Development of Agriculture in collaboration with International Institution – International Rice Research Institute

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

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Annual Report

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Rice Science for a Better World

Preface

The International Rice Research Institute has been specially targeting unfavorable rice environments in eastern India for almost a decade and has contributed to the development, testing, release, and dissemination of several genotypes tolerant of abiotic stresses across the eastern Indian states of Assam, West Bengal, Bihar, Chhattisgarh, Jharkhand, Eastern Uttar Pradesh, and Odisha. The initial lessons from interventions in Odisha have brought to the fore the need to accelerate technology adoption and scale up the production, dissemination, and delivery of quality seeds; explore better use of rice fallows; assist farmers in maintaining soil health while improving productivity; and enhance the capacity of the resource poor and women farmers to adopt new technology and enable them to face the challenges of unfavorable weather events by promoting products such as science-based crop insurance.

The government of Odisha has taken a series of policy initiatives recently to make agriculture more sustainable and vibrant, thus ensuring food security and enhancing employment opportunities in the state. As a part of these initiatives, the government recently approved a collaborative program with the International Rice Research Institute to diversify technology investment and encourage inclusive growth in the agricultural sector in the state by bringing in the best technologies available globally. Rice production in the state is getting a boost with the Odisha-IRRI initiative on "Increasing Productivity of Rice-Based Cropping Systems and Farmers' Income in Odisha." This program aims to enhance and stabilize rice productivity and increase farmers' income, particularly in stress-prone areas, and establish sustainable rice-based farming systems. The project is composed of five individual subproject interventions that involve strengthening the seed systems of stress-tolerant rice varieties through innovative demonstration and extension approaches; validating and developing an extrapolation domain mapping methodology to identify the suitability of rice-based cropping systems in underused stress-prone rice fallows and rabi fallow areas of the state; increasing profitability and productivity by introducing the Rice Crop Manager app; increasing rice productivity through innovative extension methods, creating knowledge banks, fostering partnerships, and building capacity of target partners; and reducing production risk by working with key stakeholders in developing crop insurance for farmers considering affordability and economic viability by linking up with risk-reducing technologies, etc. Each project component contributes to the overall goal to increase the productivity of rice-based cropping systems and farmers' income in Odisha.

This first-year report summarizes the activities undertaken during 2016-17, productivity gains and lessons learned under different components, impact of the interventions, outcomes, and the work plan envisaged for the second year (2017-18) based on the experiences and also guidelines and recommendations of the Department of Agriculture and Farmers' Empowerment. The report also includes the findings of work carried out with our collaborating partners for research (OUAT, NRRI, CIWA) and extension (NGO partners, seed producers and dealers, KVKs). A list of workshops, training programs, FGDs, resources created, linkages established, and publications is also appended. It is hoped that the work plan envisaged will help to establish a robust scheme for accelerated delivery and adoption of farming technologies to benefit the rice farming community living and working in adverse environments in Odisha and elsewhere with similar predicaments.

Uma Shankar Singh

Acknowledgments

This report is based on IRRI's engagement with the rice farming community in Odisha as part of the project on "Increasing Productivity of Rice-Based Cropping Systems and Farmers' Income" during 2016-17. The project is supported by the Ministry of Agriculture, government of Odisha. IRRI's work was greatly assisted by Shri Manoj Ahuja, principal secretary, Department of Agriculture and Farmers' Empowerment, who envisioned the need for focused research interventions to improve and sustain the productivity of rice grown under unfavorable environments and encouraged all stakeholders to formulate a strategic plan. Shri Pramod Meherda, and subsequently Shri Hari Ballav Mishra, director, DAFP, government of Odisha, provided the necessary guidelines to IRRI in preparing the research framework and implementation plan. IRRI acknowledges their unstinted support, without which the project would not have progressed at the pace that it actually did. A special note of thanks is also due to Shri Ashok Mohanty, joint director of agriculture, special programmes, who monitored the progress of implementation and made helpful suggestions to facilitate the process.

The implementation of the project activities in different districts was based on the advice and suggestions from the DDAs who helped in the selection of vulnerable communities facing the challenges of drought, submergence, salinity, and other yield-limiting constraints in their respective districts. This helped us in selecting appropriate site-specific interventions, which were made with the help of NGO partners, SHGs, VAWs, and Krishak Sathis, and also private seed entrepreneurs who not only assisted in targeted technology transfer but also provided logistic support in reaching out to the farmers at the block and village level. Their active role in project implementation was invaluable.

Scientific and technological backstopping by partner research institutions for achieving the common goals was critical for successful implementation of the project. The collaborative research programs undertaken with the University of Agriculture and Technology and its Krishi Vigyan Kendras, ICAR-National Rice Research Institute, and ICAR-Central Institute for Women in Agriculture provided the necessary stimulus to IRRI's efforts and helped fine-tune and localize the component technologies for accelerated adoption. The proactive role of Dr. Surendranath Pashupalak, VC, OUAT; Dr. Himanshu Pathak, director, NRRI; and Dr. Jatinder Kistwaria, director, CIWA, in providing the research support and the scientists of these institutions actively involved with their counterparts at IRRI is thankfully acknowledged.

Several public and private institutions were on board to strengthen seed production and delivery mechanisms for the stress-tolerant varieties of rice promoted through the project. The active role played by the directors of OSSC and OSSOPCA in prioritizing the production and certification of STRVs and being involved in several rounds of discussion with IRRI scientists in developing app-based programs for inventory management (SeedCast) helped accelerate the dissemination of these varieties in different districts.

Access to secondary data on agriculture provided by Dr. Rajesh Das, chief statistician, and the involvement of Shri Saroj Kant and Tarun Chotoray, officers of DAFP, in facilitating frequent dialogues with the DoA helped IRRI immensely in the periodical reporting of physical and financial progress and in carrying out workshops, capacity building programs, and knowledge management. IRRI would like to put on record their invaluable contribution. Thousands of farmer cooperators who were associated with the field testing of different technologies were the real protagonists who helped IRRI in

achieving its targets during the year. Their dedication and perseverance are very thankfully acknowledged.

Introduction

Odisha is predominantly an agrarian state, with about 60% of its population involved directly or indirectly in the agricultural/animal husbandry sector. Agriculture is thus vital to the economy of the state even though it contributes only 13% (2013-14) of the state gross domestic product (GGDP, at 2004-05 prices). The state has about 6.5 million ha of cultivable area out of a total geographic area of 15.6 million ha, accounting for 41.2%. Rice is the main crop of the state, covering 75–80% of the total cultivated area. Small and marginal farmers constitute about 83% of the farming community. Approximately 53% of the total rice grown in the state is direct seeded, mostly through broadcasting followed by beushening. Rice farming in Odisha is characterized by low productivity on account of various factors. Abiotic stresses are the most important yield-limiting factors. Almost 1.15, 1.25, and 0.15 million ha of rice area in Odisha are prone to flood, drought, and soil salinity, respectively. The productivity of these areas is both low and fragile. Other yield-limiting factors include the lack of assured irrigation, low seed/varietal replacement rate, non-availability of quality seed particularly in rainfed areas, low cropping intensity, low rate of fertilizer consumption (63 kg/ha against the national average of 140 kg/ha), low rate of pesticide consumption (158 g/ha), low rate of mechanization (only 5,000 tractors in the state, although power tillers are maximum in Odisha), knowledge gaps, etc. The dearth of irrigation and inputs, insufficient investment by the farmers, outdated agronomic practices, poor postharvest management, and the lack of marketing facilities also result in lower crop productivity and profitability. Huge gaps in yield potential and realized yield and in technology transfer provide an excellent opportunity for the state to increase productivity and production substantially.

System-level changes can be induced by interventions in key thematic areas that can influence economic decisions. These include innovations in the seed sector and the ability to choose the right variety; better use of land and conversion of fallow lands into cultivable patches, thereby increasing cropping intensity; making effective management decisions for the crop, especially on investments in fertilizers and plant protection products; and the ability to predict and prepare for climatic adversities better. There is also a need to address gaps in knowledge flows and empower the farmers with synergistic efforts to be able to make the right decisions.

In pursuance of an MoU signed between the International Rice Research Institute and the Department of Agriculture and Farmers' Empowerment, government of Odisha, IRRI implemented the project "**Increasing Productivity of Rice-Based Cropping Systems and Farmers' Income in Odisha" (2016-20) with five major** subprojects. The subprojects envisage the implementation of climate-friendly actions that focus on the following:

1. promotion, dissemination, and delivery of quality seeds of stress-tolerant rice varieties with spatial targeting of relevant regions, and novel extension approaches and innovations in the seed sector that leverage a pluralistic approach of public and private entrepreneurship;
2. better use of land and conversion of large rice fallows into cultivable patches based on resource mapping and *in situ/ex situ* moisture management with an extrapolation domain approach;
3. development and deployment of ICT-based decision tools for site-specific nutrient and crop management in irrigated and rainfed systems through Rice Crop Manager;

4. empowering farmers to choose suitable technology options based on analyses of yield gaps between progressive and other farmers (Ricecheck), knowledge management, networks; and capacity building; and
5. exploring ways to support a science-based crop insurance system relying on remote sensing-based yield estimations under normal and stressed environments.

These interventions were therefore implemented under five subprojects, all working in harmony to achieve a common goal.

Subproject 1	Strengthening seed systems of stress-tolerant rice varieties through innovative demonstrations and extension approaches in Odisha
Subproject 2	Targeting rice-fallows: a cropping systems-based extrapolation domain approach
Subproject 3	Raising productivity and profitability of rice-based cropping systems in Odisha through Rice Crop Manager
Subproject 4	Inclusive development through knowledge, innovative extension methods, networks, and capacity building in Odisha
Subproject 5	Science-based crop insurance

Progress in a nutshell/highlights

Seed system improvement

Breeder and foundation seed of several submergence- and drought-tolerant varieties, some of them with multiple stress tolerance, was procured and its conversion to foundation and certified seed facilitated to support formal (OSSC) and informal seed systems (farmer-to-farmer spread and through SHGs) in Odisha.

Drought-tolerant Sahbhagi dhan, DRR 42, and DRR 44 and submergence-tolerant varieties Swarna-Sub1 and Binadhan 11 were evaluated in drought- and submergence-prone districts of Odisha as small demonstrations of 5–10 ha to create awareness among the farmers. In all, 2,186 demonstrations took place in ten districts during 2016.

Head-to-head trials allow the farmers to compare the new STRVs with the commercial cultivars being used by the farmers. The varieties are grown under farmers' management to help them select the varieties that perform better under drought or submergence stress under their specific field conditions. Nearly 4,400 H2H trials covering 20 districts were implemented during the wet season of 2016.

About 16,000 seed minikits of STRVs were also distributed through NGO partners and a few seed dealers in different districts. The minikits help the farmers to conserve the seed and use it in subsequent years and also make it locally available for sale or farmer-to-farmer spread.

Evidence hubs with these and newly developed varieties with multiple stress tolerance and/or drought/submergence QTLs in different genetic backgrounds were also organized to identify and select those varieties with stable performance in stress-prone environments.

About 7,800 ha were covered under different trials/districts during the wet season. The yield advantage reported for the STRVs ranged from 4.5% (Swarna-Sub1 compared with Swarna) to 54.7% (Binadhan 11 compared with Haldichudi). Binadhan 11 scored ahead of all other varieties in the northern coastal zone while Sahbhagi dhan had an edge over the other varieties in the upland areas of southern and western districts, based on farmer preference. These varieties were preferred by the farmers for their fitness in the cropping system. The kharif crop was not exposed to drought or submergence stress during the year due to well-distributed monsoonal rains.

A training of trainers (90 participants) on quality seed production was organized during kharif 2016. Hands-on training for farmers on quality seed production was also organized along with field days in which more than 300 farmers participated.

Binadhan 11, DRR 42, and DRR 44 were also evaluated for their suitability in the rabi season along with salt-tolerant varieties DRR 39 and CR dhan 405 in six districts directly and through NGO partners on about 580 ha. These varieties were compared with local variety Gundri and other varieties such as MTU 1010, Lalat, and Suma. Many farmers adopted wet direct seeding using a drum seeder to grow these varieties. The farmers indicated their preference for Binadhan 11 as it has a non-lodging habit and higher yield than their existing varieties.

Targeting rice-fallows

A first draft of a flood and duration map and cropping intensity map for Odisha was prepared to characterize the rice-fallows and stress-prone areas of the state. Spatial layers of drought, spatial-temporal regimes of water, and inundation depth are being prepared.

Data related to seed-dealer locations, agro-ecologies, road density, and village boundaries were collected to develop a seed rollout plan.

Approximately 1,900 ha of area were covered under demonstrations of legumes (mungbean and blackgram) in the rice-fallow system, covering 77 blocks in 13 districts. Around 5,000 farmers in 417 villages were involved with improved packages and practices of pulses, mainly greengram (IPM 2-3, TARM-1, and SML 668) and blackgram (PU-31 and PU-35).

Root promoters (nano-solutions) and hydrogel were tested in replicated on-station trials and limited on-farm demonstrations to evaluate their role in improved crop performance (mungbean and blackgram) under drought stress. A higher number of pods and increased 1,000-grain weight contributed to increased yield in nano-treated and hydrogel-applied plots individually, with a further increase in yield when both treatments were combined.

The first version of the Rice-Pulse Monitoring System (RPMS) was released for evaluation and testing purposes. Approximately 130 participants from the DoA were trained during two TOT training programs conducted to acquaint them with the use of the mobile-based app.

Using GIS techniques and field surveys, the project team identified more than 1,200 suitable locations for the installation of solar pumps in 18 rice-fallow districts of Odisha. Site details along with a list of farmers and contact numbers were provided to the DoA and concerned implementing authorities for the installation of solar pumps. Pulse demonstrations were conducted on 580 ha at sites having lift irrigation, a solar pump, and dug wells to integrate rice-fallow targeting with the irrigation and development schemes of the government of Odisha.

Rice Crop Manager

IRRI, in collaboration with the DoA, FE, and private partners, disseminated RCM recommendations to the farmers during kharif and rabi seasons of 2016-17. Seven hundred seventy-four recommendations were provided to the farmers in kharif and 3,466 recommendations during rabi across 15 districts. About 87% of the total RCM recommendations were provided to smallholder famers with less than 1 ha of farm size.

Twenty-six TOT events were conducted during this period to capacitate the trainees on the use and operation of RCM and facilitate more rapid dissemination and outreach of RCM recommendations to the farmers. A total of 857 participants from 12 districts were oriented on the operation and use of RCM and on troubleshooting associated with its use.

Thirty-five RCM kendras were established in the district and block offices of the selected districts. These kendras are equipped with a laptop, printer, and data card for internet access. Trained staff of the DoA and FE are providing recommendations to the farmers visiting these kendras.

Experiments have begun at IRRI-OUAT experiment stations to enhance capabilities within RCM for irrigated and rainfed environments with in-season corrections.

Optimization of the potassium supply in the rice-rice system, different establishment methods and tillage practices in the wet and dry seasons, optimization of nutrient management for rice-based cropping systems, and optimization of fertilizer application (rates and timing) for rainfed rice are the major investigations being taken up.

Knowledge bank, capacity building, and women's empowerment

A meeting was held to discuss the formation of a steering/technical committee and to elaborate a regional strategy for the development and maintenance of a knowledge bank.

The capabilities of non-agricultural professionals are being leveraged to enhance the user-friendliness of the scientific knowledge. These partners have been identified and the necessary terms of reference with them have been finalized.

Data collection, validation, analysis, and testing for the development of Rice Doctor, an app-based mid-season diagnostic tool for rice diseases, pests, and nutritional problems, are being carried out by IRRI in collaboration with IIRR, NRRI, and OUAT. The Odisha crop protection group with the members from the aforesaid institutes has been set up. Design and development of the app are outsourced.

Ricecheck encourages farmers to manage their rice crop by comparing their practices with the recommended practices for producing high yet sustainable yield. A four-day state-level workshop titled "Planning a Strategy for Ricecheck in Odisha" was organized during 20-23 September 2016, after which district-level workshops/meetings were held in several districts (Bhadrak, Jagatsinghpur, Mayurbhanj, and Puri) to finalize the plan.

