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Popularising **CLIMATE SMART AGRICULTURAL TECHNOLOGIES** through **MODEL CLIMATE SMART VILLAGES**

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NORWEGIAN INSTITUTE OF BIOECONOMY RESEARCH

ICAR-NATIONAL RICE RESEARCH INSTITUTE
CUTTACK, ODISHA, 753006, INDIA

POPULARISING CLIMATE SMART AGRICULTURAL TECHNOLOGIES THROUGH MODEL CLIMATE SMART VILLAGES

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FOREWORD

Climate change has become one of the serious ecological, economic and social challenges for the world and especially for many developing countries including India. It is going to affect production of crops including rice, which is the most important cereal crop and staple food for more than half of world's population. Increase in temperature, fluctuations in precipitation, reduced water availability and occurrence of frequent extreme weather events may result in reduced agricultural productivity and are likely to aggravate the problems of food and livelihood security in future. In India, small and marginal farmers constitute >80% land holders, who are more vulnerable and likely to be affected the most by the adverse impacts of climate change.

ICAR-National Rice Research Institute, Cuttack in association with Norwegian Institute of Bioeconomy (NIBIO), Norway and Dr. MS Swaminathan Research Foundation, Chennai is working in collaboration through different projects to enhance the resilience of small and marginal farmers of India to climate change. Location-specific climate-smart agricultural (CSA) technologies are being refined and validated through model climate-smart village (CSV) approach at Sundarda and Badakusunpur villages in Cuttack district in Odisha. The village level institutions such as Village Knowledge Centers (VKC) and Self-Help Groups have been formed to facilitate the transfer of knowledge through farmer to farmer dissemination. Capacity development of small and marginal farmers is being done through training and demonstrations of CSA technologies such as stress-tolerant high yielding varieties, community nursery, site-specific nutrient management, resource conservation technologies, location-specific cropping system, drip/sprinkler irrigation, integrated pest management, agroforestry/nutri-garden, mushroom cultivation, apiculture, backyard poultry and vermicomposting. This bulletin entitled **"Climate-smart Agriculture through Model Climate-smart Villages"** is an attempt to develop and validate the model climate-smart village bringing resilience to the system at grassroot level.

I hope this bulletin would be helpful in providing guidance to different stakeholders in developing climate-smart villages in other parts of the country. My appreciation for the sincere efforts made by authors.

(T. Mohapatra)

Dated the 16th March, 2020
New Delhi

PREFACE

Agriculture must be resilient and adapt to change in order to provide sustainable food and nutrition security and able to maintain economic, ecological and social benefits in the face of climate change. Small and marginal holders who constitute major chunk of farming community in India are ill equipped in terms of resources and technologies to cope up with the adverse impact of climate change. Enhancing the resilience of small and marginal farmers has been a challenge. Sustained research and extension efforts bringing convergence of village level institutions, extension functionaries under one umbrella are needed for making a climate smart village that has capacity to adapt to climate change. In this bulletin, attempt has been made to present a climate smart village approach along with case studies of its implementations. The climate smart village aims to build climate resilience of Indian smallholders through sustainable intensification of climate smart agriculture (CSA) measures suitable to the agro-ecological (AE) conditions of the project areas in two states of India, namely Assam and Odisha.

The CSV approach is being validated in two villages namely, Badakusunpur and Sundarda villages in Cuttack district. The activities under CSV includes the village level vulnerability assessment, resource characterisation and base line assessment, formation of stakeholders advisory committee, prioritisation of climate smart agricultural technologies, establishment of village knowledge centres focusing on farmer to farmer knowledge exchange, formation of self-help groups, awareness training and field level demonstrations of CSA technologies, creating income generating avenues for marginal and landless farmers, value chain analysis and development. The agro ecology specific climate smart agricultural technology piloted through CSV approach is mainly focusing at enhancing the production and improving the resilience of small holder farmers and also mitigating greenhouse gas emission to some degree.

We acknowledge the Norwegian embassy and Department of Science and Technology, Govt. of India and Indian Council of Agricultural Research, New Delhi for providing financial assistance for undertaking these studies that led to development of climate smart villages. We hope this technical bulletin would help as a guiding tool for replicating such models elsewhere.

Authors

POPULARISING CLIMATE SMART AGRICULTURAL TECHNOLOGIES THROUGH MODEL CLIMATE SMART VILLAGES

1 Introduction

Climate change has become one of the greatest ecological, economic, and social challenges for the world and especially for many developing countries including India. Climate change is going to affect crop productions of many crops including rice (*Oryza sativa L.*) which is the most important cereal crop and staple food for more than half of world's population (Smith et al., 2014). Estimated increases in temperatures, fluctuations in precipitation forms, occurrence of extreme weather events, reduced water availability may result in reduced agricultural productivity, which is likely to aggravate the problems of food security in future (Kalra and Kumar, 2019).

Agricultural systems must be resilient and able to adapt to change in order to continue to provide food security and able to maintain economic, ecological and social benefits in the face of climate change. The extreme climatic events are likely to increase as a consequence of climate change and will likely to severely impact small and marginal holders who are ill equipped in terms of resource and technologies. Climate resilient agriculture through sustainable intensification and agro- ecological farming systems have been advocated as the possible solutions to climate change problems. Small and marginal farmers need to be supported to cope up with climate change by minimizing crop failure through increased use of CSA technologies such as *stress tolerant local varieties, mixed cropping, agroforestry, water harvesting, soil conservation practices* and a series of other traditional practices and income generating avenues (Altieri and Koohafkan, 2008). CSV approach was chosen as a pathway under "RESILIENCE" project to enhance the resilience capacity of small and marginal farmers.

