective mandates and strengths, and it is an opportune time now to integrate the efforts for synergies and accelerated impact. The coastal and interior districts need different approaches given their different resource endowments. Although the marginal areas in inland districts can benefit from agroforestry (ICRAF), the rainfed uplands and medium lands in the southern, western, and coastal districts can be cultivated with pulses if the rice harvest is advanced by a couple of weeks using shorter duration varieties or crop establishment practices (DSR, mechanized transplanting) that ensure an early harvest. Residual moisture would then be adequate for the establishment of a sequence crop of about 60 days. Some evidence exists based on the work of IRRI during the past couple of years in Odisha with rice varieties such as Sahbhagi dhan, DRR 44, and Binadhan 11 and short-duration green gram variety Virat.

Photo 2.2: RPMS app released by the director, DAFE, during the rice-fallow annual workshop

The short cropping window and temperature regime existing in the coastal plains favor the cultivation of pulses such as green gram and black gram, while chickpea can do well in northwestern districts (ICAR-IIPR, ICARDA, ICRISAT). Pulses requiring limited irrigation such as very-short-duration pigeonpea (ICPL 20338) can do well in rabi in coastal areas with appropriate crop geometry and provision for a couple of irrigations at critical stages.

2.1.6 Residualsoil moisture–derived rice-fallow suitability distribution map and area estimations

Residual soil moisture content after rice harvesting in kharif season is often sufficient in most of the districts to raise short-duration pulses (55–75 days) and oilseed crops. However, a detailed analysis of spatio-temporal profiles of soil moisture availability and duration during the rabi season was required to precisely target and use the short residual soil moisture window (varying from 10 to 30 days depending upon land and crop types).

An analysis of the long-term average of spatio-temporal soil moisture profiles can assist in identifying the areas having low, optimum, and excessive soil moisture during rabi. The daily SMAP (Soil Moisture Active Passive) and soil moisture product from months from October 2018 to April 2019 were obtained from NASA and analyzed.

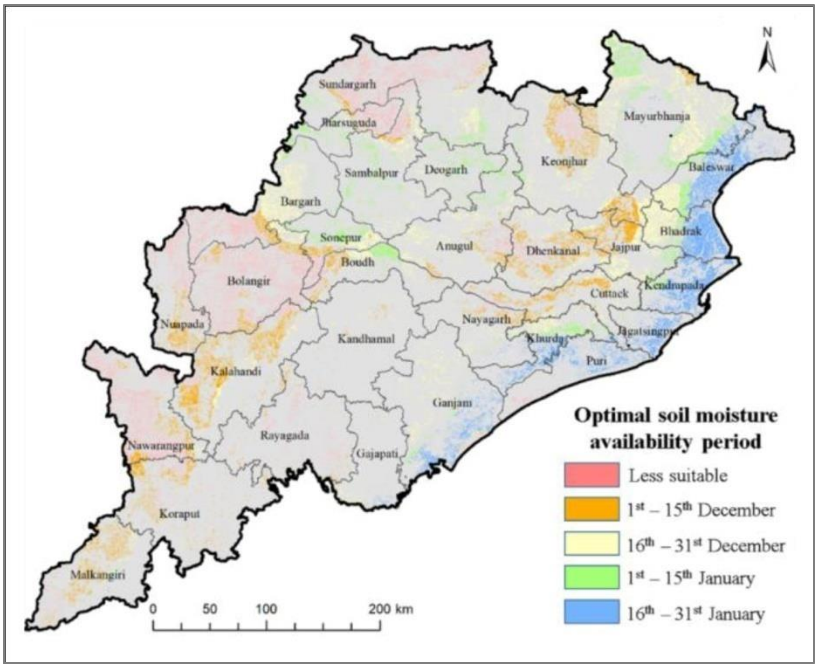


Figure 2.3. Soil moisture suitability for targeting rabi crops

The three-year average soil moisture data were used to generate a soil moisture suitability map of Odisha for targeting rabi crops (especially short-duration and water-efficient pulse crops) (Fig. 2.3). The rice-fallow area has been classified into five categories based on the optimum soil moisture availability from November to January. It also provides the information needed to (1) identify the areas where soil moisture is retained for a shorter or longer period after initial germination, and (2) determine whether adequate soil moisture can be available up to the pod formation stage of the crop. This information can significantly help to decide the type and duration of the cultivars to use as well as sowing time to target the pulse crop in the rice-fallow cropping system. Table 2.2 shows the district-wise extent of suitable area.

Table 2.2. District-wise rice-fallow suitable area estimates

District	Suitable area (ha)	District	Suitable area (ha)	District	Suitable area (ha)
Anugul	43,042	Ganjam	61,493	Malkangiri	7,157
Baleswar	120,926	Jagatsinghpur	32,824	Mayurbhanj	173,675
Bargarh	42,919	Jajpur	53,635	Nabarangpur	2,143
Bhadrak	125,408	Jharsuguda	11,578	Nayagarh	14,191
Bolangir	9,076	Kalahandi	18,423	Nuapada	6,752
Baudh	30,783	Khandamal	13,346	Puri	35,833
Cuttack	27,574	Kendrapara	79,006	Rayagada	404
Debagarh	14,092	Keonjhar	57,243	Sambalpur	48,281
Dhenkanal	19,179	Khorda	57,420	Sonepur	32,109
Gajapati	8,719	Koraput	1,170	Sundargarh	36,360
Total					**1,178,009**

2.1.7 Extrapolation domain suitability map of Mayurbhanj District

Extrapolation domain analysis (EDA) is a methodology for identifying geographical areas that are suitable for improved technologies (e.g. crops and cultivars, management practices, and thereby cropping systems) on the basis of well-defined criteria that account for each crop as part of the cropping system. With the availability of new drought-, flood-, and salt-tolerant rice cultivars, short-duration pulses, and other crops, along with improved agronomy and water management, significant opportunities exist for bringing large areas of rice fallows to double-cropped systems. The EDA approach was executed by using geo-spatial modeling and a decision tree approach to delineate the potential areas in Mayurbhanj District, which has the largest rice-fallow area of 1.86 lakh hectares.

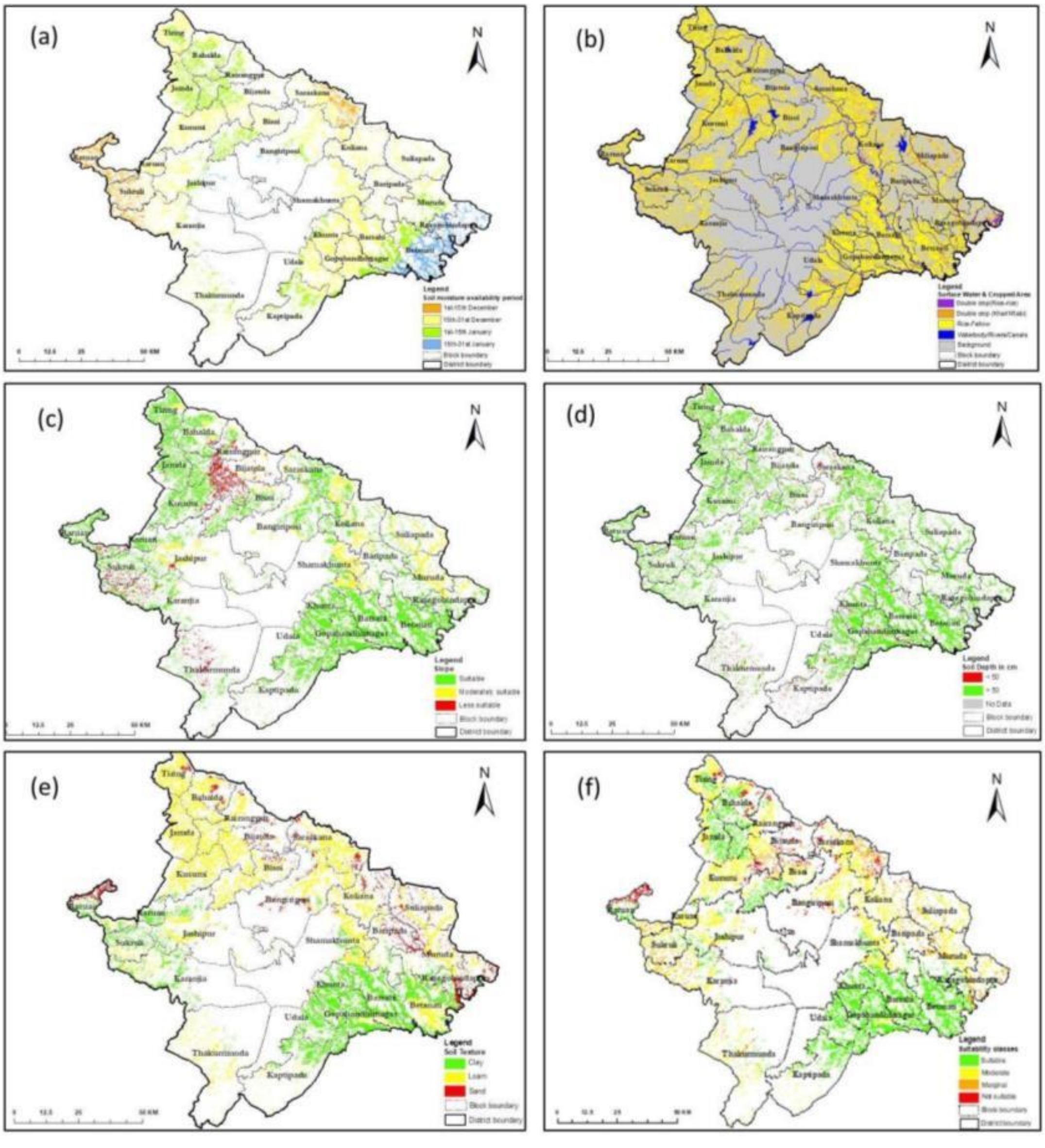


Figure 2.4. (a) Soil moisture map, (b) surface water irrigation map, (c) slope, (d) soil depth, (e) soil texture map, and (f) extrapolation domain suitability map of Mayurbhanj District

Table 2.3. Area estimates for rice-fallow suitable classes of Mayurbhanj District

SN	Classes	Area in Hectares	%
1	Suitable	86,704.3	46.7
2	Mod. suitable	70,828.5	38.1
3	Marginal suitable	17,907.5	9.6
4	Not suitable	10,301.5	5.5
Total		**185,741.7**	

Data on soil moisture, texture, slope, soil depth, and surface water irrigation map (Fig. 2.4) were used to generate an accurate extrapolation domain suitability map with four classes:(1) suitable, (2) moderate, (3) marginal, and (4) not suitable, with percentage area of 46.7%, 38.1%,9.6%, and 5.5% as shown in Table 2.3. The extrapolation domain map of suitable areas is useful to target the intensification of rabi crops in the rice-fallow system of Mayurbhanj District.

2.1.8 Rice-Fallow Atlas of Odisha

The first draft of the Rice-Fallow Atlas was prepared and shared with the DoA, for targeting water-efficient suitable short-/medium-duration crops in rice-fallow systems of Odisha. This Atlas has spatial distribution maps of rice-fallow area and soil moisture suitability area, and tables with area estimations of gram panchayat, block, and district level for all 30 districts in the state. The district-wise soil moisture profile window indicates the best time period suitable for growing rabi crops with available residual soil moisture in the particular location. State-level spatial distribution maps of different stress-prone areas such as flood and drought maps, land use/land cover maps, and cropping intensity maps are also included in the Atlas.

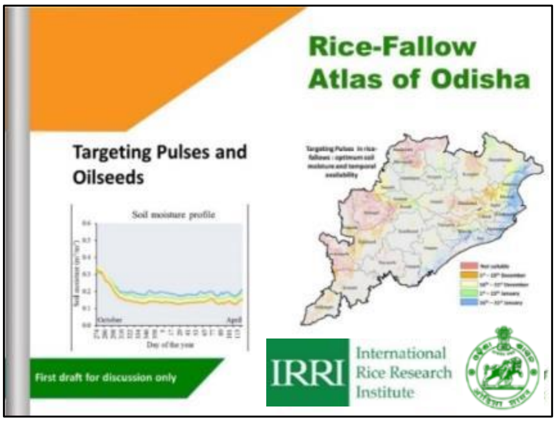


Photo 2.3: Rice-Fallow Atlas draft

2.1.9 Release of Rice-Pulse Monitoring System mobile application

Dr. M. Muthu Kumar, Director, Directorate of Agriculture and Food Production, released the Rice-Pulse Monitoring System mobile app on 9 September 2019 in Krushi Bhavan, Bhubaneswar. An updated version of the Rice-Pulse Monitoring System (RPMS) has been developed, which is a customized Android (phone/tablet)-based survey application system for rice, pulses, and oilseed crops that can be used to collect and store geo-referenced information, along with a suite of geospatial tools to visualize, analyze, and manipulate ground data for various needs of the Department of Agriculture in different projects

RPMS V2 features include coverage of rice crops (along with pulses and oilseeds in a cropping system mode), user-friendly polygon generation, and it can be converted to various formats (e.g., KML for viewing on Google Earth), has strong backend support and controls, and provides overlay and viewing facilities of geospatial layers (e.g., crop and land information, rice, rice fallow, flood, or drought areas).

RPMS V2 enables a better understanding of agricultural data for decision making for research and management purposes. RPMS's goal is to provide an open-source platform that can support online/offline applications.

Photo 2.4: RPMS app home page

2.1.10 State-level training-cum-workshop on Rice-Pulse Monitoring System mobile app

Photo 2.5: Participants of workshop on RPMS app in Krushi Bhavan, Bhubaneswar

One day of training on the RPMS mobile app was conducted for district-level scheme officers of 30 districts who are responsible for monitoring DAFE schemes such as NFSM, RKVY, and other state plans at the grass-roots level and update the Department with areas covered under different crops in each season. Sixty participants that included AAOs, DAOs, and DoA state-level officials attended the workshop. They were given a demo on RPMS app usage and application on spatially mapped crop fields of the beneficiary farmers, data on attributes, photographs, and links with the database of DBT or Aadhar on new farmers' registrations possible under individual schemes. Participants also received hands-on training on use of the RPMS mobile app and front-end and backend database to monitor all the mapped data uploaded on the server.

A one-day orientation and training program was organized on 26 September 2019 at IMAGE, Bhubaneswar. The objective of the workshop was to train the partners on pulse cultivation methods and improved management practices to establish pulse crops in the demonstrations conducted by NGO partners in various districts under the rabi 2019-20 program.

Expert faculty from OUAT provided training on best crop management practices, seed treatment chemicals, and insect and pest management practices for greengram and black gram at different stages. Participants from the 21 NGO partners, IRRI staff, and DoA officials took part in the workshop.

Photo 2.6: NGO partners and IRRI and DoA staff attending the training workshop

Multi-location audio conference on pulse seed treatment

Photo 2.7: Participants of multi-location audio conference on pulse seed treatment

Seed treatment plays an important role in production. However, not many farmers do it before sowing. IRRI, together with Reliance Foundation, organized a multi-location audio conference on seed treatment, covering 160 farmers from 10 districts (Khurda, Puri, Ganjam, Keonjhar, Deogarh, Dhenkanal, Baleshwar, Kendrapara, Malkangiri, and Bolangir). Farmers responded fairly well to this initiative and our experts have explained to the farmers how and when to practice seed treatment, which is essential for a successful crop. We received positive feedback from the farmers while interacting and they stated that it was beneficial for enhancing their knowledge. Based on this feedback, IRRI is planning to organize audio conferences on plant protection measures for healthy pulse production.

2.2 Activities in ricefallows during rabi season 2018-19

2.2.1 Varietal performance in pulse crop demonstrations in rice fallows (2018-19)

In rabi season 2018-19, 2,521 ha were targeted for pulse crop demonstrations in rice-fallow areas working with 13 NGO partners. Selected high-yielding extra-short-duration (55–75 days) disease-resistant varieties of green gram—IPM 205-7 (Virat), IPM-02-03, IPM-02-14, IPM 99-125 (Meha), and MH-421—were distributed to 4,674 farmers in 363 villages in 77 blocks of 21 districts to cover 1,541 ha. Similarly, black gram varieties PU-31, VBN-8, and Azad weredistributed among 3,625 farmers on 980 ha in 65 blocks in 19 districts, and were tested in demonstrations with a recommended fertilizer dose of 20:40:20 kg NPK per hectare in all treatments. Under the improved practice, the seeds were treated with carbendazim and imidacloprid before seed treatment with microbial cultures.

Improved practices provided a considerably higher yield than the conventional farmers' practice. Cuttack, Kendrapara, Balasore, and Mayurbhanj recorded yield as >8.5 q/ha (Figure 2.5).

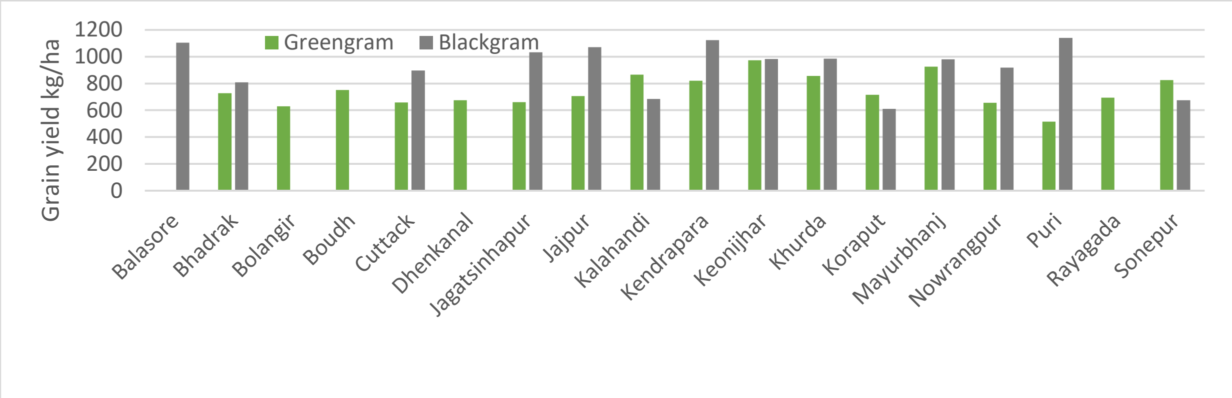
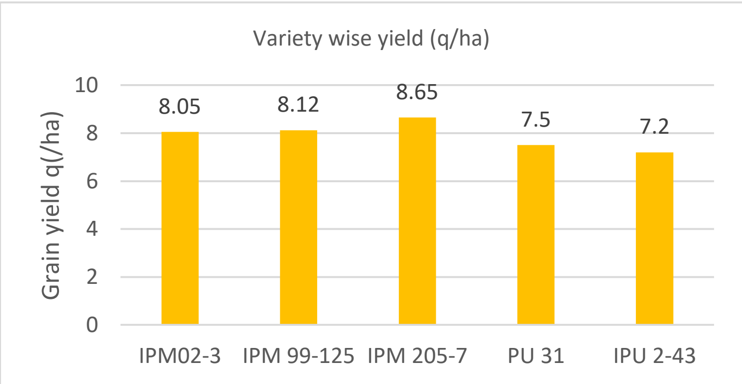


Figure 2.5. District-wise recorded yield in the demonstrated pulse crops



The highest yield was recorded with IPM 205-7 (Virat) (8.65 q/ha) and IPM 99-125 (Meha) (8.12 q/ha), whereasthe lowest yield occurred with IPU 2-43 (7.2 q/ha) (Figure 2.6).

Figure 2.6. Variety-wise recorded yield in the demonstrated pulse crops

The data reveal that yield is greater than 8.3 q/ha in mid-central table land, whereas the western undulating zone recorded the lowest yield (6.8 q/ha) (Figure 2.7).

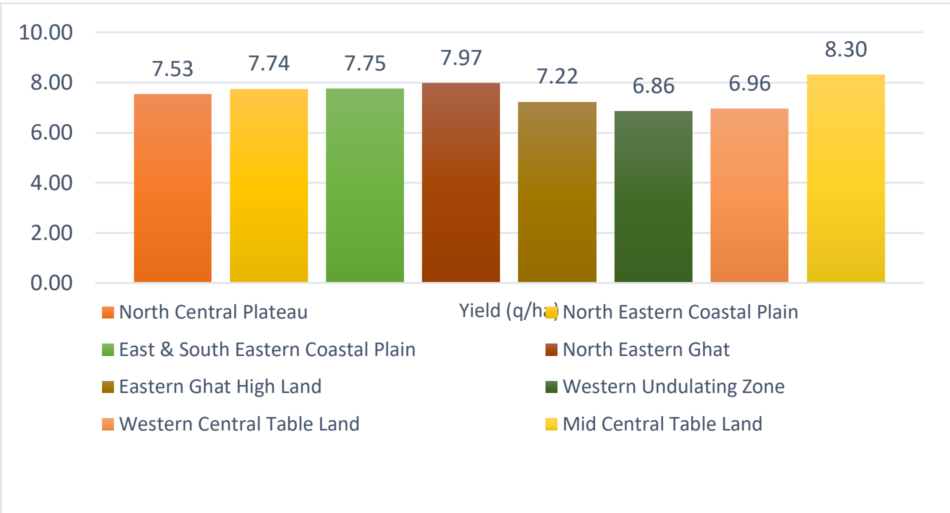


Figure 2.7. Agro-climatic zone-wise recorded yield in the demonstrated pulse crops

2.2.2 Adaptive trials of pulses in rice fallows (2018-19)

Photo 2.8: DoA officials visit IRRI adaptive trials conducted in two blocks of Puri District (2018-19)

In addition to the demonstrations, adaptive trials were taken up to explore the potential of new varieties and management practices wherein selected farmers are persuaded to try out the new interventions in comparison with their existing varieties and cultivation practices. A crop-cutting experiment (CCE) was conducted in 215 farmers' fields in 24 districts to estimate the overall crop performance. CCEs were carried out on a 25-m^2 (5m × 5m) area in fields, and the yield in each plot was computed and used to estimate yield per hectare.

2.2.3. IRRI-NRRI collaborative trials

Effect of moisture conserving and root growth promoting substances on greengram in rice fallows (2018-19)

A field experiment was carried out at the research farm of the ICAR – National Rice Research Institute, Cuttack, India during the rabi season, 2018-19 to study the effect of moisture conserving practices on green gram in rice fallows. Improved management practice (line sowing + seed treatment with fungicide, insecticide and rhizobium + recommended dose of fertilizers) was compared with farmers' practice (broadcast seeding without fertilizers) and seed-priming with hydrogel (hydrophilic polymer complex capable of cyclic absorption and desorption of water, band placed in soil along with seed), a nano-solution and *Trichoderma* (seed treatment). Nano- and bio-priming of green gram (var. Virat) with *Trichoderma* in combination with hydrogel application significantly increased number of pods and seed yield over the Improved Practice (Table 2.4). Cost of nano-chemical being prohibitive and the regulatory framework not in place for nano-chemicals, bio-priming with *Trichoderma* would be a good option, considering that this fungus had also exhibited arole in abiotic stress tolerance and biological control of sheath blight in rice.

Table 2.4. Effect of moisture conserving practices on yield and yield attributes of green gram in rice fallows

Treatment	No. of pods/ Plant	No. of grains/ Pod	Test wt. (g)	Stover Yield (q ha^{-1})	Grain Yield (q ha^{-1})	Bio mass (q ha^{-1})	HI
Farmers practice	11.12	10.06	35.28	24.82	6.51	31.33	0.21
IP	13.68	10.18	37.22	23.86	8.96	32.82	0.27
IP + Hydrogel	14.28	10.26	37.49	25.34	9.78	35.12	0.28
IP + Nano	15.2	10.66	41.2	27.7	10.31	38.01	0.27

Treatment	No. of pods/ Plant	No. of grains/ Pod	Test wt. (g)	Stover Yield (q ha^{-1})	Grain Yield (q ha^{-1})	Biomass (q ha^{-1})	HI
IP + Hydrogel + Nano	15.84	10.94	38.72	33.8	10.58	44.38	0.24
IP + Trichoderma	14.44	10.58	38.55	32.94	9.85	42.79	0.23
IP + Hydrogel + Trichoderma	15.44	10.7	37.98	30.5	10.32	40.82	0.26
IP + Hydrogel + Trichoderma + Nano	16.24	11.44	38.89	33.56	10.71	44.27	0.25
CD	1.02	0.44	1.12	3.89	0.45	3.37	0.02

2.2.4 IRRI-OUAT collaborative trials

Field and pot experiments were conducted on the OUAT research farm to test and validate productive cropping systems in rice fallows. The main objectives were to assess the effect of improved production techniques that use hydrogel and nano solution amendments to soils on green gram in a rice-green gram cropping system and upscaling best-fit management practices through adaptive trials.

Eight treatments were used with two varieties of green gram (Virat and IPM 02-14) in three replications. Plant height, pod length, yield, stover yield, and 1,000-grain weight were recorded at the time of harvesting. VIRAT yielded 252 kg/ha vis-à-vis 223 kg/ha for IPM 02-14; however, stover yield was noted at 877 kg/ha vis-à-vis 739 kg/ha for VIRAT.

Six pot experiments were conducted, in which VIRAT outperformed IPM 02-14 in plant hight (24.8 cm), pod length (5.6 cm), and yield (426 kg/ha), except for stover yield (807 kg/ha).

2.2.5 Multi-institutional crop trials (CGIAR) in rabi season in rice-fallow system (2018-19)

These trials were a follow-up to the workshops held on fallow characterization involving ICRISAT, ICARDA, and CIP as explained in section 2.1.5. Exploratory trials were conducted in rabi 2018-19 to test the suitability of other crops (chickpea, early varieties of red gram, and sweet potato). Five crops (sweet potato, pigeonpea, chickpea, black gram, and green gram) were demonstrated by three CGIAR centers (CIP, ICARDA, and ICRISAT) on 10 ha among 15 farmers in Puri District in one agro-ecological zone.

All the crops were established well but, unfortunately, cyclone Fani, which ravaged the area on 3 May, severely affected the crops in the different villages: 50% of the tubers were severely damaged by waterlogging after the cyclone. Crop-cut data indicated sweet potato yield of 1 t/ha but the farmer reported 1.2 t/ha after complete harvest of the crop. The development of super early maturing (<100days), photo-insensitive and determinate-type pigeonpea varieties such as ICPL 20338 by ICRISAT provides opportunities to expand the crop to non-traditional areas such as rice fallows with good potential to increase cropping intensity in states like Odisha.

Photo 2.9: Sweet Potato under evaluation in District Puri

In some fields, farmers managed to weed the crop with good crop stands and managed to harvest pigeonpea before cyclone Fani struck. Pigeonpea yield obtained was 0.25 t/ha. However, in some of the fields, the farmers lost the crop because of the cyclone as harvesting was delayed. Green gram and blackgram crops were at their harvesting stage during cyclone Fani. Nevertheless, short-duration greengram (Virat) yielded 7.5q/ha in the CCE.

Activities ongoing in ricefallows during rabi season 2019-20

2.2.1 Pulse cluster demonstrations targeting rice-fallow suitable areas (2019-20)

Rice-fallow crop suitability area maps (Fig. 2.8a) have been used as a basis for designing the demonstrations and adaptive trials for pulse crops. Based on suitable areas of proposed blocks and districts (Fig. 2.8b), pulse crop demonstrations are being conducted in 81 blocks in 23 districts covering about 2,500 ha (more than 6,000 farmers) through 18 NGO partners and the Odisha Livelihood Mission. Greengram varieties SIKHA, IPM 02-03, and IPM 2-14 and blackgram variety PU-31 are distributed in these demonstrations. Required certified seeds at 20kg/ha and seed-treating chemicals such as Thiram and Imidachloprid have been provided to the farmers as the most essential inputs for pulse production.

Training and awareness campaigns were conducted when distributing seeds and seed-treating chemicals. These inputs were distributed and training organized through NGO partners in the presence of DoA officials and KVK scientists. Thirty district-level training-cum-awareness programs on pulse cultivation were planned during rabi, and 18 such training programs have been completed, involving 1,112 farmers (238 women and 874 men) in 16 districts, and the programs are continuing. Senior officers of the DoA and KVK scientists are imparting training to the farmers as resource persons.

2.2.2 Adaptive trials in rice fallows

Adaptive trials with pulses are being carried out on 125 ha (green gram variety Sikha on 50 ha, Virat on 50 ha, and chickpea variety JG-14 on 25 ha) in six districts of the state (Table 2.5). Seeds are procured from IIPR-Kanpur, FIR, and RDF and herbicides and plant protection chemicals are given to the farmers.

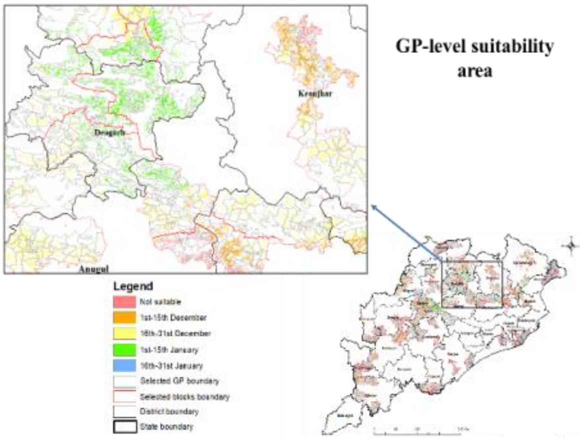


Figure 2.8(a). Rice-fallow crop suitability at GP level

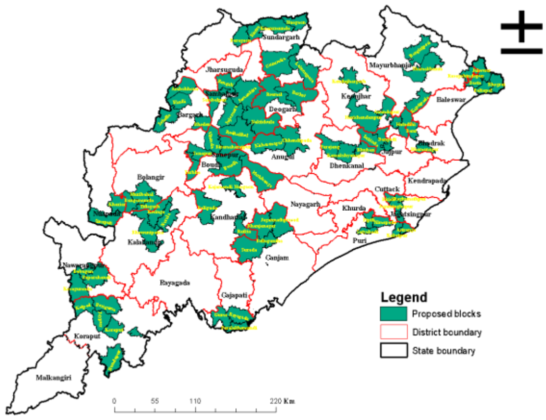


Figure 2.8(b). Proposed blocks and districts on demonstration site location maps

Table 2.5. District-wise distribution of pulse demonstrations, adaptive trials, and multi-institutional trials of rabi crops in rice fallows (2019-20)

SN	District	Demonstration area (ha)	Adaptive trial area (ha)	Multi-institutional trial area (ha)	Total area (ha)
1	Angul	60	-	-	60
2	Balasore	120	26	-	146
3	Bargarh	120	-	-	120
4	Bhadrak	62	-	-	62
5	Bolangir	90	-	-	90
6	Boudh	60	-	-	60
7	Debgarh	60	-	-	60
8	Dhenkanal	90	-	-	90
9	Gajapati	90	-	-	90
10	Ganjam	120	-	-	120
11	Jagatsinghpur	120	17	-	137
12	Jajpur	60	-	-	60
13	Kalahandi	95	8	22	125
14	Kandhamal	90	-	-	90
15	Keonjhar	120	-	2	122

SN	District	Demonstration area (ha)	Adaptive trial area (ha)	Multi-institutional trial area (ha)	Total area (ha)
16	Khurda	2	16	-	18
17	Koraput	150	-	4	154
18	Mayurbhanj	120	8	1	129
19	Nabrangpur	94	-	22	116
20	Nuapada	60	-	22	82
21	Puri	199	50	7	256
22	Sambalpur	184	-	-	184
23	Sonepur	120	-	-	120
24	Sundargarh	180	-	-	180
Total		**2,466**	**125**	**80**	**2,671**

Photo 2.10: Field visits by officers of the Department of Agriculture to Pulse demonstration sites at Khandiagiri, District Puri

Photo 2.11: IRRI team in discussion with JDA (Admn) Smt. Rajashree Singh, DAFP and CDAO, Puri, Shri C S Rao

2.2.3 IRRI-NRRI collaborative trials

Field experiments were conducted on the NRRI research farm to test and validate productive cropping systems in rice fallows. Two experiments (Experiment I: Effect of integrated crop management practices on productivity and profitability of green gram in rice fallows; Experiment II: System-based phosphorus nutrition in rice-green gram cropping system for higher productivity and profitability) were carried out with two varieties (IPM 02-03 and VIRAT) of green gram.

2.2.4 Multi-institutional crop trials (CGIAR) in rabi season in rice-fallow system (2019-20)

During 2019-20, IRRI and other CGIAR organizations jointly selected fields based on soil moisture profile data. Eleven crops (sweet potato, pigeonpea, chickpea, black gram, green gram, lentil, grasspea, onion, cabbage, brinjal, and tomato) are being demonstrated by four CGIAR centers (CIP, ICARDA, ICRISAT, and WVC) on 80 ha with 204 farmers in three districts (Mayurbhanj, Koraput, and Puri) in three agro-ecological zones.