A week-long "Women's leadership for impact course" was held at CIWA, Bhubaneswar (21-27 October 2017), targeting the personal and professional development of women scientists, extension workers, social workers, and entrepreneurs working within organizations with communities of women from poor farming communities. These women leaders will conceive, co-develop, co-implement, and lead projects with women farmers, while providing access to services, knowledge, and technologies according to the needs and demands identified within the communities.

Science-based crop insurance

More than 150 high-resolution images were acquired during kharif and rabi seasons across three tracks and 10 footprints and analyzed to estimate and generate maps of rice area, start of season, and crop phenology at monthly intervals for the six selected districts (Balasore, Bargarh, Bhadrak, Cuttack, Ganjam, and Puri) in Odisha.

Rice yields at the village level were estimated by integrating remote-sensing products into the crop growth simulation model ORYZA. Estimated yield ranged from 0.5 to 3.0 t/ha during kharif and from 3.0 to 6.0 t/ha in rabi.

IRRI conceptualized, designed, and implemented risk games and a questionnaire for a survey and prepared the design and structure of FGDs with farmers having varying risk exposure and insurance adoption levels. The study provided insight into the general ground-level situation and farmers' understanding, perceptions, and opinions about the crop insurance scheme.

Subproject 1: Strengthening seed systems of stress-tolerant rice varieties through innovative demonstrations and extension approaches in Odisha

This component, by strengthening seed systems, targets the recurring constraints of abiotic stresses (drought, submergence, and salinity) that not only suppress rice productivity but also have adverse consequences on farm income from subsequent crops, leading to food insecurity of the largely smallholder farming community in the state. IRRI has developed, tested, and released several stress-tolerant varieties in recent years that have contributed to improved yields under adverse climatic events whether they be drought, submergence, or salinity. The initial focus was to improve the stress tolerance of the mega-varieties already popular among the farmers but lacking in tolerance of specific stresses. With the success of the newly introduced varieties such as Swarna-Sub1 for submergence and Sahbhagi dhan for drought, it was pertinent to transfer major QTLs for submergence and drought into other genetic backgrounds and incrementally add traits for multiple stress tolerance for specific regions. Tolerance of drought and submergence, for example, is a desired trait for the lowlands of coastal Odisha where drought and flood may occur in the same season at different stages of crop growth.

A set of stress-tolerant rice varieties (STRVs) found suitable for the state in exploratory evaluation under the STRASA (Stress-Tolerant Rice for Africa and South Asia) project was chosen as candidates for seed system improvement. The availability of a sufficient amount of quality seeds of the right variety in time alone can contribute to enhanced production by about 15%. The development, multiplication, processing, storage, marketing, and distribution or sale of seed in the state have complex organizational, institutional, and individual operations that are broadly grouped into the formal and informal systems. The formal seed system is mainly a government-supported system involving several public institutions, private producers, and seed entrepreneurs. The informal system includes farmer-saved and exchanged seeds of both traditional and modern varieties that are accessed from the formal distribution system. Since the existing seed system in Odisha, as in other states of the country, has a formal and an informal component, IRRI's efforts were primarily to streamline and strengthen these systems so that seeds of the newly released varieties could reach the remotest parts of the state within a short span of two to three years.

Innovative approaches to improve formal and/or informal seed dissemination and adoption of stress-tolerant varieties

Seed cafeteria/evidence hub: A seed cafeteria is a replicated field trial to identify stress-tolerant varieties in an agro-climatic region. A seed cafeteria trial involving a set of new STRVs was conducted in comparison with existing popular varieties as an exploratory trial in Cuttack. This evaluation trial, with varieties planted at staggered intervals to synchronize flowering in all, served as the evidence hub for all stakeholders, including farmers and extension officials. Because the wet season during 2016 did not experience any stress due to well-distributed rainfall and the absence of episodic events, it was decided to expand the scope of the trial to all 30 districts of the state during 2017 to capture the variable performance of test varieties and select the most stable among them for promotion. These **evidence hubs** (crop cafeterias) that are organized on district farms under the guidance of the deputy directors of agriculture involve all the stakeholders of the seed value chain and give an opportunity to each of these stakeholders, including extension specialists, OSSC, KVKs, and dealers, to suggest an appropriate variety for seed increase and head-to-head trials for the subsequent years in a particular district.

A seed committee was established under the chairmanship of the deputy directors of agriculture in all districts and a seed plan was prepared for multi-environment testing of drought- and submergence-tolerant varieties (Table 1). In addition to these tested varieties, several newly developed varieties with multiple stress tolerance are being tested in the wet season of 2017.

This innovative approach is also used for the faster and more sustainable uptake of STRVs through a client-oriented crop cafeteria (STRV Expo) at prime locations, where representatives of the private and public seed sector and their critical market agents such as PACS, distributors, dealers, and agrovets are invited. This is being done in two places in collaboration with OSSC and NRRI. This approach fast-tracks awareness creation and helps build seed demand from the different stakeholders of the seed value chain.

Head-to-head trials: A head-to-head trial is a field evaluation in which two different varieties, one newly developed and the other being grown by the farmer, are directly compared with each other with respect to their performance in yield or tolerance of one or more stresses. This is usually a follow-up by farmers who have selected a variety or varieties that appealed to them during a visit to a crop cafeteria or a demonstration. Evaluation of the selected variety along with their existing variety under their own management assures them of the fitness of the variety for their growing conditions. Out of about 5,000 H2H trials planned for 2016, 4,393 were conducted covering 20 districts. Each H2H trial consisted of 10 kg of the test variety grown side by side with the farmer variety on 0.2 ha. Since these trials were also conducted through private seed dealers, subsequent demand for the variety they distributed was taken as the criterion to estimate farmer preference of the varieties evaluated. Binadhan 11 scored ahead of all the other varieties in the northern coastal zone while Sahbhagi dhan had an edge over the other varieties in the upland areas of southern and western districts.

Cluster demonstrations and minikits: NGO partners distributed 16,404 seed minikits in their respective areas of activities to promote the stress-tolerant varieties during 2016. Similarly, small demonstrations of 5 to 10 ha covering 10 districts were also organized. Field demonstrations organized in farmers' fields have been the most effective method in motivating the farmers to adopt new technologies. The purpose of the demonstrations is not only to create awareness among fellow farmers but also to make the seed locally available for sale or farmer-to-farmer spread. The area of each demonstration is limited to 5–10 ha to penetrate to more areas and enhance the horizontal spread. In this way, more farmers are likely to adopt the new varieties. In 2017, we are compulsively engaging seed dealers in the demonstrations at the block level so that they will become aware of the new products and play a role in linking demand with the supply chain.

Demonstrations through seed dealers: We are engaging the private agents that include the dealers of OSSC and private seed dealers in the awareness and diffusion process. Delivering information and demonstration directly to the seed dealers has a greater impact on the spread of new varieties. Seed dealers have strong incentives to boost demand for new varieties because they gain in business when demand is created. In addition, dealers have reputations to protect since they deal with the same farmers each year. Although OSSC and other state agencies will continue to play their role in ensuring the production and supply of quality seeds of these varieties, these private agents have a bigger role to play in the years to come to augment the public sector to make rice cultivation more market oriented. Several private seed dealers/entrepreneurs were co-opted in the dissemination of STRVs during the wet season of 2016. About 500 seed dealers from 30 districts are doing demonstrations of new varieties through their customers in 2017. Once these farmers (customers) are convinced of the performance of a variety and are confident of obtaining quality seeds of suitable varieties in time, they would not hesitate in buying the seed directly from the dealers as the cost of seeds is only 7% of the total operational cost of rice cultivation. However, the dealers have to be ready for a more knowledge-intensive regime in which the farmers would have to receive an explanation of the benefits of the new varieties, the conditions under which they sustain higher yield, and the profit that farmers can accrue due to the varieties' tolerance of drought, submergence, or salinity. Since farmers take advice from dealers on problems in the field, the dealers also need to keep themselves informed of developments in the sector of crop management and plant protection so that timely advice is given to their clientele.

In all, there were 2,186 demonstrations of STRVs of 5–10 ha (50 kg of seeds/ha) in 10 districts during kharif 2016, 4,393 H2H trials of 10 kg for 0.2 ha for each variety in 20 districts, distribution of 16,404 minikits of 5 kg each for 0.1 ha (20 districts), 13 evidence hubs at the district and state level, a seed cafeteria at NRRI, Cuttack, training of trainers on quality seed production for 90 participants, and hands-on training for farmers on quality seed production involving more than 300 participants during this period. Binadhan 11 (mean yield 5.1 t/ha) and Swarna-Sub1 (mean yield 6.3 t/ha) were the submergence-tolerant varieties provided to the farmers through these trials. The drought-tolerant varieties were Sabhagi dhan (mean yield 4.3 t/ha), DRR 42 (mean yield 5.3 t/ha), and DRR 44 (mean yield 4.6 t/ha). About 7,800 ha were covered under different districts during the wet season (Table 1).

When compared with the farmer-grown varieties, these varieties gave a yield advantage ranging from 4.5% (Swarna-Sub1 compared with Swarna under normal conditions) to 54.7% (Binadhan 11 compared with Haldichudi) (Table 2).

Table 1. District-wise coverage (ha) under STRVs under different activities during kharif 2016.

No.	District	Area (ha)	No.	District	Area (ha)
1	Kalahandi	687.38	10	Jajapur	1,527.50
2	Kandhamal	613.20	11	Cuttack	237.50
3	Nabarangpur	454.50	12	Kendrapada	174.00
4	Koraput	582.25	13	Puri	435.77
5	Raygada	157.50	14	Sonepur	224.50
6	Keonjhar	539.10	15	Balangir	351.00
7	Balasore	579.50	16	Deogragh	105.50
8	Bhadrak	325.00	17	Khurda	20.00
9	Mayurbhanj	808.25		**Total**	**7,822.45**

Table 2. Comparative performance of STRVs and farmer varieties (kharif 2016).

S. no.	District	STRV	Yield (t/ha)	Adjacent variety	Yield (t/ha)	Yield advantage (%)
1	Rayagada	Sahbhagi dhan	5.12	Lalat	4.12	24.3
2	Rayagada	DRR 44	5.49	CR 1001	5.00	9.8
3	Rayagada	DRR 42	5.07	Jajati	3.58	41.6
4	Rayagada	Bina 11	5.23	Haldichudi	3.38	54.7
5	Nabrangpur	Bina 11	6.45	Parijat	5.50	17.3
6	Nabrangpur	DRR 44	5.65	Chandan	4.10	37.8
7	Puri	Swarna-Sub1	6.23	Swarna	5.96	4.5

Monitoring and evaluation: The performance of the STRVs was monitored during the season and reports from all stakeholders were obtained during site visits and monitoring. There were no reports of drought or submergence as rainfall was well distributed. The farmers were encouraged by the earliness of Binadhan 11, which makes it possible for them to grow a second crop immediately after the harvest of the rice crop (Puri, Jajpur). A few farmers tried Binadhan 11 under direct-seeded and transplanted conditions (Fig. 1) and noted that the direct-seeded crop, while giving similar yield as the transplanted crop, provided a head-start of 1 week to grow the sequence crop in the case of direct-seeded rice. Similarly, Sahbhagi dhan was harvested early and the farmers had an opportunity to grow groundnut (Jajpur) and greengram (Fig. 2). Swarna-Sub1 performed similar to Swarna without stress (Fig. 3).

Activities during rabi 2017: Binadhan 11, DRR 42, and DRR 44 were also evaluated for their suitability in the rabi season (Fig. 4) along with the salt-tolerant varieties DRR 39 and CR dhan 405 in six districts directly and through NGO partners on about 580 ha. About 290 quintals of seed were distributed to 980 farmers during the season (Table 3). These varieties compared with local variety Gundri and other varieties such as MTU 1010, Lalat, and Suma. Many farmers adopted wet direct seeding using a drum seeder to grow these varieties. The farmers' responses indicate their preference for Binadhan 11 as it has a non-lodging habit and higher yield than the other varieties.

The farmers, however, indicated a delay in obtaining irrigation water for the direct-seeded crop. In some cases, this caused salinity problems in blocks such as Brahmagiri. Our inquiries revealed that the farmers are required to register and apply for irrigation water during the rabi season. Delay in submitting the application and processing could be avoided with proper awareness among the rice farming community in canal-irrigated areas during rabi.

Table 3. Rabi demonstrations with Binadhan 11, DRR 42, DRR 44, DRR 39, and CR 405 (rabi 2017).

S. no.	NGO partner	Total area in ha	District	Farmers' involvement in nos.	SEED supplied in quintals
1	Netaji Yuvak Sangh	56.00	Bhadrak	187	28.00
2	SOPHY	50.00	Kendrapada	69	25.00
3	PAGE	85.00	Jajpur	104	42.50
4	Loka Sebak	53.00	Kalahandi	67	26.50
5	Pallivikash	50.00	Puri, Jagatsinghpur	109	25.00
6	SEED	87.00	Jajapur, Kendrapada	144	43.50
7	Direct intervention	200.00	Puri	300	100.00
Total		**581.00**	**Six districts**	980	290.50

Capacity building and awareness creation: An aggressive awareness campaign showcasing the STRVs through field days was taken up during kharif and rabi seasons. A total of 76 field days in 20 districts with the participation of 3,910 farmers were organized (Table 4). Similarly, a quality seed production training program was also taken up in 10 districts with a view to improving the informal system of seed production locally by farmers. About 1,300 farmers were trained in seed production during the year covering 29 blocks of 10 districts (Table 5).

Seed production of STRVs through Odisha State Seed Corporation: Preferential seed increase of STRVs and its dissemination through the formal and informal sector were taken care of by providing breeder and foundation seed of selected STRVs to OSSC and facilitating its conversion to certified seed through the state farms and MOU farms during kharif and rabi 201-17 (Table 6, Fig. 5a,b).

Table 4. Field days observed during 2016-17.

S. no.	District	No. of field days	Farmers' participation	S. no.	District	No. of field days	Farmers' participation
1	Bolangir	4	160	11	Keonjhar	1	38
2	Balasore	10	334	12	Khurda	3	161
3	Bhadrak	8	278	13	Koraput	1	188
4	Cuttack	4	130	14	Mayurbhanj	6	252
5	Ganjam	3	110	15	Nayagargh	1	43
6	Jagatsinghpur	4	133	16	Puri	4	173
7	Jajpur	6	268	17	Sonepur	3	210
8	Kalahandi	7	923	18	Deogargh	1	49
9	Kandhamal	1	53	19	Raygada	3	170
10	Kendrapada	4	151	20	Nawaragpur	2	86

Table 5. Quality seed production training programs organized during 2016-17.

S. no.	District	Block	No. of participants		Total
			Males	Females	
1	Balasore	6	254	33	287
2	Bhadrak	4	159	39	198
3	Bolangir	2	89	15	104
4	Cuttack	2	92	22	114
5	Keonjhar	4	70	79	149
6	Koraput	1	5	24	29
7	Mayurbhanj	5	73	121	194
8	Nabrangpur	3	2	128	130
9	Puri	1	19	15	34
10	Subarnpur	1	23	7	30
	Grand total	**29**	**786**	**483**	**1,269**

Table 6. STRV seed production programs through Odisha State Seed Corporation during 2016-17.

Sl. no.	Variety	Seed supplied to OSSC (q)		OSSC produced (q)	
		Breeder	Foundation	Foundation	Certified
1	BINA 11	4.9	50	50	2,500
2	DRR 42	9.6	50	450	400
3	DRR 44	5.1	10	50	1,050
4	DRR 39	0.6		60	
5	Sahbhagi dhan			3,600	7,000
6	Swarna-Sub1			500	25,000
Total		20.2	110	4,710	35,950

Fig. 1. Binadhan 11 under DSR and TP (kharif 2016, Puri District).

Fig. 2. Para crop of greengram with residual moisture after rice harvest in uplands (rabi, Kalahandi District).

Fig. 3. Farmer roguing plants from his field of Swarna-Sub1 (kharif 2016, Puri District).

