A Compendium of Technologies, Practices, Services and Policies for Scaling Climate Smart Agriculture in Odisha (India)

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Foreword

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FOREWORD

The need for scaling up climate change mitigation and adaptation interventions is now globally recognised. Small-Scale farmers in Odisha often find themselves unable to make investments in improved agricultural practices due to weather related risks and inability to provide the required capital investments. Odisha rainfall experiences variable in seasonal, total and spatial distribution. Under such conditions, the farmers are vulnerable to the risks of both livestock loss and reductions in crop yields. Climate-smart Agriculture practices (CSAP) are designed to contain such risks, thus making a significant contribution to farmers' resilience. There is considerable interest among stakeholders in the potential role of adaptive and mitigation measures to climate change.

The Department of Agriculture, Govt.of Odisha, in partnership with International Rice Research Institute (IRRI) as stakeholder, have prioritised actions that build climate resilience, lower the state's greenhouse gas emissions (GHGs), and contribute to sustainable development. In this regard, we have actively welcomed innovations and programmes such as CASP.

The use of this compendium is expected to support the state's agriculture sector by maximising the climate opportunities and reducing climate change related risks on the agriculture sector making the system more sustainable.

The Department of Agriculture and Farmers' Empowerment (Department of Agriculture & Farmers' Empowerment), Govt.of Odisha would like to thank the CCAFS, IRRI, CIMMYT and other partners for the technical assistance to develop this compendium. Agricultural extension and rural advisory services, as used in this document, refer to any organization in the public or private sector (e.g. NGOs, farmer organisations, input suppliers, etc.) that provides information and advice to farmers and other rural actors.

As Principal Secretary, Department of Agriculture & Farmers' Empowerment, Govt.of Odisha, I trust that this timely document will be a robust resource material for extension officers of Department of Agriculture & Farmers' Empowerment working in various parts of the State. The field staff of the Department of Agriculture will be better prepared to carry out farmer trainings and outreach programmes to promote new climate smart technologies and practices.

(Dr.Saurabh Garg)
18/5/19

Foreword

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Odisha views climate change as a direct threat to its socio-economic development with the potential of reversing the hard earned developmental gains achieved since long back. Ensuring that agriculture becomes climate smart is a priority for addressing the need for adequate, nutritionally balanced food for a growing and more demanding population in a situation of resource limitations, and climate change and variability. According to observations and scientific studies, climate change has resulted in an increase high inter and intra-seasonal rainfall variability and in extreme cyclones for Odisha. The impacts of climate change on agriculture production have rendered a significant proportion of households' food and nutrition insecure and consequently having to rely on food aid while climate projections show that conditions will worsen.

Support to climate change adaptation and mitigation among smallholders hardly works when it is imposed from outside: local institutional frameworks for the adoption of climate-smart agricultural (CSA) practices at the Institutional arrangements and policy engagement at the district and community levels must play a facilitating role. This means that institutional frameworks that support farmer-driven adoption and adaptation must be encouraged. Supporting such frameworks usually not only involves developing new institutions but also creating synergies between existing institutions to implement policies effectively. The dissemination and uptake of climate smart technologies, tools and practices is still largely an ongoing, challenging process. Barriers at different levels must be overcome in all countries and solutions to these challenges must respond to specific local needs.

The Compendium on CSA proposes such a holistic and integrated approach, building on sustainably increasing agricultural productivity and incomes, adapting and building resilience to climate change and reducing and/or removing GHG emissions, where possible. The compendium provides a comprehensive overview of the challenges and issues for sustainable development, both related and unrelated to climate change. I hope that the Compendium on CSA will stimulate dialogue and significant progress towards the identification and implementation of sustainable solutions for the farming sector, which safeguard its fundamental role for food security while responding effectively to the challenges of climate change. Coordination and alignment between agriculture, climate change, water, energy and other sectors will be crucial for the design of sound and inclusive policies, as well as regulatory frameworks to support the adoption of CSA practices by farmers, and ensure the sustainable and equitable use of resources in the long term.

(Pramod Aggarwal)

PREFACE

Stakeholders engaged in agricultural research for development (AR4D) are increasingly tackling risks associated with climate change in smallholder systems. Accordingly, development and scaling of climate-smart agriculture (CSA) are one of the priorities for all the organizations, departments and ministries associated with the farm sector. Having a 'one-stop-shop' compiled in the format of a compendium for CSA technologies, practices and services would therefore serve a guide for all the stakeholders for scaling CSA in smallholder systems. Bringing out a Compendium on Climate-Smart Agriculture (CSA) for Odisha, India was therefore thought of during the workshop on 'Scaling Climate-Smart Agriculture in Odisha' organized at Bhubaneswar on 18-19 July 2018 by International Rice Research Institute (IRRI) in collaboration with Department of Agriculture (DoA) & Farmers' Empowerment, Indian Council of Agricultural Research-National Rice Research Institute (ICAR-NRRI), Orissa University of Agriculture and Technology (OUAT) & International Maize and Wheat Improvement Center (CIMMYT) under the aegis of CGIAR Research program on Climate Change, Agriculture and Food Security (CCAFS).

The main objectives to bring forth this compendium are: to argue the case for agriculture policies and practices that are climate-smart; to raise awareness of what can be done to make agriculture policies and practices climate-smart; and to provide practical guidance and recommendations that are well referenced and, wherever possible, based on lessons learned from practical action.

CSA programmes are unlikely to be effective unless their implementation is supported by sound policies and institutions. It is therefore important to enhance institutional capacities in order to implement and replicate CSA strategies. Institutions are vital to agricultural development as well as the realisation of resilient livelihoods. They are not only a tool for farmers and decision-makers, but are also the main conduit through which CSA practices can be scaled up and sustained. The focus in this compendium is on CSA and it's relevant aspects, i.e., (i) technologies and practices, (ii) services, (iii) technology targeting, (iv) business models, (v) capacity building, and (vi) policies.

The approaches and tools available in the compendium span from face-to-face technician-farmer dialogues to more structured exchanges of online and offline e-learning. In every scenario it is clear that tailoring to local expectations and needs is key. In particular, the voice of farmers is essential to be captured as they are the key actors to promote sustainable agriculture, and their issues need to be prioritized.

CSA practices are expected to sustainably increase productivity and resilience (adaptation), reduce Greenhouse Gases (mitigation), and enhance achievement of national food security along with sustainable development goals. CSA is widely expected to contribute towards achieving these objectives and enhance climate change adaptation.

CSA practices have to be included in State's Climate Policy as a priority intervention as the state steps up efforts to tackle climate change. Furthermore, emphasis shoud be laid on CSA training for a sustainable mode to enhance CSA adoption in the state hence the relevance of developing this document.

The adaption of climate related knowledge, technologies and practices to local conditions, promoting joint learning by farmers, researchers, rural advisor and widely disseminating CSA practices, is critical. This compendium brings together a collection of experiences from different stakeholders with background of agricultural extension and rural advisory services in supporting CSA. The contributions are not intended to be state-of-the art academic articles but thought and discussion pieces of work in progress. The compendium itself is a 'living' document which is intended to be revised periodically.

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2. SERVICES

3. TARGETING

4. BUSINESS MODEL

5. CAPACITY BUILDING

6. POLICY

LIST OF ACRONYMS

ADB	Asian Development Bank
AFOLU	Agriculture, Forestry and Other Land Uses
AR4D	Agricultural Research for Development
AWD	Alternate Wetting & Drying
BGREI	Bringing Green Revolution in Eastern India
CAE	Commercial Agri-Enterprises
CCAFS	Climate Change, Agriculture and Food Security
CH4	Methane
CIMMYT	International Maize and Wheat Improvement Center
CO_2	Carbon Dioxide
CRPs	Community Resource Persons
CSA	Climate-Smart Agriculture
CSAPs	Climate-Smart Agricultural Practices
CSI	Climate-Smart Irrigation
CSIR	Council of Scientific and Industrial Research
CSISA	Cereal System Initiative for South Asia
CSV	Climate-Smart Village
DOA	Department of Agriculture
DSR	Direct Seeded Rice
EIT	Economies In Transition
FAO	Food and Agriculture Organization
FFP	Farmer Fertilizer practice
GHG	Green House Gas
GIS	Geographic Information System
GSDP	Gross State Domestic Product
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICAR	Indian Council of Agricultural Research
IFPRI	International Food Policy Research Institute
ILRI	International Livestock Research Institute
IMD	India Meteorological Department
INM	Integrated Nutrient Management
IPCC	Intergovernmental Panel on Climate Change
IS	Irrigation Scheme
ISAT	Intelligent Systems Advisory Tool
IWM	Integrating Weed Management
IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management
IRRI	International Rice Research Institute
KVK	Krishi Vigyan Kendra
MJ	Mega Jule
N_2O	Nitrous Oxide
NAP	National Afforestation Programme
NAPCC	National Action Plan on Climate Change
NARS	National Agriculture Research System
NASC	National Agriculture Science Centre
NFSM	National Food Security Mission
NGO	Non-governmental Organization
NICRA	National Innovations for Climate Resilient Agriculture
NMSA	National Mission for Sustainable Agriculture
NPTR	Non-puddled Transplanting Rice
NRRI	National Rice Research Institute
OSSC	Odisha State Seed Corporation
OUAT	Odisha University of Agriculture and Technology
PACS	Primary Agriculture Cooperative Society
PRADAN	Professional Assistance for Development Action
RCM	Rice Crop Manager
R&D	Research & Development
RKB	Rice Knowledge Bank
RKVY	Rashtria Krishi Vikas Yojna
SDA	Services Delivery Approach
SDG	Sustainable Development Goal
SHG	Self Help Group
SI	Sustainable Intensification
SLM	Sustainable Land Management
SMS	Short Message Service
SPICE	Solar Pump Irrigators' Cooperative Enterprise
SPIS	Solar-Powered Irrigation Systems
SRI	System of Rice Intensification
SSNM	Site Specific Nutrient Management
STRASA	Stress-Tolerant Rice for Africa and South Asia
STRV	Stress-Tolerant Rice Variety
WP	Water Productivity
WWF	World Wide Fund
YMV	Yellow vein Mosaic Virus
YST	Yellow Sticky Trap

CLIMATE SMART AGRICULTURE (CSA) TECHNOLOGIES, PRACTICES, SERVICES AND SCALING UP IN THE VULNERABLE AREAS IN ODISHA (INDIA)

I. Background

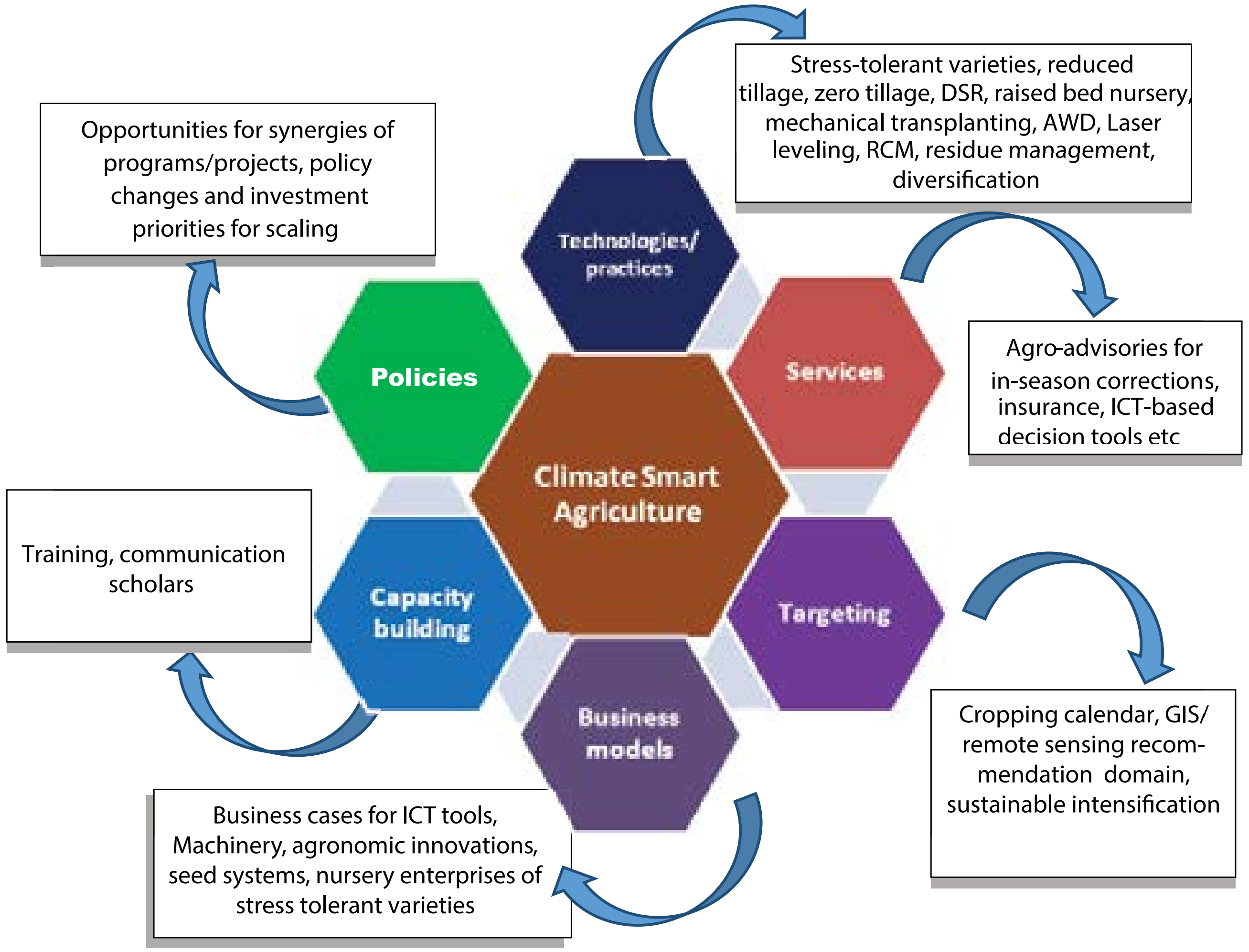
Odisha state has a big challenge of providing sustainable livelihoods for its population in the fragile ecosystems facing the issues of absolute water scarcity, erratic rainfall, drought, cyclone, flood and land degradation. About 80 per cent of its total population lives in rural areas and depends primarily on agriculture for livelihood. The performance of agriculture determines the food and nutritional security of the population and is important for reducing poverty and achieving inclusive growth. In fact, agriculture in Odisha is characterized by wide diversity and considerable spatio-temporal variations in growth and productivity. In the present agricultural scenario of Odisha, the average size of land holding is 1.25 ha for all categories of farmers but is only 0.6 ha for marginal and small farmers and is largely fragmented. The small and marginal farmers constituting more than 80% of the farming community, either own or rent a piece of land for cultivation. Odisha has cultivated area of 6.4 million ha out of 15.5 million ha geographical area. Agricultural activities depend on and are affected by natural environment in various ways via soil quality (texture, erodibility, nutrient depletion, moisture balance, salinity, etc.), water quality (surface and ground water pollution and depletion), air quality (greenhouse gas emission), bio-diversity, wildlife habitat and ecosystem as a whole. Paddy is the main crop of Odisha and is usually grown twice or even three times in a year. The coverage under Paddy during kharif is about 4.1 million ha and during rabi 0.3 million ha in a wide range of soils varying widely from highly acidic to slightly alkaline and from light sandy to stiff clays. Further, about 0.4 million ha is exposed to saline inundation, 0.35 million ha to water-logging, particularly in the deltaic areas. Odisha's climate is tropical, characterized by high temperature, high humidity, medium to high rainfall and short and mild winters. The normal rainfall of the state is 1451.2 mm.

Odisha is prone to tropical cyclones, storm surges and tsunamis. Its densely populated coastal plains are the alluvial deposits of its river systems. The rivers in these areas, with heavy load of silt, have very little carrying capacity, resulting in frequent floods. Climate change is likely to impact negatively on many aspects of agriculture including irrigation availability, soil heath, pest population, crop and livestock production. Erratic rainfall and uneven distribution of rainfall cause drought in some places wihile floods in others. Recently the state is experiencing contrasting extreme weather conditions claiming many lives: from heat waves to cyclone, from droughts to floods. During the past decade, the state has faced one or more forms of disasters like floods, cyclone, tornado or drought every year. In last 100 years, Odisha experienced flood in 49 years, drought in 30 years and cyclone in 11 years. The poor and marginal farmers are most affected by these natural calamities. A striking issue is that the small, marginal and women farmers are unreached by the green revolution and so are targeted with the conservation strategy referred to as 'on-farm management in agricultural production systems' taking into account the climate change issues.

II. CSA Framework

Climate-smart agriculture (CSA) involves sustainable increase in agricultural productivity and incomes, adapting and building resilience to climate change, and, where ever possible, reducing and/or removing greenhouse gas (GHG) emissions (FAO, 2013). There are many ways to achieve these goals, depending on the environmental and social context in which an agricultural system operates. Hence CSA practices may include all aspects of crop, soil, and water management—from tactical considerations involving time of sowing and crop maturity, to nutrient, water, and pest management and conservation tillage options, as well as strategic decisions about crop selection, rotations, and cropping patterns and investment in irrigation infrastructure. While field studies can evaluate and identify a set of "climate-smart" practices that function well at a given location, crops and cropping systems simulation using simulation models provide a means to perform such ex-ante evaluations.

Addressing the need for proven and effective climate-smart agricultural options, CCAFS has developed the Climate-Smart Village (CSV) approach as a means to agricultural research for development (AR4D). It seeks to fill knowledge gaps and stimulate scaling of climate-smart agriculture (CSA). The CSV approach is founded on the principles of participatory action research for grounding research on appropriate and location/context-specific enabling conditions, generating greater evidence of CSA effectiveness in a real-life setting and facilitating co-development of scaling mechanisms towards landscapes, subnational and national levels. In establishing a CSV-AR4D site, the very first step is to build trust and partnerships amongst diverse stakeholders; and to attain agreements and buy-in to a common approach. Once partners have agreed on the establishment of a CSV site, the major steps include baseline assessment, identification and context specific prioritization of CSA interventions, evaluation and development of portfolios of weather-resilient interventions, and scaling up through institutions and policies, and scaling out to large areas through dissemination and ICT-based approaches. Communication of timely and relevant information on climate change risks through credible sources is essential for mobilising farmers to take actions to adapt to climate change.



Framework of Climate Smart Agriculture

COMPENDIUM
Climate-smart Agriculture

SECTION 1

TECHNOLOGIES AND PRACTICES

1.1. Stress tolerant varieties impart resilience to farmers in flood-prone areas[1]

Performance of Swarna sub-1 (flood tolerant rice variety) against Swarna as local cultivar

Out of the total rice area in Odisha sixty five percent is rainfed and thirty five percent irrigated. Rainfed shallow and semi-deep water lowland rice suffers from flash floods and water logging. Like wise uncontrolled irrigation in lowlands also aggravates the problem of water logging. Heavy and intense rainfall events, sometimes tidal movements in coastal areas, cause flash floods due to overflow of rivers and canals. Normally 140-155 day duration varieties are grown in these risk prone ecosystem.

Growing the most popular high yielding rice variety Swarna, covering seventy percent of the area, no doubt gives high yield and return but in years of flood, with even a week submergence the crop gets completely devastated resulting total yield loss and zero return.

CSA Intervention

Rice variety Swarna-sub1, a variety developed by IRRI, Philippines and NRRI, Cuttack and released in 2009, is has submergence tolerance and performs better under flood situation apart from being high yielding with good grain quality. Demonstration of this variety in flood-prone ecosystem showed that it could tolerate submergence up to two weeks and could perform significantly better compared to other local and improved cultivars.

Impact

In farmers field, Swarna sub-1 produced 6.1 t/ha yield and Rs.95,167 gross return per hectare with an B-C ratio of 2.01 as against Swarna (5.9 t/ha yield, Rs.92,040 gross return and 1.9 B-C ratio) under CCAFS (P 25) supported project. This provided Rs.4295 extra income to the farmers. Swarna is largely affected by stem borer which Swarna sub-1 escaped to certain extent and thereby saved two sprayings. The the production cost was reduced by Rs.1175 per hectare with energy saving of 89 MJ . In years with normal rainfall the yield is no less.There is yield advantage of 3.4% in normal years whereas in flood years it proved with more than 90% yield advantage. More over Swarna sub-1 is having a closed plant geometry unlike the spreading geometry of Swarna for which harvesting becomes easier, quicker and cheaper. The head rice recovery with hulling percentage in Swarna sub-1 was found to be nearly 80% as against 70% in Swarna. Moreover subsidy provision for Swarna sub-1 mobilized the farmers to increase area under this variety. Under such situation Swarna sub-1 is a savior for farmers which tolerates submergence even up to 17 days.

Scaling: Scope and pathways

In recent years Swarna sub-1 is popular and almost all farmers in the intervention village and nearby ones prefer Swarna sub-1 over other high yielding varieties including Swarna. Undoubtedly this will benefit thousands of poor farmers in

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[1]Contribution from S. Biswal, OUAT, Bhubaneshwar, Odisha and D.S. Rana (IRRI), New Delhi

habiting the rainfed low land areas, who often do not harvest any crops due to floods.