2 Climate smart village approach

The CSV approach involves participatory action to disseminate appropriate CSA technologies and promote farmer to farmer exchange of knowledge. Farmers are trained and encouraged to share their experiences and feedback at regular intervals. Schematic diagram for CSV is presented in Figure 1. Based on this approach, we established three main objectives:

1. Developing a platform for learning and exchange of knowledge among key stakeholders,

2. Applying participatory approach for better integration of farmers, scientists and extension functionaries to enhance adaptation capacity of climate change, and

3. Developing up scaling model for CSA technologies.

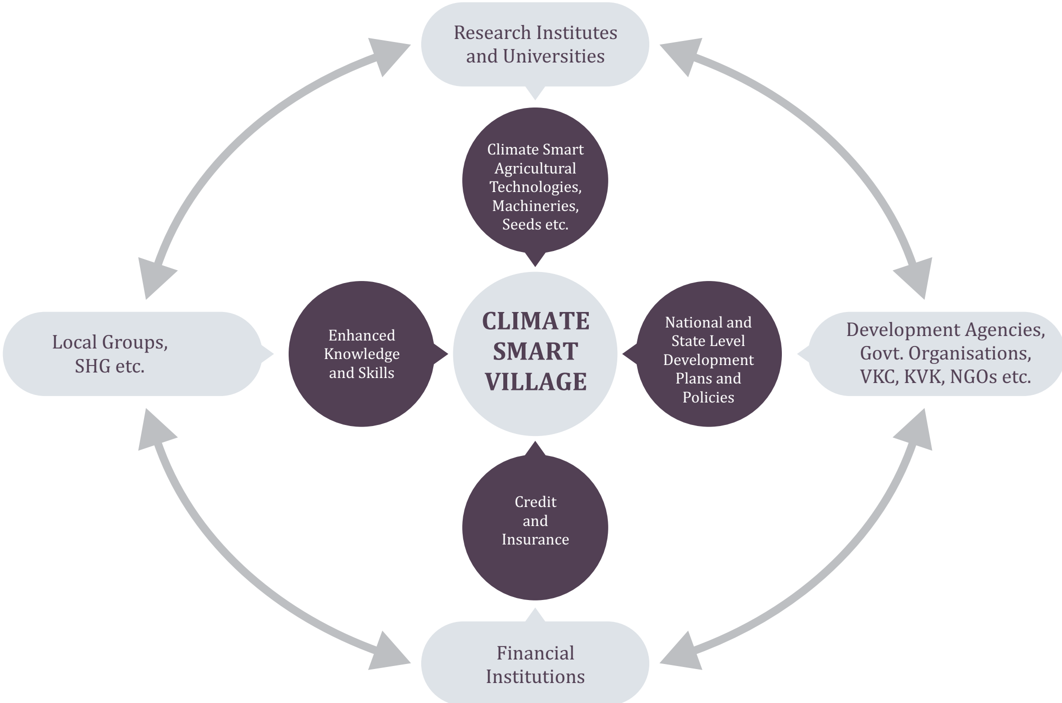


Figure 1: Schematic diagram for climate smart village

2.1 Establishing climate smart villages

The CSV villages namely Badakusunpur from Tangi block and Sundarda from Niali block, are located in Cuttack district of the state of Odisha in the eastern part of India (Figure 2).

Figure 2: Location of identified climate smart villages in Cuttack, Odisha

Trust winning of various stakeholders including the farmers is the foremost requirement for establishment of CSV. Farmers are made aware that CSV concept which is aimed at providing the technical solution of their need for agricultural technology, livelihood and nutritional security in the contest of climate change. CSV essentially doesn't include large scale distribution of materials or goods. Following steps are involved in developing climate smart village (Figure 3):

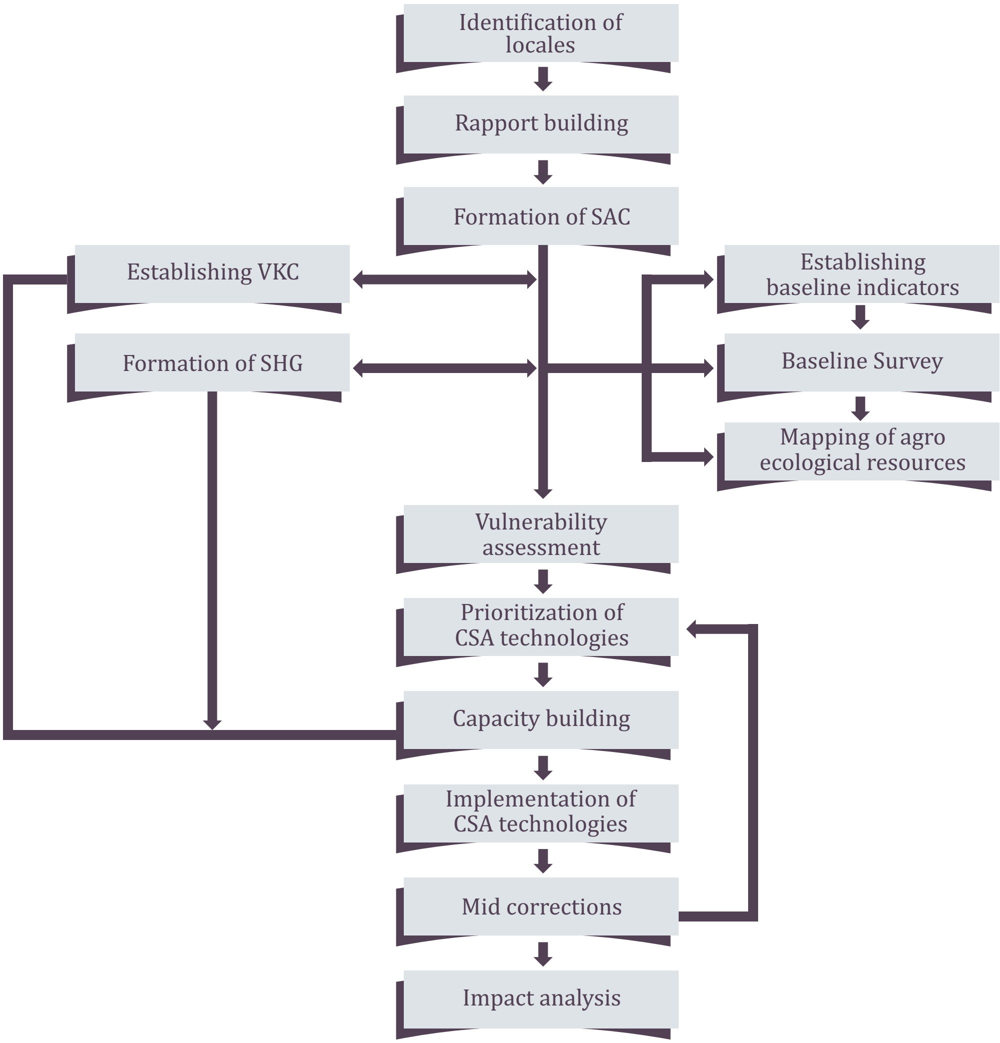


Figure 3. Flowchart of the process for climate smart village development (SAC: Stakeholders advisory committee; VKC: Village knowledge centre; SHG: Self help group)

2.2 Scaling mechanisms

The mechanism of scaling up CSA technologies through CSV are based on two principles (CCAFS, 2016).