Fig. 4. Dr. Matthew Morell, DG, IRRI, visiting DSR crop of Binadhan 11 (rabi 2017, Brahmagiri).

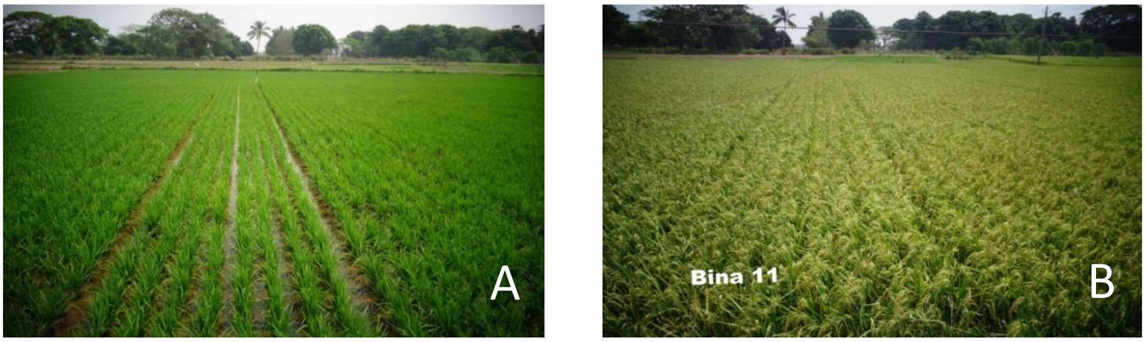

Fig. 5. Seed production by Odisha State Seed Corporation.
a. Binadhan 11 at tillering, rabi 2017. b. Binadhan 11 at maturity, rabi 2017.

Lessons learned and recommendations generated:

Subsidy to farmers through DBT for seed purchased from private entrepreneurs: The State Agriculture Policy Document 2013 states that Odisha's productivity norms are comparatively low, due to a dearth of irrigation and inputs, insufficient investments by the farmers, outdated agronomic practices, and a lack of marketing facilities. The State Agriculture Policy will attempt to create an enabling environment in all these spheres.

The promotion of scientifically bred, drought-/submergence-/salinity-tolerant and pest-resistant high-yielding and environmentally safe varieties of rice, as part of the state policy, has received much-needed impetus with the establishment of a collaborative project between the government of Odisha and the International Rice Research Institute. Several stress-tolerant rice varieties (STRVs) having tolerance of drought, submergence, and salinity and suitable for the state are currently being popularized and brought into the seed chain for sustained supply to the farmers.

Efforts are in progress to accelerate the adoption and coverage of these varieties (varietal replacement) and increase the seed replacement ratio (SRR) from the current 22% to the national average/objective of 33% by enlisting the support of OSSC and NSC and also private partnership. Private companies have a significant role to play in the dissemination and adoption of new varieties. The project is also making sure that private seed partners are a part of the awareness creation program to generate the seed demand for new varieties in the stress-prone areas where the presence of a public seed corporation is not strong. They have shown keen interest in scaling up the production of stress-tolerant varieties; however, the subsidy being provided only to the dealers associated with a public seed corporation has posed a challenge for them to compete in the market. The state has, however, clearly stated in the policy document that a "subsidy on seeds will be opened to both public and private sector agencies for the seeds produced and consumed within Odisha.'"

It is requested that the initiatives for the subsidy to private entrepreneurs mentioned in the policy document 2013 be implemented to give a boost to the seed system. It would be appropriate to provide a "smart subsidy" for new STRVs released during the last 5 years so that such varieties are preferentially multiplied and made available to the farmers.

Strengthening the informal seed system: training for women farmers for seed production under a seed village program linked to MKSP/NRLM: Local production and use/sale of quality seeds of STRVs/HYVs can improve the informal seed system, which is plagued by the problems of poor quality and purity (mixtures). These problems can be circumvented with adequate training for quality seed production for women farmers (season-long training programs to cover each stage of seed production, storage, and sale).

The Department of Rural Development (Central) implemented the program Mahila **Kisan Sashaktikaran Pariyojna (MKSP)** as a subcomponent of the National Rural Livelihoods Mission (NRLM) to meet the specific needs of women farmers and achieve socioeconomic and technical empowerment of rural women farmers, predominantly small and marginal farmers. The primary objective of the MKSP is to empower women in agriculture by making systematic investments to enhance their participation and productivity, and to create and sustain agriculture-based livelihoods of rural women. Projects are conceived in such a manner that the skill base of the women in agriculture is enhanced to enable them to pursue their livelihoods on a sustainable basis.

The Odisha-IRRI project is working to form a platform in the seed sector at the community level by involving enterprising women's groups to improve the availability and delivery of stress-tolerant rice in the target areas locally. Self-help groups have immense potential to become viable enterprises, which can be very successful and a powerful tool in providing a community safety net and generating income for groups. These groups are being trained on producing quality seed and making it available for the community through their networks. This can create sustainable agricultural livelihood opportunities for women and will not only improve the skills and capabilities of women but also contribute to enhancing their managerial capabilities by way of wealth creation and its management. IRRI, through the Odisha project, has developed a seed manual, which is designed for self-help groups to train the women for quality seed production. This manual could be used by the NRLM in its program for the mass awareness and quality assurance of the seed used by the farmers in the informal system. This will also help farmers develop their capacity in the area of seed business entrepreneurship.

Two prerequisites for managing postharvest operations need government support. Pedal threshers and winnowers increase efficiency and reduce drudgery. A seed processing plant is also essential (capacity can be decided) to locally grade the seed. Decentralized seed processing will help reduce haulage of the produced seed to the centrally located processing plant and back, and also decrease the time lag involved. Adequate subsidy to women farmers or SHGs can help establish such facilities. IRRI can plan and execute a pilot program on quality seed production by women by linking with the MKSP (NRLM) if the government supports such a proposal.

Effective demonstrations for acceptance and enhanced adoption of rice varieties: Seeds move from one farmer to another through exchanges and sharing. This process is smooth but slow and **highly fragile** because of its sensitivity to natural disasters and unpredictable and sudden weather changes. Regular access to seeds of climate-resilient rice varieties is important to address these challenges, and the supply of seeds through business channels is the only sustainable way forward.

The most commonly used method for bringing awareness about new varieties is to set up large-scale cluster demonstrations in which designated farmers apply the new technology and other farmers in the community are invited to visit and witness the process and outcome. These demonstration plots do not help farmers learn by comparing the new variety against their current technology. They can witness an outcome, but they cannot assess gain. Demonstration plots do not achieve relevance for social learning because of the huge heterogeneity in the farmers' own circumstances. The effectiveness of these demonstrations diminishes if the results are not immediately visible. The resources used are beyond the capacity of the farmers and the crop management practices are different from what the farmers adopt.

In most of the cases in which cluster demonstartions are carried out, seed supply in the subsequent years is not ensured. Local seed dealers, not being part of the mainstream extension, remain uninformed and hence fail to supply the seed demand created through such demonstrations. These dealers have a unique agreement with the seed corporations (OSSC in this case) in which they cannot return unsold seeds. This prompts the dealers to take a conservative risk for the seed sales of the new varieties. It is important to consider aligning the extension system with the seed system in a more formal manner. The following approaches are being used to integrate the extension system for scaling the adoption of new varieties:

1. Instead of large clusters (100 ha each) that do not encourage informal seed diffusion due to its restricted exposure to the farmers at one site, smaller cluster demonstrations of 1–5 ha are carried out to ensure penetration to more areas with increased horizontal spread. These demonstrations in marginal areas are conducted through organized women's seed groups to ensure the local availability of new seeds. In other places, the demonstrations are linked with the formal seed system by involving both the public seed sector (OSSC) and private seed companies. To ensure that the information about the performance of new varieties reaches dealers and demand built is addressed adequately, all the dealers in the area are involved and made part of these small demonstrations.
2. We explicitly engage the private agents in the diffusion and awareness process because the farmers have faith in the local dealers who are also part of the community at large. Incentives for wide-scale adoption will not be well aligned unless these agents play a larger role. Hence, providing extension services directly to dealers by way of information and exposure to demonstrations will have a greater impact on the spread of new varieties. Seed dealers have incentives to spread this information to their customers (i.e., marketing to farmers) because demand creation translates directly into increased profits. In addition, dealers have reputations to protect since they deal with the same farmers each year. Delivering extension services to dealers also has obvious cost advantages. The extension services need only repeated contacts with dealers, a population that in order of magnitude is smaller than the population of farmers. Seed dealers gaining access to new varieties are being linked with the seed sources that include both public and private seed companies.
3. In this project, we change the way in which learning about new seed varieties takes place. The current method of agricultural extension involves new varieties being demonstrated and exhibits a treatment, but not a counterfactual. As a consequence, this does not help farmers learn by comparing the new variety against their current technology. We demonstrate the climate-resilient rice in **head-to-head trials** in which farmers can compare these varieties with other varieties with their own management. This also improves farmers' learning in their self-managed plots. The extension agencies obtain better feedback because of the multiple checks that are used by different farmers. For example, a new drought-tolerant variety such as DRR 44 would be compared with many other conventional varieties of similar duration such as Lalat, IR64, MTU 1010, and Vijeta, and this offers a better picture of varietal performance. H2H trials can therefore replace the simple minikits that are usually distributed to farmers without obtaining adequate feedback. Thousands of such trials for stress-tolerent varieties are being conducted in farmers' fields that reveal promising results against the counterfactuals in Odisha. This process boosts the confidence of farmers and thereby helps to accelerate the adoption and acceptability of new varieties.
4. The project uses another innovative approach for the faster and more sustainable uptake of STRVs through a client-oriented crop cafeteria (STRV Expo) at prime locations, where representatives of the private and public seed sector and their

critical market agents such as PACS, distributors, dealers, and agrovets are invited. This approach fast-tracks awareness creation and helps build seed demand from the different stakeholders of the seed value chain. In a similar connection, **evidence hubs** (crop cafeterias) are organized on district farms under the guidance of the deputy directors of agriculture. These hubs usually comprise a set of 8 to 10 new varieties that have situational relevance for the stress conditions. These trials, conducted across districts as multi-location trials, involve all the stakeholders of the seed value chain of the respective districts and provide an opportunity for each of these stakeholders, including extension specialists, OSSC, KVKs, and dealers, to suggest an appropriate variety for seed increase and H2H trials for a particular district. The evidence hubs and H2H trials form the core of varietal demonstrations and can contribute to accelerated variety adoption and replacement.

Subproject 2: Targeting rice-fallows: a cropping systems-based extrapolation domain approach

Substantial areas of potentially productive land in Odisha remain fallow during the winter (rabi) season after the monsoon (kharif) rice crop because of four major factors: (1) the lack of irrigation water, mostly in the plateaus and tablelands; (2) stagnant water causing waterlogging in the coastal lowland areas; (3) high soil or water salinity; and (4) the late harvest of the kharif crop or excessive soil wetting after harvest, leading to late planting and low productivity of rabi crops. Increasing the productivity and profitability of these areas with low productivity is a major challenge for the state.

Increasing cropping intensity in fallow lands could substantially improve the food supply and enhance livelihoods in the state of Odisha. With the availability of new drought-, flood-, and salt-tolerant rice cultivars and short-duration pulse crops along with improved agronomy and water management, there are better chances of transforming significant numbers of potential rice-fallows into double-crop systems. Moreover, considerable scope exists to improve the productivity of rice-based systems by adjusting varietal characteristics (e.g., by planting shorter-duration rice, stress-tolerant rice, hybrid rice, etc.). Potential crops for rice-fallows could be greengram, blackgram, chickpea, and mustard, etc. To efficiently target these potential fallows, detailed characterization of the resource profile is needed (e.g., salinity, submergence, inundation depth, and groundwater availability, etc.) to systematically understand the potential opportunities and constraints.

The traditional single-layer characterization method may not be adequate for assessing cropping system suitability in these multi-stress, lowland, coastal environments, where resource profiles vary both spatially and temporally. Any single improved practice may not be suitable for all areas, which suggests that technologies should be targeted to their most appropriate places. Advance remote sensing-based targeting methods such as “extrapolation domains” can facilitate precise targeting and accelerated dissemination of improved technologies in fallow areas in a fast and cost-effective manner. The International Rice Research Institute has developed considerable expertise in delivering geo-spatial solutions (integration of remote sensing and GIS through a logical decision tree approach) through extrapolation domains for stress-tolerant rice varieties (STRVs) and improved cropping systems.

Objectives

1. To develop, test, and validate innovative cropping systems to target rice-fallows.
2. To identify the land-use requirements of tested cropping systems, and develop decision rules.
3. To develop extrapolation domain maps using geo-spatial modeling and a decision tree approach for targeting improved technologies (STRVs and innovative cropping systems) in rice-fallows.
4. To demonstrate different tested technologies (STRVs and cropping systems) in extrapolation domain analysis (EDA) guided farmers’ fields for accelerated dissemination.
5. To disseminate project outputs/maps/reports to national partners, government officers, and agricultural extension through various applications (e.g., open-access web-GIS system, mobile applications, atlases, and research papers).

1. Characterization of rice-fallows: Extrapolation domain analysis leads to the identification of geographic areas that are suitable for the adoption of improved cropping systems in similar recommendation domains. The development of a high-resolution geo-database is a prerequisite for EDA. During 2016-17, secondary data and remote-sensing data were collected to characterize the rice-fallows and stress-prone areas of 10 districts. Based on flood events between 2005 and 2016, a draft flood and duration map was prepared for the coastal zone and a draft cropping intensity map was prepared for all 30 districts (Fig. 1). Spatial layers for drought, spatial-temporal regimes of water, and inundation depth are being processed (Fig. 2).

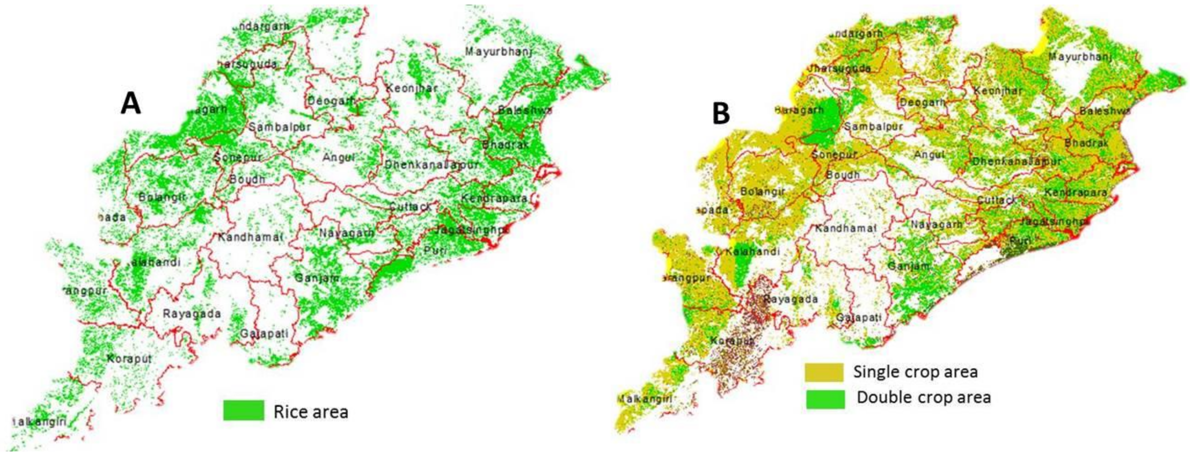

Fig. 1. Initial results: the identification of rice-fallow areas using satellite remote-sensing and GIS techniques. (A) Depicts the distribution and extent of rice area and (B) illustrates those areas that remain fallow (brown color) after a rice crop.