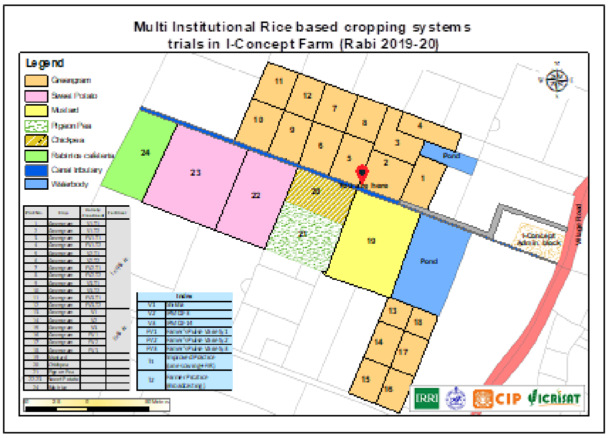


Figure 2.9. Sketch diagram for adaptive trials of different multi-institutional crops being conducted (2019-20) at I-Concept Farm, Pipili, Puri

While other CGIAR centers are demonstrating their mandated crops through this collaboration in different districts, IRRI has taken up a crop and varietal cafeteria on a farm named I-Concept with all the crops in one place for demonstration as well as evaluation of the different crops vis-à-vis the rice-rice system (Table 2.6). Four varieties of sweet potato (Kanchangad, Kisan, Bhu Krishna, and Bhu Sona) and three varieties of green gram (IPM 02-3, IPM 02-14, Shikha, and local pulse varieties) have been planted/sown with improved practices and the farmers' practice to assess the yield differences among them. Chickpea, pigeonpea, andmustard are also part of the cafeteria. Farmers in the adjacent areas are growing rabi rice. Figure 2.9 depicts a sketch diagram of the different multi-institutional adaptive trials being conducted (2019-20) at I-Concept Farm, Pipili, Puri.

Table 2.6. Collaborating institutes and area proposed under multi-institutional trials of rabi crops in different districts

Institution	Districts	Area (ha)	Demo crop	Previous cropping system in rabi	Involvement of NGOs/ partners (no.)
IRRI	I-Concept, OUAT,and NRRI	7	Pulse crop	Ricefallow/rice -pulse	3
CIP	Puri, Koraput,and Mayurbhanj	7	Sweet potato	Rice-pulse	3
ICARDA	Keonjhar	2	Pulse crop	Ricefallow/rice -pulse	1
ICRISAT	Kalahandi, Nuapada, Nabrangpur	22 ha in each district	Chickpea/ Pigeonpea	Ricefallow/rice -pulse	3
WVC	Koraput and Puri (I-Concept)	2	Vegetables	Ricefallow/rice -pulse	1

Subproject 3: Raising the Productivity and Profitability of Rice-based Cropping Systems in Odisha through Rice Crop Manager (RCM)

Subproject 3: Raising the Productivity and Profitability of Rice-based Cropping Systems in Odisha through Rice Crop Manager (RCM)

The diverse landscapes in which rice is grown in Odisha with varieties ranging in duration from ~100 to 160 days under rainfed and irrigated conditions in field plots that are direct-seeded or transplanted call for crop management that is tailored to the specific conditions. Rice Crop Manager, developed by IRRI as a web-based, site-specific nutrient management tool, caters to this need. IRRI launched RCM in Odisha during 2016 and has so far disseminated recommendations to more than 75,000 farmers in the major rice-growing districts. During 2019-20, IRRI strived to establish accessible and outbound channels to increase the reach of RCM recommendations and facilitate the adoption of recommendations by farmers through farmer-managed comparative evaluations of RCM recommendations vis-à-vis farmers' practices. These trials have shown yield advantages ranging from 0.5 to 1.0 t/ha/season, and monetary gain of INR~11,000/ha/season for farmers by way of additional yield and/or reduced input costs when following RCM recommendations. To make the benefits cascade to rice growers across the state, IRRI partnered with several extension agencies that facilitated wider dissemination of RCM through their channels. The efficacy and sustainability of these channels as information providers was also assessed. Research trials to further refine the tool were conducted in parallel.

Dissemination of the RCM tool: awareness, accessibility, and acceptability

Photo 3.1: ToT for district managers of CSC

RCM recommendations are robust when accurate information is fed to the tool through farmers' interviews. Hence, it is important to train the stakeholders on conducting the interviews, recording and feeding the responses correctly to generate plot-specific recommendations. During kharif 2019, 67 training programs were held and 1,114 participants belonging to DoA, NGO partners, private partners, and progressive farmers were trained to use the RCM tool and generate recommendations (Photo 3.1). During rabi 2019-20, the focus will be on involving and training more rural youth and women farmers on the RCM tool.

Dissemination of recommendations

During kharif 2019, recommendations were generated for around 75,000 farmers. Different channels were used for interviewing farmers and generating recommendations. Apart from the regular channels of the DoA and NGOs, two new extension channels, Common Service

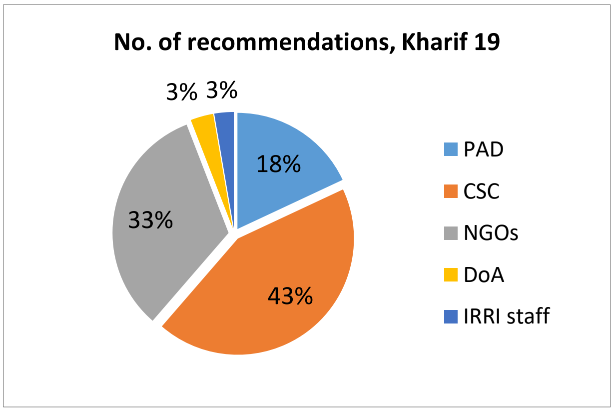


Figure 3.1. Proportion of recommendations generated by different channels

Centers (CSC) and Precision Agriculture for Development, India Foundation (PAD-IF), were convinced to reach the farmers (Figure 3.1).

Photo 3.2: CSC are providing RCM recommendations to visiting farmers

A Letter of Agreement (LoA) was signed between IRRI and CSC in 2018 to use their network of widely distributed service centers to promote the use of balanced fertilizer among rice farmers by providing them with RCM recommendations. CSC, run by franchisees called Village-Level Entrepreneurs (VLEs), provide various electronic services to citizens across rural India. These centers are available at the GP level and are frequently visited by farmers to register for different government schemes such as Pradhan Mantri Fasal Bima Yojana (PMFBY). During 2019, RCM was integrated onto the web portal of CSC. District managers of all the districts of Odisha were trained in a ToT mode and, in turn, they trained the VLEs to operate and generate recommendations using RCM. During kharif 2019, around 30,000 recommendations were provided to the farmers by VLEs through CSC spread across the state (Photo 3.2). During rabi 2019-20, around 4,000 farmers have received RCM recommendations.

Photo 3.3: PAD staff are disseminating RCM recommendations through the call center

PAD-IF supports farmers by providing customized agricultural information via their mobile phones. Initially, PAD-IF collaborated with IRRI to send RCM recommendations via voice calls to farmers synchronized with the time of application of fertilizer doses to reinforce the advisory provided by IRRI at the beginning of the season as printed recommendations. During kharif 2019, call center staff of PAD (n=40) in Bhubaneswar were trained to operate RCM also (Photo 3.3). The trained staff interviewed around 12,500 farmers through the call center and generated recommendations for them. These recommendations were then converted into voice calls and field-specific recommendations were sent to the interviewed farmers on their mobile phone. To record farmer feedback, a survey call after each application advice call was sent and the responses from farmers—whether they have followed the recommendations or not—were recorded. For ongoing rabi, interviews are in progress and advisories are being sent through voice calls.

Demonstrations: seeing is believing

More than 500 demonstrations were established in farmers' fields during kharif 2019 with an objective to showcase the benefits of balanced fertilizer application using RCM recommendations. Farmers were able to compare the advisories being given through RCM with their existing practices through crop cuts (Photo 3.4). In partnership with the BGREI scheme across seven districts, 285 farmers received RCM recommendations along with other BGREI technologies. In

RCM plots, a yield gain of 0.5–1.0 t/ha was recorded from the monitored plots (10% of the total recommendations).

Photos 3.4: Demonstration plots with RCM recommendations

Awareness through multi-media communications

Photo 3.5. Advertisement in newspapers and audio-conferencing to increase awareness on RCM

Reliance Foundation, under its rural transformation program, uses print and electronic media to disseminate information on improved agricultural technologies. IRRI partnered with them for promotion and awareness creation about various technologies, including RCM. Advertisements and information on the availability of RCM in the CSC and DoA block offices were published in the newspaper in collaboration with RF (Photo 3.5). One audio conference was organized to make the farmers aware about the tool and its benefits, to which more than 150 farmers across the state participated (Photo 3.5).

Posters were placed in public places such as panchayat offices, schools, community offices, government buildings, etc., to spread the message regarding availability and benefits of RCM recommendations (Photo 3.6).

Photos 3.6: Promotional banners

Field days, crop cuts, awareness meetings, farmers' fairs, and World Soil Day were some of the events used to create awareness about RCM across the state (Photo 3.7). These events were used to tell farmers about the benefits of applying field-specific nutrients in the right quantity at the right time.

Photo 3.7: Awareness through field days and Krushi mela

Studies undertaken/ongoing

Assessing efficacy of dissemination channels: Three students from ISB interned with IRRI for three months to study the dissemination channels being used by IRRI for promoting RCM and to assess the possibility of developing business models. They analyzed primary and secondary data and interviewed channel partners for the study. A priority matrix formulation for districts based on density of rice area spread, rice area of the district as a percentage of Odisha's rice area, and yield was created (Photo 3.8).

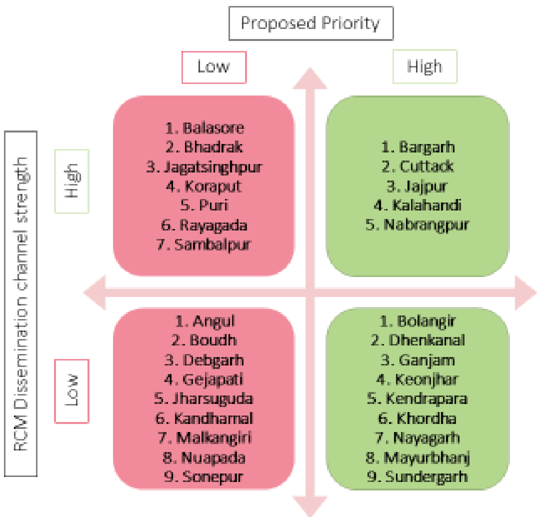


Photo 3.8. Priority matrix for districts in Odisha

Some important recommendations from the study were the following:

- Savings per ha (average) from RCM should be printed on the recommendations sheet/pamphlet
- Training of women leaders from the village who can approach self-help groups and promote the adoption of RCM will help to further disseminate the RCM tool
- Advertising RCM on fertilizer bags can add benefit and create awareness

Strategic and adaptive research

Several experiments were conducted for developing and evaluating better nutrient and crop management systems (Table 3.1). The results from these experiments will be used to develop better decision trees for rainfed environments in RCM.

Table 3.1. Details of strategic and adaptive trials conducted during 2019-20

No./ Activity	Experiments	Targets			Achievements	Kharif 2019 and rabi 2019-20
		Number	Districts	Blocks		
1. Development of better nutrient and crop management for rice	Evaluation of RCM with different STRVs for wet DSR	1	1	1	1 (kharif)	IRRI-OUAT experimental station
	Evaluation of crop management component of RCM (weed management)	16	3	6	15 (kharif) + 1 (on-station)	IRRI-NRRI Total: 16 trials
	Development, validation, and evaluation of RF component of CMRS	40	11	15	40 (kharif) + 40 (rabi)	Total: 80 trials (along with subcomponent 1)
	Development and evaluation of RCM for wet DSR	10	4	8	40 (kharif) + 40 (rabi)	Total: 10 trials
	Adaptive trials on using GIS-based yield monitoring for developing higher yield targets	30	2		19 (kharif) + 17 (rabi)	Total: 36 trials (along with subcomponent 5)
	Development of better zinc management for rice-based systems for Odisha				95 farmers (kharif) +75 farmers (rabi)	Total: 170 farmers
2	Development of better nutrient management module for rice-pulse systems for Odisha	50	10	15	18 trials (rabi)	Total: 18 trials (along with subcomponent 2)

Salient findings recorded during kharif 2019 and rabi 2019-20 from various trials

Photo 3.9: IRRI-OUAT trial on direct-seeded rice and RCM

Under the IRRI-OUAT **collaborative project**, one on-station experiment was conducted (Photo 3.9). Direct seeding of STRVs coupled with RCM-based nutrient management practices was close to transplanted coarse rice for variety BINA 17 (5.43 t/ha) followed by Sahbhagi dhan (5.11 t/ha). Additionally, with DSR, there was a saving of about INR 3,000–4,500 per hectare due to optimum nutrient management using RCM and nursery management, and a saving in labor cost and irrigation water. DSR with reduced tillage has been reported to be an efficient resource-conserving technology.

During kharif 2019, 15 on-farm trials were conducted in three districts (Puri, Jajpur, and Cuttack) under the **IRRI-NRRI collaborative project**, for evaluating the crop management component of RCM (weed management) (Photo 3.10). The crop cut and farmers' awareness program were followed by data collection. The treatments consisted of T_1: Farmers' practice (both nutrient and weed management), T_2: Farmers' practice + RCM-based weed management only, T_3: RCM-based nutrient management only, T_4: RCM-based nutrient- and herbicide-based weed management, and T_5: RCM-based nutrient and mechanized weed management. T_4 treatment resulted in higher yield (18%) than with T_1. The herbicide-based weed management includes the following:

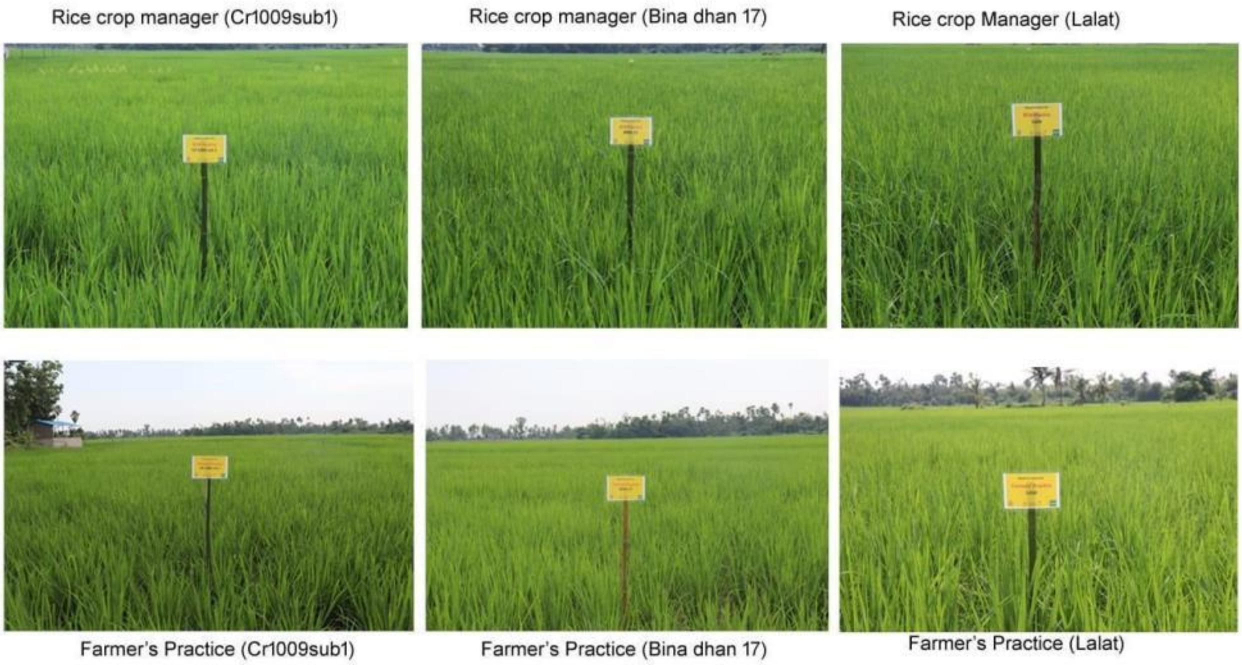
- Pre-emergence application of pretilachlor (40 g/ha) at 2–3 DAT
- Post-emergence application of bensulfuron methyl + pretilachlor (60+600 g/ha) at 5–7 DAT

Photos 3.10: NRRI-OUAT collaborative trials on nutrient and weed management

Development, validation, and evaluation of rainfed component of CMRS

Balanced fertilizer application ensures better crop response and climate and environmental sustainability. Recognition of within-field variability in soil characteristics, crop nutrient need, nutrient supply, and crop yield by site-specific nutrient management (SSNM) is gaining acceptance among farmers as technology advances in Odisha. Stress conditions (either flood or drought) in rainfed conditions affect nutrient management strategies. Management of nutrients inrainfed environments under stress conditions needs to be studied and therefore the present study has been implemented to develop better nutrient management options for rainfed environments.

In kharif 2019, selected farmers (n=40) of the different districts of Odisha were provided with stress-tolerant rice varieties as per sitesuitability. In head-to-head trials, every farmer's field was divided into four plots with the help of bunds (Photo 3.11). The treatments applied were as follows: (1) farmer fertilizer practice (FFP) + site-suitable stress-tolerant rice variety (STRV), (2) Rice Crop Manager (RCM) + farmer variety (FV), (3) RCM + site-suitable STRV, and (4) a check of FFP + FV.



Photos 3.11. Multi-location head-to-head trials on testing combined effect of STRVs and RCM

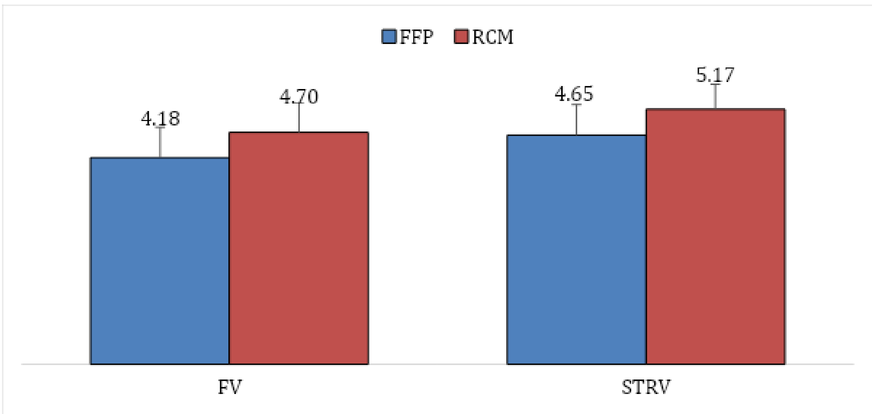


Figure. 3.2. Performance of nutrient management and STRVs in head-to-head trials: stress-prone rainfed condition

Over the FFP, RCM recommendations could produce a yield advantage of 0.52 t/ha and 0.52 t/ha, respectively, in the context of a farmers' variety and site-suitable STRV. The average yield gain was even more (0.99 t/ha) when a better nutrient management practice (RCM) and site-suitable STRV were considered together (Fig. 3.2). Thus, the potential profit in paddy selling is INR 17,325/ha if the farmers follow IRRI practice instead of their own practice. Such an increment in yield and profit might be due to fractional nutrient substitution (i.e., the right dose at the right time).

Development and evaluation of RCM for wet DSR

Photos 3.12: Field demonstration of RCM and wet direct-seeded rice

Direct-seeded rice (DSR) is gaining momentum in areas where there is a scarcity of labor, water, and energy, and unbalanced nutrient application and rising cost of production, along with climate variability. In kharif 2019, selected farmers (n=10) in two districts (Puri and Bhadrak) received recommendations using Rice Crop Manager for wet DSR (Photo 3.12). Each farmer was to follow an RCM-based recommendation in one of the plots and his own farmer fertilizer practice in a similar plot. The average yield of wet DSR through broadcasting under the RCM recommendation was 5.49 t/ha and 4.92 t/ha for the FFP, hence recording a yield gain of 0.57 t/ha for DSR-RCM (Fig. 3.3). Such an increment in yield leads to profit of INR 9,975/ha.

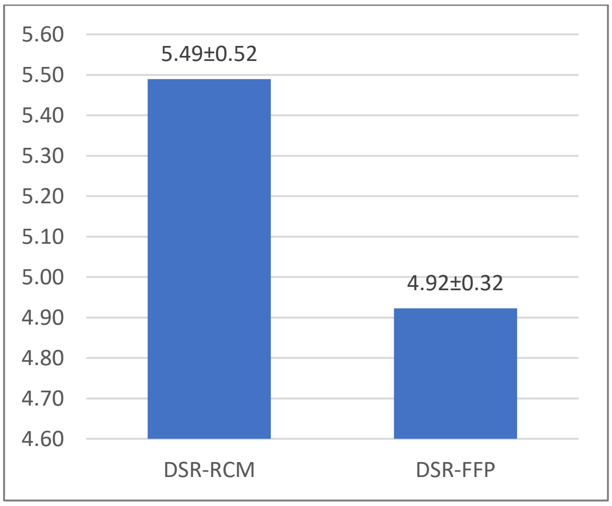


Figure 3.3a and 3.3b. Grain yield and average NPK applied in DSR-RCM and DSR-FFP trials

Adaptive trials on using GIS-based yield monitoring for developing better yield targets

Selected farmers in Puri and Balasore districts, Odisha, were provided with two types of Rice Crop Manager recommendations. Currently, the RCM tool uses yield data from the last season and crop modeling using ORYZA to set the target yield. The GIS-based RCM set target yield using a GIS tool considering soil, plant, and local environmental conditions.

The objective of this study was to understand the accuracy of the GIS approach for yield estimation over a farmers' questionnaire: (1) using GIS-based RCM yield input (treatment) and (2) using farmer-based RCM yield input (check). Average fertilizer dosages under the intervention are shown in Figure 3.4. Average target yield, average actual yield, and the mean difference were more for farmer-based RCM yield (Fig. 3.4), but the obtained yield per kg NPK application was more under GIS-based RCM.

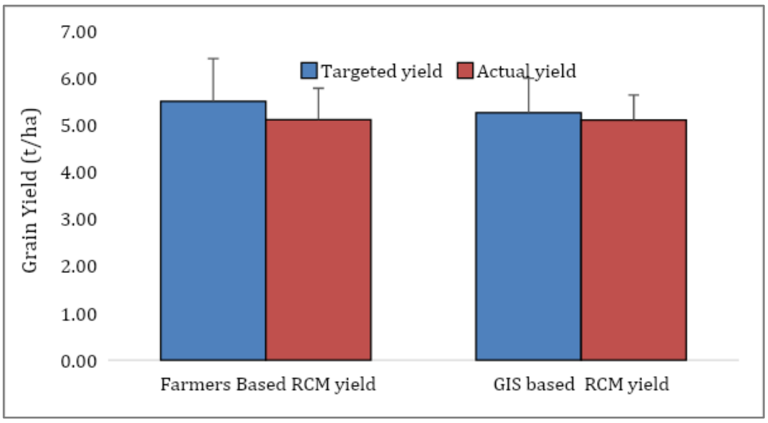


Figure. 3.4. Average grain yield: GIS-based RCM yield vs farmer-based RCM yield

Zinc management options for Rice Crop Manager

Zinc (Zn) is now considered the fourth most crucial yield-limiting nutrient after nitrogen, phosphorus, and potassium, respectively. Its deficiency causes a significant decline in yield and quality of the rice crop. The timing and rate of application of Zn are critical for obtaining higher crop yield and improving its use efficiency. Zn management in rice requires serious attention as inappropriate knowledge of application rate and timing may result in an imbalanced application of commercial Zn fertilizers, which are expensive.

Photos 3.13: On-farm zinc management trials

An on-farm study was therefore conducted in different districts of Odisha in order to understand the effect of timing and rate of Zn application in site-specific nutrient management. Fifty selected farmers from different districts were provided with RCM recommendations under the following treatments: (1) half dose of zinc in nursery, (2) full dose of zinc in nursery, (3) half dose of zinc in transplanted field, and (4) full dose of zinc in transplanted field (Photo 3.13). These treatments were further compared against the RCM recommendation generated based on the practice of applying compost in the nursery. Figure 3.5 depicts treatment-/check-wise average yield.

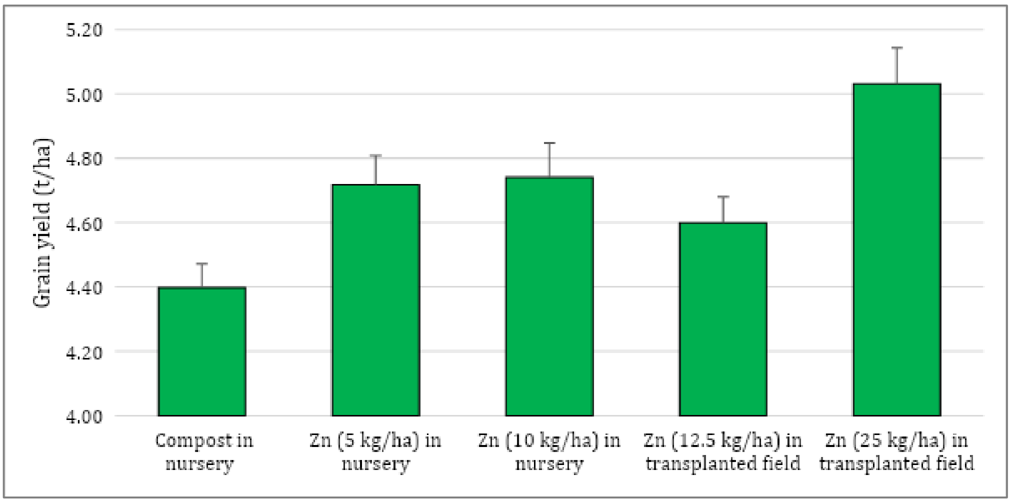


Figure. 3.5. Treatment-wise yield obtained by $ZnSO_4$ application based on transplanted area (kg/ha) with RCM NPK recommendations

The maximum yield obtained was in the treatment using a full dose of Zn in the transplanted field, which averaged 0.63 t/ha more than the minimum yield recorded with compost application in the nursery. Zinc application in the nursery was also found more promising than compost application in the nursery. Overall, the profit obtained was INR 11,036/ha in the best treatment. Application of only 5 kg/ha gives a monetary benefit of INR 5,547 compared with INR 3,483 when 12.5 kg is applied in the main field (Fig. 3.6). Because zinc is costly, farmers will prefer to apply 5 kg in the nursery to obtain a higher benefit.

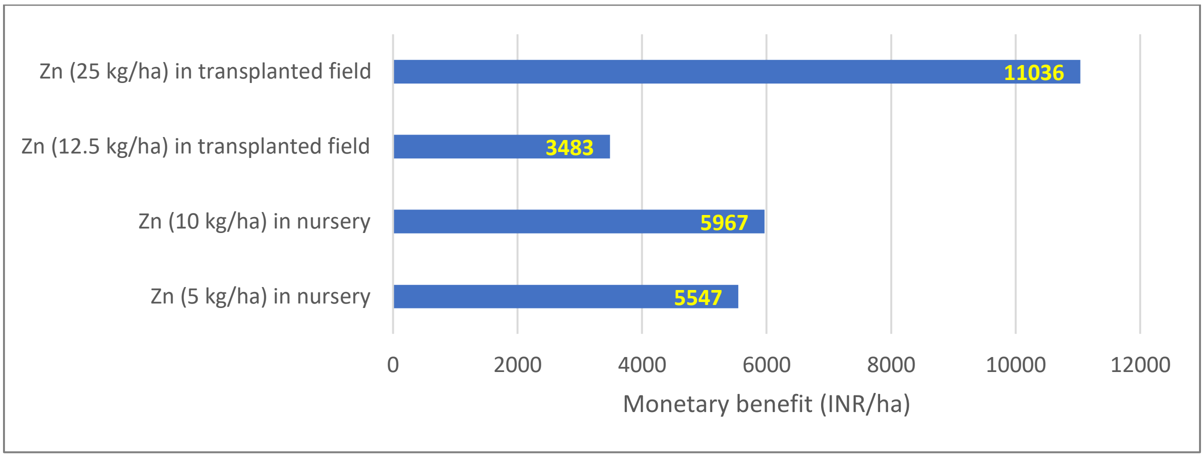


Figure 3.6. Monetary benefit by $ZnSO_4$ application along with RCM NPK recommendations

Demonstration of Rice Crop Manager practice vis-à-vis farmers'fertilizer practice

RCM provides the recommendation on the basis of site specificity, which ensures balanced nutrition for the rice crop and helps improve the productivity of rice suitable for both irrigated and normal rainfed conditions. Demonstration plots were established in farmers' fields in a head-to-head manner in different districts of Odisha where the RCM practice was compared against the farmers' fertilizer practice (FFP) (Photo 3.14). Crop cuts in kharif 2019 were done in a few selected monitored plots in the presence of government officials, farmers, and other relevant stakeholders. An average grain yield of 5.38 t/ha (n= 50) was recorded from RCM-monitored plots vis-à-vis 4.67 t/ha (n = 48) from FFP; thus, a yield gain of 0.71 t/ha (15.2% higher yield) using RCM (Fig. 3.7). In monetary terms, this translated into a profit of INR 12,425/ha using RCM practice.

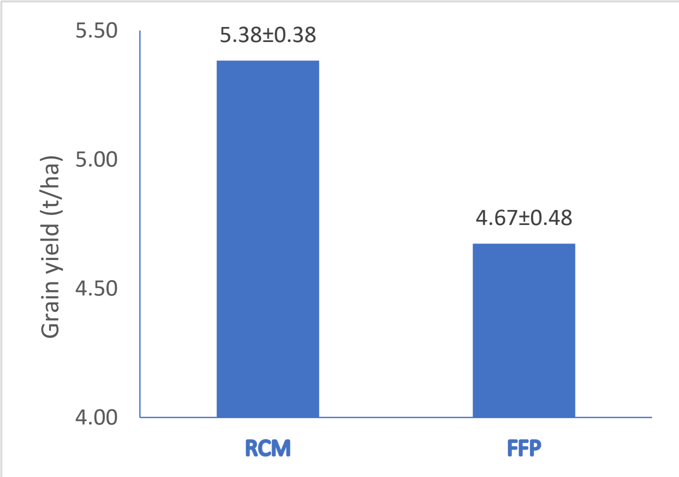


Figure 3.7. Average grain yield of RCM vs. FFP

Photo 3.14. On-farm demonstration of RCM vis-à-vis farmers' fertilizer practice

Subproject 4: Inclusive Development through Knowledge, Innovative Extension, Methods, Networks, and Capacity Building in Odisha

Subproject 4: Inclusive Development through Knowledge, Innovative Extension, Methods, Networks, and Capacity Building in Odisha

Food and nutrition security and livelihood resilience are not only a technological challenge but equally a social and institutional one. All farmers are not a homogeneous group and have differential access to knowledge, technologies, and resources needed to apply the technologies. Women and smallholder farmers are a case in point. In addition, technologies are not neutral. The outcomes experienced by different social groups from the use of technologies depend on the social and institutional context in which they are embedded. Hence, one size does not fit all. As we pursue knowledge-driven agricultural transformation, to have the widest impact, we need differentiated strategies to make knowledge and technologies accessible and to develop a responsive institutional system that recognizes and addresses these differences. To promote the use of knowledge-intensive agriculture, extension and advisory services also need to adopt innovative methods of knowledge transfer and are key for creating an enabling environment for the development, dissemination, and adoption of new science and technologies. To be able to drive this, their capacities in turn need to be enhanced.

The subproject "Inclusive development through knowledge, innovative extension methods, networks, and capacity building" aims to catalyze changes in the capacities of a wide range of actors, including researchers and agricultural extension agents, making them more responsive to the differential requirements of the rice farming community. This subproject also focuses on women farmers' entrepreneurship development to capitalize on the positive environment and enabling conditions created by the state government to support collectives such as FPOs and FPCs. The project works with a diverse set of partners in this process, including ICAR-CIWA, ICAR-NRRI, ICAR-IIRR, OUAT, Access Livelihoods Consulting India, Center for Research on Innovation and Science Policy (CRISP), and several NGOs, to achieve the following objectives:

- Development of Rice-based Cropping Systems Knowledge Bank (RKB), Odisha
- Development of Rice Doctor (RD), Odisha
- Designing and testing context-specific integrated pest management (IPM) interventions
- Strengthening capacity of extension and advisory service (EAS) providers
- Leadership and Entrepreneurship development of women in Agriculture Program (LEAP)
- Research capacity development through Scholars Program

The activities undertaken and outputs achieved in these areas are described in the following sections.

4.1 Rice-Based Cropping Systems Knowledge Bank (RKB) Odisha

Rice Knowledge Bank (RKB) Odisha is a digital extension service that provides practical knowledge solutions, tailored for smallholder farmers in Odisha. The knowledge bank showcases rice production techniques, agricultural technologies, and good farming practices relevant to Odisha based on available knowledge from research findings, learning, and media resources.

It is available as a digital repository of a set of accessible and usable materials in the form of management practices, ICT tools, videos, fact sheets, awareness materials, etc. The knowledge bank is available as both a website and mobile app. The standardized web portal can be accessed from the World Wide Web, and the mobile app can be downloaded from play stores and app stores. It is available in both English and Odia to help users navigate the portal and mobile app in their preferred language. The Odia module has been integrated with Odia Unicode fonts to enable computing devices and users to read the available content without installing additional language programs or software.