Recommendation domain

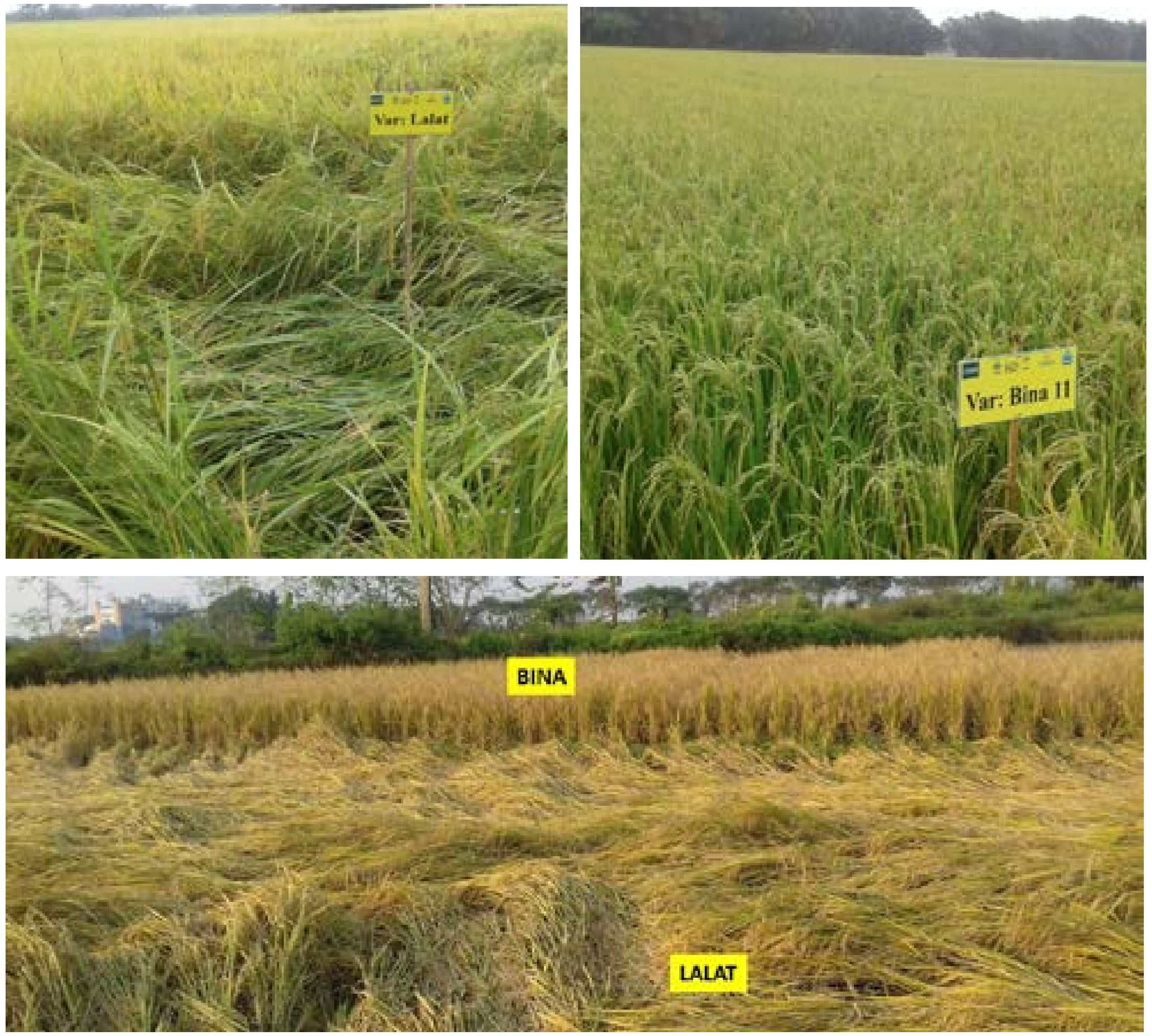
Rainfed shallow and semi-deep water lowland including flood prone/ submergence ecosystem in Odisha, accounting to nearly 1.5 million has can be brought under this and other submergence tolorent varieties which will act as a premium under challenging climatic scenario. It can be well fitted to the rice-pulse or rice – fallow system.

Business model perspective

Rural Self Help Groups and innovative/ progressive farmers can take up the seed production programme to make them meet the growing demand for all the stress tolotant varieties including Swarna sub-1.

Government of Odisha is already making significant efforts in strengthening the seed system of swarna sub-1. This can be achieved through seed hubs involving NGOs, SHGs and local seed dealers.

1.2. Lodging-resistant paddy cultivar in cyclone and heavy rainfall situations[2]



Effect of Var.Bina Dhan-11 (lodging-tolerant) demonstrated resistance to lodging in farmers' fields after cyclone

[2]Contribution from S. Biswal and T. Panigrahi, OUAT, Bhubaneshwar, Odisha

Paddy var. Lalat has remained as the most popular medium duration variety among the farmers of Odisha. In summer season (0.3 million ha, 8 per cent area) it happens to be the most potential variety under irrigated ecosystem. But in recent years, frequent occurrence of hail storm/thunder storm and subsequent heavy rain in advanced ripening phase, lodge the crop, sometimes completely, increase chaffiness and making the harvest difficult. The mechanical harvest by combine harvester or reaper becomes impossible. The only option left is manual harvesting which involves extra labour as well as production cost. Depending on availability of labour force the harvesting is lingered and any rain during this phase damages the produce and its quality. The entire produce thus loses market value and also become unsuitable for consumption.

CSA intervention

Lodging-resistant varieties that can withstand up to maturity in affected areas were demonstrated in CSVs. Var. Bina Dhan 11 was demonstrated in farmers fields in frequently affected areas. Although its duration was 5-7 days more, it sustained completely against lodging. It also registered tolerance to certain extent against BPH. Delayed harvesting also did not increase any shattering loss.

Impact

The variety Bina Dhan 11 produced 5.8 t/ha yield with an yield advantage of 11.5% over Lalat (5.2 t/ha). The production cost was reduced by Rs.6435 with the B-C ratio of 1:8 (Lalat-1:4) saving around 10 labour days/ha. The energy input in Bina Dhan 11 was 44701 MJ/ha (as against 45211 MJ/ha in Lalat) with an energy use efficiency of 2.6 (Lalat-2.3). The gross return realised by Bina Dhan 11 was Rs.95,167 per hectare as against Rs 81,120 in Lalat.

Scaling: Scope and pathways

Therefore the variety Bina Dhan 11 has become quite popular and can substitute Lalat and act as a premium against lodging due to hail and thunder storm in summer and also can occupy a substantial area under kharif paddy. In addition the average yield of Bina Dhan 11 is around 7.0 t/ha while others was around 6.0 t/ha.

Recommendation domain

Summer paddy occupies eight per cent paddy area (0.3 million ha) in Odisha. Lalat being the dominant variety, Bina Dhan 11 can substitute it in irrigated medium land ecosystem more so in cyclone affected areas under rice-rice system.

Business model perspective

Rural Self Help Groups and advanced farmers can take up the seed production programme to make them meet the growing demand for all the stress tolotant varieties including Bina Dhan 11.

Partners

With the help of appropriate extension strategy the coverage under Bina Dhan 11 can be expanded with involvement of NGOs and farmers organisations. Initial support through seed subsidy can make the process faster.

1.3. Non-puddled transplanted rice (NPTR) –a resource saving approach[3]

Transplanting paddy under puddled condition has remained a common practice which involves lots of energy and high water used for puddling incurring higher cost. If conditions are not favorable, land preparation/puddling can not be carried out in time and transplanting gets delayed.

CSA intervention

Adoption of climate resilient conservation agriculture practice of non-puddled transplanted rice through access to appropriate farm machinery at reasonable cost brings precision to agricultural operations and efficiency in use of resources . Thus non puddled transplanting is a suitable substitute which enables transplanting with low water, energy and cost as well as timely establishment.

Impact

Although the yield difference is not significant non-puddled transplanting (var. Swarna sub-1 in Kharif) yielded 5.82 t/ha with net return of Rs.43213 and B:C of 1.91 with the energy use

[3]Contribution from S. Biswal and Jyotiprakash Mishra, OUAT, Bhubaneshwar, Odisha

Mechanical transplanting of rice under non-puddled condition

efficiency of 7.8. The most important resource i.e. water consumed in puddling was just 1000 m^3 in non-puddled transplanting against 2500 m^3 in puddled transplanting. Energy in form of diesel fuel used for puddling was reduced by 12% (11 L/ha). More importantly with less amount of water transplanting operation could be completed in time ensuring water availability to other areas. Not only paddy but the subsequent crop in sequence gets a favorable soil environment for better root growth.

Scaling: Scope and pathways

Non-puddled transplanting can be successful in place of puddled transplanting with less water and energy. Thus the area under transplanted paddy can be increased with available water resource.

Recommendation domain

Non-puddled rice transplanting provides low land farmers with the same flexibility of timing and planting establishment with the onset of monsson rains as does the normal farmer practice.

Partners

With the help of appropriate extension strategy the coverage under non-puddled transplanting can be expanded with involvement of NGOs and farmers' organisations. Initial support through incentive attached schemes under RKVY and NFSM can make the process faster.

1.4. Diversification with green gram and groundnut for resource conservation[4]

Rice-rice crop rotation has been practiced for decades. The summer rice which consumes huge quantity of water was grown with the lift irrigation water from river Ganga. This river carries most of the irrigation water sewage from Bhubaneswar city and is highly contaminated. In Kharif due to large flow in the river the contaminants get diluted. However in summer season gradually the water quality deteriorates and irrigation water causes irritation and skin diseases. Moreover, due to rising water requirement in summer season the flow in the said river is insufficient for raising summer paddy.

CSA interventions

Diversification strategies play a crucial role in ensuring food security under climate change, as they have the potential to address two of the CSA pillars by contributing to food security and adaptation to climate change.

In search of a suitable alternative, green gram (var. IPM 02-14) was grown by utilizing the residual moisture from Rabi rice crop. With one supplemental irrigation at flowering or pod formation stage the crop performed well. This variety shows resistant to yellow vein mosaic virus (YMV) which is quite common region in the locality. Under prevailing situation groundnut was also a suitable alternative and the variety 'Devi' was grown utilizing the residual moisture succeeding Kharif paddy. Green gram and groundnuts showed potential of diversification of rice-rice system in Odisha.

[4]*Contribution from S. Biswal, OUAT, Bhubaneshwar, Odisha and D.S. Rana &Sheetal Sharma, IRRI, New Delhi (India)*

Group of Farmers visited green gram and groundnut fields

Impact

In comparison to summer paddy green gram can be grown with 43.7% less fuel, 21.7% less labor, 48.5% less cost and a saving of 93.9% irrigation water (15,500 m3). The energy input in green gram was 3264 MJ/ha as against 44701 MJ/ha in summer paddy and energy use efficiency of 5.5 as against 2.6 in paddy. The green gram crop recorded a yield of 7.2 quintals/ha giving a paddy equivalent yield of 8.46t/ha in rice-green gram system. The drill seeded groundnut variety Devi yielded 21.4 quintal per hectare in 120 days with a paddy equivalent yield of 6.86 t/ha and system equivalent yield of 12.78 t/has as against 11.9 t/ha in rice-rice system. The yield advantage in rice-groundnut system was 7.3% as compared to rice-rice system. With an investment of Rs. 53,880 /- per hectare the groundnut crop realized a gross return of Rs.1,07,000 and net return of Rs. 53,120 per hectare and B-C ratio of 2.0. It could save 37.7% fuel, 41.6% energy and 100 % irrigation water.

Scaling: Scope and pathways

With less investment, less labour and less water green gram proved to be a better substitute to summer rice crop. Since the crop was harvested early (78 days) the gap between the succeeding summer rice and Kharif crop was sufficient enough to consider various options available. Now most of the farmers are switching over from `rice-rice system to rice-green gram system and the area is increasing.

Recommendation domain

Most of the summer rice area, in well drained heavy soils, where water crisis is aggravating green gram can prove to be a suitable alternative for resource conservation and restoration of soil health. In comparatively light soil with high water retention capacity, ground nut is more payee if seed material is made available in time to sow the crop with residual moisture.

Partners

With the support of farmer groups, development department and ICAR research project, OUAT and IRRI could make the beginning. State department of agriculture- extension wing, seed supply agencies, farmers organisations may put joint effort to diversify the summer paddy area and bring it under energy rich pulse (green gram) and oilseed (groundnut) crops.

Gender and youth relevance

Storing seed groundnut by women farmers using $CaCl_2$ can ensure seed availability for timely sowing, make best use of residual moisture, can store better seed lot and save the cost. The produce (both green gram and groundnut) can be further processed for value addition and can be sold with a higher margins for improving the incomes.

Policy support

Schemes like RKVY, NFSM and BGREI can provide support to strengthen the stake holders and farmers in the mission. Farmer producer groups can support in marketing and save against distress sale.

1.5. Climate-smart adaptation for rainfed agriculture[5]

[5]*Contribution from S Nedumaran, Kadiyala M. D. M & Anthony Whitbread, ICRISAT, Patancheru, India and Roberto Valdivia, Oregon State University, USA*

Combination of various technologies including crops mechanisation and better input use

Rainfed agriculture in India plays an important role in the livelihoods of many rural households in semi-arid regions. These households are highly vulnerable to the adverse impacts of climate variability and change especially drought and heat stress. Government of India is investing and promoting different adaptation options to overcome the adverse impacts of climate variability in rainfed farming and to build household resilience through different programs. The adoption of one or two CSA technologies or practices may increase the crop yield or resource use efficiency but does not improve the overall farm household resilience to persistent climate variability or change e in the future. So under a multi-disciplinary project called AgMIP (http://www.agmip.org/), a location specific regional climate smart adaptation package (including biophysical, socio-economic and policy components) was developed through series of stakeholder consultation in the region and evaluated to understand the potential of the CSA package in the Kurnool district of Andhra Pradesh.

CSA Intervention

To reduce the risk of climate change on overall farm income and particularly on rainfed farming in state of Andhra Pradesh, possible adaptation options were framed based on discussions with various stakeholders. Since the agriculture production system in the regions is mostly rainfed (61% of the total cropped area) and is affected by variability and distribution of monsoon rainfall, we designed the adaptation package to be climate- smart to make the production systems more resilient to climate variability. The adaptation package is a combination of different biophysical and socio-economic interventions like use of new crop cultivars (short duration, high yielding for major crop like chickpea), introduction of new crop in the kharif season (foxtail millet) to increase the system productivity since the majority of the farmers practice fallow-chickpea cropping system in the black cotton soil (vertisols) region in the State. We also included the provision of critical irrigation at 60 DAS through harvested rain water in a farm ponds, reduction in the cost of production as a result of application of fertilizer as per scientific recommendations (20 Kg N), and use of mechanical harvesters to reduce harvesting costs by Rs.2200 per ha.

Impact

The evaluation of adaptation strategies (combination of biophysical, economic and policy options) across diverse farms in Kurnool district of Andhra Pradesh using the multi-model approach revealed:

- Increase in the chickpea productivity on average by 40% in the district by adopting high yielding drought-tolerant cultivars with critical irrigation

- Increase in the net farm returns to the tune of 60% by adopting the climate-smart adaptation package which include the new crop in the kharif season (foxtail millet)
- Increase in the per capita income by 34%
- Reduction in the poverty rate in the region from 26.8% to 16.4% across the farm households in Kurnool district

Scaling: Scope and pathways

Recommendation domain

- The CSA package developed in consultation with different stakeholders in the state is having high scope to upscale in the rainfed farming region where the farmers practice Fallow-Chickpea cropping system. The new crop (foxtail millet) and high yielding drought tolerant chickpea cultivar as part of adaptation package will increase the system productivity as well as farm income especially in the drought year than in the normal rainfall year in the region. Due to labour scarcity and high wage rate during the peak harvest season in the state, the department of Agriculture and Agriculture University is now developing and promoting machine harvestable Chickpea cultivar in the regions. The construction of farm ponds in the fields to provide lifesaving irrigation to the crops will increase the water efficiency at the field level.

Gender and youth relevance

- Currently during harvest season chickpea cultivation in the regions demands high women labour for harvesting, threshing and cleaning of grains. But if the adoption of machine harvestable chickpea cultivars will reduce the drudgery of the women labour and they could use this additional time to create alternative source of income and also social and household empowerment. This CSA package could also have potential to provide entrepreneurship to the youth in the region by establishing custom hiring centers and millet and pulses processing units to add value to the locally produced grains.

Business model perspective

The adoption of machine harvestable chickpea cultivar in the regions will help to develop local entrepreneurs/business to provide custom hiring services of combined harvester for harvesting and threshing of chickpea in the field. There is also scope for small millet processing unit as business for youth or local agro-entrepreneurs to process and add value to the small millets produced in the region. It has large business opportunity in the urban food markets.

Partners

The adaptation package was developed by ICRISAT in consultation and support from ANGRAU, AP State Department of Agriculture and farmers' representatives.

The DOA will provide support to scale up this CSA package as part of different on going central and state sponsored schemes and programs.

Policy support

AP government's Primary Sector Mission (Rythu Kosam Mission) is with the aim of achieving double digit growth in agriculture and allied sectors. Primary Sector mission could support and scale up this CSA package to improve the resilience of the rainfed farmers in the state.

1.6. Stress-resilient maize hybrids for drought-prone environments[6]

Erratic/un-even distribution pattern of monsoon rains occasionally causes drought or excessive moisture/waterlogging at different crop growth stage(s) within the same crop season, which is probably the main factor responsible for relatively low productivity of rainfed maize. Due to the uncertainty of assured returns, farmers are often hesitant to invest on recommended cropping management practices, which results in low soil fertility, and eventually poor yields. Also, in recent years Asian tropics has experienced frequent and widespread severe drought years. With the increasing climate variability with uncertainties, current agricultural research, including developing of crop variety need to pay major attention on resilience towards variable weather conditions rather than tolerance to individual stress in a specific situation or at particular crop stage.

[6]*Contribution from P.H. Zaidi, CIMMYT-Asia Maize Program, Hyderabad, India*

Women farmers actively engage in stress-resilience maize program

CSA technologies/practices

In CIMMYT-Asia maize program, we focused on to enhance resilience in maize germplasm for an array of climatic conditions. The overarching goal of the stress-resilience maize program has been to improve upside yield potential with downside risk reduction. The new generation of stress-resilient hybrids possess combination of traits, including tolerance to drought/waterlogging/heat stress and resistance to key diseases with respectable yields under optimal trial. These hybrids were licensed to partners (on semi-exclusive basis), including OUAT and two Odisha based SMEs. These high-yielding stress-resilient hybrids is being taken forward for deployment and scale-out to reduce yield losses under stress-prone growing conditions at farmer's field.

Impact

- At least 2.0 tones more yield under stressful conditions and at par with commercial seed company hybrids optimal conditions.
- At least 20% less irrigation water and enhanced nutrient use efficiency due to stress tolerance
- Relatively low susceptibility to erratic/un-even distribution pattern of monsoon rains

Partners

NARS partners including both public and private sector in South Asia, including OUAT, OSSC and Odisha based SMEs

Policy support

Odisha Govt. RKVY, NFSM and Seed program

1.7 System of crop intensification adopted in rice and finger millet[7]

SRI in rice and finger-millet helps in adaptation to climate advisories

Rice and Finger Millet are staple food of farmers in Koraput District. The total cultivable area is 3, 01,000 ha, from which 62% land are covered under paddy and millets. 9.30 % of cultivable lands are irrigated in Kharif and 5.48 % lands irrigated in Rabi. Out of 137028 land holdings, 70% are small and marginal farmers having < 1 ha land holding dependent on rain fed agriculture. Due to undulating topography, soil erosion and climate Change effects like erratic rainfall and recurrent disasters affects crop cycle and productivity leading to food insecurity, and distress migration.

Rice traditionally grown under inundated conditions with hybrid varieties, chemical fertilizers and pesticides have increased cost of cultivation. Area under millets and productivity is gradually declining. Due to adoption of traditional practices, productivity is low causing nutritional food insecurity. System of crop intensification can substantially enhance yield under the climatic stress and reduce GHG emissions.

The problems like food insecurity, high investment costs, water scarcity and climate change affects require a paradigm shift in the cropping systems from input intensive methods to improved practices like system of crop intensification. System of Rice Intensification is an innovative method for higher yield, water saving, and coping with the adverse effects of climate change, having at the same time considerable impact on green house gas emissions with a net reduction of 20-40% per ha and more per kg. of rice produced because of different practices for plant, soil, water and organic ways of nutrient management. In addition SRI is estimated to reduce fresh water use in rice cultivation by about 40-50% which is already established by research.

[7]*Contribution From Prabhakar Adhikari and Luna Panda, Pragati, Koraput, Odisha, India*

CSA intervention

The practices of crop intensification are also applicable to production of finger millets and other crops for increasing productivity to almost double in comparison to traditional practices while withstanding climatic stress to reduce the hunger gap and nutritional insufficiency.

System of crop intensification in these staple crops can addresses the major constraints affecting the livelihoods of small and resource poor farmers, their limited resources of land, labour, water as well as losses from pests and diseases while reducing their dependency on external inputs.

System of crop intensification especially in rice and millets is an innovation in technology that can adapt to changing climate and withstand adverse affects of climate change. The technology changes the way that the plants, soil, water and nutrients are managed and has multiple impact.

Impact

Increase in Yield

- The yield increases by almost double in comparison to traditional methods of rice and millet cultivation. The yield per acre paddy has increased on an average to 16 qnt per acre in SRI from 8 to 9 qnt per acre in traditional transplanting method. Similarly, the production of finger millet has increased from 4 qnt per acre in traditional transplanting to 8-9 qnt per acre due to system of millet intensification.

Improvement in resource use efficiencies

- Since SRI fields are not kept continuously flooded, water requirements are reduced, generally by 25-50%.
- The system does not require purchase of new varieties of seed, chemical fertilizer, or agrochemical inputs. Costs of production are usually reduced, usually by 10-20%, although this percentage varies according to the input-intensity of farmers' current production.
- Saving in terms of labour by 30 to 35 % due to less population of plants transplanted, mechanized weeding and harvesting is easier.
- Reduction in drudgery of women in transplanting, weeding and harvesting operations.

Increase in net profit

- Household food security has increased with additional availability of food for 5-8 months from own consumption.
- There is increase in income of the farmers as they have surplus for selling. The net income has been increased up to Rs 15,000 to 25,000 per season.

Adaptation to climate change risk

- Organic matter-enriched soils are able to store more water and furnish nutrients helping to develop strong root system resulting in a robust plant physiology that is more adapted to climatic adversities.
- It has been observed that the plants under the system of crop intensification can sustain drought like situations, submergence and strong winds due to its stronger root systems.

