Climate Smart Agriculture (CSA):
Interventions, Prioritisation and Extension Models – A Multi-Stakeholder Analysis

Discussion Paper – 3

MANAGE – Centre for Climate Change and Adaptation (CCA)

National Institute of Agricultural Extension Management (MANAGE)
(An Autonomous organisation of Ministry of Agriculture and Farmers' Welfare, Govt. of India)
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About the Publication

The research report is based on the research conducted by Mr. A. Vincent, Consultant and Dr Sanndeep Kaur, MANAGE Fellow under the Centre for Climate Change and Adaptation (CCA).

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Study Team

(Mr Vinccent A
Dr Sandeep Kaur
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Foreword

FOREWORD

With mounting climate change risks, agricultural productivity of the entire world is projected to be declined in future, thereby affecting food and nutritional security. Several technologies are promoted by national and international organisations to sustainably increase productivity, income and enhance adaptation and resilience to climate change risks. At this juncture, I am happy that the Centre for Climate Change and Adaptation (CCA), MANAGE has undertaken a research study titled "*Climate Smart Agriculture (CSA): Interventions, Prioritisation and Extension Models – A Multi-Stakeholder Analysis*" to understand various adaptation and mitigation measures promoted by Department of Agriculture under Project on Climate Resilient Agriculture (PoCRA), Krishi Vigyan Kendra (KVK)-Jalna under Indo German Watershed Development Programme (IGWDP) and Water Trust Organisation (WOTR) in Jalna district of Maharashtra state which is highly vulnerable to frequent occurrence of drought and other climate extremities.

It is interesting to know from the study that all three organisations have given more emphasis to water security to address the frequent occurrence of drought. The CSA technologies such as Climate Smart Varieties, shade net houses, micro irrigation, supply side water management interventions, Integrated Farming System, Agroforestry based farming systems, Automated Weather stations, ICT applications, usage of renewable energy in irrigation, involvement of private sectors in input and output markets, Custom Hiring Centres and extensive capacity building of stakeholders helping the farmers to become more resilient to changing climate conditions, increase crop diversity and enhance their income. I am pleased to note that the adoption behaviour of farmers is influenced by the various extension approaches such as participatory watershed approach, Participatory water budgeting, involvement of farmers/community institutions, Farmers Field Schools (FFS), Gender smart extension, facilitated by field extension professionals. I hope that, the report will provide insight for various stakeholders who are involved in the promotion of CSA at the farmer's level.

I congratulate Dr Sandeep Kaur, MANAGE Fellow and Mr Vincent A, Consultant for undertaking this timely study. I also appreciate Dr N Balasubramani, Director, Centre for Climate Change and Adaptation (CCA), MANAGE for guiding and motivating them to undertake this much-needed study and bringing it out as a Discussion Paper.

Dr P Chandra Shekara
Director General, MANAGE

Executive Summary

Executive Summary

Global scenario of climate change risks

Globally, from 1970 to 2019, weather, climate and water hazards accounted for 50% of all disasters, 45% of all reported deaths, and 74% of all reported economic losses. Of all disasters that occurred between 1970 to 2019, riverine floods accounted for 24%, tropical cyclones 17%, general floods 14%, general storms 7%, drought 6%, flash floods 6%, landslides 5% and others 21% (WMO, 2021). Such extreme events are a result of climate change, both caused by natural and human interventions. India as well succumbed to extreme events with a ranking of 7 on the Global Climate Risk Index, 2021 and 90 among 181 countries on the World Risk Index, 2021.

Impact of extreme events of climate change

These extreme events resulting from climate change are directly impacting agriculture, thereby, indirectly impacting the economy of secondary and tertiary sectors. With changing climate, the agricultural productivity of the entire world is projected to decline between 3 and 16% by 2080. Moreover, in developing countries (many of which have average temperatures that are already near or above crop tolerance levels), productivity is predicted to decline between 10 to 25%. India's agricultural productivity is estimated to decline by 30 to 40% by the same period. Evidence shows that there is a 12.8% decline in kharif crop yield and 6.7% in Rabi crop yields due to extreme rainfall shocks alone. Therefore, there is a need to enhance the adaptation of the food systems to climate vulnerabilities, minimise the impacts of climate change on crop productivity and reduce the emissions of GHGs from food systems with climate-adaptive interventions. Many stakeholders across the world starting from FAO to local agricultural institutions make efforts to adapt food systems to be more responsive, adaptive and resilient to identified vulnerabilities and uncertain climate change risks, calling it Climate Smart Agriculture (CSA).

Stakeholders of the study

Against this backdrop, the study entitled "Climate Smart Agriculture (CSA) – Interventions, Prioritisation and Extension Models – A Multi-Stakeholder Analysis" was undertaken in Jalna district, Marathwada region of Maharashtra state. Three stakeholders such as the *Department of Agriculture (DoA), Krishi Vigyan Kendra (KVK)-Jalna and Water Trust Organisation (WOTR)* were identified with the criteria such as a major organisation in the promotion of CSA interventions, having more number of adopted/project villages, and implemented several projects of CSA.

Methodology

An ex post facto method was followed. Further, the purposive sampling method was adopted to select project villages namely (i) Tupewadi and Tapovan villages of DoA under Project on Climate Resilient Agriculture (PoCRA), (ii) Kadwanchi village of KVK under Indo German Watershed Development Programme (IGWDP) and (iii) Kotha Jahangir village of WOTR. To assess the farmer-level adoption of CSA interventions promoted by respective stakeholders in their adopted villages, a total of 60 farmers were selected i.e. 20 beneficiaries from each stakeholder's project villages. These beneficiaries were chosen using a random sampling method. Primary data were collected by conducting stakeholder meetings, Focus Group Discussions (FGD) and In-person interview with the officials of DoA, KVK and WOTR. For this purpose, a total of 24 officials i.e. eight each from DoA, KVK and WOTR were chosen. The information related to the prioritisation of interventions on agronomy, soil and water conservation techniques, energy

–saving technologies, infrastructure and institutional approaches were collected along with major extension models used by stakeholders. Further, to assess the impact of interventions on food system resilience, access to institutions, productivity and income, farmer-level data were collected using a semi-structured interview schedule, focus group discussions and in-person interviews. Secondary data were collected from the annual reports, booklets, mid-term evaluation reports, project reports, magazines and field notes, published by respective stakeholders.

Major findings and recommendations

It is evident from the research study, CSA interventions promoted by all three stakeholders have enabled the food systems to be more resilient to risks of drought, which is the major risk occurring with more intensity and frequency owing to changing climate in Jalna. Findings further show that there is no single-fit CSA intervention that can improve the adaptation of food systems to drought, but it is inherently linked to the adoption of a mix of interventions, for instance, diversification of cropping patterns from rainfed cotton to vegetables was plausible due to the adoption of farm ponds, drip irrigation coupled with the availability of, and accessibility to good quality seeds. However, the results show that the willingness of farmers to adopt a recommended CSA intervention be it agronomic technology or soil and water conservation practices & techniques, or farm mechanisation is determined by the extent of the subsidy support and prioritisation of CSA interventions by stakeholders viz., DoA, KVK and WOTR. Among CSA interventions, water-smart interventions have received the top priority among all three stakeholders. DoA under PoCRA is providing direct subsidy support for farmers to adopt farm ponds, micro irrigation, BBF technique and Zero Tillage. Whereas KVK and WOTR are facilitating the farmers to avail the subsidy support from line departments through convergence with schemes such as National Horticulture Mission (NHM), Rashtriya Krishi Vikas Yojana (RKVY) and Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGA) Besides, all three stakeholders have focused on the promotion of CSA interventions such as organic agriculture, Integrated Farming System (IFS), Integrated Pest Management (IPM), Integrated Nutrient Management (INM), improved varieties etc. However, there existed a difference among them in promoting capital-intensive technology such as shade net house. Study illustrates that DoA was the only organisation that provided subsidy support under PoCRA for farmers to adopt shade net houses as a major CSA intervention. The other stakeholders have not promoted it due to the requirement of huge capital. Hence, Undoubtedly, subsidy support was the major factor in the adoption of CSA interventions by farmers (more specifically marginal and small farmers).

Recommendations

- ✓ Stakeholders may study the potential of shade nets houses in terms of adaptation, productivity and mitigation and promote them at scale.
- ✓ Stakeholders like WOTR being NGO may collaborate with PoCRA and NHM for getting subsidy for farmers on shade net houses in their adopted villages.
- ✓ Shade net house, promoted under PoCRA has not only helped in the adaptation and resilience of food systems, but it has also generated more income for farmers, resulting in an overall improvement of socio economic status of farmers. Hence, it may be promoted at scale covering all the districts in Maharashtra state (elsewhere).

Moving towards solar farming

Moreover, stakeholders' prioritisation towards the promotion of energy smart interventions such as solar pumps received little importance. Only a few farmers in the sample villages have adopted solar pumps with subsidy support from Mukhyamantri Saur Krushi Pump Yojana (MSKPY), implemented by the State Government of Maharashtra. One of the studies shows that a 5-HP irrigation pump run on diesel and grid-electricity operational for 1,250 hr/year, would emit 5.2 and 4 t of CO2/year, respectively. Therefore, replacing just 5 million diesel pumps in India with solar pumps might help mitigate 26 million tons of CO2 emissions annually.

Recommendation

- ✓ Solar pump is becoming a major energy smart CSA intervention, particularly in minimising CO_2 emissions, hence, stakeholders may allocate more budget and prioritise their extension efforts towards the promotion of solar pumps. This will be an additional boost to farmers in adaptation and mitigation.
- ✓ Fostering convergence between PoCRA and MSKPY scheme of Maharashtra may result in the adoption of solar pumps at scale.

Accelerating adaptation through agroforestry

Results further show that only 301 farmers have adopted agroforestry covering 12.89 ha as of September 2021 since 2018. However, none of the sample beneficiary farmers of PoCRA in Tupewadi and Tapovan villages has adopted agroforestry. Similarly, the extension efforts of KVK and WOTR were not prioritised towards agroforestry.

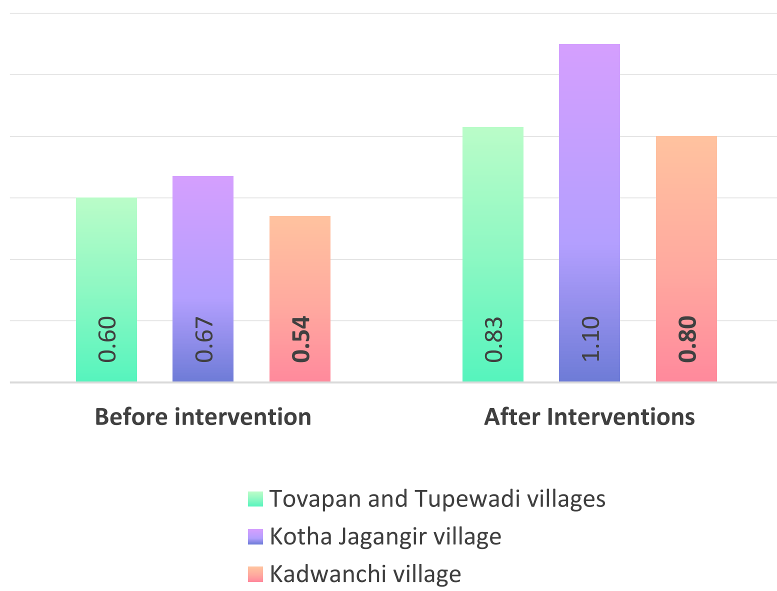
Recommendation

- ✓ Given the role that agroforestry can play in climate change mitigation and adaptation by sequestering carbon, reducing greenhouse emissions, etc., stakeholders may strengthen its extension and other support services for promoting agroforestry.
- ✓ There is also a need for mass-scale awareness among farmers to adopt agroforestry and create access to authorised quality tree nurseries and linkages to private firms and domestic & international carbon markets to earn carbon credits for farmers and realise the full potential of agroforestry.
- ✓ stakeholders may also strengthen its convergence with state and central government schemes (sub-Mission on Agroforestry) to promote agroforestry both in farmer's lands and wastelands.

Study results also illustrate that most of the CSA interventions promoted by stakeholders are aiming to improve the food system adaptation, improving productivity, farm income and post-harvest management. Though a few interventions such as zero tillage, conservation agriculture etc., aimed at the mitigation potential of food systems, the benefits from these interventions were not measured mainly due to a lack of standardised methodology, which in turn deprived of the benefits to farmers in terms of mitigation of GHGs such as carbon credit.

Recommendation

- ✓ Stakeholders may invest in developing a standardised methodology for measuring the farm-level mitigation potential of GHGs out of CSA interventions, comparable with the earlier conventional practices and technologies of farmers.
- ✓ Before the implementation of any CSA project and promotion of CSA technologies and practices, stakeholders may take into account the GHG emissions with a baseline survey and adopt an internationally accepted standardised methodology to measure the reduction in GHG emissions at farm levels compared with previous practices.
- ✓ Such reduction measures will help the stakeholders to facilitate earning carbon credits for farmers by linking them to domestic and international carbon markets.



Soybean yield tones per acre reported by sample farmers

All these interventions have resulted in the overall improvement in adaptation, for example, diversification towards high value commercial crops has drastically improved the resilience of the food system. The area under vegetable crops in Tupewadi and Tapovan villages (DoA under PoCRA) increased by 57%, the area under chilli in Kotha Jahangir village (WOTR) increased by 85% and the area under grapes increased by 94% (KVK). Crop diversification is linked to assured water availability through farm ponds and water use efficiency through drip or sprinkler irrigation systems. Results show that cent per cent of the sample beneficiary farmers have adopted drip irrigation in all four villages, and cent per cent of them in Kadwanchi and Kotha Jahangir had farm ponds, except for Tupewadi and Tapovan villages where only 25% of the sample beneficiary farmers constructed farm ponds. Also, crop productivity has increased due to the adoption of good agronomic practices along with soil and water smart interventions. Results show that the soybean crop yield of sample beneficiary farmers of PoCRA in Tupewadi and Tapovan villages has increased to 0.83 tonnes on average from 0.60 tonnes per acre. Similarly, sample beneficiary farmers of WOTR who were growing soybean reported an increase in soybean yield to 1.1 tonnes from 0.67 tonnes per acre. Beneficiary sample farmers of KVK in Kadwanchi village reported that the average soybean yield increased to 0.80 from 0.54 tonnes.

Similarly, for other crops, the yield has increased compared to before adopting CSA interventions. This increased cropping diversification and yield has a direct impact on increase in farm income. For instance, the average income of the beneficiary sample farmers of DoA (PoCRA), KVK (IGWDP) and WOTR reported an increased income of 4.07 from 2 lakhs per ha, to 7.87 from 2.56 lakh per ha and 2 from 1.25 lakhs per ha, respectively. This shows that the adoption of CSA interventions has enabled the farmers to earn farm income nearly double when compared to before the adoption of CSA interventions. In addition to this, there is an increased employment opportunity for people, which in turn minimised the seasonal migration of agricultural labourers. However, the adoption of CSA interventions is inherently linked to incentives and huge investment support.

Extension support services

Apart from subsidy support, knowledge and extension advisory models have played a pivotal role in awareness creation and capacitated farmers to move towards CSA. Among all extension support services, Farmers Field School (FFS) has emerged as the major model. Both DoA and WOTR have organised FFFs to create awareness, inculcate skills to practice and change the attitude of farmers towards the benefits of CSA in transforming food systems to an identified climate change vulnerability. Further, to ensure the participation of the farming community in all CSA interventions, all three stakeholders have created local community institutions, gender extension models, as well as adopted participatory watershed and water budgeting approaches. Also, the digital extension models such as customised extension services through *FarmPrecise App* (WOTR) and providing subsidies to the beneficiaries through *PoCRA DBT portal* (POCRA) emerged as the major ICT based support services. Therefore, the adoption of CSA interventions by farmers needs subsidy provision on the one hand and extension support on the other hand. Both go hand in hand in improving the adoption of CSA interventions in the adaptation of food systems to climate change vulnerabilities and mitigation of GHGs.

Though CSA interventions promoted by all three stakeholders have several benefits and co-benefits in terms of adaptation, productivity and income. Organisations have to strengthen their CSA interventions and extension approaches with more focus on mitigation measures and carbon credit linkage, beyond their focus on adaptation. Also, they can foster convergence for promoting capital intensive CSA technologies such as shade net houses to further strengthen inter organisation collaboration and enhance resilience.

Introduction

CHAPTER – I

Introduction

1.1 Background

Climate change and weather variability have emerged as one of the greatest environmental challenges globally (Deepika et al, 2018). Globally, from 1970 to 2019, weather, climate and water hazards accounted for 50% of all disasters, 45% of all reported deaths, and 74% of all reported economic losses. Of all disasters that occurred between 1970 to 2019, riverine floods accounted for 24%, tropical cyclones 17%, general floods 14%, general storms 7%, drought 6%, flash floods 6%, landslides 5% and others 21% (WMO, 2021).