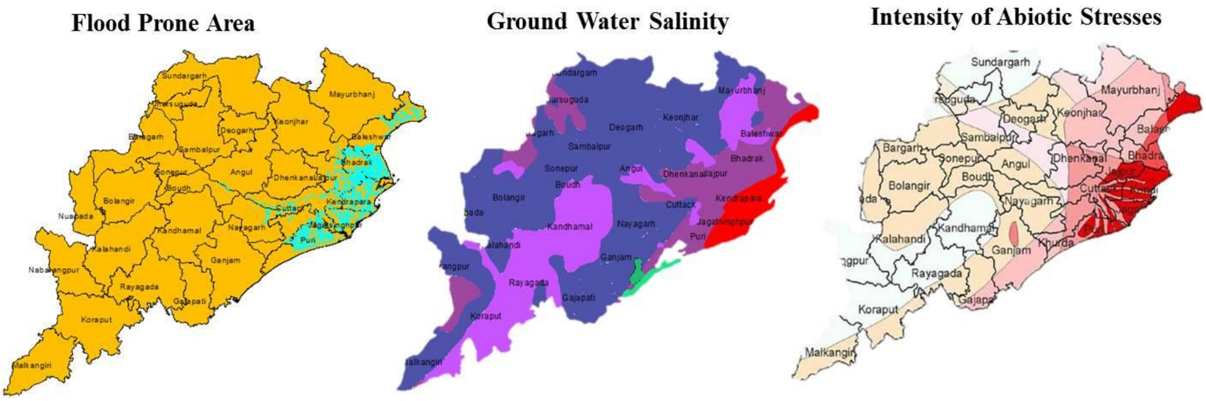

Fig. 2. Initial results: examples of geo-spatial layers and datasets prepared for stress-prone areas for targeting stress-tolerant cultivars in different subecosystems of Odisha.

2. Effect of improved crop management practices on grain yield of greengram in rainfed conditions: Rice-greengram is one of the important rice-based cropping systems in the rainfed areas of Odisha. However, the productivity of greengram varies across ecosystems due to the high spatial variability of residual soil moisture in the state. Enhancing productivity of this system can help farmers in raising their income and profitability. Keeping this in view, a field experiment was conducted at ICAR's National Rice Research Institute in Cuttack in the dry season of 2016-17 to study the effect of nano-solution, hydrogel, and *Trichoderma harzianum* on greengram in the rice-greengram cropping system. The experiment was laid out in a randomized block design with seven treatments: farmers' practice (broadcast without fertilizer application), improved practices (line sowing + seed treatment with FIR (fungicide, insecticide, and *Rhizobium*) + RDF), improved practices + hydrogel (2.5 kg/ha), improved practices + seed treatment with nano-solution, improved practices + hydrogel + seed treatment with nano-solution, improved practices + seed treatment with *Trichoderma*, and improved practices + hydrogel + *Trichoderma* (seed treatment), replicated four times. The variety IPM 02-03 was used in the experiment. The recommended fertilizer dose of 20:40:20 N:P_2O_5:K_2O (kg/ha) was applied in improved practice treatments. Under improved practices, the seeds were treated with carbendazim and imidacloprid before seed treatment with the microbial treatment. The nano-solution was applied by making the solution in warm water and soaking the seeds in warm water for 3 hours.

Results indicated that the highest grain yield of 10.29 q/ha (Table 1) was achieved in greengram variety IPM 02-03 with improved production technology (line sowing + seed treatment with FIR + nano-solution + RDF + hydrogel at 2.5 kg/ha), which was significantly higher than in the other treatments and 29.4% higher than in the improved practice of line sowing + seed treatment with FIR + RDF. All three factors (application of hydrogel, seed treatment with *Trichoderma*, or nano-solution alone or in combination with improved practice (line sowing + RDF + FIR treatment)) recorded significantly higher grain yield than in the farmers' practice (broadcast crop without application of fertilizer). Improved practice + hydrogel and improved practice + nano-solution treatment produced significantly higher grain yield than the improved practice but the application of *Trichoderma* could not increase seed yield significantly over that of the improved practice. The highest seed yield achieved in improved practice + hydrogel + nano-solution could be attributed to the higher number of pods (498/m^2) and 1,000-grain weight recorded in the treatment compared with the rest of the treatments. The results of adaptive trials conducted in farmers' fields are well in line with our experiment station results (Tables 2 and 3).

Table 1. Effect of improved crop management practices on grain yield of greengram.

Treatment	Grain yield (q/ha)
Farmers' practices	4.48
IP (line sowing + RDF)	7.95
IP + hydrogel (2.5 kg/ha)	9.40
IP + nano-solution	9.41
IP + hydrogel + nano-solution	10.29
IP + *Trichoderma*	8.60
IP + hydrogel + *Trichoderma*	9.17
CD (P = 0.05)	0.67

Table 2. Effect of different treatments on blackgram yield in adaptive trials conducted in Puri (Pipli block).

Treatment*	Replications (no.)	Yield (kg/ha)		Increase over control (%)
		Control	Treatment	
T_1	17	404	644	59
T_2	9	417	728	75
T_3	1	394	963	144
T_4	1	423	1,056	150

Table 3. Mungbean yield as influenced by different treatments in adaptive trials conducted in farmers' fields in Puri District.

Treatment*	Replications (no.)	Yield (kg/ha)		Increase over control (%)
		Control	Treatment	
T_1	23	351	572	63
T_2	4	363	821	126
T_3	1	377	992	163
T_4	1	398	1,132	184

*T_1: improved practices (line sowing + seed priming/treatment with fungicide and insecticide)

T_2: improved practices + hydrogel

T_3: improved practices + seed treatment with nano-solution

T_4: improved practices + hydrogel + seed treatment with nano-solution

Control: farmers' practices (broadcast without fertilizer application)

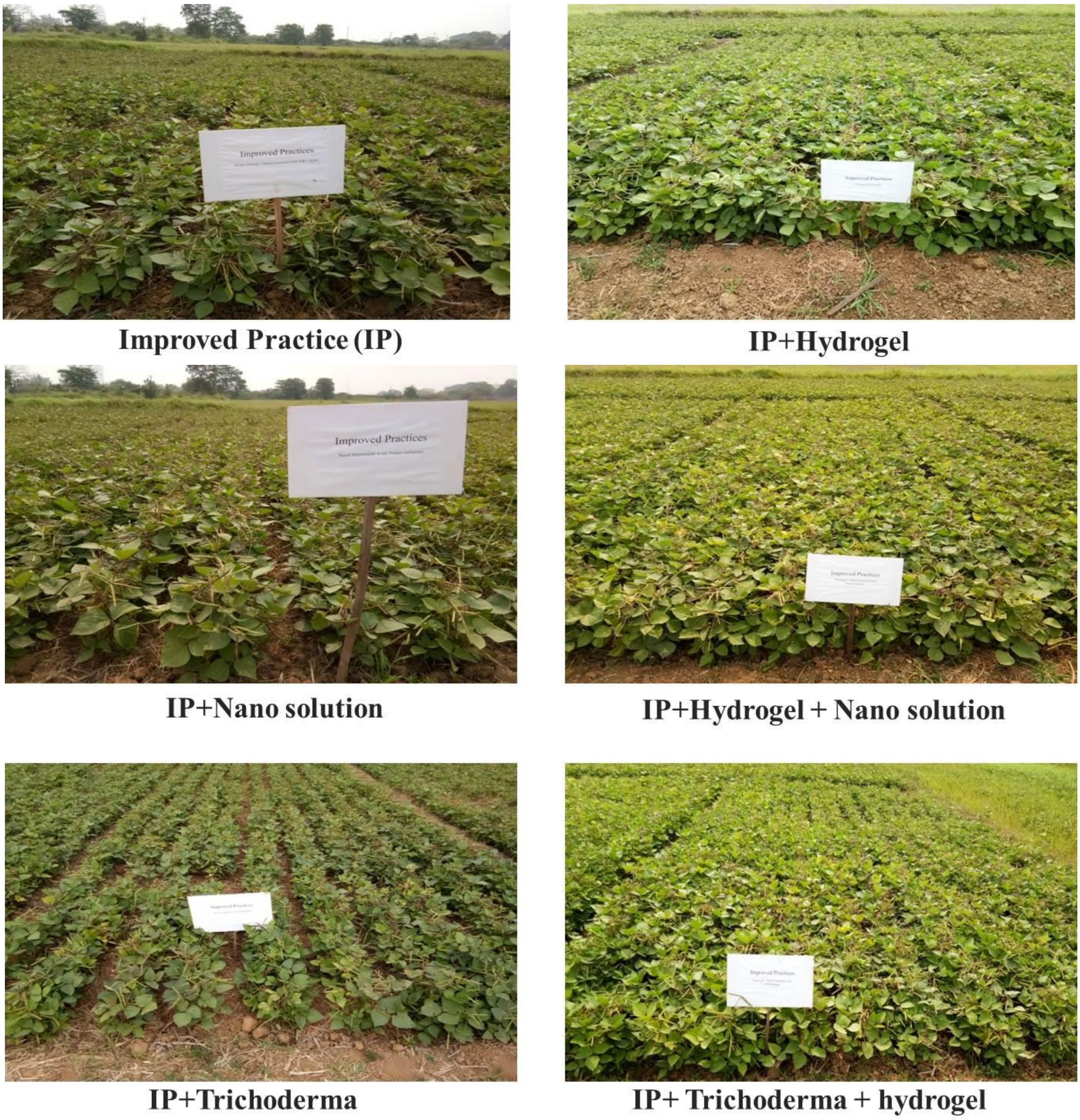

Fig. 3. Field view of different treatments to evaluate the effect of improved crop management practices on grain yield of greengram in rainfed conditions.

3. Demonstrations of pulses in the rice-fallow system and assessment of land-use requirements: The demonstration of improved cultivation practices for greengram and blackgram was targeted in 13 districts of Odisha covering 1,897 ha in Bhadrak, Balasore, Jajpur, Jagatsinghpur, Kendrapara, Keonjar, Kalahandi, Koraput, Kandhmal, Navrangpur, Mayurbhanj, and Puri districts (Table 4). A total of 4,967 farmers in 417 villages were involved with improved packages and practices of pulses (mainly greengram and blackgram). Improved disease-resistant (YMV) varieties were introduced, including PU-31 and PU-35 of blackgram and IPM 2-3, TARM-1, and SML 668 of greengram. A total of 186 field days/farmer interactions were carried out at regular intervals for imparting the necessary technological knowledge for better crop management. The details are as follows:

Table 4. IRRI-DoA demonstration activities during rabi season 2016-17 in the rice-fallow cropping system in Odisha.

District	No. of blocks	No. of villages	Variety	No. of farmers	Area under demonstration (ha)	Field days/farmer interactions
Blackgram						
Balasore	5	29	PU 31	225	56	5
Bhadrak	5	15	PU 35	214	72	7
Jagatsinghpur	2	14	PU 31	128	87	6
Jajpur	1	9	PU 31	36	31	8
Kalahandi	5	23	PU 31	264	193	34
Kandmal	3	6	PU 31	153	32	4
Kendrapara	3	6	PU 31	62	20	4
Keonjhar	1	2	PU 35	70	28	4
Koraput	1	13	PU 31	38	13	6
Mayurbhanj	6	36	PU 35	257	77	8
Nabrangpur	2	5	PU 31	171	40	6
Puri	1	6	PU 31	84	33	2
Subtotal	35	164		1,702	682	94
Greengram						
Balasore	5	46	Tarm 1	545	140	4
Bhadrak	5	15	Tarm 1 IPM 2-3	717	190	8
Jagatsinghpur	2	20	IPM 2-3 SML668	232	97	6
Jajpur	1	11	IPM 2-3	262	149	9
Kalahandi	10	30	SML 668	202	121	20
Kandmal	4	28	IPM 2-3 SML 668	321	181	14
Kendrapara	1	1	SML 668	21	9	4
Keonjhar	1	4	Tarm 1	7	4	2
Koraput	2	32	SML 668	288	94	9
Mayurbhanj	6	50	Tarm 1 IPM 2-3	461	149	9
Nabrangpur	4	10	SML 668	105	33	5
Puri	1	6	SML 668	104	47	2
Subtotal	42	253		3,265	1,214	92
Total (blackgram + greengram)	77	417		4,967	1,896	186

4. Results of head-to-head trials of improved pulse cultivars in stress-prone districts: Analysis of data received from H2H trials conducted on 260 ha in four stress-prone districts (Bhadrak, Jagatsinghpur, Jajpur, and Kalahandi) revealed that the average yield of greengram for 716 farmers in control plots varied from 318 to 497 kg/ha whereas for improved varieties it varied from 650 to 774 kg/ha. Similarly, there was a 66% yield improvement in blackgram yield from 527 kg/ha (control) to 840 kg/ha (improved varieties) in these districts. The maximum improvement in yield of greengram over the control was observed in Jagatsinghpur District (87%), followed by Kalahandi (85%), Bhadrak (55%), and Jajpur (19%). A similar trend was observed in the yield of blackgram, although the percentage of yield gain varied from district to district. The major disease was yellow mosaic virus (YMV), while among pests white fly, stem fly, thrips, and aphids were noticed.

Table 5. Influence of IRRI's targeted approach on yield improvement of greengram and blackgram in selected stress-prone districts of Odisha.

District	Number of farmers targeted	Control plot yield (kg/ha)	Demonstration plot yield (kg/ha)	(% increase over control)
Greengram				
Bhadrak	2	425	660	55
Jagatsinghpur	183	372	697	87
Jajpur	256	707	841	19
Kalahandi	95	486	897	85
Blackgram				
Jagatsinghpur	42	435	829	91
Jajpur	92	672	780	16
Kalahandi	46	476	911	92
Total	716			

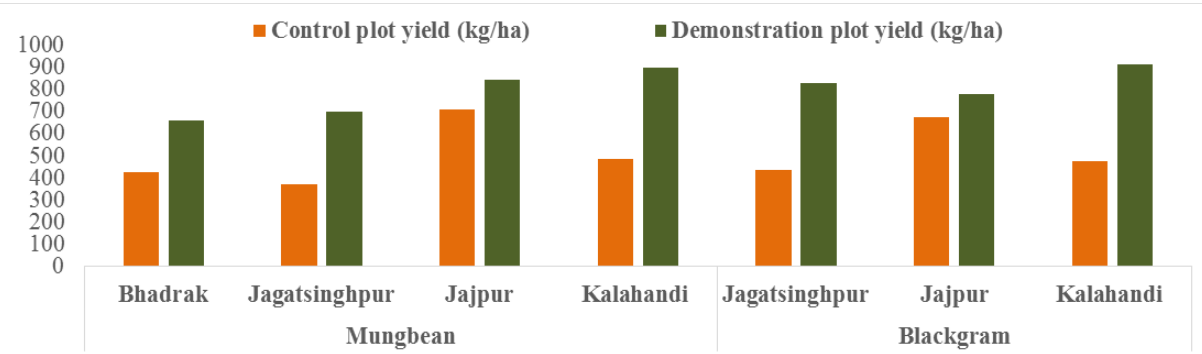

Fig. 4. Comparison of yield gain in head-to-head trials of greengram and blackgram in selected stress-prone districts of Odisha.