Contribution to Mitigation

- Methane (CH_4) is reduced by between 22% and 64% when soils are maintained under mostly aerobic conditions rather than being flooded.

Under the crop management system nitrous oxide (N_2O) is only slightly increased or sometimes even reduced as the use of N fertilizer is reduced; $N_2$0 increases do not offset CH_4 reductions, so Global Warming Potential is reduced.

Scaling: Scope and pathways

Recommendation domain

There is scope to scale up the technology under the rain fed farming systems and also to address water stress and adverse climatic conditions which is beneficial for the small and marginal farmers of Odisha for food security, increase their income level and also at the same time to reduce the investment cost in inputs to reduce the vulnerability to debt and distress migration. As the land under cultivation is decreasing, water resources are getting scarce and climatic conditions are fragile, the technology can provide solution to the need of small and marginal farmers by optimum use of existing resources.

Gender and youth relevance

As women are involved in 60- 70 % of operations in rice and millet farming, it is necessary to enhance their skills, access to inputs, information and drudgery reduction technologies, organise their collectives for value addition and market linkages so that they can be involved in a more productive manner. The introduction of mechanized weeding, primary processing like threshing of millets have reduced drudgery of women which need further scale up. To increase the role of youth in System of Crop Intensification, there is further need of capacity building on climate resilient crop production, farm mechanization and enrollment of youth in farmer collectives for value addition and market linkages.

Scaling up the System of Crop Intensification requires farm mechanization like mechanized transplanters, power weeders and sprayers which can be provided to the farmers at subsidized prices to motivate the farmers for increasing adoption of technology. Agro Service centres can be established in clusters which can provide machineries on hire at fair prices. Such kind of farm mechanization and Agro Service centres can create employment opportunities for rural youth who can be equipped with skills as service providers and also manufacturers for the implements. The rural youth can also establish their own business for sales and services through bank linkages.

Partners

Pragati has partnership with OXFAM, Government of Odisha, Tata Trusts, Government of India, NABARD, Odisha Millet Mission, Edel Give Foundation, Digital Green, IRRI and Trocaire for promotion of System of Crop Intensification from 2006 till date. Pragati has developed different extension mechanism like trainings, demonstrations, videos, seed villages, field days, farmers' fairs involving different stakeholders as well as created community cadres for scale up.

- OXFAM supported for introducing SRI in 2006.
- Introduced SRI village programme by Government of Odisha under the RKVY Scheme.
- NABARD supported for Seed Village programme with SRI.
- Tata Trusts supported from 2008 till date for promotion of SRI & SMI which is scaled up to 15471 Farmers.
- Odisha Millet Mission supporting for promotion of SMI.
- IRRI supported Stress Tolerant Varieties of Rice.
- Edel Give Foundation supporting for system of crop intensification.
- Digital Green supported for video based extension systems for scale up.

Policy support

The Odisha Millet Mission is providing incentive to the farmers for adoption of System of Millet Intensification and also establishment of value addition and marketing of millets. The Government is also including millets in the Food Security Schemes which will encourage farmers to adopt SMI to increase production. The Centrally Sponsored Scheme, National Food Security Mission (NFSM) launched from 2007-08 in the State has also one of the objective to increase production of rice through SRI.

However, there is further need of policy support for promotion of crop intensification in the context of climate change and the condition of small and marginal farmers which will reduce their investment in inputs as well as infrastructures for assured crop production.

1.8. Drought tolerance and high yielding fodder varieties, hydroponic fodder cultivation and processing and storage of feed and fodder[8]

Improved fodder variety for better livestock productivity

Livestock plays an important role for reducing the poverty in a mixed farming system that pre-dominants in Odisha. It contributes around 20 per cent of the agricultural GDP of the State. Feed cost constitutes the major share (60 per cent) of cost livestock rearing. Therefore, judicious feeding mechanism is the most important pillar of economical dairying and also livestock rearing. The farmers in Odisha mostly depend on paddy straw, however they don't do any processing/treatment before feeding to their animals which extract minerals like calcium from body by forming oxalate salt. In addition, due to erratic rainfall, declining grazing land and use of harvestor for rice harvesting. It is estimated that Odisha has shortage of more than 80 per cent of concentrate, 55 per cent of green fodder and 30 per cent of dry fodder. To improve the livestock productivity in the state, it is required to improve the feeding management practice though grazing land management, increase feed efficiency, supplementary feeding and thereby reducing the enteric emission. As state has only 37% cultivated land is under irrigation, drought tolerance perennial fodder variety can be promoted.

CSA Intervention

The increasing of crossbreed population and declining grazing land, demand for concentrate and green fodder is increasing. However, due to lack of water, market failure, lack of institutional support and low level of knowledge on fodder cultivation led to shortage of feed. In this context, promoting new variety of fodder with less water requirement and having high nutrient content is a viable alternative for increasing the feed and fodder availability in the state. In addition, identification of locally available good quality of feed and fodder in a particular zone and enrichment of those would help to increase the livestock productivity.

ILRI has been promoting the new varieties of fodder crops such as drought tolerance perennial sorghum (COFS-29 and COFS-31) and new variety Hybrid Napier Bajra (CO-5 and Sampoorna) and fodder trees (Agasti, Morigna and Hedge leucern). In addition, new feeding practices based on availability of local feed and fodder. This gives an opportunity to farmers for improve their livestock productivity.

Impact

Improved feed and management practice will reduce the cost of livestock production. Cultivating new variety of fodder and following better management practice will enable us to mitigate the effects of climate change and thereby increasing the productivity in following ways:

Reduced the cost of milk production/feed up to 45%.

- Increased the milk quality (FAT) by 10%
- Increased milk yield by 20 %
- Reduced dependency on the grazing land

[8]Contribution from Braja Bandhu Swain and H Rahman, ILRI, New Delhi, India

- Increased the digestibility and that leads to reduce the methane emission.
- Increase the total income of the farmers by 6000 per lactation.

Scaling: Scope and pathways

Recommendation domain

There is scope to upscale the new feeding practices and fodder cultivation in dairy potential areas of the State.

Gender and youth relevance

Dairying at household level is largely the domain of women, where they are actively involved in various aspects of dairy farming activities like care of new born calf, cleaning of animal shed, cleaning of utensils, and storage of feed, feeding, grooming and cleaning animals. It is possible to enhance the access of technologies, inputs, credits and markets and result in elimination of gender differences and discriminations in rural areas. As the demand fodder is goring in milk intensive areas, commercial green fodder production/seed production provide a unique opportunity for employment or rural youth. By creating and establishing the fodder group/ cooperatives, it is envisaged that many rural enterprises come up and employments are generated in their real life situations.

Business model perspective

As informed, Odisha has shortage of feed especially concentrate and green fodder. This can be enhanced only through community and promoting through local service provider. Taking up this into a larger area can help to service provider for develop the business case of supplying fodder block, feed blocks, chopping and such others as a viable option.

Partners

With whom the intervention was developed: Fisheries & Animal Resources Development Department. Govt. of Odisha, Directorate of Animal Husbandry & Veterinary Services (DAH & VS) Odisha, Cuttack and OMFED

Potential partners for scaling: Directorate of Animal Husbandry & Veterinary Services (DAH & VS) Odisha, Cuttack, Govt. of Odisha, OMFED and Odisha University of Agriculture and Technology (OUAT)

Policy support

Fisheries and Animal Resources Development (F & A.R.D) department have been supporting through State Plan Scheme to promote better feeding practices in particular agro-climatic zones. In addition, Several schemes have been supported through RashtriyaKrishiVikasYojana (RKVY). The fund approval by Govt. for dairy development has increased significantly from 4.69 Crores in 2007 to 67.23 Crores in 2014.

This programme can be support through RKVY, F. & ARD Department, Govt. of Odisha and Water Resources Development Department and other donor agencies.

1.9. Improved maize production practices for plateau ecology of Odisha[9]

On upland plateau, rice farming is becoming highly vulnerable to in-season drought. The area consists of light textured soil so doesn't hold moisture for enough time to support rice during dry spells. Frequent post-monsoon showers also coincide with rice harvesting that leads to crop lodging and inferior grain quality.

Alternatively, maize has been tested to withstand such scenarios more effectively. In-season drought of this degree merely affect maize crop and post-monsoon showers can be avoided by selecting maize varieties of longer duration.

Problem associated with maize farming is use of traditional maize varieties under traditional production practices. These varieties produce abysmally low yield and have no takers in the market as commercial produce. Small and fragmented incomes are made through sale of green cobs only. Altogether, it puts growers under serious food and income security.

[9]*Contribution from Nabakishore Parida, WasimIftikar, Anurag Ajay, R K Malik & A McDonald CIMMYT, South Asia*

CSA Intervention

Production of commercial maize under best bet agronomic practices is the intervention to address climatic risks and ensure income security. Commercial maize means cultivation of hybrids those can be readily bought by institutional buyers. These hybrids should be of long maturity class (120 days) as their yield potential is high and they can surpass post-monsoon rains. Best bet agronomic practices include planting in rows with optimal plant population, appropriate fertilizer application and proper weed management. Maize planting in rows should be preferably done through seed-cum-fertilizer drill. Fertilizers should be applied at the rate of 150 kg urea, 100 kg DAP & 80 kg potash per hectare. In addition, 5-10 tones/ha of compost should be applied. Good weed management can be achieved through application of one post-emergence herbicide followed by one manual/ mechanical weeding. Weeding should be performed by mechanical power weeder that would reduce cost by performing weeding and earthing-up in one single go. Output market integration can be achieved through produce aggregation at village level and establishing linkages with the proximate feed millers.

Increased engagement of women farmers in Mayurbhanj & Keonjhar districts for commercial maize production

Impact

- Increase in Yield – This intervention increases maize yield from an average of 3 ton/ha to 6 ton/ha.
- Improvement in resource use efficiencies – Use of seed-cum-fertilizer drill amplifies fertilizer use efficiency by precise placement of basal fertilizers in right quantity. Seed rate is also calibrated as per desired plant population of 75,000 plants per ha. Power weeder improves efficiency of urea by immediate earthing-up.

- Increase in Net Profit – With established output market, the intervention has potential to generate net income of Rs 40,000 per ha. The average gross revenue per ha is Rs 75,000. Out of which, Rs 35,000 is cost of cultivation taking all cost factors into consideration.

Adaptation to climate change risk

Occurrence of in-season drought and post-monsoon rains are the two major climatic aberrations. Shifting to maize from rice overcomes the challenge of in-season drought as the water requirement of maize is comparatively lower than rice. Selection of long duration maize hybrids avoids risks associated with post-monsoon rains.

Scaling: Scope and pathways

Recommendation domain

Gender relevance: Several women based self-help groups (SHG) have been formed in this region under livelihood mission program of the state. These women SHGs are taking-up this intervention as an income generating opportunity. Although they either own little farm land or no land, they are taking large tracts on rent and practicing this intervention. So far, almost 1500 women farmers are engaged in Mayurbhanj & Keonjhar districts for commercial maize production.

Business model perspective

Service providers: There are three areas under this intervention where agriculture machine service provision model operates. These are – planting by seed-cum-fertilizer drill, weeding by power weeder and threshing by maize sheller. Individual farmer from the community buy any of these three machine or multiple machines on Govt. subsidy and provide service to neighboring farmers on rental basis.

Produce aggregator: People from the community who have some background of business dealings, buy maize produce from individual farmers in the village. They perform drying and cleaning based on buyers requirement and finally sell it in bulk after keeping their margin. Some of the service providers are also involved in this kind of business.

Partners

District team of Department of Agriculture (DoA) and women self-help groups (SHG) are potential scaling agent. People who have been trained by us in DoA and women SHG on best-bet agronomic and post-harvest practices can backstop adopting farmers. This process has led to expansion of commercial maize area to 4000 ha in Mayurbhanj & Keonjhar by 2017 from almost nil in 2012.

Policy support

Subsidy program for farm mechanization accelerates the purchase of number of seed-cum-fertilizer drills and power weeder. e-NAM scheme can greatly help in establishing market linkages for maize produce.

1.10. Direct seeded rice (DSR) for better resource management[10]

Rice is predominantly cultivated in Odisha of which nearly fifty per cent is transplanted. Transplanting requires at least 25 ha-cm of water for puddling operation, which creates a dense clay layer in the sub-soil to prevent seepage losses. The crop requires about 130 ± 10 ha-cm of irrigation in addition to adoption of suitable variety and recommended dose of fertilizers to realize yield levels of above 6 t/ha. Generally, about 40% of all irrigation water goes to paddy cultivation in the region. It is estimated that flooded rice fields produce about 10% of global methane emissions. Also, injudicious use of nitrogenous fertilizers is a common feature in paddy cultivation which is a source of nitrous oxide emissions. In Odisha, farmers generally take up transplanting of coarse rice. The current practice of excessive exploitation of ground water has led to a decline in the quality of natural resources i.e. land and water.

CSA intervention

A comprehensive water management programme was conducted for the farmers. Different methods of irrigation were discussed including DSR. Direct Seeded Rice reduced water use by reducing the number of irrigation events required, it can reduce water use by up to 25%. It can help farmers cope with water scarcity and increase reliability of downstream irrigation water supply. It is also a water management practice in irrigated lowland rice that saves water and reduces greenhouse gas (GHG) emissions while maintaining yields.

Researchers have developed suitable direct seeding alternatives to transplanted paddy. In DSR cultivation, raising of nursery for transplantation is done away with. Farmer can avoid the major problem faced in labour shortage for transplanting during peak demand. In case of delay in monsoon or shortage of water, DSR provides flexibility to take up direct sowing of

[10]*Contribution from S. Biswal, OUAT, Bhubaneshwar, Odisha and D.S. Rana (IRRI), New Delhi (India)*

Direct Seeded Rice cultivation saves water and reduces greenhouse gas emissions while maintaining yields paddy with a suitable duration variety to fit into the left over season. This allows timely sowing of the succeeding crop. Direct sown rice consumes relatively less water compared to transplanted flooded rice. Energy demand for pumping of irrigation water is also less and saving can be much higher during deficit rainfall situations.

Impact

Direct seeding of paddy var. Lalat yielded 5.51 t/ha that was close to transplanted coarse rice was 5.6 t/ha. But with DSR there was a saving of about Rs 3300-4200 per hectare in labour cost and irrigation water. However, extra expenditure is required on herbicide applications.

DSR with reduced tillage is an efficient resource conservation technology that holds promise in view of the following advantages:

- Saving in water up to 25%
- Sating in energy up to 27% of diesel as pumping energy is saved for field preparation, nursery raising, puddling and reduced frequency of applying irrigation water
- Saving of 35 to 40 man days /ha
- Enhanced fertilizer use efficiency due to placement of fertilizer in the root zone
- Early maturity of crops by 7-10 days helps in timely sowing of succeeding crops
- Reduction in methane emissions and global warming potential
- Little disturbance to soil structure
- Enhanced system productivity

Scaling: Scope and pathways

Direct sowing can be practiced for cultivating both coarse rice and basmati rice wherever feasible in all themedium and low land ecosystem. Direct seeded rice is relatively more popular in the rainfed rice growing tracts. There is scope to upscale the technology inrainfed well as irrigated rice growing areas in Odishato promote higher water use efficiency , to reduce cost and conserve agricultural resources.

Partners

State department of agriculture, farmers organisations, OUAT and IRRI jointly are working hard in popularising the practice.

Policy Support

Governmental support of incentivising through various schemes like RKVY, NFSM and BGREI puts lot of encouragement to farming community in adoption of the practice.

1.11. Alternate Wetting and Drying (AWD) for saving water and labour[11]

[11]Contribution from S. Biswal, OUAT, Bhubaneshwar, Odisha and D.S. Rana (IRRI), New Delhi (India)

Growing good crop of rice using AWD in rainfed condition

Transplanted rice grown in irrigated and rainfed areas are increasingly facing water scarcity due to deficit rainfall, declining groundwater table due to insufficient recharge, late and limited release of irrigation water from canals or poor inflows into tanks. Land preparation for nursery and main field require copious amounts of water. It also involves huge labour force for nursery raising and subsequent transplanting. Water shortage at the transplanting time leads to delay in transplanting and thus use of over aged seedlings with limited tillering capacity. This is an issue that every farmer faces during both in kharif as well as in rabi seasons. Again, farmers also follow traditional method, termed "shallow flood irrigation" where the fields are submerged with a shallow water layer during most of the rice-growing season, resulting in high use of water.

CSA intervention

Water and labour saving AWD technique of irrigation in rice is a feasible option to reduce their irrigation water consumption in rice fields without compromising on yield. In AWD, irrigation water is applied a few days after the disappearance of the ponded water observed through irrigation tubes. Hence, the field gets alternately flooded and dried. The number of days of non-flooded soil between irrigations may vary depending on the number of factors such as soil type, weather, and crop growth stage.

When grown in conventional irrigation system rice needs 16500 m^3 water (land preparation=700 m^3, nursery raising 100 m^3, puddling 2500 m^3 and main field irrigation =13200 m^3) whereas grown under alternate wetting and drying (AWD) system the rice crop needs 13200 m^3 (land preparation=700 m^3, nursery raising 100 m^3, puddling 2500 m^3 and main field irrigation =9900 m^3). Irrigation was scheduled in main field on depletion of water level below 15 cm in the perforated irrigation tube. In the main field alternate wetting and drying system consumed 33% less water, saving six numbers of irrigation.

Alternate wetting and drying provide a way to change irrigation practices and it is regarded as one of the more important rice cultivation methods that can dramatically save freshwater. The saved water may be utilized in increasing area under low water consuming crops. The AWD irrigation was accompanied with irrigation via channels, which allowed exact water required into the field, the drainage was easier. Time required for irrigation also reduced. AWD method can increase grain yield because of enhancement in root respiration and growth, remobilization of carbon reserves from vegetative tissues to grains and grain-filling rate.

AWD can reduce the cost of irrigation by reducing pumping costs and fuel consumption.

This method could also reduce the labor costs by improving field conditions at harvest, allowing mechanical harvest. AWD leads to firmer soil conditions at harvest, which is suitable to operate machines in the field. Therefore, AWD increases net return of farmers.

AWD provides the means for rice to adapt to water scarcity and at the same time mitigate greenhouse gas emissions by reduction in methane emissions. AWD reduces methane (CH_4) emission that is produced by the anaerobic decomposition of the organic material in the flooded paddy field. This method has been assumed to reduce CH_4 emissions by an average of 48% compared to continuous flooding.

Alternate wetting and drying reduce cadmium accumulation in rice grains. It can dramatically reduce the concentration of arsenic in harvested rice grains. Periodic soil drying reduces the incidence of fungal diseases and other insect pests.

Impact

The yield recorded under alternate wetting and drying irrigation system (var. Bina Dhan 11in summer season) was 5.88 t/ha as against 5.56 t/ha in conventional system giving as yield advantage of 5.8%. But the energy input was 38222 mJ/ha in alternate wetting and drying system whereas in conventional system it was 44701 mJ/ha saving 1500 mJ energy with energy use efficiency of 3.1 in AWD as against 2.5 in conventional irrigation system.

In alternate wetting and drying system the production cost, gross return and net return realized was Rs.49784, Rs.91728, Rs.41944, respectively with B-C ratio of 1:87 whereas in conventional system it was Rs.51,284, Rs.86,732, Rs.35,452, respectively with B-C ratio of 1:64.

Scaling: Scope and pathways

Under CCAFS, AWD in paddy was demonstrated in 26 ha covering 23 farmers in Jayapur Patna, Kuanarpur and Taraboi Sasan villages in Odisha and resulted in an average increase in yield and benefit cost ratio compared to current practice of irrigation. There is scope for wider adoption of AWD in the state under summer rice and autumn rice, primarily grown with irrgated water.

Partners

The practice can reach a large numbers of rice growers in the state through training and guidance from state department of agriculture, SAU, IRRI, department of water resources, directorate of water management etc supported by the National Mission on Sustainable Agriculture.

Policy support

Water being the most crucial and scarce resource formulating government policy to price it and imposing restriction on its use for rice farming may pressurise for its judicious use.

1.12. Intensifying rice fallows with green gram var. IPM 02-14[12]

The climate of Odisha is hot sub humid with hot summers and mild winters, the mean winter temperature and rainy days are most suitable for rice - pulse production. In Odisha, paddy crop is mainly cultivated in kharifseason covering 30.74 lakh hectare. Following this kharif paddy, only 18.51 lakh ha is cultivated in rabi, of which green gram covers 6.31 ha area grown under residual soil moisture, while other 12.2 lakh ha is left as fallow. Due to rise in temperature and susceptibility of existing varieties to YMV the crop yield of green gram is decresing resulting in increase in fallow. To address the growing concerns, there is a need to look at the climate resilient crop variety and practices to sustain and stabilize green gram productivity.

CSA Intervention

The green gram var. IPM 02-14 was introduced in Rice-fallow/pulse cropping. In this system rice is harvested early, allowing to cultivate pulses to take advantage of the residual moisture stored in the soil with minimum tillage. To utilise the stored moisture effectively, green gram is drill seeded instead of traditional broadcasting. Yellow sticky trap (YST) was installed to protect the crop from YMV by trapping the vectors.

Impact

Drill seeding ensured sufficient plant population through proper utilization of residual moisture. Green gram var. IPM 02-14 was tolerant to high temperature, With YST, it was found free from YMV. As a result, it yielded (7.2 q/ha) advantage of 57 per cent over the broadcasted traditional variety. The gross return realized was Rs 41,400 with a B-C ratio of 1:6

[12]*Contribution from S. Biswal and T. Panigrahi , OUAT, Bhubaneshwar, Odisha*

Green gram var. IPM 02-14 show resistance to YMV and can help to adapt to climate change

Scaling: Scope and pathways

Rice pulse system with Green gram var. IPM 02-14 can be adopted in all the districts. However, districts with large area under rice fallows hold good potential to scale-up. By preferring shorter duration rice varieties this system can also be extended to the districts where rice fallow is predominant.