- Horizontal scaling: Targeted through demonstration and dissemination of CSA technologies and farmer-to-farmer learning. This is facilitated by formation of self-help group (SHG) and VKC.
- Vertical scaling: The results and lessons learned from demonstration and interventions implemented in experiment mode in the CSV helps us to refine the technologies/interventions to prepare policy brief that will guide the researchers and policy makers for effective replication of the CSV.

2.3 Selection of baseline indicators

The following baseline indicators along with measuring units were developed to assess the output and outcome of the climate smart agriculture technology and climate smart village approach (Table 1).

Table 1*:* Baseline indicators *for climate smart village* and their classification under CSA pillar context.

Baseline indicator	*Unit*	*CSA pillar*		
		Adaptation/ Resilience	*Productivity*	*Mitigation*
Crop yield	*t/ha*		*X*	
Household income per year	*Rupee/yr*		*X*	
Water productivity	*Kg paddy /m^3*		*X*	
Nutrient use efficiency for Nitrogen (N)	*Kg paddy /kg N*			*X*
System productivity (SP)	*REY, t/ha*		*X*	
Area diversity index (ADI)	$ADI = \frac{1}{\sum_{i=1}^{n}\left(a_i / \sum_{i=1}^{n} a_i\right)^2}$	*X*	*X*	
Cultivated land utilisation index (CLUI)	$CLUI = \frac{\sum_{i=1}^{n} ai.di}{A \times 365}$	*X*	*X*	
Sustainability index (SI)	$SI = (Y - sd) / Y_{max}$	*X*	*X*	*X*
Farmers practicing Integrated pest/disease management (IPM) and other pest measures	*%*	*X*		*X*
Farm HH (household) aware of CSA/AE interventions	*%*	*X*	*X*	
Farm HH and other stakeholders trained on CSA/AE interventions	*%*	*X*	*X*	
Farm HH practicing CSA/AE interventions	*%*	*X*	*X*	
Women HH participating in household decision making	*%*	*X*	*X*	
Farm HH participating in local institutions (e.g. value-added markets, seed banks,)	*%*	*X*	*X*	
Household dietary diversity	*Index (0 - 12)*	*X*	*X*	
Farm HH (men & women) aware of their food nutritional value	*%*	*X*	*X*	

REY: rice equivalent yield; ai= area occupied by the i-th crop; di = days that i-th crop occupied; n = total number of crops; A= total cultivated land area; Y is the average yield over years n, sd is the standard deviation and Ymax is the maximum yield obtained in any of the year.

2.4 Baseline survey for agro ecological resource mapping

Biophysical resources were surveyed and presented in Figures 4, 5 & 6. The rice ecologies describe the landform and rice farming situations. Three broad stratification of rice ecology were identified (upland, medium and lowland in Badakusunpur (Figure 4) while only one: lowland in Sundarda (Figure 5).

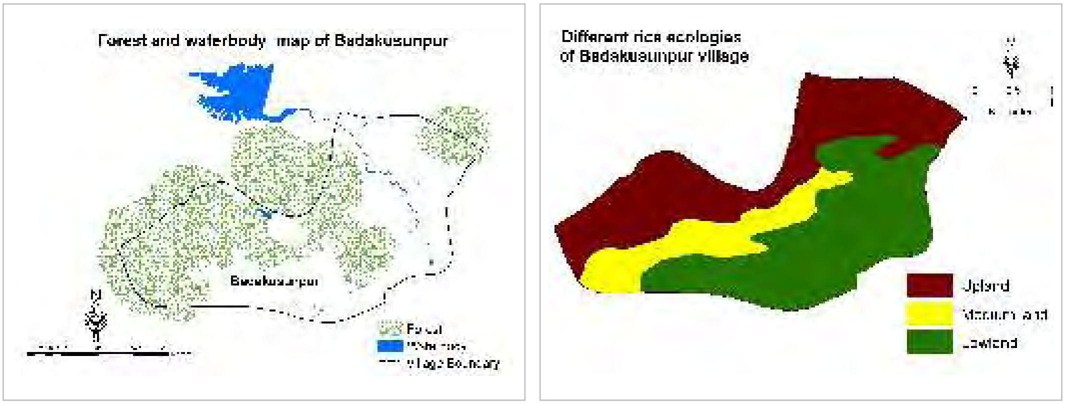


Figure 4: Permanent water bodies, forest and different rice ecologies present in the Badakusunpur village

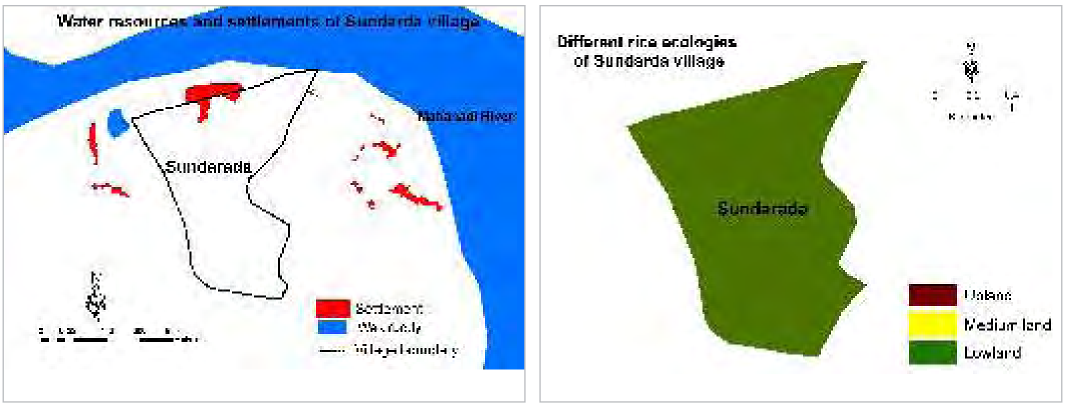


Figure 5:Permanent water bodies and different rice ecologies present in the Sundarda village

Spatial features like existence of small water reservoirs and irrigation facilities were available in Badakusunpur on its north-east and north-west site (Figure 4). Rice is the main crop in *kharif* season for both the project villages. In Sundarda, rice-green gram is a dominant cropping system followed by rice fallow whereas rice-rice in irrigated area and rice fallow in rainfed area in Badakusunpur (Figure 6). Rice is the main crop in *kharif* season for both the project villages.