India as well experienced 1,058 climate disaster events such as floods, cyclones, droughts, cold waves and heatwaves from 1995 to 2020. Similar to global, floods accounted for 33% of disasters, followed by heatwaves (24%), droughts (22%), cold waves (16%) and cyclones (5%) (Gupta *et al*, 2021). The Economic Survey 2017–18 reveals that the annual rainfall in India has declined by about 86 mm in the last three decades. While kharif rainfall has declined on an average by 26 mm, the decline in Rabi rainfall has been by 33 mm. Further, unsustainable groundwater extraction has resulted in decreased water resources for agriculture and drinking purposes. In terms of groundwater resources in 2020, about 14 – 17% of blocks are overexploited, followed by 15% of blocks belonging to semi-critical level and 3-5% are critical. Blocks with safe groundwater declined to 64% in 2020 from 73% in 2009. Occurrence of these extreme events is a result of climate change, which affects the balance of life in ecosystems and essential human activities including agriculture and irrigation.

Most importantly, the effects of climate change are directly impacting agriculture, thereby, indirectly impacting the economy of secondary and tertiary sectors. With changing climate change risks, the agricultural productivity of the entire world is projected to decline between 3 and 16% by 2080. Moreover, in developing countries (many of which have average temperatures that are already near or above crop tolerance levels), productivity is predicted to decline between 10 to 25%. India's agricultural productivity is estimated to decline by 30 to 40% by the same period (CfGD, 2017). There has also been a 12.8% decline in kharif yields and 6.7% in Rabi yields due to extreme rainfall shocks (The Economic Survey, 2017-18).

To overcome the risks and uncertainties of climate change faced by the agricultural sector, the introduction and implementation of climate smart agriculture innovations, technologies, practices and support services have become essential. These interventions will sustainably increase productivity, income and enhance adaptation and resilience to climate change risks while improving the livelihood of farmers, coupled with contributing to the sustainable production and consumption of SDG Goal – 12 (Senyolo et al. 2018; Fusco et al. 2020). In this context, several agricultural stakeholders are involved in optimisation of agricultural resources including natural resources for increased productivity, sustainability of farms and overall development of the farm family through Climate Smart Agriculture (CSA). CSA envisions the creation and implementation of innovative models for attaining multiple benefits and resilience not just for the farming community but a wide range of stakeholders (Shah, 2018).

Over the past two decades, extension services have evolved from being solely vested in public extension systems to a mix of public, private and civil society groups that provide a broader range of services to rural communities. Such extension services range from the sharing of technology and information; to advice related to farms, organizational & business management; and facilitation in rural development and value chains. The increasing pluralism in extension advisory services has been mainly due to the increasing participation of private sector providers that deal with agricultural inputs, agribusiness services and financial services; international and local non-governmental organizations (NGOs); producer groups, cooperatives and associations; consultants, either acting independently or in association with agribusinesses and producer associations; and services based on information and communication technologies (Sala et al, 2016; FAO, n.d; (Khatri-Chhetri, et al, 2019). Among the various services provided for farmers, extension service providers including the private sector have focused on the promotion of CSA as it is a "transformative and sustainable kind of agriculture that tries to increase productivity, ensuring food and nutritional security as well as food production systems, using a combination of the pillars of climate change (adaptation, resilience, and mitigation) as well as smart and new technological knowledge. CSA builds capacity of farmers in terms of farming techniques, increases farm profit, reduces the vulnerability of food systems including livestock through the reduction of GHG emissions. However, the promotion of different CSA interventions and scale of operation are dependent on the availability of capital, manpower, available resources, partnership, convergence, choices, funding options, etc., (Adesipo *et al*, 2020).

1.2 Various CSA interventions and extension approaches – a global overview

Technological innovations will play a prominent role in the transition of food systems to CSA (Long et al, 2016; Zilberman et al, 2018). CSA interventions can be categorized into agronomic (crop rotation, judicious use of fertilizers, Integrated Pest Management mechanical), biological (e.g. use of improved seeds and varieties), mechanical (e.g. tractors). Further, institutional innovations such as farmers' groups, water user groups, Farmer Producer Groups and cooperatives, arrangements for markets and contract farming are playing a major role in CSA. In West Africa, agroforestry (farmer-managed natural regenerations), soil and water conservation technologies such as zai, half-moon, tie/contour ridges and conservation agriculture are the major climate smart practices followed by farmers. The major extension services on these climate smart innovations and practices are provided by the community, multi-stakeholder innovation platforms at national and regional levels, national science policy dialogue platforms on CSA in parts of West Africa and the formulation of the West Africa (Partey et al, 2018). Farmers in North Eastern Tanzania have adopted improved crop varieties, agroforestry, and scientific practices to combat the risks of drought (Nyasimi et al , 2017). In Tanzania, farmers were adopting the integration of livestock with crops, better irrigation practices, application of chemical fertilisers and agroforestry to overcome the risks of climate change. In Ghana, Olam partnered with the Rainforest Alliance (a network working for biodiversity conservation and sustainable livelihood promotion) to establish a project, which aimed to break the link between cocoa production and deforestation by building cocoa agroforestry production areas to make the system more resilient to moisture and temperature changes resulting from climate change. Additionally, the project aims to allow Olam to be the first company to bring climate-friendly cocoa to market, diversify opportunities and increase income for farmers, build efficient value chains, and serve as a learning model for future expansion of the project. The extension approach followed by Olam was partnership with stakeholders at all levels through a variety of means to accomplish these goals. Also, the partnership has been working closely with the Forestry

Commission, traditional authorities, and private concession holders on partially or wholly devolving land rights to local communities who can then support sustainable forest management practices and develop these resources into REDD (Reducing Emissions from Deforestation and Forest Degradation) projects (Sulaiman, 2017).

In South Africa, conservation agriculture, rainwater harvesting and seed varieties that are drought tolerant and early maturing are the most suited and adopted technologies for climate-smart agriculture, particularly by smallholder farmers. Also, drought tolerant and early maturing seed varieties faced less adoption barriers. However, conservation agriculture and rainwater harvesting required high initial investment costs and additional labour requirements (Senyolo et al, 2018). In Lower Bari Doab Canal (LBDC) irrigation system of Punjab, Pakistan, the practices such as raising crops on bed, laser land levelling, conjunctive use of water, drainage management, minimum tillage, use of less chemical inputs, crop rotation and improved varieties i.e., tolerant to drought, flood and heat/cold stresses are adopted by cotton farmers. These technologies and practices help farmers to overcome the risks of droughts, conserve declining groundwater and overcome soil salinity due to climate change (Imran et al, 2018).

In India as well, various CSA interventions are promoted to enable farmers to adapt food systems to climate change. Among various technologies and practices, the use of stress tolerant crop varieties is most popular in India. For example, Swarna Sub 1 and IR 64 Sub 1 of rice, which was found to be best under submergence conditions during flood; Similarly, CSR-1 and K-3119 - salt-tolerant rice varieties; KRL 19 - high salt-tolerant variety of wheat; KRL 213 and KRL 210 - mild salt tolerant varieties of wheat were found to p'erform better under varied salinity condition. For heat stress tolerance, NDW 1014, Halna, WR 544 and PBW 154 were highly productive and stable. Further, adjustment of planting dates, conservation agriculture such as minimal soil disturbance (ploughing the field not more than 15 cm depth), ensuring soil cover (ground cover must be more than 30%) and crop rotation (rotation should involve at least three different crops); crop diversification, improved pest management practices and water saving technologies are promoted by various agricultural stakeholders. In addition to this, disseminating weather and climate information through expert to farmers, lead farmers to farmers, ICTs etc., has emerged as one of the major CSA strategies among stakeholders. (Mahdi et al, 2015). Further, organic farming is promoted at scale as it has the potential to recycle wastes of plant and animal origin to return nutrients to the land, thus minimizing the use of non-renewable resources; reducing global warming by lowering the emission of greenhouse gases and enhancing biological diversity within the whole food systems. Also, its co-benefits extend to non-use of pesticides that affect human and animal health, biodiversity of wildlife and cause environmental pollution (Sartaj et al, 2013).

In Odisha, 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) have been promoting several CSA technologies. For example, farmers were made aware of Swarna sub-1 (Paddy variety) as a result, farmers who adopted Swarna sub-1 (Paddy variety) produced 6.1 t/ ha yield and gross return of Rs.95,167 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). Further, Swarna sub-1 can tolerate submergence even for up to 17 days. Similarly, lodging-resistant paddy variety - Bina Dhan 11 was adopted by farmers to overcome lodging problems. Further, the diversification of rice to rice cropping patterns to rice with green gram and groundnut is gaining importance. In comparison to summer paddy (a usual farmers' practice), green gram can be grown with 43.7% less fuel, 21.7% less labour, 48.5% less cost and saving of 93.9% irrigation water (15,500 m3). Moreover, System of Crop Intensification in Rice and Finger Millet, Direct seeded rice (DSR) for better resource management, Alternate Wetting Drying (AWD), Integrating weed management (IWM) technology for higher productivity, Field-specific nutrient management for rainfed rice through Rice Crop Manager (RCM), Solar Power as a Remunerative Way to Minimize Climate Risks, Solar powered irrigation system and Mechanization of farming for tackling labour scarcity have enhanced the adaptation capacity of farmers in the project areas of CCAFS. Among all, the supportive services promoted under CCAFS such as Women-led informal seed production and distribution of climate resilient rice varieties, community mat nursery for ensuring availability of paddy seedlings under contingent situations, weather-based advisories for groundnut and science-based crop insurance system for increasing farmer's resilience have become an integral part of CSA in Odisha (Sharma et al, 2020).

In Pune, Ahmednagar, Satara, Ratnagiri and Amravati of Maharashtra state, the adoption of CSA technologies such as drip irrigation, sprinkler irrigation (water management technologies), crop and livestock insurance were the high-ranked CSA interventions among stakeholders. This is followed by nutrient management techniques and practices such as farmyard manure, vermicompost, residue incorporation etc, crop sowing methods like broad bed furrow, minimum tillage, use of improved seeds and crop diversification received major extension support from stakeholders. However, the CSA interventions of CSA such as green manuring, gully control structure, legume integration and mulching received a low preference (Khatri-Chhetri et al, 2019). In Karnataka, the farmers in Sadappalli and Gundlapali, Bagepalli block, Chikballapur district have adopted mixed cropping, trap crops, change of time of sowing and crop diversification under changing the cropping pattern as an adaptation strategy. Also, farmers have adopted agroforestry (e.g. eem, Pongamia spp., Coconut etc.,), IFS (e.g. cattle, buffaloes, sheep and goat), alternative livelihoods (e.g. petty business, Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) as adaptation (Kattumuri et al, 2015).

Laser-Assisted Precision Land Levelling (LLL) was introduced in the western Indo-Gangetic Plain in 2011 under the Rice-Wheat Consortium for the Indo-Gangetic Plains, an initiative that was convened jointly by CIMMYT, the International Rice Research Institute and several national and sub-national research institutes in the region. LLL is a tractor-towed, laser-controlled device that makes an exceptionally flat surface. Evidence from Punjab and Haryana shows that laser levelling of rice fields reduced irrigation time by 45-55 hrs per ha per season. In wheat, the reduction was 10-12 hrs per ha per season, yield increases resulting from LLL were estimated at 340 kg/ha for rice and 320 kg/ha for wheat and the resulting net present value of the increased income stream amounted to US$ 113 per hectare in the first year and by US$ 175 in the second year (Gill, 2014). Also, farmers in Eastern Indo-Gangetic Plain (IGP) have preferred to adopt laser land levelling (LLL), crop insurance, and weather advisory services and farmers in Western IGP LLL, direct seeding, zero tillage, irrigation scheduling, and crop insurance to adapt food systems to climate aberrations such as droughts, floods, and outbreaks of pests and diseases (Taneja et al, 2019). Farmers in Nasik district of Maharashtra state and Guntur district of Andhra Pradesh state have adopted surface farm ponds to respond to the risks of climate change by securing water for irrigation at critical stages of crops (Banerjee, 2015).

In Himachal Pradesh, the state government has launched a new scheme Prakritik Kheti Khushal Kisan Yojana to encourage Natural Farming (NF), which helps the farmers to reduce the cost of cultivation, conserve soil and optimise the output. Under this, project, the budget provided for chemical fertilizers and chemical pesticides will be used for providing bio-pesticides and bio-insecticides. This may encourage the farmers to adopt NF at farmer level and adapt agriculture to changing climatic aberrations. Similarly, under energy smart, the Department of Rural Development, Government of Himachal Pradesh has been promoting bio-gas production. Till March 2017 since inception, 44,815 bio-gas plants have been installed in the state. Similarly, several states have introduced natural farming as an adaptation measure to address the risk of climate change. In addition to the line department, several NGOs are working in Himachal namely Pradesh Community Empowerment Organisation for development (Chamba), Sure Society for Upliftment of Rural Economy (Kullu), Kisan Sabha, Sanjeevani (Mandi) etc. and their activities also include CSA such as better irrigations facilities, ridge and furrow method in bitter gourd (Palee), vermiculture, mulching, drought tolerant varieties (e.g. Wheat HPW 360), crop diversification with Bitter gourd Chaman/Palee, Bottle gourd round (Marvi), pheromone traps for fruitfly in bitter gourd, mineral mixture feeding in cross bred animals and provision of power tiller through CHC (Kapri and Saravanan, 2020). In Rajasthan state, farmers in low rainfall zone had adopted crop insurance, weather-based crop agro-advisories, and rainwater harvesting structures as CSA options (Khatri-Chhetri, 2017). However, the adoption of CSA interventions is subject to technical, social, environmental and economic barriers (Long et al, 2016). Given the context that the CSA interventions play a major role in adaptation and resilience, various approaches and extension models are followed by stakeholders to ensure a wide scale promotion and high adoption rate at farmers level (Zilberman et al, 2018).

1.3 Extension models for promotion of CSA interventions

Farmer-level issues have to be prioritized for promoting CSA interventions (Sala et al, 2016). Adoption of CSA interventions is dependent on various extension approaches and support incentives. Funding support for adopting technology, access to farm credit, increase in knowledge and skills (capacity building) and accessibility to market are a few determinants that influence the adoption behaviour of farmers (Khatri-Chhetri et al, 2019). Therefore, there is an increasing need for understanding the farmers' needs and problems, also to know the performance of previous farm-level interventions, along with assess initial socio-economic status, capacity needs, existing cropping and farming systems, yield and income and mitigation potential. A successful CSA implementation requires efficient extension providers and systems. some of the extension methods and approaches are interpersonal interaction, field days, extension campaigns, plant rally, printed materials (traditional methods), radio, mobile phones, video, social media (ICT approaches), farmer field schools, rural resources or knowledge centre; market-oriented approaches such as marketing, value addition and enterprise skill development; etc., linking, networking, facilitation, brokering, coordination services; in addition to this, monitoring, advocacy and policy support are becoming pivotal for extension providers to effectively address the risks of climate change (Sala et al, 2016). The priority areas of CSA interventions of various stakeholders and their extension approaches may vary at national and local levels depending on the cropping systems and agro ecological zones. Some of the prominent extension models are as follows.

Agro meteorological information: Increasing risks of climate change on agriculture draw the need for accurate and timely weather information to plan and undertake field operations (Kalimba and Culas, 2020). Several agro-meteorological tools are emerging and can be used by extension stakeholders for promoting CSA. These tools are useful for measuring daily rainfall, agro ecological observations, early warnings on droughts, floods, heat waves, precipitation along with advice and information on protection measures. The extension tools such as bulletins, internet based communication, radio, broadcast, face-to-face, and group meetings are some of them (Sala et al, 2016). These services would help farmers to prepare farmers against unprecedented weather events (Kalimba and Culas, 2020). In countries like Sahel, radios are used for providing weather information in local language. However, access to radio programmes on climate and weather information is gender-biased (Sala et al, 2016). In Senegal, the implementation of CGIAR Research Programme on Climate Change, Agriculture and Food Security (CCAFS) play an important role in delivering information on seasonal rainfall and long-term weather forecasts. CCAFS scientists have worked with the national meteorological agency (Agence Nationale de I'Aviation Civile et de la meterorologie/ANACIM) and developed downscaled seasonal rainfall forecasts and raised the capacity of partners to provide long-term climatic information for farmers with more actionable services. The agro-meteorological services are tailored to meet the specific needs of farmers and are delivered to them. Further, an association has been made with community radio to provide services to all farmers in all local languages of Senegal. Also, communication of climate information through SMS is widely adopted. Extension agents who receive SMS from ANACIM relay it to their contact farmers and farmers in turn pass it on to other farmers. This ensures a larger reach and a high rate of adoption potential by local farmers. At present, around 7.4 million rural people were reached with climate information under this project (Sala et al, 2016). However, the lack of sub-national level administrative zones was a challenge for ANACIM to design the downscaled seasonal rainfall forecast information. Also, many local multidisciplinary working groups (GTPs) were not covered, coupled with a lack of financial resources to plan training and capacity-building programmes for GTPs, Journalists and other actors deterred the scaling up.