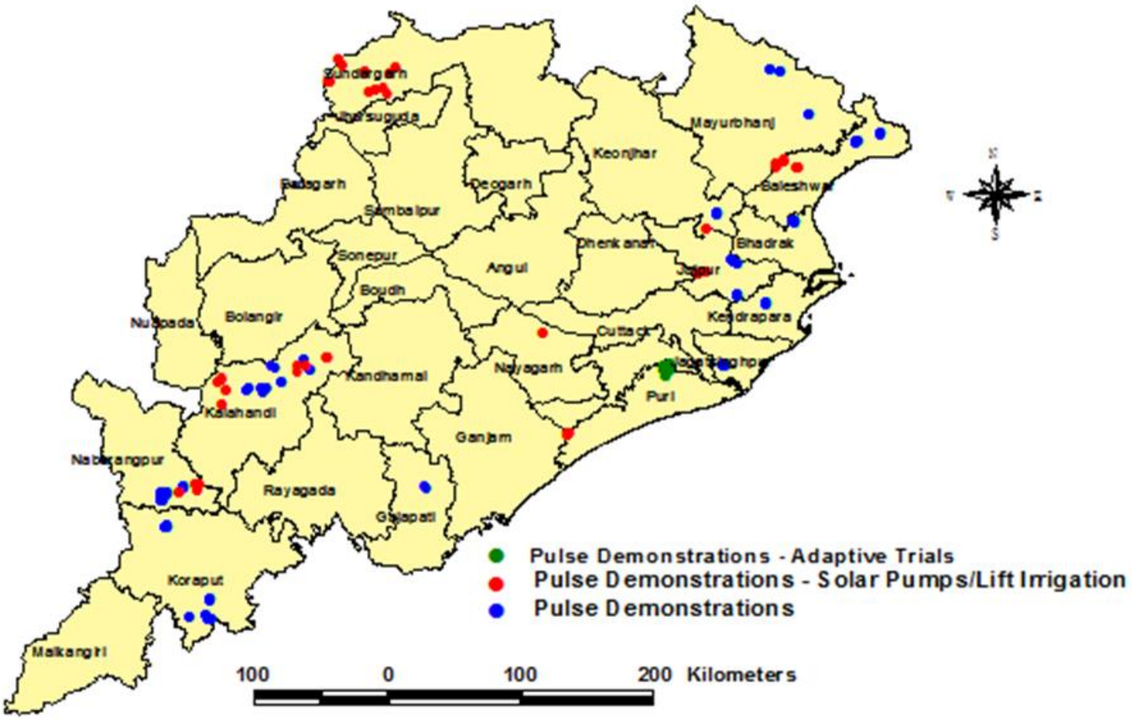

Fig. 5. A map illustrating the demonstrations, adaptive trials, and experiments conducted in different rice-fallow districts of Odisha.

5. Rice-Pulse Monitoring System (RPMS): The Rice-Pulse Monitoring System (RPMS) is an Android (phone/tablet)-based survey application system for pulses and oilseed crops. RPMS is a customized application built on an open-source platform called "Geographical open data kit (GeoODK)." RPMS provides an application to collect and store geo-referenced information, along with a suite of tools to visualize, analyze, and manipulate ground data for various needs of the Department of Agriculture in different projects. Through geo-spatial viewing and integration with various geo-thematic layers, RPMS enables a better understanding of agricultural data for decision-making, research, and management purposes. As a multi-dimensional application, RPMS's goal is to provide an open-source platform that can provide online/offline application to cater to the needs of existing and future agricultural data collection in a geo-spatial mode.

Most of the project activities had a need to gather, geo-spatially validate, and implement data collection methodologies for various reasons. This is where GeoODK was found useful. Various mapping functionalities as well as their integration with survey-based information are prerequisites. These include offline mapping, visualization of collected data on the phone/tablet, and the ability to collect point, polygon, and GPS tracing data (and then associate this spatial information with all the collected form information). Based on the suggestions from DoA authorities, we have also added basic details of almost 1.7 million registered farmers of Odisha State of India in the system.

At this stage, RPMS handles the form data collection and geo-spatial viewing adequately, but lacks the query part, remote-sensing data integration, and report generation components. In RPMS version 2, emphasis will be on adding the above-mentioned components and improved execution of this system by further simplifying the process and its integration with various other modules.

Rice-Pulse Monitoring System (Beta Version 1) provides

1. An Android (phone/tablet)-based survey application for pulses and oilseed crops
2. An online form for data collection
3. A polygon-based survey application along with geo-spatial display for each demonstration plot for precise tracking and monitoring (collect field data using the GeoODK app)
4. Inbuilt records of all existing registered farmers (currently 17 lakh) of Odisha State of India
5. Automatic updating capability of farmers' and survey records at the server end
6. Downloading and conversion of data into a geo-enabled format (Excel, CSV, KML, etc.)
7. Crop and land information (establishment method, inputs, and yield) and technological details, along with photographs of three stages (sowing, pod formation, and harvesting) of demonstration plots
8. Yield and other related attributes of control and demonstration plots

Line sowing of nano-solution-treated greengram using seed drill in residual moisture

DOA official visiting adaptive trial site in Puri

Greengram at germination stage: improved practices + nano-solution

Farmer inspecting his rainfed mungbean crop in Kalahandi District

Greengram at vegetative stage: improved practices + nano-solution

Farmer participating in farmer field

Principal secretary and director agriculture releasing RPMS during TOT session held on 8 May 2017

Extension officer of DoA attending TOT sessions

Field view of adaptive trials of mungbean in a farmer's field in Puri: improved practice + hydrogel

Women farmers participating in postharvest processes

Subproject 3: Raising productivity and profitability of rice-based cropping systems in Odisha through Rice Crop Manager

Rice Crop Manager (RCM) is a decision support tool that can be accessed through a web browser on computers, tablets, and smartphones. This tool provides farmers with field-specific crop and nutrient management recommendations customized to their farming conditions and needs. It can be used by extension workers, crop advisors, and service providers to interview farmers before the start of a rice cropping season. The answers given by the farmers are used to generate a recommendation, which aims to increase farmers' income through more efficient input use and better crop management practices. RCM uses a nutrient balance approach through plant uptake.

Rice Crop Manager for Odisha (http://webapps.irri.org/in/od/rcm/) was adapted, developed, evaluated, and verified for use with personal computers and smart phones through collaboration of IRRI with the Odisha University of Agriculture and Technology (OUAT) and the National Rice Research Institute (NRRI) during 2012 to 2015 with support from the BMGF-funded project Cereal Systems Initiative for South Asia (CSISA). It is being further enhanced in collaboration with the DoA, OUAT, and NRRI. The Department of Agriculture and Farmers' Empowerment will support the RCM research and dissemination project from April 2016 to March 2021 with the objective of further developing and enhancing RCM for irrigated and rainfed environments and its dissemination with personal computers and mobile phones in addressing the emerging needs of rice farming in Odisha. Research activities and socioeconomic studies will go in parallel to further strengthen the application and to monitor and evaluate the impact of RCM.

In addition to research for further enhancing RCM, there is recognized support for wide-scale dissemination, which provide farmers with field-specific rice farming advice through printed recommendations and text messages.

The specific objectives of this five-year project are

- To increase the profitability of rice farming through a climate-informed RCM service providing rice farming advice as printed guidelines and SMS to farmers.
- To train various stakeholders in using an ICT-based tool.
- To develop capabilities within RCM for irrigated and rainfed environments with in-season corrections.
- To identify the best-fit dissemination model for an ICT-based RCM tool across different stakeholder groups.
- To estimate the impact of the ICT-based RCM tool on the productivity of rice-based systems.

This project, through a part of the team based at IRRI in Los Baños, Philippines, is maintaining the operation of RCM and ensuring that it remains available to interview farmers and provide RCM recommendations. The part of the team based in Odisha is working with the Department of Agriculture and Farmers' Empowerment and other partners to develop dissemination pathways for reaching large numbers of farmers and also support research for enhancing the capabilities of RCM to cater to rainfed environments. This project, in partnership with the DoA and FE and agro-service providers, will also develop and sustain a cost-effective mobile messaging service based on SMS.

RCM recommendations as printed guidelines and SMS to farmers: IRRI, in collaboration with the DoA and FE and private partners, disseminated RCM recommendations to the farmers during kharif and rabi seasons of 2016-17. During the reporting period, IRRI maintained the continual operation of RCM mainly in the coastal districts of Odisha and exploratively in interior Odisha. IRRI ensured that RCM was continually accessible through the web browser of a smartphone, tablet, or personal computer at http://webapps.irri.org/in/od/rcm/. The information collected by RCM and transmitted by RCM to farmers was captured in a database. Figure 1 (a,b) shows the number of printed RCM recommendations provided to farmers during the reporting period. A total of 774 recommendations were provided to the farmers in kharif 2016 during the initial stage of the project. During rabi 2016-17, more defined collaborations and efforts led to the generation of 3,466 recommendations across 15 districts. About 87% of the total RCM recommendations were provided to smallholder farmers with less than 1 ha of farm size (Fig. 2).

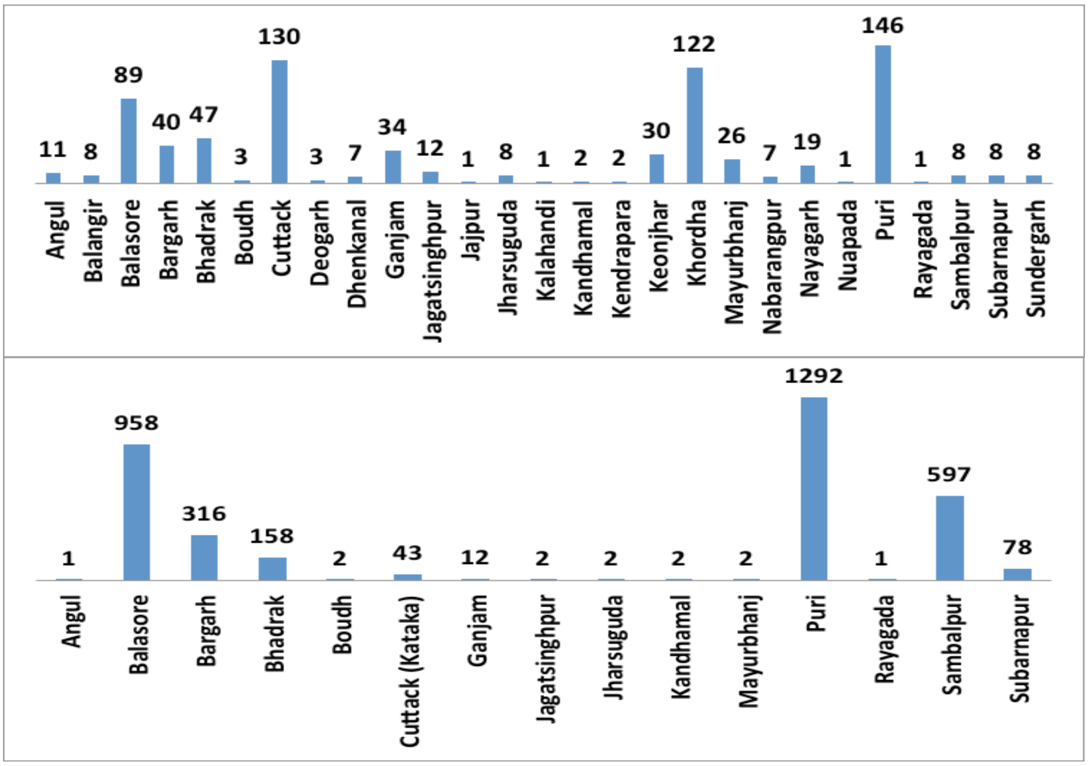

Fig. 1. Number of printed RCM recommendations provided to farmers during (a) kharif 2016 and (b) rabi 2016-17.

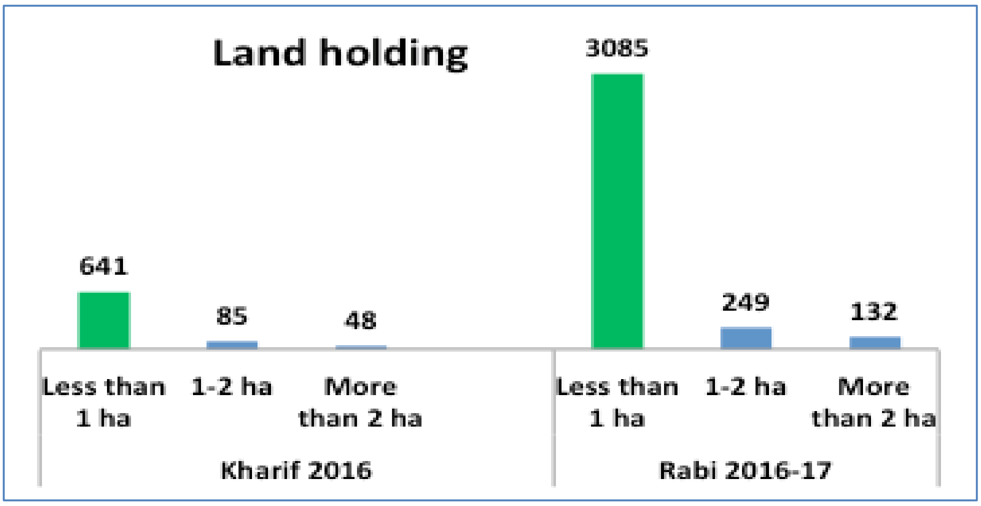

Fig. 2. Number of RCM recommendations provided to farmers based on landholdings.

RCM kendras in district and block DoA offices for RCM dissemination: RCM kendras are being established in the district and block offices of the selected districts. Thirty-five such kendras were established during 2016-17. These kendras are equipped with a laptop, printer, and data card for internet access (Plate #1). Trained staff of the DoA and FE are providing recommendations to the farmers visiting these kendras.


Photo 1. RCM kendra and district DoA and FE office equipped with laptop, printer, internet facility, and reference materials

<u>Training for various stakeholders in using the ICT-based tool:</u> RCM was selected as an ICT tool under the Soil Health Care Scheme for the dissemination of field-specific nutrient management recommendations. The DoA and FE conducted various training programs across the state at the district and block levels to build the capacity of their extension staff to generate RCM recommendations. IRRI provided technical support for the 26 *Training of Trainers* (TOT) events conducted during the reporting period (Tables 1 and 2). The purpose of the training was to capacitate the trainees on the use and operation of RCM and facilitate more rapid dissemination and reach of RCM recommendations to farmers. A total of 857 participants from 12 districts were oriented on the operation and use of RCM and on troubleshooting associated with its use. Moreover, they were tasked to commit to provide at least 50 RCM recommendations per season per village-level worker (VAW), identify team members for RCM dissemination, and come up with an action plan. Plate #2 shows various training sessions organized with the DoA and FE. Three additional training programs were also conducted with private partners Lutheran World Services India Trust and Reliance Foundation.

Photo 2. Snapshots of various training sessions conducted with DoA and FE.

Table 1. District- and block-level RCM TOTs conducted during kharif 2016.

Sl. no.	Training	Date	Location	No. of participants
1	RCM training at IMAGE, Bhubaneswar	28 April 2016	Bhubaneswar	60
2	Hands-on training on RCM, DoA Cuttack	20 July 2016	Cuttack	36
3	Hands-on training on RCM, DoA Salepur	22 July 2016	Salepur	40
4	Hands-on training on RCM, DoA Athgarh	26 July 2016	Athgarh	40
5	Hands-on training on RCM, DoA Banki	27 July 2016	Banki	34
6	Hands-on training on RCM, DoA Puri	23 July 2016	Puri	32
7	Hands-on training on RCM, DoA Nimapara	21 July 2016	Nimapara	38
8	Hands-on training on RCM, DoA Sakhigopal	25 July 2016	Sakhigopal	44
9	Hands-on training on RCM, DoA Bhdrak	9 August 2016	Bhadrak	65
10	Hands-on training on RCM, DoA Khurda	7 August 2016	Khurda	31
11	Hands-on training on RCM, DoA Tangi	10 August 2016	Tangi	30
12	Hands-on training on RCM, DoA Bhubaneswar	5 August 2016	Bhubaneswar	43
13	Hands-on training on RCM, DoA Nayagarh	3 October 2016	Nayagarh	42
14	Hands-on training on RCM, LWSIT	10 March 2016	Nimapara	17
15	Hands-on training on RCM, LWSIT	17 March 2016	Nimapara	40
16	Hands-on training, Reliance Foundation	5 July 2016	Bhubaneswar	17
Total	16			609

Table 2. District- and block-level RCM TOTs conducted during rabi 2016-17.

Sl. no.	Training	Date	Location	No. of participants
1	RCM training in Sambalpur	8 November 2016	Sambalpur	45
2	RCM training in Bargarh	9 November 2016	Bargarh	46
3	RCM training in Cuttack	22 November	Banki	12

		2016		
4	RCM training in Ganjam	23 December 2016	Polsara	10
5	RCM training in Puri	24 December 2016	Nimapara	32
6	RCM training in Balasore	26 December 2016	Jaleswar	20
7	RCM training in Ganjam	27 December 2016	Rangeilunda	15
8	RCM training in Ganjam	28 December 2016	Soroda	10
9	RCM training in Balasore	29 December 2016	Baliapal	35
10	RCM training in Bhadrak	5 January 2016	Bhadrak	23
Total	10			248

Enhance capabilities within RCM for irrigated and rainfed environments with in-season corrections: The following experiments have started at the IRRI-OUAT experiment station. The results from these experiments will be used to develop decision trees for rainfed environments.