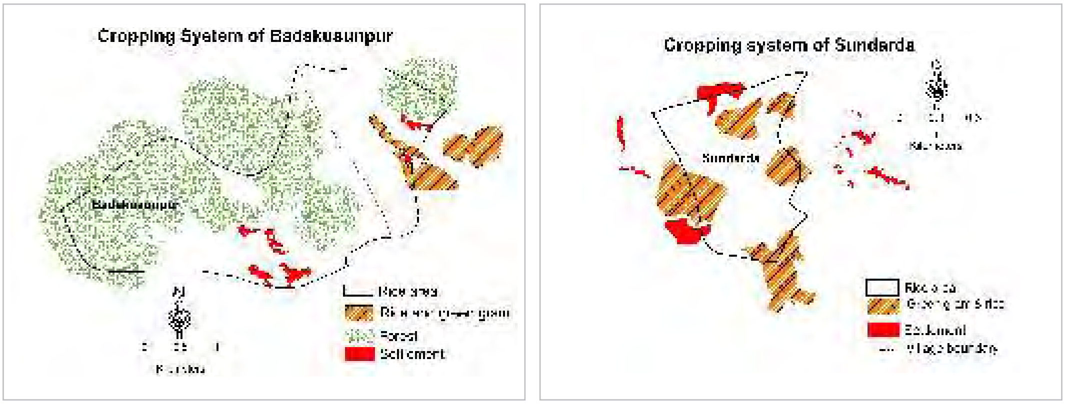
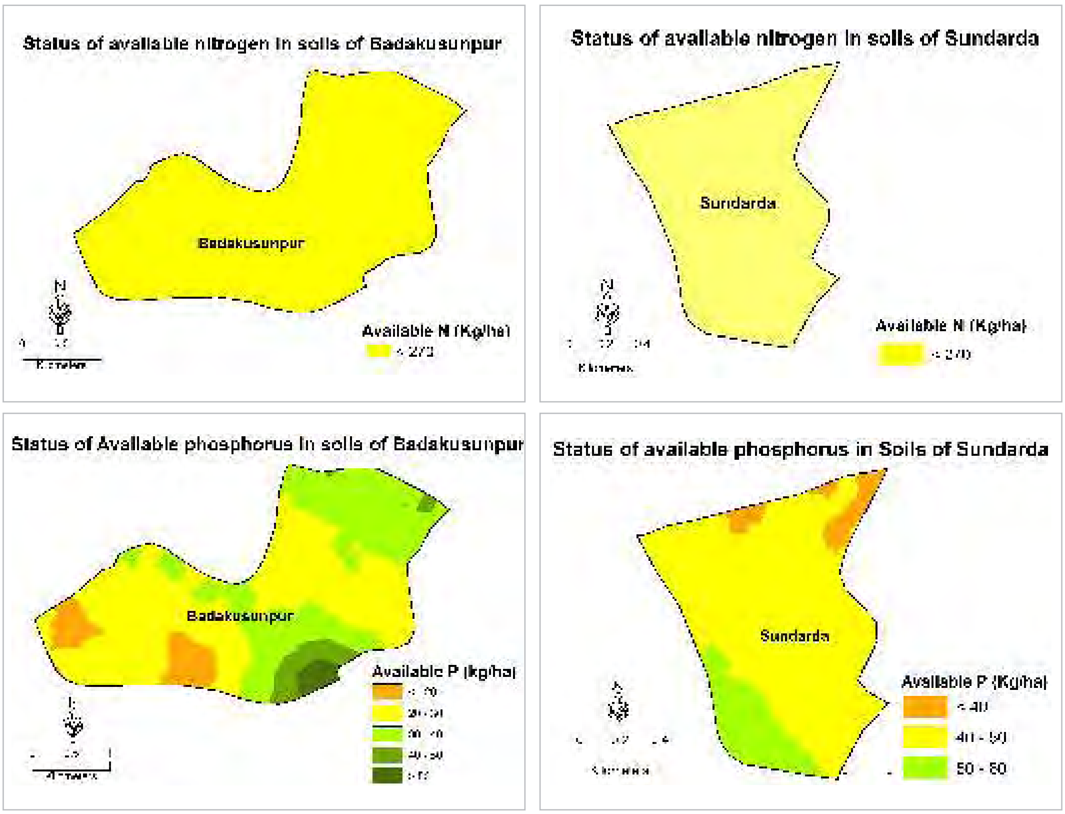


Figure 6: Cropping system of the Climate smart villages

The topsoil's (0-20 cm) in both sites are characterised by low to moderate level of available N in Badakusunpur (175.9 to 238.6 kg N ha^{-1}) and Sundarda (155.3 to 201.7 kg N ha^{-1}) (Figure 7). Available P (P_2O_5) was also in low to moderate range with a mean value of 40 and 45 kg ha^{-1} in Badakusunpur and Sundarda respectively. Available K was also low to moderate in Badakusunpur (85.3 to 280.6 kg ha^{-1}) and Sundarda (57.5 to 190.3 kg ha^{-1}) (Figure 7).



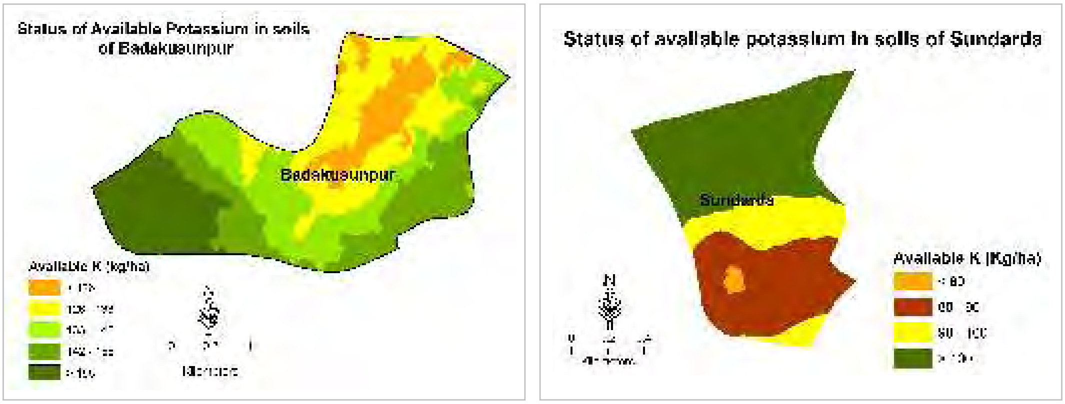


Figure 7:Soil available nitrogen, phosphorous and potassium map of CSV villages Badakusunpur and Sundarda villages

2.5 Climate change vulnerability

Vulnerability to climate change is represented by three dimensions – sensitivity, exposure, and adaptive capacity. The Badakusunpur and Sundarda villages are having varying degree of sensitivity to the extreme events because of their location and landform. Heavy rainfall, long dry spell and cyclone are frequent phenomenon in these regions. There is always a threat of inundation and flooding in the low to medium land during heavy rain fall, whereas drought occurs in the event of few days of rainless situation in upland areas. Absence of proper drainage and irrigation facilities, adoption of traditional varieties and traditional practices makes them sensitive; with little knowledge about climate-resilient and modern farm technologies. Lack of crop insurance coverage makes them less adaptive to climate change situations. Smaller farm size, lower education, climatic shocks are some of the factors that significantly decrease the level of per-capita income of households and hence increase their vulnerability.