Gender and youth relevance

Livelihood and employment opportunities can be created by enhancing the productivity and income through crop intensification.

Business model perspective

Value addition system (particularly, mini Dal mills and processing units in the vicinity of production areas) can provide additional employment and income to youths and farm women groups.

Partners

Odisha University of Agriculture and Technology (OUAT), IRRI and State department of agriculture.

Policy Support

Through convergence of different initiatives and missions this can leave useful options for increasing productivity and income in all the thirty districts of Odisha in partnership with the Department of Agriculture, OUAT, IRRI etc.

1.13. Integrating weed management (IWM) technology for higher productivity [13]

Integrated weed management is the key for climate change adaptation and decreases dependence on chemicals

Weed causes major yield loss in both direct seeded and transplanted rice crop. It involves lots of labour force for weeding. But due to labour crisis weeding is delayed which not only reduces crop yield but also becomes a source for spread of insect and diseases.

CSA interventions

Integrating the manual, mechanical and chemical means of weed control not only reduced cost of production but also timely operation resulted in higher yield. Application of Pretilachlor within two days after transplanting at 1.0 l/ha followed by a mechanical weeding by rotary weeder or conoweeder three weeks after transplanting controlled maximum weeds. The rest of the weeds were removed manually at six weeks after transplanting.

Impact

In village Jayapurpatna in Khorda district farmers used IWM technology and by this

[13]*Contribution from S. Biswal, OUAT, Bhubaneshwar, Odisha and Sanjoy Saha, ICAR-NRRI, Cuttack, Odisha*

around 30 man days and Rs.4050 /ha were saved on weed control. Due to prompt and timely weeding the crop yielded about 5.91 t/ha for the rice variety Swarna sub-1 giving yield advantage of 13.7% with integrated weed management as compared to manual weeding in Kharif season. The production cost was reduced by 7.6%, labor requirement was reduced by 67% with energy use efficiency of 7.8 as against 7.1 unit in manual method of weed control. The gross return (Rs.92, 196) and net return (Rs.43, 217) increased by 13.7% and 53.8%, respectively with B-C ratio of 1:9.

Scaling: Scope and pathways

There is scope to upscale the technology in the rainfed as well as irrigated rice growing areas in Odisha. Integrating weed management practices has a potential to reduce production cost and to improve rice productivity and profitability. Minimum use of herbicide but timely application combined with mechanical and manual approaches can minimise the crop weed competition.

Partners

IRRI, DAFE of Odisha, OUAT, and NRRI

Policy support

Providing mechanical weeder and proper herbicides at a subsidised cost and capacity building can build up the confidence of the farmers for wider use. This can reduce the chemical load as well as the GHG emission.

1.14. Field-specific nutrient management for rainfed rice through Rice Crop Manager (RCM)[14]

Odisha, the state on the south-eastern fringes of India, is largely producer and consumer of rice; however, the average state productivity is quite low as compared to the national average. The agrarians of this region cultivate rice crop mostly in Kharif season and grow it in Rabi season where irrigation facility is available. However, a significant portion of the area in Kharif season is under rainfed ecology. Like other management issues, nutrient management under such a scenario is a serious business. Enhancing the state productivity under rainfed ecology is required for increasing profitability and farmers' income. The state has developed a blanket fertilizer recommendation for rice growing areas across the state. It is a known the fact that nutrient management is one of the variable inputs of cultivation, which is influenced by field conditions, water availability, season and local weather condition. Hence, for increased nutrient use efficiency, requires an approach that facilitates the adjustment of the nutrient application to local field and weather conditions.

CSA intervention

SSNM based approach for irrigated rice developed and evaluated and found suitable for

[14]*Contribution from Sheetal Sharma and Rajeev Padbhushan, IRRI, New Delhi, India*

RCM to make better decisions on key nutrient management

adjusting nutrient application for smallholding farmers of Odisha. For rainfed conditions, SSNM based method developed and further evaluation through on-farm testing carried out in different agro-ecological zones of Odisha. The idea behind this decision support tool is to apprehend through the study to sort out the fertility issues that have the thought-provoking constraint for yield under rainfed scenario due to unpredictable water situation. Farmers, in this region, often apply fertilizers inefficiently, unaware of the concept and benefits of site-specific nutrient management. It results in lower yields and poor soil health. SSNM based approach ensures better nutrient management under both rainfed and irrigated conditions. In rainfed scenario water availability at the time of fertilizer application is measured as helpful and helps to improve the agronomic efficiency of the applied nutrient. SSNM approach considers the integrated nutrient management (INM) system considering all available sources of nutrients and implies use of nutrients based on supply and demand concept for particular field to improve productivity and soil health.

Impact

Odisha lies in the in the tropical belt of India and occupies only 3% of total rice area in India but shares 7% of India's total rice production. Farming is the main occupation and rice is the chief source of energy for the people of the state. The socio-economic status of the state is low and entirely depends on agriculture. The state faces natural calamities like drought, cyclones and flash floods that affect production and productivity of the crop. Cultivable land in the state is 6.18 Mha; the area coverage under paddy crop is 3.88 Mha during Kharif season and 0.3 Mha during Rabi season. Out of the total cultivable land, 46% of the area is under rainfed condition. The rice productivity of the state is 2.44 t/ha which is lower than the national average.

Based on the rainfall patterns in the different districts of Odisha and in consultation with the department of agriculture, Odisha, 61 sites in 11 districts were selected for on-farm testing of RCM in Kharif, 2017. Each site consisting of four plots, four treatments namely Rice Crop Manager + Stress-tolerant rice variety (RCM+STRVs), Rice Crop Manager + Farmer variety (RCM+FV), Farmer Fertilizer practice + Stress-tolerant rice variety (FFP+STRVs), and Farmer Fertilizer practice + Farmer variety (FFP+FV) were randomly distributed among. FV includedthe variety selected by the farmers based on their own decision, and based on the suitability STRVs were provided by IRRI. In all four treatments, rice crop was established by transplanting the seedlings in the puddled fields. The recommended dose of fertilizers in the RCM plot was estimated through one-to-one interviews with the farmers using RCM tool. In FFP, the nutrient management information was collected from the farmers before the start of the experiment and used by researchers to monitor the time and amount of application during

the season. Except for differences in fertilizer rate, timing, and variety in these plots, all other management practices were same. At maturity, the crop cut was done in the presence of farmers, extension workers, and government officials to observe, witness, and evaluate the treatments.

Use of RCM based recommendations reported a yield advantage of 21-22 percent over FFP (0.73 t/ ha with FV and 0.77 t/ ha with STRVs). Use of RCM recommendation along with STRVs realised a benefit of 283$/ ha from rice yield over FFP with FV (minimum support price for rice is 23.97 $ /q). The net added benefit in RCM +STRV treatment was 276$/ ha (fertilizer cost for RCM plot is 7$ more over FFP).

Scaling: Scope and pathways

There is scope to upscale the technology in the rainfed rice growing areas in Odisha as RCM has a potential to improve rice productivity and profitability in rainfed environments. This is possible either by increasing the yield or decreasing the fertilizer cost or a combination of both. Application of fertilizers at times when it is required increases the nutrient use efficiencies. Correcting the time and amount of fertilizer not only increase crop yield but could be a better option for soil health management by saving the fertilizer loss to atmosphere and water bodies.

Gender and youth relevance

Gender and youth, considered as a factor for planning and implementing the agricultural programmes, has always scope to enhance the access of technologies, inputs, credits and markets, ultimately, result in elimination of gender differences and discriminations in rural area. Also, it created awareness among rural youth for better nutrient management practices. During studies it was observed that in RCM technology, women's and youth's role (either as an individual or collective) was more pronounced in decision making. Gender sensitized rice production among tribal farmwomen of Odisha through RCM technology approach resulted in enhanced knowledge level, productivity and income.

Business model perspective

Taking up RCM in larger areas on community basis can help to service providers for develop business case of printed sheet when disseminated by input dealers and agro-based community service centers. To harness the benefits, a small cost of the printed sheet could motivate to use this technology. Thrust may be given for popularization of low cost smart phone and internet facilities for making this technology a viable option for nutrient management.

Partners:

IRRI, DAFE of Odisha, OUAT, and NRRI

Policy

A centrally sponsored Soil health card mission and National Food Security Mission (NFSM) has been launched from 2007-08 in the State with the objective of increasing production of rice and pulses through area expansion and productivity enhancement in a sustainable manner in the identified districts. DAFE/NRRI/OUAT will have to own this technology for more outreach.

1.15 Solar power as a remunerative way to minimize climate risks[15]

Irrigation covers about 54% of agriculture land in Odisha and about 21% of total irrigated area is covered by lifting underground water with tubewell and electric or fossil fuel-based pumps. For many farmers, poor irrigation systems, the high cost of pumping groundwater and limited access to electricity are major problems. As their costs fall, solar irrigation pumps could replace farmers to use solar energy to pump water during periods of rainfall defficit can provide big opportunity in agriculture.

Solar Cooperatives: Lessons from Gujarat

In 2016,the International Water Management Institute, CCAFS, the CGIAR (formerly the Consultative Group for International Agricultural Research) Water, Land and Ecosystems Program, and the India-Tata Program collaborated to pilot the Solar Pump Irrigators' Cooperative Enterprise (SPICE) model for sustainably promoting solar pumps in the water-scarce area of Gujarat. A group of farmers in thevillage of Dhundi in the Kheda district were encouraged to form a cooperative to test solar irrigation systems (https://mnre.gov.in/file-manager/akshay-urja/august-2016/44-45.pdf). The state government and the project subsidized the cost of the solar pumps. The cooperative also negotiated anagreement with the local power distribution company to buy surplus project power when

Establishment of solar panels for solar pump is an economic method of irrigation

farmers did not need irrigation.

CSA intervention

The pilot project has generated income from both the improvement in agricultural production and the sale of surplus energy. It has also promoted a range of CSA interventions, such as efficient technologies for water use in vegetable farming, improved seed and nutrient management, minimum tillage, and introduction of crops that require less water. Cooperative members use solar energy to irrigate their own crops and sell irrigation services to neighbouring farmers before selling the residual energy to the power company. Figure 26 shows the changing dynamics of electricity generated and irrigation use. Between January and May (the dry season), cooperative membershad solar energy to meet their own and their neighbors'irrigation needs, and from May 2016 they could sell it to the power company. This model was also effective in reducing the use of power and water in agriculture without impinging on farmer incomes.

Scaling: Scope and pathways

Since the cooperative was launched, many stakeholders and farmers have visited the project location to better understand the model, as have government officials, academics, and representatives of the solar industry. Within six months, stakeholder interest and high-profile visits stimulated significant state and national policy discussions, and the government of Gujarat has drafted a policy based on the solar cooperative model. The model, now generally considered a success, has been endorsed by the Indian Ministry of Non-Conventional Energy Resources and popularized through the Urban Jyoti Abhiyaan (URJA) -Integrated Power Development Scheme (IPDS)-the priority program of Ministry of Power, Govt. of India. The program could be of great significance for Himachal Pradesh given its small but critical water requirements for open and polyhouse cultivation, abundance of small streams and rivulets for water lifting, and the dispersion and remoteness of its farms, orchards, and pastures, not all of which can be connected to the power grid.

[15]Contribution from Arun Khatri-Chhetri, CCAFS, BISA, New Delhi and Tushar Sahah, IWMI, Ananda, Gujarat, India

1.16. Climate resilient rice varieties for risk reduction and sustainability in stress prone areas of Odisha [16]

Varietal difference in growth of rice crop

Crop Cafeteria can help in varietal selection

Display of rice seed varietiesfor varietal selection

The state of Odisha is known for recurrent events of flood and drought year after year in the coastal and inland districts respectively. Though the quantum of seasonal rainfall has not changed drastically during the last 25 years, the distribution has been erratic, with longer drought spells and intensive precipitation occuring more frequently and causing distress to farmers. Incidence of drought and flood occurring within the same season further complicate the already delicate situation in some years. Every alternate year and sometimes consecutive years have witnessed serious crop loss or damage due to these climatic stresses. Many poor and marginal farming households are, therefore, at the peril of food and livelihood insecurity. Rice being the predominant food crop covering 69% of the cultivated area in the state, losses resulting from reduced productivity and production are substantial. Given this vulnerability of millions of farmers of the region, climate resilient rice varieties are one of the necessary adaptation strategies to reduce the risk and sustain production.

CSA Intervention

Climate resilient rice varieties often popularly known as STRVs (stress tolerant rice varieties) have been developed to make the crop remain unaffected or relatively less affected compared to other high yielding varieties under stress conditions like drought, flood or salinity. When

[16]Contribution from Swati Nayak, Mosharaf Hossain and Mukund Variar, IRRI, New Delhi, India

targeted in appropriate ecology, these varieties have the ability to withstand the stress and give considerable yield advantage under stress and no yield penalty under normal condition, compared to other locally grown high yielding varieties. The STRVs give a range of options for farmers to deal with the problems of drought, flood, salinity or even multiple stresses (drought and flood, abiotic and biotic stresses). Many of the flood tolerant varieties have been developed from the local mega or popular varieties by adding flood tolerance trait in them and have the potential to completely replace the older varieties by keeping other traits almost same. e.g., Swarna sub1 (SS1), a flood tolerant variety well accepted by the farmers of flood prone ecology in Odisha, by replacing the mega variety Swarna. SS1 gives 14 days of submergence tolerance as additional trait. Similarly, Bina Dhan 11, Samba Mahsuri Sub 1 and many more varieties for flood and Shahbhagidhan, DRR44 and others for drought have the potential for large scale adoption in the state.

Impact

- Nearly 15 released in the STRVs pipeline have been tested under the local ecology through comparative trials. Sub 1 genes are now incorporated in a number of genetic backgrounds.
- 40 varietal cafeterias have been hosted as evidence hubs for multi-variety comparative trials. These hubs have been connected with different stakeholders for participatory evaluation and ratings.
- The stakeholders who have been part of joint evaluation and selection of suitable varieties are local government agriculture officers, KVK scientists, farmers, dealers, researchers, seed production officers, pvt.seed entrepreneurs, NGOs.
- Drought tolerant varieties have been tested in more than 3000 ha under upland ecology through direct interventions and demonstrations in last 3 years (2016-2018)
- More than 9000 ha was covered under comparative trials and demonstrations in lowland ecology in the state in flood affected districts in 3 years.
- Apart from above direct coverage under trials/ demonstrations, there is an expected spill over/multiplier effect in terms of farmer saved/ sold/shared seeds gradually increasing the area by approximately by 55000 ha in last 2 years alone (with an estimated rate of 5-10% of harvest being reused or distributed as seed).
- Apart from this; OSSC, and local seed entrepreneurs steadily increasing the volume of STRV in their supply channel, many more new farmers are being reached out year after year.
- Awareness creation through demonstrations have led to higher seed demand for Bina Dhan 11, Sahbhagi Dhan, DRR 44 which have been brought under seed chain by state seed corporation.
- Breeder seed demand for STRVs for Kharif 2019 is about 55% of the total seed indent by the Department of Agriculture, Odisha. State Seed Corporation and/or private seed producers have sourced and converted breeder and foundation seeds to certified seeds to make it available to farmers in different districts.
- STRV like Sahabahagidhan and DRR 44 have shown average yield advantage of 0.43 t/ha to 0.5 t/ha against local checks under stress (11-15 days of drought spells).
- Bina Dhan 11, a flood tolerant variety, gave average yield advantage of 0.5 t/ ha under 14 days of submergence. Being early in duration, this variety provides the required time window to grow an additional crop after rice harvest. The variety is also getting popular in the rabi season because of its ideal duration, non-lodging character and high productivity.

Scaling: Scope and pathways

Recommendation domain

In order to accelerate the adoption for climate resilient varieties, there needs to be integrated effort to strengthen not only the seed systems for the new varieties but also the delivery systems for same.

i) Farmer centric learning: The adoption rate could be triggered with farmer led learning process and making them participate in scientific evaluation of varieties under their own farm conditions.

ii) Engaging extension functionaries: Extension agents from public, private or civil society sector are the major agents of change for taking the varietal knowledge to farmers and playing role in motivating them for their adoption. They could play a key role in mobilization as well. Creating learning platforms and appropriate linkage for these agents can make the difference.

iii) Strengthening seed systems: Both formal and informal seed systems need to be strengthened for new varieties for sustained adoption. Creating institutional linkage for breeder seed, engaging government stakeholders, public seed corporation and private companies for varietal evaluation process can create better policy avenues and planned procurement/production of seeds in formal chain. Similarly capitalizing the strength of various community institutions of farmers and especially women; informal seed production and dissemination can also be triggered through capacity building.

iv) Engaging seed delivery agents/dealers: Empowering dealers through exposure to varieties by organized trials supervised them and linking them to various varietal evaluation, selection and promotion platforms / events can lead to creation of market demand as well as supply of seeds.

Partners:

IRRI, DoA, NRRI, OUAT

Policy support

IRRI in convergence with Odisha Livelihoods Mission can intensify the seed system strengthening activities engaging wide network of women farmers' institutions. In convergence with OTELP-IFAD initiative, a lot of drought prone areas can be brought under climate resilient rice and decentralized seed production led by tribal farming households and community agents can ensure adequate quantity of quality seeds in time. Odisha government led multiple climate change related programmes are potential medium for meaningful convergence. Direct income support to farmers through the recently launched Kalia scheme can help the farmer to invest more in good quality seeds of appropriate varieties leading to better harvests and income.

1.17. Solar Powered Irrigation Systems[17]

Solar irrigation systems

Dwindling surface water has forced the farmers to access aquifers to meet the agricultural water demand. Electric and diesel pumps have taken over the traditional pumping mechanisms, which were rendered dysfunctional due to decreasing ground water level. Currently, 30 million irrigation pumps are being used throughout the country (out of which around 70% use electricity while 30 percent rely on diesel).

In order to meet the Nationally Determined Contribution of India, Solar Powered Irrigation Systems offer a way to adapt agricultural water management to Climate Change.

CSA Intervention

Solar Powered Irrigation System (SPIS) offers a climate-smart and sustainable approach to simultaneously extend the area under irrigation while using renewable source of energy. SPIS offers both adaptive and mitigating benefits to curtail climate change, through solarisation of agriculture and agricultural pumping. Burgeoning technological innovations are reducing the investment cost required for owning solar powered irrigation systems (SPIS). This coupled with substantial amount of subsidy schemes being rolled out by the present government is giving necessary fillip to SPIS installations.

With increasing focus on solar energy use in agriculture, several pilots and models of solar irrigation systems have been rolled out in the country. It has led to significant increase in the income of the farmers while simultaneously abating the ever rising greenhouse gas emissions. It offers farms the opportunity to reduce the cost of energy by reducing the requirement to invest in diesel to run the pumps or be dependent on the vagaries of electricity supply. Solar power generation offers a solution which amalgamates clean energy technology with increased food production.

Impact

- Increase in yield
- Improvement in resource use efficiencies
- Increase in net profit
- Adaptation to climate change risk
- Contribution to mitigation (if available)

Scaling: Scope and pathways

Recommendation domain

- Soil, climate & biophysical conditions
- Cropping/production system

Business model perspective

Various business models have come up around the usage of the excess clean energy produced by using solar panels. Energy is being produced at the following levels: Individual farmers, farmer cooperatives and large scale entrepreneurial level. Examples have shown that at each level the produced energy is being used to generate additional income, such as selling energy itself to the Distribution Companies, using energy to pump water and selling the water, using energy for other production activities such as running sewing machines/ cold storage etc.

Partners

Almost all of the pilot interventions have been taken up with the support of some external agency such as national or international non-profit organizations. These organization have supported the intervention in either or all of the ways: by providing funds; by providing access to technical knowledge; providing coordination support etc.

With the existing institutional framework it is challenging to scale out and ensure subsistence of the Solar Powered Irrigation System Technology, without the support of grass-root level NGOs, funding organisations as well as knowledge partners. A policy which facilitates these organisations to extend their support to such scaling out initiatives is the need of the hour.

Policy support

KUSUM (Kisan Urja Suraksha Evam Utthaan Mahaabhiyan) Scheme launched by the government of India, aims to support farmers to use solar powered irrigation systems to meet the energy demand for agricultural water requirement.

[17]*Contribution from Paresh Bhaskar, CCAFS, BISA, New Delhi, India*

1.18. Residues management for improving soil health and yield enhancement[18]

Discussed between farmer and researcher about crop residue management

In Odisha, paddy crop is cultivated mainly in kharif season covering 30.74 lakh hectare. Of this only 18.51 lakh ha is cultivated in rabi, while other 12.2 lakh ha is left as fallow. With growing labour crisis most of the farm operations are heading towards mechanisation particularly the sowing/ transplanting and harvesting and threshing of paddy. Use of combine harvester clears the land early within short period so that the rabi crop grown on residual moisture is sown in time. But it leaves the entire residue (straw/hay) in field which is not essentially reused by most farmers. It is also difficult to incorporate and decompose the residue in the following dry crop(puises and oilseeds). Collection and disposal of this huge biomass is also time consuming and expensive. Therefore the farmersprefer to burn the residues to clear the land for ease and timely sowing.This leads to increased CO emissions and also is a great loss to the farmer as well as to the land, as the land is deprived of biomass that helps in build up of precious soil organic carbon.

CSV intervention

There are many already proven residue management practices that can help farmers adapt to the likely adverse effects of increasing weather variability and climate change, and that can, in many cases, also reduce agricultural greenhouse gas emissions.

In order to encourage farmers to change this practice, residue incorporation/mulching is to be introduced in the selected villages. The residue can be chopped into small pieces, spread and incorporated in-situ thoroughly by machines with varying efficiencies depending upon the left over residue. This can be well decomposed within short period by use of microbial inoculation.