Farmer Field Schools (FFS) are now followed for CSA. It was initially an extension approach for promoting Integrated Nutrient Management (INM) and Integrated Pest Management (IPM). FFS in Indonesia raised awareness of climate change and popularized solutions to overcome changing rainfall patterns, particularly knowledge on recording and interpretation of on-farm, rainfall measurements and in-field water harvesting (Sala et al, 2016). FFS was a major extension approach of Mitigation of Climate Change in Agriculture (MICCA) pilot project implemented in Tanzania between 2011 and 2014. Through this FFS, the project team promoted Conservation Agriculture (CA) practices such as minimum tillage, soil cover by leguminous crops and mulches and crop rotation without slash and burn. Farmers who adopted CA practices perceived that there is more than 100 per cent increase in Maize yield, thereby generating more income. All these farmers had received training through FFSs and other extension methods. However, insecure land tenure was the major obstacle in the adoption of labour-intensive CA practices such as double digging in terracing. This is mostly because the improvement in fertility and farm productivity may lead to taking back of the lands by owners. These practices helped reduce the slash-and-burn agriculture from 55 to 39 per cent at the end of the project (Sala et al, 2016). In India, FFS is gaining importance for disseminating CSA technologies and services (Banerjee, 2015). Science Field Shops Approach, an emerging approach, has been implemented in villages of Indramayu, NW Java, Indonesia since 2010. under this approach, farmers are trained to document the rainfall data, agro ecological observations (soil, plants, water, biomass, pests, diseases and other climate extremities) and these farmers are further informed with new knowledge on the management practices to the above observations. Moreover, there is an increased exchange of knowledge among farmers and it is facilitated by farmers' facilitators who were selected for this process of exchange of information to combat risks in climate change (Sala et al, 2016).

Plant clinic approach: It is widely practised for CSA. It is implemented in 33 developing countries. The crop problems brought to pant clinics by farmers, the extension worker is entrusted to note down the problems in a format (offline or online) and advice is provided to address the problems. In Sri Lanka, 16 out of 25 districts have plant clinics with about 290 clinics functioning to address the farmers' problems. This is an effective extension approach for CSA as the advice given by the extension worker has a direct effect on reducing crop yield, income and adaptation to climate change (Sala et al, 2016). *Community-level institutions* are also important approaches in CSA. Most countries and extension players all over the world are employing community initiatives to deliver locally relevant information and support services (Sala et al, 2016). *Digital technology* can guide crop and input selection, facilitate credit and insurance, and provide weather advisories and disease- and pest-related assistance, and real-time data on domestic and export markets (Goswami. S & Lele). Weather forecast information services were the import CSA service available for the farmers in North Eastern Tanzania (Nyasimi et al, 2017). Also, agricultural information received orally from a variety of sources including government extension workers, seed companies, researchers, traditional experts, neighbours, radio agricultural shows, religious groups, farmer groups, and family members are the major information sources for farmers (Nyasimi et al , 2017). Mobile-phone enabled agro-advisory services has the potential to reduce information gaps and generate awareness about improved technologies which leads to improved adoption of technology (Mittal and Hariharan, 2018).

1.4 Other major extension models

Demonstrations are a very useful approach to transferring knowledge of new technology and building skills (Kalimba and Culas, 2020). Capacity building in agriculture and allied sectors is essential to address the establishment and strengthening of public, private and NGOs including CSOs and farmers groups (juvvadi, n.d.). Networking & partnership development, collaboration & coordination of extension activities, information & knowledge sharing, collaborative research, co-learning with multiple & diverse actors may enable the stakeholders as well as farmers to adapt to climate change (Kamruzzaman et al, 2020). Users association is steadily rising in developing countries. For example, Solar pump irrigator cooperative in Dhundi Village of Gujarat (India) was set up by the International Water Management Institute (IWMI) and the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) along with support from Tata Trust and the CGIAR Research Program on Water, Land and Ecosystems (WLE). This project has resulted in increased use of solar energy for agricultural irrigation, better earnings for farmers by selling excess solar energy to the public power distribution system, reduce overexploitation of groundwater and reduced the subsidy burden of government on free farm power. Also, many extension service providers distribute seeds and inputs after extreme events (Sala et al, 2016) and climate information services as highly valued promising options for climate change adaptation and risk management in West Africa (Partey et al, 2018). Though these extension methods are largely employed by developing countries. There is a need for intensifying these methods to better address the risks of climate change.

Against this backdrop, the study of Climate Smart Agriculture (CSA): Interventions, Prioritisation and Extension Models – A Multi-Stakeholder Analysis in Jalna district, Maharashtra state was undertaken with objectives (i) to assess the various CSA technologies and practices (refer to as CSA interventions) promoted by the select stakeholders, (ii) to analyze the CSA priority areas of stakeholders, within the organisation and between them, adoption levels and performance at farmers levels; (iii) to understand the impacts of CSA interventions in terms of productivity of crops, income of farmers, adaptation and mitigation of food systems to climate change risks; as well as challenges encountered by the stakeholders and farmers in ensuring food system adaptation and mitigation to climate change risks.

Methodology

Chapter – 2

Methodology

2.1 Background of the study area

One-sixth of the total topographical region in India falls under the Drought Prone Area (DPA), with less than 750 mm of the annual average rainfall (World Bank. n.d; SAMBODHI and TERI, n.d.). The state Maharashtra was selected purposively as about 40% of the Maharashtra State falls under DPA. It is the third largest State in India accounting for 9.4% of the total geographical area of the country and the second most populous state with more than 112 million people living in the state. The state has 22.6 million ha of land under cultivation (gross cropped area) and area under forest is 5.21 million ha. About 84% of the total area under agriculture is rainfed and dependent only on the monsoon. Total food grain production in the state is estimated at 9.91 million tonnes in 2014-15. During 2014-15, production of pulses and oil seeds in the state was recorded at around 1.75 million tonnes and 2.12 million tonnes, respectively. The major crops grown in the state are cotton, soybean, pigeon peas and chickpeas and jowar. Farmers with small, unirrigated land holdings are more vulnerable to climatic risks. Such risks pose irreversible losses.

Within Maharashtra, Marathwada region was selected as it is more prone to drought conditions since 2012 with the highest rainfall deficit in the country at 48% in 2014. Marathwada comes under Aurangabad Division and consists of 8 districts namely; Aurangabad, Bid, Latur, Osmanabad, Parbhani, Jalna, Nanded and Hingoli. The region has a population of about 1.87 Crores and a geographical area of 64.5 Thousand sq. kms. Agriculture is the major source of income generation for over 64% of the state's population. Drought situation of Marathwada region is not only the result of the erratic distribution of monsoon rain but also associated with a lack of water governance, poor implementation of watershed development projects and nonjudicial use of irrigational water. one-sixth of the total topographical region in India falls under the DPA, with less than 750mm of the annual average rainfall (World Bank. n.d; SAMBODHI and TERI, n.d.).

2.2 Selection of locale

Jalna district was selected as it is one of the major drought-prone districts in the Marathwada region. It is one of the 35 districts in Maharashtra state that comes under Central Maharashtra plateau Zone (MH-7).

2.3 Agriculture in Jalna

Out of the total geographical area (7.72 lakh ha), 91% of them are cultivable (7.12 lakh ha). The net sown area is 5.96 lakh ha. With a gross cropped area of 6.88 lakh ha, Jalna's cropping intensity comes to around 122%. Out of the total net sown areas, 78% is rainfed and the remaining is irrigated areas with the major source of irrigation being open-dug wells and farm ponds. With an area of 2.09, 0.69, 0.58, 0.51 and 0.44 lakh ha, cotton, pearl millet, maize, redgram and green gram forms the major field crops of Jalna. Also, the area under vegetables, fruits, spices and flower crops is substantially increasing (Agricultural Contingency Plan, NICRA). The average productivity of cotton is 0.29 tonnes of lint per ha, pearl millet - 0.93 tonnes per ha, maize - 2.15 tonnes per ha, reg gram - 0.66 tonnes per ha and green gram - 0.38 tonnes per ha. With 7.21 lakh livestock population, Jalna's share of the total livestock population of Maharashtra is 2.22%. Of 7.21 lakhs, 4.14 lakhs are cattle population including 3.71 lakh of indigenous breeds, 0.25 lakhs of sheep, 1.83 lakhs of goats and 1.81 lakhs of fowls.

2.4 Climate change impacts

Marathwada region consists of eight districts namely Aurangabad, Jalna, Beed, Osmanabad, Nanded, Latur, Parbhani and Hingoli. Out of these eight districts, five districts are considered to be the worst affected, namely Beed, Parbhani, Nanded, Osmanabad and Jalna. Within these five districts, Jalna is categorised as a district highly vulnerable to drought, followed by an increase in temperature, heatwaves, extreme rainfall and prolonged dry spells. There is a rising number of different pests and diseases jassids and whitefly in cotton, Spodoptera in soybean, sphingid in green and black gram and Heliothis in redgram. Also, Jalna is categorised as one of the most vulnerable districts to climate change risks (ADB, 2021 and State Adaptation Plan) and drought was reported in Jalna district for the last five consecutive years due to deficit rainfall. With 324 mm, Jalna recorded its lowest rainfall in 2012 (Vedeld et al, 2014). On the other hand, the year 2021 recorded rainfall of 1245.2 mm. Annual average rainfall is 750.4 mm with 85% of which is received during the South West Monsoon (June to September). Jalna district, famous producer of sweet lime had been the worst hit by the drought in 2013.

2.5 Study methods and sampling procedures

An ex post facto study design was followed for the study.

2.5.1 Selection of stakeholders

A total of three stakeholders were selected for the study purposively representing the front line extension system (Department of Agriculture), ICAR extension system namely Krishi Vigyan Kendra (KVK) and NGO extension system i.e. WOTR. The major reason for selecting these three stakeholders was that they represent the public and private extension systems and became the major stakeholders in addressing the risks of climate change in the food systems.

Department of Agriculture (DoA) being the major frontline extension system, is implementing the world's largest climate smart agricultural project i.e. Project on Climate Resilience Agriculture (PoCRA) in Maharashtra state funded by the World Bank. About 5142 climate risks vulnerable villages of 15 districts were covered under PoCRA. KVK on the other hand is emerging as one of the major extension systems in addressing the farm challenges by conducting capacity-building programmes, technology assessment, refinement and demonstrations at farmers' level, knowledge and resource centres for public, private, NGOs and farmers. KVKs-Jalna has successfully implemented several watersheds and CSA development projects namely Indo German Watershed Development Programme (IGWDP). In NGO extension systems, WOTR was identified as the major extension player working on CSA as it is implementing many climate smart agriculture projects in partnership with national and international organisations. More than 5200 villages of nine Indian states were covered under integrated watershed development, Eco System based adaptation, climate resilient agriculture by WOTR including kotha Jahangir village.

2.5.2 Selection of project sites

For the study, three project sites were identified randomly after thorough discussion with the officials of DoA, KVK and WOTR. The selected project sites are

- ✓ Tupewadi & Tapovan villages under PoCRA project of Department of Agriculture
- ✓ Kadwanchi village under Indo German Watershed Development Programme (IGWDP) of KVK and
- ✓ Kotha Jajangir village of WOTR.

Table 1. Selection of project sites

S.No.	Name of state	Name of District	Name of Taluk	Name of Villages
1.	Maharashtra	Jalna	Badnapur	Tupewadi
2.			Bhokardan	Tapovan
3.			Jalna	Kadwanchi
4.			Bhokardan	Kotha Jahangir

2.5.3 Collection of data

Primary data were collected by conducting stakeholder meetings, Focus Group Discussions (FGD) and In-person interview with the officials of DoA, KVK and WOTR. For this purpose, a total of 24 officials i.e. eight each from DoA, KVK and WOTR were chosen. The information related to the prioritisation of interventions on agronomy, soil and water conservation techniques, energy-saving technologies, infrastructure and institutional approaches were collected along with major extension models used by stakeholders. Further, to assess the farmer-level adoption, adaptation (food system resilience, access to institutions, productivity and income), 60 farmers were selected i.e. 20 beneficiaries each from the randomly chosen CSA project sites of stakeholders. Secondary data were collected from the annual reports, booklets, mid-term evaluation reports, project reports, magazines and field notes.

Table 2. Sample selection

S.No.	Name of the project sites	Name of stakeholders	No of farmers
1.	Tupewadi and Tapovan villages	Department of Agriculture (DoA)	20
2.	Kadwanchi village	Krishi Vigyan Kendra (KVK) or Farm Science Centre	20
3.	Kotha Jahangir	Watershed Organisation Trust (WOTR)	20
		Total	**60**

Further, a total of 20 farmers each were selected from Tupewadi &Tapovan villages (PoCRA of DoA), Kadwanchi village (IGWDP of KVK) and Kotha Jahangir (WOTR).

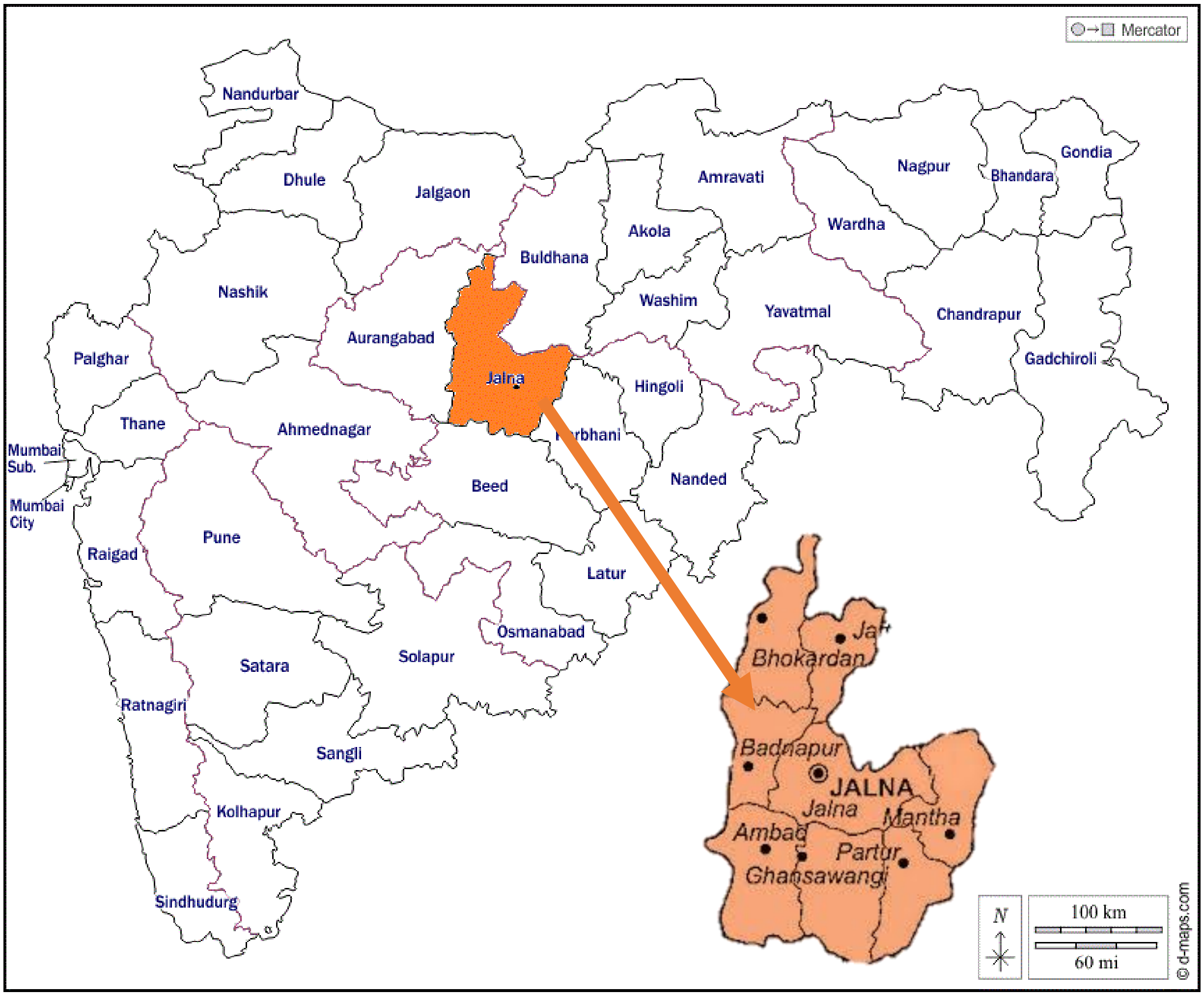


Figure 1. Map showing Jalna district

2.5.4 Data collection tools

A semi-structured interview schedule was used for collection of data from officials and farmers related to different climate smart agriculture interventions, adoption level, impact of interventions on crop diversification, water storage structures, productivity of crops, income level of farmers, adaptation capacity in terms of improved access to different institutions.