Historical weather data analysis revealed that the village Badakusunpur is more vulnerable for deficit moisture stress (drought) and comparatively lesser to flooding because of predominance of upland situation. Sundarda village is more vulnerable to flooding and cyclone due to closeness to sea coast and lowland situations.

2.6 Socio-economic analysis

The literacy rate of Badakusunpur village is 81.7% out of which 86.1% males and 77.0% females are literate. In Badakusunpur, >75% population are Scheduled tribe (ST) and 17% from other backward caste (OBC). About 13% villagers, mostly from tribal population of Badakusunpur are landless. Their main source of livelihood is farming and working as agricultural wage laborers. They grow traditional rice varieties in *kharif*, while most of the land remains fallow during rabi season. While in Sundarda village, general caste constitutes, 41%; OBC, 43%; and Scheduled caste (SC), 15% of the total village population and literacy rate is 96.4%. The farmers from this village also earn their livelihood mostly from farming but few farmers also have dairy business. In kharif, mostly semi deep-water rice varieties like Pooja and Sarala are cultivated and green gram is cultivated in *rabi* season in some patches and most of the land remains fallow.

Most of the farmers fall in the categories of small and marginal farmers. Agricultural mechanization in the villages is poor. About 95% populations don't own power tiller, rotavator, tractor drawn leveler, disc harrow etc. Only around 5% populations have sprayers for herbicide and pesticide spray. About <1% population have power thresher. Only 4% farmers are availing credit for the farming work. There is no post-harvest processing facility for the agricultural produce and very limited facility to market their farm produce. Very few farmers sell their produce to Govt. procurement centers at Minimum Support Price (MSP).

2.7 Formation of stakeholder advisory committee

The Stakeholder Advisory Committee (SAC) comprises

- Lead farmer,
- Director, Institute on Management of Agricultural Extension(IMAGE), Bhubaneswar,
- Deputy Director Agriculture, Cuttack,
- Dean Extension, OUAT, Bhubaneswar,
- Thematic Agriculture expert,
- Reliance Foundation Information Service, Bhubaneswar and
- RESILIENCE project PI, Cuttack

The SAC gives advises on implementation of climate smart agriculture in CSV and strengthen science-policy linkage and development of policy and upscaling frameworks. It supports the achievement of optimal science-policy linkages in Odisha state and oversees policy and societal issues related to the conduct of project activities in Odisha.

3 Climate-smart agricultural (CSA) technologies

Climate-smart agricultural (CSA) technologies are required for sustaining and/or enhancing the crop production in the wake of climate change. CSA consists of three pillars of climate-smart agriculture (Figure 8) namely;

1. *Production:* Increasing agricultural productivity for increasing farmers' income and food security
2. *Adaptation:* Adaptation to the climate change and increasing resilience to climate change
3. *Mitigation:* Reduction of GHG emission from agriculture

3.1 Identification and prioritisation of CSA technologies

A set of climate smart technology inventories those include weather smart, water smart, nutrient smart and market smart practices are prepared by conducting

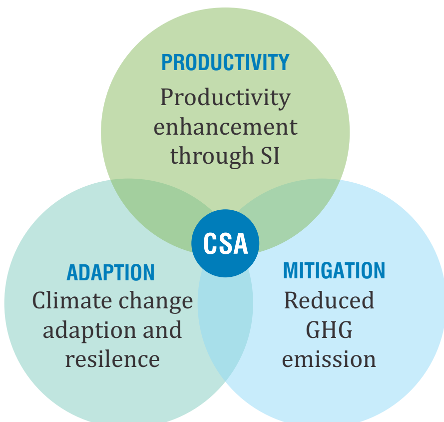


Figure 8: Three pillars of Climate Smart Agriculture (CSA) (SI: Sustainable intensification)

expert meeting comprising scientist from Agricultural Universities, ICAR institutes, KVK personnel, NGOs and officers from agriculture department who are aware about the physiography, soil and water and cropping situations of the sites. A brief description about these technologies is provided in Tables 2-5.These technologies are prioritized by experts with the help of a pre-designed questionnaire for identifying the most relevant CSA technologies for the project villages. The experts included scientists from ICAR Institutes, Universities, farmers, NGO, state Govt. officials who are having knowledge about the situations of project villages, climate resilient agriculture. The experts are oriented about criteria of prioritisation of CSA technologies based on three pillars. The experts are asked to fill up the questionnaire containing provision to record the basic information about the experts and criteria for prioritisation. The individual pillars are assigned weightage in ratio of 35:35:30 to arrive at a sum total of 100.

There are 7 indicators for three pillars of CSA, each technology is judged based on weightage assigned to these indicators.

1. Increases yield?
2. Increase income?
3. Improve nutrient use efficiency?
4. Improve water use efficiency?
5. Does it reduce vulnerability and risk?
6. Does it reduce GHG emission?
7. Is it energy efficient?

The weightage are assigned by the expert by evaluating a particular technology for its role according to the above mentioned 7 indicators for the project villages. The first two factors come under production, 3rd, 4th and 5th factors come under adaptation and the 6th and 7th factors come under mitigation.

3.2 Scoring for each CSA indicator

The scoring of the technologies is done by giving score ranging from -10 to +10. The experts are asked to individually score each technology against each indicator with the criteria that, if the particular indicator increases or decreases by 10% the score is to be raised or decreased by one, respectively. For example, a technology is to be given a score of 10 against productivity (indicator) if it is increased by 100%. Similarly, a score of 5 is to be given if it is increased by 50%. Negative scoring is to be assigned if technology has negative effect for indicators.

The cumulative score was calculated based on the weightage and scoring for each technology.