Impact

It helps in early seedbed preparation soon after harvesting kharifcrops for sowing of rabicrops, improves the soil physical properties and hence, results in increased crop yield. Incorporation of crop residue adds both major and micronutrients into the soil. This results in saving of chemical fertilizersin long run. Residue or biomass incorporation builds up soil organic carbon which improves water retention capacity and benefits the crop. This practice of in situ incorporation of crop residues can bring about reduction in residue burning which aggravates GHG emissions and air pollution.

[18]*Contribution from S. Biswal, OUAT, Bhubneswar and D. S. Rana, IRRI, New Delhi, India*

Scaling: Scope and pathways

In CSVs, in situ incorporation of paddy and pules residues and biomass of green manuring crops can be scaled up across several districts. In CSVs the machine is to be made available through custom hiring centers for wider adoption by farmers for resource conservation to improve soil health and productivity and reduce GHG emission.

Recommendation domain

In areas of paddy-pulse/oilseed cropping system or where a dry crop is taken in rabi preferably with residual soil moisture ammounting to around 15 lakh ha can be brought under machine harvest as well as residue incorporation in order to reduce GHG emission and increase soil health.

Partners

Availability of machines in large scale even through custom hiring can encourage the farmers to opt for the practice. In this endeavour rural youth groups and custom hiring centres can play a major role.

Gender and youth relevance

Bailing the residue using tractor mounted bailers and lifting them from field can clear the land for sowing as well as preserve the residue for further use. It can be used as potential animal feed after mixing additives or can be sold to paper industries or packaging industries for gainful return. Availability of machines in large scale through custom hiring can encourage the farmers to opt for the practice and can provide employment to the rural youths.

Policy support

Government ban on residue burning and incentive for recycling can encourage farmers for this greater cause.

1.19. Solar power - a potential source to minimize climate risks[19]

A farmer's family happy to used solar power system

The entire summer crops, portion of rabi crops (15 lakh ha) and kharif crops under exigency (31 lakh ha) are irrigated. canal is the main source of irrigation. However in summer season as the canal source is exhausted and in areas out of reach of canal command area irrigation is done mainly with minor irrigation sources by using diesel or electric water pumps. For most farmers, poor irrigation systems, the high cost of pumping groundwater, and limited access to electricity are major problems.The rising diesel cost and frequent power shredding in summer season, frequent damage to distribution systems by cyclones and over loading drags the crops to suffering.

[19]*Contribution from S. Biswal, T. Panigrahi, OUAT, Bhubaneshwar, Odisha and*

CSV intervention

Solar Powered Irrigation Systems offer a way to adapt agricultural water management to Climate Change. As the costs falls and timely water supply is ensured, solar irrigation pumps could replace diesel or electric pumps a possibility the state government is aggressively popularizing. Moreover when crops do not require irrigation surplus project power may be sold to local grids to earn additional income.

Impact

Apart from ensuring higher crop yields through timely farm operations and mitigating GHG emission and climatic risks it may also promote a range of CSA interventions, such as: efficient technologies for water use, improved seed and real time nutrient management, minimum tillage, and introduction of low water requiring crops. Like Gujrat , solar cooperatives may be formed where cooperative members use solar energy to irrigate own crops and sell irrigation services to neighbouring farmers before selling the balance energy to the local power company.

Scaling: Scope and pathways

The stakeholders, farmers,government officials, academicians, and representatives of the solar industry may visit the project location to better understand the model for stimulating significant state and national policy.The program could be of great significance for Odisha given its small but critical water requirements.

Recommendation domain

The project may be initiated in small scale in pilot mode but it can spread to all the crop fields wherever and whenever irrigation is needed.

Partners

State department of agriculture, OREDA, Power companies, NABARD, farmer cooperatives, NGOs, SHGs can join hands

Gender and youth relevance

Women farmer groups and rural youth organisations may start the project in business mode and sale irrigation water to local farmers and surplus energy to power grids .this can support the employment generation to a great extent that to in rural sector.

Policy support

Both the state and central government should liberally support the project by incentivising in several sectors.

1.20. Mechanization of farming for tackling labour scarcity[20]

Mechanised transplanting and harvesting of rice crop

In rainfed areas, the window for taking up of timely farm operations like land preparation, sowing and inter-culture operations is quite narrow, especially in the low rainfall zones. Failing to exploit this limited window often leads to a compromise on productivity and resource use efficiency in crop production. On the other hand labour crisis at peak period of demand is a serious problem faced by farmers. Delayed farm activity especially sowing not only affects the current crop but also the crops in succession. In high rainfall areas dominated by heavy soils, drainage is more crucial to prevent damage to crop from excess soil moisture in the root zone.

CSA technologies/practices

Adoption of climate resilient practices are linked to timely access to appropriate farm machinery at reasonable cost. Several options are now available to increase the efficiency and timeliness of agricultural operations even on small farms by using farm machinery.

Mechanization brings in timeliness, uniformity and precision to agricultural operations, greater field coverage over a short period, cost-effectiveness, efficiency in use of resources and applied inputs, conservation of available soil moisture under stress conditions and provision of adequate drainage. Farm implements could successfully empower farmers to tide over the shortage of labour and improve efficiency of agricultural operations.

Impact

Transplanting has remained as a potential establishment method. Manual transplanting is a common practice but with rising labour crisis and uncertainty in water availability sometimes it is delayed and done with age old seedlings resulting in yield reduction.

Mechanization has come to the rescue under such disadvantage which saves around 40 labour days on uprooting and transplanting normal seedlings. For mechanical transplanting mat nursery has proved an additional advantage which saves 90% labour and 20-25 kg/ha seeds as against conventional method. With mechanical transplanting only five labours can assist in transplanting an hectare area. Uniform and shallow transplanting at 24 cm × 14 cm spacing with 3-4 seedling of 18 days old produced higher tillers (14-16/hill) as against manual transplanting (12-14/hill). The operations could be completed in time without affecting seedling age. As a result, a yield level of 6.2 t/ha could be realised with 14.8 per cent yield advantage. The net return was Rs 48,991 with B-C ratio of 2.03 under mechanical transplanting as against Rs 31,511 under manual transplanting.

Similarly, using combine harvester could save 62 labourers and a cost up to Rs10175 from one hectare area with an added advantage of simultaneous threshing. By combine harvesting the cost and time period for threshing was saved which ensured early marketing in local Mandi; the subsequent crop is also sown in time to utilize residual moisture. Any one taking early maturity variety prefered to use the reaper for early harvest to utilise 100% straw similar to manual harvesting.

Scaling: Scope and pathways

Looking at the advantages of mechanical transplanting, supported by subsidized cost of procurement the no of transplanters in the CSVs is increasing at a faster rate. This can spread to all the transplanted areas either due to labour or water crisis. Harvesting through combine harvesters, being a group assignment is easily adopted to save the produce from cyclonic storms and heavy rain at the fag end of the crop. For hiring combine harvester all the farmers in a patch used to grow the same variety for synchronization in maturity which strengthens the cooperation.

Business model perspective

Hiring transplanters, combines also provides extra employment to the young farmers and solves the labour crisis to a great extent. Thus establishing custom hiring centers for mechanised farm operations has become the demand of the day. This can generate rural employment and also can modernise agriculture.

Partners

State department of agriculture, agro-industries Corporation, implement factories, can join hands in making the progress faster.

Policy support

Liberally incentivising custom hiring centres to mechanised farming can mobilise farmers to modernise agriculture and make it climate resilient. This can be linked to various other schemes like RKVY, NFSM and BGREI etc. Factories for impements play a key role in this endeavour and therefore should also be promoted.

[20]Contribution from S. Biswal, OUAT, Bhubaneshwar, Odisha and D.S. Rana, IRRI, New Delhi (India)

IRRI

COMPENDIUM

Climate-smart Agriculture

SECTION 2

SERVICES

2.1. Weather-based advisories for groundnut[21]

Weather based advisories can improve adaptation to climate change in groundnuts

Weather variability significantly affects crop yields. Clear understanding of climate helps in devising suitable management practices for taking advantage of the favourable weather conditions and avoiding or minimizing risks due to adverse weather conditions. Early planting is advantageous but in certain years, this is offset due to the presence of long dry spell after planting, which leads to seedling death and necessitates re-planting. There is a tendency for lower yields for late sowings beyond first week of August; because of the high risk of end-season long dry spells. Farmers having access to climate and weather information are more likely to take better crop management actions. Understanding of optimum sowing period, growing season characteristics with reference to rainfall pattern helps farmers in making informed decisions in designing strategic planting management options.

CSA Intervention

Devanakonda Mandal in Kurnool district, Andhra Pradesh (AP), India, receives an annual rainfall of about 606 mm in 35 rainy days and groundnut is the major rainfed crop. ICRISAT and Microsoft have jointly taken up a pilot project under the Andhra Pradesh "Rythu Kosam" Project for disseminating sowing and other crop-management advisories to the rainfed groundnut farmers of Devanakonda. Farmers' Group Meetings were organized and 175 farmers have registered their mobile phone numbers for receiving sowing advisories. Historic climate data for 30-years (1986-2015) was used to understand the rainfed growing season characteristics and optimum sowing window was identified using PNUTGRO crop-growth simulation model. Beginning of groundnut crop growing period for the year 2016 was identified based on the Moisture Availability Index. Advisories were prepared both in Telugu (local language) and in English and were disseminated to the registered farmers during the groundnut crop-growing period of 2016. Advisories included recommendations on land preparation, soil-test based fertilizer application, FYM application, sowing, seed treatment, optimum sowing depth, preventive weed management, maintaining proper plant density, applying nutrients if needed, harvesting, shade drying of harvested pods and storage.

Impact

Weather advisories brought climate awareness among groundnut farmers and encouraged them to initiate sowing at the optimum time. They followed weather-based agro advisories for proper crop management and obtained better yields and are out of loss compared to some farmers who have sown earlier. Some registered farmers who have sown as per our advisory have obtained about 30 per cent increase in groundnut yields compared to some of the non-registered farmers, who have sown in the first week of June 2016. More farmers are now showing interest to register their mobile phone numbers for receiving the sowing and other advisories.

[21]Contribution from AVR Kesava Rao, Suhas P Wani, Sreenath Dixit and K Srinivas ICRISAT Patancheru 502 324, Telangana, India

Scaling: Scope and pathways

Recommendation domain

Inter-annual and intra-seasonal rainfall variability has become a reality, probably due to climate change, and many farmers are turning towards climate services and are seeking support on choices of climate smart crops and varieties and their optimum sowing windows. There is great scope to upscale this initiative in the rainfed groundnut and pigeonpea crop growing areas in Odishato reduce the risk of sowing failures and to promote better crop management practices based on medium range weather forecasts and advisories. India Meteorological Department (IMD) has initiated issue of weather forecasts at Block level and these will help in developing crop-specific agromet advisory services in Odisha.

Gender and youth relevance

Women are unable to voice their specific requirements even though the impact of climate change affects women and men differently. It is therefore required to boost resilience of women and youth to climate change through climate-smart agriculture practices.

Business model perspective

Weather-based crop management services for the farmers are to be offered free of cost, as per current policy.

Partners:

ICRISAT, OUAT, IMD

Policy support

ICRISAT is implementing a project supported by the Government of Odisha on "Enhancing Agricultural Productivity and Rural Livelihoods through Scaling-up of Science-led Development in Odisha: Bhoochetana". The objectives of the project include assessment of the nutrient status of agricultural soils and to identify the best soil, water, crop, and nutrient management options for increasing productivity in all the thirty districts of Odisha in partnership with the Department of Agriculture, OUAT and other partners from Odisha through convergence of different initiatives. Enhanced Agromet Advisory Services can be planned on a pilot scale for groundnut and pigeonpea in selected locations.

2.2. Reaching farmers with context specific and actionable agro-advisories: The Intelligent Systems Advisory Tool (ISAT) [22]

The Intelligent Systems Advisory Tool (ISAT)

[22]Contribution from Dakshina Murthy Kadiyala, KPC Rao, Ram Dhulipala, and Anthony Whitbread, ICRISAT, Patancheru, Telangana and Mithun Das Gupta&SoudaminiSreepada, Microsoft India (R&D) Pvt. Ltd, Gachibowli, Hyderabad

In recent years, climate services have emerged as an important means to address the challenges posed by climate variability and change. Advances in climate and weather predictions have opened up new opportunities for smallholder farmers to better understand, anticipate and respond to the risks and opportunities presented by variable climatic conditions. At present, the forecast-based advisories tend to be generic and not very contextual due to use of district as a boundary which is very coarse for this type of service. Hence by taking advantage of the recent advances in climate science which made significant contribution to improve the availability and quality of climate information and using advanced analytical techniques and state of the art system simulation models there is a need to design and deploy an automated messaging system for smallholder farmers and extension workers to deliver real-time, location-specific, crop-based, agro-advisories using scalable methodologies for managing climate risk.

CSA Intervention

ICRISAT with its partners (Microsoft India Pvt. Ltd and ANGR Agricultural University) developed and deployed "Intelligent Systems Advisory Tool (ISAT)" which enables farmers to make informed decisions by providing them with tailored location and crop specific advisories communicated to their mobiles through Short Message Service (SMS). The whole process of delivering agro advisories starts with development of decision trees or algorithms for all the decisions depending on the time of sowing. In the decision tree, each branch represents a possible outcome or an action and the selection of most appropriate action is guided by the result of test conducted at different nodes in the tree. Hence, putting the decision tree into action involves getting or accessing real time data from various sources as required to test the criteria set at each node, evaluate the criteria and select the most appropriate action. Microsoft, India has developed the required algorithms and program to implement these steps. Messages were communicated initially at the beginning of the season on cropping systems to be followed based on the seasonal climate forecast released by IITM, Pune. The regular bi- weekly agro advisories during crop season were pushed automatically using last (previous?) week's actual weather data, coming week forecasted weather and two weeks weather outlook obtained from IMD. The contextual information thus provided, enables farmers to manage their farms more efficiently and profitably by making timely decisions and conducting operations with precision.

Impact

- Nearly 79% of the farmers are satisfied with the weekly frequency of the messages
- 93% of farmers from the project villages are satisfied with the coverage of various issues in the messages
- About 58% of the farmers rated the information as "mostly correct" or "correct 75% of the times" and another 33% of the farmers rated as "correct more than 50% of the times"
- About 78% farmers used the information for timely sowing, more than 66% farmers used the information in planning harvesting and 57% used it in scheduling spraying and fertilizer applications
- On average 16.2% increase in groundnut yields achieved by farmers in treatment villages with access to climate information than by farmers in the control villages without access to climate information

Scaling:Scope and pathways

Recommendation domain

There are several SMS type platforms that exist which could be substantially improved by adopting the iSAT methodology. IKSL for example, currently has an ICT platform that makes available climate related advisories to about two million farmers mainly through SMS service. Integrating with existing commercial or government platforms will ensure that the project and the outputs are sustainable and have an opportunity to scale. It is also anticipated that many governments will find such knowledge-based systems extremely useful in making their extension systems effective by providing them with up-to-date location specific advisories using the methodology developed under this project.

Gender and youth relevance

In India, women who play a key role in the decisions for many farm operations (e.g. enterprise selection, timely farm operations and alternative livelihood practices). By using gendered farmer and indigenous knowledge engagements, training and outreach to interpret and use probabilistic climate information, women will benefit equally from increased availability of relevant climate information, improving access to credit, and therein strengthening household food and nutrition security.

Business model perspective

There are several progressive IT solutions and services startup companies concentrating on agri business by focusing on effective use of information technology in India (specifically in the public sectors) for the benefit of farming communities. These startup companies are a free to use platform for communicating the climate information to the end users through mobile devices and web browsers. Different stakeholders of agriculture like farmers, traders, input dealers, Farmer Producer Organizations, students, scientists and researchers, etc., can use information from these platforms to share their needs, ask & answer questions, receive news & information like farm advisories, market linkages, etc., which can be a business model for the startupcompanies.

Partners

- Microsoft India Pvt. Ltd.
- ANGR Agricultural University
- ICRISAT
- Vasudhaika Software Private Limited

Policy support

The application could be linked can be integrated with any existing platform (e.g.IKSL) for sustainable scaling up. This tools can very well be integrated with the electronic agricultural extension systems that many state governments are promoting.

2.3 Science-based crop insurance system for increasing farmes' resilience[23]

Agricultural production is an outcome of biological activity highly sensitive to weather changes. Climate change impose negative effect on agricultural production through: (i) increasing the frequency of losses from extreme weather events including floods, droughts, and cyclones, (ii) changing absolute and relative variability of such losses, (iii) shifting spatial distribution of such losses, (iv) damage function increasing exponentially with weather intensity, (v) abrupt and non-linear changes in losses, (vi) widespread geographical simultaneity of losses, (vii) more single events with multiple correlated consequences. Thus with climate change, the agricultural risk will not only accentuate but also will become very complex and cumbersome process necessitating devising new mechanisms and measures to address such risks. Therefore, there is a great need for crop insurance with the following goals (Pradhan Mantri Fasal Bima Yojana – PMFBY, 2016)

1) Financial support to farmers in the event of failure of crop as a result of natural calamities and pests, diseases etc.

2) To encourage farmers to adopt progressive farming practices and improved technology in agriculture.

3) To help stabilize farm incomes

4) Improve farm livelihoods

Considering the number of farmers at risk, dynamic of the risks, moral hazards, and limited resources by governing and monitoring entities of PMFBY implementation in the state, at issue is how PMFBY program can effectively assess claims in the case of extreme weather events within the strict timely requirements stated in the policy.

CSA Intervention

Earth observation and remote sensing technology facilitates effective monitoring of agricultural crops at large scale on a repetitive basis. In the case of lowland rice, Synthetic Aperture Radar (SAR) option for earth observation is advantageous due to pervasive cloud cover during monsoon, the time most expansive time of rice cultivation and in the case of floods and cyclone events. Remote sensing technology especially when integrated with crop modeling approach can offer an attractive solution of non-bias and transparent loss assessment delivered within the required timing defined in PMFBY policy. Use of processed-based crop modeling allows yield information to be projected while

[23]Contribution from T.D. Setiyono, D. Murugesan#, A. Maunahan#, E.D. Quicho#, M. Variar*, J. Singh*, P. Kumar*, A.K. Pradhan*, H.A. Pramanik* and S. Khanda* (*IRRI-Odisha, India; #IRRI-Los Baños, Philippines)*

season is still in progress thru incorporation of weather forecast allowing loss assessment in the case of weather extreme events (e.g. floods, droughts, and cyclone impacting rice production). Remote sensing approach supported with ground-truthing can reliably map start of season and rice growth indicators and thereby can effectively monitor whether any parts of monitoring coverage exhibit cases of preventive sowing and/or fail sowing. Rice area derived from remote sensing and delineation of it according to land ecosystem also useful for targeting sampling area for CCE for PMFBY. Integrating remote-sensing data and crop growth model is more promising than the empirical approach for yield estimation as the integration allows remotely sensed vegetation indices translated directly into crop yield and production values. The integration approach exploits the synergies between: (i) remote-sensing technology strength in capturing spatial and temporal variation related to agro-practices (e.g., crop establishment dates) and seasonal crop development (i.e. phenology) and vegetation status (e.g. leaf area index); and (ii) process-based crop growth model strength in reliably simulating yield by capturing biophysical growth drivers (microclimate, water, and nutrient). In addition to supporting risk reduction efforts by supporting crop insurance, the information from remote-sensing technology can be used to identify and target hot-spot areas for interventions to reduce yield gaps and optimize resource use to ensure sustainable rice production.

Impact

Satellite-based rice monitoring and crop insurance:

IRRI implements remote sensing technology, specifically earth observation using cloud penetrating synthetic aperture radar (SAR) data, to timely monitor rice planting progression and provide in-season yield forecast. Multi-temporal SAR data (January to December, every 12 days) spanning across 3 tracks of Sentinel 1A and Sentinel 1B satellites are used for rice cultivated area extraction of Odisha during Kharif and Rabi seasons and for discrimination of land cover types to develop rice baseline map. Optical images from Landsat 8 and Sentinel 2 satellites were used to cross-check and verify rice area classification based on SAR data.

Quantified in range for

- Developed a rice monitoring system for Odisha to provide accurate and timely estimates on rice area, yield and production along with planting date.
- District-wise rice area was estimated and consolidated at state level after validating rice area map at individual district. During 2018 Kharif season, SAR based rice area estimates indicated a total of 35.04 lakh ha rice cultivated. Accuracy of rice area estimates across the state of Odisha was 94.4%. Rice area map accuracy at the individual district level ranged from 87.7 to 99.1%. Seasonal dynamics of the Kharif season was effectively captured through the use of multi-temporal SAR data. Start-of-season map indicated that the peak of planting occurred during August which accounts for 47% of the total planted rice area that comes under early winter, 31% during June, considered as Autumn rice along with mixed Autumn and early winter in July with 16% of area and 6% of late winter in September.
- Yield estimation system was implemented based on integration of SAR data with ORYZA crop growth model using Rice Yield Estimation System (Rice-YES). RICE-YES interprets LAI maps from MAPScape-Rice to simulate yield accordingly while capturing meteorological and agronomic information through the use of spatially disaggregated weather data, varieties, soil, and nutrient management information.
- Crop damage assessment in case of drought, flood, and cyclone for all rice-growing areas, to provide data and information derived from remote sensing to support implementation of Pradhan Mantri Fasal Bima Yojana (PMFBY) for paddy in Odisha.
- During the wet and dry season, IRRI generated rice area map, estimated yield and provided flood maps affected by the cyclones 'Titli', during October 2018 and 'FANI, during May 2019. These efforts were followed by socio-economic and policy research to identify factors that affect crop insurance uptake and ways to improve acceptance of the insurance scheme by bundling risk reducing technologies and other options.
- Field level monitoring and damage assessment in case of floods and droughts using Unmanned Aerial Vehicle (UAV) were deployed to complement information derived using satellite earth observation.
- Local capacity building programmes and hands-on training sessions to NARES partners consisting of DoA staffs and the Odisha Space Applications Centre (ORSAC) staffs were conducted targeting know how of remote sensing data processing using MAP Scape-Rice software and yield mapping using Rice-Yield Estimation System (Rice-YES) software.