Data collection from a farmer at Kadwanchi village, Jalna Block and District

2.5.5 Data analysis

Simple percentage analysis and average were used. Stakeholders' CSA prioritisation was assessed by analysing the percentage share of the investment cost on a particular CSA theme of the total investment cost utilised for the promotion of CSA. To assess crop diversification, Simpson index of crop diversification was used.

Results and Dicussion

Chapter – III

3. Results and Discussion

3.1 Agronomic smart interventions

Agronomic practices aim at farm management to improve soil quality, enhance water use, manage crop residue and improve the environment through better fertilizer management (Ahmad et al, 2017).

3.1.1 Agronomic smart interventions and their level of prioritisation by stakeholders

"PoCRA is the world's largest world bank funded climate smart agriculture projects intenting to benefit the farming community from immediate threats of climate change risks more transparently and climate proof agriculture for future Says............Dr Vijay Kolekar, Project Leader (PoCRA)

Crop diversification is the single most agronomic smart intervention prioritised by all three stakeholders as it can bring more profit to farmers even with the failure of one crop due to climate change risks. For example, Department of Agriculture under PoCRA is encouraging farmers to diversify their cropping pattern towards high value vegetables and fruit crops under drip irrigation from traditional crops such as cotton, maize, sorghum, etc. The data shows that as of September 2021, a total of 10,451 farmers (in the project sites) shifted their cropping pattern towards fruit crops such as guava, custard apple and sweet lime and 2491 farmers cultivate vegetables including 2222 farmers under shade net conditions. The area under horticulture crops in the adopted villages of PoCRA was 7713.93 ha as of September 2021. Results show that cent per cent of the farmers in Teupewadi and Tapovan villages diversified their cropping pattern towards high value vegetable crops. About 85% (17 nos) of them were growing vegetables under shade net houses (Fig.2). Also, one of the beneficiary farmers is growing Gerbera under a shade net house generating a net income of Rs.1 lakh every month (***Case 5***). The diversification towards high value/commercial crops is linked to the assured water supply through establishing individual farm ponds, drip irrigation systems and shade net houses, the adoption of these CSA practices and technologies is in turn linked to the high subsidy provided under PoCRA. Similarly, KVK under Indo-German Watershed Development Programme (IGWDP) aims to promote crop diversification by creating assured water supply through farm ponds and community water ponds along with facilitating the adoption of drip irrigation. Results illustrate that the number of beneficiary sample farmers in Kadwanchi village adopting grapes in place of cotton or soybean has increased to 37% due to farm ponds and drip irrigation. Results further show that cent per cent of the sample beneficiary farmers has drip irrigation and farm ponds. Of them, 75% of the farmers adopted farm ponds and drip irrigation systems with the subsidy support of the State and central government schemes. KVK has played a major role in facilitating farmers to get subsidy support for installing drip irrigation systems and farm ponds. The foremost reason is attributed to the establishment of check dams and other water harvesting structures established under Kadwanchi watershed programme under IGWDP. It remains one of the best watershed models in India. These supply-side water management initiatives such as check dams, community farm ponds and individual farm ponds coupled with the adoption of drip or sprinkler irrigation have ensured the water availability for crop production throughout the year. Also, beneficiary sample farmers of WOTR in Kotha Jahangir village have diversified their cropping pattern towards chilli, tomato etc., under the conditions of assured water supply through farm ponds/community farm ponds, check dams, Gabion structures, Nala deepening, etc (***Refer to para 3.2.1 and 3.2.2)***.

Table 3. Agronomic smart interventions promoted by selected stakeholders

S.No.	Particulars	Department of Agriculture (PoCRA)	Krishi Vigyan Kendra (KVK) (IGWDP)	WOTR
1.	Changing and adjustment of sowing or planting dates	✓	✓	✓
2.	Improved seeds/varieties	✓	✓	X
3.	Climate smart crops/changing cropping pattern/ Diversification	✓	✓	✓
4.	Intercropping/Mixed cropping	✓	✓	✓
5.	Integrated Farming System (IFS) with goats, sheep, cattle and fisheries, poultry etc.,	✓	✓	✓
6.	Integrated Pest Management (IPM)	✓	✓	✓
7.	Integrated Nutrient Management (INM)	✓	✓	✓
8.	Crop rotation	✓	✓	✓
9.	Agroforestry	✓	X	X
10.	Organic farming	✓	✓	✓
11.	Natural farming	X	X	X
13.	Catch crops (increased organic carbon content)	X	✓	✓
14.	Soil Health Card-based nutrient recommendation	✓	✓	✓
15.	Vermicompost	✓	✓	✓
16.	Farm Yard Manure	✓	✓	✓
17.	Green manuring	✓	X	X
18.	Green Leaf Manuring	✓	X	X
19.	Sensor-based nutrient and water management technologies	X	X	X
20.	Use of waste decomposer	X	X	X
21.	Broad Bed Furrow technique in Soybean	✓	✓	✓
22.	System of Crop Intensification (SCI)	X	X	✓

Intercropping of redgram with soybean in Kotha Jahangir village, Jalna district

Also, the promotion of organic agriculture finds equal importance among the stakeholders as it enhances soil and crop productivity. For example, concerning organic agriculture, WOTR focuses on training the farmers on the importance of vermicompost beds and imparting skills on the preparation of organic formulations such as Amrut Pani and Dashparni Ark. However, in the Kotha Jagangir village, though training programmes were organized on organic agriculture, only a few reported sample farmers were using organic formulations due to non-possession of livestock. Only 20% of the sample farmers had cows/buffaloes, mostly for milch purposes. However, the field staff indicated that about 70% (i.e. more than 200 farmers) in Kotha Jagangir village prepare and use Amrut Pani, Jeevamruth, Neemark, vermicompost, Dashparni Ark etc., for crop production in combination with inorganic fertilisers. Similarly, DoA under PoCRA is creating awareness among farmers in preparation of their own organic inputs, know-how of compost pits and use of organic manures in crop production, besides subsidy is provided under PoCRA for establishing vermicompost and organic input production units. Data shows that 429 farmers established organic input units in the villages adopted by DoA under PoCRA till September 2021. However, results show that the beneficiary sample farmers in the villages of Tupewadi and Topavan have not adopted organic agriculture as they are still dependent on external chemical inputs for crop production and pest & disease control. This is also due to growing of high value commercial crops under shade net houses.

3.1.2 Climate Smart Varieties

One of the growing agronomic interventions to address the risks of climate change and especially drought and erratic rainfall is the adoption of Climate Smart Varieties (CSVs). Among the three stakeholders, DoA has shown more interest in promoting CSVs. DoA under PoCRA promotes CSA varieties such as Jackie-9218, Vishal (Phule G-. 87207), Akash (BDNG – 797), BDNGK – 798 of Bengal Gram; MACS-1188, MAUS-71, 158, 162 and JS-2029 of Soybean. Results show that 8.90% of the farmers in Tupewadi and 42% of the farmers in Tapovan villages have adopted these CSA varieties (Fig.1.).

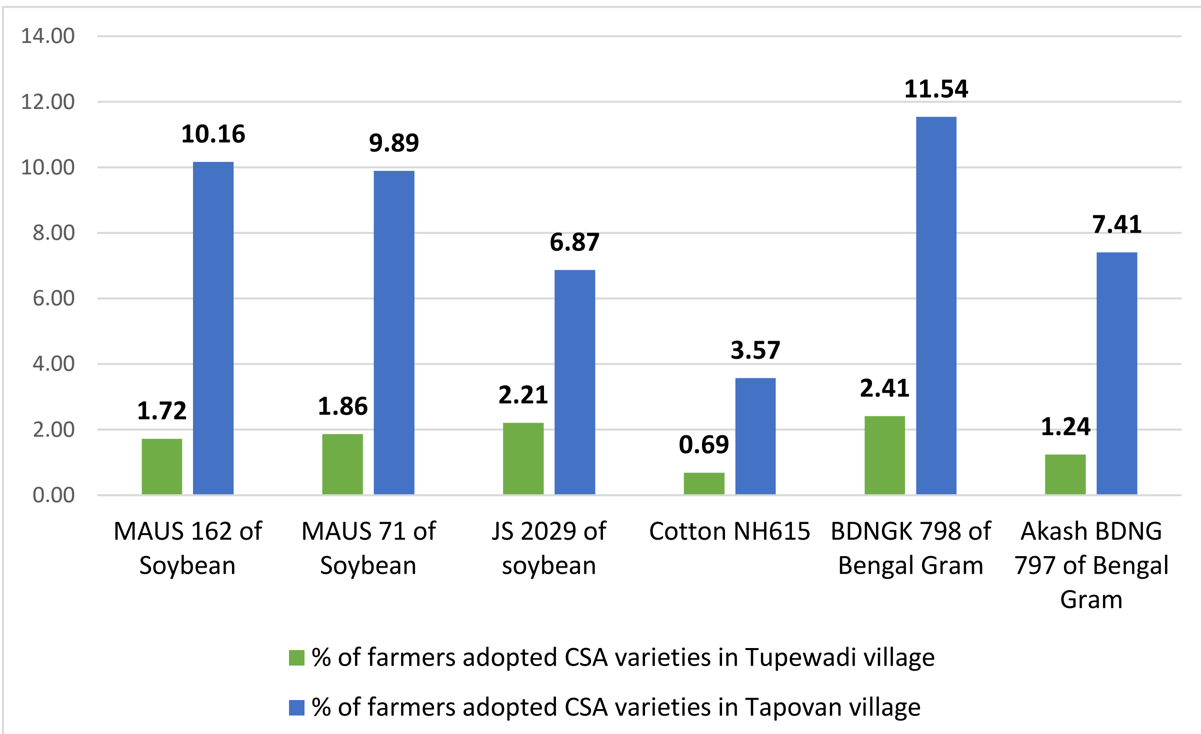


Figure 2. Adoption % of CSA varieties by farmers in Tupewadi and Tapovan villages, Jalna taluk, & district, Maharashtra

Table 4. CSA varieties and their climate resilient characteristics demonstrated under PoCRA

S.No.	Crops	Varieties	Released by	Major climate risks	CSA characteristics
1.	Soybean	MAUS – 162	Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra	Pod shattering due to drought conditions and high temperature	Resistance to pod shattering; useful for machine harvesting;
		MAUS – 71			High yielding, tolerant to rust, resistant to pod shattering on Broad Bed Furrow conditions
		JS - 2029	Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh	Drought	Early maturing (90 to 100 days), high yielding (2.4 tonnes per ha), resistant to Yellow Mosaic Virus (YMV)
2.	Bengal Gram	BDNGK - 798	Mahatma Phule Krishi Vidyapeeth, Rahuri. Maharashtra	Wilt diseases in Marathwada region	Tolerant to wilt and gram pod borer and bold seed variety
		Akash (BDNG – 797)			Resistant to wilt, tolerant to pod borer
3.	Cotton	NH 615	Cotton Research Station, Nanded	Drought	Tolerant to drought; improved seed cotton & lint yield; tolerant to major sucking pests; suitable for High Density Planting (HDP)

KVK is also mandated to promote and demonstrate improved varieties. However, the adoption rate is very less as their role is limited to demonstration and on-farm trials, unlike PoCRA. Therefore, the frontline extension system has to utilise the resources of KVK and upscale the technologies that are proven to be climate resilient and adaptive. Conversely, the activities of WOTR are prioritised toward the conservation and cultivation of local cultivars. Though there is no specific approach to promote CSA varieties developed at SAUs or ICAR research stations, WOTR advises farmers to use varieties or hybrids from SAUs and ICAR research stations. However, the sample farmers reported that they use mostly Bt for cotton, private hybrids for soybean, grapes, maize, and all vegetables and fruit crops. It is also evident that private companies are dominating the seed supply chain in Maharashtra state. Some of the private seed companies are Maharashtra Hybrid Seeds Company Private Limited (Mahyco), A.G.Sunseeds Pvt.Ltd, Advanta India Limited; etc., to name a few. Though the State Agricultural Universities such as Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Mahatma Phule Krishi Vidyapeeth, Rahuri, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani etc., have developed several promising varieties of soybean, Bengal gram, redgram, sorghum etc. There is still a need for developing competent resilient varieties by State Agricultural Universities (SAUs), ICAR institutes etc., to outpace the private seeds.

Though all three stakeholders promote IPM, INM, catch crops and other agronomic climate smart practices. The degree to which, it is adopted by farmers depends on their farming system needs. For example, WOTR is promoting System of Crop Intensification (SCI) as a major CSA agronomic smart, wherein awareness is created among farmers on the need for adopting scientific crop geometry, IPM, INM and soil & water conservation measures to minimise the risks of droughts and maximise the yield. Data shows that 3,577 ha of farmland is covered under the System of Crop Intensification (SCI), extending its benefits to 9,506 farmers. Results also indicate that all the sample beneficiary farmers of WOTR have adopted IPM such as sticky traps for pest management, soil and water conservation measures like plastic mulching in chilli, drip or sprinkler irrigation in cotton, soybean, chilli etc., mostly in combination.

There is also a growing interest among stakeholders in the promotion of Integrated Farming System (IFS) as it helps in resilience and ensures food security for a larger number of marginal and small farmers in addition to sustained income. DoA under PoCRA is promoting rearing of small ruminants, backyard poultry, fishery, sericulture, and apiculture. Around 6755 farm families were assisted with the subsidy for undertaking various activities of IFS till September 2022. However, results indicate that only one beneficiary farmer in Tupewadi and Tapovan villages was practising IFS, largely due to their specific needs being limited to shade net houses and drip irrigation as their adoption resulted in growing of high value commercial crops and high-income generation. As the creation of individual farm and community farm ponds is the major CSA activity of PoCRA, the potential for adoption of fisheries by farmers is high. However, the farmers reported that the non-adoption is intrinsically linked to a lack of access to fingerlings, marketing facilities, while throughout the year labour need for shade net cultivation. However,

Goatary with crop production at Kadwanchi village there is a crucial need for large-scale promotion of IFS to make the farming system more responsive to climate change risks. Similarly, prioritisation of CSA efforts of WOTR and KVK towards IFS has a conspicuous impact on the adaptation of food systems to climate change risks. However, the results show that only 5% and 20% of the sample beneficiary farmers of WOTR and KVK, respectively adopted IFS.

Further, agroforestry is getting wider attention worldwide in CSA programmes as it not only helps in food security but also increases resilience and mitigates the emissions of Green House Gases (Amadu *et al*, 2020). Among the three stakeholders, DoA under PoCRA is emphasising the importance of agroforestry. It aims to develop an agroforestry model for the creation of carbon sinks. It further facilitates the procurement of locally appropriate species of forest plants from government and government approved private nurseries to ensure their availability. Further, the plantation in community land is done through a participatory approach to establish norms for grazing restriction or controlled grazing on treated areas, especially in areas under afforestation treatment and a ban on tree felling. However, the data of PoCRA shows that only 301 farmers have adopted agroforestry covering 12.89 ha as of September 2021 since 2018. Also, none of the sample beneficiary farmers of PoCRA in Tupewadi and Tapovan villages has adopted agroforestry. However, given the role that agroforestry can play in carbon sequestration and GHG emission reduction, there is a need for a more focused approach to encourage farmers to adopt agroforestry, improve convergence with forest departments to ensure saplings availability and enhance community participation for growing trees in wastelands. Also, WOTR and KVK's priorities for the promotion of agroforestry are inadequate. The less adoption of agroforestry is also attributed to the low preference of farmers due to its delayed benefit. For example, tree crops will attain their economic value mostly after 5 to 10 years. Despite its high impact on reducing GHG emissions, farmers are willing to adopt those subsidised or low-cost CSA practices or technologies that will result in immediate benefits to them in terms of enhanced crop yield and income. Out of the total sample farmers (60nos), only one farmer from Kadwanchi village had an agroforestry system. He was growing Magoghany, which was intercropped with soybean (**Case 1.**). However, the scope for promoting agroforestry is high to make farming systems more resilient to the frequent occurence of drought.