Cumulative score

$$= \frac{[(W1*w1*a)+(W1*w2*b)+(W2*w3*c)+(W2*w4*d)+(W2*w5*e)+(W3*w6*f)+(W3*w7*g)]}{[(W1*2+W2*3+W3*2)*(w1+w2+w3+w4+w5+w6+w7)]}$$

Where, W1, W2, W3 are weightage of CSA pillar; *w1, w2, w3, w4, w5, w6, w7* are weightage of CSA indicator and a, b,c,d,e,f,g are score of a specific technology against each CSA indicator

The technologies are prioritized based on the cumulative scoring. Assessment of technologies is done by taking the views of villagers through focused group meetings whether it is highly essential, essential or non-essential. Multinomial probit model is run with different independent and dependent variables in the study area affecting the adoption of CSA technologies that give a better positive and negative relationship on the basis of which further elimination or retention of particular technologies is done. The list of prioritized technologies for both the sites is presented in Annexure I. The most promising technologies are selected for testing and validation.

Table 2: Brief description of CSA technologies (*Weather smart technologies*) used for location specific prioritization

	Technology/Practice/Services	How it helps to adaptation/mitigation of climatic risks
1	Weather based agro-advisory	Agro-meteorological advisories vital to stabilize yields through management of agro-climatic resources
2	Information and communication technologies (ICT)	Advance climate information help reduce climate risk or take advantage of better seasons e.g. RiceXpert Mobile App
3	Agro-ecological crop intensification	Optimal crop/varietal combinations ensure higher productivity from limited land
4	Drought, flood, heat and cold stresses tolerant variety including short duration improved crop varieties	Crop varieties that are tolerant to drought, flood and heat/cold stresses
5	Contingent crop planning	Reduces the adverse effect of climatic hazards through crop compensation
6	Community nursery	In stress prone areas such as submergence or flood affected areas, nursery is raised in some identified places sufficient to meet the demand of all the farming families
7	Changing of time of sowing/planting	Helps to overcome the adverse effect of temperature

Table 3: Brief description of CSA technologies (Water smart technologies) used for location specific prioritization

	Technology/Practice/Services	How it helps to adaptation/mitigation of climatic risks
1	Alternate wetting and drying (Rice)	Follows the principles of how much water to be given and when to irrigate, which increases the yield and water use efficiency
2	Aerobic rice	Enhances water productivity in rice production system and uses rain water efficiently
3	Direct seeded rice	Less water requirement against transplanted rice, reduces N loss and increase water use efficiency

4	Water harvesting structures/ Farm ponds	Collection of rainwater prevents run-off and can be used for agriculture in rainfed/dry areas
5	Check dams	During monsoon season, to collect and impound surface runoff from catchments small water storage structures are constructed across small streams or *nallas*
6	Groundwater use (Dug wells/ shallow tube wells)	Extract ground water for irrigation purpose. Tube wells are more efficient and productive to trap ground water from different depth
7	Ground water recharge	Recharge both shallow and deep aquifers by diverting water from surface (surplus water from runoff, reservoirs, storm water, tank, canal etc.) to aquifers
8	Low energy irrigation system (Drip and sprinkler irrigation)	Water applied directly to crop root zone which avoid water loss and increase water use efficiency in drip system whereas sprinkler irrigation gives a uniform rainfall condition and protects crops from climatic aberrations
9	Laser land levelling	Quick and more effective land levelling practice which modifies the land to a uniform surface and reduces water and nutrient loss
10	System of rice intensification (SRI)	Increase yield, water productivity
11	Integrated farming system	Integration of enterprises i.e. Crop, Livestock, Fishery, Forestry etc makes optimal utilization of inputs/reduction of external inputs
12	Drainage	Prevent anaerobic condition in root zone, reduce methane emission and also reduce leaching and denitrification of NO_3^{--}-N
13	Mulching	Mulch is any type of material that is spread or laid over the surface of the soil as a covering. It is used to retain moisture in the soil, suppress weeds, keep the soil cool, and make the garden bed look more attractive Organic mulches also help improve the soil's fertility, as they decompose. e.g. Bark, compost, composted manure, newspaper, straw etc.
14	Furrow irrigated bed planting	This method offers more effective control over irrigation and drainage as well as rainwater management during the monsoon (also improves nutrient use efficiency)
15	Raised bed planting	Conserve water and allows better drainage and run-off
16	Minimum tillage/Zero tillage	Reduces amount of energy use in land preparation. In long-run, it also improves water infiltration and organic matter retention into the soil
17	Soil moisture sensor	The soil water sensors mimics the way a plant experiences the amount of water in the soil by measuring how hard the roots have to suck (the tension required) to extract moisture after calibrating to different soil types

Table 4: Brief description of CSA technologies (*Nutrient smart technologies*) used for location specific prioritisation

	Technology/Practice/Services	How it helps to adaptation/mitigation of climatic risks
1	Site specific nutrient management (SSNM) using rice crop manager (RCM), soil health card and real time nitrogen management (RTNM) using CLCC, SPAD, etc.	Optimum supply of soil nutrients over time and space matching to the requirements of crops with right product, rate, time and place
2	Organic manuring (FYM, GM, BM, etc.)	Improves soil health by enhancing nutrient and water holding capacity
3	Intercropping with legumes	Cultivation of legumes with other main crops in alternate rows or different ratios. This practice improves nitrogen supply and soil quality
4	Bio-fertiliser (Rhizobium/PSB/ Azolla etc)	Bio fertilizers promotes growth by increasing supply of primary nutrients to the host plant and reduces cost of cultivation
5	Fodder banks	Conservation of fodders to manage climatic risks

SSNM: Site specific nutrient management; RTNM: Real time nitrogen management; CLCC: Customised leaf colour chart developed by ICAR-NRRI, SPAD: Soil plant analysis development; GM: Green manuring; BM: Brown manuring;PSB: Phosphate solubilising bacteria; FYM: Farm yard manure

Table 5: Brief description of CSA technologies (*Market smart technologies*) used for location specific prioritisation

	Technology/Practice/Services	How it helps to adaptation/mitigation of climatic risks
1	Integrated pest management/ Organic pesticides/botanicals	Reduces use of chemicals
2	Integrated weed management	Use of stale seedbed along with mechanical/chemical method of weed control and reduces chemicals, water and nutrient requirement of the crop
3	Agro-forestry	Land use management system in which trees or shrubs are grown around or among crops or pastureland
4	Livestock, poultry & Fishery as Diversification Strategy	Reduce risk of income loss due to climate variability
5	Crop insurance	Crop-specific insurance to compensate income loss due to vagaries of weather
1.	Crop diversification with vegetables	Growing vegetables along with other crops and helps to augment income
2.	Seed systems/banks	Ensuring farmers access to climate ready cultivars
3.	Renewable energy	Increased access to power through renewable energy (Solar, wind, bio) for irrigation and other agriculture tasks; adaptation and mitigation

3.3 Identification of seed farmers and CSA demonstrations

CSA technologies viz. *drought and flood tolerant varieties, direct seeded rice (wet and dry), site specific nutrient management using rice crop manager and soil health card, real time N management (RTNM) using customised leaf colour chart (CLCC), mechanical transplanting, integrated pest management, community nursery, cropping system-based intensifications and nutritional garden/agroforestry* were selected for farmers field demonstration in project villages (Table 6-7) by following the standard methodology described in the previous sections. To demonstrate the climate smart technologies, seed farmers were selected based on the agroecological survey and willingness to participate in the project by conducting participatory rural appraisal (PRA) and focus group discussion (FGD). Some of the interventions on CSA undertaken in the project villages are depicted in Figure 9. Income generating activities like *back yard poultry, mushroom cultivation, bee keeping, and vermicomposting* were introduced for landless tribal, small and marginal farmers specifically focussing on women farmers (Figure 10). Nutritional gardens/Agroforestry was established for ensuring the nutritional security of the people.