Scaling: Scope and pathways

Timely forecast of crop yield during mid-season are critical preparedness requirement against natural calamities. In the event of crop failure as a result of natural calamities and pests, diseases outbreak, key information needed for accessing economic loss relies on information of the expected productivity of the affected farms. Satellite and drone based advanced remote sensing technology is feasible and scalable intervention for effective support crop insurance program to reduce vulnerability of farmers to negative impact of climate change.

Recommendation domain

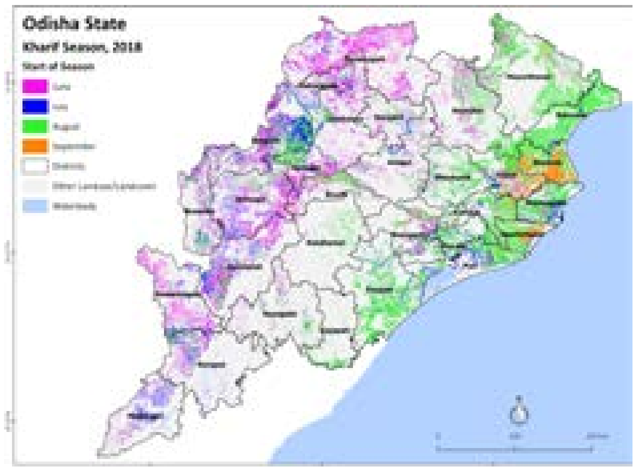
Current implementation of PMFBY heavily relies on Crop Cutting Experiments (CCEs) to determine the yield and yield loss. Remote sensing and crop modeling technology implement by IRRI has the potential to complement delivery of yield loss information and thereby promoting a more reliable claim processing and thus promote better acceptance of the program by farmers. Climate change has increased late season heavy rains and cyclones causing an increasing threat of heavy economic loss from post-harvest inundation. Protocol for loss assessment using complementary information derived using Unmanned Aerial Vehicle (UAV) can further strengthen information delivery in strict time requirement under extreme weather events including localized events of post-harvest inundation which has a very high damaging threat to the economy of small holds paddy farmers.

Partners

IRRI, SARMAP, DOA and ORSAC

Policy support

Disseminating accurate and real-time information on rice area for throughout cropping seasons to state government to facilitate in policy decision making, implementation of insurance products and crop damage management.



Rice crop start of season map with different colors represent to different start of season dates over rice area during Kharif-2018

Color-coded map shows the district-level estimated yield for Kharif-2018

IRRI

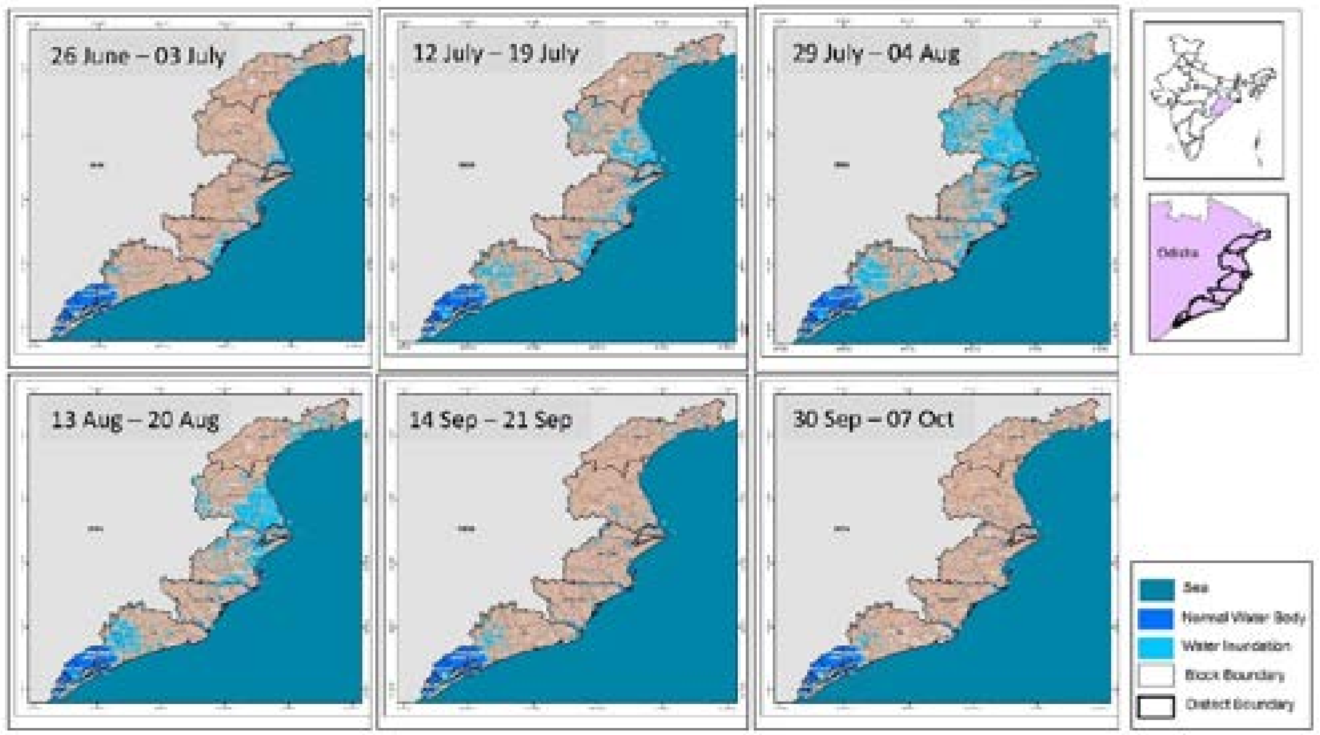
COMPENDIUM

Climate-smart Agriculture

SECTION 3

TECHNOLOGY TARGETING

3.1. Coastal flood-prone zone identification for timely establishment of paddy[23]



Weekly weather mapping using MODIS

In coastal area of Odisha, abiotic stress such as flood water inundation directly affects the rice productivity. Initial crop establishment in direct-seeded rice and survival upon submergence in transplanted rice is poor and impacts the productivity. Decoding the spatio-temporal dynamics of coastal flood prone areas through geospatial technology substantially contributes to the productivity enhancement measures.

Flood prone zone identification was done using MODIS (Aqua & Terra) 250 m EVI images at 8-day interval for 5 years, (2010-2014). Time series images between end of May to end of October for each year was analyzed to help identify the flood prone zone in each year and subsequently demarcate those areas which were relatively consistent. This work was done for coastal districts of Balasore, Bhadrak, Kendrapara, Jagatsinghpur and Puri. Later for each district, zones were aggregated at block level for necessary intervention.

Impact:

Spatio-temporal dynamics shows that Bhadrak districts was most affected flood prone zone followed by Puri and Kendrapara. Among all the years, 2014 was relatively most affected by flood.

[24]*Contribution from Amit Kumar Srivastava and Balwinder Singh, CIMMYT, New Delhi, India*

Especially between the mid-July to mid-August – and that the water receded only after the last week of August thereby affecting the possible areas of DSR and transplanting.

Scaling : Scope and pathways

Recommendation domain

Geospatial technology has the potential to monitor and evaluate the flood zone extent at landscape level, which subsequently can be an important tool for agronomist and policy makers. Moreover, availability of time-series satellite data can substantially support the dynamic decision making at regular interval. With the launch of micro satellites, the tradeoffs between spatial and temporal aspects are reducing. Recent advancement in the technology, e.g. high spatial and temporal resolution satellites such as Sentinel, Planet Lab, is crucial in mitigating risk with persistent and precise monitoring. Drones are facilitating a higher-level of precision in agricultural data by creating an opportunity for real-time monitoring. Another important and emerging aspect of this technology lies in availability of open source data, software and user-friendly toolkits, which can act as a powerful tool for not only the geospatial professional but for people who requires quick area specific or landscape level analysis.

3.2 Targeting rice-fallows: A cropping system-based extrapolation domain approach[25]

A large portion of potentially productive cropland in Odisha remains fallow during the winter (Rabi) season after the monsoon (Kharif) rice season due to three major factors: (1) lack of irrigation water, mostly in the plateaus and tablelands; (2) stagnant water causing water logging in the coastal low land areas; and (3) high soil or water salinity in the coastal zone. Late harvest of the Kharif crop or excessive soil wetting after rice harvest leads to late planting and low productivity of the Rabi crop. At issue is and major challenge for the state is how to increase productivity and profitability of these agricultural lands. Bringing these fallow lands into cultivation could substantially improve food production and enhance livelihoods of rural communities in this geography. Availability of drought-, flood-, and salt-tolerant rice cultivars and short-duration pulse crops, along with improved agronomy, water management, and mechanization, and technology targeting using GIS and remote-sensing, significant numbers of potential rice-fallows areas can be brought into cultivation.

CSA Intervention

To intensify cropping in rice-fallow lands by targeting water-efficient crops like pulses, the spatial distribution and extent of the rice-fallow system area need to be mapped. Using improved remote sensing and geospatial technologies, IRRI has carried out mapping of rice fallows (current and permanent fallows) and its spatial-temporal change (by comparing the rice fallows in the year 2006, 2010, 2016, 2017 and 2018) along with the mapping of major associated abiotic stresses (e.g., flood, drought, and salinity) and other reasons for leaving productive lands under fallow (e.g identification of areas having long duration rice cultivars). Residual soil moisture content after rice cultivation is often sufficient in most of the districts to raise short-duration pulses (55-75 days) and oilseed crops. However, a detailed analysis of spatiotemporal profiles of soil moisture availability and duration during the Rabi season was required to precisely target and utilize the short residual soil moisture window (varies from 10-30 days, depending upon land types). IRRI worked to develop extrapolation domain maps of fallows with potential for double cropping by integrating remote sensing and GIS mapping with logical decision tree approach and following it up with on-farm trials and demonstrations of pulses after rice in different locations in Odisha. Extrapolation domain mapping identifies the suitability of rice based cropping systems for targeting improved stress tolerant cultivars, agronomic and water management practices in 'underutilized stress prone rice fallow areas' in Odisha.

Impact

Rice-fallow characterization and management in Odisha

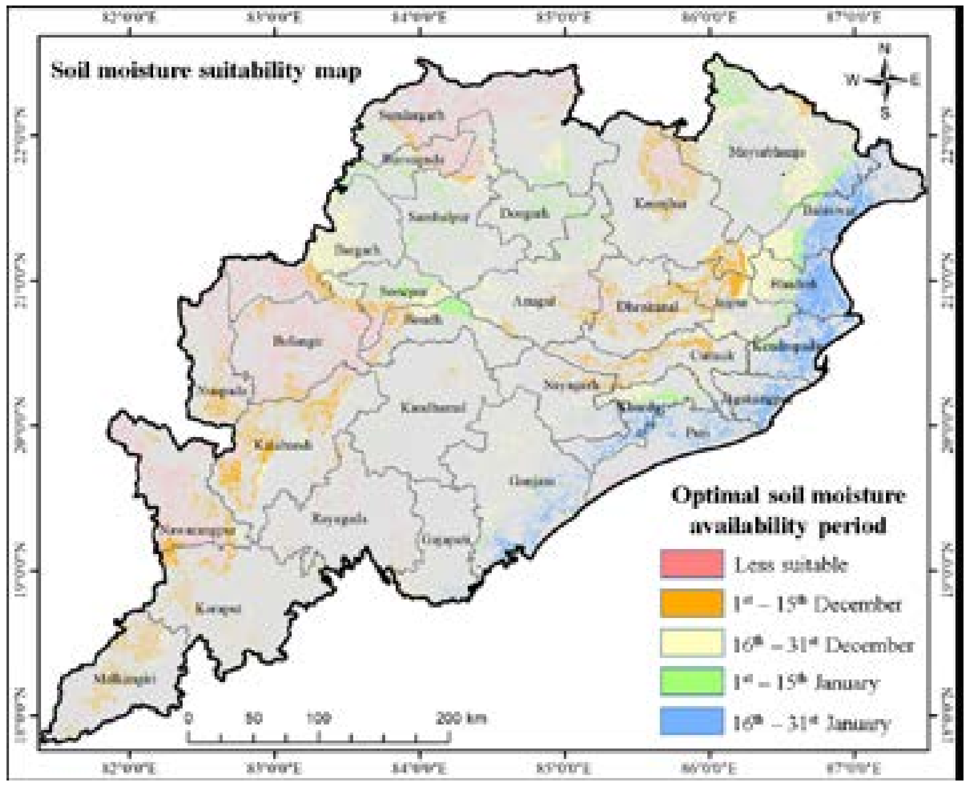
Integrated analysis of time series remote sensing satellite data of Sentinel-1 (SAR) microwave and Landsat OLI (optical) imageries for the three-year period 2016-18 revealed that fallow area ranged from 1.97 to 2.20 million ha in Odisha (40 to 45% of the net cropped area), out of which about 1.34 million ha would be considered as permanent rice fallow as revealed by the analysis of frequency of common area for the three mapping years of 2015-16, 2016-17 and 2017-18. Nine among the 30 districts, i.e., Mayurbhanj and Keonjhar district in North-Central plateau, Bargarh and Bolangir district in Western-Central table land, Baleshwar and Bhadrak district in North-Eastern coastal plain, Sundargarh district in North-Western plateau, Kalahandi district in Western undulating zone, and Nawarangpur district in Eastern Ghat highland, account for about 50% of total Rice-Fallow area. Rice-Fallow area is considerably less in the districts situated in the South-Eastern coastal plain.

Extrapolation domains using remote sensing and GIS can facilitate precise targeting and accelerate the dissemination of improved technologies in fallow areas in a fast and cost- effective manner:

- Rice-fallows and stress prone areas were effectively characterized for the entire state of Odisha
- Flood and drought prone areas were mapped for rice varietal targeting at village level
- Village wise area and suitability map of potential areas in rice-fallows were made available to facilitate targeting of water efficient suitable short/medium duration crops in rice- fallow systems in Odisha
- Improved cropping systems for Rabi and Kharif fallows were tested and recommended
- High yielding, short duration and disease resistant pulse varieties were disseminated to farmers along with best-bet agronomy, appropriate varietal selection, and sustainable water resources development through direct intervention
- Intensification and diversification is expected to enhance farmer's income with efficient agronomic management practices and land use requirements for various situations
- Rice Pulse Monitoring System(RPMS) App has been developed to collect and store geo-referenced information, along with a suite of geo-spatial tools to visualize, analyze and manipulate ground data for data management and decision making.

Quantified in range for:

- Potential crops for rice fallows could be green gram, black gram, chickpea and mustard, etc. can be grown.
- An analysis of the long-term average of spatio-temporal soil moisture profiles can assist in identifying the areas having low, optimum, and excessive soil moisture during the sowing period during Rabi. It also provides the information needed (1) to identify the areas where soil moisture is retained for a shorter or longer period after initial germination, and (2) to determine whether adequate soil moisture can be available up to the pod formation stage of the crop. This information can significantly help to decide the type and duration of the cultivars to use as well as sowing time to target the pulse crop in the rice-fallow cropping system.
- Demonstration of pulses were carried out during Rabi seasons of 2016-17, 2017-18 & 2018-19 with improved cultivation practices for green gram and black gram in 23 districts in Odisha covering more than 7,200 ha and involving more than 25,000 farmers
- Selected high yielding extra short duration (55-75 days) disease resistant varieties of black gram (IPU-31, VBN-8 and Azad) and green gram (VIRAT, IPM-02-03, IPM-02-14 and Meha-421) were demonstrated at different locations
- Short-duration, high yielding varieties, along with improved agronomy and water management practices on pulse yield, increased net profit of farmers
- A collaborative programme was initiated by



[25]Contribution from P.K. Yeggina, M. Variar, D.D. Sinha, P.K. Dhal, A. Kar, S. Sahoo and T.D. Setiyono (IRRI-Odisha, India)

ICAR and Ministry of Agriculture, India, to test five different crops in fallow areas targeting (i.e., sweet potato, black gram, green gram, chick pea, and pigeon pea) piloted on field trials in Puri district during Rabi 2018-19, involving other CGIAR organizations including CIP, ICARDA, ICRISAT and IRRI.

Scaling:Scope and pathways

Recommendation domain

The scope of advance remote sensing and geospatial analysis based targeting method including extrapolation domains can facilitate precise targeting and accelerated dissemination of improved technologies in fallow areas in fast and cost-effective manner and when combined with thorough cropping systems research, the integrative approach can facilitate increase income of farmers, the ultimate beneficiary of the technology intervention because it allows recommended contextually-relevant improved cropping systems and stress tolerant varieties (STRVs). The approach allows considerable scope 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.) and evaluating potential crops for rice-fallows (green gram, black gram, chickpea, mustard etc.) through the use of on station experiments and demonstrations in farmers' fields. Managing fallows with a sequence crop, beyond the primary benefits of increased cropping intensity and higher farm returns, also add carbon to the soil, and extract plant available N thereby reducing N2O emissions by preceding rice crops.

Partners

IRRI, OUAT, DOA, NRRI, CGIAR (CIP, ICARDA, ICRISAT)

Policy support

- Village wise area and suitability map of potential areas in rice fallows supports the DOA to disseminate pulses seeds to farmers under various government schemes
- Information on abiotic stress prone areas (Flood, Drought, Salinity) are used for stress tolerant varieties (STRVs) targeting and recommendations
- RPMS mobile application and Open WebGIS portal were developed for real time monitoring of Rice-fallows and support decision making.

IRRI

COMPENDIUM

Climate-smart Agriculture

SECTION 4

BUSINESS MODEL

4.1. Rice nursery enterprise model[26]

Nursery bed preparation for enterprise model

Odisha is an agrarian state with 70% of the state's population depending on agriculture and allied sector. Even though the quantum of rainfall in Odisha is quite high, its distribution during monsoon period is highly uneven and erratic. As a result, flood and drought occur regularly with varying intensity impacting the production of kharif rice which occupies 67 per cent of the total cropped area and plays a significant role in food security. About 50 per cent of the rice area is established through transplanting methods in Odisha predominantly in rainfed medium or lowland agro-ecology which face problems of erratic rainfall leading to the forced use of weak, older and infested rice seedlings. Delayed transplanting of paddy due to the failure of rain in July affects productivity, as over aged seedlings suffer from low tillering ability. On the other hand, 91 per cent of the farmers have small holding (<1 ha) and can't afford to raise the nursery once it is damaged due to drought/flood. In this scenario, rice nursery enterprise model seems to be an effective solution where a rice nursery entrepreneur takes it as a business to produce healthy rice seedlings in staggered manner and supplies required quantity of healthy seedlings as and when required to farmers at an affordable price. The rice nursery entrepreneur adopts best agronomy practices and this becomes a win-win model for both the entrepreneur and farmers.

[26]Contribution from Bidhan Mohapatra, Prakashan Chellattan Veettil, P. Panneerselvam, and Sudhanshu Singh IRRI-India, NASC Complex, New Delhi, India

CSA Intervention

The lack of resources and quality seed and lack of knowledge in better nursery management in times of monsoon variability demands a source from where farmers can buy healthy seedlings as and when required for transplanting. Staggered mat nursery of paddy with long, medium, and short duration varieties were raised on 15th June (1st nursery), 1st July (2nd nursery) & 15th July (3rd nursery) respectively and supplied to farmers as and when rainfall is enough for transplanting. Hence, farmers transplanted with the right aged seedlings when rainfall is enough for transplanting so farmers saved time and used rainfall effectively. On the other hand, individual rice nursery entrepreneur or SHG developing community nursery earn sufficiently by selling the seedlings in a span of two months. Individual rice nursery entrepreneur and community rice nursery groups developed and promoted in collaboration with various stakeholders like the department of agriculture and KVKs. In this model, rice nursery entrepreneur in consultation with farmers selected the variety, other inputs and management practices and grew it in staggered manner. Farmers availed seedlings from entrepreneurs when their fields got ready and when rainfall was sufficient for crop establishment. In case of extreme climate, staggered nursery raised with quality seeds in trays minimized the damage and able to supply seedling when needed. Due to the volume of business, s(he) or community could be able to minimize the cost and earn good profit.

Impact

Rice nursery enterprise is a win-win model for both entrepreneur and farmer as it opens seasonal livelihood opportunity for rural youth and women and a strong solution that ensures crop establishment by supplying healthy seedling as and when required at affordable price against critical situation of monsoon variability. It saves money and conserve resources as the entrepreneur follows best management practices to grow healthy seedlings in order to sustain his/her business.

- *Increase in Yield:* The farmers who used rice seedlings from entrepreneur increased their rice yield by 0.44 t/ha compared to farmers who uses their self-grown nursery with overaged seedlings.
- *Cost of nursery production:* The mat type nursery has less cost for producing rice nursery (INR 2381) for one ha of main field transplanting compared to manual nursery (INR 4762).
- *Improvement in resource use efficiencies:* An entrepreneur uses almost all inputs (land/seed/fertilizer/water) judiciously because of his technical skill and better-bet management practice.
- *Increase in net Profit:* An average entrepreneur made a profit of INR 15070 in a span of two months in kharif season from selling rice seedlings for 16.09 ha of main field transplanting. Similarly, manual nursery entrepreneur made a profit INR 6300 for selling rice seedlings for 7.85 ha of main field transplanting.
- *Adaptation & mitigation to climate change risk:* Due to nursery enterprises, farmers could be able to establish the crop at right time and no land was left un-transplanted.
- *Business for enhanced income:* By engaging potential individuals particularly youth and women groups through skill development promoted entrepreneurship and contributed to local economy by creating localized service provision in agriculture.

Scaling: Scope and pathways

Although low land rainfed ecology where monsoon variability is a serious issue; hugely demands such a model, it can succeed at any climate and biophysical conditions. The business model is more beneficial in rice-rice cropping system and this rice nursery model is not only useful for mechanical transplanted rice but also for manually transplanted rice.