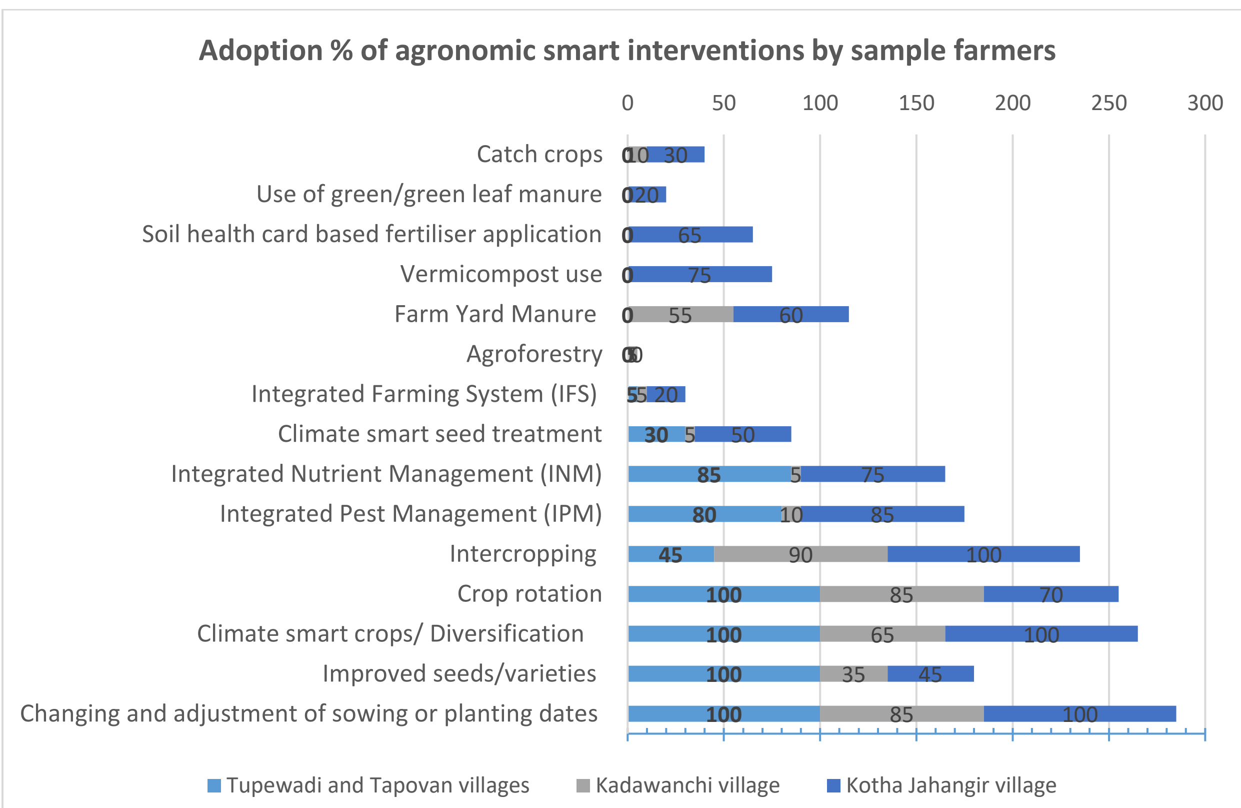


Figure 3. Adoption % of agronomic smart interventions by sample farmers

Case 1. Carbon credit through agroforestry – A testimony of a young farmer from Kadwanchi village, Jalna district

Mr Ganesh Baghavan Sirsagar at his agroforestry field intercropped with soybean, Kadwanchi village, Jalna district

A 22-year young farmer, Mr Ganesh Baghavan Sirsagar from Kadwanchi village has been practising agroforestry to minimise Green House Gases (GHGs) and to improve soil carbon content since 2020. Working with his father since childhood has elicited his interest in Sustainable Agriculture (SA), In a search for SA, he came across a fellow farmer in his village practising agroforestry, who was earning carbon credit for the plantation of Mahogany. Mr Ganesh found that it was remunerative, which motivated him to search more about Mahogany plantation through YouTube channels and brought 500 saplings from a private nursery @Rs.100 per sapling. He has planted Mahogany trees under drip irrigation on one acre of his 30 acres of land. He said that he invested about Rs. 1.5 lakhs for planting Mahogany including procurement and transport charges. He says that Mahogany trees are capable of mitigating greenhouse gas emissions and have a direct influence on rainfall. Many studies also show that the carbon sequestration potential of Mahogany trees is more. For example, in Mount Makiling Forest Reserve, Philippines, Mahogany plantation has a total biomass production of 1,120 Mg ha-1 which is equivalent to 542 Mg ha-1 of C and 1,989 Mg ha-1 of CO2. Within 10 years, it registered a biomass buildup of 43 Mg ha-1 yr-1 and sequestered carbon at 22 Mg ha-1 yr-1 and 81 Mg ha-1 yr-1 of CO2 (Racelis et al, 2019).

Further, he cultivates soybean and redgram as intercrops on Mahogany plantation, thus he can generate an additional income of Rs.35 to 40,000/- in a season. He indicated that after 10 years, each Mahogany tree can be sold for around Rs.10,000 to 20,000/., thus taking his overall gross income to Rs. 50,000,00 to 100,00,000. Therefore, the promotion of Mahogany will play a major role in increasing the income of farmers drastically with greater contribution to mitigation. However, not all the farmers have adopted this practice, out of 20 farmers taken as a sample from Kadwanchi village, he is the only farmer who started practising agroforestry under drip irrigation. However, given its initial investment, coupled with huge incentives from Government (as evident from the present case that the yearly incentive support of Rs.50,000) was the major motivation for Mr Ganesh to adopt agroforestry. Therefore, creating a mass-scale awareness among farmers will result in bringing more area under agroforestry. Also, the other support services such as linking farmers to authorised quality tree nurseries and private firms (which are mandated to buy Carbon Credit) and domestic & international carbon markets to realise the full potential of carbon credit.

3.2 Soil and water smart

Due to increased risks of climate change on soil in terms of soil erosion, loss of soil fertility, reducing Soil Organic Matter (SOM), the prioritisation of many CSA technologies by stakeholders is aligned with soil and water smart interventions such as mulching, contour farming, cover crops, zero/conservation tillage, broad bed furrow systems, ridge and furrow systems, loose boulders, check dams, diversion drains, etc. (Kumawat et al, 2020). In this study, the soil and water conservation measures promoted by stakeholders are grouped into demand and supply side water management interventions.

3.2.1 Demand side water management

Demand side water management emphasises the need for reducing the excess water for irrigation and increasing water use efficiency. These interventions range from the use of technologies such as micro irrigation to practices for instance System of Rice Intensification (SRI), Alternate wetting and Drying (AWD), zero tillage etc.

Table 5. Demand side water management interventions

S.No.	Particulars	Department of Agriculture (PoCRA)	Krishi Vigyan Kendra (KVK) (IGWDP)	WOTR
1.	Zero tillage	✓	X	X
2.	Drip irrigation	✓	✓	✓
3.	Sprinkler irrigation	✓	✓	✓
4.	BBF technique	✓	✓	✓
5.	Compartmental bunding	✓	✓	✓
6.	Plastic mulching	✓	✓	✓

All three stakeholders promote demand-side water management technologies and practices in agriculture. Under PoCRA, more focus is given to the use of water for agriculture efficiently and sustainably. These soil and water conservation activities are carried out in collaboration with Groundwater Surveys & Development Agency (GSDA), Indian Institute of Technology (IITs), State Agricultural University (SAUs) etc. The interventions on water management include in-situ conservation (e.g. compartment bunding, across/ contour trenches, sowing across/contour, opening of furrows and use of BBF); catchment area treatment; drainage line treatment (e.g. Gully plug, Loose boulder structures, Earthen Nala bund, Cement Nala bund); Construction of new water harvesting structure (e.g. Community farm ponds, Individual farm ponds (with or without lining), Open dug well); Rejuvenation of existing water harvesting structures (Repair of existing water harvesting structure, Desilting of such structures); Recharging groundwater (e.g. Artificial recharge of open Well and bore well); Micro irrigation systems and Protective irrigation (e.g. Water pumps and pipes). Considering the importance of drip and sprinkler irrigation in addressing risks of drought by improving water use efficiency in agriculture, about 62% (Rs.1333.1 crores) of the total cost (Rs.2181.43 crores) of PoCRA utilised till August 2022 was disbursed to farmers as subsidy for the adoption of drip and sprinkler irrigation covering 2,80,181 farmers. Also, nearly 65% of the beneficiaries are belonging to the beneficiary category of drip and sprinkler irrigation under PoCRA. In terms of subsidy support, the department of agriculture under PoCRA provides around 75% per farmer with 2 ha and 65% per farmer with 2 to 5 ha of the total cost of the installation of drip irrigation and sprinkler irrigation systems.

Drip irrigated cotton in Kotha Jahangir village in Jalna district

The study findings show that, after PoCRA intervention, around 216 and 79 farmers in Tupewadi and Tapovan villages, respectively (i.e. 62% of farmers of the total farmers in both villages) have adopted drip and sprinkler irrigation respectively. The baseline survey data of Tupewadi village shows that within two years of PoCRA implementation (2020 onwards), 35.5 % more arable land was covered under drip irrigation. I.e. the area under drip irrigation has increased to 720 ha after PoCRA from 464 ha before PoCRA. Similarly, 75% increase in area coverage under sprinkler irrigation. Before PoCRA, only 20 ha were under sprinkler irrigation, it has increased to 79 ha within two years.

Subsidy support plays a major role in adoption of high cost CSA technologies by farmers, among the three stakeholders, Department of Agriculture under PoCRA provides 75 to 80% subsidy for installation of micro irrigation, shade net houses, farm ponds, sericulture, small ruminents etc., for marginal farmers and 65 to 75% for small farmers in their project villages

The high subsidy support and transparency in the disbursement of subsidies through DBT portal were the major contributing factors in the rapid adoption of high-end micro irrigation technologies by farmers. Similarly, KVK and WOTR are promoting drip and sprinkler irrigation as a soil and water smart approach under CSA. However, the role of WOTR and KVK is limited to facilitating and creating awareness about the subsidy support given for farmers to adopt micro irrigation systems from the line department. Farmers are linked to avail the susbsidy support from the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), National Horticulture Mission (NHM), Mahatma Gandhi Rural Guarantee Employment Scheme etc., implemented by line departments. The beneficiary farmers of WOTR in Kotha Jahangir village of Bhokardan taluk reported that they have adopted drip irrigation in soybean, cotton, chillies etc. with the funding support of the line department. However, they indicated that WOTR has encouraged them to get registered to such schemes and given handholding support till receiving of subsidy. More than 200 farmers in Kotha Jahangir village have adopted micro irrigation with 100% adoption in chilli till August 2022 (*Focus Group Discussion and unpublished village panchayat data*). Further, the data shows that the area under drip irrigation in Kotha Jagangir village increased to 520 ha from a mere 20 ha due to the convergence of WOTR with central and state government schemes and programmes. Similarly, the area under drip irrigation in Kadwanchi village increased by 93.5% after the implementation of IGWDP by KVK i.e. the area covered under drip irrigation increased from a mere 52 ha to 800 ha. The successful adoption of drip irrigation by farmers hinges on convergence efforts (as in the case of KVK and WOTR) and direct high subsidy support (e.g. PoCRA). Results show that cent per cent of sample farmers adopted micro irrigation.

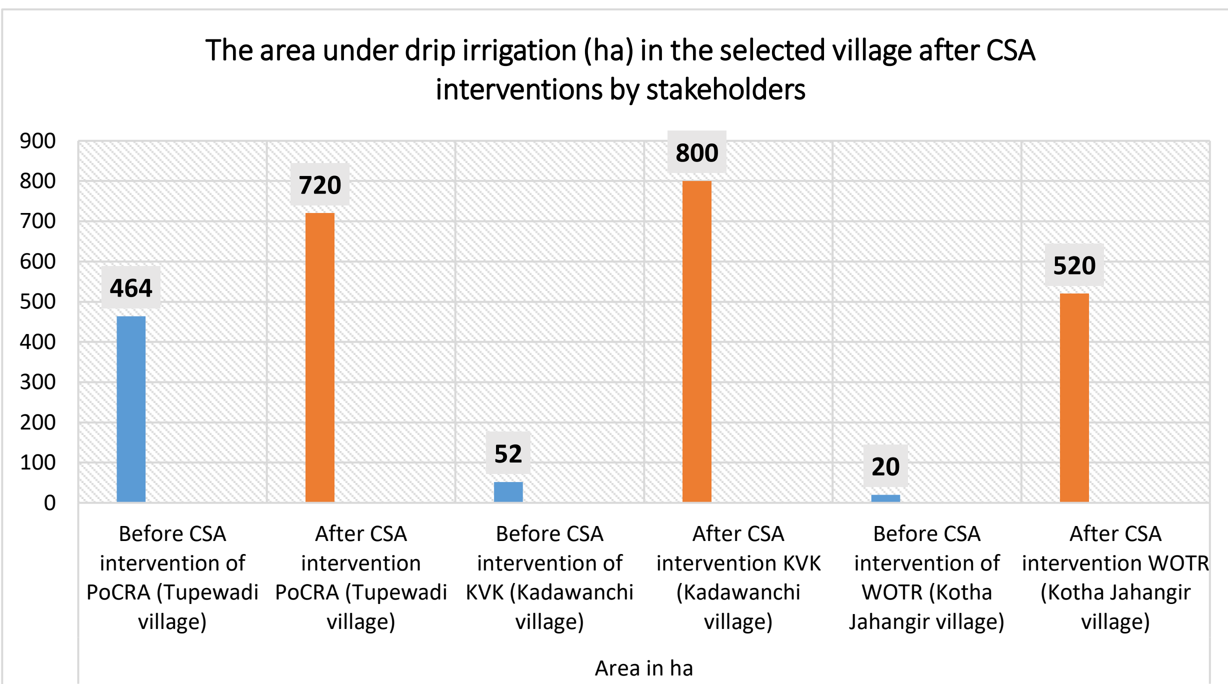


Figure 4. Area (ha) under drip irrigation in the selected villages

Further, in demand-side water management, zero tillage is not majorly prioritised by WOTR due to the soil condition in their project areas (Black cotton soil), but they encourage farmers to plough their fields only up to 10 to 15 cm, called minimum tillage. Likewise, KVK is promoting minimum tillage practices among the farmers in their adopted villages. Contrarily, DoA under PoCRA advises farmers to adapt to zero tillage through FFS. Data shows that around 300 farmers in project villages adopted zero tillage in cotton, soybean, maize and marigold since 2019. The reduced tillage has enabled the farmers to grow three crops per year on average. Report further shows that the yield of cotton increased from 0.6 per acre to 1 tonne per acre under no-till conditions. Similarly, the yield of soybean increased to 2 to 3 per acre from 0.7 to 1 tonne per acre when cultivated under zero tillage. Also, the other economic and environmental co-benefits of zero tillage include energy & time saving, reduced soil erosion, minimum requirement of irrigation, less labour requirement etc., which will further enhance the adaptation and mitigation. DoA is gradually promoting ZT to cover their entire project area. Considering its importance, the other stakeholders may study the feasibility of zero tillage and promote it at scale in their project areas.

Incentive support makes farmers to adopt BBF technique. 100% or Rs.1000 per ha is given as an incentive to farmers who adopt the BBF technique in soybean. Also, DoA under PoCRA provides a subsidy for CHC centres (One CHC per adopted village of PoCRA) to procure BBF planters, thereby enabling rainfed soybean growers to rent and use BBF machines

Broad Bed Furrow technique (BBF) in soybean is increasingly promoted by all three stakeholders as a major soil and water conservation technique. The Broad Bed Furrow (BBF) technique is adopted to minimise the risks as it can conserve water during drought and drain off the water during excess rainfall. Before the PoCRA intervention, many farmers were not able to adopt BBF due to the non-availability of Broad Bed Furrow machine despite that, it was frequently advocated by ATMA, yet, presently, About 927 farmers benefited from BBF technique due to the increased availability of the BBF machine at Custom Hiring Centre (CHC) established at village level with the funding support of PoCRA. Further, 100% or Rs.1000 per ha is given as an incentive to farmers who adopt the BBF technique in soybean. Moreover, DoA under PoCRA provides a subsidy for CHC centres (Two CHC per adopted village of PoCRA) to procure BBF planters, thereby enabling rainfed soybean growers to rent and use BBF machines. Farmers in Tupewadi and Tapovan villages stated that though they were aware of BBF, they never adopted BBF due to the non-availability of BBF machinery. However, after PoCRA, BBF machine has become easily available to them through CHC funded by PoCRA. Hence, the promotion of CSA technique with proper auxiliary services as in the case of BBF technique might result in a high adoption rate and desired results. However, it is evident from the results that the beneficiary sample farmers with soybean have adopted drip irrigation, thus, minimising the need for adopting BBF as it is the recommended CSA practice in rainfed soybean. In terms of incentive support for BBF, DoA is the only organization that provides incentives (Rs.1000/- per ha) for farmers to adopt BBF under PoCRA.