Although this endeavor started with a focus on rice, in 2019, it was expanded to include other crops that are pertinent to the rice cropping systems in various parts of Odisha. IRRI organized writeshops with domain experts to develop content for the RKB, which was subsequently vetted by the state-level knowledge management committee. Four writeshops were organized to cover genetics and plant breeding, soil science, agronomy, plant protection, mechanization, and postharvest management. The writeshops were attended by scientists and experts from the Directorate of Agriculture and Food Production, Odisha; ICAR-National Rice Research Institute; Odisha University of Agriculture and Technology; ICAR-Indian Institute of Water Management; and IRRI. The approved products were later translated into Odia. On 1 August 2019, the state knowledge management committee finalized the structure of the Rice-based Cropping Systems Knowledge Bank Odisha, and also discussed the maintenance and updating of technical content, real-time interaction solutions for farmers, voice services, user testing, etc.

Photo 4.1: Launching of RKB at Krushi Odisha 2020

Subsequently, the RKB mobile app was developed. Data in various formats under different modules were uploaded, re-checked, and the beta-version developed. The Rice-based Cropping Systems Knowledge Bank was released on 23 January during Krushi-Odisha (Photo 4.1) by the Government of Odisha.

Structure and content of the knowledge bank

Home: The home page of the RKB is the gateway to all the sections, language option, key links, partner information, contact details, and social media (Photo 4.2). One option allows users to send their feedback. The search function works as a single entrypoint for accessing website information through keywords. The link to access the RKB is [www.rkbodisha.in.](http://www.rkbodisha.in)

Photo 4.2: Home page of Rice-Based Cropping Systems Knowledge Bank. Web Portal

Cropping systems:

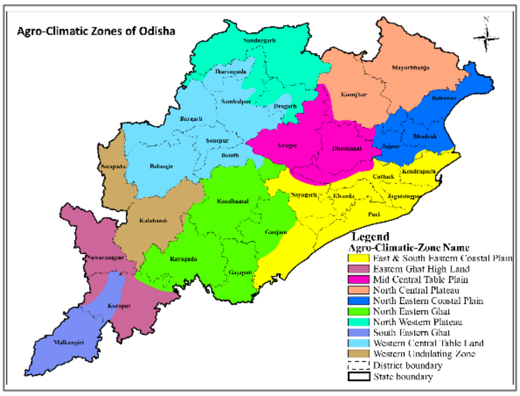


Photo 4.3: Agro-ecological zones of Odisha

This section provides information about the choice of crops, sequence of crops grown, and their practices. It highlights all cropping sequences (mono-cropping, mixed cropping, sequence cropping, etc.) practiced in Odisha under ten different agro-climatic zones. Maps delineating districts and regions covered under each agro-climatic zone are included (Photo 4.3). Information related to geographic area, soil type, source of irrigation, climate, rainfall, main crops grown, etc., is furnished for better understanding of cropping patterns.

Rice: This section contains information pertaining to rice cultivation in Odisha under different ecosystems and climatic conditions, in addition to information on crop management and systems of rice cultivation in the state. A filtering option is available for 30 districts to select suitable varieties based on environment, season, and stress conditions. The varietal information was collated from IRRI surveys, OSSC, SeedNet portal, ICAR-NRRI, etc., and updated during content writeshops. Varietal selection results appear in the following format as mentioned below.

- Variety duration
- Suitable ecology
- Suitable season
- Plant height
- Grain type
- Days to 50% flowering
- Abiotic stress tolerance
- Biotic stress tolerance
- Special feature potential yield

Figure 4.1. A sample varietal information sheet

Information about a particular variety can be downloaded as a varietal information sheet in PDF format from the download option attached to each variety (Fig. 4.1).

Production practices across various stages have been presented in pictorial form and include information on rice varieties, seed quality, crop calendar, land preparation, planting, water management, nutrient management, weed management, pest and disease management, harvesting, drying, storage, milling and processing, and rice by-products (Fig. 4.2).

Seed production: This section provides comprehensive information on rice seed production methods, stages of seed multiplication, and the certification process in Odisha.

Pulses and oilseeds: This section focuses on the main pulses and oilseeds grown in the state, their production system, and practices going from field preparation to storage. Crops covered include green gram, black gram, horse gram, groundnut, mustard, and sesame.

Figure 4.2. Stages of production

Tools section: This section showcases and provides access to ICT tools, namely, RKB Odisha mobile app, Rice Doctor mobile app, Rice Crop Manager (RCM) web app, Rice-Pulse Monitoring mobile app, and Crop Insurance Simulation app. Using the links provided, RCM can be accessed directly and other tools can be downloaded.

Resources section: Dropdown menus provide access to various materials, including factsheets, manuals, and videos. Using the filter option, both English and Odia factsheets can be accessed. A total of 152 factsheets in English and Odia are now available for download covering different subjects such as crop establishment, crop planning, biotic stresses, abiotic stresses, land preparation, mechanization, nutrient management, postharvest management, seed, variety, water management, and weed management.

A set of keywords has been added to the programming in the filter option for making factsheet search easier. The result appears after Search in the format below, and the download option in the last column has both an English and Odia version of the factsheet in PDF format.

Factsheet title	Subject	Summary	Download

The materials section is an archive of several types of material such as booklets, brochures, leaflets, success stories, and user guides, etc., for view and download. All the materials are available in PDF format.

Gallery section: In this section, images related to various topics covering seed and varieties, land preparation, nursery management, crop establishment, pests and diseases, crop management, postharvest mechanization, and capacity building can be viewed.

RKB Odisha mobile app

The RKB Odisha mobile app (Photo 4.4) is available in Google Playstore for Android devices and in App Store for Apple devices. The mobile application is available in both English and Odia. The app has two major sections, rice and other crops, along with cropping systems information, ICT tools, a download section with all knowledge materials, videos, and a feedback section for questions and suggestions. The app is designed with quick-access icons to obtain information easily. The content of the web portal and mobile app has been synchronized to manage updates and information.

Photo 4.4: RKB Odisha mobile app

RKB orientation

Photo 4.5: RKB orientation

Orientation on the Rice-Based Cropping Systems Knowledge Bank has been completed in five districts: Kalahandi, Puri, Nayagrah, Khordha, and Cuttack (Photo 4.5). Six more districts have been planned for the rabi season. Orientation included presentation, discussion, and hands-on training. Training was given to extension agents of the state agriculture department, progressive farmers, and seed dealers. This orientation followed the good-quality rice seed production and Seedcast training.

4.2 Development of Rice Doctor Odisha as a diagnostic tool for extension advisors and farmers in Odisha

Rice is subject to a variety of biotic and abiotic stresses, which, if left untreated, can lead to significant yield losses and poor return on investments. In a study conducted by IRRI, it was found that, on average, farmers lose 37% of their rice yield to insect pests and diseases, and these losses can range from 24% to 41% depending on the production situation (https://blog.plantwise.org/2015/08/06/ecological-engineering-approach-for-rice-pest-management-need-to-popularise-its-advantages/). To be able to manage yield-limiting factors effectively, the most important step is an early and correct diagnosis of the problem. Once a diagnosis is established, managing the problem is critical to avoid production losses. The right management techniques must be applied correctly and at the appropriate time.

Farmers seek information and help from fellow farmers, agri-input dealers, village agricultural workers, and other extension service providers to manage field problems. Ready access to information on a handheld device allows extension advisors, farmers, and other stakeholders to identify problems in the field and immediately take action to prevent further injury to crops.

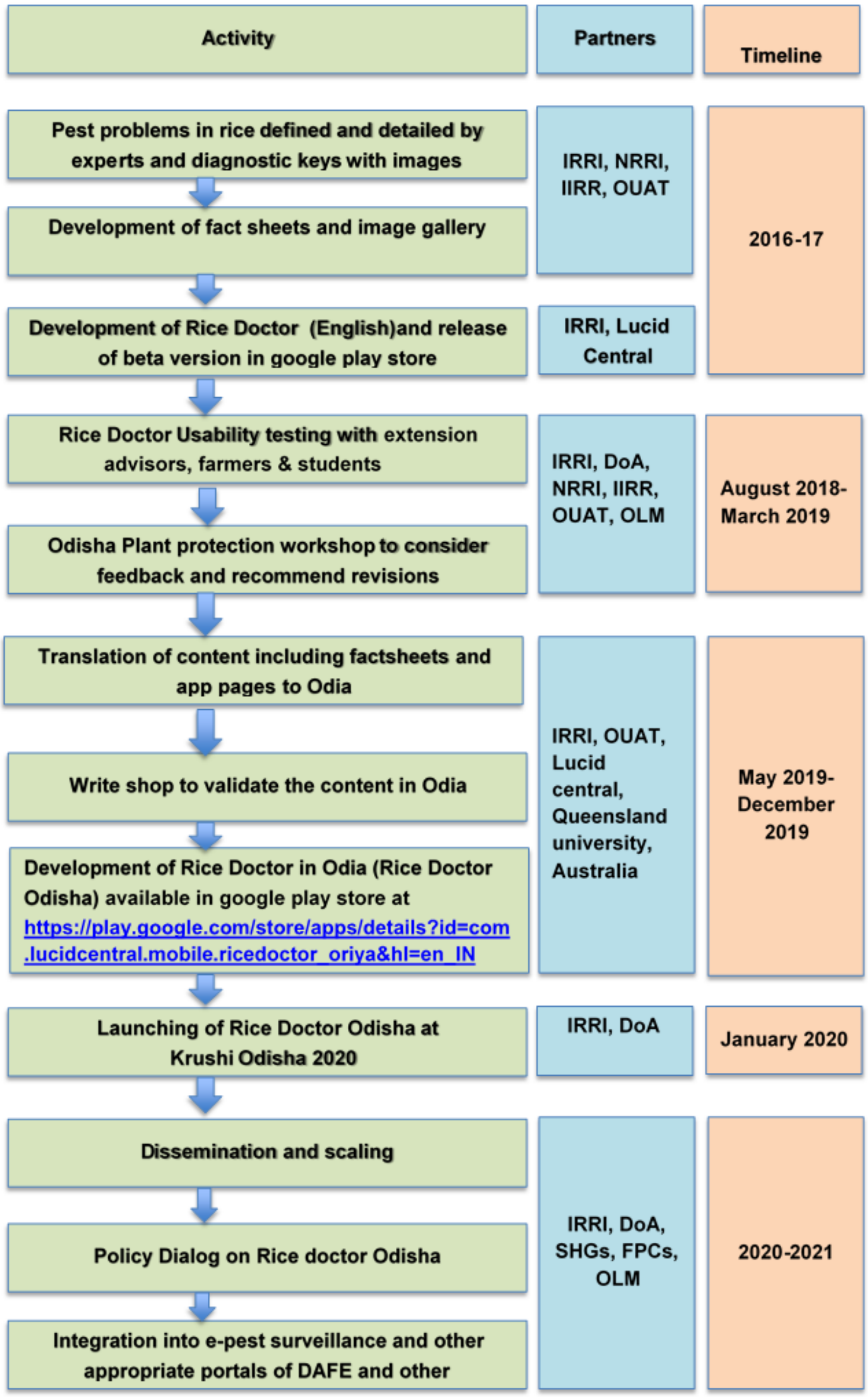


Figure 4.3. Rice Doctor Odisha development process

Rice Doctor (RD) is a mobile app developed by IRRI and built on the Lucid Identic platform to expedite and simplify the task of identifying pest and disease problems. RD is a mid-season diagnostic tool that helps agricultural extension advisors and farmers obtain accurate and timely diagnosis of nearly 80 crop problems caused by insect pests, diseases, and abiotic stresses caused by nutrient deficiencies and toxicities, and other problems, including agronomic mismanagement. The tool also provides access to information about correct management and prevention options, which include cultural, mechanical, biological, and chemical methods.

The process followed in the development of Rice Doctor Odisha is depicted in Figure 4.3 along with collaborators and a timeline.

Rice Doctor usability testing was done in collaboration with the DoA in the districts of Puri, Nayagarh, Jagatsinghpur, and Cuttack; with Odisha Livelihoods Mission (OLM) in the districts of Nayagarh and Sundargarh; and with postgraduate students of Odisha University of Agriculture and Technology (Photo 4.6). The test used both quantitative and qualitative methods using questionnaires and group discussion. Three domains were considered while testing the usability: efficiency, effectiveness, and user satisfaction. This was compared with visual and material-guided methods.

Photo 4.6: Field testing of Rice Doctor

Photo 4.7: Writeshop for Rice Doctor Odisha

A writeshop with plant protection experts from ICAR-NRRI, OUAT, and the DoA was organized to validate the content of Rice Doctor Odisha (Photo 4.7). The content was critically reviewed, and experts recommended changes, all of which were incorporated. Subsequently, the Odia content was fed into the Fact sheet Fusion software developed by Lucid Identic, University of Queensland, Australia. Then, the app was upgraded to Odia Version as Rice Doctor Odisha.

Rice Doctor Odisha was launched on the occasion of Krushi Odisha on 23 January 2020 in the presence of Honorable Agricultural Minister, Govt of Odisha, Dr. Arun Kumar Sahoo, and other dignitaries (Photo 4.1). The Odia version of Rice Doctor is available in Google Playstore and can be downloaded at the following link:
https://play.google.com/store/apps/details?id=com.lucidcentral.mobile.ricedoctor_oriya&hl=en_IN.

4.3 Testing integrated pest management (IPM) interventions in rice

Integrated pest management interventions were tested along with farmers' practices in collaboration with ICAR-NRRI (Sambalpur, Boudh, Sonepur, Kendrapada, Cuttack), ICAR-IIRR (Puri, Jajpur, Ganjam, Gajapathi), and OUAT (Ganjam, Gajapathi, Puri, Jajpur) as shown in photo 4.8. The details of IPM interventions are presented in Table 4.1. The IPM practices introduced were simple to adopt. The presence of active farmer groups and their participation offer an opportunity for acceptance of good management practices and the introduction of conservative biological control techniques such as ecological engineering.

Photo 4.8: IPM trial in Jajpur

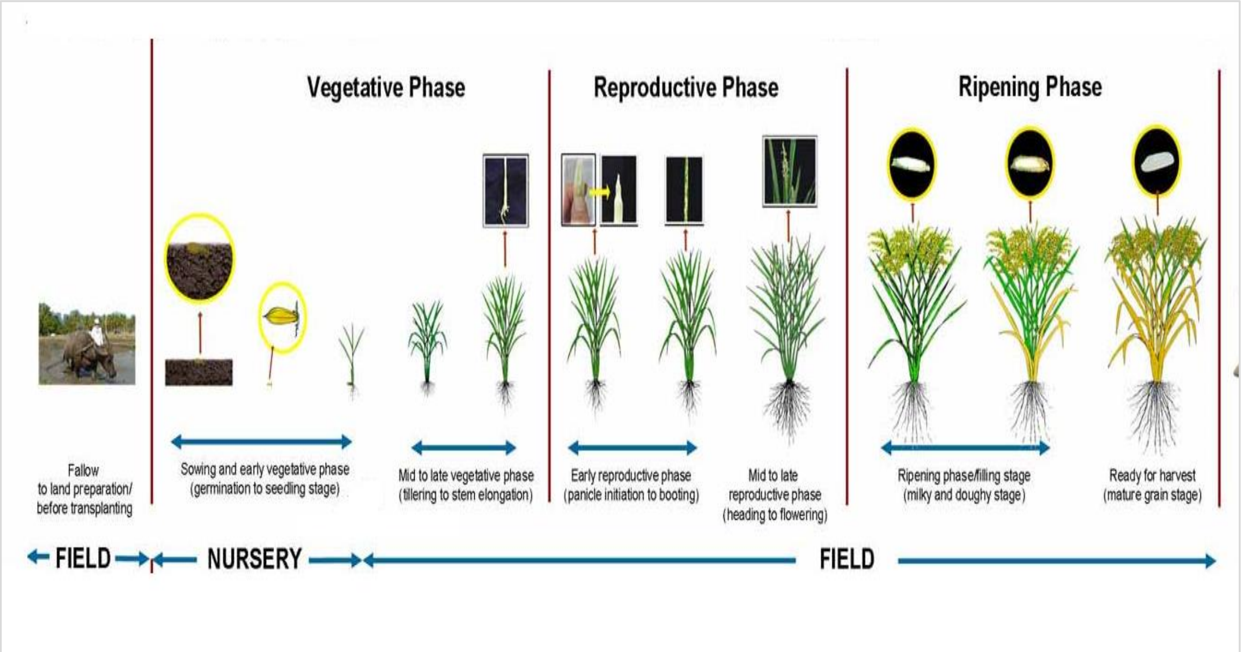


Table 4.1. Details of integrated pest management (IPM) interventions tested against farmers' practices

Nursery	Main field
• Select locally adopted resistant varieties and disease-free seed. • Seed treatment with *Trichoderma* formulation at 5–10g/kg seed. Soak the seeds in water for 4–5 hours, drain out the water, and treat with *Trichoderma* formulation and keep overnight. • Apply carbofuran granules 5 days before pulling seedlings from nursery for transplantation (in gall midge endemic areas).	• Transplant seedlings at a spacing of 20 × 15 cm. • Leave alleyways of 30 cm after every 2 m or 10 rows. • Plant a bund crop (ecological engineering) for conservation of natural enemies. • Nutrient and weed management as per Rice Crop Manager. • Survey for pest incidence and level of damage at weekly interval starting from 15 DAT. • If BLB symptoms are seen from 20 to 30 DAT, split doses of nitrogen may be delayed, particularly the second dose. • At 15 DAT, install pheromone traps with 5 mg lure at 8 traps/ha for stem borer monitoring. While installing, make sure that the trap remains above the crop canopy. • Use Trichocards 21 DAT and repeat every 15 days till flowering at two to three cards per acre. • Observe the bund area and, if sheath blight is observed on weeds, spray triazole fungicides. • One spray of Cartap hydrochloride 50 WP at 600 g/ha at 60 DAT (against stem borer/leaf folder, if incidence surpasses ET value). • Mid-season drainage should be followed in case of BPH incidence. Need-based application of propiconazole. (If false smut and grain discoloration are prevalent in the region, it's better to apply a prophylactic spray at flowering.)

Preliminary results show that insect pest and disease incidence was reduced in IPM plots and farmers indicated reduced white ear damage by stem borers in IPM plots in southern Odisha districts of Koraput, Nabarangpur, Kalahandi, Rayagada, and Malkangiri (Table 4.2). Incidence of brown planthopper (BPH) decreased in IPM trials due to regular monitoring and appropriate management methods.

Table 4.2. Incidence of insect pests and disease across southern Odisha districts

Practice	Stem borer damage (%)	Leaf folder damage (%)	Gall midge damage (%)	Mean population (no./5 hills)		Incidence (% damage)	
				BPH	WBPH	Sheath blight	Blast
IPM	4.85	12.28	4.51	11.46	3.29	4.34	2.16
Farmers' practice	10.62**	21.28**	6.92**	15.42	6.26**	5.72**	3.85**

#Mean of three observations.
*** P<0.05.*

Field days were conducted in Jajpur, Boudh, and Sambalpur districts to compare the effect of IPM-based interventions with farmers' practices. The extension officials from different blocks and scientists participated in field days and interacted with farmers about insect pest and disease management practices. The field day and interaction with farmers indicated limited awareness of nonpesticide methods and IPM principles for insect pest and disease management. Among the IPM interventions, seed treatment with *Trichoderma* formulation showed better results with increased plant growth. However, the lack of timely availability of pheromone traps, trichocards, and other bio-agents was highlighted as a constraint for farmers wanting to adopt IPM.

Photo 4.9: Farmer with tillers of IPM plot and farmers' practice plot

Capacity building to support women-led enterprises for bio-agent production

A 3-day training program ("**On farm production of bio-agents for promotion of sustainable agriculture")** was organized on 27-29 January 2020 at the National Institute of Plant Health Management (NIPHM), Hyderabad, with 30 farmers from Adarsh Dharmagarh Women Farmers Services Producer Company (ADWFSPC) of Kalahandi District, Society for Women in Agriculture and Rural Development (SWAD), and I-Concept Initiative from Puri District.

The training involved the production of bio-pesticides (solid and liquid formulations of *Trichoderma* and *Pseudomonas*), bio-fertilizers (*Rhizobium*, *Azotobacter*, *Azospirillum*, phosphate solubilizing bacteria, *Azolla*, mycorrhizae), trichocards (egg parasitoids), and reduviid bugs (predators).

Photo 4.10: Women farmers of ADWFSPC practicing production of Trichocards

Photo 4.11: Women farmers from SWAD testing making **Trichoderma** *solid formulation*

Capacity building of extension and advisory services (EAS)

Dialogue on Capacity Needs of Extension and Advisory Services in Odisha: IRRI, in collaboration with the Centre for Research on Innovation and Science Policy (CRISP), organized a policy dialogue on 17 August 2019 at IMAGE, Bhubaneswar, under the chairpersonship of the Principal Secretary, Department of Agriculture and Farmers' Empowerment (DAFE), to share the results and recommendation of the Capacity Needs Assessment (CNA) workshop held in July 2018, including the action plan developed.

Photo 4.12: Policy dialogue on EAS

This policy dialogue was attended by the director of DA&FP, senior officials of the Directorate of Agriculture (DoA) and Directorate of Horticulture (DoH), State Agriculture University (SAU), Odisha Livelihoods Mission (OLM), and staff of a few prominent NGOs working in Odisha. The action plan aimed to

- Develop training modules (four) and organize training of trainers (ToT) for SAMETIS/ identified key resource persons in Odisha (Table 3):
  - Value chain extension
  - Enabling EAS for climate-smart agriculture
  - Facilitation for development
- Design and deliver gender-responsive EAS

- Carry out organizational and management review of Odisha extension system (DAFE)
- Review current induction training activities (AAOs) and develop a new training module and impart it (along with IMAGE/MANAGE faculty)

The chairperson suggested forming a state-level EAS committee to review and monitor EAS activities on behalf of the department.

Constitution of Advisory Committee-Extension and Advisory Services*:* Based on the recommendations of the policy dialogue held in August 2019, an advisory team was formed consisting of the Joint Director Agriculture (Information) of the DoA, representatives from the DPME (Directorate of Planning, Monitoring & Evaluation) cell of OUAT, KVK of ICAR-Central Institute of Freshwater and Aquaculture (CIFA), CRISP, Pradan (a national NGO working in the state), and IRRI. The role of the committee was to oversee the activities undertaken by IRRI for developing capacityfor EAS in the state, support formulating an appropriate action plan for better delivery of extension services to farmers, and advise and support the planned Organizational and Management Review (OMR) of DAFE. The first meeting of the committee was held on 22 October 2019. The director of CRISP appraised the members on the progress and plan of IRRI in the state through a presentation on the EAS activities.

Pilot Testing of Training of Trainers Modules: IRRI, in collaboration with CRISP, along with resource persons from different parts of India, pilot-tested four ToT modules (Table 4.3). Although a request was made to encourage participation of women and men in a balanced manner, very few women attended the training activities.

Table 4.3. ToT modules pilot-tested

SN	Title	Date	Total participants	Females	Males	Govt.	NGO
1	Value Chain Extension	5-7 Sept. 2019	22	1	21	19	3
2	Climate-Smart Agriculture	18-20 Sept. 2019	17	4	13	11	6
3	Facilitation for Development	8-10 Jan. 2020	27	5	22	21	6
4	Designing and developing a gender-responsive EAS	4-6 Feb. 2020	35	16	19	30	5

Photo 4.13: ToT on facilitation for development

Training modules have been developed for each of these and refined after the pilot delivery of the training. They are all being translated into Odia and both English and Odia versions will be published and made widely available. They can also be accessed through the RKB.

Photo 4.14: ToT on designing and delivering gender-responsive EAS

The objective of conducting ToTs was to build the capacity of the senior officials working with EAS and develop a pool of master trainers (MTs) who could, in turn, train the next-level officials for better delivery of extension services to farmers in districts. Some of the participants expressed a desire to conduct similar training in their respective districts to build the capacity of district-level extension officers by using the learning and training materials provided to them during ToTs.

Organizational and Management Review of Odisha extension system (DAFE): The Government of Odisha is keen to transform agriculture and has recognized the need for dynamic EAS to meet the emerging challenges. Although extension staff at different levels need new capacity to deal with these challenges, reforms are also needed at the organizational and management level. An Organizational and Management Review (OMR) is a tool that can help organizations reflect on their performance, identify important factors that aid or impede their achievement of results, and situate themselves with respect to their vision and objectives. CRISP led an OMR during the year as a part of the project activities.

During the first Meeting of the Advisory Committee held in Bhubaneswar on 22 October 2019, the methodology for the review was discussed and agreed upon, in addition to developing a draft list of key informants for interviews. A document review and interviews with key stakeholders were held during October-December 2019 and a draft report has been prepared. The key findings will be presented to key stakeholders, feedback obtained, and the report and recommendations revised and submitted during March-April 2020.

The review adapted the Institutional and Organizational Assessment Model (IOA Model) elaborated by Universalia and the International Development Resource Centre (IDRC) and the FAO's EAS Assessment Tool to organize this exercise. The IOA Model stresses the importance of an organization's motivation, capacity, and external environment while reviewing organizational performance, whereas the FAO EAS Assessment articulates the need to understand the collective/sectoral performance of the pluralistic EAS system. The highlights from the findings are summarized as follows:

Vision, Objectives, and Strategy*:* Although these are clearly articulated in the Agricultural Policy 2020 (SAMRUDHI), the DAFE has yet to develop an operational strategy for implementing this vision and strategy. Without a supporting operational strategy that is based on achieving the eight pillars of the SAMRUDHI, the vision and objectives of the policy are unlikely to be achieved. A small working group needs to be formed to drive the development of appropriate strategies for each pillar. Each group could be led or facilitated by the JDA (L-1) approved under the new structure of DAFE.

Human Resource Development (HRD): There is no HRD strategy for EAS at the state level, although the need for developing a human resource management and capacity development policy for agricultural extension employees in the state has been articulated earlier (GoO). A Compendium on Guidelines and schemes, programmes, and policies. 2017-2018. RITES. Dhenkanal. Agriculture & Farmers' Empowerment Department). Human resource upgrading and skilling is also one of the pillars of the SAMRUDHI. Developing a strategy for HRD that clearly articulates the human resource requirements (number of staff at different levels as well as their technical and functional capacities) aligned with the organizational vision and strategies should be a priority for DAFE. The strategy should also contain policies, procedures, and programs for capacity development, including recruitment, performance review based on appropriate indicators, and identification of capacity gaps.

DAFE has several organizations in place that can support capacity development of EAS providers. These include IMAGE, RITES (3), and MI&WU. However, the following constraints limit the performance of these organizations:

- Lack of mechanisms to recruit trainers-based on their skill and aptitude for capacity development and also experience in organizing different types of capacity development programs, including training. Mere upgrading and certification by ASCI on platform skills is not enough
- IMAGE, which should have been leading the capacity development of senior and mid-level extension employees on improving functional skills related to enhancing extension effectiveness (design and delivery of extension programs), is now undertaking many other tasks, which include training farmers and youth and VAWs on technical knowledge and skills, and it has become the implementing agency for central sector schemes such as NFSM and RKVY
- The different sessions in the training programs of state-level agencies aforementioned lack clear objectives and outcomes, and, because of the lack of core expertise on topics for the training, there is a lot of dependence on external resource persons. The lack of appropriate training modules also adds to the problem
- Training at RITES focuses mostly on becoming familiar with program implementation guidelines of different central and state schemes
- It is not clear whether anyone is doing a systematic capacity needs assessment at regular intervals to decide on topics for the training calendar

- To facilitate cross-learning, interaction among participants, and using varied training tools (e.g., role play, group work, ice breakers, energizers, games, etc.), the training halls should have flexible seating arrangements. In most cases, the training halls have fixed seating (either boardroom or theatre) that constrains the organization of effective training activities
- The state also lacks pools of resource persons on varied topics to provide deep understanding and insights into specific topics and share practical experiences and stimulate critical reflection and dialogue among participants
- The induction training programs for staff (e.g., AAOs) have lost focus as these have become a venue for creating awareness of schemes and implementation guidelines and communicating new technological developments in agriculture (often by university professors). Most of the recruits at the AAO level are fresh from universities and they do not need further training on technologies. What they ideally need is functional skills to become effective change agents

The development of separate guidelines for recruitment of faculty at training institutions (not by seniority or other considerations) and identification of a pool of resource persons on varied topics is necessary. Resource persons and faculty at training centers need to be supported to deepen their understanding of the specific topics they work on. The training infrastructure needs to be strengthened and RKVY funds could be used for this purpose.

Knowledge Management (KM)*:* Knowledge is one of the most important assets for any organization. KM is a system that helps people within a system share, access, update, and use relevant knowledge and information. The traditional understanding of knowledge management is focused on centralized production of knowledge materials and disseminating it downward to others in the sector (especially farmers in the case of agriculture) using traditional (print, radio, television) and modern media (ICT tools such as SMS, text message, etc.). The KM strategy is now revolving around faster sharing of knowledge among and across varied stakeholders and is based on the application of new ICT tools such as knowledge portals and social media. A lot of knowledge is available, especially among extension field employees in the state working to solve farmer problems and disseminate lessons from the implementation of several programs. However, no mechanism exists, including platforms, incentives, or other mechanisms, to upgrade skills related to documentation and sharing this knowledge (mostly tacit knowledge) across extension field employees and, in this process, very important tacit knowledge related to best practices is lost, especially when staff are promoted to different levels or when they retire. To overcome these problems, the following measures are recommended:

- Developing a directory of extension employees (pluralistic EAS comprising public, private, NGO, and producer organizations) in each district. This responsibility could be given to either ATMA or KVK, or even an NGO active in the district
- Developing an online knowledge platform to serve as a repository of information and good practices that could be contributed by varied extension employees (which could be named

Odisha Agricultural Extension Network), and this could be started and incubated by either DAFE or OUAT, or by any other agency interested in and capable of doing the same
- Developing a network of pluralistic extension practitioners and forming a core group on varied topics in which the members are interested, and this process could also be moderated online
- Identifying key staff within DAFE who can lead this process and develop capacity of staff ingood practices in writing, etc

Developing Gender-responsive Service Provision and Organizational Culture: The State Agricultural Policy identifies women as a priority target group to achieve agricultural transformation. The policy mentions at least 30% women's participation in almost all central sector programs (especially NFSM, BGRI SMAM, Support to State Extension Programme for Extension Reforms Scheme). It is mandated that at least 30% of resources on programs and activities be used for women farmers and women extension employees. The state policy also talks about dedicating 30% of the horticulture and small livestock scheme budgets to women. However, the DAFE currently lacks a strategy to track investments earmarked or used by women farmers. Tools such as gender analysis, gender audit, and gender-based budgeting are yet to be integrated into organizational policies and programs. DAFE should advocate for land titles in the name of women farmers as this is one of the main barriers that constrain women farmers from accessing services. DAFE can achieve much greater development impact if it partners more systematically with organizations such as OLM and Mission Shakti, as both of these programs have a strong focus on women and smallholder farmers. As women play a very important role in addressing nutrition at the household level, there is a need to design and implement programs on nutrition-sensitive agriculture (beyond promoting horticulture, agro-forestry, and millets). Ensuring nutrition security is also part of the vision statement of the State Agricultural Policy.

Although the policy mentions providing a conducive and safe environment for female extension staff, no mechanisms exist to assure this. The only mechanism DAFE has is an informal gender committee to look into grievances related to harassment whenever reported. Although DAFE has recruited a large number of women AAOs and has improved the gender ratio, there hasn't been any attempt to build a gender-responsive culture within the organization and to integrate gender concerns into the organizational agenda. Female extension workers reported a lack of adequate sanitary facilities in many of the offices. The following measures are suggested in this regard:

- Establish a functional gender cell at the state level to frame an organizational gender policy and initiate gender-based budgeting across all programs
- Create mechanisms to achieve convergence with OLM and Mission Shakti at the district and block level
- Conduct gender audits periodically
- Create awareness among staff at all levels on gender equality employing a diverse set of methods, including training, communication, on-the-job mentoring, identifying gender champions, etc

- Introduce topics related to gender and gender-responsive extension as part of the induction training of DAFE staff

Partnerships: DAFE has partnered with several national and international centers, NGOs, and CBOs to introduce new technologies and processes and also strengthen its capacity. Although a lot of scope exists for greater public-public and public-private collaboration at the district level, including NGO partnership, these opportunities are not exploited fully because of a lack of guidelines and capacity in this area. As there is very little communication about these initiatives beyond the state level, senior employees and many stakeholders are not fully aware of the activities taking place under these partnerships and in general very little appreciation exists of each other's efforts. DAFE can benefit significantly from the availability of this wide expertise, experiences, and good practices provided by these partners. Some measures that could help include the following:

- Exchange visits across these initiatives for both farmers and field employees and resources under the ATMA cafeteria could be used for this
- Documentation and sharing good practices from these initiatives so that there is higher awareness and appreciation of various efforts. Joint learning around both technical and process aspects of these collaborative efforts should be an explicit output in these initiatives and should be budgeted for. Opportunities to share results and experiences should also be made available
- The virtual knowledge management platform suggested earlier could be used for this purpose

Monitoring and Evaluation: DAFE has established mechanisms for tracking the implementation of schemes (e.g., Agricultural Dashboard) in partnership with ADAPT using social media applications. Simple online forms to capture farmer issues at the block level have also been developed and remedial measures are being taken. Most officials are sharing pictures of their interventions through WhatsApp groups. But, there is very little analysis on how these initiatives are contributing to enhanced program effectiveness. There is a need for more evidence in this area.