Gender and youth relevance

Due to its low income, rural youth are departing from agriculture in rural areas. On the other hand, women are losing job in agriculture due to mechanization (in transplanting, weeding, harvesting). Hence, the nursery enterprise model has been conceptualized and successfully piloted with youth (individual entrepreneur) and women groups (community nursery) and found successful in Puri, Balasore and Bhadrak districts.

Business model perspective

If seed, why not seedling! That, if farmers are struggling to get quality seed and raising nursery under high risk, why not they buy readily available healthy seedlings from entrepreneur. This is one of the motivational factor of this model. Moreover, it has been observed that the business model is beneficial to both entrepreneur and the farmer. However, as this is new to the geography, a big push is needed. Government may launch a special scheme with substantial incentivization so that youth and women group will be able to establish seedling factories. To make it more effective and sustainable, this may be linked to mechanical transplanted rice schemes .

Partners

This module can be operationalized and established through active collaboration with international partners like IRRI, CIMMYT, IFPRI and can be scaled up through Department of Agriculture, KVKs, CBOs .

Policy support

The scheme such as Capital Investment Subsidy for Commercial Agri-Enterprises (CAE) for unit establishments and Farm Mechanization can support this nursery business model. The Govt. has been promoting line transplanting through service provision models and this can be linked with rice nursery business model.

4.2. Women-led informal seed production and distribution of climate resilient rice varieties[27]

Women Farmers involved in quality seed production

Adoption and dissemination of climate resilient rice varieties has emerged as one of the key strategies to tackle the challenges of climate change and making rice farmers in Eastern India more resilient and food secure. However, for sustained adoption of these relatively newer varieties, farmers need sustained access to affordable good quality seeds at the right time. This requires a robust seed system for these resilient varieties which are not yet mainstreamed in the formal public sector channels. Among the various approaches to achieve this, informal and social networks including farmer to farmer dissemination of seed and knowledge could play a significant role. Over the last few decades, women led community-based institutions including self-help groups and their federations have evolved as one of the strong entry points for social and economic change. Building on their capacity, community mobilization skills and wide reach, these institutions can serve as effective platforms for faster dissemination and sustainable production of seed. Their network gives an opportunity for building sustainable adoption and scaling models with a large consumer base to create demand as well as utilize the production.

[27]Contribution from Swati Nayak, Rohini Ram Mohan and Ranjitha Puskur, IRRI, New Delhi, India

CSA Intervention

IRRI in association with other CGIAR institutions and through collaborative projects like CSISA and STRASA, helped establishing an informal seed production and distribution model where new climate-resilient rice variety seeds were provided to a set of farmers within various women's SHG federations, multiplied, returned and redistributed to another set of members. This model of community led seed reinvestment proved to be one of the most effective modes for faster varietal adoption and seed dissemination in tribal areas of Odisha. Starting in the year 2014, IRRI in association with experts from NRRI organized focused training in quality seed production for community resource persons (CRPs) from two women federations in Mayurbhanj namely 'Sampurna' and 'Swayamsiddha'. These CRPs further trained other women farmers. This training was their first exposure to the climate resilient rice varieties and quality seed production practices in rice. Sahbhagi Dhan (a drought tolerant rice variety) was introduced to the upland areas through these institutions. Being the representative body for several village level women self-help groups and thousands of women farmers; these institutions not only ensured distribution of these seeds among member farmers through seed distribution and reinvestment but also saw other women farmers , especially in the neighbouring villages and communities exchanging these seeds for grains and trying them in their farms. They ensured that every farmer receiving the seeds, multiplied them and returned the same volume to community pool after the harvest. The community institutions ensured those pooled seeds and fresh procured seeds from Department of Agriculture, facilitating NGO or similar projects running in the area are re-distributed among new farmers. Equipped with advanced knowledge and skills, these women members ensured high quality seed production for themselves as well as others. This model, in spite of the lack of any monetary transactions or incentive, was a huge success as exemplified by a rapid dissemination of the variety in region, creating a demand for the seeds year after year.

Impact

Introduced to less than 1000 farmers in the year 2014-15; the revolving seed production and distribution led to scaling of Sahbhagi Dhan among 2000 additional including new farmers in the next season itself. Apart from the compulsory contribution to community pool many old farmers were also part of informal exchange of seeds with other farmers.

The key outcome of this intervention was the creation of capacities in seed production and demand for new varieties. By working with two women led institutions (federations), the know-how and seeds of the resilient rice reached several thousands of women farmers who are members of these institutions. These member farmers were also found to spread the benefits to non-members within and beyond their villages in form of information and/or seed.

Many villages where Sahbhagi Dhan was introduced with few women farmers a few years ago, now have the variety being used in almost all households. Malati, a woman leader from village Jhalkiani of Sampurna Federation says; "Every household in our village now has either grain or seed of Sahbhagi. Each one of us now consume this variety. If I recall, it was only me and few other members of our group, who had the seeds in 2014". This indicates the multiplier effect of this intervention.

Inspired by the popularity and growing demand of variety, facilitating NGOs (PRADAN) and their collaborators also simultaneously disseminated the variety in many other drought prone districts. This contributed to consolidated demand for this variety growing steadily in the state. Other women federations in nearby Keonjhar district also started asking for these varieties.

This momentum gradually helped in continuous circulation of these varieties and entering various formal channels like department of agriculture, zonal outlets of OSSC, dealers, PACS, LAMPS operating in the concerned districts. Spurred by efforts from Department of Agriculture and OSSC, the varietal landscape of the region has been gradually changing. As per primary data from dealers and OSSC growers, the sales of Sahbhagi Dhan only in Jashipur and Karanjia (the operational blocks of the above mentioned women federations) through formal channels has reached 400 quintals (catering 2000 acres) in 2018. This also indicates the potential impact of women's collectives ushering in change through their strong social and informal networks which are trust-based. Several women farmers also reported that they now don't have to exchange farm saved seeds for the variety as they have established seed supply which also ensures the seed quality, seed replacement and diverse seed sources for the community.

Apart from reported yield advantages over traditional upland varieties, many women liked the cooking quality, taste, colour of this variety and preferred to store this variety (Sahbhagi Dhan) for home consumption to use as food or in religious/ cultural events.

By the year 2017, there were several villages across Jashipur and Karanjia blocks of Mayurbhanj that witnessed introduction of other climate resilient varieties like Bina Dhan 11, DRR 42 etc. through same institutional networks.

In some villages like Patbil in Karanjia, women also reported that they faced some resistance within the households when introducing these varieties, but were successful in negotiating and trying these varieties and spreading the word about them in the village. They became proactive in seed sourcing and assessing the quality of the seeds procured for the season. The exposure to new package of practices and extension support through the village level federation of SHGs ensured that women were more confident and involved in varietal selection.

Scaling: Scope and pathways

The womens' SHG network has proved to be one of the strongest community platforms for introduction, scaling and adoption of technologies, seeds and knowledge. The role of the federations and Village Organizations (VOs) can be further strengthened through access to modern technology, equipment, and knowledge support around large scale seed production programmes for all potential varieties. This can give a significant boost to state level varietal replacement programmes and strengthen seed system of new climate resilient varieties.

With existing exposure to book keeping and coordination skills, their business development skills can be enhanced to run commercially-oriented enterprises around seed and other products. Encouraging more villagers to take up seed production by helping them identify assured markets, aiding the planning and procurement of the materials, assisting the mobilization of resources to establish machinery for processing are a few of the immediate actions that can sustain the interest of these groups in running enterprises.

Many trained community resource persons, master trainers, and women farmers from community as individuals or collectives can be linked to the formal seed certification process and registered as growers for public or private seed suppliers.

Partners:

IRRI, CIMMYT, DOA, NRRI, PRADAN

Policy support

National Rural livelihood Mission supported programmes around women farmers' empowerment, MKSP (Mahila Kisan Shashaktikaran Pariyojna); and initiatives by Odisha Livelihood Mission; programmes like Mission Shakti; and Seed Village programmes of Govt. of Odisha are some of the best opportunities to replicate and scale out these models and equip these institutions with skill and resources for spurring further growth and development.

4.3. Community mat nursery: ensuring availability of paddy seedlings under contingent situations[28]

Transplanting has remained as a potential establishment method whereas manual transplanting is a common practice. With rising labor crisis and uncertainty in water availability sometimes it is delayed and old seedlings result in yield reduction. Mechanization has come to the rescue under such adversary which saves around 40 labour days on uprooting and transplanting normal seedlings.

[28]*Contribution from S. Biswal, T. Panigrahi, OUAT, Bhubaneshwar, Odisha*

CSA intervention

Farmers adopted this technique and jointly produced seedlings to ensure timely transplanting of correct age seedlings of higher productivity and reduce the risk associated with deficit or delayed onset of monsoon.For mechanical transplanting mat nursery has proved an additional advantage which saves 90% land, 20-25 kg seed as against conventional method which requires 1000 m^2 nursery area and 62-75 kg seed.

Farmers picked up timely nursery and are getting a good crop results

Impact

A community nursery in 5 acres/panchayat and 150 acres in each district was taken up. The subsidy for each nursery given to the farmer is Rs.6500/acre to cover the cost of production and Rs.1000/acre to farmers for purchasing of seedlings for transplanting in 10 acres from 1 acre of nursery. The total amount supported by the department for 1 acre of community nursery worked out to Rs.16,500.

Scaling: Scope and pathways

State Department of Agriculture has launched a scheme for promoting farmer managed community nurseries under assured irrigation to make paddy seedlings available for transplanting to meet contingent situations. It is suggested to promote community nursery with short duration varieties in the event of deficit rainfall situation / early drought in July as is experienced in several districts .

Recommendation domain

In rainfed ecology where monsoon variability is a serious issue; badly demands such an approach. However it can succeed at any climate and biophysical conditions. The community nursery model is more beneficial in rice-rice cropping system. It is not only useful for mechanical transplanted rice but also for manually transplanted one.

Gender and youth relevance

Majority of farm activities are carried out by women in growing paddy. However they are losing jobs due to mechanization. Hence, the community nursery model has been conceptualized keeping women farmers, SHGs and has been found successful in Puri, Balasore and Bhadrak districts.

Business model perspective

When farmers are struggling to get quality seed and raising nursery under high risk, they shall prefer to buy readily available healthy seedlings from community nurseries. This is one of the motivation factors of this model. Moreover, it is beneficial to both entrepreneur and the farmer. However, for this support and encouragement from government sector is essential. Government may launch a special scheme to incentivize the youth and women groups who will be able to establish seedling community nurseries.

Partners

- Department of Agriculture, KVKs, CBOs, CSISA partners – IRRI, CIMMYT, IFPRI
- Potential partners for scaling – Department of Agriculture, KVKs, CBOs, women SHGs

Policy support

The Govt. has been promoting line transplanting through service provision model which can be linked with community nursery model.

IRRI

COMPENDIUM

Climate-smart Agriculture

SECTION 5

CAPACITY DEVELOPMENT

5.1. Creating a standardized knowledge platforms for institutional capacity development[29]

Using ICT devices for diagnostics

Rice food security is a priority issued for national governments. Shortfalls in production can accentuate food prices, which can in turn impact the government itself. National rice research institutions are responsible for the rice-based systems recommendations for their country. Recommendations for farmers for variety choice for the diversity of ecosystems, for crop management from seed to market and pest management demand credible knowledge and recommendations from scientists and informed extension services. This underpins the public system and this feeds into the institutional knowledge of the diverse actors working for extension of rice knowledge for farmers. In the current scenario, farmers and extension agents are subject to pluralistic extension systems that convey contrasting and conflicting knowledge and data, often biased. Small farmers in the most marginalized of ecologies and communities, especially women are the group that struggle the most when it comes to receiving on time, coherent, up-to-date knowledge. What is the way forward and can neutral organizations like IRRI play a role in this process?

CSA Intervention

Advances in technologies source from different origins and collating knowledge that is up-to-date, credible, timely and in formats understandable to farmers is a big challenge. Equipping multiple extension services with these messages to establish the feedback loop with ongoing research is an added layer of complexity. ICT platforms for knowledge exchange and learning are a means for bridging the divide and have been major game changers. The response by IRRI to the challenge of translating research into extension communication for giving farmers access to knowledge on new technologies was initially internal. IRRI built the IRRI Training Bank that became the IRRI Rice Knowledge Bank (RKB). This extended to working with national research/extension institutions for building their own knowledge banks in local language. A key principle in the development of the RKB was single source publishing, which allowed credible content to be used in multiple communication formats. The RKB approach was to enable a collation of rice-based knowledge that was country specific and reflected national agricultural authority. This is then accessible to ICT intermediaries and rural services agencies for using as is, or repackaging for dissemination through to farmers.

RKB has over the years developed a systematic approach to working with national partners for the development of their own knowledge bank or a knowledge platform, through workshops and discussion fora. Key components of country knowledge platforms are

- Bringing together a wide range of stakeholders from government research and extension institutions and agricultural information services, civil society organizations and as available the private sector
- Exercises on priority extension materials to be developed.
- Types of communication materials
- Capacity building needs of actors in multiple channels
- Consistency of messaging

Impact

The example of knowledge banks for rice as an example is illustrated with IRRI and the case studies of Bangladesh and the Philippines where processes and knowledge are transferable and scalable for agricultural enterprises beyond rice. The process followed for the knowledge platforms can equally be applied to vegetables, livestock, fisheries and non-rice crops.

Scaling: Scope and pathways

A credible source of knowledge in a system can serve as a hub within countries for dissemination of the information needed for coherent and rapid out scaling of new technologies. The out scaling agencies may be the Department of Agriculture Extension or Agriculture Information Services, or NGOs with an ICT for Extension program or ICT private sector companies which are adding value to information for farmers (examples are Digital Green using the rice knowledge platform as the source for its virtual training institute, OLM using the RKB as a base for building their knowledge on rice). A government institution may have limited ICT capability but its role in credible content becomes a low cost win for dissemination. A further example is the south-south video extension model of Access Agriculture (http://www.accessagriculture.org/). Its video library can be extended through local NGO video development for new technologies as promoted on the national rice knowledge platform for scaling out within country and potentially used in other countries.

For the range of private sector ICT for Extension companies open access to the national knowledge platform is essential for converting into call center services for extension. At present a practice has been for an ICT for Extension firm to hire young agricultural graduates or consultants to compile extension material. The recommendations provided for farmers may or may not resonate with the national research and extension efforts. Scaling through multiple agencies is desirable but with credible content.

[29] *Contribution from Poornima Shankar, Shakti Prakash Nayak and Noel Magor, International Rice Research Institute, New Delhi, India*

5.2. Village-level seed training to combat seed shortages in groundnuts[30]

Training farmers on improved seed storage options for groundnut

Groundnut is the most promising oilseed crop of Odisha. It covers 2.7 lakhs ha in kharif rabi. Most of rabiareas depends on residual soil moisture. This necessitates early sowing. But seed material available from kharif produce is not sufficient for rabi crop. Hence state depends on seed supply from adjoining states. This is usually delayed and so yield loss is an usual phenomena. Farmers also get exploited by the middle men who supply seeds and in return pick up the entire produce at low price besides charging heavily for seeds, fertilizers and pesticides in terms of interest. Thus timely availability of quality seeds for rabigroundnut that too at a lower price is a great headache for the State Department of Agriculture.

Impact

The groundnut seeds loses viability when stored in kharif season due to its exposure to high humidity. Storing seeds with $CaCl_2$ gives prompt and effective germination.

Farm women were mostly trained to store seed groundnut using $CaCl_2$. As a result farmers could 100 per cent good and bold and perfect quality seeds. This could realize 87 per cent germination and 2.38 t/ha yield as compared to 83 per cent germination and 2.14 t/ha yield with fresh seeds. With an expenditure of Rs 39,243/ha farmers could be benefitted to the tune of Rs. 79,757/ha. In addition this could free the farmers from bondage with middle men.

Scaling: Scope and pathways

This technology can be used by each and every groundnut farmer of the state if only $CaCl_2$ and polybags are made available so that the crop can be sown in time using farmers; own seed that too at a lower price.

Recommendation domain

Groundnut grown in rabi season under stored soil moisture where kharif produce/seed is not available in sufficient quantity (most of costal districts having deltaic alluvium) can be covered under this and early sowing in rabi season can ensure proper and prompt germination.

Gender and youth relevance

Rural youth, preferably farm women and farmers organisations after expertizing can try this technology in a business mode. They can procure seeds at harvest at a lower price, can store it for the local farmers and sale them at sowing time at reasonable price and can earn huge profit.

Partners

State department of Agriculture, Odisha State Seed Corporation, women SHGs and farmers' organization and OUAT can work jointly to address this vital issue and solve the crisis.

Policy

State Govt. need to encourage the farmers to store their own seeds and save lot of money spent on seeds, purchase and transport and also can save lot of precious time at critical period in ensuring seeds availability at farmer door step. Rather a part of this expense can be diverted in providing $CaCl_2$ and storage bags. Ultimately this can ensure timely sowing and higher productivity and higher return to farmers and to the state.

[30]Contribution from S. Biswal and T. Panigrahi, OUAT Bhubaneshwar, Odisha

5.3. Increasing capacity of grass root level extension workers in using ICT based tools[31]

At present the extension personnel in department of agriculture has the major responsibility of transferring technologies to the farming community from time to time. But at this juncture the personnel also have the limitation of transferring field specific crop management practices to the farmers in a user-friendly way. The existing transfer of technology mechanisms and extension programs mostly government run are either slow or ineffective in bridging the linkages between the research community and the farmers. This is partly due to inadequate exploitation of new means of knowledge and information dissemination by these agencies.

CSA Intervention

Using the principles of SSNM, IRRI has developed the Rice Crop Manager (RCM), an application that provides farmers with crop management recommendations tailored to their fields and rice-growing conditions through the internet and text messages. In collaboration with the Government of Odisha, IRRI is investing in developing the capacity of extension workers

[31]Contribution from Sheetal Sharma and Preeti Bharti,IRRI, Bhubaneshwar, Odisha

to ensure the sustainability of the usage of RCM. The extension workers at the block and village-level have been trained through Training of trainers (ToT) programme to operate the tool, interview the farmers and to transfer the crop management advisories to them in a printed one-pager format. Till date around 2800 extension officials have been trained on how to use the RCM app. To re-inforce the advisories, reminders are also sent through voice-calls and text messages to the farmers. As the adage goes "seeing is believing", demonstration plots are established and through crop cuts farmers are made aware of the comparative advantage of following RCM recommendation over the conventional practices.

Impact

- Over 100,000 recommendations have been generated for rice growing farmers of Odisha, Bihar and Eastern Uttar Pradesh
- Use of RCM recommendations resulted in an average yield increase of 1t per ha equivalent to around USD 188 /ha/cropping season
- Around 2,800 extension workers of DoA and NGOs in Odisha were trained to use the RCM app. These extension workers are disseminating recommendations to the rice growing farmers of their area.
- 101 RCM kendras (centers) have been established at district and block agricultural offices, NGO offices across the state of Odisha to function as one-stop information hubs for nearby farming communities. These kendras are equipped with ICT devices used by trained extension staff of the DoA to provide RCM recommendations to the farmers.

Crop advisories through voice and text messages are being sent to registered farmers on their mobile phones throughout the season.

Scaling : Scope and pathways

- Soil, Climate & Biophysical conditions
- Cropping/production system

Gender and youth relevance

In India, women's role in agriculture has been traditionally limited to transplanting, weeding, and similar tasks. Although rural women play a significant role in agriculture, their leverage to influence decision-making for purchasing and applying fertilizer and other inputs in the field remains low. IRRI is working towards creating awareness among women farmers regarding balanced nutrient application, soil health and improved crop management practices by providing them with RCM recommendations and explaining them the advisories. They are also being involved in establishing trials and demonstrations. These women farmers who have already benefitted from following RCM recommendation can be a potential channel for promoting RCM among other farmers at large scale. Similarly, village youth who own android phone and are proficient users can be trained to use the RCM app and to disseminate RCM recommendation among nearby farmers.

Business model perspective: There is a huge potential to develop dissemination of RCM recommendations through a business model. Developing a business model will also ensure sustainable availability of RCM recommendations at a large scale. There are many organizations/ service providers in the state, which use ICT kiosk model to deliver a range of services among farmers/rural people. There is a possibility to collaborate with these existing system, build their capacity on RCM app usage, and to deploy those to disseminate RCM recommendation to farmers by charging a nominal amount for the services.

Partners

RCM was introduced in Odisha in 2013 for rice. It was adapted, developed, evaluated, and verified in partnership with Indian Council of Agricultural Research-National Rice Research Institute and Odisha University of Agriculture & Technology. The development of Rice Crop Manager was made possible through support from the Cereal Systems Initiative for South Asia (CSISA), funded by the Bill and Melinda Gates Foundation and the U.S. Agency for International Development. In 2015, IRRI and the Government of Odisha signed a memorandum of understanding.

IRRI

COMPENDIUM

Climate-smart Agriculture

SECTION 6

POLICY

6.1. Climate smart agriculture village policy for Odisha[32]

Using farmers participatory approaches for policy interventions around CSA

After 60 years of contraction of its share in Gross State Domestic Product (GSDP), the monsoon dependent agriculture sector of Odisha has started reviving since 2010. The share of agriculture & allied activities in GSDP increased from 17.9% to 22.2% between the year 2011-12 and 2014-15. Farm mechanization, soil health management, assured irrigation, fertilizer use, organic and integrated farming and extension of agricultural services are key policy and institutional support given by the state government during this period. Despite that, the revival process of agriculture sector in Odisha is not stable, rather fluctuating. In the year 2016-17, agriculture sector in Odisha observed an unprecedented high growth of 20%, whereas there was 13% fall in growth in the preceding year. Climate variability and its impact on agriculture is one of key factors behind this fluctuations in agricultural growth of this state. Intermittent incidence of drought, flood and extreme weather events like cyclone are most frequently observed climate incidences in Odisha that affect agricultural production and growth. Further, it has been predicted that the climate (temperature and rainfall) may get worse in Odisha. Studies on the state's rainfall and temperature variations reveal that the summers are getting longer, and the intensity of rainfall has increased in the state (Orissa Climate Change Action Plan 2010–2015).