Table 6: Selected CSA technologies interventions in CSV- Badakusunpur village

Experiment	Varieties	No of seed farmers	Implementation	
			Acre	No.
Community nursery*	*Maudamani, CR Dhan 801*	1	1	-
Stress tolerant high yielding varieties for water limiting condition	*Maudamani, CR Dhan 206 and CR Dhan 801*	8	9.5	-
Site specific nutrient management (SSNM and RTNM)	RCM and CLCC	1	1.5	-
Direct seeded rice (dry direct seeding by seed drill, Wet direct seeding by drum seeder and zero tillage dry sowing)*	*CR Dhan 206, Sahbhagidhan, Lalat*	8	4	-
Integrated pest management	Pheromone Trap, Sweep net and trichocard and need based pesticide	20	-	-
Intervention for rabi season				
Intercropping with legumes, rice-pulse (green gram and black gram)	Green gram (*IPM 2-3, IMP 2-14* and local variety) Black gram (*PU-31*)	15	16	-
Agroecological crop intensification- Rice-maize; rice-oilseed and residue mulching	Maize (*DHM-117*) with and without mulching; Sunflower (*KBSH-41, NSPH-1001*); Sesame (*Kalika, Pita*)	13	3	-
Alternate wetting and drying /SRI	*CR Dhan 206*	1	1	
Soil moisture sensor	Chameleon sensor for three ranges; wet (0 to 20 kPa); moist (20 to 50 kPa); dry (> 50 kPa)	1	-	1

Nutritional garden/ Agroforestry (Homestead and community based)	Mango (*Totapuri, Amprapali, Neelachal kesari, Banganpalle, Mallika, Banarasi, Dassehri*); Lime (*Gangakulia*); Banana (*Grand naine*); Guava (*Banaras round, Lucknow 49, Golekhaja*); Amla (*Chakia*); Sapota (*Cricket ball*); Drumstick (*PKM 1*); Bael (*Kunda*); Jamun (*Ram jamun*); Anar (*Ganesh*)	27	-	143
Mushroom cultivation	Oyster mushroom (*Pleurotus ostreatus*)	10	-	10
Apiculture (Bee keeping)	Honey bee *(Apis mellifera)*	2	-	-
Back yard poultry	Rearing of *Vanaraj*	25	-	625
Organic manure (Vermicomposting)	Using earth worms (*Eisenia fetida*)	2	-	-
Biofertiliser	Seed treatment of green gram and black gram with *Rhizobium*	10	7	-

**The varietal interventions in 2019-2020 (there is scope for varietal replacement); CSA: Climate smart agriculture; CSV: Climate smart village; RCM; Rice crop manager; CLCC: Customised leaf colour chart; SSNM: Site specific nutrient management; RTNM: Real time nitrogen management*

Table 7: Selected CSA technologies interventions in CSV- Sundarda village

Experiment	Varieties	No of seed farmers	Implementation	
			Acre	No.
Community nursery	Pooja, Gayatri, Maudamani	1	1	
Stress tolerant high yielding varieties for stagnant flooding/Submergence prone area	Maudamani. Pooja, Gayatri, CR Dhana 802	10	15	
Nutrient management (SSNM and RTNM)	RCM and CLCC	2	2.6	
Mechanical line transplanting	Pooja	1	1	
Integrated Pest Management	Pheromone Trap, Sweep net and trichocard and need based pesticide	20		
Intervention for rabi season				
Intercropping with legumes, Rice-pulse (green gram and black gram)	IPM 2-3, IMP 2-14 and local variety	26	15	-
Agroecological crop intensification-Rice-fodder	Hybrid Napier			
Crop diversification with vegetables (rice-vegetable)	Pumpkin (Arjun); Brinjal, Tomato (Arka rakshak), Chilli (Daya), Ladies' finger; Potato (*Rengun satha*)	6	0.6	-
Drip/Sprinkler irrigation	Emitter (drip system) with 12 mm and 2 lph discharge	8	0.6	-

Soil moisture sensor	Chameleon sensor for three ranges; wet (0 to 20 kPa); moist (20 to 50 kPa); dry (> 50 kPa)	6	-	4
Integrated Pest Management	Need based pesticide application			-
Agroforestry/Nutrigarden (Homestead and community based)	Mango (Totapuri, Amprapali, Neelachal kesari, Banganpalle, Mallika, Banarasi, Dassehri); Lime (Gangakulia), Banana (Grand naine); Guava (Banaras round, Lucknow 49, Golekhaja); Amla (Chakia); Sapota (Cricket ball); Drumstick (PKM 1); Bael (Kunda); Anar (Ganesh)	22	-	287
Biofertiliser	Seed treatment of green gram and black gram with Rhizobium	2	1	

Diversification of rabi rice with maize at Badakusunpur

Farmers using 'riceNxpert' app for N recomendation at Badakusunpur

Dry-DSR in kharif at Badakusunpur

Wet season community nursery at Sundarda

Wet-DSR in kharif at Badakusunpur

RTNM using CLCC at Sundarda

Mat nursery for kharif season at Sundarda

Mechanical transplanting in kharif at Sundarda

Chameleon sensor based water mangement in potato

Diversification of rabi rice with sunflower at Badakusunpur

Figure 9: CSA implemented in Badakusunpur and Sundarda villages

Vermicomposting at Badakusunpur

Back yard poultry farming at Badakusunpur

Agroforestry/nutrigarden at Badakusunpur

The agroforestry plantation at Badakusunpur

Mushroom cultivation at Badakusunpur

Apicuture unit at Badakusunpur village

Back yard poultry farming at Badakusunpur

Figure 10: Income generating activities implemented in Badakusunpur and Sundarda villages

4. Establishment of village knowledge centres (VKC)

One VKC was established for facilitating the knowledge sharing, technology extension through various ICT based programmes in CSV villages (Figure 11). The extension method used in VKC include phone in programme, audio conference, video conference, video-based learning and plant clinics on agriculture, weather, animal husbandry and health related topics. VKC is disseminating weather based agro-advisory given by District Agro Meteorological Unit (DAMU). So far 547 male and 44 female farmers registered for these audio advisories and getting benefits.