Review of current induction training (AAOs) and developing a new training module and pilot delivery (with IMAGE/MANAGE faculty)

Induction training is important for new recruits as this helps them to become productive and efficient as quickly as possible. Employers also have the responsibility to provide new employees with all relevant information regarding organizational policies and programs. Assistant agricultural officers (AAOs) are the face of the public extension system at the block level. They are generally graduates in agriculture (minimum qualification for recruitment as an AAO) and are currently recruited-based on a written test and interview conducted by the Odisha Public Service Commission.

Ideally, an induction training module should include the following:

- **General training** relating to organizational values, history, structure, and philosophy
- **Mandatory training** relating to pay scales, promotions, facilities and amenities, attendance and leave, occupational safety, health and insurance, income tax deductions, rights and legal issues, procedures related to grievance and discipline, career path, appraisals, awards, and incentives
- **Job training** relating to the roles that the new recruit will be performing

As per their job description, the AAOs are expected to[1]

- Monitor and guide the work of AAOs, VAWs, Krusak Sathis, and ATMA staff at the block level
- Implement different schemes and programs of DAFE and its concurrent evaluation
- Plan effective extension programs and dissemination of proven technologies
- Prepare integrated cropping programs, including action plans for each VAW/AO circle
- Undertake field visits and record observations on the performance of demonstrations, trials, crop cuttings, and pest situation, and participate in group meetings
- Supervise activities of input dealers to ensure compliance with rules
- Document successful achievements for wider promotion (publication)

Although most AAOs are posted at the block level, a few are also posted with specific schemes, seed/fertilizer/pesticide testing labs, and training centers.

In Odisha, IMAGE is responsible for organizing the induction training, which is also referred to as orientation training. There are no clear guidelines on the content of the induction training for AAOs. For instance, during 2013, the training lasted 7 days, whereas it was for 3 days during 2014 and 2015. In 2016, the program lasted 30 days, but in 2018 it was for only 3 days, which was subsequently extended to 15 days. The different topics covered under these programs[2] are as follows:

General topics

- Structure and functions of the DAFE, agricultural policy

Mandatory topics

- Objectives and guidelines related to scheme implementation (central sector schemes and state schemes); process of collecting soil samples and seed certification process; rules related to insecticide act, fertilizer control order, essential commodity act, and quarantine; maintenance of cash book, stock book, and other financial records; noting, drafting, and code of conduct; professional ethics and CCA rules

---

[1] Synthesized from the Job Chart of AAOs: https://agriodisha.nic.in/content/pdf/2323-Restructuring%20of%20Agriculture%20Service%20Cadre.pdf.

[2] Course content of one month of induction training of newly recruited AAOs (18 August to 17 September 2016, IMAGE).

Technical topics

- Land-use planning, problematic soils, plant nutrients, bio-fertilizers; seed production, weed management, SRI cultivation; WTO, supply chain management; climate change, contingent crop planning, NRM, command area development; major insects and pests, pest surveillance, bio-control, IPM, solid and liquid waste management; cultivation practices of rice, pulses, commercial crops, oilseeds, sugarcane; farm mechanization, solid and liquid waste management; agro-based livelihood enhancement activities

Functional/extension-related topics

- Extension reforms, SAEM, new dimensions in extension; conducting demonstrations, organizing farm schools, FFS and Farm Climate School; attitude and leadership; group approach; participatory monitoring and evaluation with social auditing; market-led extension; training management; sequential extension interventions; human resource management; communication skills; and documentation for print and electronic media

Most of the technical and functional topics are handled by experts from outside DAFE/IMAGE and are in classroom lecture mode. The program also has field visits to RITES, soil and insecticide testing labs, agromet advisory center, and ICAR stations (CTCRI, IIHR) in the state.

The current training has good coverage of mandatory topics and inclusion of field visits is helpful. However, it appears that there is overemphasis on technical aspects related to crop production and management. The general topics are not adequately covered. The mandatory topics lack some crucial ones such as sensitization on harassment, team work, gender in the workplace, pay scales, promotions, facilities and amenities, attendance and leave, occupational safety, health and insurance, income tax deductions, rights and legal issues, procedures related to grievance and discipline, career path, appraisals, awards, and incentives. Coverage is inadequate of functional/extension-related topics. There is too much reliance on classroom/lecture methodology and a wider range of methods and tools could be used in training (cases, videos, role plays, games, group exercises, card exercises) to make it more interesting and interactive. There are also no specific training modules for induction training and learning objectives are also not set. The content depends primarily on what the faculty (mostly external) brings to the classroom.

Almost all the trainees are young and fresh out of college after 4 years of agricultural courses. They would benefit from general, mandatory, and functional skills that are needed in the organizations and fields where they could apply their technical knowledge. Orientation on organizational history and organizational values and the institutional landscape of agricultural development organizations in the state and how other organizations in the state involved in agricultural development depend on and contribute to DAFE's activities would help them perform their duties more effectively. Extension-related topics could include a wider range of extension approaches with clear guidelines on what approaches will work for a particular set of challenges.

A recommendation is made for induction training that focuses on strengthening the extension/functional skills of AAOs. The revision of other aspects related to general and mandatory aspects can be better addressed by the resource persons of DAFE by examining the limitations that have been highlighted. The structure of the proposed training module is presented in the Annexure 4.1.

Leadership and Entrepreneurship Program for Women in Agriculture (LEAP): The objective of LEAP is to enhance the income of women farmers and their families by building their agri-enterprise development and business capacity. The initiative aims to double the income of the women farmers in the next four years by providing a portfolio of services that include agriculture: supply of seed, fertilizer, bio-pesticides, custom hiring of agricultural machinery, procurement, processing and marketing of seeds; and financial: loan for inputs, consumption, and allied activities (poultry/goat rearing/dairying) and door-step supply of household groceries and allied items. The use of cutting-edge technology for farmer traceability and improving efficiencies will be a core of the project. The Adarsh Dharmagarh Women Farmers Services Producer Company (ADWFSPCL) Ltd. supported by IRRI, Access Livelihoods Consulting India (ALCI) Ltd., and DAFE was registered in June 2019 in the block of Dharmagarh of Kalahandi, which is one of the aspirational districts of Odisha.

Mobilization and Membership Enrolment: A long and systematic process of orienting women farmers in the target villages resulted in enrolling 1,751 women farmers from 29 villages to date as members in the PC and INR 17.10 lakh was raised as share capital. With the help of this share capital, the PC established linkages with credit institutions such as FWWB (Friends for Women World Banking) and accessing INR 2 crores as a soft loan that would be used for seed procurement, processing, marketing, and infrastructure development.

Photo 4.15: Member mobilization

Institution Building: The office of the company was established in Boden Village of Dharmagarh, Kalahandi. The company developed its human resource policy and recruited six staff (3 women and 3 men) along with 23 village community resource persons (CRPs) called Adarsh Saathi. A Board of Directors (BoD) was selected based on set criteria and 12 directors were leading the governance of the PC. Women Farmers' Affinity Groups (WFAGs) were formed at the village level. The PC has representatives from all WFAGs in the Representative General Body (RGB). RGB meetings are conducted quarterly to share information and decisions with members related to the PC and issues and challenges faced by the members and devising ways to address them.

Competency Development: Competency development training programs were designed and implemented for the BoD, RGB leaders, PC staff, and other members as per the requirements. The BoD was trained on producer company governance and management, financial management, business planning, and a vision-building exercise. RGB leaders were trained on the vision-building exercise and procurement management. PC staff were trained on producer company management, business planning, financial management, accounts, and production technology. Members were trained on benefits of the producer company, importance of member capital, technical training in seed treatment, paddy and pulse seed production, paddy production, and pulse production.

Women Entrepreneur Program (WEP): This started with 25 aspiring women entrepreneurs and includes both classroom and practicum in various enterprises. All the participants were exposed to various entrepreneurship activities and workshops within the state and outside to build their capacity and confidence to explore multiple ideas of entrepreneurship. This is an intensive program stretching over a period of six months consisting of sessions on transformational leadership, business trusteeship, structuring life and personal excellence, personal empowerment tools, internal and external stakeholder management, tackling enterprise growth challenges, principles and practices of collective enterprises, financial accounting management, production and operation management, value chain management, governance, and audit and legal compliance.

Photo 4.16: Members in a competency development exercise

Paddy seed production and processing: The Adarsh Producer Company took up paddy seed production with 145 women seed growers in kharif 2019, covering 72.52 ha. Seed growers were selected based on the location of the land, irrigation facilities, and other resources available for successful seed production. Farmers' registration was done with Odisha State Seed and Organic Products Certification Agency (OSSOPCA) following necessary due diligence from the Department of Agriculture. The growers were provided with foundation one (F1) and certified one (C1) seeds for taking up seed production activities and trained on the steps and processes of seed production. The officials of OSSOPCA, from both the state and district, visited and inspected the crop during the process of seed production. The PC leased space for processing and storing seeds, and purchased a seed-processing unit. A management information system (MIS) for production monitoring was used throughout the production cycle. About 2,500 quintals of unprocessed paddy seed were procured by the PC from the women seed growers during kharif 2019 at INR 1,900/quintal and payment was made to individual members. The PC then processed the seed and branded it. A market plan was prepared for sale of seeds in March 2020. The PC also acquired a state seed license and applied for a fertilizer license.

Photo 4.17: Role play on connecting various natural resources

The PC took up paddy seed production in rabi 2019 with 184 farmers on 157 hectares. Along with paddy, a pulse seed production program of green gram variety IPM-2-14 was also implemented

Photo 4.18: Field inspection by certification agency (OSSOPCA)

with 25 farmers on 18 hectares on a pilot basis. Sixteen farmers were provided with foundation seed (F1) of chickpea (JG14) for demonstrations during rabi 2019. Farmer registration for both paddy and pulse seed production was completed as per the norms of OSSOPCA. Odisha State Seed Corporation (OSSC Ltd.) supported the PC by providing necessary approval and authorizations for using their seed-processing facility in the district and procurement support as appropriate. This seed production program as a whole strengthened the capacity of women farmers and gave them a boost for further taking this up as a business. This has made the women growers and PC members familiar with the protocols and processes of a seed business along with technical know-how for seed production.

Input supply: The PC has played a pivotal role in procuring and supplying inputs (seed and fertilizer) at the door-step at a lower price than the market by harnessing economies of scale. A total of 673 farmers received paddy seeds and 667 farmers received fertilizer during kharif 2019. In rabi, 110 farmers received paddy seed and fertilizer at their door-step and 77 farmers pulse seed.

Photo 4.19: Input trading by the PC

Loan services: The PC distributed fertilizer to 667 members in the form of an agricultural loan. The loan was recovered after six months and used for providing further loan services to other interested members.

Poultry business: Fiftywomen farmers from six villages of Kokasara block started a Desi poultry business by establishing individual sheds on their homestead. The women farmers were trained on the business basics by experts in this field.

Grocery retail service: This service was launched and 1,000 women members were provided with cheaper and good-quality grocery products at their door-step.

Women entrepreneurship initiative with ICAR-CIWA

Photo 4.20: Seed system interface meeting

IRRI-Odisha had continued its partnership with the Indian Council of Agricultural Research (ICAR)-Central Institute for Women in Agriculture (CIWA) for capacity building and fostering women entrepreneurship activities with two grantee organizations, SWAD (Society for Women Action and Development) in Puri District and Pragati from Koraput District.

Drawing on some of the learnings and needs assessed by the partner organization and grantees, IRRI facilitated some key activities toward their goals of strengthening of seed systems and value addition in the postharvest stage. As a part of SWAD's overall objective of capacity building with women farmers to ensure that STRV seeds are accessible in all-weather conditions through linkages with dealers and vendors, a "Seed system interface meeting" of women members from 20 different groups along with seed dealers, vendors, and DoA and OSSC officials was conducted.

This served as a significant step in starting a network with the various seed stakeholders within the government for the women farmers associated with the organization. Another initiative through SWAD was promoting good seed storage practices by providing IRRI Super Bags to 500 women farmers and training them on scientific seed storage practices.

IRRI started establishment of the mini rubber sheller rice mill for the women FPC group promoted by Pragati after assessing their needs and the potential in the region for milled rice. This purports to serve as a critical resource and input for further training of women farmers involved in value addition, packaging, and branding for expanding the business potential of the FPC.

Steering a platform for reflection and cross- learning among women-led FPCs

IRRI, together with ICAR-CIWA, NRRI, and IIRR and with support from DAFE, Government of Odisha, has organized a series of activities with women-led farmer producer companies in Odisha to share experiences, distill good practices, and help establish a network among women leaders of the women FPCs in the state. The activities were undertaken in three phases, and included key FPC promoters in Odisha.

Three phases of learning activities of women-led FPCs in Odisha

Activities	Dates	Total participants
A learning workshop on Developing viable women-led farmer producer companies (FPCs): opportunities and challenges	21-22November 2019	**60**
Exposure visit of FPC members and facilitators i) Pune ii) Nabarangpur (Odisha)	11-12February 2020 24February 2020	**25**
Quality circle on Accelerating growth of viable women-led FPCs in Odisha: opportunities, challenges, and the way forward	3-4 March 2020	**25**

Learning workshop: IRRI, with support from the Government of Odisha, conducted a learning workshop on "Developing viable women-led farmer producer companies: opportunities and challenges" on 21-22 November 2019 in Krushi Bhawan, Bhubaneswar, in which 40 women members from 10 FPCs along with their facilitators participated. Officials from the Government of Odisha, DAFE, ORMAS, OSSOPCA, APICOL, ICAR-CIWA, NRRI, IIRR, and other stakeholders also participated. The objective of the workshop was to provide a platform to women-led FPCs in Odisha to share their experiences, learning, good practices, challenges, and business opportunities. Details of the participating FPCs appear in Annex 4.2.

Photo 4.21: World cafe session

Participants over two days actively reflected on their constraints and learning and exchanged ideas on possible ways of enhancing their mode of operations and expanding their business. Interestingly, some challenges cut across the diversity of portfolios and the scale of operations. Two of the most oft-cited challenges were the inability to mobilize adequate member share capital and the operation of middlemen, who are known to cheat, charging higher for raw materials and setting a lower price on the produce sold by farmers. Infrastructural and climate-based vulnerabilities posed additional challenges. The FPC members and facilitators also acknowledged that poor amounts of member capital in the long term could inhibit the development of the services and business potential of the FPC. A wide range of operational and legal challenges emerged when discussing the volume of administrative work required to run FPCs. Legal aspects including navigating various rules and ensuring compliance and a

Photo 4.22: Focus group discussion with FPC facilitators

lack of an integrated communication channel and interface with the various government departments on various policies and procedures were some very important problems raised by the facilitators as issues that needed immediate policy attention. Some possible solutions were exchanged among the groups, establishing a sense of community among the participants. The workshop was seen as a significant step forward in building a robust environment for promoting and facilitating viable FPCs in the state.

Exposure visit of women-led FPCs: An exposure visit of women members and facilitators from eight FPCs, and officers from the Department of Agriculture, GoO, was organized for selected FPCs in Pune (Maharashtra) during 9-13February 2020. The main objective of the visit was to interact with and learn from the well-functioning FPCs, on their take-off and growth, scale and size of functioning, activities, role of women and men farmers, operational structure and business planning, and members' participation in production, functioning, marketing, and decision making for FPC activities.

Photo 4.23: FPC team of Odisha with BoD members of Shetmall FPC at their input centre

The team visited five FPCs in and around Nasik, Ahmednagar, and Pune in Maharashtra, two of them being horticultural crop-based FPCs and the other three are mixes of cereals, pulses, and vegetable crop-based FPCs.

A common feature among most of these FPCs is that they have established their companies with existing SHGs and membership varies from 250 to 600+ with mostly small and medium farmers, but membership requests are scrutinized thoroughly and only granted after observation for 2–3 years. The FPCs tie up with large numbers of local farmers for suppliers of produce to increase volume and take up processing, grading, packaging, and marketing under a brand. They provide storage and other necessary infrastructure and facilitate market linkages. For example, one is linked with Food Corporation of India (FCI) for selling tur and sorghum for their buffer stock. Some of them engage in seed production and those dealing in perishables have a production calendar based on well-analyzed customer demand in their target markets.

The ingredients for success of FPCs appear to be (1) careful selection of members and their active involvement; (2) professionally trained and well-capacitated Board of Directors with a strong role in planning and day-to-day supervision, with a larger vision and growth pathway for the FPC; (3) a meaningful level of membership fee for robust share capital; (4) no initial dependence on government support or subsidies and reliance on members' paid-up capital, which helps inculcate a sense of business and avoids dependency syndrome, whereas government support is sought for subsequent expansion; (5) they are part of federations or clusters and have MoUs with private and public institutions to make them robust and resilient; and (6) awareness and use of modern technology for agro-advisory services, grading, packing, and marketing. Some key challenges observed are that most of the CEOs and members of Boards of Directors are men farmers and women farmers are nominated only to meet the requirements of FPC policy and output marketing and stabilizing production to meet demand.

A quality circle on "Accelerating growth of viable women-led FPCs in Odisha: opportunities, challenges, and the way forward" was held on 3-4 March 2020 in Krushi Bhavan, Odisha. This broght together facilitating organizations, resource institutions, stakeholders, and experts to (i) identify the critical success factors and barriers that facilitate or hinder the establishment and effective and sustained functioning of viable FPCs, including the enabling policy and institutional environment, and (ii) develop solutions and strategies and define the role of various stakeholders in implementing these to address the most limiting barriers and amplify the success factors to enable effective governance and functioning of FPCs in Odisha. It is anticipated that the outcomes of the discussions at this event will provide a basis for policy options for the government that can provide an enabling environment for FPC growth and viability, and ensure effective implementation of FPC policy to nurture more viable FPCs in the state.

IRRI and ICAR-National Rice Research Institute (NRRI) Fellowship Program

This fellowship was started in 2018-19 for supporting research scholars under PhD and Master's programs in the broad areas of research listed below. Accompanying seed systems, plant breeding, and varietal evaluation are the following:

- Geospatial analysis and yield modeling, land use-land cover mapping, and extrapolation domains
- Crop insurance and impact assessment
- Knowledge management, innovations in extension, gender and youth research, and entrepreneurship in agri-food systems

Two selected PhD students are working on crop insurance in Odisha and identifying the genomic region associated with vegetative-stage drought tolerance in rice. Two Master's students worked on genetic variation and association of molecular markers with physical, physiological, and biochemical traits for seed vigor in ric.

Subproject 5: Science-based Crop Insurance
5A: Remote Sensing-based Rice Monitoring and Yield Estimation

Subproject 5: Science-based Crop Insurance
5A: Remote Sensing-based Rice Monitoring and Yield Estimation

Remote sensing of rice–growing areas can not only contribute to the precise mapping of rice areas but also help in predicting yield, analyses of disease and pest occurrence and near-real time assessment of damage due to drought, flood or other weather related events. Mapping of rice crops across a diverse range of environments, as it exists in Odisha, is possible with the availability of multi-temporal Synthetic Aperture Radar (SAR) data. SAR imagery is highly suitable for detecting rice, especially in tropical and subtropical regions, where pervasive cloud cover in the rainy seasons precludes the use of optical imagery. Multi-temporal SAR data, sourced from Sentinel 1A and 1B, semi-automated processing, in-season field monitoring and end of season validation is used to generate cultivated rice area and leaf area index. Optical images from Landsat 8 and Sentinel 2 helps to cross-check the map. SAR data is integrated with ORYZA crop growth model --- Rice Yield Estimation System (Rice-YES) --- to estimate rice yield. In addition to the estimation of rice area and yield, IRRI used the rice monitoring platform to monitor the effects of adverse weather events. This sub-project was implemented with the following specific objectives:

- Develop a remote sensing based rice monitoring system for Odisha state;
- Provide accurate and timely estimates on rice area, yield and production along with planting time;
- Estimate damages in case of flood and drought for all the rice-growing areas;
- Provide data and information derived from remote sensing to implement PMFBY and
- Build the capacity of the stakeholders to use the Satellite Based Rice Monitoring System

The satellite-based rice monitoring system (SRMS) was used to capture the progression of rice planting in a near real-time manner, ensuring that the generated rice area map products are relevant and reliable. During kharif 2019, the project team advanced with activities implementing remote-sensing technology, specifically Earth observation using cloud-penetrating synthetic aperture radar (SAR) data, to timely monitor the progression of rice planting and forecast rice yield. In addition to the previously used data sourced from Sentinel 1A, the team made use of SAR data from Sentinel 1B covering a portion of the northeastern part of Odisha (Fig. 5.1). Multi-temporal SAR data at 12-days interval (January to December 2019) spanning three tracks of Sentinel 1A and 1B were used for discrimination of land-cover types to develop the rice baseline map (Fig. 5.2). Data from the 2019 kharif season (June to December 2019, every 12 days) were used to generate cultivated rice area (Fig. 5.4), start of season (Fig. 5.5), and leaf area index (LAI, Fig. 5.9) maps. Optical images from Landsat 8 and Sentinel 2 satellites were used to cross-check and verify the classification of rice area and detection of the start of the season. We intensively collected ground data for model calibration at the beginning of the season (Fig. 5.3), followed by field visits for validation with independent ground datasets during the latter part of the season (Fig. 5.6).

Aside from rice area, the team continued to implement a yield estimation system based on integrating SAR data with the ORYZA crop growth model using Rice Yield Estimation System (Rice-YES) capturing meteorological, management, and varietal factors. For the yield estimation, the team integrated the multi-temporal SAR data with ORYZA using Rice-YES. Rice-YES interprets LAI maps from MAPScape-Rice to simulate yield, while capturing meteorological and agronomic information through the use of spatially disaggregated weather data and varietal, soil, and nutrient management information.

In the case of flood induced by cyclone (Fig. 5.11), the rice monitoring platform was also used during this reporting period to assess the extent of rice area affected by such climatic adversaries.

Product generation

This report includes rice monitoring products for the kharif 2019 season that were generated for the state of Odisha involving three tracks of Sentinel 1A satellite providing multi-temporal C-band SAR imageries with VV and VH polarization (owned by EU and developed and operated by ESA) (Fig. 5.1 and Table 5.1). Whereas Tracks 19 and 121 were captured by Sentinel 1A, Track 48 was captured by Sentinel 1B.

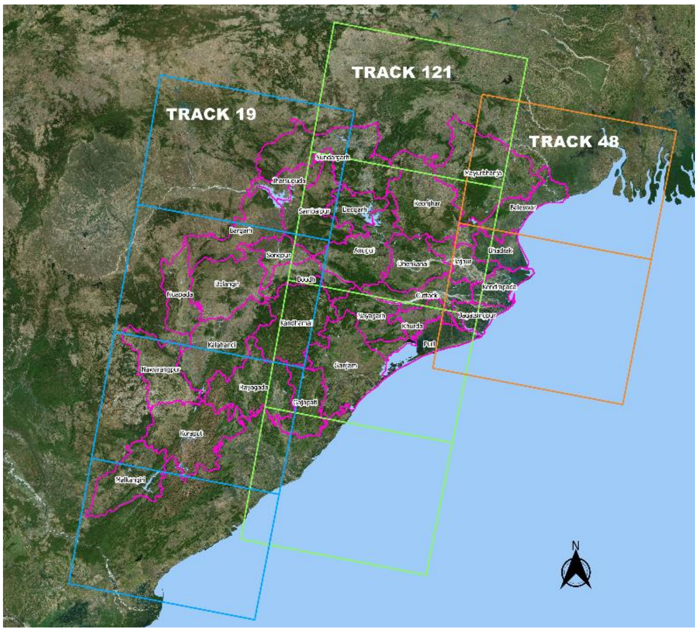


Figure 5.1. Sentinel 1A tracks covering Odisha

Table 5.1. Sentinel 1A acquisition schedule, kharif 2019

Track 19		Track 121		Track 48	
19Jun	10Nov	14Jun	5Nov	3Jun	1Oct
1Jul	16Nov	26Jun	11Nov	15Jun	7Oct
13Jul	22Nov	8Jul	17Nov	27Jun	13Oct
25Jul	28Nov	20Jul	23Nov	9Jul	19Oct
6Aug	4Dec	1Aug	29 Nov	21Jul	25Oct
18Aug	10Dec	13Aug	5Dec	27Jul	31Oct
30Aug	16Dec	19Aug	11Dec	2Aug	6Nov
11Sep	22Dec	25Aug	17Dec	8Aug	12Nov
23Sep	28Dec	6Sep	23Dec	14Aug	18Nov
29Sep		18Sep	29Dec	20Aug	24Nov
5Oct		30Sep		26Aug	30Nov

Track 19		Track 121		Track 48	
11Oct		6Oct		1Sep	6Dec
17 Oct		12 Oct		7 Sep	12 Dec
23 Oct		18 Oct		13 Sep	18 Dec
29 Oct		24 Oct		19 Sep	24 Dec
4 Nov		30 Oct		25 Sep	30 Dec

Rice area and start-of-season map generation

The processed multi-temporal SAR data were analyzed with collected map calibration points that include both rice and non-rice points. The multi-temporal signatures of these ground data are thoroughly checked in an agronomic perspective, which also requires a priori knowledge of rice maturity, calendar and duration, and crop practices from field information. This analysis was done in order to properly set rice area classification parameters in MAPscape-Rice.

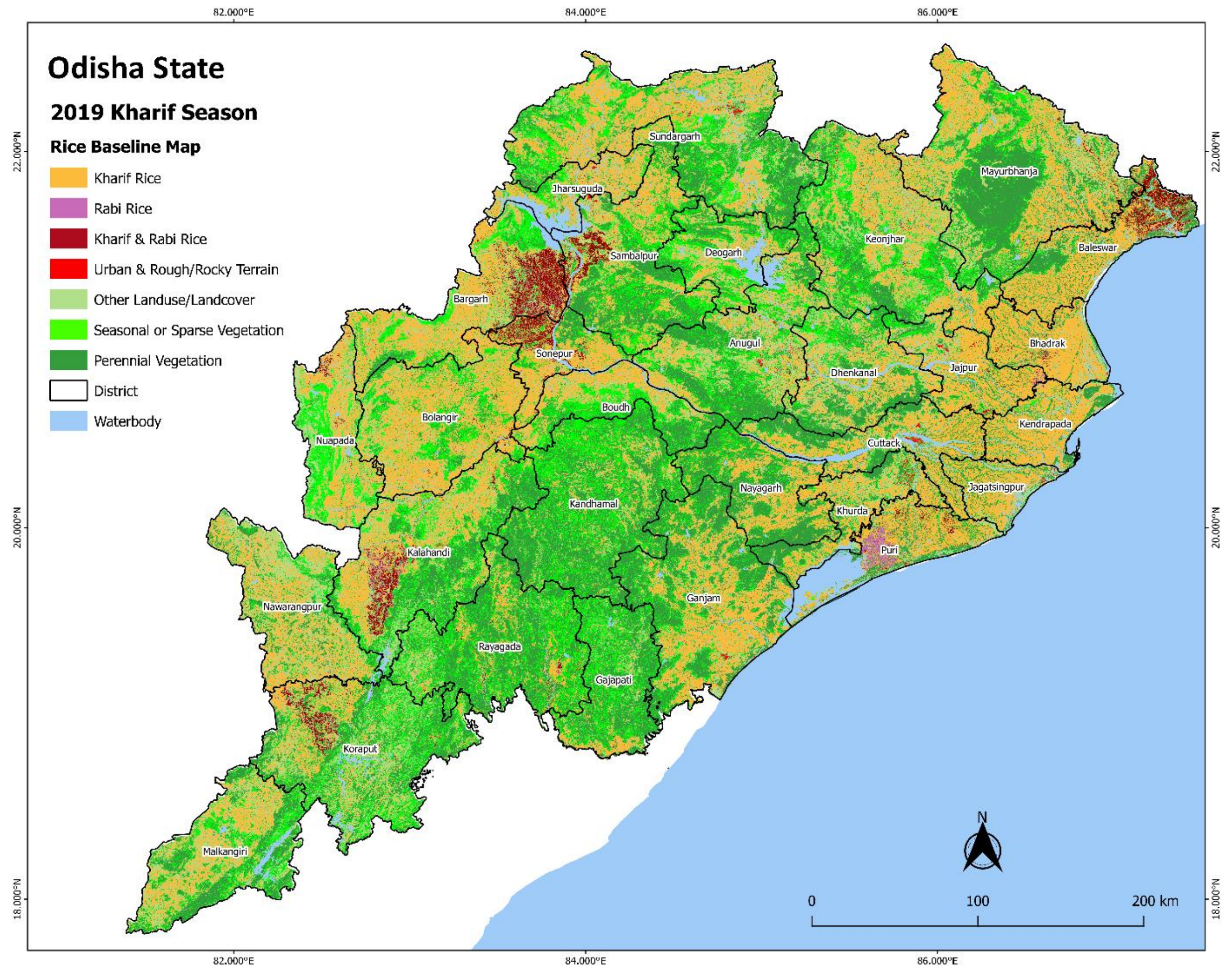


Figure 5.2. Odisha rice baseline map, as of kharif 2019

The classification parameters can vary considerably from one geography to another, mostly depending on agronomic practices and the ecosystem (e.g., irrigated, rainfed, direct-seeded, transplanted, etc.), water availability, and climatic conditions. The tuning of parameters has been done at the district level with reference to collected calibration points from each district.

For some districts, where the rice products are inconsistent with respect to reference ground information, multiple iterations of the classification process (i.e., modifying the parameter settings) were performed until a good agreement with the reference data was reached. These calibration data were used only for map calibration, not to validate the map. Besides these calibration data, an additional set of ground data (rice and non-rice points) was obtained toward the end of the season. The rice baseline map (Fig. 5.2) derived from temporal SAR data (Sentinel 1A and 1B) and optical satellite data (Landsat8 and Sentinel2) served as a mask in generating the rice area (Fig. 5.4) and start-of-season (Fig. 5.5) maps.

During kharif 2019 season, the team mapped the autumn rice-growing area first, followed by the kharif rice-growing area (autumn + winter) throughout the state. Generally, autumn rice is grown in the upland area with short-duration varieties, sown from mid-June to mid-July, a fortnight earlier than the winter rice sowing/planting period. We conducted two different sets of ground data collection to map the autumn and whole kharif rice area, early in the growing season. A total of 902 rice points were collected, which consist of 398 points from autumn rice fields across 14 identified autumn rice-growing districts and 504 points from winter rice fields across all 30 districts of Odisha.

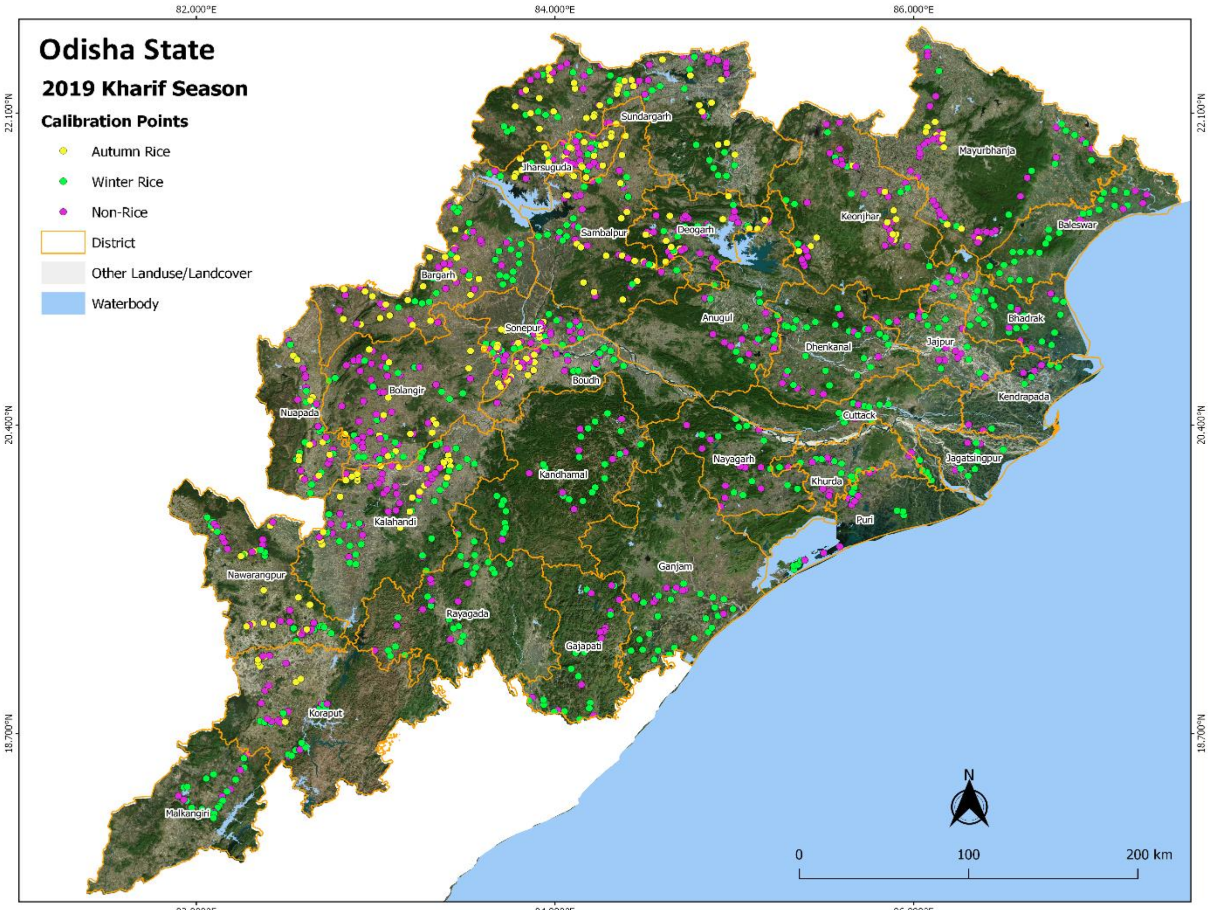


Figure 5.3. Location of the rice (autumn and winter) and non-rice ground samples used for rice area classification

These rice points have information on planting date, planting method, geotagged pictures, etc. Simultaneously, 518 non-rice (particularly other kharif crops) points were also collected. This ground data collection was carried out from the first week of June to the end of July 2019 in autumn rice fields, followed by winter field data collection spanning the first week of August to the first week of September 2019. The majority of rice fields started sowing/planting in the first week of June and this lasted until the first week of September.