Therefore, to adapt with this climate variability, reducing risk due to climate related shocks and increasing resilience are key pillars for sustainable and steady growth in Agriculture sector and are the need of the hour. To achieve this, emphasis on integration of climate action strategies in existing schemes and policies both at national and sub-national levels are essential. In this context, the Government of India's National Action Plan on Climate Change (NAPCC), 2008 was a comprehensive strategy for dealing with the inevitable impact of climate change, which required adaptation measures in several critical areas as well as mitigation of emissions of Green House Gases (GHGs). The Union Government has also set up 12 missions to respond to climate change through different mitigation and adaptation measures. Odisha is one of the states to formulate a comprehensive Orissa Climate Change Action Plan (2010-2015) followed by Odisha State Climate Change Action Plan (2015-2020).

[32]Contribution from Barun Deb Pal, IFPRI, New Delhi, India

Although the Odisha State Climate Change Action Plan (hereafter SAPCC) is a welcome step towards identifying vulnerability and an agenda for taking suitable adaptation and mitigation measures. Agriculture sector needs special attention andlot need to be done to implement climate actions for agriculture sector. Climate Smart Agriculture in this context would be logical step to transform Odisha's agriculture into adaptive, resilient and sustainable under progressive climate change scenarios.

CSA Intervention

Several of India's policies and programmes already directly or indirectly address climate change impacts on the agricultural sector covering many of the CSA approach components. However, this is currently being done in an uncoordinated manner and are not uniformly spread across the country. For example, NMSA is currently focusing on rainfed areas, whereas climate change vulnerability is also arising in irrigated areas. Given that human and financial resources are scarce it will be more effective and efficient to have a synergized national policy to address climate change in the agricultural sector.

This policy will bring about convergence of all ongoing as well as proposed activities at the national and state level related to climate change adaptation and mitigation. It is further proposed that emphasis be laid on considering agriculture as part of a larger landscape to make the system more integrated and sustainable. Such a policy can aid in judicious utilization of natural, physical and financial resources as well as alleviate poverty and food insecurity conditions under climate change and variability.

What distinguishes climate smart village from other developmental models is its explicit consideration of climatic risks that are emerging more rapidly and with greater intensity today than in the past coupled with emphasis on addressing adaptation and mitigation challenges. The Climate Smart Village approaches entail higher investments in (i) managing climate risks; (ii) understanding and planning for adaptive transitions that may be needed and iii) exploiting opportunities for reducing or mitigating greenhouse gas emissions, where feasible.

Impact

According to the Standing Parliament Committee on Agriculture in India, there is already a discerning effect on food grain production due to climate change. Further, Significant negative impacts have been projected with medium-term (2010-2039) climate change, for example, yield reduction by 4.5 to 9%, depending on the magnitude and distribution of warming (Standing Committee on Agriculture, 2017). Since agriculture makes up roughly 20% of Odisha's GSDP, a 4.5 to 9.0% negative impact on production implies cost of climate change to be roughly between 1 to 2% of GSDP of Odisha per year. Since more than 60 % of people of the state depend directly or indirectly on climate sensitive agriculture sector and concentration of poor is high in rural areas than in urban areas, climate change impacts will increase income inequality in this state. Therefore, transforming agriculture into more adaptive, resilient and sustainable is need of the hour for rural development of Odisha.

To achieve this goal Climate Smart Agriculture Village Programme can be an integrative approach to address the interlinked challenges of food security and climate change that aims to:

(i) sustainably increasing agricultural productivity, to support equitable increase in farm incomes, food security and development;

(ii) adapting and building resilience of agricultural and food security systems to climate change;

(iii) and reducing greenhouse gas emissions from agriculture

Scaling: Scope and pathways

Benefits of a village level approach are already being demonstrated through the programme on National Innovation for Climate Resilient Agriculture (NICRA) in 121 villages across the country covering its 11 agro-climatic zones. Also, Climate Smart Agriculture pilot projects are being implemented through the CGIAR research programme that are showcasing successes in making agriculture at village level climate resilient.

Keeping in view that the vulnerability level of districts across India will change as the climate warms in short, medium to long term (CRIDA, 2013), the Climate Smart Village Agriculture policy must be dynamic and evolve with the changes across time and space.

The starting point to implement this policy will be the Village Agriculture Plan. The program will need to lay special emphasis on developing village level plans for sustaining agriculture production systems, food and livelihood security for all villages that have been classified as, high and highly vulnerable to climate change as per the CRIDA assessment (CRIDA, 2013). Therefore, budgetary provisions need to be made to enable making of these plans. The plans will be guided by an initial climate change vulnerability assessment done using NICRA guidelines on the same. Based on the vulnerabilities assesses the CSA practices will be identified that will be introduced in the villages and corresponding proposals formed. These will be formed by the villagers with scientific inputs from the departments. While considering the best technological practices the plan will enable the following:

- Optimized sustained agriculture production in the wake of climate change
- Ensure food security of the village or cluster of villages
- Ensure livelihood protection of the farmers

Policy support

Possible convergence of CSA components with existing programmes and schemes of the government

Practices	Possible Interventions	Programmes/Schemes
Soil Management	• Adopting Zero Tillage • Increasing mulching practices • Growing leguminous species for nutrient replenishment • Promoting the use of organic fertilizers • Choosing urea-based fertilizer over ammonia based Nitrogen fertilizer • Contour ploughing • Micro-catchments • Land terracing • Contour stone bunds	• National Mission for Sustainable Agriculture (NMSA) • Rashtriya Krishi Vikas Yojna (RKVY) • Soil Healthcard Scheme • National Afforestation Programme (NAP) • National Food Security Mission (NFSM) • New Urea Policy (2015)
Crop Management	• Use of drought tolerant varieties • Use of heat tolerant varieties • Use of shorter duration varieties • Use of pest and disease resistant varieties • Crop diversification	• National Food Security Mission (NFSM)
Water Management	• Aquifer recharge • Rainwater harvesting • Community management of water • Laser leveling • On-farm water management • Precision Irrigation	• Prime Minster Agriculture Irrigation Plan (NSCAVP) • National Mission for Sustainable Agriculture (NMSA) • RashtriyaKrishiVikasYojna (RKVY) • National Food Security Mission (NFSM) • Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) • Mission for Integrated Development of Horticulture (MIDH) • Scheme for Repair, Renovation and Restoration (RRR) of water bodies

Practices	Possible Interventions	Programmes/Schemes
Livestock Management	• Improved feed resources • Vaccinations programmes • Use of disease resistant animals • Management of herd size and age structure • Livestock insurance	• National Livestock Policy • Rashtriya Krishi Vikas Yojna (RKVY) • Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS)
Fisheries and Aquaculture	• Prevent coastal habitat destruction • Selective breeding and genetic improvements • Weather warning systems	• Rashtriya Krishi Vikas Yojna (RKVY) • Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS)
Forest and Agroforestry Management	• Integrating trees in farming systems	• National Agroforesty Policy • National Afforestation Programme (NAP) • Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS)
Energy Management	• Use of biofuels • Residue management • Minimum tillage • Use of solar pumps	• Renewable Power Program • Rashtriya Krishi Vikas Yojna (RKVY) • National Food Security Mission (NFSM)
Landscape Approach	• Land use planning • Landscape management	• National Agroforestry Policy
Value Chains	• Increase production and harvest efficiency • Investment in storage and cooling facilities • Improvement in packaging and processing techniques • Improvement in transport infrastructure • Improving access to markets • Promotion of agri-businesses	• Integrated Scheme on Agriculture Marketing (ISAM) • National Food Security Mission (NFSM)
Index Based Insurance	• Financial support to farmers for losses due to unforeseen circumstances	• Pradhan Mantri Fasal Bima Yojana (PMFBY) • Livestock Insurance Scheme
Climate Information Services	• Timely dissemination of climate information	• National Mission for Sustainable Agriculture (NMSA)

References:

- C.A. Ramarao, BMK Raju, AVM Subba Rao, KV Rao, VUM Rao, Ramachandran, B Venkatesarlu, AK Sikka, 2013. Atlas on Vulnerability of Indian Agriculture to Climate Change. Published under the aegis of National Initiative on Climate Resilient Agriculture (NICRA) by Central Research Institute for Dryland Agriculture, ICAR.
- Standing Committee on Agriculture, 2017. Comprehensive Agriculture Research based on Geographical Conditions and Impact of Climatic Changes to ensure Food Security in the Country. Ministry Of Agriculture And Farmers Welfare.
- Odisha Economic survey 2017-18, Planning and Convergence Department, Government of Odisha.

6.2. Intensifying rice fallows with pulse crops in Odisha[33]

Fallow fields with pulse crop cultivation

[33]Contribution from Kaushal Garg, Girish Chander and Sreenath Dixit ICRISAT, Patancheru Telangana, India and Arabinda K Padhee, Director, ICRISAT, New Delhi, India

In Odisha, paddy crop is mainly cultivated in kharifseason covering 30.74 lakh ha. After paddy cultivation in Kharif, only 18.51 lakh ha is cultivated in rabi, while other 12.2 lakh ha is left as fallow. Under the climate change scenario, tropical wet-dry ecosystems have undergone a noticeable change and the pulse production under this zone has reduced by more than 56%. To address the growing concerns with regard to climate change and its impact on farming systems, there is a need to build climate resilient/ climate smart farming practices to sustain and stabilize crop productivity.

Rice-Fallow cropping system is one such climate smart farming practice that address the climate change impact on farming systems. The climate of the Odisha state is hot sub humid with hot summers and mild winters, the mean winter temperature and rainy days are most suitable for rice fallow pulse production. Utilizing the rice-fallow cropping system will help to build climate resilience and also improve farmers' livelihood and contribute to India's enhanced pulse production.

CSA Intervention

Rice-fallow cropping system helps farmers to grow two crops a year, where traditionally farmers used to grow one crop. This system includes early maturing varieties of rice with pulses viz. chickpea, green gram and black gram. As this system allows rice to be harvested early, allowing to cultivate pulses to take advantage of the residual moisture stored in the soil with minimum tillage. This practice allows farmers to grow a second crop with no additional cost on irrigation and tillage.

Rice-fallow cropping system requires no/ minimum tillage, no basal fertilizer application, no weeding and can harvest crop in five months. After harvest of the paddy crop, one shallow cultivation is required followed by dibbling of seeds at spacing of 30 x 20 cm. Foliar spray of 2% urea at 20-30 days after sowing followed by spraying of 6% urea at every 15-20 days interval during vegetative stage will boost the crop productivity. Preventing the pulse crops from cattle grazing (through community participation) would be desirable.

Impact

Cultivating pulses, such as chickpea, after rice fallow utilizes the available residual moisture for 2-3 months, enhances soil nutrient status to the succeeding crop, fix nitrogen up to 140 kg/ha, increases soil health by adding organic matter, provides farmer feed and fodder to livestock with productivity of 1500 kg/ha, which provides additional income to farmers.

Scaling: Scope and pathways

Recommendation domain

Soil, Climate & Biophysical conditions:

Rice-fallow pulse system can be adopted in all 30 districts, however, districts with large area under rice fallows such as, Balasore, Bhadrak Mayurbhanj, Bargarh, Jharsuguda and Sundergargh hold good potential to scale-up. This system can also be extended to other districts of the state where rice fallow is predominant.

Gender and youth relevance

Provides livelihood and employment opportunities while enhancing the productivity and income through crop intensification.

Business model perspective

Value addition system (particularly, mini Dal mills and processing facilities in the vicinity of production areas) can provide additional employment and remunerative income to youths.

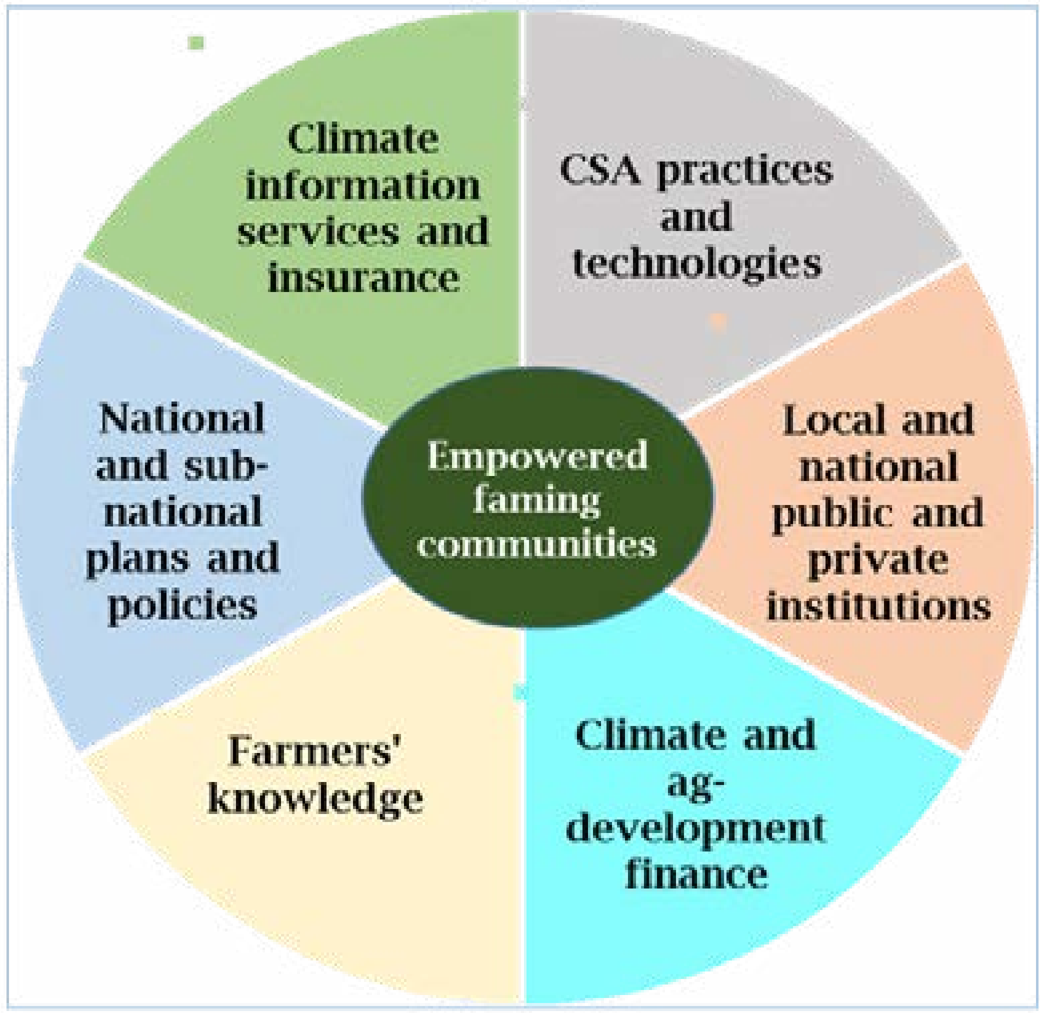
Partners

Govt. of Odisha, Odisha University of Agriculture and Technology (OUAT), IRRI and CIMMYT.

Policy support

ICRISAT is implementing a project supported by the Government of Odisha on "Enhancing Agricultural Productivity and Rural Livelihoods through Scaling-up of Science-led Development in Odisha: Bhoochetana". The objectives of the project include assessment of the nutrient status of agricultural soils and to identify the best soil, water, crop and nutrient management options for increasing productivity in all the thirty districts of Odisha in partnership with the Department of Agriculture, OUAT and other partners from Odisha through convergence of different initiatives.

6.3. Climate-smart villages: Bundling of CSA technologies, practices and services[34]



Components of a CSV-Agriculture Research for Development (AR4D) approach

Odisha is one of the most vulnerable states to climate change. Rise in average temperatures, changes in rainfall patterns, and increasing frequency of such extreme weather events as dense fogs, snow and hailstorms in winter, droughts and heavy rainfall, and even floods in rainy seasons have been observed in different agro-ecological zones of the state, posing significant threats to livelihoods and food security. Experts have devised technological, institutional, and policy interventions to manage these climate risks and to mitigate GHG emissions. Action is now needed to integrate top-down government schemes and scientific innovations into climate-smart villages, which are already in operation in several Indian states to build the resilience of Odisha's agriculture to climate risks.

[34]*Contribution from Arun Khatri-Chhetri and Pramod K Aggarwal CCAFS, BISA-CIMMYT, New Delhi, India*

CSA Intervention

Climate Change Agriculture and Food Security (CCAFS) Program has designed a Climate-Smart Village (CSV) approach using participatory methods to test technological and institutional options for dealing with climate change in agriculture. Started in 2012 in India and now active in several states, it aims to scale-up and scale-out effective options. The testing is done by a multi-stakeholder collaborative platform at the CSV sites, which are generally a cluster of villages. The goal is to generate evidence on synergies and trade-offs between options in terms of productivity, adaptation, and mitigation. Figure below illustrates the major components of a typical CSV approach. There is no fixed package of one-size-fits-all interventions. Options differ based on the CSV site, its agro-ecological characteristics, the level of development, and the capacity and interest of the farmers and local government. The results are usually a portfolio of CSA options and institutional and financial mechanisms that can be scaled up by the state government, NGOs, and private groups in the region (Aggarwal et al. 2018).

Odisha experiences frequent drought and flood; its 480 km long coast line is cyclone prone in most part of the crop season. The climate of the Odisha state is hot sub humid with hot summers and mild winters. The farmers are mostly small and marginal groups having low income and so low risk taking ability. Thus the state is greatly affected by the climate change in terms of farm production, income and livelihood. Rice being the major crop of the state, attempts are made to intervene selectively to make the rice based farming system climate smart. Few of such suggestions are detailed below.

- Stress tolorent crop varieties(both biotic and abiotic) that can face Challenging weather conditions like drought, flood, cyclones can make farming smart and resilient. A basket of options can widen the resource base under unforeseen exigencies.
- Sixty five Per cent rice area is grown rain fed where the sowing/ planting window is quite narrow due to erratic rainfall. Similarly early and quick harvest is required to get rid of cyclonic/ thunder storms at harvest in both kharifand rabi season. But labour crises does not allow it in time. This necessitates mechanisation (transplanter and combine harvester) that can save time as well as the labour cost and can avoid massive crop loss. Establishing custom hiring centers can also create rural employment.
- Alternate irrigation system (like AWD) with channel to field irrigation can save water loss, extend crop area and increase crop growth and yield by facilitating root respiration.
- Laser land levelling can save water resource by higher distribution efficiency, ensures timely harvest and sowing of successive crop with uniform moisture status.
- Resource conserving rice establishment methods (DSR, NPTR) carry better scope in resource scarce farming for climate resilience.
- Using solar power for irrigation and other farm processes can avoid dependancy on electricity / fossil fuel in inaccessible areas and for timely farm operation.
- Establishing commercial Community paddy nurseries , by individuals or in groups, can supply Right aged seedlings as per the requirement under exigencies and can benefit both the farmers and entrepreneurs.
- Real time nutrient management approaches by use of RCM, green seekers etc can effectuate precission agriculture, increase productivity, profitability and sustainability.
- Integrated pest and weed management approach can reduce the chemical load, GHG emission , can be cost effective, productive and sustainable.
- Conserving crop residues, especially paddy straw, and recycling it can add to soil health; reusing it can add to the income.
- Crop diversification from rice-rice system to rice-green gram / ground nut system can save water and other resources, reduce GHG emission, can restore soil health and can render higher profit.
- In Odisha, paddy crop is mainly cultivated in kharifseason covering 30.74 lakh hectare (ha). After Kharif paddy, only 18.51 lakh ha is cultivated in rabi, while other 12.2 lakh ha is left as fallow. Growing pulses with heat tolerant varieties can take advantage of the residual moisture stored in the soil with minimum tillage in rice-based system. Processing and value addition can make the approach more remunerative particularly to farm women.
- Capacity building for seed storage can ensure timely sowing for effective utilization of resources including residual moisture, can reduce the cost and increase yield and profit.
- Smart agro-advisories ensure timely farm operations, can protect the crop and the farmers.
- Convergence of various schemes and partner and stake holders can make the mission rapid and fruitful.

Impact

Currently, the government of Haryana, in collaboration with CIMMYT, is implementing the results of the CSV sites in 500 villages with a focus on resource-conserving machinery and sensors for optimizing fertilizer use and reducing GHG emissions. The governments of Bihar, Maharashtra, Madhya Pradesh, and

Telangana have also proposed to finance use of this approach for building resilience in agricultural systems in thousands of villages. The government of Odisha might also seriously consider establishing at least 5 CSV clusters in four regions of the state.

Scaling: Scope and pathways

Research in the states of Punjab, Haryana, Bihar, Maharashtra, and Telangana has yielded models of CSA portfolios for building resilience that can be adapted for Odisha. Following are thus needed:

1. Establish CSV sites as learning platforms for building evidence for CSA. Individuals and collectives of farmers, local governments, industry, and other stakeholders may be involved, along with knowledge centers like state agriculture universities, the Odisha Climate Change Knowledge Centre, Krishi Vigyan Kendra(s) (KVK), and Indian Council of Agriculture Research (ICAR)/ Council of Scientific and Industrial Research (CSIR)/ state institutions, in participatory evaluation of all the CSA technologies and practices.
2. Organize farmers' fairs, video testimonials, and village bulletins to disseminate good CSA practices and promote farmer-to-farmer learning.
3. Create strategies to integrate the portfolio of options from CSV sites with the agricultural development strategies and programs of the government and donors.

Partners

BISA, CIMMYT, ICAR, State Govt.

Policy support

The government of India is taking a similar approach in most states through its National Initiative on Climate Resilient Agriculture (NICRA) program.

COMPENDIUM ON
CLIMATE-SMART AGRICULTURE

The Compendium seeks to provide an overview of approaches and practical tools to support extension services in the field of climate-smart agriculture.

For more information please visit on link

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