- Optimization of potassium (K) supply and plant nutrition through different K management practices under the rice-rice system in Odisha
- To study the effects of different rice establishment methods and tillage practices in rice in both the dry and wet season on crop performance, nutrient- and water-use efficiency, and soil characteristics
- Optimization of nutrient management for rice-based cropping systems
- Optimizing fertilizer application rates and timing for rainfed rice in Odisha

In addition to this, adaptive research will be conducted in farmers' fields to evaluate RCM for enhanced features in collaboration with NRRI, NGOs, and other subcomponents of the project. The locations and the protocols have been finalized for the studies.

- Head-to-head trials to demonstrate the benefits of RCM to farmers and to build trust, in collaboration with NGOs.
- Head-to-head trials to evaluate RCM for weed management recommendations, in collaboration with NRRI.
- Head-to-head trials to evaluate RCM recommendations under stress environments, in collaboration with Subproject 1: "Strengthening seed systems of stress-tolerant rice varieties through innovative demonstrations and extension approaches in Odisha."
- On-farm trials to develop capability in RCM for using GIS and RS approaches for yield targeting and in-season correction, in collaboration with Subproject 5: "Science-based crop insurance."

Stakeholders/partnerships: The following stakeholders were identified and the partnerships developed during the reporting period.

Type of partner	**Name of partner**	**Districts**
Dissemination partner	Balasore Social Service Society	Balasore, Bhadrak, Mayurbhanj, Keonjhar
Dissemination partner	Dhan Foundation	Mayurbhanj, Balasore
Dissemination partner	Lutheran World Services India Trust	Jajpur, Puri
Dissemination partner	Netaji Jubak Sangh	Jajpur and Bhadrak
Dissemination partner	Harsha Trust	Koraput
Dissemination partner	ISARA	Ganjam
Research partner	NRRI	Cuttack
Research partner	OUAT	Khorda
Awareness generation	Reliance Foundation	-

Summary and Conclusions

During the reporting period from April 2016 through June 2017, IRRI

- Maintained operation of RCM (http://webapps.irri.org/in/od/rcm/), which enabled 4,240 printed RCM recommendations to be generated for farmers.
- Maintained a database with information collected through farmer interviews and provided to farmers through RCM.
- Assisted a "technical expert" engaged by the DoA and FE in developing content for the RCM TOTs and then in providing technical support to TOTs at the district and block levels.
- Conducted strategic and adaptive research for RCM enhancement.
- Monitored "sample farmers" for benefits of RCM adoption through follow-ups and crop cuts.

Subproject 4: Inclusive development through knowledge, innovative extension methods, networks, and capacity building in Odisha

This component aims to create the enabling and catalytic environment that is required for the effective dissemination and internalization of the technologies that are being targeted. The component supports the creation of a local actor-led knowledge bank in Oriya, with the latest and most up-to-date knowledge, information, and technological options that will support crop diversification, intensification, and improved nutrition. The component supports an innovative and structured approach for collaboration across government, business, nonprofit organizations, and farmers themselves (inclusive of small and marginal farmers, women, and youth) that enables technology identification coupled with rapid outscaling. The component builds local capacity through a model of collective action and impact for the development and empowerment of knowledge networks and institutions. The mode of working follows.

The key principle for the component is the establishment of partnerships to enable local actors in the public and private sector as well as in civil society to provide a catalytic role that enables the farming community to derive benefits from emerging technologies in rice science and associated cropping systems. The Knowledge Forum for Odisha will span districts functioning with key stakeholders for leveraging local/regional actors and resources, building capacity, and using ICT tools to amplify impact, with marginal farmers, women, and youth as priority groups. The network accelerates impact through seed, mechanization, crop management, and GIS rice crop mapping, with all work underpinned through ICT.

The network will operate at the grass-roots level and includes community-based organizations, NGOs, women's programs, and the local network of dealers, regional research institutions, agricultural information services, and the Department of Agricultural Extension and micro-financial service agencies.

The component has four specific outputs, which include a Rice Knowledge Bank for the state of Odisha, a Rice Doctor for the state of Odisha, innovations in extension vis-à-vis Ricecheck, and capacity development implemented through the women’s leadership for impact course and strategic capacity development of organizations.

Rice Knowledge Bank for the state of Odisha

Development of a knowledge bank, in collaboration with the NRRI and OUAT and other stakeholders and contextualized for rice-based systems in Odisha, will serve as a one-stop access for knowledge for extension intermediaries and progressive farmers. Activities during 2016-17 focused on content development for the knowledge bank. The modus operandi was also finalized. This process includes several steps and processes, which are elaborated below.

Identification of lead agency*:* It is important to have a host agency that would provide the leadership to develop, manage, and assume the responsibility for maintaining and updating the knowledge bank. This agency would also be responsible for coordinating activities among knowledge bank contributors, designers, managers, decision makers, media, and others as needed to continue to develop and maintain the knowledge bank. For Odisha, the primary actors involved in the process with IRRI are OUAT, NRRI, and other national schemes and projects. IRRI would take the lead in the establishment of the knowledge bank in collaboration with other partners and pass it on to the Department of Agriculture and Farmers' Empowerment after development and testing for sustainability after the project period. Defining an exit strategy at this stage is very important as that will allow us to put things in place that would set up the identified organization with capacity and resources, etc.

Rules, processes, and tools: A meeting with all relevant stakeholders was held to discuss the formation of a steering/technical committee and develop a regional strategy for the development and maintenance of a knowledge bank. It included the process of endorsement by the competent authority for the materials to be hosted in the knowledge bank. It was decided to use the seed committees of the district headed by the DoA to act as the endorsing agency for the content. This will allow the developed knowledge products to be recognized by the target audience and integrated in the DoA.

Leveraging the capabilities of nontraditional actors: The inclusion of nonagricultural professionals while developing materials is required to enhance the user-friendliness of the scientific knowledge. These include adult education specialists, communication specialists, program designers, etc. Such partners can also help to think about different formats for packaging information and knowledge, and different modes of communication. Such partners have been identified and the necessary ToRs with them have been finalized (Biggshift communications for video development).

Use of media: Developing, compiling, hosting, and storing materials would ensure availability. Propagating news about the availability of materials among their various users would ensure quick dissemination of these materials. Media can help disseminate the information through different channels: TV, radio, website, blogging, advertisement, etc. Collaboration has been established with the Reliance Foundation for information dissemination through the newspaper Sambad. Emerging agencies in various countries develop knowledge bank-type web-based tools. Such agencies could be good partners for co-development of the knowledge bank. These are vital as most public sector scientific and extension agencies do not have the skill sets or human resources to develop and maintain such sites efficiently. Discussions have been held with organizations to outsource the design and development of the knowledge bank.

The proponents of the knowledge bank may need to interact with the relevant projects and programs from the beginning of the process of development and dissemination and can be the host agency. Such interaction would help in the acquisition of materials, dissemination, and use of those materials immediately by different relevant groups of users without major cost. It can also help to start with something small and focused and this can later be integrated into a knowledge bank developed and managed by national institutes. Discussions have been held with OLM to facilitate this process.

Content development progress: manuals (3), factsheets available (225), and videos being developed (20).

Rice Doctor for the state of Odisha

Rice Doctor (RD) is a midseason diagnostic tool that can provide agricultural extension workers (public and private) and farmers with accurate and timely diagnosis of more than 80 crop nutrition problems, pest infestations, and disease infections. It allows the identification of the problems as well as recommendations. It can also be used by students, private input dealers, and others who help in bridging the information gap between research and farmers. In 2016-17, the process for the development of the RD Odisha was finalized in consultation with collaborating institutes. This includes five specific stages: (1) data gathering, validation, and analysis; (2) development of the program; (3) usability testing; (4) launch of the final product; and (5) design of the user interface.

Data collection, validation, analysis, and testing are being carried out by IRRI in collaboration with IIRR, NRRI, and OUAT. The Odisha crop protection group with the members from the afore-mentioned institutes has been set up and will be meeting in August 2017 to finalize the integrated pest management protocol to be evaluated and tested via the Rice Doctor in kharif 2017. Design and software development are outsourced.

Innovations in extension vis-à-vis Ricecheck

Ricecheck encourages farmers to manage their rice crop by comparing their practices with the recommended practices for producing the highest yield. It involves crop monitoring, measuring crop performance, and analyzing results. Observing, measuring, recording, comparing, and adopting best practices are the learning steps involved in identifying the strengths and weaknesses of their management.

The Ricecheck process (Fig. 2) involves a series of deliberations with different stakeholders, ranging from the district level to the farm level. A series of stakeholder consultations was held to finalize the process of Ricecheck for the state.

These included

1. State-level workshops: A four-day workshop titled "Planning a Strategy for Ricecheck in Odisha" was organized during 20-23 September 2016.
2. District-level workshops: Following the state-level workshop, meetings were held in Jagatsinghpur, Puri, Bhadrak, and Mayurbhanj districts to finalize the plan.
3. Finalization of protocol: The protocol for implementing Ricecheck in kharif 2017 has been finalized and is detailed in the table below.
4. Finalization of ToR with OUAT: The ToR has been finalized with OUAT for kharif 2017 and implementation of Ricecheck will begin in August 2017.
5. Content development for Ricecheck: Content support for the Ricecheck process is integral for the smooth implementation of the plan. The team has worked on making available the following content for the next season.
    - Ricecheck booklet template
    - Factsheets required
    - Strategic capacity development of organizations and institutions in the state
    - Women's leadership for impact course
    - This leadership course targets the personal and professional development of women scientists, extension workers, social workers, and entrepreneurs working within organizations with communities of women from poor farming communities. The main goal of the course is to impact 50,000 women farmers and small entrepreneurs in 5 years through the intervention of these women professionals. These women leaders will conceive, co-develop, co-implement, and lead projects with women farmers, while providing access to services, knowledge, and technologies according to the needs and demands identified within the communities. The course vies for sustainability and the scaling potential of the projects. The women professional leaders identify the women

leaders in their own communities and strive in turn to empower them to take initiatives that will benefit them.

- The secondary goal of this initiative is to create a viable platform of organizations dedicated to women's empowerment in agriculture that will function collaboratively by pooling their knowledge and good practices in order to see the projects reach a large scale within the organizations. The course takes place as two initial workshops of 8 and 5 days each, with an accepted interval. Workshop 1 took place from 21 to 27 October 2016 on the premises of the Central Institute for Women in Agriculture. Workshop 2 was delayed due to the late receipt of funds, and was conducted from 29 May to 5 June 2017. A detailed report on the course will be shared after the completion of all three workshops of the strategic capacity building for Odisha.
- System-level changes in agriculture can be induced by interventions in key thematic areas that can influence economic decisions in Odisha. These include systematically building the capacity of all stakeholders and addressing gaps in skills, knowledge, and empowerment. Capacity building in particular looks into developing a new generation of rice scientists, agricultural extension specialists, and skilled mechanics, as well as training farmers on rice and rice-based farming systems, postharvest management, and empowering women and youth in rice farming.
- The importance of developing high-quality personnel cannot be overemphasized. It is key to the realization of Odisha's rice sector development goals and should be given priority, not just by the government but by other stakeholders, including international research and development organizations. Thus, a capacity development policy dialogue is proposed to identify strategies and specific interventions that will ensure the capacity of the human resources required to implement and realize the goals of the state.
- The implementation of this program will commence post-March 2017 due to the late receipt of funds.

Collaborating agency	NGO	DA&FE	OUAT	IRRI
Capacity building		*	*	*
Site selection	*	*	KVK	
Implementation and execution	Field worker/Group leader	AAO	KVK	
Knowledge materials development			*	*
Monitoring	*	*	*	*
Documentation	*		*	*
Feedback collection	*	*	*	*
Coordination			*	*
Overall facilitation for learning sharing at state and district level networks/ platforms			*	*

Fund flow from IRRI through	State/district level organizations	DAO	Controller of finance	
Exposure visit	*	*	KVK	
Farmers exchange programme		*	*	*
Student involvement			*	

Subproject 5: Science based crop insurance

Component 5a: Remote Sensing Based Rice Monitoring and Yield Estimation

Introduction

With recent advances, Synthetic Aperture Radar (SAR) based crop observation has enabled crop monitoring during the monsoonal cropping seasons with high spatial and temporal resolution. This component aims to create and maintain a dynamic digital database to monitor rice growth, estimate rice area and yield in various rice ecosystems and assess damage (flood and drought) during rice cropping season in near-real time using remote sensing technology. With this view this component is in operation to facilitate the farmers, extension workers, crop insurers and policy makers through a dynamic decision support system. Continuous monitoring of rice area and timely damage assessment (flood and drought) will enable the decision makers for efficient planning.

Product generation

i)Satellite Data acquisition: High resolution Sentinel 1A Synthetic Aperture Radar (SAR) imageries (developed & operated by European Space Agency) and other related imageries were acquired by IRRI and sarmap (sarmap provides earth observation based services/remote sensing software for land based applications) . A very large dataset involving over 150 satellite imageries during Kharif and Rabi seasons across 3 tracks and 10 footprints were obtained during May 2016 – April 2017 to cover both cropping seasons (Figure 1 and Table 1).

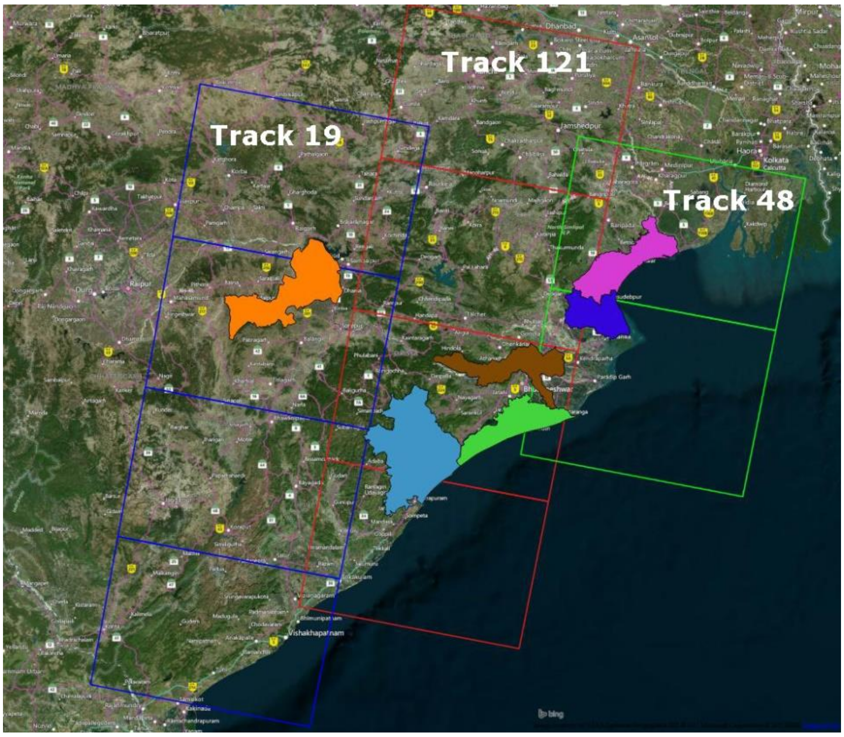

Figure 1. S1A tracks covering Sate of Odisha

Table1. Sentinel 1A acquisition schedule

Track_19	Track_121	Track_48
24-May	31-May	26-May
05-Jun	12-Jun	07-Jun
17-Jun	24-Jun	19-Jun
29-Jun	06-Jul	01-Jul
11-Jul	18-Jul	13-Jul
23-Jul	30-Jul	25-Jul
04-Aug	11-Aug	06-Aug
16-Aug	23-Aug	18-Aug
28-Aug	04-Sep	30-Aug
09-Sep	16-Sep	11-Sep
21-Sep	28-Sep	23-Sep
03-Oct	10-Oct	05-Oct
15-Oct	22-Oct	17-Oct
27-Oct	03-Nov	29-Oct
08-Nov	15-Nov	10-Nov
20-Nov	27-Nov	22-Nov
02-Dec	09-Dec	04-Dec
14-Dec	21-Dec	16-Dec
26-Dec	02-Jan	28-Dec
07-Jan	14-Jan	09-Jan
19-Jan	26-Jan	21-Jan
31-Jan	07-Feb	02-Feb
12-Feb	19-Feb	14-Feb
24-Feb	03-Mar	26-Feb
08-Mar	15-Mar	10-Mar

ii) Data processing and generation of Rice area maps: During first year these imageries were used to estimate and generate maps of rice areas, start of season and crop phenology maps at monthly interval for the six selected districts (Balasore, Bargarh, Bhadrak, Cuttack, Ganjam and Puri) in the state of Odisha. These imageries were processed using rule based algorithms developed by sarmap implemented in the MAPscape-RICE® software. The customised MAPscape-RICE® software developed by sarmap was used for continuous monitoring of rice. The rice area maps show the total cultivated rice area during Kharif 2016 (Figure 2a). The Start of the Season (SoS) maps show the rice planting dates in those selected districts (Figure 2b). These rice area classifications were verified using 240 (75% rice and 25% other land cover types) ground data locations for 2016 Kharif and 197 (64% rice and 36% other land cover types) for 2017 Rabi seasons. In terms of rice acreage, an increase of 10% in average in the 2016 Kharif season has been measured with respect to the official government statistics of 2013-14.

iii) Crop Yield Estimation: IRRI team estimated rice yields and hence production at district, block and at village level by integrating remote sensing products i.e., rice area, Start of the Season (SoS), and LAI (derived from SAR signature) into the crop growth simulation model

ORYZA using RiceYES interface developed by IRRI. Estimated yield data and maps were generated for Kharif 2016 for six selected districts (Balasore, Baragarh, Bhadrak, Cuttack, Ganjam and Puri) of Odisha. Estimated yield ranged between 0.5 - 3.0 t/ha, with some of the areas having 0.4 t/ha and >3.0t/ha (Figure 3). Estimated yield was verified with the CCE data provided by component-1 of this project. For Rabi 2017, estimated yield were generated for the same six districts. Estimated yield ranged from 3.0 - 6.0 t/ha. Yield estimates for both seasons are available at village level. Estimated rice area and aggregated yield at block levels for both Kharif and Rabi seasons are presented in Table 2.