Rice area estimates were derived from SAR data from Sentinel 1A and 1B for all 30 districts in Odisha (Fig. 5.4) and suggested an overall 3,339,834 ha of rice cultivated during the 2019 kharif season. District-level rice area estimates are shown in Table 5.2 along with a comparison of rice area estimates against data from the previous year from the Department of Agriculture (2012-13 to 2015-16), with an overall agreement at 81.4%.

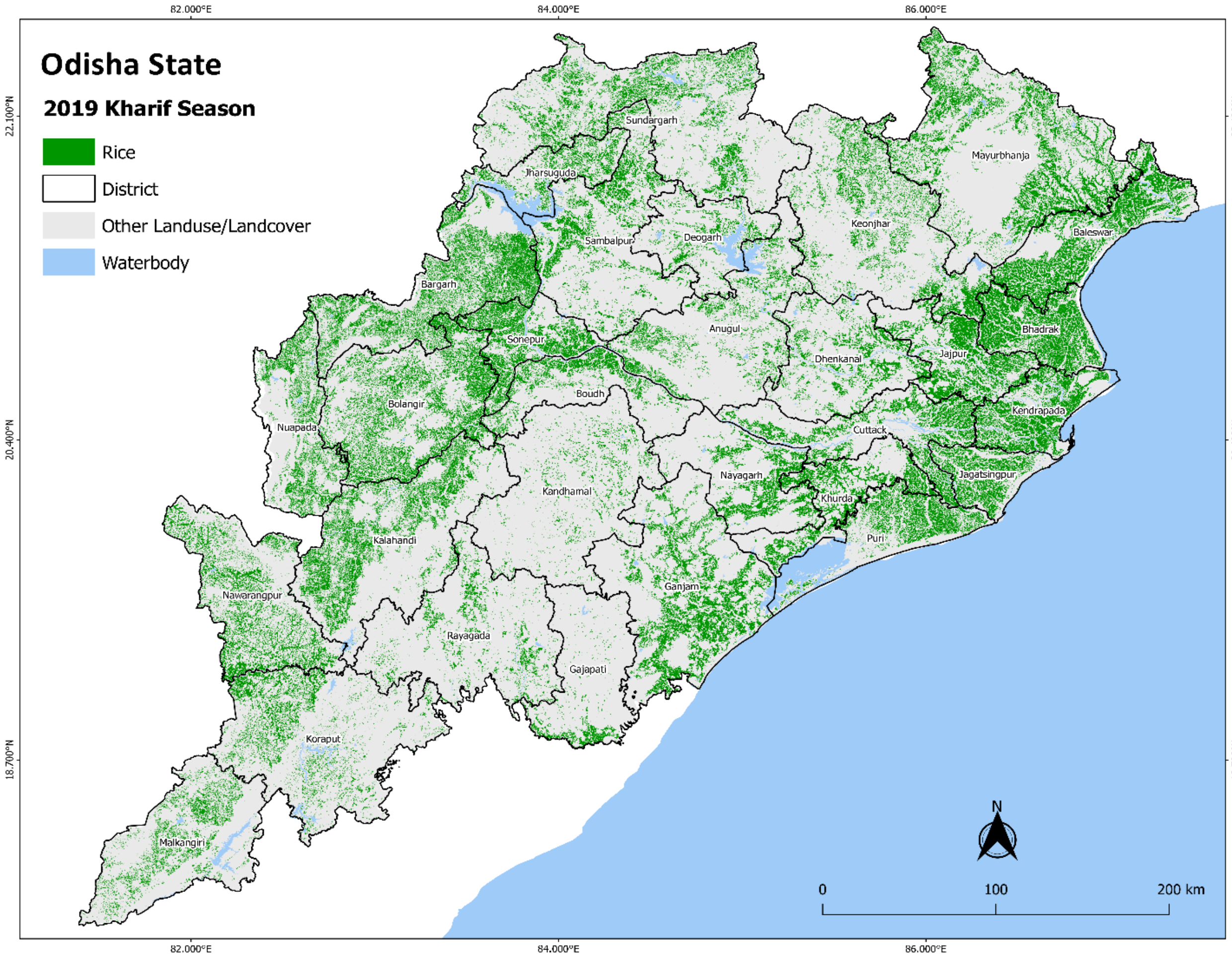


Figure 5.4. Kharif 2018 rice areas in Odisha

Table 5.2. Kharif 2019 season satellite-based planted area estimates at the district level as compared with the previous year's rice area statistics from the Department of Agriculture

District	SRM estimates ('000 ha)	Average of previous year's reported rice area ('000 ha)	RMSE	NRMSE	Agreement (%)
Angul	84.5	82.3	2	2.7	97.3
Balasore	170.7	187.0	16	8.7	91.3
Bargarh	206.6	234.7	28	17.7	82.3
Bhadrak	139.6	162.0	22	13.8	86.2
Bolangir	205.0	197.3	8	11.4	88.6
Boudh	56.5	62.9	6	10.2	89.8
Cuttack	108.6	121.9	13	19.4	80.6
Deogarh	36.0	47.3	11	23.8	76.2
Dhenkanal	73.1	89.7	17	18.5	81.5
Gajapati	25.6	35.8	10	28.6	71.4
Ganjam	194.4	253.3	59	23.2	76.8
Jagatsinghpur	72.1	79.0	7	8.7	91.3
Jajpur	106.4	120.3	14	11.5	88.5
Jharsguda	49.4	48.1	1	2.8	97.2
Kalahandi	173.1	198.8	26	12.9	87.1
Kandhamal	43.3	41.2	2	5.2	94.8
Kendrapara	115.6	128.8	13	10.2	89.8
Keonjhar	137.4	174.3	37	21.2	78.8
Khurda	86.7	96.2	9	9.8	90.2
Koraput	105.4	105.4	0	0.0	100.0
Malkangiri	77.7	97.8	20	20.5	79.5
Mayurbhanj	232.8	303.4	71	23.3	76.7
Nabarangapur	137.8	143.3	5	3.8	96.2
Nayagarh	75.4	94.7	19	20.4	79.6
Nuapada	89.0	92.7	4	4.0	96.0

District	SRM estimates ('000 ha)	Average of previous year's reported rice area ('000 ha)	RMSE	NRMSE	Agreement (%)
Puri	86.7	103.5	17	16.3	83.7
Rayagada	60.9	57.2	4	6.6	93.4
Sambalpur	113.9	137.6	24	17.3	82.7
Sonepur	101.3	103.7	2	2.4	97.6
Sundargarh	159.5	200.2	41	20.3	79.7
Odisha	**3,325.0**	**3,800.1**	**24**	**0.19**	**81.4%**

The map of rice crop start-of-season (SoS) for Odisha (Fig. 5.5) shows the rice sown/planted dates across Odisha during this reporting period. It was derived from detection of the lowest backscatter (dB) value of multi-temporal SAR signature, the trend after the detection of the lowest dB, and its consistency of NDVI values. During this kharif2019, the start-of-season dates were detected starting from the first week of June with autumn rice-growing area and peak of planting observed in August in winter rice-growing area. By delineating rice area estimates based on start-of-season estimates, it was possible to generate the monthly progression of cultivated rice area across districts of Odisha (Table 5.3).

Our start-of-season map indicates that, during kharif 2019, rice crop season progressed as below:

- August was the peak sowing/planting period, covering about 51.7% of total rice cropped area, which we classified as early winter rice
- A total of 31.4% of the rice area was planted during June, which we classified as autumn rice
- About 10% of the rice area was planted during July, which constitutes autumn rice and a mixture of autumn and early-winter rice
- The remaining 6.9% of the area was planted in September and could be considered as late-winter rice

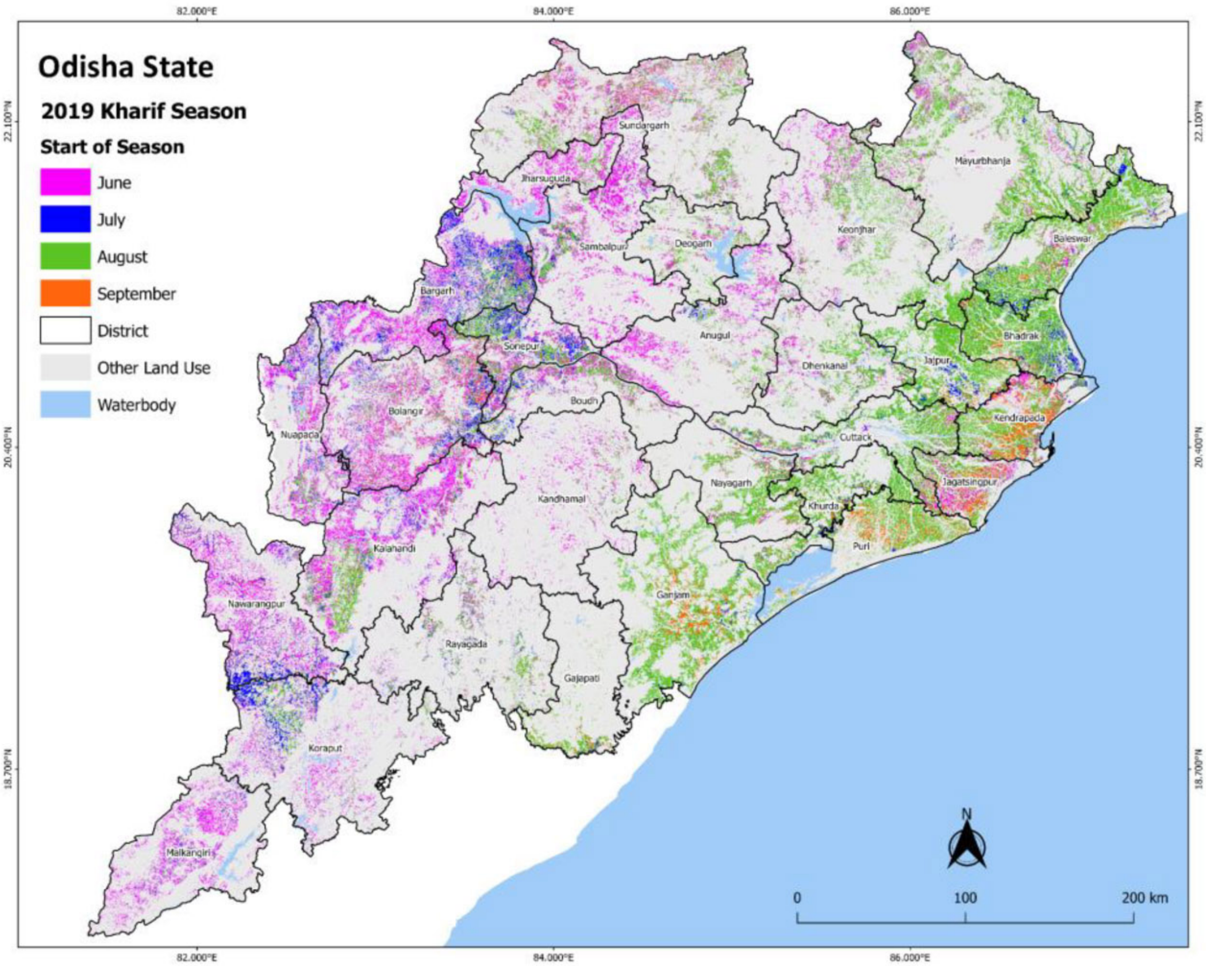


Figure 5.5. Rice crop start-of-season map with different colors representing different start-of-season dates during kharif 2019

Table 5.3. Rice area estimate results at the district level, kharif 2019 (June-December)

District	2019 Monthly rice area estimates (ha)				2019 Kharif rice estimates (ha)
	June	July	August	September	
Angul	54,827	3,027	25,868	731	84,453
Baleswar	9,300	9,683	142,312	9,418	170,713
Bargarh	92,961	66,797	45,620	1,188	206,566
Bhadrak	2	16,412	112,715	10,508	139,637
Bolangir	1,09,525	30,868	45,632	18,956	204,981
Boudh	22,378	7,072	25,810	1,254	56,514
Cuttack	13,001	4,761	85,932	4,955	108,649
Deogarh	11,039	979	22,820	1,159	35,997

District	2019 Monthly rice area estimates (ha)				2019 Kharif rice estimates (ha)
	June	July	August	September	
Dhenkanal	16,701	2,554	53,698	133	73,086
Gajapati	1	1,554	19,554	4,483	25,592
Ganjam	10	3,930	162,318	28,157	194,415
Jagatsinghpur	18,624	1,773	30,282	21,453	72,132
Jajpur	14	9,074	88,787	8,512	106,387
Jharsuguda	39,921	602	8,879	-	49,402
Kalahandi	98,786	19,191	48,398	6,684	173,059
Kandhamal	31,142	1,458	10,602	130	43,332
Kendrapara	10,730	3,670	59,475	41,769	115,644
Keonjhar	35,986	3,018	97,185	1,209	137,398
Khurda	882	4,993	73,501	7,335	86,711
Koraput	47,648	29,811	27,293	689	105,441
Malkangiri	63,154	7,985	5,700	875	77,714
Mayurbhanj	34,970	7,232	183,809	6,752	232,763
Nabarangpur	89,604	29,149	18,902	189	137,844
Nayagarh	7,840	1,759	60,156	5,608	75,363
Nuapada	53,781	16,584	16,455	2,177	88,997
Puri	3	1,568	60,785	24,304	86,660
Rayagada	17,311	7,484	34,743	1,389	60,927
Sambalpur	79,773	6,623	27,382	81	113,859
Sonepur	27,346	26,933	44,368	2,634	101,281
Sundargarh	58,051	4,378	81,221	15,857	159,507
Odisha	**1,045,311**	**330,922**	**1,720,202**	**228,589**	**3,325,024**

Rice area map validation

To validate the satellite-derived rice maps of Odisha, rice and non-rice (RnR) ground truth data were collected extensively (1,662 rice points and 1,444 non-rice points) at the end of the season across Odisha, with each district having approximately 100 ground truth points (ca. 50 rice and 50 non-rice). Accuracy assessments using these points were conducted and the result shows an overall accuracy of 95.6% (with kappa index of 0.91) at the state level (Table 5.4). The accuracy assessment at the district level is summarized in Table 5.5 and rice area estimates along with the validation points are shown in Figure 5.6. The summary of the RnR data collection shows that the majority of the rice crops were already at maturity to harvest at the time of data collection. Ground data used in the validation procedure are independent from the ground data used in the calibration of rice area classification.

Table 5.4. Odisha rice area map accuracy computation (state level)

Confusion matrix computations				
Predicted class from the map				
		Rice	Non-rice	Accuracy
Actual class from survey	Rice	1,595	67	96.0%
	Non-rice	71	1,373	95.1%
	Reliability	95.7%	95.3%	95.6%
Average accuracy		95.5%		
Average reliability		95.5%		
Overall accuracy		95.6%	Good accuracy	
Kappa index		0.91		

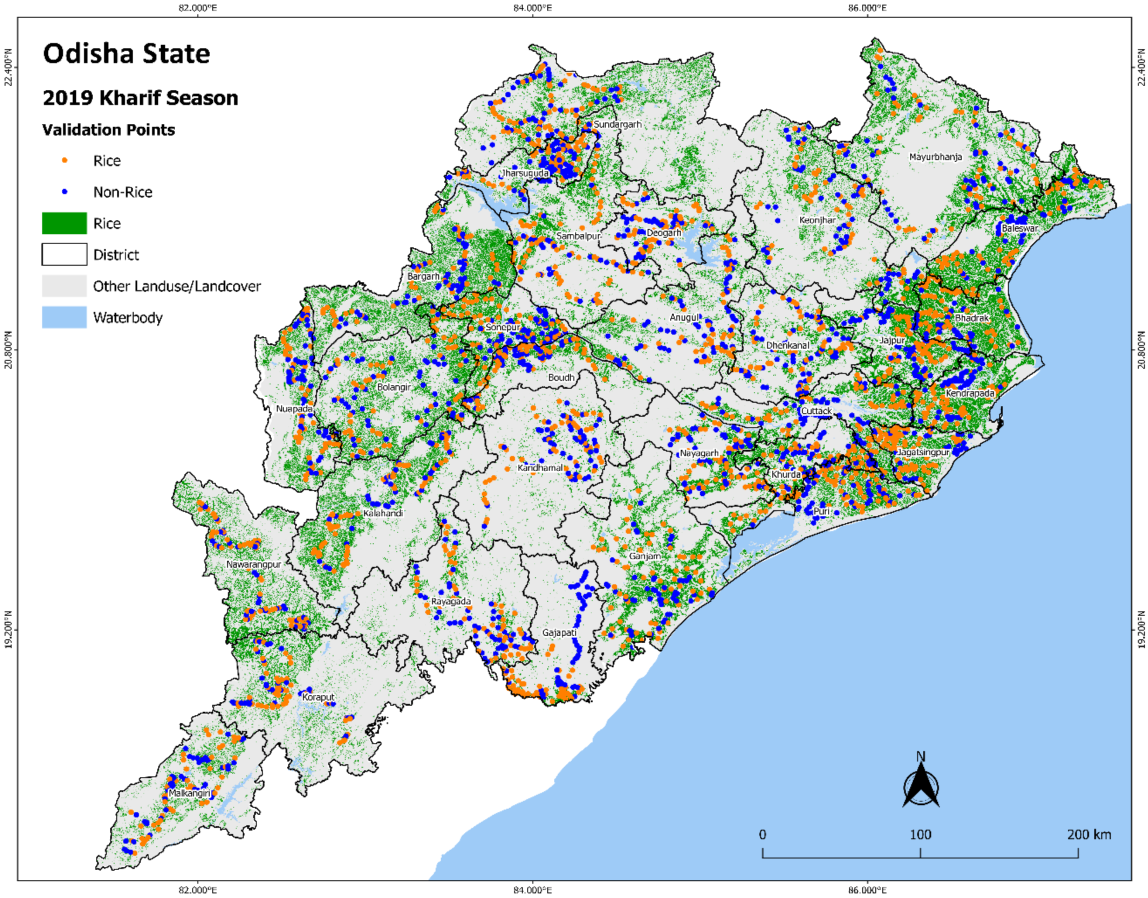


Figure 5.6. Kharif 2018 rice areas with validation points

Table 5.5. Rice area map accuracy by districts in Odisha

District	Validation points	Average accuracy (%)	Average reliability (%)	Overall accuracy (%)	Kappa index
Angul	103	93.2	93.2	93.2	0.86
Baleswar	104	97.1	97.3	97.1	0.94
Bargarh	97	94.8	94.9	94.8	0.90
Bhadrak	102	99.2	98.8	99.0	0.98
Bolangir	107	95.2	95.4	95.3	0.91
Boudh	97	97.0	96.9	96.9	0.94
Cuttack	100	97.0	97.0	97.0	0.94
Deogarh	101	97.0	97.2	97.0	0.94
Dhenkanal	100	99.0	99.0	99.0	0.98
Gajapati	102	96.1	96.1	96.1	0.92

District	Validation points	Average accuracy (%)	Average reliability (%)	Overall accuracy (%)	Kappa index
Ganjam	115	94.9	94.7	94.8	0.90
Jagatsinghpur	102	96.6	98.7	98.0	0.96
Jajapur	108	98.1	98.2	98.1	0.96
Jharsuguda	105	87.6	87.6	87.6	0.75
Kalahandi	103	90.6	90.1	91.3	0.83
Kandhamal	102	98.0	98.1	98.0	0.96
Kendrapara	103	96.8	97.5	97.1	0.94
Keonjhar	104	88.4	88.4	88.5	0.77
Khurda	112	97.2	97.5	97.3	0.95
Koraput	101	96.8	97.1	97.0	0.94
Malkangiri	102	89.2	89.2	89.2	0.78
Mayurbhanj	107	98.1	98.2	98.1	0.96
Nabarangpur	100	97.9	97.9	98.0	0.96
Nayagarh	105	98.1	98.1	98.1	0.96
Nuapada	99	95.9	96.1	96.0	0.92
Puri	102	97.0	97.1	97.1	0.94
Rayagada	109	89.0	89.0	89.0	0.78
Sambalpur	106	96.5	95.3	96.2	0.92
Sonepur	109	95.4	95.4	95.4	0.91
Sundargarh	100	97.1	96.8	97.0	0.94
Odisha	**3,106**	**95.5%**	**95.5%**	**95.6%**	**0.91**

A pilot study for rice area map validation at insurance unit level

The unit of crop insurance in PMFBY is a gram panchayat (GP). Besides our usual district-level area accuracy assessment, we carried out an additional accuracy assessment at the insurance unit level. To this end, we randomly selected a GP from two districts, namely, Badbausen and Murusundhi from Bargarh and Sonepur districts, respectively. From each GP, a total of 60 ground truth (ca. 30 rice and 30 non-rice) points were collected during the flowering stage of the rice crop (in September). The collected rice and non-rice (RnR) points were compared with mid-season generated maps for the respective GPs. The estimated rice area along with the ground truth points are presented in Figures 5.7 and 5.8. Although the rice area maps were generated around mid-season, we observed overall accuracy of 87.1% and 93.3% for Badbausen and Murusundhi GPs, respectively (Tables 5.6 and 5.7).

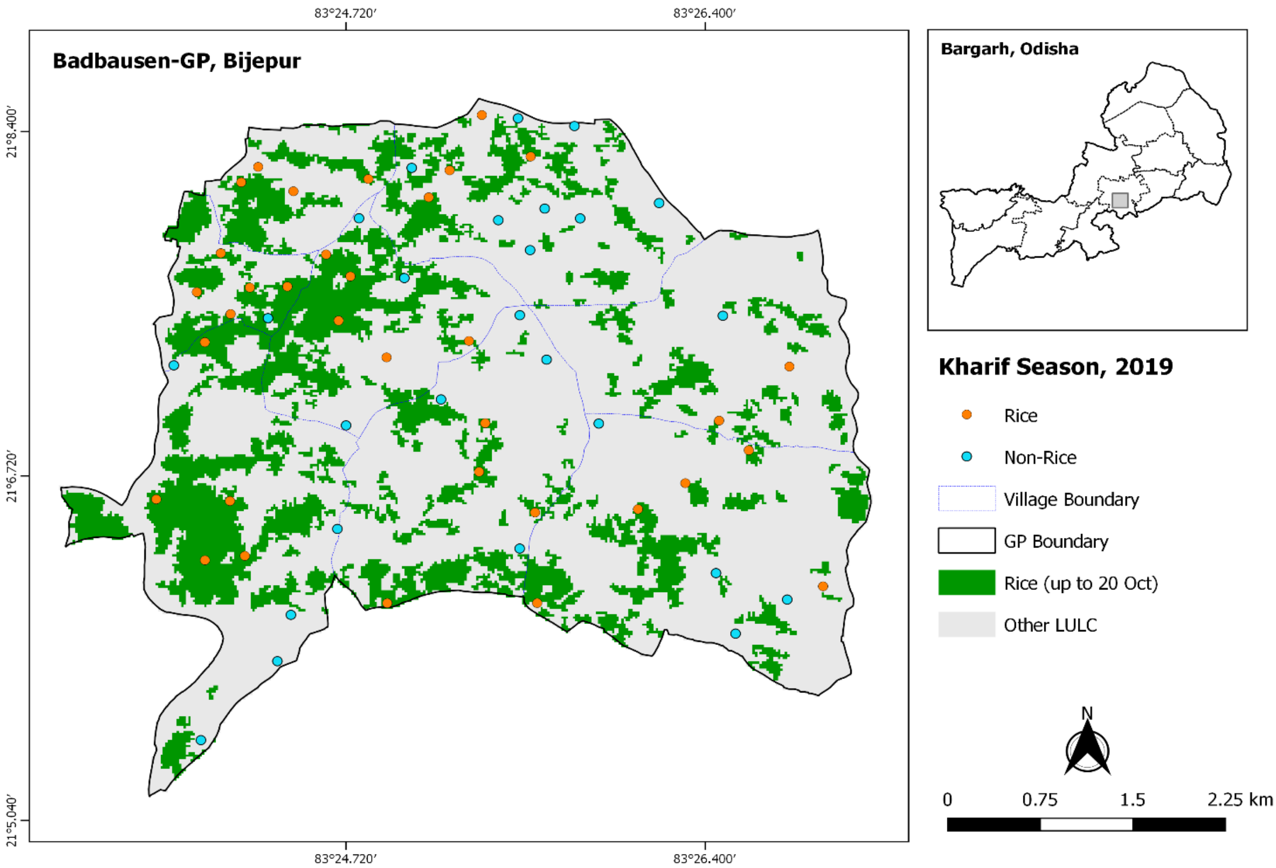


Figure 5.7. GP-level validation points with kharif 2019 mid-season rice areas in Bargarh

Table 5.6. Rice area map accuracy computation for Badbausen GP from Bargarh District

Confusion matrix computations				
Predicted class from the map				
		Rice	**Non-rice**	**Accuracy**
Actual class from survey	**Rice**	27	7	79.4%
	Non-rice	1	27	96.4%
	Reliability	96.4%	79.4%	**87.1%**
Average accuracy		87.9%		
Average reliability		87.9%		
Overall accuracy		**87.1%**	**Good accuracy**	
Kappa index		0.74		

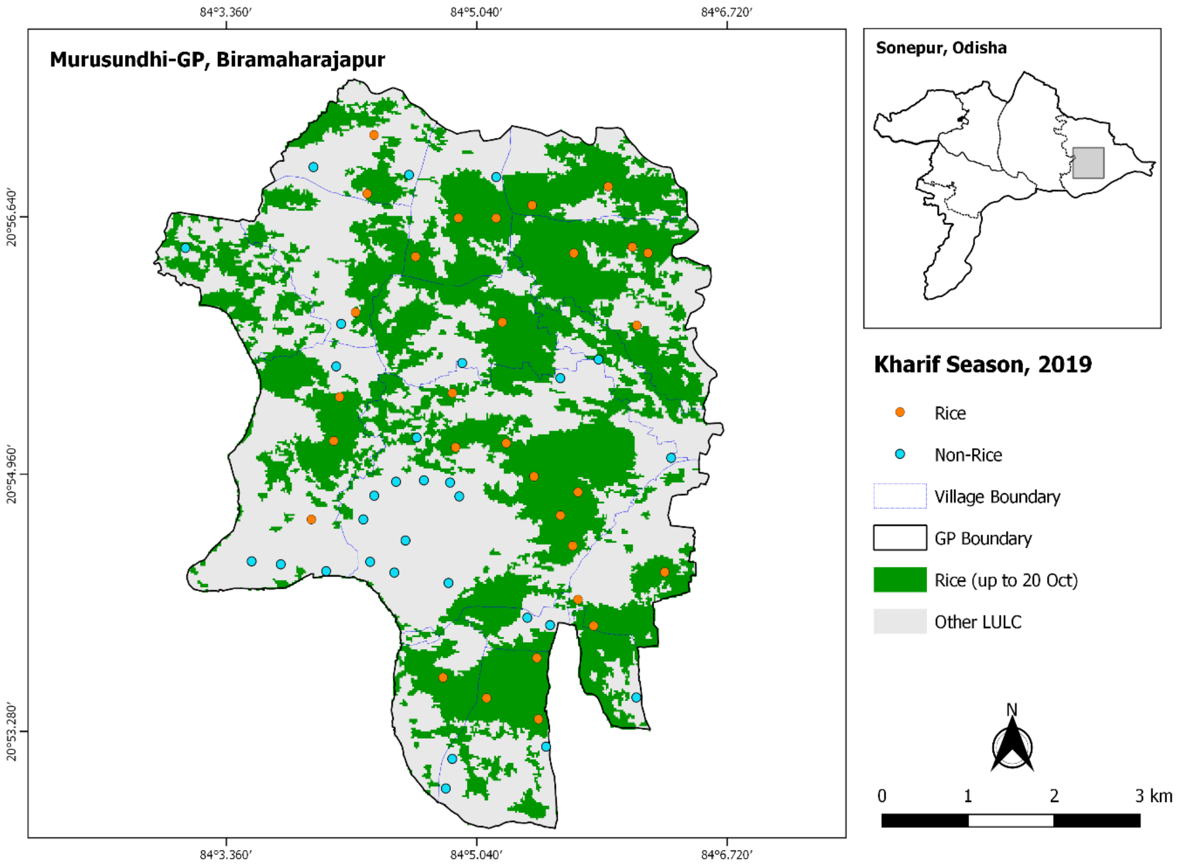


Figure 5.8. GP-level validation points with kharif 2019 mid-season rice areas in Sonepur

Table 5.7. Rice area map accuracy computation for Murusundhi GP from Sonepur District

Confusion matrix computations				
Predicted class from the map				
		Rice	**Non-rice**	**Accuracy**
Actual class from survey	**Rice**	28	2	93.3%
	Non-rice	2	28	93.3%
	Reliability	93.3%	93.3%	93.3%
Average accuracy		93.3%		
Average reliability		93.3%		
Overall accuracy		**93.3%**	**Good accuracy**	
Kappa index		0.87		

Generation of the inputs for crop yield modelling

Generally, in our generation of crop yield model inputs, we use only cross-polarization (VH) from dual-polarized SAR acquisitions since it provides a better correlation with the leaf area index than co-polarization (e.g., VV). But, during this reporting period, instead of depending only on VH from dual-polarized SAR to deliver LAI, the monitoring team used the Dual Polarization Index (DPSVI), which consists of, and influence, both co- and cross-polarizations

(VV and VH) from Sentinel SAR acquisitions. The DPSVI, SAR-based vegetation index is very well correlated with NDVI (Periasamy 2018) and can be developed without any ancillary data. A specific algorithm in MAPScape-Rice (developed jointly by IRRI and sarmap) computes the LAI from the SAR intensity measured at about one-third of the season; the approximate season duration must be known a priori (Fig. 5.9). The final outputs consist of LAI values and SoS dates, along with weather data identifiers that are then used to run ORYZA for forecasting pre-harvest yield and estimating end-of-season yield.