Sprinkler irrigation in soybean

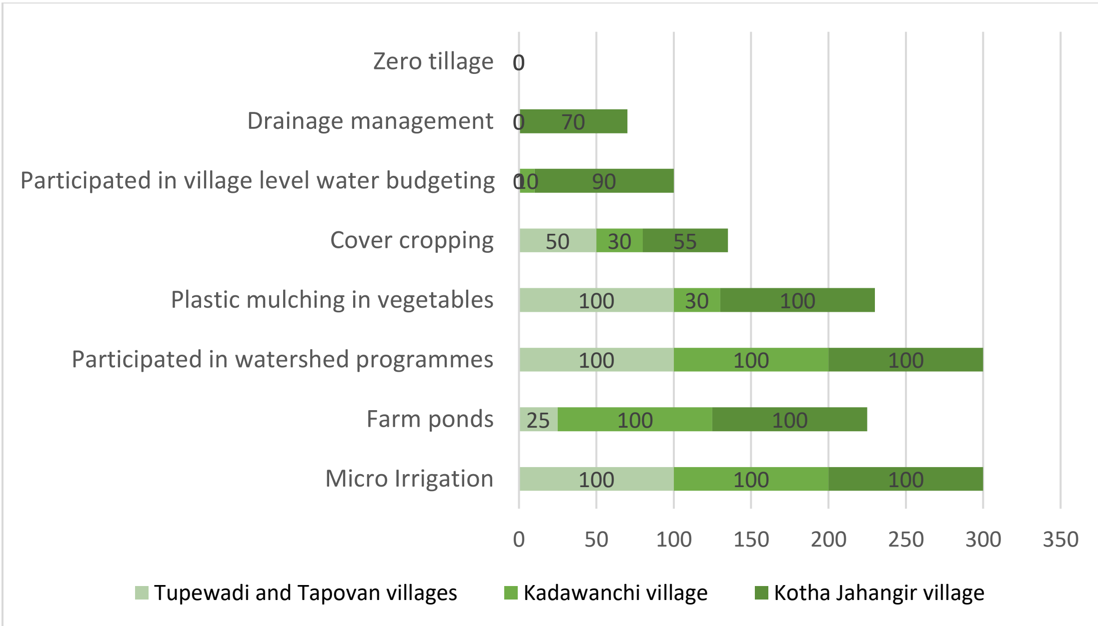


Figure 5. Adoption % of water smart interventions by sample farmers

Case 2. An inspiring story of Mrs Leela Bhai Laxman Sonawani – A campaigner for water conservation

Mrs Leela Bhai Laxman Sonawani at Kotha Jahangir village

Very old by age but not by action! Mrs Leela Bhai Laxman Sonawani has been into farming for more than 50 years. Initially, she was growing Jowar and Bajra under rainfed conditions. However, the frequent occurrence of drought has adversely affected her crops, thereby she faced a drastic yield loss in Bajra and Jowar, and affecting her only source of income. During the challenging periods, WOTR created awareness among farmers about the importance of micro irrigation in conservation of water and water use efficiency in crops against the ever increasing drought in frequency and intensity. These awareness programmes encouraged Mrs Leela Bhai to adopt micro irrigation. She was one among many farmers who adopted micro irrigation in 2017 (drip irrigation on two acres and sprinkler irrigation on two acres, covering the entire four acres of her farm) with the subsidy support of Department of Agriculture, Jalna. She was given a subsidy of 50%

(Rs.30,000) out of the total investment of Rs.60,000 for drip irrigation and Rs.15,000 out of Rs.30,000 for installing sprinkler irrigation. WOTR has further encouraged her to diversify crops to chilli from Jowar, Bajra and cotton (Table 6.). She informed that the adoption of micro irrigation resulted in efficient use of water for irrigation, improved yield and sustained income. Seeing her success in water conservation, UNDP awarded her with the certificate of *Woman Water Champion Award*.

Certificate given to Mrs Leela Bhai for her water conservation activities

Table 6. Crops and yield

S.No.	Name of crop	Coverage	Yield in tonnes	Income (Rs)
1.	Maize	1 acre	2.5	45000
2.	Cotton	1 acre	0.8	50000
3.	Soybean	0.50 acre	0.45	15000
4.	Chilli	0.50 acre	4	60000
			Total	1,70,000

She reported that there is a marked increase in income due to the diversification of crops, and also the adoption of micro irrigation has resulted in the conservation of water. She has become a campaigner for water conservation in her village and persuades every farmer to adopt drip and sprinkler irrigation as a water conservation measure. Today, she is seen as a respectable women farmer of Kotha Jahangir village, which can be seen from her selection as one of the representatives in the Village Level Committee called Sant Tukaram Uddheshiy Sevabhavi Sanstha/Acqufier Mapping Committee. She has become an inspiration to many farmers of not only Kotha Jahangir but also nearby villages in Jalna district.

3.2.2 Supply side water management

According to FAO, supply side water management approaches aim at physically managing water through technical and engineering means that capture, store, delivers and treats water.

Table 7. Supply-side water management interventions

S.No.	Particulars	Department of Agriculture (PoCRA)	Krishi Vigyan Kendra (KVK) (IGWDP)	WOTR
1.	Farm pond and plastic lining of farm ponds	✓	✓	✓
2.	Community water pond	✓	✓	✓
3.	Check dam	✓	✓	✓
4.	Nala deepening	X	X	✓
5.	Nala Bunding	X	X	✓
6.	Composite Gabion structure	X	X	✓
7.	Rejuvenating and De-silting of reservoirs	X	X	✓
8.	Aquifer recharge	✓	X	✓
9.	Gully Plug	✓	✓	✓
10.	Loose boulder structures (LBS)	✓	✓	✓
11.	Open dug well	✓	✓	X
12.	Contour trenches	✓	✓	X

Study results illustrate that farm or community farm ponds are growing as the most important supply-side water management intervention and promoted by all three stakeholders. DoA under PoCRA provides direct subsidy support @75% (max: Rs. 162000/-) up to 2 ha or 65% (Max: Rs. 156127/-) from 2 to 5 ha for farmers to adopt farm ponds. Whereas, KVK and WOTR are facilitating farmers to avail the subsidy support from the state department in convergence with various schemes and programmes of state and central governments. For example, WOTR links farmers to the National Horticulture Mission (NHM) and Rashtriya Krishi Vikas Yojana (RKVY) schemes to avail of subsidy support. Similarly, KVK facilitates their farmers to link to various ongoing schemes such as NHM, RKVY and Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) for construction of individual or community farm ponds. However, it is limited to the adopted villages. DoA under PoCRA has created farm ponds in 3742 farmers' fields and supported 2625 farmers to line the existing farm ponds with the polythene sheet in their project areas. As of August 2022, about 3% (Rs.66.9 crores) of the total cost of PoCRA was spent as a subsidy for developing farm ponds at individual farmer and community levels. Likewise, KVK supported the creation of 503 farm ponds in Kadwanchi village with the funding assistance of DoA. About 71% of the funding support (Rs.1000 lakhs out of 1400 lakhs) of DoA was utilised for providing subsidies for digging farm ponds. Similarly, WOTR has supported about 809 farm ponds or lining from 2021-22 to 2018. It signifies that direct funding support under a project approach will

By and large, the promotion and construction of the individual and community polythene lined farm ponds were prioritised by all three stakeholders as it enables the farmers to store water by pumping the extra water from the subsurface after rainfall and use it for critical stages of crops for crops during erratic/failure rainfall periods during.

play a crucial role in establishing on-farm smart water interventions such as creation of individual or community farm ponds. Further, the data of PoCRA show that 68 and 37 farm/community farm ponds were constructed in Tupewadi village and Topovan villages, respectively. KVK under IGWDP has supported creation of 503 farm ponds in Kadwanchi village through convergence with schemes and WOTR has supported the creation of around 48 individual farm ponds in Kotha Jahangir village.

Results also illustrate that only 25% of the beneficiary sample farmers of PoCRA adopted farm ponds. It is mostly because the need for farm ponds is minimal as all the farmers adopted shade net houses coupled with drip irrigation (with subsidy) which require minimal water for irrigation and can be met from the open dug well, which is the major source of irrigation. Whereas, cent per cent of the beneficiary sample farmers in Kadwanchi and Kotha Jagangir villages have farm ponds. Moreover, results indicate that 25% (05 nos) of farmers in Kadwanchi village dug farm ponds without availing any subsidy support. However, 80% of them belonged to the medium farm holding category with their farm income averaging Rs.6.3 lakhs per year (from a minimum of Rs.2.5 to as high as Rs.16 lakhs a year). Therefore, subsidy support is crucial for marginal and small farmers to adopt CSA interventions, which are capital-intensive. Without such support, the likely adoption of such high-cost CSA interventions by marginal and small farmers is minimal due to the less farm income.

In addition to these, all three stakeholders are promoting compartmental bunding, Continous Contour Trenches (CCT), deep CCT, Gully Plug (GP) etc. KVK under IGWDP covered 408 ha under CCT and deep CCT and constructed 1209 nos of Loose Boulder Structures and Gully Plugs in Kadwanchi village. DoA under PoCRA dug CCT and deep CCT covering 492 ha; established nine Composite Gabion Structures, six earthen

Nala bunds, 55 cement Nala bunds, compartmental bunding covering 27273 ha and rejuvenated 253 old water harvesting structures in a few of their project sites. Such activities were not yet initiated in Tupewadi and Tapovan villages. Similarly, WOTR has undertaken Nala deepening covering 3 Nala with 5 KM in length, construction of six check dams, five composite gabion structures, installation of one aquifer recharge of groundwater and farm bunding covering 416 ha.

Farmers at Gabion Structure established by WOTR at Kotha Jahangir village

DoA under PoCRA was able to subsidise more climate smart technologies including high-end technologies such as shade net cultivation, drip irrigation, sprinkler irrigation, etc., to farmers. Whereas, WOTR, being an NGO, focuses mostly on climate smart practices that can address the risks without much requirement of capital investment. Though it prioritises its water conservation activities toward developing supply-side water harvesting structures such as community water tanks, farm ponds, farm bunding, Nala bunding, Nala deepening, check dams, Gabon structures, de-silting and aquifer recharge, etc., the funding requirement was borne by the donor agencies and partly by the contribution of farmers. This signifies that the willingness of farmers to pay for creating such demand-side supply water management is an essential part of climate smart agriculture, especially for NGO extension systems. Whereas the Department of Agriculture under PoCRA has its funding support from World Bank, hence, they were able to subsidise several capital-intensive technologies alongside practices that can minimise the risks of drought and other identified climate change vulnerabilities. Further, the results show that the emphasis on the creation of farm ponds is maximum among all three stakeholders than other supply-side water management activities as it is directly contributing to the augmentation of water supply for irrigation at the farm level.

3.3 Energy smart

According to FAO, interventions promoting energy efficiency or energy-smart food production focus on reducing carbon dioxide emissions through the increased use of renewable energy. Therefore, shifting to more energy-smart food systems is an important step toward reaching the broader goals of climate-smart agriculture.

Table 8. Energy smart interventions

S.No.	Particulars	Department of Agriculture (PoCRA)	Krishi Vigyan Kendra (KVK) (IGWDP)	WOTR
1.	Bio fuels and biogas production	X	X	X
2.	Fuel-efficient engines	✓	X	✓
3.	Solar Pump	X	X	✓
4.	Solar Fence	X	X	X
5.	Solar sprayers	X	X	X
6.	Solar Driers	X	X	X
7.	Solar and wind power-operated storage structures	X	X	X
8.	Wind Energy (e.g. Small Windmills)	X	X	X
9.	Solar lights/lamps in the farms	X	X	X

Despite the role that solar pumps will play in adaptation capacity of food systems and mitigate the emissions of GHG, stakeholders priortisation to the promotion of solar pump is still minimal

Stakeholders' prioritization of the promotion of energy smart interventions is minimal compared to soil & water and other agronomic interventions. Though the stakeholders are creating awareness among farmers about the importance of use of solar-based pumps for irrigation, more than 90% of farmers in all four villages were using diesel or electricity pumps for lifting water from farm ponds and open-dug well. This will further increase the release of GHGs from the field. According to FAO, solar pump is emerging as an alternative to fossil fuel pumps and paves a way for low-carbon irrigated agriculture. The use of solar pumps has several co-benefits such as more economical compared to diesel or grid electricity, requiring less maintenance cost and high water use efficiency (Agrawal and Jain, 2019). It uses available free sunlight, thereby curbing down the cost incurred for diesel or electricity by farmers. It has a long operating life and is highly reliable and durable. However, the sample farmers indicated that the capacity of solar pumps is very less to uplift water from an open dug well when the depth of water is low during summer. Further, they stated that during rainy and cloudy days solar pumps cannot be used.

Box -1. Mukhyamantri Saur Krushi Pump Yojana – Adapting agriculture and mitigating carbon emission

The state government of Maharashtra is implementing Mukhyamantri Saur Krushi Pump Yojana (MSKPY) as part of solarising farms to pave a way for mirigation of GHGs. The three broad objectives of MSKPY are, (i) to enable farmers to use solar energy for irrigation, (ii) to replace diesel engines in a phased manner and (iii) to minimise the subsidy burden on farm electricity. It has targeted to distribute 25,000 solar pumps in the first phase of the Atal Solar Agriculture Pump Scheme, 50,000 solar pumps in the second phase, and 25,000 solar pumps in the third phase to farmers to meet their irrigation demands. Farmers with less than 5 acres of agricultural land will receive a subsidy of 95% of the total cost of a 3 HP solar pump set, while farmers with more than 5 acres of land will receive 5 HP solar pumps for 90% subsidy. Maharashtra State Electricity Distribution Company Limited (Mahadiscom) is the nodal agency for implementing MSKPY. Farmers can apply for subsidy to install solar pump through online portal. After verification of details, the farmers will receive the subsidy for installing.

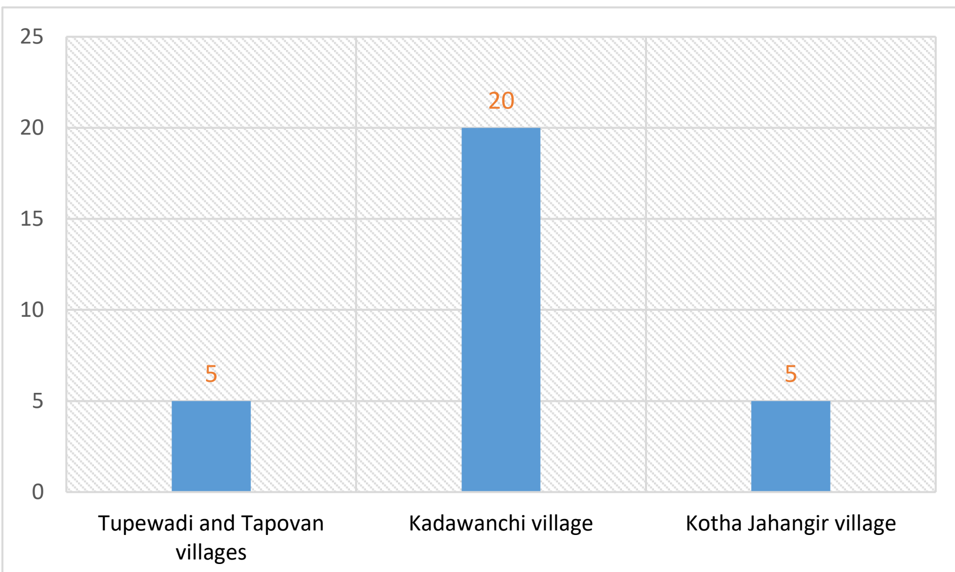


Figure 6. Adoption % of solar pumps by sample farmers

Evidence shows that there is no subsidy support given for solar pumps under PoCRA. On the other hand, DoA under PoCRA improves the access of farmers to irrigation by providing subsidy support for procuring diesel or electricity grid-based water pumps which will enable them to protect their crops from increasing risks of drought. However, these diesel or electricity water pumps will lead to more emissions of CO_2. Though PoCRA aims for CSA and mitigation of GHGs, the non-prioritisation of the promotion of solar pumps might minimise its overall contribution to CSA and GHG mitigation efforts. Data shows that DoA under PoCRA has benefited 30008 farmers by distributing water pumps having a capacity of 5 HP that either run on diesel or electricity. Findings also indicate that 39 farmers in Tupewadi and Tapovan villages have received subsidies worth Rs. 5.71 lakhs for procuring diesel or electric pump engines. As PoCRA intends to improve the adaptation capacity of food systems and mitigate the emissions of GHG, it has to widen its scope of CSA by promoting solar water pumps in place of diesel or electric water pumps. One of the studies shows that a 5-HP irrigation pump run by diesel and grid-electricity operational for 1,250 hr/year, would emit 5.2 and 4 t of CO2/year, respectively. Therefore, replacing just 5 million diesel pumps in India with solar pumps might help mitigate 26 million tons of CO_2 emissions annually (Jain et al., 2013). The subsidy support may be extended for replacing diesel or grid electricity pumps with solar pumps in the ensuing days. Also, fostering convergence between PoCRA and MSKPY scheme of Maharashtra will facilitate the adoption of solar pumps on a larger scale. Similarly, WOTR and KVK are not directly promoting solar pumps. However, WOTR facilitates the farmers to get registered to Mukhyamantri Saur Krushi Pump Yojana (MSKPY) of Maharashtra and avail of the subsidy to some extent. Around seven farmers have adopted solar pumps for irrigation with the subsidy support of MSKPY. Therefore, there is a need for increased focus on the promotion of solar pumps by all three stakeholders.