Based on the information collected from the field by IRRI team, there was 65-75% reduction in rice cultivation during 2017 Rabi season especially in Ganjam district.

iv. Ground-truthing and accuracy assessment: Field observations/ data collections were carried out using GPS and smart phones throughout the season at sample locations and updated on real time basis. Observations on latitude and longitude, photos of the status of the crop, plant height, water depth, weather condition, and crop stage were collected and matched with Image acquisition data. Information on the variety cultivated, irrigation source, crop establishment / management practices and inputs such as fertilizer were also collected.

Collected data from the field and field information were used for calibration and validation of satellite based products for each season.

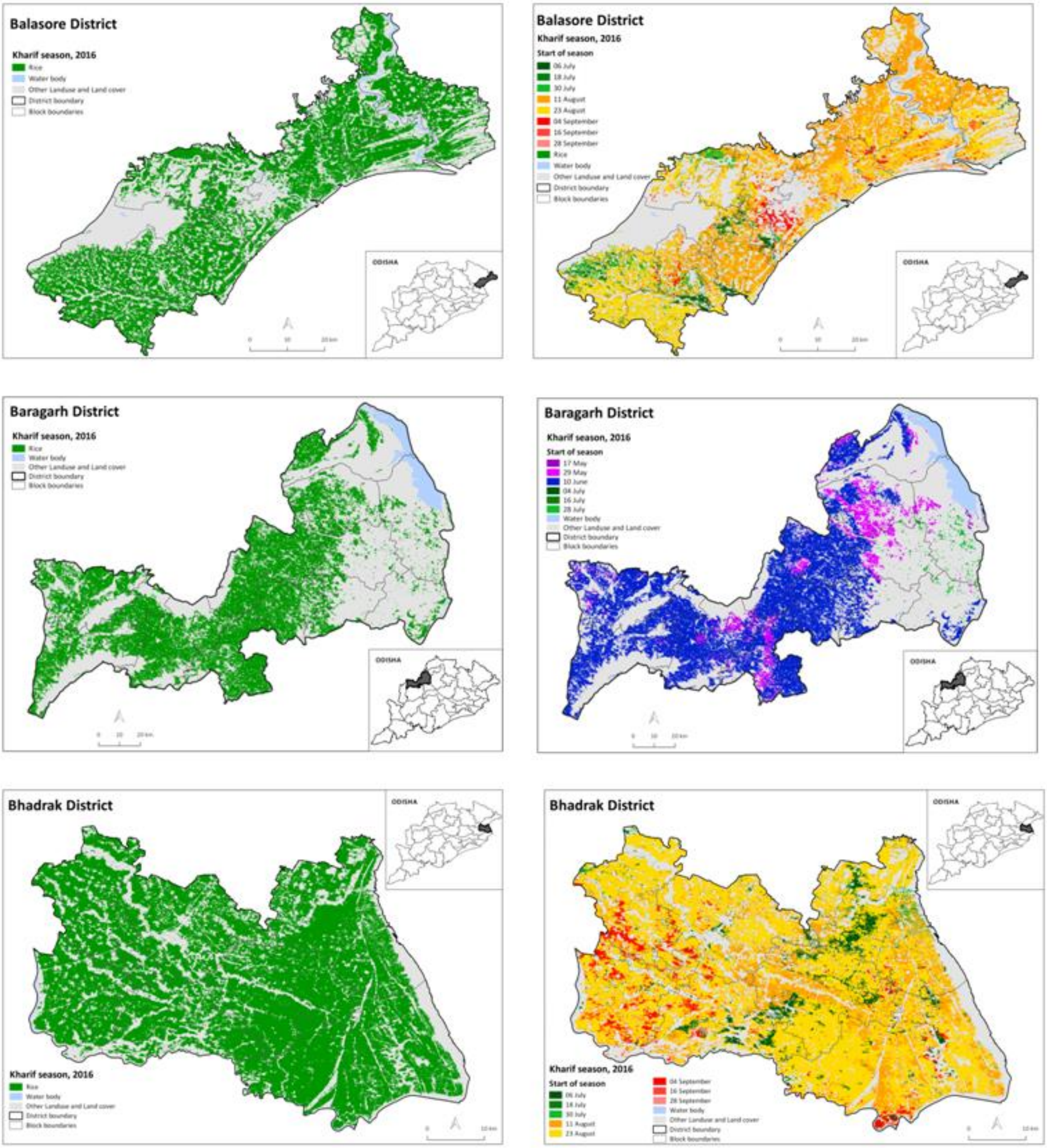

Fig 2a. RIICE rice area map and Start of Season map for S1A in Balasore, Baragarh and Bhadrak districts, 2016 Kharif.

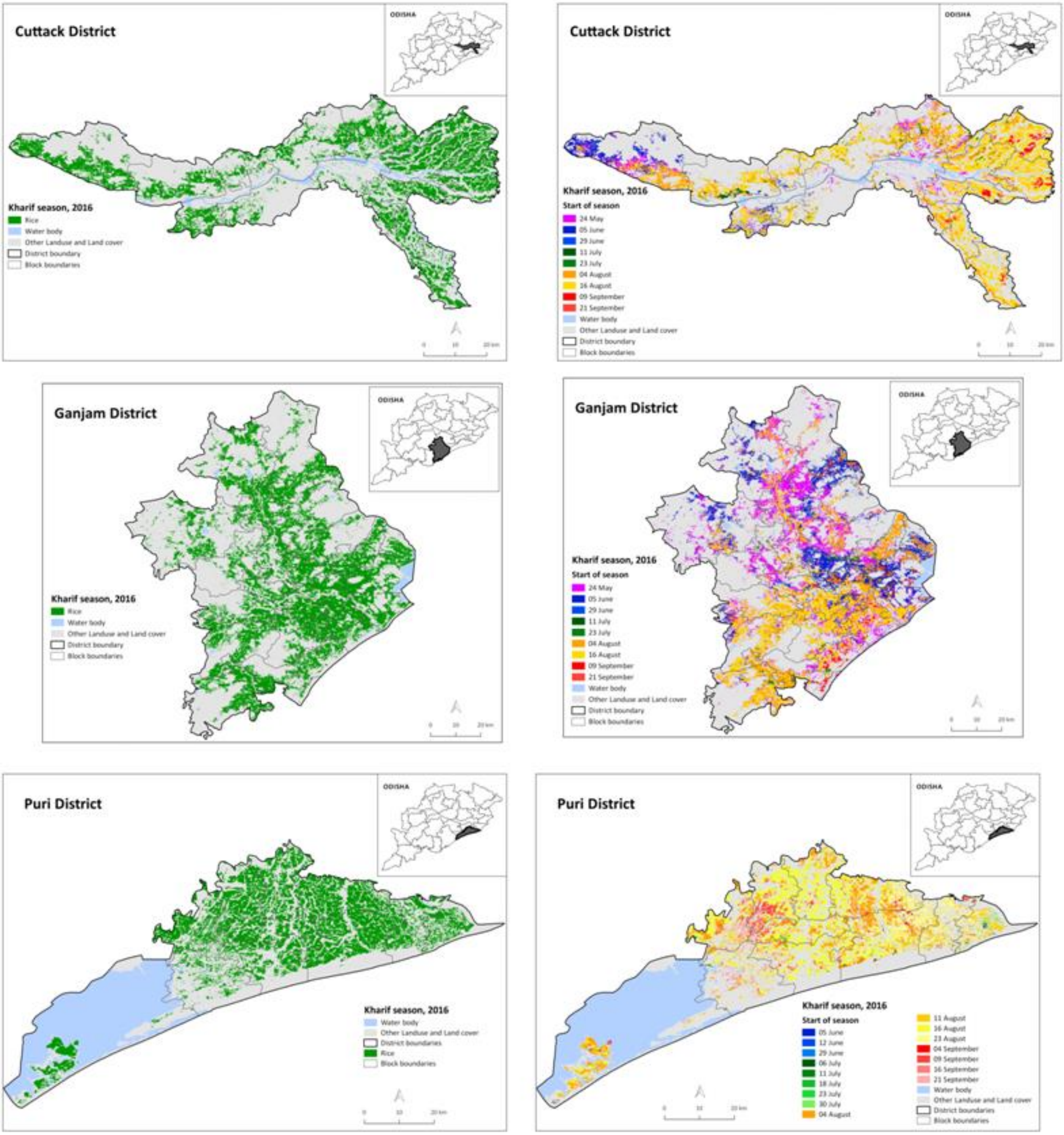

Fig. 2b. RIICE rice area map and Start of Season map for S1A in Cuttack, Ganjam and Puri districts, 2016 Kharif.

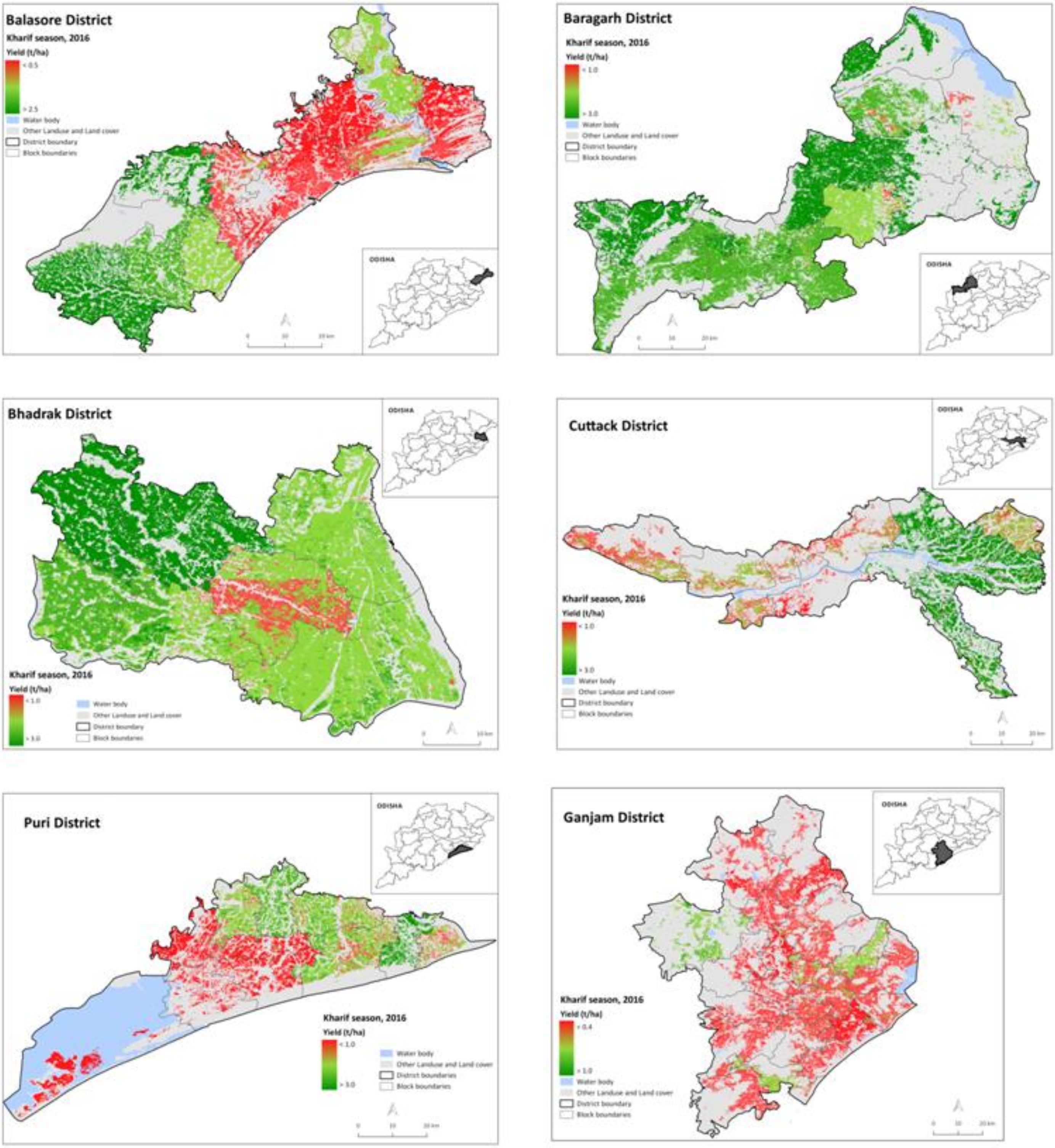

Fig. 3. Yield estimates map generated for S1A in Balasore, Bargarh, Bhadrak, Cuttack, Ganjam and Puri districts, 2016 Kharif.