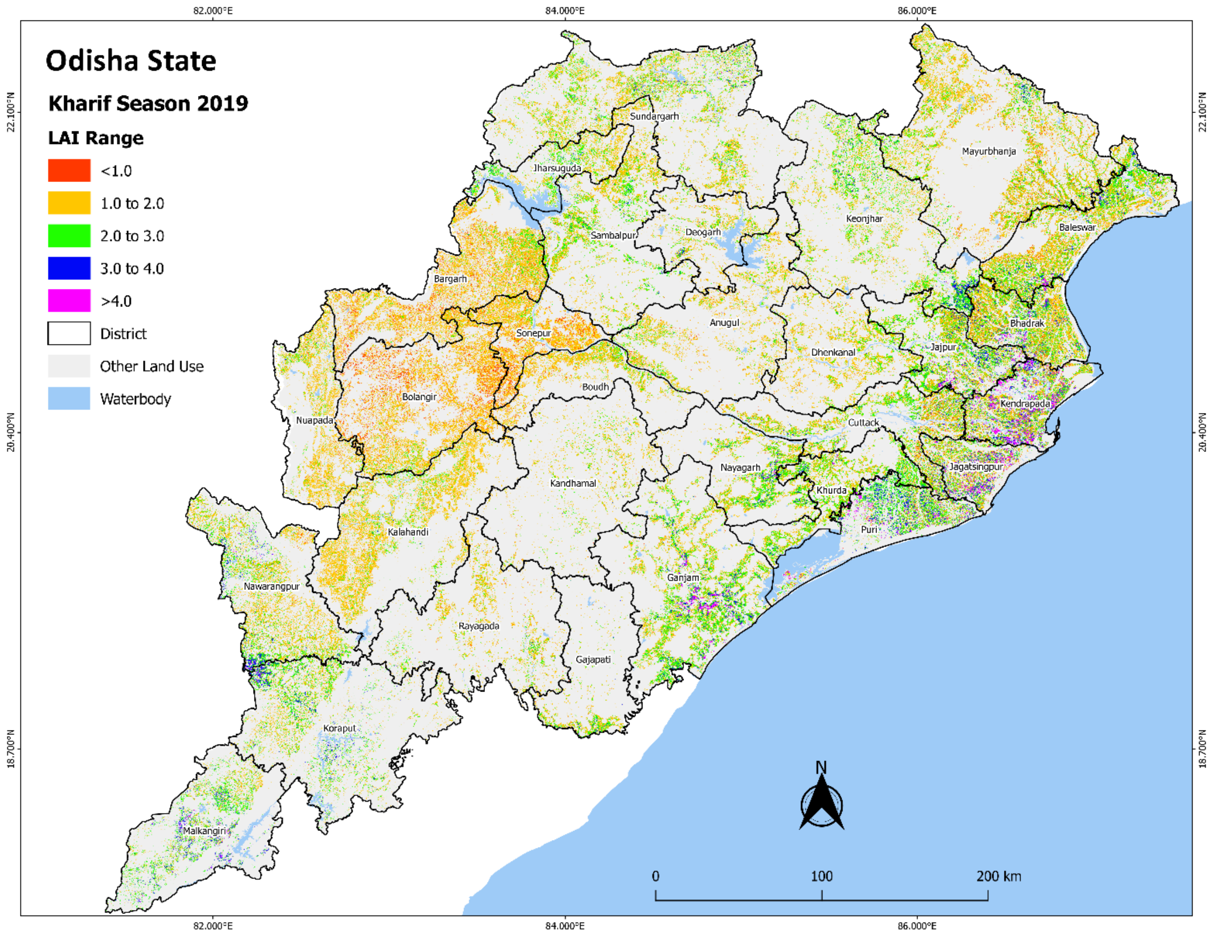


Figure 5.9. Rice LAI map with colors from red to green to magenta corresponding to progressively increasing values

2019 Kharif-season yield estimates

We estimated rice production and yield at the district level by integrating remote-sensing-based rice products with a crop growth model (Table 5.8). The rice yields (at 14% moisture content) were estimated using ORYZA and Rice-YES. The Rice-YES interface facilitated integrating the remote-sensing information (i.e., rice SoS and SAR-derived LAI) into the crop model along with non-remote-sensing inputs (weather, soil, agronomic management, rice varietal characteristics). The following input data were used in the Rice-YES tool: (i) processed SAR images from Sentinel 1A and 1B satellites (from 3 June to 30 December) of all three tracks across the state, and (ii) weather data, varietal characteristics, soil data, and crop management information. The weather data consist of total daily values for solar radiation, minimum and maximum temperature, average daily wind speed, average daily vapor pressure, and total daily precipitation. The crop management parameters were composed of crop establishment method, irrigation practices, and amount of applied inorganic N fertilizer. The production estimates were calculated by multiplying end-of-season yield estimates by rice area estimates.

Figure 5.10 shows the spatial distribution of end of season rice yield while Table 5.8 shows the aggregated district level yield estimates for 2019 *Kharif* season. District level end of season yield estimates range from 2.0 t/ha (Jharsguda) to 5.4 t/ha (Dhenkanal) with majority of the districts having yields between 2.0 t/ha to 3.0 t/ha. State-wise average yield was recorded at 3.2 t/ha. The total rice production in Odisha for 2019 *Kharif* was estimated at 10.7 million metric tons. Unlike last year, higher productivity was seen in the districts of Dhenkanal, Bolangir, Nabarangapur, and Sonepur and this could be attributed to good rainfall distribution throughout the cropping season.

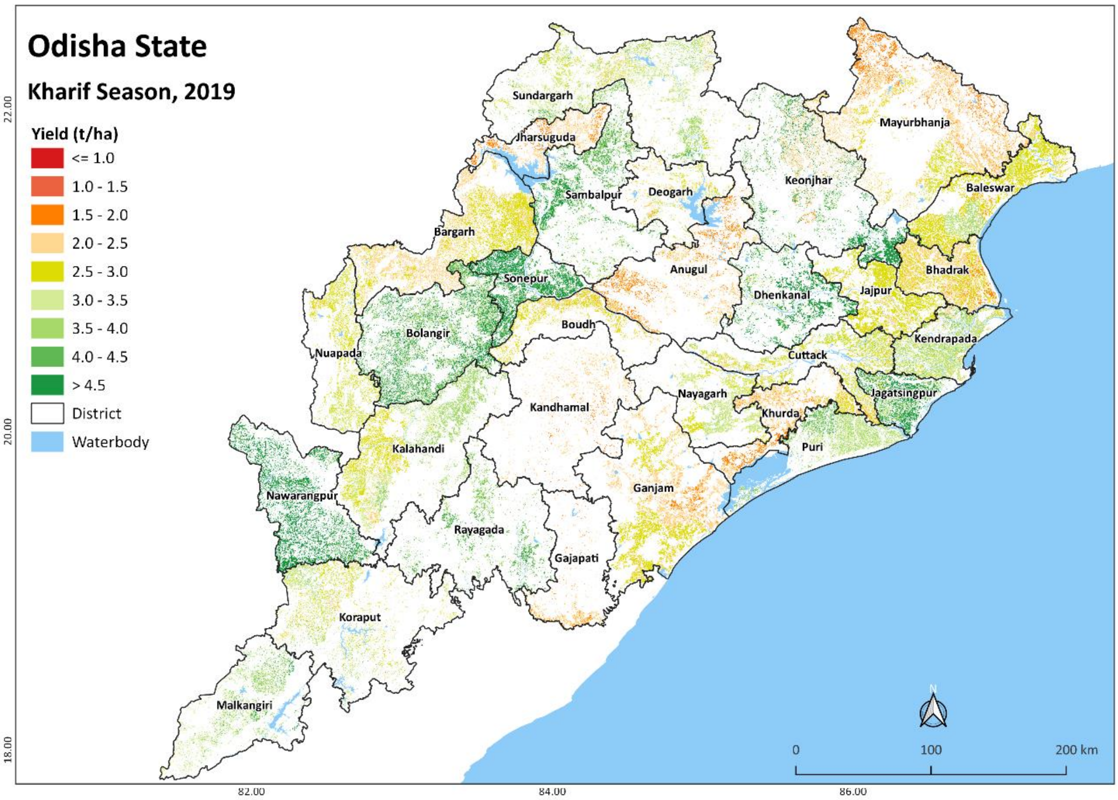


Figure 5.10 End of season rice yield estimates map, 2019 Kharif, Odisha

Table 5.8. Rice yield (at 14% moisture content) and production estimates aggregated by district during kharif 2019 season in Odisha, India

District	Yield, t/ha)	Production (t)	District	Yield, t/ha)	Production (t)
Angul	2.09	176,433	Kandhamal	2.20	95,176
Baleshwar	2.94	501,833	Kendrapara	3.33	385,540
Bargarh	2.55	525,741	Keonjhar	3.76	516,882
Bhadrak	2.45	341,901	Khurda	2.18	188,666

District	Yield, t/ha)	Production (t)	District	Yield, t/ha)	Production (t)
Bolangir	4.43	908,522	Koraput	3.07	323,506
Boudh	2.59	146,366	Malkangiri	3.59	278,769
Cuttack	2.15	234,116	Mayurbhanj	2.26	525,669
Deogarh	2.82	101,371	Nabarangpur	4.84	666,630
Dhenkanal	5.38	393,137	Nayagarh	3.15	237,550
Gajapati	3.03	77,489	Nuapada	2.89	256,772
Ganjam	2.42	469,561	Puri	3.67	318,323
Jagatsinghpur	4.85	354,708	Rayagada	4.11	250,438
Jajapur	2.70	286,943	Sambalpur	4.26	485,399
Jharsuguda	2.02	99,928	Sonepur	5.20	527,116
Kalahandi	3.25	562,157	Sundargarh	3.26	520,563
Odisha				**3.24**	**10,757,205**

A pilot study for intensive yield estimation

IRRI agreed to provide remote-sensing-based yield estimation at the GP level in two selected districts, Puri and Jagatsinghpur, to support the government in implementing Pradhan Mantri Fasal Bima Yojana (PMFBY) by complementing yield assessment normally conducted with sample crop cuts.

For the intensive yield estimation, the team gathered the key input parameters needed for the Rice-YES system (mentioned above). In addition, to increase the rigorousness of our yield estimation process, we collected information from farmers about observed yield and their management practices. We also conducted crop-cut experiments (CCEs) in farmers' fields in these districts, which enabled us to validate the RS-based yield estimates. Brief details of the CCEs conducted to validate yield estimation for this study appear in Table 5.9.

The final RS-based yield estimation was made for these districts and the estimates are being validated with CCE-based yields at different levels (i.e., point, GP, block, and district). The results of RS-based GP-level aggregated yield of Jagatsinghpur have shown 83.4% (range 78-99%) agreement with the CCE GP-level yield (Table 5.10). Validation for Puri District is in progress. The final results will be shared with the government soon.

Table 5.9. Details of CCE conducted by IRRI in pilot districts

District	Total no. of CCE	No. of GP/villages covered	Approx. no. of CCEs per village/GP
Jagatsinghpur	85	16	5
Puri	189	18	10

Table 5.10. Kharif 2019 season remote-sensing-based yield estimates at the GP level vis-à-vis crop-cut experiment results

Block	Gram Panchayat	CCE per Gram Panchayat	GP average CCEs yield (kg/ha)	RS based GP level yield (kg/ha)	RMSE (kg/ha)	NRMSE (%)	Agreement (%)
Balikuda	Nagapur	5	3,264	4,176	912	21.8	78.2
	Rahana	5	3,080	4,600	1,520	33.0	67.0
Biridi	Adhanga Majurai	4	3,652	4,241	589	17.7	82.3
	Hajipur	5	4,323	4,261	62	1.5	98.5
Erasama	Goda	5	3,083	4,638	1,555	11.4	88.6
Jagatsinghpur	Jankoti	5	4,670	4,326	344	19.4	80.6
	Odasa	4	4,473	3,766	707	18.8	81.2
Kujang	Badabalikani	4	4,003	3,851	152	3.9	96.1
	Pandua	5	4,780	4,498	282	6.3	93.7
Nuagaon	Alana	6	3,805	3,974	169	4.3	95.7
	Rohia	5	3,482	3,928	446	11.4	88.6
Raghunathpur	Chikinia	4	4,676	4,746	70	1.5	98.5
Tirtol	Jagannathpur	5	4,096	4,617	521	11.3	88.7
	Tulanga	5	4,563	4,566	3	0.1	99.9
District		**67**	**3,996**	**4,290**	**714**	**0.17**	**83.4%**

Flood damage assessment during kharif 2019

Cyclone Fani made landfall in coastal Odisha in Puri District on 3 May 2019, triggering heavy rainfall coupled with high-velocity wind exceeding 120 km/h. The rice monitoring team in Odisha assessed the extent of flood as an aftermath of the cyclone using SAR technology.

- Figure 5.11 shows the inundated area in Puri District caused by cyclone Fani with the background of 2018 rabi season rice and pulse area. In Puri District, total flooded area in the aftermath of cyclone Fani was 33,380 ha (9.7% of the total district area), of which 3,435 ha are rice and 29,945 ha are other agricultural fields that include pulse fields. The estimated rice area in this district was 28,063 ha. Ground observation and reports from the government indicated that most of the rice fields were already harvested prior to the cyclone. The effective early warning system and mobilization of awareness campaigns by the government and the period of the cyclone event contributed to relatively less rice area affected by the cyclone
- Ground observation (Fig. 5.12) and SAR signature analysis indicated that some rice crops that were at early ripening stage recovered a few days after the cyclone but eventually lodged and experienced 20–30% yield loss due to heavy winds (shattering grains). Unlike rice, pulses that were at the pod-filling stage at the time of flooding in Pipli and Nimapada blocks experienced severe damage as observed on the ground and detected by SAR signature. The flood map had an accuracy of 80% with kappa value of 0.6 based on validation of ground data (Fig. 5.11)

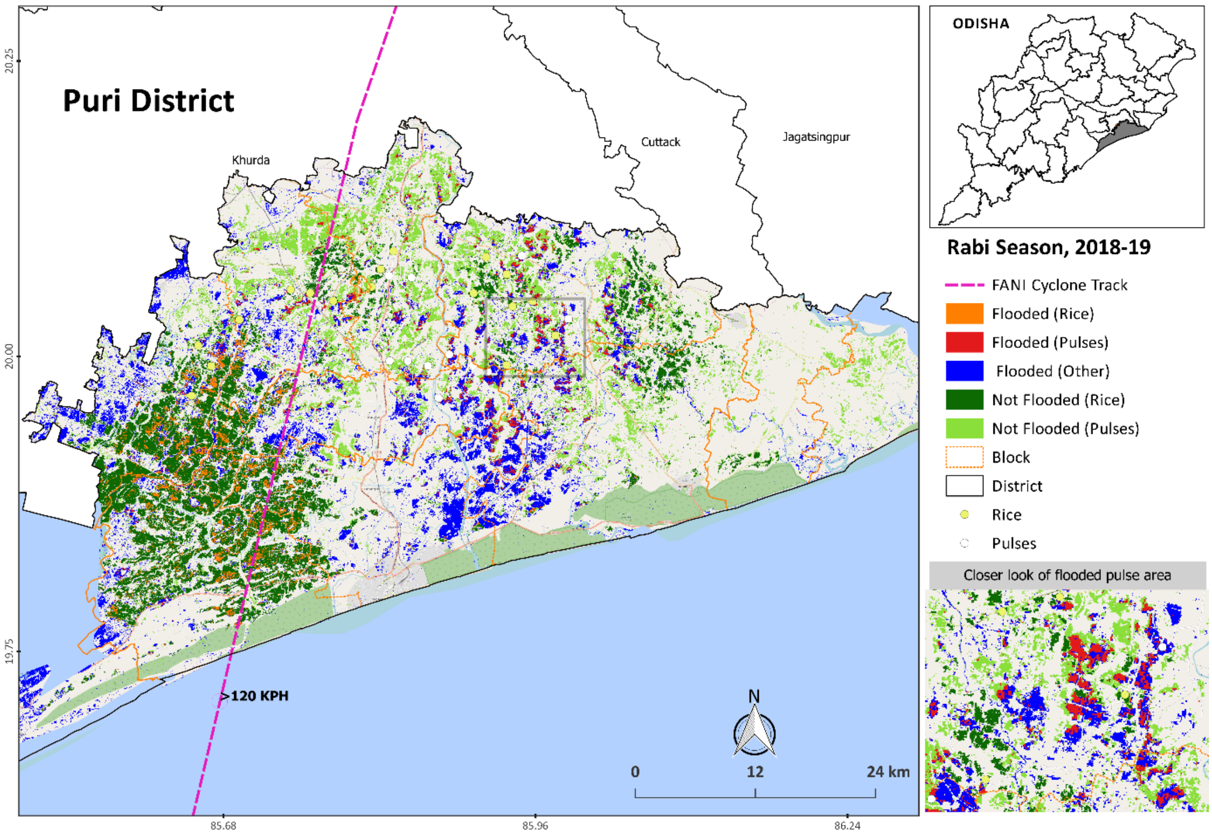
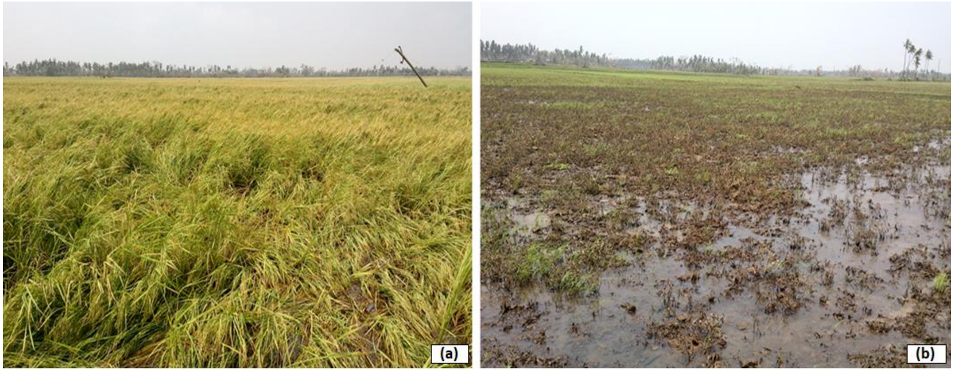


Figure 5.11. Flood extent in Odisha on 4 May 2019 caused by cyclone Fani on 3 May 2019 (SAR data source: Sentinel1, baseline; TerraSAR-X, inundated area)



Photos 5.1. Rice (a) and pulse (b) fields affected by cyclone Fani in Puri District as observed on 11 May 2019

Table 5.11. Puri flood-affected rice areas, May 2019

Block name	Total rice area (ha)	Flooded rice area (ha)	Other flooded area (includes pulse area) (ha)
Astaranga	6	0	134
Brahmagiri	10,962	1,596	1,836
Delanga	1,691	107	1,875
Gop	1,289	19	2,961
Kakatpur	205	0	167
Kanas	6,336	995	3,295
Krushnaprasad	192	14	9,288
Nimapada	2,348	6	3,064
Pipili	677	6	1,053
Puri	3,127	471	3,367
Satyabadi	1,230	222	2,905
District total	**28,063**	**3,435**	**29,945**

Capacity development

A "Learning Alliance Workshop on Crop Insurance" was organized at Tamil Nadu Agricultural University on 23-24 September 2019 to explore and experience the implementation of the crop insurance scheme by the state. The workshop consisted of a one-day interaction session with Tamil Nadu Department of Agriculture in Chennai, followed by a one-day visit and meeting with the remote sensing and GIS team at Tamil Nadu Agricultural University in Coimbatore, Tamil Nadu. The visiting team consisted of officials from PMFBY Nodal Office, GoO, IRRI scientists, and representatives from the concerned crop insurance agencies.

A follow-up workshop was conducted at Krishi Bhavan on 21 October 2019 for officials from the DoA and insurance agency representatives. This workshop focused on ways to fine-tune the remote-sensing work and facilitate the crop insurance program in Odisha. Insurance unit-level (GP) remote-sensing products are being generated to assist the PMFBY, and were presented at this event.

Conclusions

The rice monitoring team successfully identified **rice area** fairly accurately considering the complexity of the monitored area: different crop practices such as direct-seeded vs. transplanted, different environmental/climatic conditions such as rainfed and irrigated, dynamic sowing/planting for autumn rice-growing area (mostly in upland) and winter rice-growing area (mainly in medium land and lowland), fragmented areas with different crops or with very different stages of rice growth, etc., and the resolution of the satellite data. Systematic observation by the rice monitoring team across different seasons and years has given good knowledge on crop cultivation practices across the state. This has led to good improvement in rice area accuracy for kharif 2019 (95.6%) vis-à-vis the previous year (87.6%) and for kharif 2017 and 2018 (93.5%). The results obtained from a pilot study of GP-level rice area accuracy assessment also showed that satellite-based technology could help to raise the accuracy to more than 85% at the insurance unit level, which is the ultimate requirement for the PMFBY. Nonetheless, it is very encouraging for the technologists as well as policymakers to have good confidence in using the satellite-based technology in crop insurance (PMFBY) to improve the process efficiency.

Our results from rice SoS detection suggest that our products are able to detect rice area at the start of the season well in both transplanted and direct-seeded fields. However, we observed higher discrepancies in the case of autumn rice fields of western districts of Odisha, which contain mostly direct-seeded rice. The reason could be a rain event during June, which triggered widespread grass growth in winter rice fields, which is similar to autumn rice growth, for which sowing occurred from the first week of June to early July.

Yield estimation has been completed for 13 districts of the state and the estimation for the other districts is in progress. The results indicate that the current estimation process can detect the yield distribution pattern depending on the ecosystem where the crop is grown. The estimated yield ranged between 2.0 to 3.0 t/ha for most districts, with few districts having >4.0 t/ha average yield. Average yield for the state was estimated at 3.2 t/ha and the total kharif rice production was estimated at 10.7 million metric tons.

In a pilot study of intensive yield estimates at the GP level for Puri and Jagathsingpur districts, the RS-based GP-level yield has a good agreement of 83.4% in Jagatsinghpur and validation is in progress for Puri. However, government yield statistics are also needed to validate the yield estimates from crop modeling. Likewise, continuous collection of management practices and accurate weather information will help to improve the current estimation processes.

Subproject 5: Science-based Crop Insurance
5B: Delivering a Science-based Crop Insurance System for Increasing Farmer Resilience

Subproject 5: Science-based Crop Insurance
5B: Delivering a Science-based Crop Insurance System for Increasing Farmer Resilience

Awareness and literacy of agricultural risk mitigation strategies are proven to have direct bearing on technology or service adoption and agricultural investment (Gaurav et al 2011, Nakano et al 2018, Pan et al 2018). The Government of India, in the revised guidelines of Prime Minister Fasal Bima Yojana (PMFBY), has targeted achieving a 10% incremental increase in coverage of voluntary insurance take-up (non-loanee farmers). Insurance companies are mandated to spend 0.5% of the gross premium collected toward publicity and awareness creation. Given the complexity of the process and product features, we do not expect low-cost information campaigns (such as wall painting and loudspeaker announcements) to have a significant impact on farmers' awareness and literacy of crop insurance, which has large implications for crop insurance uptake. Further, crop insurance is complex to comprehend for farmers in general (Gaurav and Singh 2012) and, in particular, it is a big hurdle for Odisha farmers, given low literacy and awareness about PMFBY (less than 30% of the farmers had heard about PMFBY). Even among the farmers who have registered for PMFBY, either voluntarily or credit-linked, some are not aware of under what conditions the compensation is paid. In addition, PMFBY does not cover individual loss at the farm level; rather, it covers climatic covariate risk at the GP level, which adds further complication to farmers' comprehension on PMFBY. Thus, unlike a mass awareness program, a well-designed awareness program targeting improving farmers' understanding and literacy on crop insurance is needed to update their current belief structure, which consequently impacts their uptake. Therefore, structural re-designing of the existing crop insurance program is required to ensure widespread acceptance and adoption and to have welfare impacts from PMBFY. A socially acceptable crop insurance product aims to stabilize farmers' income and increase technological adoption by providing coverage against climatic shocks at an affordable premium. This subproject aims to develop policy options for designing comprehensive and socially acceptable crop insurance by aligning farmers' preference with various insurance attributes and developing and testing different options for insurance awareness and literacy campaigns, as well as ways of bundling insurance with other risk-reducing technologies.

The major objectives of this subcomponent are to

- Identify key indicators of an ideal crop insurance product based on farmers' preference
- Elicit farmers' insurance literacy levels and awareness about the PMFBY
- Test innovative farmers' training interventions for information dissemination and capture their effects on farmers' awareness and insurance uptake
- Design a variable crop insurance product bundling crop insurance with stress-tolerant rice varieties and examine farmers' preference for and uptake of coupled insurance products

Activities and outputs in 2019-20

Sample description: Taking into account the diverse conditions of the state, 15 representative districts were selected, accounting for factors such as weather risk, gross cropped area under rice, agro-climatic zones, and insurance clusters classified by the Government of Odisha. Figure 5.12 represents our sampled districts in the state. Using the probability proportional to size (PPS) sampling approach, 300 villages were randomly selected from the 15 selected districts. Only rice-cultivating farmers were considered when sampling the farmers.[3] In each village, 10 farmers were randomly selected to carry out a detailed household survey.

Baseline survey: A baseline survey was carried out during June 2018 and it was conducted with a total of 3,000 farmers. The survey aimed to collect the baseline household information (prior to interventions) about farmers' awareness and uptake of PMFBY and other relevant agricultural production details. In addition, we also elicited farmers' preference for crop insurance attributes based on the choice experimental approach.

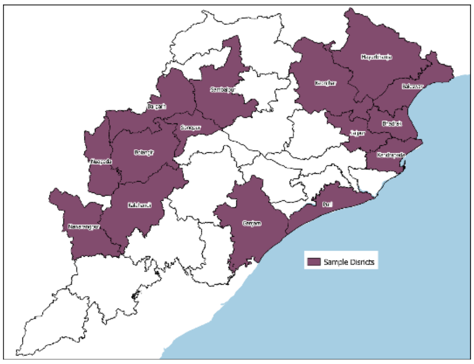


Figure 5.12. The selected districts in our study

Educational intervention and bundled insurance product: During June 2019, we conducted a randomized control trial (RCT) by randomizing the different educational training interventions in our baseline sample villages. The randomization was done at the village level, where 252 villages were provided with different training interventions (see details in Section 2.2).

Basic characteristics: Before we explain the farmers' preference for insurance and outcomes of our interventions, we describe the basic characteristics of our sampled farmers. Prior to the intervention, only around 34% of the farmers took out a crop loan during kharif 2018, whereas only 10% of the farmers received credit in rabi 2018-19 (Table 5.12). The Primary Agricultural Cooperative Society (PACS) is the main source of formal credit in both kharif and rabi seasons, followed by public-sector banks (Figs. 5.13 and 5.14).

Nevertheless, 15% of the farmers who received credit sourced it from the informal lending system. This indicates that about 75% of the farmers (non-loanees and informally taken credit) are not part of the mandatory crop insurance system, and who are to be targeted under the voluntary insurance take-up strategy. In addition, only 34% of the farmers knew about PMFBY before the training programs.

[3]Prior to sampling of farm households, a village census was conducted in these selected villages to gather basic information about the farming households and crop insurance status.

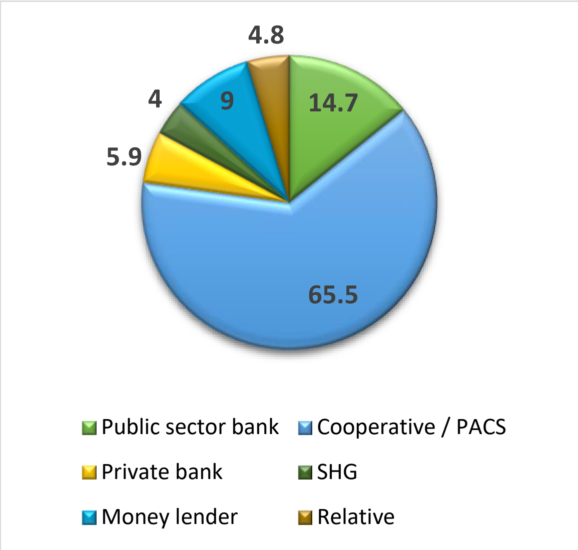


Figure 5.13 Credit sources, kharif 2018

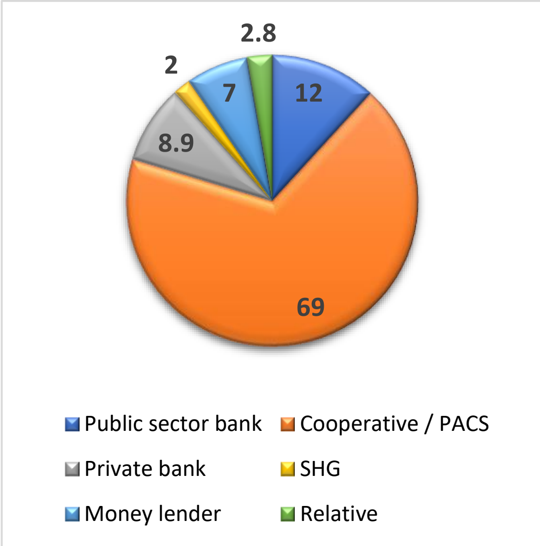


Figure 5.14 Credit sources, rabi 2018-19

Table 5.12. Basic characteristics of sampled farmers

SN	Particular	Percentage
1	Farmers who received crop loan during kharif 2018	33.94
2	Farmers who received crop loan during rabi 2018-19	10.17
3	Farmers who knew about PMFBY before our training programs	34.43
4	Farmers who registered for PMFBY in kharif 2018	
4.1	Percentage who were aware of PMFBY	24.23
4.2	Percentage of total sample	9.00
5	Farmers who registered for PMFBY in rabi 2018-19	
5.1	Percentage who were aware of PMFBY	7.14
5.2	Percentage of total sample	2.50
6	Average area registered under PMFBY by a household in kharif 2018 (acres)	3.45
7	Average area registered under PMFBY by a household in rabi 2018-19 (acres)	2.89
8	Farmers who purchased other insurance policies (life, health, vehicle, etc.)	18.08
9	Average rice cultivated area in kharif 2018 (in acres)	2.87
10	Average rice yield during kharif 2018 (in quintals per acre)	11.71

Among the farmers who were aware of the PMFBY scheme in the baseline survey, only 24% of them had registered for PMFBY during kharif 2018 and only around 7% during rabi 2018-19. Among those who had registered for the scheme, the average areas registered by a household were 3.45 and 2.89 acres in kharif 2018 and rabi 2018-19, respectively (Table 5.12). Further, we looked at the take-up of other insurance such as life, vehicle, and health insurance.

We found that only 18% of the sample purchased any general insurance policy. The average yield farmers received during kharif 2018 was almost 12 quintals per acre (2.9 t/ha). The results pointed to the need of a program specifically targeting non-loanees and marginal and smallholder farmers through appropriate insurance awareness and educational programs to increase insurance take-up, which consequently insulates them against climatic risks.

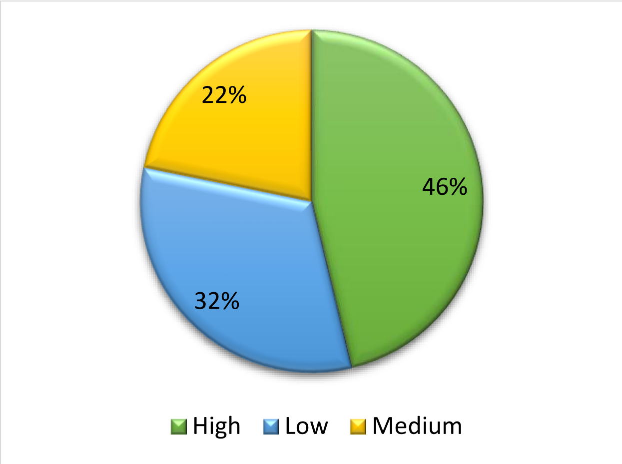


Figure 5.15 Farmers' risk aversion elicitation

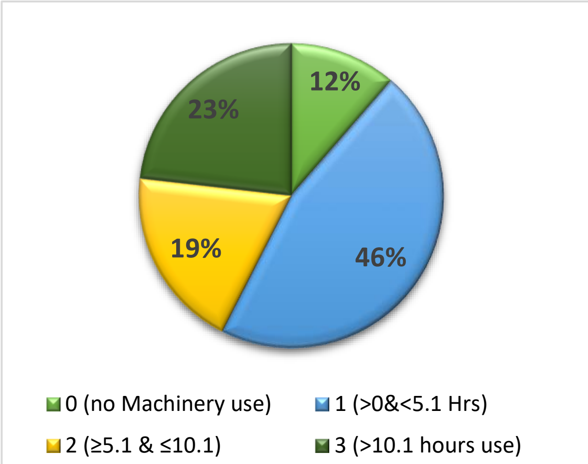


Figure 5.16 Machinery use in kharif 2018

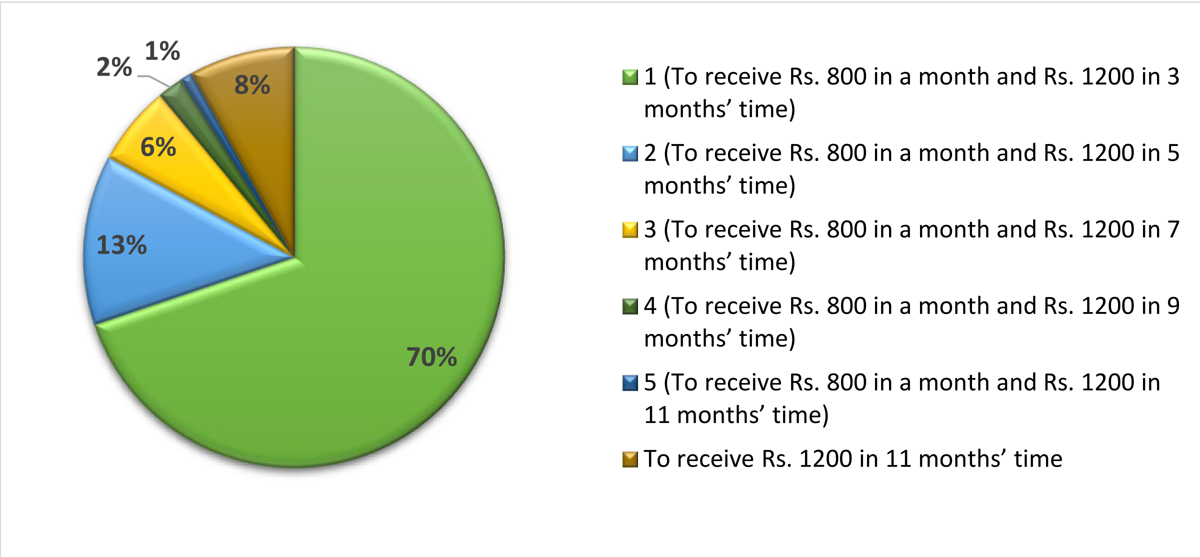


Figure 5.17 Farmer time preference characteristics

Much evidence suggests that the ability of farmers to take risk and credit constraints determine their investment behavior as well as ability to adopt new technologies (Sunding and Zilberman2001, Liu 2013). With this background, we elicited farmers' risk and time preferences using Sutter et al (2013) risk modules. The results showed that 68% of the farmers are high to medium risk averse (Fig. 5.15). Time preference elicitation suggests that a majority of the farmers would like to discount their future benefits for a lower amount sooner in time rather than a larger amount later (Fig. 5.17). Around 70% would not prefer to wait even an additional two months for compounded benefits of 50% (INR 400), which indicates that farmers have liquidity constraints and/or more urgent needs that compel them to forgo compounded benefits. Our results indicate that farmers have behavioral constraints that are directly influenced by their resource limitations, which restrain them from adopting new technologies. This is evident from the machinery use of farmers in rice cultivation. We observed that around 60% of the farmers' use of machinery was less than five hours per acre during kharif 2018 (Fig. 5.16).