Figure 11: VKC inauguration and address by Director, NRRI to the farmers about the climate smart villages

5. Formation of self-help group (SHG)

Two self-help group (SHG) groups were formed in the CSVs involving15 farm women each with an objective to empowering rural women and enhancing resilience against climate change through skill enhancement and capacity building (Figure 12). Two SHGs namely Nari Shakti and Swayamsnigdha are formed in Badakusunpur and Sundarda, respectively. Registration of the SHGs has been initiated under Odisha livelihood mission schemes as per Government rule to access the Governments developmental scheme. The farm women have been trained with mushroom cultivation mostly Oyster and paddy straw mushroom, vermicomposting, honey bee keeping, and back yard poultry.

Figure 12: Discussion with SHG members in Sundarda and Badakusunpur

6. Establishment of seed village

Non-availability of quality paddy seeds at right time reduces yield by 15-20 percent (Chauhan et al., 2016). Selected seed farmers were trained for production of quality climate resilient paddy seed to meet their own and other farmers' requirement in the villages through farmer to farmer (F2F) seed exchange. Implementation of the seed village programme will help in ensuring timely availability of quality seed. Additionally this will help in disseminating the high yielding climate resilient varieties faster than that happens through public sector seed chain.

7. Value chain analysis and market linkage

The value chain analysis has been undertaken in collaboration with MSSRF, Chennai to identify dynamic linkage between productive activities. The core process in the value chain of paddy at the project villages involves pre-production process (supply of inputs) cultivation, post-harvest handling, agro processing, marketing. Key inputs involved in the production were seeds, manures, pesticides, labour, irrigation, credit and technology are used for production of paddy. Post-harvest operations include harvesting, threshing, cleaning and storing. Processing of paddy is done in mills or hullers to produce clean rice for self-consumption and sale in the local market marketed through Government procurement, mill owners, whole sellers and retailers.

The critical players in the value chain are producers, middleman, traders, processors. The local level traders/ town level trader/ commission agents associated with farmers from long years, lend money to the farmers in credit for labour cost, inputs like seeds, fertilizers, pesticides by charging 5-7% interest per month for a period of 5-6 months. The pay back by the producer happens when the same credit provider procures the produce of the farmers, sells in regional hub/ processing units and gets back money. A local/town level trader receives profit @Rs 200-300/bag/ quintal of Paddy. Town level Traders & agents are procuring the product from the village point @1350- 1450 per quintal. Post-production, harvesting and post harvesting facilities are poor in both Badakusunpur and Sundarda villages which affects the quality of produce. Through the CSV model, capacity building of farmers is targeted by helping them to do some processing and value addition and elimination of middlemen in the marketing process. Farmers have been trained to leverage e-marketing platform such as riceXpert etc.

8. Capacity building and training

Capacity building programmes for the stake holders were conducted in CSV as well as in the ICAR-NRRI campus (Table 8).The farmers were briefed about the activities of the CSV including the climate smart technologies for adaptation to climate change. Training on CSA, dissemination of technologies through riceXpert app, IPM and riceNxpert training on income generating activities and orientation meeting for SHGs were conducted in ICAR-NRRI in collaboration with MSSRF, Chennai.

Table 8 : Various capacity building programmes implemented

Name of the event	Place	Date
Workshop on “Integration of stakeholders for promoting Climate- Smart Technologies through Digital Agriculture”	ICAR-NRRI, Cuttack	23rd December, 2019
Farmer's meet on 'Building climate resilient of Indian small holders”	Abhaypur, Tangi-Chaudhwar;	19th March, 2019
Inception workshop of RESILIENCE project	ICAR-NRRI, Cuttack;	23rd March, 2019
VKC inauguration and training to farmers	KVK; Santhapur	20th June, 2019
Connecting rice farmers through ricexpert app for real time information on rice farming	ICAR-NRRI, Cuttack;	21 June, 2019
Crop production technologies, agroforestry, bee keeping, vermicomposting and poultry farming	Badakusunpur & KVK, Santhapur	20 August, 2019
Awareness for establishing seed village, climate smart village and insect pest management in rice	Sundarda, Niali	4th October, 2019
Focussed group discussions	Badakusunpur	23rd March, 2019
	Sundarda	22 June, 2019

Sensitising farmers about the RESILIENCE project

Focussed group meeting and training on riceXpert

Training on climate smart technologies in Sundarda Village

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Annexure I

Climate Smart Technologies prioritized for the Climate smart villages in Cuttack district of Odisha

Badakusunpur (Tangi Block)	Rank	Sundarda (Niali Block)
Rainwater Harvesting/farm pond	I	Drainage
Drought, flood, heat and cold stresses tolerant variety including short duration crop varieties	II	Drought, flood, heat and cold stresses tolerant variety including short duration crop varieties
Integrated pest management/Organic pesticides/botanicals/Integrated weed management	III	Groundwater use
Weather based agro-advisory	IV	Rice based IFS
Contingent crop planning	V	Real time nitrogen management using CLCC, SPAD, riceNxpert; Site specific nutrient management using Rice crop manager, Soil health card etc.
Directed seeded rice (dry and wet)	VI	Integrated pest management/Organic pesticides/botanicals/Integrated weed management
Agro-ecological crop intensification	VII	Crop insurance
Drip and sprinkler irrigation with soil moisture sensors	VIII	Weather based agro-advisory
Livestock, poultry and fishery as diversification Strategy	IX	Drip and sprinkler irrigation with soil moisture sensors
Site specific nutrient management using Rice Crop Manager, Soil Health Card etc. Real time nitrogen management using CLCC, SPAD, riceNxpert;	X	Agro-ecological crop intensification
Mechanical transplanting	XI	Directed seeded rice (dry and wet)
Alternate wetting and drying (Rice)/SRI	XII	Community nursery
Information and communication technologies (RiceXpert)	XIII	Forage/Fodder cultivation
Nutritional garden/ Agroforestry	XIV	Contingent crop planning
Laser land leveling	XV	Information and communication technologies (RiceXpert)

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