Table 2a. Estimated rice areas and yield at block level in the districts of Bargarh, Bhadrak and Cuttack generated by IRRI in collaboration with sarmap for 2016 Kharif and 2017 Rabi season

District	Block	2016 Kharif estimated rice area (ha)	2017 Kharif estimated yield, t/ha	2017 Rabi estimated rice area (ha)	2017 Rabi estimated yield, t/ha
Bargarh	Ambabhona	2482957	5.14	25	4.47
Bargarh	Attabira	2907743	4.8	18075	4.17
Bargarh	Bargarh	1759318	4.56	9184	4.03
Bargarh	Barapali	1247298	5.28	3555	5.23
Bargarh	Bhatli	1833480	4.41	965	4.7
Bargarh	Bheden	1679934	5.22	10390	5
Bargarh	Bijepur	1032050	5.17	162	5.11
Bargarh	Gaisilet	1145247	4.92	4	5.69
Bargarh	Jharbandha	1948332	5.37	22	3.4
Bargarh	Padampur (Rajbarasambar)	2007987	5.22	56	4.87
Bargarh	Paikamal	2572009	5.61	25	4.1
Bargarh	Sohela	1874203	4.99	112	3.73
Bhadrak	Basudebpur	30226	3.66	80	5.16
Bhadrak	Bhadrak	22943	5.03	95	5.07
Bhadrak	Bhandaripokhari	19157	4	166	5.53
Bhadrak	Bant	19192	5.04	63	4.5
Bhadrak	Chandabali	41909	3.76	10	4.73
Bhadrak	Dhamanagar	18861	3.75	397	5.21
Bhadrak	Tihidi	27352	3.74	203	4.98
Cuttack	Athagad	9356	4.3	60	5.19
Cuttack	Banki-Dampara	3518	4.23	1079	4.86
Cuttack	Banki	6908	4.51	108	4.64
Cuttack	Badamba	8559	3.92	2	3.23
Cuttack	Barang	5254	5.22	41	5.42
Cuttack	Cuttack Sadar	6674	5.77	39	5.64
Cuttack	Kantapada	4422	5.3	104	4.77
Cuttack	Mahanga	12151	4.17	152	4.97
Cuttack	Narasinghpur	16870	4.18	2	4.48
Cuttack	Niali	7236	4.87	220	4.65
Cuttack	Nischintakoili	10557	5.04	171	4.77
Cuttack	Salepur	11375	5.05	34	4.7
Cuttack	Tangi-Choudwar	13919	5.51	97	5.61
Cuttack	Tigiria	2252	4.42	-	-

Table 2b. Estimated rice areas and yield at block level in the districts of Ganjam and Balasore generated by IRRI in collaboration with sarmap for 2016 Kharif and 2017 Rabi season

District	Block	2016 Kharif estimated rice area /ha	2017 Kharif estimated yield, t/ha	2017 Rabi estimated rice area/ha	2017 Rabi estimated yield, t/ha
Ganjam	Asika	8345	3.42	33	5.26
Ganjam	Beguniapada	12670	3.17	101	5.02
Ganjam	Bellaguntha	11014	3.16	88	5.48
Ganjam	Bhanjanagar	19267	2.83	191	6.05
Ganjam	Buguda	11817	3.44	57	5.23
Ganjam	Chhatrapur	12492	2.95	87	4.11
Ganjam	Chikiti	9683	2.85	53	4.08
Ganjam	Dharakote	6895	3.55	4	4.53
Ganjam	Digapahandi	18914	3.19	8	3.34
Ganjam	Ganjam	10854	3.47	94	4.23
Ganjam	Hinjilicut	9795	3.23	84	4.57
Ganjam	Jagannathprasad	22550	3.57	7	5.61
Ganjam	Kavisurjyanagar	9887	3.47	20	4.8
Ganjam	Khalikote	19492	3.49	96	5.19
Ganjam	Kukudakhandi	13413	2.95	31	3.58
Ganjam	Patrapur	16296	3.18	73	4.07
Ganjam	Polasara	12142	3.59	36	5.24
Ganjam	Purusottampur	13778	3.28	132	4.63
Ganjam	Rangeilunda	11843	2.91	339	3.63
Ganjam	Sanakhemundi	10554	3.34	195	4.28
Ganjam	Seragad	8282	3.18	68	4.67
Ganjam	Surada	15343	3.56	10	5.13
Balasore	Bahanaga	16888	4.19	34	5.34
Balasore	Baleshwar (Sadar)	25772	3.57	1619	6.09
Balasore	Baliapal	13958	3.7	5878	6.05
Balasore	Basta	20576	3.94	4453	6.04
Balasore	Bhograi	17284	4.08	8796	5.86
Balasore	Jaleswar	22565	3.96	8272	5.9
Balasore	Khaira	22569	4.96	7	5.44
Balasore	Nilagiri	13269	5.06	70	3.82
Balasore	Oupada	6666	4.71	2	4.7
Balasore	Remuna	16220	3.8	559	5.4
Balasore	Similia	13383	5.05	2	5.61
Balasore	Soro	15486	4.74	9	5.04

Table 2c. Estimated rice areas and yield at block level in the district of Puri generated by IRRI in collaboration with sarmap for 2016 Kharif and 2017 Rabi season

District	Block	2016 Kharif estimated rice area /ha	2017 Kharif estimated yield, t/ha	2017 Rabi estimated rice area/ha	2017 Rabi estimated yield, t/ha
Puri	Astaranga	5692	3.52	38	5.45
Puri	Brahmagiri	5907	3.39	10494	5.45
Puri	Delanga	11250	4.28	1346	5.23
Puri	Gop	20710	4.55	1058	4.91
Puri	Kakatpur	6817	4.75	283	4.62
Puri	Kanas	10220	3.36	3853	5.26
Puri	Krushnaprasad	8725	3.4	1003	4.97
Puri	Nimapada	15895	4.36	1423	5.07
Puri	Pipili	11083	4.36	314	5.58
Puri	Sadar (Puri Sadar)	11059	3.77	3085	5.81
Puri	Satyabadi	8953	3.66	924	5.26

Capacity building: IRRI conducted three training on "Ground Data Collection Protocols" specifically for the SoS verification in March and July 2017 to local staff hired under Component 5. Theoretical session was held at the CSISA office in Bhubaneswar, Odisha, while the hands-on session for ground data collection were held at the rice fields in Puri and Cuttack. The 5-day training focused on the protocol and guidelines on how to collect the rice area field locations using GPS (Garmin E-Trex 10), photographs to capture the condition of the field being observed and entering field information in the hardcopy ground data encoding forms. Training was provided on the data transfer from GPS to computer, accuracy assessment using google map and data encoding using excel.

Coordination and other activities: IRRI team organized and participated two meeting with various governments' organizations. IRRI team coordinated and participated following events during this reporting period:

- A meeting on knowledge sharing and 2016 kharif season product sharing was held on 17 March 2017 in Bhubaneswar, Odisha. Component 5 leader Dr. Nasreen Khan and her team presented 2016 Kharif season products on rice area, start of season and estimated yield maps. Following participants from various institutions attended the meeting.

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5b: Crop Insurance:

Risk of agricultural production, especially of rice crop in Odisha, has increased due to the effects of climate change. In consequence, the frequency of loss events has increased affecting the sustainability of farmers' income and livelihood. The crop insurance scheme, (Pradhan Mantri Fasal Bima Yojana – PMFBY, 2016), therefore, plays an important role in transferring such production risks to another party at a cost (premium) and thereby reduce impact of yield loss to the farmer. The main aims of the scheme are (a) to provide financial support to farmers in the event of failure of crop as a result of natural calamities and pests, diseases etc., (b) to encourage farmers to adopt progressive farming practices and improved technology in agriculture, (c) to help stabilize farm incomes, and to improve farm livelihoods. The scheme's arrangements however are facing social barriers of implementation along with technical. In order to address the social barriers, this component is test farmers' acceptance of different ways of integrating stress reducing technologies / crop management practices with the crop insurance scheme. To implement this, the focus is on i) risk profiling of farmers, ii) farmers' awareness and perception, and iii) farmers' preferences for crop insurance, and iv) farmers' acceptance of crop insurance and its integration with technology using field framed insurance experiments.

During the year 2016-17, we conceptualised, designed and implemented the risk games and questionnaire for the survey, prepared design and structure of Focus Group Discussion (FGD) with farmers having varying risk exposure and insurance adoption levels. The study provided insight on general ground level situation and farmers' understandings, perceptions and opinions about the crop insurance scheme. Risk profiling analysis is in progress and expected to deliver the report in 2017-2018. Preliminary stakeholder consultation with the government, empaneled insurance companies as well as few NGOs have also been done. Secondary data/information on crop insurance coverage in Odisha during the previous two seasons (Kharif 2016 and Rabi 2016-17), were gathered from insurance companies, government departments and websites to substantiate the study. Pilot surveys were conducted to make improvements and necessary changes based on the ground level information and feedback followed by the main survey.

Workplan 2017-18: Component 1: Seed system improvement

No	Activity	Number	Districts	Blocks	Area/Number	Partners
1	Demonstrations (5 ha each)	1090	30	109	5450	DoA, NGOs, OSSC dealers
2	H2H trials	2180	30	109	218	AAOs, NGOs, Farmers, Dealers
3	Demos through OSSC dealers & their customers	10900	30	109	1090	OSSC dealers, Krishak Sathis, OSSC
4	Evidence Hubs (crop cafeteria)	30	30	Dt level	50 Dec. Each	DDAs, OSSC, KVK, Dealers & Farmers
5	District Level Seed Meetings	30	30	Dt level	30	DDAs, KVK, OSSC, AAOs, Dealers
6	Client oriented Crop Cafeteria	2	2	2 in state	100 Dec. (Each)	NRRI, OSSC, Pvt Seeds
7	Quality seed production trainings for farmers (25 per training)	109	30	109	2725	DDAs, IRRI, KVKs, OUAT, NGOs
8	Formation of women led seed groups	30	30	30	30	NGOs, SHGs, DDAs
9	Training of trainers for QSP and management practices	2		1	100	NRRI, OUAT, KVKs, IRRI
10	Awareness creation meetings (2/season) 100 farmers each	218	30	109	10900	DDAs, NGOs, Farmers
11	Pilot SeedCast	1	10	30		DDAs, AAOs, Dealers, PACS, OSSC outlets, OSSC (Pvt in phase 2)

Workplan 2017-18: Component 2: Fallow management

No	Activity	Number	Districts	Blocks	Area/Number	Partners
1	Village level Rice fallows and cropping intensity maps	2	30		30 districts	DOA, NRRI, and OUAT
2	Village level Flood, drought and salt prone areas maps for varietal targeting	3	10		10 districts	DOA, NRRI, and OUAT
3	Rice Pulse Monitoring System	1	30		30 districts	DOA, NRRI, and OUAT
4	Hydrogel and Nano-materials are tested at multiple sites - includes station experiments and adaptive trials	50	5	15	20 ha	DOA, NRRI, OUAT and NGOs
5	Land Use requirement & assessment and preparation of decision rules/tree for extrapolation domains – at least 2 major cropping systems are covered	2	10		10 districts	DOA, NRRI, and OUAT
6	Pulse Varieties are tested and demonstrated under crop cafeteria – at least 3 improved pulse varieties are tested	2	2		2 districts	DOA, NRRI, OUAT, IIPR and NGOs
7	Demonstrations of pulses in Rice fallow system and suitable flood tolerant cultivars in flood prone rice-fallow system – at least 1250 ha is covered during dry season and 200 ha in wet season fallows	7250 minikits	10	60	1450 ha	DOA, NRRI, OUAT, IIPR and NGOs

Workplan 2017-18: Component 3: Rice Crop Manager

1. Dissemination of CM recommendations to the farmers and development of dissemination and scaling pathways.

Activity	#	**Districts**	**Blocks**	**Area/ Number**	**Partners**
Setting up of RCM Kendras	91	7	69	69 block offices ,7 DDA offices, 15 NGO offices	DoA
Training of trainers (AAOs) in kharif and rabi	20	7	69	At 7 districts	DoA and NGOs
Training of VAWs	25	7	69		
Training of NGO partners	10	7			
Dissemination of recommendations	50000	10	85	10 districts	DoA, NGOs
Monitoring the use of recommendations	5000	10	85	10 districts	DoA, NGOs
Demonstrations (comparison of RCM vs. Farmers method)	100	10	20	10 districts	IRRI staff, NGOs
Identifying and developing dissemination and scaling pathway for ICT based RCM		3	15	2500 households	DoA, NGOs KISS, SKYMET, IFFCO

2. Development of better Nutrient and Crop Management for Rice based systems in stress prone environments of Odisha

Activity	#	Districts	Blocks	Area/ Number	Partners
a) 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	1	1	1	1	OUAT
b) Optimization of Potassium (K) supply and plant nutrition through different K management practices under rice-rice system in Odisha	1	1	1	1	OUAT
c) Optimization of Nutrient management for rice based cropping system	1	1	1	1	OUAT
d) Optimising Fertilizer application rates and timing for rainfed rice in Odisha	1	1	1	1	OUAT
e) Evaluation of crop management component of RCM- (weed management)	1	1	1	1	NRRI
f) Development, validation and evaluation of RF component of CMRS-	70	10	20		NRRI, OUAT, Component 1
g) Adaptive trials on using GIS based yield monitoring for developing better yield targets in RCM	30	10		At 10 districts	Component 1 & 5, SKYMET

Workplan 2017-18: Component 4: Knowledge management, capacity building

1. Rice Knowledge Bank - in Oriya with district level localized knowledge

Activity	#	**Districts**	**Area/ Number**	**Partners**
Content localized for the state and provided as fact sheets	100		100	OUAT, NRRI, CIWA, NGOs and local experts
Videos produced on management practices of STRVs (SS1, SD)	2		20	Biggshift communications
District level coordination teams identified for validation of the content	30			
Knowledge management workshop to set up knowledge bank	1			
Beta version of KB made available to partners	1	5		
District level KB available		5		

2. Rice doctor– a mid-season, on field, real time pest and disease diagnostics tool

Activity	#	**Districts**	**Area/ Number**	**Partners**
Workshop - plant protection group	1			OUAT, NRRI, IIRR, IRRI experts
Beta version of Rice doctor (English) mobile application for Odisha available in Kharif 2017	1			
Pre-testing of rice doctor	200	5		
Translation of Rice Doctor to Odia language	1			Jan-18
Beta version of Rice doctor (Odia) mobile application for Odisha available in March 2018	1	30		

3. Integrated pest management in Odisha

Activity	#	**Districts**	**Partners**
Finalization of IPM module	1		
Testing of IPM module	15	15	OUAT, NRRI and IIRR

4. Rice check

Activity	#	**Districts**	**Area/ Number**
Implementation of rice check kharif	1	30	90
Training of facilitators	1	30	90
Rice check booklets for distribution	1	30	90
Implementation of rice check rabi	1	tbd	tbd

5. Organizational capacity building

Activity	#	Area/ Number	Partners
Women's leadership for impact initiative	1	15 orgs./1000 farmers	CIWA
Research for Development Capacity building			OUAT, NRRI, CIWA, DoA
i) Rice research to production course	1	3 candidates	
ii) Data management training	1	5 candidates	
Innovative extension capacity strengthening			MSSRF/CARE/Digital Green/CRISP
i) Season long training programme for DoA - Kharif	1	40	
ii) Season long training programme for DoA - rabi	1	40	

Workplan 2017-18: Component 5: Science based crop insurance

5a. Remote sensing based rice monitoring system

No	Activity	Number	Districts	Partners
1	Ground data collection for Start-of-Season (SoS) verification & calibration		30	Possible partner DoA
2	Ground data collection for rice-and-non-rice (RnR) area validation		30	Possible partner DoA
3	SAR (Sentinel-1) and Optical (landsat 8) acquisition planning		30	
	SAR (Sentinel-1) and optical (landsat 8) data processing and analysis		30	
4	Early season product generation : rice area maps and area estimation		30	
5	Early season product generation: SoS maps		30	
6	Data collection for historical yield; historical & current daily weather data; agronomic management; and official yield data		30	
7	Mid-season product generation and yield forecast		30	
8	End-of-season (EoS) product generation and yield estimates		30	
9	RnR area map validation and accuracy assessment		30	Possible partner DoA
10	EoS validation of yield estimates		30	Possible partner DoA, component-1 and component-3
11	Abiotic stress map (Flood / drought) in case of natural disaster event.			Areas affected by the abiotic stress will be monitored and mapped
12	Training on SoS and RnR data collection procedures	2		
13	Training on MapscapeRice	1		

5b. Crop insurance

No.	Activity	Number	Districts	Area/ Number	Partners
1	Farmers' Risk Profiling	1500	15		Madhyam/GKS foundation (NGO)
2	Focus Group Discussions	12		2 in each of the 6 notified district clusters*	DoA, Madhyam/GKS foundation (NGO) *The government has grouped/notified the districts into 6 clusters based on the risks, for implementation of insurance scheme (PMFBY). We are following this clustering for implementation of our study.
3	Choice experiments and risk preference games	2000-3000	15		DoA, Madhyam/GKS foundation (NGO)
4	Stakeholder Workshop	1			
5	Product profiling and insurance games for their viability	2000-3000	15		DoA, Madhyam/GKS foundation (NGO)