Interventions in crop insurance

1. Socially acceptable insurance: willingness to pay and hypothetical bias

1.1 The context

Insurance is a complex product to many, as it requires an individual's understanding of the probability of risk discounted over a period of time and possible payout under different scenarios. Given the poor literacy among farmers in developing countries, their ability to process information on insurance products varies substantially. The economics and psychology literature have discussed the limitations and implications of an individual's ability to process information on choice behavior. In addition, individuals may attempt to avoid conflict when choices are complex, leading to simpler heuristic choices, sticking to the status quo, and non-attendance to attributes. At the same time, goods and services are often viewed by consumers as a bundle of attributes, and preference for a product can be segregated into preferences for different attributes attached to that product or service. We used the choice experiment (CE) approach to elicit farmers' willingness to pay (WTP) for insurance attributes, which will help us to identify the most (least) preferred insurance attributes and help re-design the product to be socially acceptable.

The use of the CE method under the hypothetical settings was criticized in the literature for its overestimate of individual preferences and consequently their willingness to pay. Under hypothetical settings, individuals do not have to commit to the choices they made during the elicitation and no other incentive exists for them to report true WTP; thus, the estimated value for the good is known to be over-reported (Loomis 2011). Stating that, the WTP estimated using CE for insurance product attributes suffers from hypothetical bias and cannot be used directly for policy decisions. It is well evident that incentivizing choices while eliciting preference decreases hypothetical bias, thus enabling policymakers to gather true preferences, which aids in estimating unbiased demand for product and price appropriately. In this context, we introduced an incentive-compatible insurance CE to understand socially acceptable insurance product attributes and farmers' WTP.

1.2 Intervention: incentive-compatible choice experiment

In the present study, we conducted an artifactual field experiment with rice farmers who make decisions on purchasing crop insurance. We carried out a CE in 300 selected villages covering 15 representative districts in Odisha during June 2018 (see sampling description section). Following between-subject design, we implemented an incentivized choice experiment (ICE) and hypothetical choice experiment (HCE), which are randomized at the village level, that is, an equal number of villages received HCE and ICE treatments. In contrast to the HCE, in the ICE treatment, farmers have to purchase the insurance product from the endowment provided in the experiment if they choose the insurance option. Our design consists of five attributes: insurance unit, types of risk covered, yield assessment method, claim settlement time, and transparency of the insurance system. Each farmer was faced with four choice cards and, on each card, they chose the most preferred option among three alternatives consisting of two alternative crop insurance products and an opt-out option. Before the decision on the choice card, we elicited the farmers' cognitive ability using existing verbal and non-verbal modules such as mathematical ability (Frederick 2005) and logical ability (Ravenet al 1998) using a pre-structured questionnaire.

One of the initial steps in designing a CE is to identify the choice alternatives, comprising relevant attributes (Hanley et al 2002, Hensher et al 2005). The identification of attributes was tested with several stakeholders. The attributes were finalized according to importance and scope of improvement. The identified non-price attributes are insurance unit (IU), risk coverage (RC), yield loss estimation procedure (YEP), claim settlement time (CST), and process transparency (PT), and a sixth, price attribute, premium and/or sum-insured, is introduced in the choice experiment to estimate the WTP for each attribute. These six attributes are briefly described below.

- The attribute ***insurance unit (IU)*** refers to a parcel of land for which the premium is calculated and claim settlement is made if that parcel of land experiences yield loss due to specified weather risks. The IU could have four levels: an individual plot, village, gram panchayath, and block

- The attribute ***risk coverage*** means that insurance products can offer coverage for various types of risks and uncertainties. In crop insurance, present insurance products could potentially cover different types of risks. (a) *Prevented sowing,* in which the insurance product offers to cover the loss endured by farmers if 70% of the area in the insured unit had been intended to sow or plant and incurred expenditure, but could not be sown or planted due to adverse weather conditions such as flood, drought, and other natural disasters. In such cases, farmers do not obtain any output and the insured unit will be eligible to receive a claim equivalent to 25% of the sum insured. (b) *Full crop coverage (FCC):* This product covers all the risk that the crop could face in the production process from the time of pre-sowing to threshing. (c) *FCC with market risk coverage:* Along with covering all the crop risk from pre-sowing time to postharvest, the insurance product provides an edge against a fall in the market price, that is, it ensures covering price risk if the market price falls below a threshold price (INR 12 per kg of paddy) in the season (see Table 5.13)

- The attribute ***yield loss estimation*** is an important process when designing the insurance product and for making a decision about the claim settlement in case of crop loss. The insurance provider or regulator can use different methods to estimate crop yield loss and decide about the indemnity to be paid to the insured person. In the present study, the insurance provider mainly uses the following three methods to estimate crop loss: (a) *Crop-cut experiment (CCE).* To carry out a CCE, a 5m × 5m-area in a randomly selected rice field in the insurance unit is chosen. The farmer harvests the crop in the designated area, calculates the moisture content, and weighs the produce. The weight obtained in the 5 × 5-m area is then extrapolated to estimate yield per acre. (b) *Remote sensing.* This uses satellite information along with historical yield data and meteorological data to estimate crop yield in the locality and estimate the yield loss due to extreme weather or other events. This method uses advanced weather models to predict the loss. (c) *Self-reporting.* Insured farmers in the locality can report the yield they obtained in the season and it will be compared to five successive preceding normal years to decide about the indemnity payment

Table 5.13. Attributes and levels used in choice experiments

Attribute name	Attribute description	Attribute levels
Insurance unit (IU)	A parcel of land/area of the crop for which the premium is calculated and claim settlement is made	1. Block,2. GP, 3. village, 4. individual plots
Risk coverage (RC)	Insurance products that offer coverage for various types of risks and uncertainties	1. Prevented sowing 2. Full crop coverage (FCC) 3. FCC + market price risk
Process transparency (PT)	A transparent system that provides clear information about the YEP, estimated yield, comparison with respect to the previous threshold yield, the decision about eligibility for claim settlement, claim settlement details, and update/status of an application for insured individuals through SMS	1. Transparent 2. No transparency
Claim settlement time (CST)	This is the time lag between the time of damage and the time the insured person receives an indemnity	1. Within 3 months from the damage time 2. Within 6 months 3. More than 6 months
Yield loss estimation process (YEP)	The approach that the insurance provider/regulator uses to estimate the crop yield, calculate the loss, and decide about the indemnity to be paid to the insured person	1. Crop-cut experiment (CCE) 2. Remote sensing 3. Self-reporting
Premium and sum insured	The amount to be paid to cover the risks against which the crop insurance is designed	

- The attribute ***claim settlement time (CST)*** is defined as the time lag between the time of damage and the time the insured person receives an indemnity. Insurance providers take *less than 3 months*, *less than 6 months,* and *more than 6 months* to settle claims for the insured plot from the time of damage

- The attribute ***process transparency (PS)*** mainly addresses the level of system transparency. A *transparent system* provides clear information about the yield estimation process, estimated yield, comparison with respect to the previous threshold yield, the decision about eligibility for claim settlement, claim settlement details, and update/status of an application for insured individuals over SMS. In this system, the claim settlement is processed digitally and indemnity is transferred directly to the beneficiary's account. In contrast, a *non-transparent system* lacks this transparency and no digital information is sent to update insured individuals about their crop insurance policy

In the current insurance product prevailing in the country, the PMFBY scheme, the rice crop is insured with the GP as an IU, offered full crop coverage, uses CCE for yield estimation, and has a claim settlement time of more than 6 months. The system basically lacks transparency in terms of communication to insured farmers. Finally, the price attributes (*premium* and *sum insured*) are attached to each alternative by accounting for the current premium level of the PMFBY as well as the cost of the improvement.

1.3 Results

We estimated the utility preference and marginal WTP using both a multinomial logit (MNL) and mixed logit (MXL) framework. The coefficients of all insurance attributes are significant, suggesting that these attributes are relevant for farmers to make decisions on purchasing crop insurance (see Table 5.14). The significant standard deviation parameters in the MXL model (M2) confirm the presence of strong preference heterogeneity, which suggests that the one-size-fit of insurance products is not suitable for all farmers in Odisha.

Therefore, accounting for different tastes of farmers, the MXL model needs to be estimated for further interpretation. The WTP for changing risk coverage from prevented sowing to full crop risk coverage and to full crop plus market risk coverage is INR 427 and INR 510 per acre, respectively. We observed a negative WTP for changing insurance unit from an individual plot to GP or block (INR –100 or INR–87 per acre, respectively), which is intuitive as moving from a smaller IU to larger IU increases the basis risk, thus reducing the WTP. The farmers prefer remote sensing to the CCE method of yield estimation (INR 23 per acre); however, they do not prefer self-reporting-based yield estimation (INR –16 per acre). Surprisingly, we observed a positive and significant WTP for claim settlement time of more than 3 months. The most preferred timeline for claim settlement is 3 to 6 months (WTP of INR 34 per acre), yet there exists a timeline of less than 3 months for CST. Given that the current crop insurance scheme takes more than 6 months for claim settlement, farmers might think that less than 3 months is not a practical solution.

We found that the farmers are highly positive toward process transparency and are willing to bear the additional costs for transparency in the insurance process (WTP for PT is INR 45 per acre).

We calculated the hypothetical bias (HB) for each attribute by cumulating the estimated parameters. The calculated HB is presented in the last two columns. For the attribute risk coverage, the estimated HB is INR 67.12, that is, on average, the respondents in the hypothetical treatment reported higher WTP for full crop coverage by INR 67.12. The respondents' cognitive ability significantly contributes to reducing the hypothetical bias. Not accounting for cognitive ability, the HB would have been 5 times higher (INR 355.92; 49.63%). Similarly, for the FCC with market risk coverage attribute, the HB is INR 63.69 (7.25%). Other simple insurance attributes, such as insurance unit, also showed a similar trend in escalating HB when not accounting for cognitive ability of farmers.

Table 5.14. Discrete choice models and willingness to pay for crop insurance

Attribute	Basic MNL		Basic MXL		MXL with MS		MXL with LS		MXL with MSLS	
	Coeff. (S.E.)	WTP (S.E.)	Coeff. (S.E.)	WTP (S.E.)	Coeff. (S.E.)	WTP (S.E.)	Coeff. (S.E.)	WTP (S.E.)	Coeff. (S.E.)	WTP (S.E.)
	M1	**W1**	**M2**	**W2**	**M3**	**W3**	**M4**	**W4**	**M5**	**W5**
Premium	–0.005 (0.000)***		–0.008 (0.000)***		–0.006 (0.000)***		–0.012 (0.000)***		–0.006 (0.000)***	
Risk coverage (RC) (reference: prevented sowing)										
Full crop (FC)	–2.059 (0.077)***	427.23 (7.09)***	–3.480 (0.142)***	426.72 (5.84)***	–2.648 (0.192)***	409.22 (8.33)***	–6.021 (0.167)***	514.16 (3.29)***	–2.577 (0.193)***	412.05 (8.36)***
FC + market Risk (FCM)	–2.442 (0.099)***	506.61 (9.94)***	–4.158 (0.178)***	509.96 (8.26)***	–3.113 (0.241)***	481.17 (12.24)***	–7.520 (0.211)***	642.15 (4.54)***	–3.026 (0.242)***	483.84 (12.40)***
Insurance unit (IU) (reference: individual plot										
Village (IUV)	–0.103 (0.044)*	21.28 (9.17)**	–0.133 (0.060)*	16.33 (7.37)**	–0.207 (0.063)***	31.94 (10.23)***	0.092 (0.054)*	–7.83 (4.58)*	–0.181 (0.061)***	29.02 (10.21)***
Gram panchayat (IUG)	0.475 (0.034)***	–98.46 (7.43)***	0.818 (0.052)***	–100.34 (6.09)***	0.617 (0.062)***	–95.31 (7.86)***	1.502 (0.053)***	–128.28 (3.82)***	0.583 (0.060)***	–93.17 (7.84)***
Block (IUB)	0.415 (0.039)***	–86.09 (7.99)***	0.709 (0.068)***	–86.99 (7.52)***	0.402 (0.085)***	–62.15 (10.93)***	1.733 (0.071)***	–147.99 (4.25)***	0.303 (0.086)***	–48.47 (12.03)***
Yield estimation procedure (YEP) (reference: crop-cut experiment)										
Remote sensing	–0.085 (0.038)*	17.73 (7.98)**	–0.191 (0.055)***	23.38 (6.81)***	–0.207 (0.056)***	32.01 (8.93)***	–0.129 (0.049)***	10.98 (4.18)***	–0.169 (0.055)***	26.97 (9.00)***
Self-reporting	0.132 (0.029)***	–27.30 (6.25)***	0.132 (0.040)***	–16.23 (4.98)***	0.137 (0.040)***	–21.19 (6.50)***	0.082 (0.035)**	–6.96 (2.98)**	0.118 (0.039)***	–18.83 (6.53)***
Claim settlement time (CST) (reference: <3 months)										
3 to 6 months	–0.137 (0.029)***	28.48 (5.95)***	–0.280 (0.042)***	34.34 (5.04)***	–0.278 (0.042)***	42.98 (6.75)***	–0.400 (0.035)***	34.18 (3.05)***	–0.255 (0.041)***	40.82 (6.81)***

Attribute	Basic MNL		Basic MXL		MXL with MS		MXL with LS		MXL with MSLS	
	Coeff. (S.E.)	WTP (S.E.)	Coeff. (S.E.)	WTP (S.E.)	Coeff. (S.E.)	WTP (S.E.)	Coeff. (S.E.)	WTP (S.E.)	Coeff. (S.E.)	WTP (S.E.)
	M1	**W1**	**M2**	**W2**	**M3**	**W3**	**M4**	**W4**	**M5**	**W5**
>6 months	–0.073 (0.028)*	15.10 (5.79)**	–0.121 (0.039)**	14.88 (4.68)***	–0.123 (0.040)***	18.99 (6.06)***	–0.232 (0.035)***	19.78 (2.91)***	–0.114 (0.039)***	18.26 (6.13)***
Process transparency (PT)	–0.233 (0.028)***	48.31 (5.10)***	–0.367 (0.040)***	44.98 (4.23)***	–0.225 (0.047)***	34.76 (5.94)***	–0.682 (0.039)***	58.24 (2.45)***	–0.221 (0.046)***	35.37 (6.01)***
Treatment variables (interacted with insurance)										
Cognitive ability (MS)					0.430 (0.185)**	–66.40 (31.00)**			0.384 (0.194)**	–61.35 (32.85)*
Cognitive ability (LS)					–		0.940 (0.285)***	–80.28 (25.27)***	0.696 (0.291)**	–111.27 (48.44)**
Incentive					0.742 (0.128)***	–114.65 (22.13)***	–0.057 (0.131)	4.84 (11.14)	0.693 (0.126)***	–110.75 (22.81)***
Awareness score					0.793 (0.202)***	–122.55 (32.93)***	–0.308 (0.215)	26.28 (18.13)	0.589 (0.205)***	–94.26 (33.66)***
Standard deviation										
Premium			–0.003 (0.000)***		–0.003 (0.000)***		0.007 (0.000)***		0.003 (0.000)***	
RC: Full crop (FC)			–0.016 (0.163)		0.020 (0.156)		–0.067 (0.194)		0.085 (0.168)	
RC: FC + market Risk			–0.342 (0.147)*		–0.391 (0.136)***		–0.132 (0.190)		–0.256 (0.161)	
IU: Village			–0.463 (0.134)***		–0.610 (0.123)***		–0.094 (0.222)		–0.452 (0.136)***	

Attribute	Basic MNL		Basic MXL		MXL with MS		MXL with LS		MXL with MSLS	
	Coeff. (S.E.)	WTP (S.E.)	Coeff. (S.E.)	WTP (S.E.)	Coeff. (S.E.)	WTP (S.E.)	Coeff. (S.E.)	WTP (S.E.)	Coeff. (S.E.)	WTP (S.E.)
	M1	**W1**	**M2**	**W2**	**M3**	**W3**	**M4**	**W4**	**M5**	**W5**
IU: Gram panchayat			–0.596 (0.112)***		–0.810 (0.115)***		0.099 (0.160)		0.257 (0.124) **	
IU: Block			1.371 (0.118)***		1.286 (0.114)***		0.211 (0.134)		1.473 (0.114) ***	
YEP: Remote sensing			–0.470 (0.096)***		–0.615 (0.092)***		–0.161 (0.113)		–0.644 (0.087) ***	
YEP: Self-reporting			0.230 (0.118)		0.192 (0.116)***		0.138 (0.150)		0.343 (0.111) ***	
CST: 3 to 6 months			0.625 (0.091)***		–0.616 (0.093)***		0.062 (0.136)		0.428 (0.102) ***	
CST: >6 months			0.033 (0.101)		–0.082 (0.104)		0.081 (0.130)		–0.101 (0.105)	
Process transparency			0.535 (0.071)***		–0.462 (0.073)***		0.004 (0.110)		–0.475 (0.072) ***	
AIC	20,115		18,705		18,637		18,617		18,631	
Log likelihood	–10,046***		–9,331***		–9,293***		–9,284***		–9,291***	
No. obs.	11,988		11,988		11,988		11,988		11,988	

****P <0.001, **P <0.01, *P < 0.05; CA = cognitive ability, MS = mathematical score, LS = logical score.*

Table 5.15. Decomposing hypothetical bias (CA – mathematical score (MS), CE model – mixed logit estimations

Attributes	Conditional WTP in HCE	Cognitive ability (CA)	Familiarity (FA)	Contribution to hypothetical bias (HB)			HB (% of α)	HB_{noCA} (% of α)
	α	ϕ	π	INC (θ)	CA (ψ)	FA (ξ)	($\theta + \psi + \xi$)	($\theta + \xi$)
Risk coverage (RC)	717.13 (130.78)***	–421.03 (187.42)**	26.23 (84.92)	–307.50 (143.20)**	423.04 (189.55)**	–48.42 (89.86)	67.12 (9.36%)	–355.92 (49.63%)
Risk coverage (MR)	878.58 (163.61)***	–506.50 (228.73)**	19.91 (98.13)	–399.92 (178.89)**	508.83 (231.00)**	–45.22 (103.54)	63.69 (7.25%)	–445.14 (50.67%)
Insurance unit: village	16.06 (20.21)	–10.79 (28.32)	9.81 (10.91)	5.41 (21.65)	3.27 (28.47)	–6.71 (9.71)	1.97 (12.27%)	–1.30 (8.09%)
Insurance unit: GP	–190.77 (40.57)***	114.03 (58.45)**	–21.49 (22.19)	97.24 (43.42)**	–111.19 (59.14)*	20.76 (18.58)	6.81 (3.57%)	118.00 (61.85%)
Insurance unit: block	–146.92 (37.58)***	61.73 (52.88)	–38.47 (20.96)*	47.30 (40.71)	–47.29 (52.78)	40.23 (20.94)**	40.24 (27.39%)	87.53 (59.58%)
YEP: remote sensing	23.59 (24.22)	–5.45 (6.67)	2.13 (12.74)	1.32 6.(66.00)	6.41 (36.91)	–3.11 (12.68)	4.62 (19.58%)	–1.79 (7.59%)
YEP: self-reporting	–13.40 (8.53)	–13.16 (16.10)	10.26 (9.18)	–0.36 (8.53)	12.72 (15.75)	–10.62 (8.77)	1.74 (12.99%)	10.98 (81.94%)
Process transparency	87.04 (16.59)***	–51.50 (23.53)**	7.54 (9.34)	–50.72 (17.97)***	47.45 (24.10)**	–7.18 (9.47)	–10.45 (12.01%)	57.90 (66.52%)
CST: 3 to 6 months	50.92 (15.07)***	–17.55 (23.31)	9.83 (14.03)	–16.91 (15.86)	19.27 (23.48)	–6.25 (12.73)	–3.89 (7.64%)	23.16 (45.48%)
CST: >6 months	25.89 (4.55)***	–15.51 (6.76)**	2.93 (3.14)	–12.46 (4.91)***	14.60 (6.89)**	–3.07 (3.19)	–0.93 (3.59%)	15.53 (59.98%)

$^{***}P<0.01$, $^{**}P<0.05$, $^{*}P<0.10$, robust standard error reported in parentheses except for HB.

For GP, we observe negligible hypothetical bias of INR 6.81 where cognitive ability is significantly contributing to mitigate HB. For transparency and CST, the HB is small and negative in direction, suggesting that these attributes are simple to understand, which requires low cognitive ability.

A notable feature from Table 5.15 is that HB is large for the attributes that are complex to understand (exert cognitive cost) such as risk coverage and insurance unit. Thus, the contribution of respondents' cognitive ability is higher in mitigating these biases for attributes that are complex to comprehend. In summary, we observed a significant effect of cognitive ability on hypothetical bias, but were unable to affirm a similar effect for being familiar with insurance. Since the cognitive ability significantly reduces HB and the direction of the coefficient of cognitive ability is opposite to that of incentive factor, we confirm that *hypothetical bias is large when the cognitive ability of the farmer is low* and the farmers with low cognitive ability make inconsistent preferences between hypothetical and non-hypothetical settings.

1.4 Key implications

- A large preference heterogeneity for the risk coverage attribute was observed, with some farmers preferring to cover prevented sowing and others preferring to cover postharvest losses, etc. Therefore, keeping the option open for farmers to choose the type of risk that they would like to cover and linking the risk coverage with premium would work better than blanket provision of risk coverage. This would be more efficient to increase insurance acceptability
- We observed a large preference inconsistency for insurance attributes for farmers with low cognitive ability. This suggests that these farmers make their choices uninformed; hence, a targeted educational program is necessary to make them aware and increase their literacy. Such programs can improve understanding of the benefits of available options and making decisions consciously given their limited resources
- Insurance process-related attributes (transparency and claim settlement time) are the most important attributes for improvement. All the farmers, irrespectively of their cognitive ability to assimilate the information, mentioned these attributes to be improved, indicating that preference is consistent and any intervention in these attributes will have a significant impact on insurance choice. Therefore, policymakers and insurers should adopt information and communication tools to improve transparency and communicate and update the status related to loss estimated and status of claim release to the insured
- Farmers prefer remote-sensing yield estimation to the existing CCE method. This indicates a demand from farmers for crop insurance that assesses yield quickly and objectively. Thus, structural changes with respect to loss estimation are called for, and more so to replace the manual method with advanced and precise technology that derives yield objectively and is nearly accurate

2. Insurance awareness: educating farmers about insurance

2.1 The context

Results from the baseline survey showed a poor awareness among farmers (30%) and less than 10% of them take out crop insurance. But, the most important concern is that, although credit is by default registered into PMFBY, 80% of the loanee farmers reported that they have not taken out crop insurance. The elicited insurance literacy score of 0.29 indicates poor insurance literacy among farmers with regard to insurance terms such as premium, sum-insured, claim settlement, etc. The complexity of crop insurance requires an individual's understanding of the probability of risk discounted over a period of time and possible payout under different scenarios. Given the lower formal education levels in rural areas of Odisha, the farmers' ability to process and use the information on insurance products varies substantially. Therefore, disseminating information on complex products such as insurance may not be effective with low-cost information campaigns. This requires innovative methods to enhance insurance literacy among farmers to spur the take-up. In this context, we designed and tested the efficacy of three educational training programs, which are explained briefly in this section.

2.2 Interventions

Using an RCT approach, we designed and tested three different training programs, classroom training, stylized videos, and virtual decision experience using a crop cycle simulations app, which are randomly mixed with psychological modules that target improving farmers' confidence and execution ability.

2.2.a. Classroom training

A detailed standard manual consisting of crop insurance, information on STRVs, and holistic agricultural risk management in general was developed in Odia language based on research evidence, government documents and guidelines, and interactions with farmers, insurance companies, and other stakeholders (Figure 5.17). The training mainly focuses on the details of PMFBY, including crops covered, type of risks included, timeline and sources of registration, STRVs along with illustrations, experiences of a few farmers who have adopted the program, and follow-up group discussions. Regarding PMFBY, the training provides details about its importance, benefits, the premium amount, when and how to register, and its implementation and protocol for claim estimation and disbursement. For STRVs, the training details the names of varieties suitable for upland and lowland areas, the type and extent of risk they can withstand, and the duration, yield, and availability of STRVs in Odisha. The training also highlights the welfare effects of insurance in various risk scenarios as well as experiences from farmers about the use of STRVs and benefits of PMFBY. The classroom trainers were given rigorous training by IRRI staff on how to conduct classroom training with farmers. The training is conducted in classroom settings with writing boards for illustrations of examples, a training manual, and flip charts. Each training session on average required from 2 to 2.5 hours to complete, including the discussion and sharing of experiences. On average, 20 farmers took part in each training session.

2.2.b. Stylized training video

We developed a video in Odia with a detailed script containing the same information as that of the classroom training manual but delivered in the mode of a theatre production and story-based format with local context. The video shooting was done using local artists to give a human touch for effectiveness. In addition, the video used audio-visual effects, animations, graphs, and tables to simplify the complex aspects of insurance and explain examples for better comprehension. This video provides detailed information on holistic agricultural risk management, mainly crop insurance along with STRVs. In addition, it includes clips of interviews with real experiences of farmers who have adopted STRVs and crop insurance, and a motivational speech. This digital approach has potential of scalability with cost-effective dissemination and a clear understanding of the insurance scheme.

The video was played to farmers in groups, where each group consists of 15 to 20 farmers. The total length of the video is 35 minutes and the video is now made open-source at this link.

2.2.c. Virtual decision experience using crop cycle simulation app prototype

We developed a simulation app that runs farmers through different agricultural, financial, and risk management decisions for several rounds and the farmers have to make decisions in each activity choosing between alternatives. In the app, the initial wallet amount was indicated as the amount that the farmers have saved from the previous crop season and that is available in the following season. In the beginning of each season, farmers must decide on how much of the endowed money to allocate to education, health, insurance, and farming inputs such as seeds and fertilizer as well as farming methods.

The process starts with a credit allocation among production, insurance, and consumption activities. Then come varietal selection (STRV and non-STRV), land preparation (machine or manual), planting method (broadcasting/transplanting), harvesting method (manual/mechanical), etc. Four kinds of risk are introduced based on their probability of occurrence based on real data. At the end of every season, counterfactuals in graphical and table format are transmitted to the farmers on how much they earned from farming with and without insurance, with and without STRVs, and under risk and no-risk scenarios. This exercise helps farmers understand the importance of holistic risk management and the long-term effects of adaptation of risk mitigation strategies in a better way.

Farmers experience the virtual decision in the app individually after the general instruction. Each farmer faced five rounds of decision, with each round corresponding to each season. If the farmers earn a positive amount after investing from the wallet, it is accumulated along with the saved wallet for the next round of investment. Figure 8 shows some snapshots of farmers making decisions in the crop cycle simulation app.

Photos 5.2: Classroom training on holistic agricultural risk management

Photos 5.3: Snapshots of the stylized training video

Photos 5.4: Farmers making vivid decisions in the crop cycle simulation app

Psychological module

As indicated before, crop insurance is a complex concept and hence the information in the training is relatively difficult for farmers to understand at a glance. This complexity may induce disinterest among them and they may think that this is due to their low capacity to understand. In order to boost their confidence, increase receptivity, and improve their execution ability, we introduced specific psychological scripts into the training. The farmers were asked to set their next-season goal with respect to agriculture and identify the impediments and how to overcome them to reach that goal. The goal-setting exercise was done in smaller groups and later shared with all trainees so that everyone got to share their goal, impediments, and how to overcome them with the group. Thus, farmers can understand how others overcome the impediments in achieving their goal.

Randomization and implementation

The educational training was introduced under four different treatments:

- Classroom training
- Video training
- Classroom training + simulation app
- Video training + simulation app

These four training treatments were randomized at the village level. In total, we assigned training treatments for 252 villages and the rest were assigned as control. In order to test the effectiveness of the psychological intervention module, we randomly conducted the training with and without psychological modules during the training.

The training was conducted at the block-level common service center. The team was split into four groups according to different clusters and training was conducted simultaneously at four locations across Odisha. Field mobilization of farmers is done with the support of SurveyJena and CSC. Before the training, short structured face-to-face interviews were conducted to know their understanding about insurance and their agricultural expectation in the coming season. After the training, the farmers were interviewed to assess their knowledge on insurance terminology and they took an insurance quiz. From this, we elicited insurance awareness and literacy and compared them with the baseline insurance knowledge and literacy.

2.3 Results

Preliminary results of the impact of educational training showed a positive and significant increase in insurance awareness and literacy (see Figs. 5.18 and 5.19). The effect of psychological and simulation app treatments showed higher effects, whereas video is slightly higher than classroom training (Tables 5.16-5.19). We observed that the video (alone or in combination with the simulation app) has a similar effect on insurance awareness and literacy as that of the classroom (alone or in combination with simulation). But, when administered with the psychological module, video training marginally outperformed classroom training. This could be attributed to the visual effects of experience sharing of farmers who have adopted insurance or STRVs in the video training that were lacking in the classroom, wherein the farmers' experience was read out from a script. The experiment proved that video can be used for effectively scaling the insurance awareness and literacy program; however, it is now evident that combining video training with the psychological module to improve farmers' execution function would be more effective. From the evidence, we conclude that creating awareness about crop insurance and other agricultural risk mitigation strategies is one of the major areas to be targeted in order to increase farmers' (insurance) literacy, which helps farmers to make informed decisions consciously given their household condition. This would consequently affect the adoption of insurance or other risk mitigation strategy that would have a larger welfare impact on farmers in the era of climate change.

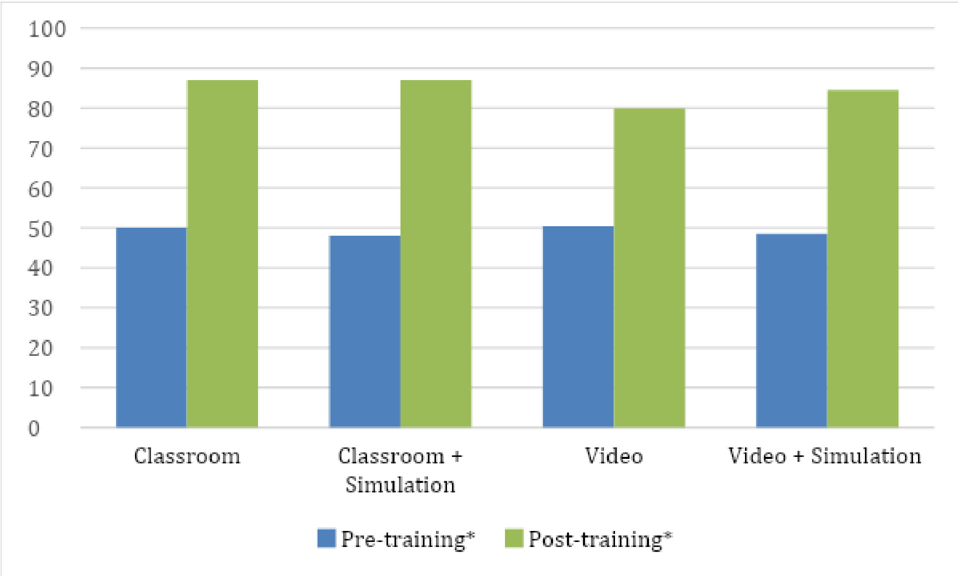


Figure 5.18. Impact of training on farmers' awareness about insurance terminology (% increase)

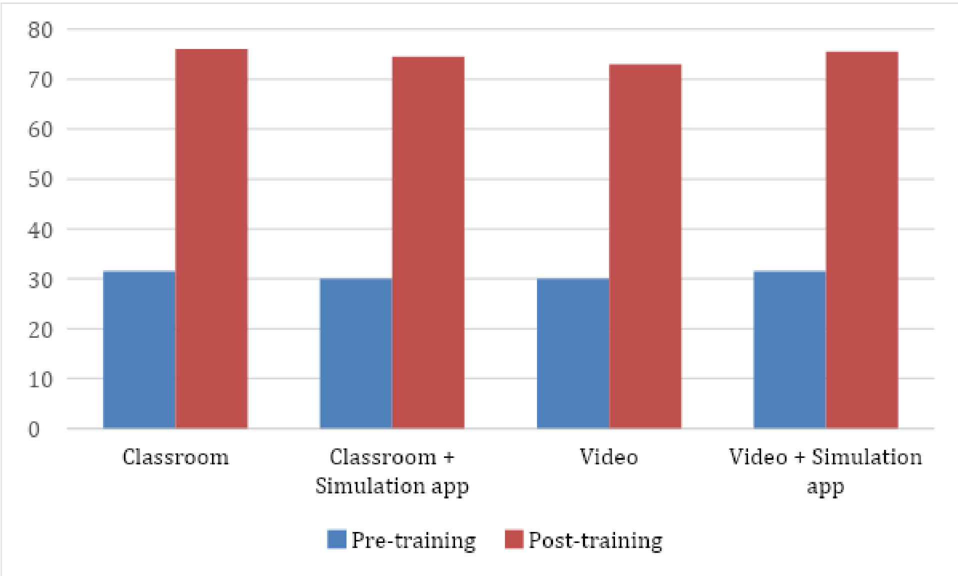


Figure 5.19. Impact of training on farmers' insurance literacy (% increase)

Table 5.16. Impact of training on farmers' knowledge on insurance terminology (percentage difference between before and after training)

Treatment type	With psychological module	Without psychological module	Total
Classroom only	67.86	63.04	65.84
Classroom followed by simulation app	70.37	72.99	71.63
Video only	69.23	62.38	64.83
Video followed by simulation app	71.79	69.15	70.45
Total	**69.78**	**66.81**	

Table 5.17. Impact of training on farmers' insurance literacy (percentage difference between before and after training)

Treatment type	With psychological module	Without psychological module	Total
Classroom only	55.04	58.88	56.66
Classroom followed by simulation app	56.53	59.22	57.74
Video only	57.18	56.28	56.62
Video followed by simulation app	57.91	57.05	57.47

Note: Baseline quiz score is considered as before training.