Case – 3. Solar irrigation pumps – Mitigating the GHG emission

Mr Bhanudas Bhagwanrao Ichche (Left) with extension officials of WOTR

Mr Bhanudas Bhagwanrao Ichche, a beneficiary farmer of Mukhyamantri Saur Krushi Pump Yojana (MSKPY) from Kotha Jahangir village. He has installed 5 HP solar pump for irrigation under MSKPY with subsidy support of 95%. As a major extension service provider in Kotha Jahangir village, WOTR has created awareness of the MSKPY scheme and its benefits to farmers. Mr Bhanudas was one of a few farmers who showed interest to adopt solar pumps in place of diesel pumps. WOTR has further facilitated him to fill in the application form to avail the subsidy benefits of solar pump. He spent only Rs.16,500 to install solar panels in his field. He further indicated that the solar pump is capable of irrigating his 5-acre farm and meeting the water requirement of redgram, soybean and cotton in Kharif and wheat and sorghum in rabi season, in addition to meeting the water requirement of cows, buffaloes and household needs. He noted that before adopting solar pump, he was using diesel and electricity motor pumps, which cost him around 10 litres of diesel a day worth Rs.8,000 to 10,000 in addition to the subsidised farm electricity bill of Rs.3,000 per acre during the irrigation period. However, the installation of solar pumps has resulted in 80% reduction in the cost of irrigation without much maintenance cost. However, only seven farmers (2.41%) in kotha Jahangir village have adopted solar pumps till August 2022, others are still dependent on diesel or electricity pumps for irrigation, despite the awareness about MSKPY. Hence, there is a need for more awareness and training programmes relating to the importance and use of solar pumps, and the environmental benefits that the solar pump generates over a period in terms of adaptation and mitigation. Further, a standardised methodology needs to be developed to measure the reduction in CO_2 emission per farmer due to the use of solar pumps, which will help the farmers to earn carbon credits.

3.4 Infrastructure smart

In India, there are inadequate on and off farm infrastructure like greenhouses, shade nets, storage houses, pack houses, supply chain management, Automatic Weather Stations, etc. Infrastructure is essential right from supply of input, sowing of crops and post-harvest management. Therefore, there is a need for huge investment in strengthening the agricultural infrastructure sector at cluster level, which in turn enhances productivity and reduces post-harvest losses.

Table 9. Infrastructure smart interventions

S.No.	Particulars	Department of Agriculture (PoCRA)	Krishi Vigyan Kendra (KVK)	WOTR
I	**Off farm infrastructure**			
1.	Processing or value addition	✓	X	X
2.	Storage or godowns	✓	X	X
3.	Linkages to warehouse	✓	X	X
4.	Community water structures	✓	✓	✓
5.	Automatic Weather station	X	✓	✓
6.	Manual rain gauges	X	✓	X
II	**On farm Infrastructure**			
7.	Shade net house	✓	X	X

Though most of the CSA interventions are aimed at promoting water and soil conservation technologies and practises, the CSA is inclusive of resilient on and off farm infrastructure that will facilitate addressing the emerging risks of climate change. Considering the importance of multi-dimensional approaches in CSA, DoA under PoCRA is aimed at promoting shade net houses on a large scale in its adopted project sites. Before PoCRA interventions, only the select farmers with all on-farm resources were identified by private seed companies for producing seeds (mostly vegetable seeds) on a contractual basis. However, PoCRA provides subsidy support (*75% of the total cost*

Adoption of shade net houses by farmers in the PoCRA project villages enabled them to diversify their cropping to high value vegetable crops, get recognised by private seed companies for seed production of vegetables thereby earning more income, and enhancing their resilience to risks of climate change

of construction of shade net houses) for farmers to adopt shade net houses as an on-farm drought-resilient technology, which are enabling several marginal and small farmers to adapt to high value crops such as tomato, chilli, capsicum, gourds, etc., for production of quality seeds. Data shows that around 3041 established shade net houses with subsidy support till September 2022. Results also indicate that before PoCRA interventions, the farmers in Tupewadi and Topvan villages were growing vegetables for seed purposes under a bamboo shade net, which is highly prone to heavy precipitation and wind. Farmers in Tupewadi and Topvan villages indicated that many a time, they incurred huge losses due to damage to bamboo structures owing to heavy wind and rainfall. This has resulted in severe income loss as seed companies who contracted them did not pay during such a period. Against this backdrop, PoCRA has focused on the demand of farmers to subsidise the GV pipe-based shade net houses to enhance their adaptive capacity and minimise the crop losses resulting from droughts. Farmers who have shade net houses indicate that their income has doubled (*The details are given in impact section*). However, neither KVK nor WOTR has prioritised the promotion of such on-farm infrastructure – Shade net house. However, data shows that about 16 farmers in Kadwanchi have constructed shade net houses for vegetable production with funding support from NHM and private seed companies. Given the role that shade net houses coupled with drip irrigation will play in food systems adaptation to climate change risks, there is a need for promoting shade net houses by KVK, WOTR and other stakeholders in convergence with PoCRA and other ongoing schemes (e.g. NHM) to ensure the scale of its adoption across the state of Maharashtra.

Box –2. Shade net house as an effective CSA technology for dryland farmers – A case of Tupewadi village

Shade net house is a capital intensive technology says farmers of Tupewadi village. Therefore, they never thought of creating a permanent GV pipe based shade net. It cost them around Rs.10 to 12 lakhs for constructing shade net house on a half acre. However, farmers were encouraged by DoA officials to apply for subsidy support under PoCRA for construction of GV pipe shade net houses (permanent house). Unwillingly, farmers registered for shade net houses by trusting their words. To their surprise, many farmers have received pre – sanction soon after the application, which resulted in successful adoption of shade net house. The subsidy portion for the shade net houses was transferred to the AADHAR-linked accounts of the beneficiaries through PoCRA DBT system immediately after verification by the project officials. The subsidy support has encouraged many other farmers to apply for subsidy. Till August 2020, about 7% (213 nos) of farmers who benefited from shade net subsidy were from Tupewadi village. However, the adoption of shade net houses is alone not resulted in increased adaptive capacity of farm to climate change risks i.e. drought. Further, the farm income of the beneficiary sample farmers having shade net increased to Rs. 3.25 lakhs from Rs.1.64 lakhs per acre per year (cultivation of crops without shadenet). Beneficiary armers indicated that the major reason for increased income is adoption of shade net houses coupled with drip irrigation, connected to either farm ponds or open dug wells. Thi has also contributed to the overall improvement in adaptation of agriculture in Tupewadi village to the frequent occurance of drouhts. This case shows that there is a need for more focus on high value CSA infrastructure like shade net or protective cultivation to enhance the adaptation to climate change risks.

3.5 Automatic Weather Station (AWS)

Installation of Automatic Weather Station (AWS) has received the foremost priority among both KVK and WOTR. However, the focus of DoA under POCRA on the installation of AWS is minimal. However, PoCRA in convergence with IMD, SAU and KVK, Jalna updates the weather information in the PoCRA portal, which in turn facilitates the farmers to receive the day-to-day weather data. Whereas, WOTR's CSA approach is inclusive of the creation of AWS at the cluster level depending on the need and availability of donor funding support. Till 2020-21, WOTR had 132 active AWSs across India, including one AWS at Kotha Jahangir village. The AWS of WOTR is one such initiative that can be considered a CSA intervention as it not only focuses on disseminating mere weather data (e.g. rainfall, temperature, wind velocity and Relative Humidity) to farmers but crop advisory depending on the prevailing or anticipated weather. The AWS established in Kotha Jahangir covers a radius of 5 KM and generates weather data for nine villages surrounding Koth Jahangir. This AWS is linked directly to the Management Information System (MIS) at WOTR Hq, Pune. The weather data is processed by the scientists/Subject Matter Specialists at Headquater. They prepare relevant cluster-level crop advisories related to the date and time of sowing/planting, weed management, irrigation scheduling, pest and disease management etc and are sent as SMS once in three days to 2600 registered farmers, including 217 farmers of Kotha Jahangir village. Farmers of Kotha Jajangir reported that they adopted the crop advisory services received through SMS based on the relevancy of climate information. This indicates that the dissemination of crop advisory services along with weather data will result in a higher adoption rate, thereby enabling the adaptive capacity of farmers to the changing weather pattern. The prioritisation of WOTR towards the creation of AWS can be linked to its emphasis on village-level water budgeting, and specific crop advisory services based on rainfall and temperature. Therefore, the creation of a village or cluster-level AWS is essential for WOTR to provide tailored advisory services to the prevailing or anticipated weather conditions. Whereas the adaptation capacity of beneficiary farmers of PoCRA is hinged on high value and capital-intensive CSA technology such as creation of protective cultivation at farmer level (Shade net houses), community farm ponds, drip/sprinkler irrigation systems etc., in turn, these technologies are subsidised to a tune of 75%, resulting in a high adoption rate. Also, under PoCRA, the weather information is disseminated to farmers with the help of IMD and KVK. However, the highly uncertain weather pattern has necessitated DoA to propose the development of a mobile application to provide crop advisory by integrating weather data at block levels. Development of a weather based crop advisory Mobile Application was under progress during the study period (August 2022).

Sarpanch of Kotha Jahangir village with Automated Weather Station

In addition to this, KVK, Jalna has established 16 AWS in different locations of the Jalna district, they are connected to the centralised service provider i.e. Weather Risk Management Services Pvt Ltd (WRMS) located in Gurugram, Haryana. It receives the weather data from AWSs and disseminates it to the registered farmers by SMS. Moreover, KVK has appointed a technical person to monitor and collect weather data from AWS. However, the weather data is not translated into crop advisory as specific to the clusters or farmers receiving the data as in the case of WOTR. Hence, to make AWS installed by KVK become a more CSA approach, converting weather data into crop advisory and disseminating it to farmers for wider adoption is crucial. In addition to AWS, KVK is promoting rain gauge. About 25 manually measured rain gauges were installed till August 2022 in different locations of Jalna district to enable the farmers to measure the amount of rainfall received and plan for different farm operations and cropping pattern based on the rainfall data. These rain gauges were installed in the most progressive farmers' fields in the selected village/cluster. These farmers are called “Jaldoot” and “Jalpremi” and are responsible for measuring the rainfall data and recording them in a register. The data is further disseminated to the village farmers through WhatsApp groups or through village meetings to plan and make necessary farm decisions related to crop production. However, only rainfall data can be measured through rain gauges. As CSA needs weather forecast for a certain period (at least 15 days) to make necessary decisions relating to the selection of crops, change of cropping pattern, sowing date, etc., provision of holistic weather data by establishing more village or cluster level AES may be proritised by KVK.

Box – 3. Rain gauge based rainfall forecast – A replicable model of Kadwanchi village

Drought was the major risk in Kadwanch village, Jalna block of Jalna district. The farmers were not able to utilize their farm to the fullest potential due to water scarcity. Against this backdrop, KVK-Jalna has adopted Kadwanchi village for the development of watersheds under Indo German Watershed Development Programme (IGWDP) and convergence with line departments. As a result, KVK created eight check dams and 503 farm ponds to support farmers. One of the beneficiaries of this watershed approach is Mr Chandra Kant Shivajikhir Sagar, who adopted farm ponds with a capacity of 264X264X50 feet (04 crores litres). He invested 11 lakhs, of which 5.5 lakhs was subsidised under the National Horticulture Mission (NHM). As he was using the open dug well alone, he faced water scarcity for irrigation especially during the months of January to May, i.e. for about 05 months. However, the adoption of farm ponds has ensured water availability throughout the year. Initially (1990s), his farm income was not exceeding Rs.25,000 from an acre. Today, he generates about Rs.35 lakhs from his 30 acres. Over a period, he understood the importance of water and weather data in deciding the farm operations related to crop production. He therefore installed a rain gauge for measuring the rainfall in 2015. He collects the data after every rainfall and keeps a record of them. The data is also shared with all the farmers of Kadwanch village through WhatsApp groups (i.e. *KVK-Jalna* and *Agro1 Marathwada*) as a group admin. He says that this data is helpful for the farmers to take appropriate decisions related to crop production practices of cotton, soybean, grape, redgram, Maize and groundnut.

Rainfall data of Kadwanch village as per the record book of Mr Chandra Kant Shivajikhir Sagar

S.No.	Year	Rainfall (mm)
1.	2017-18	405
2.	2018-19	604
3.	2019-20	644
4.	2020-21	655
5.	2021-22 (Till 23rd August 2022)	437

This shows that the adoption of rain gauges helps in assessing the rainfall data and making farm decisions according to the daily average rainfall.

Among the three stakeholders, DoA under PoCRA has focused on strengthening Post-Harvest Management (PHM) by supporting the establishment of food processing units including fruits, vegetables and grain processing units, milk processing units etc. However, the number of FPOs/FPCs/SHGs applying for subsidy support for PHM is limited. Only one FPC till September 2022 from 2018 has shown its interest in establishing food processing unit. Likewise, Considering the importance that the PHM will play in the overall improvement of CSA at the village level, PoCRA has to strengthen its PHM, particularly food processing and value addition. This will further result in improving the income of the farmers as the farmers in beneficiary project villages of PoCRA are shifting their cropping pattern towards high value vegetable and fruit crops.

3.6 Major extension models followed by stakeholders in achieving CSA

Many extension models are emerging to improve the adaptive capacity of farmers to the emerging climate change risks. This study has elucidated the most important extension models/approaches followed by all three stakeholders in the promotion of CSA interventions.

Table 10. Institutional smart interventions

S.No.	Particulars	Department of Agriculture (PoCRA)	Krishi Vigyan Kendra (KVK) (IGWDP)	WOTR
1.	Seed / fodder bank	X	X	X
2.	Community water user groups	X	✓	✓
3.	Custom Hiring Centre (CHC)	✓	✓	X
4.	Godown and warehouse	✓	X	X
4.	Farmers collectives/FPO	✓	✓	✓
5.	Watershed or village development committee	✓	✓	✓

Institutional mechanism is an essential part of sustaining any development project. All three stakeholders have emphasised the creation of village level committee to ensure the effective implementation of CSA interventions and mobilisation of farmers including women farmers to ensure effective participation and monitoring of the progress of CSA activities. DoA under PoCRA is promoting a Village Climate Resilient Management Committee (VCRMC) at the gram panchayat or village level to ensure the mobilization and participation of farmers in the project activities related to CSA. Further, it is responsible for planning, implementing and monitoring the project activities. Unlike many other climate-smart village-level community institutions, VCRMC is formed under the provisions of Section 49 of the Maharashtra Gram Panchayat Act, 1959. Thereby, making it the statutory body. Hence, ensuring the permanency of the committee even after the withdrawal of PoCRA after its project period, 2024. Each VCRMC consists of 17 members (13 Executive members and 04 non-Executive members) with two third of them belonging to small or marginal landholders and one-third of them being members of the Gram Panchayat. Further, to ensure social inclusion priorities are given SC, ST and Divyaang. To ensure gender inclusiveness, 50% of all

VCRMC members are women. A total of 3756 VCRMCs have been formed till August 2022. VCRMC is mandated to prepare participatory village micro-plans, select beneficiaries for individual benefit activities, plan and execute community works as per the approved annual action plan, (iv) be responsible for the maintenance of assets, and facilitate the social audit of the project activities. Also, the 'Krishi Tai' (Women Farmer Friend) who is responsible for mobilising women farmers to the project activities is transparently nominated by VCRMC. Considering the role that VCRMC played in ensuring CSA at the village level, the Government of Maharashtra has replicated this model with slight modification and constituted village agriculture development committee at every village in the non-PoCRA regions. KVK also created Kadwanchi Village Watershed Committee (KVWC) in 1996 as part of its watershed implementation. It is a registered committee with 21 members. However, the membership is reduced to 12. Of which, 25% are women farmers, nearly 40% are marginal farmers and the remaining belong to the large farmers' category. It maintains a separate bank account with Rs.16 lakhs as saving for repair and maintenance of supply-side water structures such as check dams, community farm ponds etc. From 1996 to 2005, KVWC has given loans to farmers. However, it was terminated due to an increase in the number of commercial banks for agricultural loans at low-interest rates. The effective implementation of WOTR's CSA activities in Kotha Jahangir village is linked to village-level institutions such as Village Development Committee (VDC) and Acqufier Committee (AC). VDC consists of 21 members with 33 % of them (07) representing women farmers category, which ensures gender inclusiveness. To adequately address the climate change risks challenges faced by marginal and small farmers, 3/4th of the VDC farmers are the representative of marginal (12 nos) and small farm holding farmers (05 Nos) categories, also including four large farmers. The number and size of the VDC vary from village to village of the project sites of WOTR. Also to ensure, effective budgeting and utilisation of water for irrigation, WOTR instituted an Acquifier Committee, called Bhujal sameti locally. It consists of 14 members including 02 women farmers. It also ensures the adequate representation of marginal and small farmers. Of 14 members, 07 and 05 are marginal and small farmers (85%) as well as 02 large farmers. AC is responsible to ensure that no farmer digs a borewell beyond 200 feet in depth. As a result, there is a 5 feet increase in groundwater level from 40 to 35 feet depth. However, unlike the registered village committees of PoCRA and KVK, VDC and AC of WOTR are not registered to any society or panchayat act. They are mostly involved in social mobilisation, discussing the challenges faced by farmers (under the prevailing climate change risks), the need of farmers and giving feedback on the progress of adoption of various CSA practices and technologies etc. This facilitative role has enabled WOTR to effectively utilise time and focus on CSA interventions that pertain to their farm and crop situations.