Table 5.18. Literacy level across treatments and control (in %)

Treatment	With psychological module	Without psychological module	Total
Classroom only	86.45	87.52	86.90
Classroom followed by simulation app	90.01	84.50	87.57
Video only	77.13	82.69	80.54
Video followed by simulation app	84.33	84.84	84.59

Table 5.19. Insurance quiz across treatments and control (in %)

Treatment	With psychological module	Without psychological module	Total
Classroom only	78.49	82.44	79.47
Classroom followed by simulation app	79.92	78.89	80.16
Video only	76.78	77.76	79.43
Video followed by simulation app	78.50	80.32	77.39

2.4 Key implications

- The impact of educational training reported that training has doubled farmers' insurance knowledge and literacy. The evidence suggests that the government as well as insurance companies need to take up these types of effective educational training to improve the knowledge base of farmers on insurance, which ultimately influences adoption decisions

- The stylized video training has proven to have larger impacts than traditional classroom training. This is a low-cost and very effective mass communication tool for scaling insurance awareness and literacy, which the government as well as insurance companies can adopt easily. This video is now handed over to the crop insurance cell of the Government of Odisha to screen at farm fairs, farm exhibitions, and other agricultural training programs. This video is also released on [YouTube, which the public could use for knowledge purposes]

- Interestingly, our psychological modules along with video have made the highest impact. This suggests (along with dramatic and pictorial explanations of training content) that any training programs should be adopting the psychological modules that boost farmers' confidence and execution ability to reach higher impact

Providing a virtual experience of decision making under different risk scenarios in the context of resource limitations had a significant impact on farmers' ability to learn and understand the insurance product. Although the cost of implementing the simulation app training is similar to that of the video training, it requires an expert's presence and increases the administration cost. Alternatively, a combination of video and simulation app is promising. **One size does not fit all.**

Prospects and complementarity of bundling STRVs with crop insurance

3.1 The context

Integrated risk management is essential in agriculture as a technological solution or product does not fit with all types of shocks/risks. Farmers face varying risks over a period of crop cycles, including droughts, floods, cyclones, untimely rains, and dry spells, with varying intensity. In such contexts, varying the mix of risk adaptation and mitigation strategies is proposed, and in this study we explore the potential and prospects of bundling STRV seeds with the PMFBY crop insurance product. Primarily, we investigate how STRVs and crop insurance in complementcan reduce farmers' vulnerability to climatic stresses. Although both are fairly straightforward concepts and closely related to familiar approaches to mitigating drought risk, each has evolved rapidly in recent years. In contrast to the general notion of competitive innovations and inefficiencies, the complementarity between STRVs and crop insurance is the basis of the argument for a bundled product.

3.2 Crop insurance

In India, crop insurance is a safety net program that aims to reduce farmers' vulnerability by securing their income against climatic stresses. The crop insurance program Pradhan Mantri Fasal Bima Yojana is an area-yield-based index insurance approach that insures for yield loss from climatic stress occurring in gram panchayats. Given the design of the current insurance product, which covers only covariate climatic shocks but not individual (idiosyncratic) losses, this reduces the moral hazard for the insurer to a large extent. Technological advances in remote sensing and automated weather measurement globally have led to innovations in the estimation of crop losses due to different stresses, including prevented sowing, mid-season adversities, postharvest yield losses, etc. This has provided various opportunities to innovate insurance contracts. Leveraging the technological advances, PMFBY currently offers insurance contracts that cover prevented sowing loss, seasonal yield loss, postharvest losses, losses due to localized calamities, and pest and disease attack.

Although PMFBY provides coverage against the majority of climatic risks, insurance uptake by farmers is modest and tepid. Several studies point out that both supply- and demand-side factors affect insurance uptake. It is understood that supply-side constraints such as inability to cover individual losses can be overcome using potential technology and higher order contract design. However, several demand-side constraints such as basis risk (low correlation between actual and estimated yield) and low insurance literacy are challenging to overcome (Carter 2012).

3.3 Stress-tolerant rice varieties (STRVs)

The development of STRVs has been a long-standing breeding objective to address the effect of climatic risk on productivity and welfare of farmers. IRRI and other public/private players have developed several STRVs and they have been tested widely across different stress levels. These STRVs are found to thrive in modest flood/drought conditions without a decrease in yield compared with non-STRVs (see Fig. 5.20). Drought-tolerant rice varieties such as Sahbhagi dhan and DRR44 show no reduction in yield up to 10 days of drought during flowering. The flood-tolerant varieties Swarna-Sub1, CR1009-Sub1, and Binadhan11 can tolerate flash floods up to 14 days after planting without a decrease in yield. (Given the local context, we distributed the seeds of Swarna-Sub1 and CR1009-Sub1.) In other words, in a location where the severity of the climatic stress (either flood or drought) is low/moderate, the STRVs act as insurance introduced into the seeds.

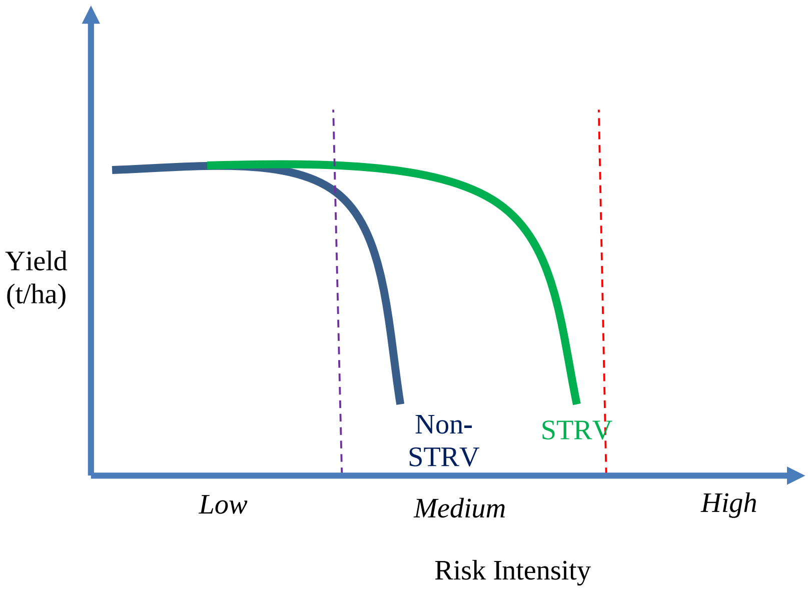


Figure 5.20. Yield function of STRVs in relation to intensity of risk

3.4. Bundling crop insurance with STRVs

As the severity of the stress increases, the yield advantage of STRVs disappears. Stress occurrence at the early stage for drought-tolerant rice varieties and during panicle initiation or flowering stage for flood-tolerant rice varieties quickly erodes the stress tolerance–based yield advantage of STRVs. Therefore, any intensity of stress beyond the optimal stress stage for STRVs does not ensure the yield promised. In addition, STRVs are not foolproof for multiple stresses such as cyclones and postharvest losses (Gurian-Sherman 2012), and even the amount of coverage for a particular risk is limited to low to medium intensity. Thus, STRVs would only cover part of the production risk, which necessitates an additional shield for the residual risks associated with crop production (or value addition). The bundled product offers a better proposition to farmers and other stakeholders as, by adopting STRVs, the insurance needs to cover only the residual risks and this thereby reduces the premium rate. Insurance companies would benefit through reduced incidence of yield loss and hence a lower rate of indemnity payout. At the same time, confidence in the product increases among stakeholders, and therefore we expect an increased acceptance of bundled product among consumers.

3.5. Interventions

Under the variable insurance contract design, we first estimated the damage function for STRVs and non-STRVs by considering the risk frequency and intensity faced by each district of Odisha. Then, we converted the damage function into value by integrating the area under the damage function. The difference in the cumulative value function between STRVs and non-STRVs was subtracted from the general premium function to establish the new premium amount. In simple terms, the amount of risk covered by the STRVs is converted into value and subtracted from the PMFBY premium for each district to arrive at the new premium amount. The rest of the contract terms of the PMFBY was unaltered, which we called bundled crop insurance, which provides similar risk coverage as standalone crop insurance but at a reduced premium.

Now, farmers had three options to mitigate the risk to their farm: (1) adopting only crop insurance, (2) adopting only STRVs, and (3) bundled crop insurance (PMFBY+STRV). In order to find out the farmers' preference for the bundled product, we offered them three coupons: crop insurance, STRV, and crop insurance + STRV (see Fig. 5.21). We integrated the intervention of bundling of insurance products along with training intervention. With this, we can simultaneously analyze the effect of training on farmers' preference for bundled insurance product. We believe that the choices the farmers made on these coupons revealed their true preference, because they had to bind for the choices they made and pay the residual price (actual price of the product minus the coupon amount) when encashing the coupon, that is, after their choice, the farmers can encash the coupon via the nearest common service center located within their village or GP to obtain the subsidy attached to the coupon.

To see the effect of training on coupon choice, we randomly allocated six farmers to have training followed by coupon choice, two farmers to have training followed by cash provision, and two farmers to only coupon choice with no training. The coupon treatment allocation across different training programs is presented in Table 5.20. Before the coupon selection, a brief explanation on coupons and their encashment procedure was provided to the farmers, including the types of coupons, how much subsidy they carry, how and where to encash them, deadline for encashment, etc.

Figure 5.21. Insurance coupon design

Table 5.20. Treatments and their allocation samples

Treatment: training	Treatment: coupon allocation			
	No training,only coupon	Training followed by coupon	Training followed by cash	Total
Classroom training	504	248	248	620
Video training		256	256	640
Classroom+ simulation app		248	248	620
Video+ simulation app		256	256	640
Control				480 (48)
Total	**504 (252)**	**1,008 (252)**	**1,008 (252)**	**3,000 (300)**

Numbers in parentheses indicate number of villages.

3.6 Results

As observed in Table 5.21, about 70% of the farmers chose the bundled insurance coupon, followed by the STRV coupon. We observed that only 12% of the farmers chose the insurance alone coupon. This trend of choice is similar for all different training programs. Then comparing the choices of farmers who received training before the choice of coupon with the farmers who made their choice without any training, we found no difference. This indicates that bundling and reduced cost had more effect on the choice of coupon than information provision.

With respect to coupon encashment, the early results indicate that the rate of coupon encashment is higher for the bundled coupon than for the standalone coupon. The coupon encashment rate of farmers who have received training and not received training on average appears to be the same. However, with different training, the rate of encashment of the bundled insurance coupon is higher for video and video +simulation app training relative to classroom training. It is interesting to note that the farmers who have not received training equally made an effort to encash the coupon, which indicates the importance of the financial incentive of the bundled product, which highlights our findings that a bundled product has significantly higher acceptance across all types of farmers.

Table 5.21. Preferences for bundled product

Treatment		Voucher chosen (% of households)			Encashed voucher (% of households)		
		Insurance	STRV	Insurance + STRV	Insurance	STRV	Insurance + STRV
Training followed by coupon	Classroom	10.8	19.1	70.1	14.3	27.4	58.3
	Classroom + simulation	13.0	12.5	74.5	13.7	14.5	71.8
	Video	11.5	18.7	69.9	9.4	19.7	70.9
	Video + simulation	12.4	19.3	68.3	9.5	20.2	70.2
No training, only coupon	Coupon only	11.7	17.9	70.4	10.7	15.6	73.7

A quick analysis of the reasons for no encashment coupon revealed that more than 70% of the farmers find difficulties with CSC resource persons who are involved in distributing seeds and handling registering for crop insurance (see Table 5.22).

Table 5.22. Reasons for no encashment of coupons

SN	Reason for not encashing coupon (n=442)	Households (%)
1	CSC person did not contact me in time	27.15
2	I approached CSC person, but there was no seed	24.66
3	Seeds were not available	16.97
4	I didn't know how to encash the coupon	9.50
5	Not interested in buying seeds or insurance or both	4.75

SN	Reason for not encashing coupon (n=442)	Households (%)
6	I had my seeds, but not interested in insurance	2.04
7	I didn't have money	1.58
8	I did not trust the ability of seeds to withstand drought/flood	0.90
9	Others	12.44

3.7. Key implications

- As a majority of the farmers preferred bundled products (insurance + STRV seeds) across all treatments, this suggests that the bundling strategy has high potential for better welfare distribution to farmers (via reduced incidence of loss, lower premium, and abatement of psychological stress), and reduced burden on insurance companies or the public exchequer in the PMFBY program
- Encashment of coupons of bundled product is significantly higher than for the other two coupons, suggesting that the financial incentive of reduced premium made the bundled product more successful. Thus, any program should target beneficiaries with the right incentive (monetary such as reduced premium and non-monetary such as bundling) to spur the adoption rate
- The crop insurance facilitating institutions play a key role in the effectiveness and success of program implementation. As many farmers experience that the common service center resource personnel are not timely available and are non-cooperative, this discouraged them from encashing coupons, which otherwise would have given them a chance to experience the complementary benefits of crop insurance and STRVs
- In addition, the IRRI team experienced that many CSC resource persons had no prior exposure to PMFBY as well as how to register for it, which was surprising. IRRI took initiative to train them about PMFBY, registration, and documents required, as well as how to work with farmers sensitively. Although CSC has ambitious goals and reach in Odisha, it requires structural changes in terms of management and operations as well as capacity enhancement to act as a serious and reliable development partner

Work Plan 2020-21

Work Plan 2020-21

Subproject 1: Strengthening Seed Systems of Stress-tolerant Rice Varieties through Innovative Demonstrations and Extension Approaches

#	Activities		Number	Districts	Blocks	Area/No.	Remarks
1	On-farm demonstrations/ trials	Demonstrations (10 ha each)	5600	20	80	5600 ha	Four blocks in each district
		H2H Trials	1600	20	80	1600 No	20 trials in each block
		Demos through OSSC Dealers & their Customers	1200	20	80	1200 No	80 dealers in 20 districts
		Crop Cafeteria	20	20			Two sets
		Client Oriented Crop Cafertia	2	2			In partnership with NRRI, OUAT
2	Trainings	QRSP (25 farers per training)	160	20		4000 No	2 QSP trainings per block
		ToT on QRSP and Management Practices	3			150 No	At NRRI/ISARC, Varanasi
3	Workshops	District Level Seed Meetings	30	20		30 No	Planning meeting with CDAO/DAO/AAOs
		Demonstration with women led collectives	20	20		30 No	In partnership with NGOs, SHGs
		Awareness creation meetings	390			15600 No	At sowing and harvesting season
4	Research Support	Research support for seed quality maintenance, digital traceability.					With NARES
		Learning and sharing workshop with seed system stakeholders					
		Breeding program, varietal testing with NARES					Research collaboration with NRRI, OUAT, IIRR
		Operationalising SeedCast					App will be transferred to OSSC and DoA
		Rabi demonstrations/Minikit distribution					Demo and seed increase

Subproject 2: Targeting Rice-Fallows: A Cropping System-based Extrapolation Domain Approach

#		Activities	Number	Districts	Blocks	Area/No.	Remarks
1	Demonstrations	Demonstrations of pulses in Rice fallows	12500	21	80	2500	Rabi 2020-21
		New pulse varieties are tested and demonstrated in clusters	5	5	9	5 districts	New releases from NARES with checks
2	Research Support & Supplies	Procurement of high Resolution DEM to generate the Inundation depth and duration maps , gravity drainage maps, water and soil salinity, ground water depth, quality					Work in progress –to be completed by June
		Procurement of LISS-IV Satellite data from NRSC-ISRO to generate village level extrapolation domain maps showing potential areas for cropping intensification at village level					Work in progress - to be completed by Aug
		Research Collaboration for development of improved pulse technologies for rice fallow areas.					Collaboration with NRRI and OUAT, rabi 2020-21
		Prepare and release of revised version of Rice-fallow Atlas					To be completed by December 2020
		Plant growth enhancers are tested at multiple sites – on-station and adaptive trials	750	5	15	150	DoA, NRRI, OUAT and NGOs
		Testing and evaluating different rabi crops for intensification of rice-fallow systems in selected districts	2	10		10 districts	DoA, NRRI and OUAT
3	WebGIS & RPMS	Open WebGIS portal incorporating Rice-fallow, cropping systems, Stress-prone and suitability map layers is prepared and hand over to Govt.					DoA
		Training on RPMS app - updated version					
		Training on WebGIS portal usage system					DoA, NRRI, OUAT (two trainings)

Subproject 3: Raising the Productivity and Profitability of Rice-based Cropping Systems in Odisha through the Rice Crop Manager (RCM)

No	Activities	Number	Districts	Remarks
1	**Dissemination of CM recommendations to Farmers**			
1.1	Training of progressive farmers and rural youth	75	10	DoA , NGOs
	Training of SHGs	75	10	DoA , NGOs
	Training and awareness meetings with NGO partners	15	30	NGOs
	Dissemination of recommendations	60000	30	DoA, NGOs, CSC, OLM
	Monitoring the use of recommendations	7000	30	DoA, NGOs, CSC, OLM
	RCM/ h2h Demonstrations	500	17	IRRI staff, NGOs, OLM
1.2	Sensitizing students and faculties of private agriculture universities on digital technologies for crop management			IRRI staff
1.3	Development of Mobile App			With Appslure web solutions
2	**Strategic & adaptive research- Development for better Nutrient and Crop Management**			Collaborative research with NARS
	Study the effects of different rice establishment methods and tillage practices in rice in both dry and wet season on crop performance, nutrient and water use efficiency and soil characteristics in farmers field			OUAT
	Optimization of Nutrient management for rice based cropping system			OUAT
	Crop and nutrient management under DSR			
	Development of better nutrient management module for rice pulse systems for Odisha			Integration with Subproject 2
	Optimising fertilizer application rates and timing for rainfed rice in Odisha			OUAT
	Evaluation of crop management component of RCM-(weed management) in farmers field			NRRI
	Development, validation and evaluation of RF component of CMRS-			NRRI, Subproject 1
	Adaptive trials on using GIS based yield monitoring for developing better yield targets in RCM			Subproject 1 & 5, SKYMET

Subproject 4: Inclusive Development through Knowledge, Innovative Extension Methods, Networks, and Capacity Building in Odisha

No	Activities	No	Remarks
1	**Rice-based cropping system knowledge bank**		
	Refinement of technical aspects of RKB web pages, mobile app	1	Crushaders Tech. Solutions
	Orientation of DA&FP officers	1	DA&FP
	RKB dissemination	1	Reliance Foundation, Ama Krushi, etc.
	User metrics report	1	
	Oreintation of Ama Krushi and other dissemination agencies	3	
	RKB handover meeting with DA&FP technical team	1	DA&FP
2	**Rice Doctor and IPM**		
	Development of business model for Rice Doctor Odisha	1	DA & FE
	Scaling and adoption strategies of Rice Doctor Odisha in major rice growing districts of Odisha	1	Scaling based on outcome of RD use
	Odisha Plant Protection workshop	1	NRRI, OUAT, DoA
	Policy dialogue on sustainable pest management interventions	1	DoA & FE
3	**Strengthening Extension and Advisory Services**		
	Seminar on findings from EAS in Odisha	1	CRISP, DA & FE
	Policy dialogue on reimagining EAS	1	CRISP, DA & FE
4	**Scaling**		
	Compendium of technical and institutional innovations for rice-based cropping system in Odisha	1	AUXIN
	Ready Reckoners	10	AUXIN
	Videos on key technologies and approaches		SWAHA, CSC, DA&FE
	Audio jingles on promising rice varies and other innovations	8	SWAHA, Reliance Foundation, PAD, DA&FE
	Outcome story booklet	1	AUXIN, DA&FE, ATMA
	Dissemination of technologies and innovations through posters and other media	6000	AUXIN, DA&FE, OUAT, Other Universities
	Learning documents on Rice Fallow Management, Rice Crop Manager dissemination, Promotion of STRVs and Seed Systems to support development of scaling strategies	3	AUXIN, OUAT
5	**Leadership and Entrepreneurship for Women in Agriculture Program (LEAP)**		
	Policy dialogue on Women-led Farmers' Producer Company (WFPCs)	1	APU, NDDB Services, ALCI, DA&FE
	Learning and insights from pilot Women Entrepreneurship development activities	1	OUAT, CIWA
	Monitoring report on WFPC in Kalahandi	1	ALCI
	Toolkit for monitoring Women Entrepreneurship activities	1	

Subproject 5: Science-based Crop Insurance

5A: Remote sensing based rice monitoring system

No	Activities	No	District	Area/No	Remarks
1	**Remote sensing-based rice monitoring**				
	Ground data collection for Start-of-Season (SoS) verification & calibration	30	30	50	Possible partner DoA
	Ground data collection for rice-and-non-rice (RnR) area validation	30	30	50	Possible partner DoA
	SAR (Sentinel-1) and Optical (landsat 8) acquisition planning	1	30		
	SAR (Sentinel-1) and optical (landsat 8) data processing and analysis	1	30	Entire state	
	Early season product generation : rice area maps and area estimation	1	30	Entire state	
	Early season product generation: SoS maps	1	30	Entire state	
	Mid-season product generation and yield forecast	1	30	Entire state	
	End-of-season (EoS) product generation and yield estimates	1	30	Entire state	
	RnR area map validation and accuracy assessment	1	30	Entire state	With DoA
	EoS validation of yield estimates	1	30	Entire state	With DoA
	Preventive sowing mapping	2	30		
	Abiotic stress map (Flood / drought) in case of natural disaster event.	1			
	Rice Ecosytem Map Generation	1		Entire state	
	Rice Ecosytem Map field Validation and stakeholder consultation	30		Entire state	
	Drone data collection	1			
2	**Capacity building**	1			
	Training on MapscapeRice				
	Training on RiceYES (Yield Estimation)	1			

5B: Crop Insurance

No	Activities	Districts	Blocks	No	Remarks
1	Comprehensive crop insurance (Socio-economics)				
	Crop Cutting Experiments and data analysis	15	177	3000	Survey Jena
	Polygon mapping and basis risk estimation	15	177	3000	
	Endline Survey	15	177	3000	Survey Jena
2	**Stakeholder Policy workshop with insurance companies CSC and banks**				I
3	**Community screening of Awareness Video**	5	80	4000	
4	**Simualtion App testing in field**	5	5	100	

References

Biennial Update Report, UNFCC, India. 2015. Ministry of Environment, Forest and Climate Change.

Buresh RJ, Witt C. 2007. Site-specific nutrient management. In: Fertilizer Best Management Practices. Part 1. General Principles. p 47-55.

Carter, M., 2012. Designed for development impact: next generation approaches to index insurance for small farmers. In: Churchill, G., Matul, M. (Eds.), Protecting the Poor: A Microinsurance Compendium, volume 2. International Labor Organization, Geneva.

Ching LL. 2018. Importance of empowering women. In: Agro-ecology for sustainable food systems. Environment and Development Series, Third World Network. Penang, Malaysia.

FAO (Food and Agriculture Organization). 2011. The State of Food and Agriculture 2010-2011. Women in Agriculture–Closing the Gender Gap for Development. FAO, Rome.

Frederick S. 2005. Cognitive reflection and decision making. J. Econ.Perspectives 19(4):25-42.

Gaurav S, Singh A. 2012. An inquiry into the financial literacy and cognitive ability of farmers: evidence from rural India. Oxford Dev. Studies 40(3):358-380.

Gaurav S, Cole S, Tobacman J. 2011. Marketing complex financial products in emerging markets: evidence from rainfall insurance in India. J. Marketing Res. 48(SPL): S150-S162.

Government of India. 2018. An Overview of India's Economic Performance in 2017-18. In: Economic Survey 2017-18, Ministry of Finance, Government of India. Vol. II, Chapter 1. 185p.

Government of Odisha. 2019. Odisha Economic Survey 2018-19. Directorate of Planning and Convergence.

Government of Odisha. 2020. State Agricultural Policy Samrudhi 2020.

Gurian-Sherman D. 2012. High and dry: Why genetic engineering is not solving agriculture's drought problem in a thirsty world. Union of Concerned Scientists.

Hanley N, Wright RE, Koop G. 2002. Modelling recreation demand using choice experiments: climbing in Scotland. Environ.Res. Econ. 22(3):449-466.

Hensher DA, Rose JM, Greene WH. 2005. Applied choice analysis: a primer. Cambridge University Press.

International Year of Rice. 2004 Concept Paper. FAO, UN. 21p.

Liu EM. 2013. Time to change what to sow: risk preferences and technology adoption decisions of cotton farmers in China. Rev. Econ. Stat. 95(4):1386-1403.

Loomis J. 2011. What's to know about hypothetical bias in stated preference valuation studies? J. Econ. Surveys 25(2):363-370.

Nakano Y, Tsusaka TW, Aida T, Pede VO. 2018. Is farmer-to-farmer extension effective? The impact of training on technology adoption and rice farming productivity in Tanzania. World Dev. 105:336-351.

Pan Y, Smith SC, Sulaiman M. 2018. Agricultural extension and technology adoption for food security: evidence from Uganda. Am. J. Agric. Econ. 100(4):1012-1031. https://doi.org/10.1093/ajae/aay012.

Periasamy S. 2018. Significance of dual polarimetric synthetic aperture radar in biomass retrieval: an attempt on Sentinel-1. Remote Sens. Environ. 217:537-549.

Raven J, Raven JC, Court JH. 1998. Manual for Raven's progressive matrices and vocabulary scales. London: Oxford Psychologists Press.

Roberts TL. 2007. Right product, right rate, right time, and right place … the foundation of best management practices for fertilizer. In: Fertilizer Best Management Practices: Part 1. General Principles, International Workshop on Fertilizer Best Management Practices. International Fertilizer Industry Association Paris, France. p 29-32.

Sunding D, Zilberman D. 2001. The agricultural innovation process: research and technology adoption in a changing agricultural sector. Handbooks in Economics 18(1A):207-262.

Sutter M, Kocher MG, Glätzle-Rützler D, Trautmann ST. 2013. Impatience and uncertainty: experimental decisions predict adolescents' field behavior. Am. Econ. Rev. 103(1):510-531.

Yan M, Pan G, Lavallee JM, Conant RT. 2020. Rethinking sources of nitrogen to cereal crops. Global Change Biol. 26(1);191-199.

Annexure

Annex 4.1. Proposed induction module for AAOs

DAY 1	
Session 1	**Introduction to the Induction Training**
	Icebreaking and Self-Introduction by the Participants (name, education, and prior work experience)
	Training Objectives and Outcomes
Session 2	**Introduction to the Department of Agriculture and Farmers' Empowerment (DAFE), Odisha**
	History, organizational values, ethics, and philosophy; organizational structure; vision, objective, and strategy of the DAFE; role of other actors in the state involved in agricultural development
DAY 2	
Sessions 3 & 4	**Employees' entitlements and responsibilities**
	Sensitization on harassment; team work; gender in the workplace; pay scales, promotions; facilities and amenities; attendance and leave; occupational safety, health and insurance; income tax deductions, rights and legal issues, procedures related to grievance and discipline; career path, appraisals, awards, and incentives
DAY 3	
Session 5	**Exposure visit**
	Orientation to the exposure. Clarifications on the key questions the groups should address for presentation on Day 4. Participants divided into four to five groups and taken on an exposure visit to four-five different units of the DAFE (soil conservation and watershed development, horticulture department, APICOL, OSSC, OLM, seed testing laboratory, KVK, etc.) and related organizations/initiatives that the DAFE is partnering with.
DAY 4	
Session 6	**Learning from exposure visit**
	Presentations from the groups on what they learned from the exposure visit using PowerPoints.
Session 7	**Orientation on Departmental Schemes and Programs**
	Central sector schemes
DAY 5	
Session 8	**Orientation on Departmental Schemes and Programs**
	Central sector schemes

Session 9	**Orientation on Departmental Schemes and Programs**
	State sector schemes
DAY 6	
Session 10	**Financial management and accounting**
	Maintenance of cash book, stock book, and other financial records; noting, drafting, etc.
Session 11	**Guidelines on input storage, sales, quality, and distribution**
	Rules, guidelines on insecticide act; fertilizer control order; quarantine; seed certification
DAY 7	
Session 12	**Role of extension in agricultural transformation**
	New challenges in agriculture and role of extension in addressing these; changing dimensions of extension (pluralism, need for new capacity at different levels)
Session 13	**Tools and techniques for farmer needs assessment**
	Participatory tools and methods; short surveys/rapid analyses, etc.
DAY 8	
Session 14	**Extension approaches and tools**
	Features of various extension tools; when and where to use the tools
Session 15	**Facilitation for development**
	Various roles of a facilitator; community mobilization; how to diagnose and design/plan with groups; how to broker partnerships and linkages
DAY 9	
Session 16	**Gender-responsive extension**
	Why gender matters in agricultural development; applying a gender lens to program design and implementation; working with women's groups; simple tools for gender analysis
Session 17	**Extension for climate-smart agriculture**
	Role of extension in adaptation and mitigation; vulnerability assessment; promoting climate-smart agricultural techniques
DAY 10	
Session 18	**Linking farmers to markets**
	Different forms of linking farmers to markets; value chains, organizing producer groups, establishing FPOs; good practices in linking farmers to markets

Session 19	**ICTs and knowledge management for extension**
	Types of effective communication; how ICTs are used in extension (use of social media)
DAY 11	
Session 20	**Youth and agripreneurship**
	Attracting and retaining youth in agriculture; ways of promoting agripreneurship
Session 21	**Nutrition-sensitive extension**
	Why extension should address nutrition; extension practices for promoting nutrition-sensitive agriculture
DAY 12	
Session 22	**Exposure visit**
	Orientation to the exposure visit. Clarifications on the key questions the groups should address for presentation on Day 13. Participants divided into four to five groups and taken on an exposure visit to intervention sites (NRM, social mobilization, value chain, women-led initiatives, climate-smart projects, etc.)
DAY 13	
Session 23	**Learning experience from exposure visit**
	Presentations from the groups on what they learned from the exposure visit using PowerPoints
Session 24	**Planning, implementation, and monitoring of extension programs**
	Good practices in planning, implementation, and monitoring of extension programs
Session 25	**Feedback session**
	Feedback from participants: how they benefited from the training; how they would use this in their work

Annex 4.2 FPCs that participated in the learning workshop

SN	Facilitating organization	Name of the FPC	Area of operation and (no. of members in parentheses)	Activities
1	ALCI	Adarsh Dharmagarh Women Farmers Services Producer Company Ltd.	Boden, Dharamgarh, Kalahandi (1,751)	Seed and fertilizer services, financial services
2	Youth Council for Development Alternatives (YCDA)	Bhimbarul Krushak Producer Company Ltd.	Sindhigora, Masinagora, Boudh (285)	Value addition and marketing, paddy seed supply to members with subsidiary rate, commercial vegetable cultivation
3	NRRI	Cuttack 4S4R Seed Farmer Producer Company Ltd.	Bhaunria, Sukhleshwar, Mahanga, Cuttack (1,000)	Paddy seed, organic rice, protein rice production, sales marketing, fertilizer sales
4	ORMAS	Devagiri kisan Agro Products Producer Company Ltd.	Parlakhemundi, Gajapati (9,076)	Mango, cashew, hill broom, pineapple, maize, and turmeric
5	I-Concept	GUPTI FPCL	Banbiharipur, Gupti (50)	Rice and vegetable production, marketing
6	IIRR	Vaibhava Jyothi FPC Ltd.	Nalgonda, Telangana (380)	Trading, marketing, and input business
7	WOSCA	(MPCL) Maalaxmi Producers Company Ltd.	Mandua, Keonjhar (371)	Mango, cashew, vegetable, and fertilizer marketing
8	Harsha Trust	Swornajyoti Producer Company Ltd.	Bissamcuttack, Rayagada (604)	Processing, marketing
9	Pragati	Chiti Dora Farmers Producer Company Ltd.	Kotpad, Koraput (387)	Production and marketing of aromatic rice
10	Gram-Utthan	Maa kharakhai fish farmers producer company Ltd.	Rajkanika, Kendrapara (293)	Fish farming and marketing

International Rice Research Institute
340 C, Saheed Nagar
Bhubaneswar-751007, Odisha, India
Tel: +91-0674-2594 929
Web: www.irri.org; www.rkbodisha.in

IRRI