Table 11. Village committee for effective CSA implementation

S.No.	Name of the Committee	Constituted by	M	F	MF	SF	MF	LF	Total
1.	Village Climate Resilient Management Committee (VCRMC) – Tapovan village	PoCRA	06	07	13	-	-	-	**13**
2.	Kadwanchi Village Watershed Committee (KVWC)	KVK	09	03	05	-	-	07	**12**

3.	Village Development Committee (VDC)	WOTR	14	07	12	05	-	04	**21**
4.	Aquifer Committee (AC) or Bhujal sameti		12	02	07	05	-	02	**14**

M-Male, F-Female, MF-Marginal Farmer, SF-Small Farmer, MF-Medium Farmer, LF-Large Farmer

3.6.1 Custom Hiring Centre (CHC)

Farm equipment and machinery of CHC under PoCRA

Tractor (> and< 35 bhp), Trailer/ Trolley, Tractor driven power tiller/ Broad Bed Furrow/Combine Harvester, Cultivator, Disc plough, Forage harvester, Furrow opener, Harrow, Mould board plough, Multi crop planter, Multi crop thresher, Power tiller, Hydraulic Reversible Plough, Rotavator, Seed cum Fertilizer Drill and Thresher/ Multi crop thresher.

Use of mechanical power will result in reducing the drudgery of farmers, ensuring the timeliness of farm operations and improving productivity of crops. However, the farm power availability of marginal and small farmers is limited. Therefore, to ensure the availability of required farm equipment and farm machinery at affordable prices, Custom Hiring Centre (CHC) model has been well recognised in India.

CHC has received more attention under PoCRA to improve the farmers' access to farm machinery. DoA has approved and established 1604 CHCs worth Rs. 15923. 75 lakhs in the project areas of PoCRA. PoCRA in convergence with Agricultural Technology Management Agency (ATMA) identified and encouraged FPOs and SHGs (supported and created by ATMA) to establish CHC. Results also show that 373 CHCs worth Rs. 40.70 crores were established in Jalna district with subsidy support till August 2022 including one at Topavan village, which has led to the increased use of Broad Bed Furrow machinery by soybean growers. Farmers reported that before CHC, they did not follow BBF in soybean due to its non-availability. Before PoCRA, there were no CHCs in Jalna district. It shows that the prioritisation of funding support towards the establishment of CHC will facilitate the adoption of climate resilient practices. Further, an incentive of Rs.1,000 per ha is provided to farmers to adopt BBF in soybean. PoCRA data shows that out of 1604 CHCs, 275 CHCs alone covered about 450 ha till September 2021. Therefore, the adoption of CSA practice is concomitant with support services like access to farm machinery at affordable charges. Also, PoCRA has approved the establishment of 156 godowns and warehouses to enable farmers to store vegetables and other perishables at a minimum rent and sell them to markets at high demand periods. Results also show that a SHG in Tapovan village was supported under PoCRA to establish a godown. KVK has also established a CHC at its campus, making it available to farmers of surrounding areas. However, it is limited to its campus. WOTR is also not directly establishing any CHC, yet they encourage their FPOs to establish CHCs. Being an NGO, most of its CSA activities are donor funded and are centred on ensuring water security and other on-farm CSA practices as means of adaptation and mitigation. The non-prioritisation of WOTR to CHC is attributed to the need for a huge capital for procuring various farm equipment and machinery. For example, the procurement of one tractor of 35 HP and a tractor-drawn 7 or 9 tyne will cost about Rs. 6 and 0.5 lakhs, respectively depending on the company and models.

Officials of PoCRA visiting CHC established at Tapovan village, Jalna district

Case 3. Custom Hiring Centre – A case of Institutional support for CSA

Mr Onkar Manik Rao Kadhavane with his CHC estabihsed under PoCRA at Tapovan Village in Jalna district

Though a graduate of B.Tech, Mr Onkar Manik Rao Kadhavane's special interest triggered him to enter into agriculture. He also established a Self Help Group with the support of ATMA in Tapovan village. Through this group, he provided advisory services to all of his village farmers to adopt good practices of agriculture and adopt Broad Bed Furrows (BBF) in soybean to conserve water, many farmers were not willing to adopt them due to the inadequate availability of BBF machine. Under these circumstances, the subsidy support provided under PoCRA for various infrastructure and farm machinery enabled him to buy BBF machines and rent them to his village farmers at an affordable charge. Details of farm machinery brought by him under PoCRA are given in the Table.

Table 12. List of on and off- infrastructure subsidized to SHG of Mr Onkar Manik Rao Kadhavane

S.No.	Particulars	Total cost (Rs. in Lakhs)	Subsidy (Rs. in Lakhs)
1.	CHC (Tractors, BBF machine etc.,)	20.00	12.06
2.	Godown (350 MT)	27.00	11.15
3.	Shade net (0.5 acre)	06.00	04.00
4.	Community Pond (34X34X4m)	3.25	3.25
5.	Drip irrigation (15 acres)	9.00	6.45

These on and off farm interventions supported by PoCRA have ensured the storage facilities, cultivation of high value crops such as tomato, cucumber, chillies, capsicum etc., for seed production, and water for irrigation. He stated that he gets a net income of about Rs.5,00,000 per year from godown and Rs.1,00,000 per year through renting farm machinery. Thereby, he can generate an additional income of Rs.6,00,000 per year through climate smart on and off farm interventions. In addition to this, he provides employment opportunities to around 6 to 7 people for maintenance of godown, CHC and crop production daily at Rs.400 per person per day.

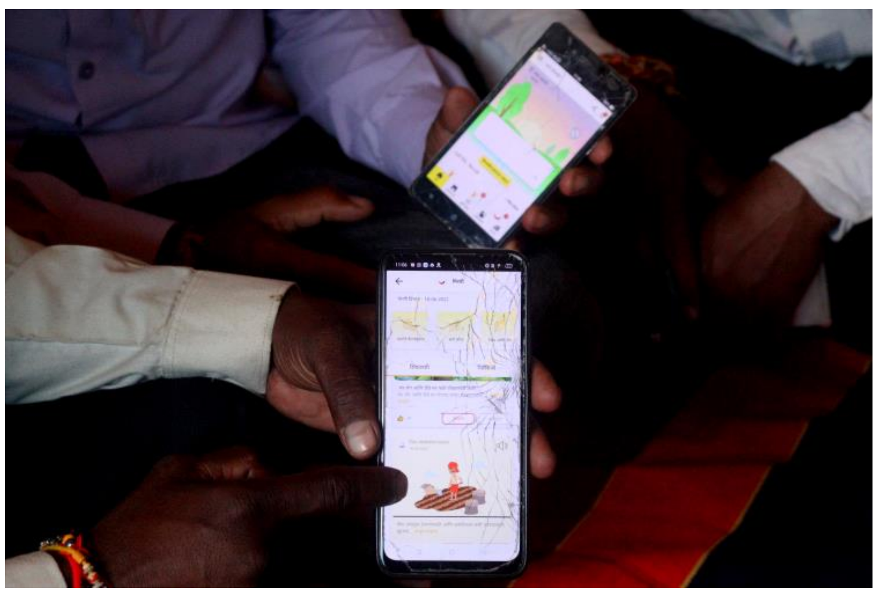
Box – 4. Mr Krishna Shir Sagar of Kadwanch village – Rise of an entrepreneur

After the watershed intervention of KVK, Jalna in Kadwanch village the area under perennial grapes and chilly has increased drastically. However, the increased area and production have not translated into the marketing potential of farmers. He stated that many farmers had to sell their grapes and chilly at distressed farm prices, thus affecting their overall income. Therefore, to overcome this high production and low price situation, he promoted his own FPO called Samuruthi with an initial investment of Rs.3,00,000. About 10,000 farmers who grow grapes and chilli have enrolled in his FPO. He himself has established a grape production on 3 acres with help of 4 lakh credit from Bank. He provides consultancy services on good agricultural practices on grape and chilly through this FPO for all the members and they in turn advise fellow farmers. Further, he provides end-to-end consultancy services to fellow farmers who show interest in the cultivation of grapes with a minimal charge of Rs.20,000. He says that many farmers are now approaching him for consultancy on grapes. This has also enabled him to repay his three-year loan in 15 months. This case illustrates that even a well motivated farmer can become an entrepreneur, establish FPO at his own risk and provide solutions for marketing challenges.

Krishna Shir Sagar at his grape orchard, Kadwanchi village

3.6.2 ICT smart interventions

ICT interventions are becoming a major tool to facilitate farmers to adopt timely CSA practices and technologies to overcome climate change risks. Results illustrate that the stakeholders have emphasised the need for ICT approaches to tailor the information which is specific to each farm, customise information based on individual farms and rapid dissemination of climate information to all relevant stakeholders. For example, DoA under PoCRA has created PoCRA Direct Benefit Transfer Portal to allow farmers to apply for subsidies related to various CSA interventions specific to their needs as part of ICT-based extension support. Farmers applying for subsidies under PoCRA have to register their Aadhar numbers along with filling in the relevant application form. Often, it is facilitated by VCRMC constituted by DoA under PoCRA. The data entered by farmers are verified by project officials in terms of eligibility, prevailing assets etc., before releasing the grant to the bank account linked to Aadhar. The successful adoption of CSA technologies by farmers is a result of the PoCRA DBT portal as it has eliminated the intermediaries, portal itself identifies the neediest farmers based on the pre-automated programming and the subsidy is released. Similarly, FPOs/FPCs/SHGs can apply for subsidy support to buy machinery or equipment to facilitate post-harvest processing, seed supply chain, and establish custom hiring centres. The beneficiary sample farmers of PoCRA indicated that they received the subsidy amount within two months, which further encouraged the neighbouring farmers to apply for subsidised CSA technology in PoCRA portal. It shows that IT-enabled DBT paves a way for farmers to avail the benefits of PoCRA instantly, thereby encouraging them to adopt various CSA technologies. Therefore, the dryland farming system in the PoCRA villages including Tupewadi and Topvan villages is slowly transiting to garden land systems.



Farmers showing FarmPrecise App downloaded by them

WOTR has developed a *FarmPrecise app* in collaboration with IIT-Ahmedabad to provide dynamic weather-based, crop management advisories tailored to crop and farm-specific conditions. The major features of this app include personalized crop advisory (on feeding farmers' crop information right from sowing), an interactive platform to allow farmers to discuss their crop production problems with agronomists (e.g. chat), advisories to the crop images infected with pests and diseases which are captured and uploaded by farmers themselves, application of fertiliser with the help of fertiliser calculator inbuilt in the app, farm diary to help farmers to calculate their cost of production and daily feeding of market price and farm news. It has a customised package of practices for more than 25 crops. FarmPrecise app is supported by Qualcomm Inc. A total of 31,831 farmers have downloaded this app including farmers from Kotha Jagangir village. Results also show that 90% (18 nos) of the beneficiary sample farmers use the FarmPrecise app. It is available in five major languages namely, English, Hindi, Telugu, and Odia including Marathi, the mother tongue of Maharashtra state. The users reported that they started following the recommendations that they receive on the App as they are specific to the stages of their crops.

Case – 4. FarmPrecise App paves a way for real time adaptation to changing climatic conditions

Mr Dattu Agle (middle) at Kotha Jahangir village shows the FarmPrecise App used by them

Mr Dattu Agle was unaware of the insect that attacked his chillie field grown under drip irrigation. The emergence of new pests and diseases has become the most common phenomenon and resulted in severe loss of yield. As the damage to the chilli crop became apparent, immediately, he captured and uploaded the image of pest to FarmPrecise App, which identified the pest as black thrips. Soon after the diagnosis, he applied a mix of biopesticides such as dashparani ark and chemical pesticides to control it. He indicated that the use of this app has also benefited in undertaking farm activities based on the crop advisory received through this app. Also, he sells his chilli to market agents based on the market rate shown in the app. As he follows the recommended package of practices received through FarmPrecise App, the yield has doubled says Mr Dattu, from Kotha Jagangir village, Bhokardan block, Jalna district. He says that today his crop yield is more than what he was getting before using the App owing to the application of fertiliser and pesticides based on the recommendations received through the App.

3.6.3 Gender smart models

To further ensure gender inclusiveness in CSA implementation, DoA under PoCRA empowers women through Krishi Tai approach (Women Farmers' Friend). There are two to three Krishi Tais at village level or a cluster of villages. Their skill is enhanced through frequent exposure visits and training. About 3782 of them were identified and trained till September 2021. They play a key role in the mobilisation of women farmers to ensure their maximum participation in the CSA activities carried out by DoA under PoCRA. Also, act as an interface between women farmers and PoCRA implementing officials, KVK and gram panchayat. However, they were not able to effectively mobilise the women for various CSA activities. For example, a total of six FFS were conducted, i.e. three each in Tupewadi and Topovan villages till September 2021. However, none of them was observed to be woman farmers out of 30 farmers who participated in the

FFS. Therefore, there is a need for a more focused approach to ensure the inclusiveness of women farmers.

WOTR has also prioritised most of its CSA activities in enhancing the capacities of women farmers, thereby improving their social and economic status, besides ensuring their leadership qualities and decision making ability. Results show that 50% of Village Development Committee members of Kotha Jajangir village are women farmers and 15% of members of Aquifer Committee are represented by women. They are responsible for mobilising women farmers to adequately represent them in demonstrations, water budgeting meetings etc., organised by WOTR. This adequate representation in major village institutions developed by WOTR elucidates that the role of women in climate smart agriculture development is inclusive and addresses gender issues effectively. Moreover, WOTR's gender smart activities include skilling women farmers on the preparation of organic formulations such as Dash Pani Ark, Jeevamruth, Neemark, Amruth Pani and vermicompost and encouraging them to adopt kitchen gardens to meet their entire households' vegetable and fruit requirements. Results also show that about nearly 25% of farm households (70 nos) are practising kitchen gardens in Kotha Jagangir village. The beneficiary women indicated that they were able to save about Rs.250 to 300 per household per week on vegetable and fruit expenditure. This indicates that CSA activity which is inclusive of women farmers can result in a higher adoption rate and enhanced adaptation to climate change risks while improving their economic status.

3.6.4 Farmers' Field School

Farmers Field School (FFS) is emerging as one of the best models for improving the knowledge and capacities of farmers to adapt to climate change risks and enhance crop productivity. The successful adoption of CSA technologies and practices such as bio fertiliser production, IPM, INM, BBF, Zero tillage etc., by PoCRA beneficiary farmers is closely associated with their enhanced knowledge through FFS. FFS starts with the selection of host, guest farmers & facilitator, cropping pattern; preparation of FFS schedule; organising classes as per schedule with the demonstration of various CSA practices and technologies; monitoring by FFS coordinator through FFS App, approval of FFS by Sub Divisional Agricultural Officer (SDAO), visit of facilitator to guest farmers' fields to assess the adoption of technologies learnt in FFS and enter the details of adoption in FFS app. Also, the technical competency of facilitators and coordinators is supplemented by FFS mobile app. Based on the nutrient and pest information of FFS plots entered into the app by facilitators, the app provides end to end solutions on the selection of seed varieties, use of different types of fertilizers, pesticides and technologies to ensure CSA in the selected cropping pattern. A total of 30141 FFSs were conducted till September 2021. Further, DoA identified 7534 host farmers to carry out all practices under FFS to their fellow farmers and paid an honorarium of Rs.2800/- per year. About 1.64 lakh farmers participated in FFS conducted in the project villages. Also, the major attribute of FFS conducted under PoCRA is gender inclusive. About 30% of host farmers of FFS should be women farmers, with a preference for marginal, small, SC/ST women. Data shows that 10.73% of host farmers belonged to women farmers. On the contrary, the results show that out of the Host Farmers selected from Tupewadi and Topvan villages, three farmers each. All were male farmers. Hence, there is a need for concerted efforts to ensure gender inclusiveness.

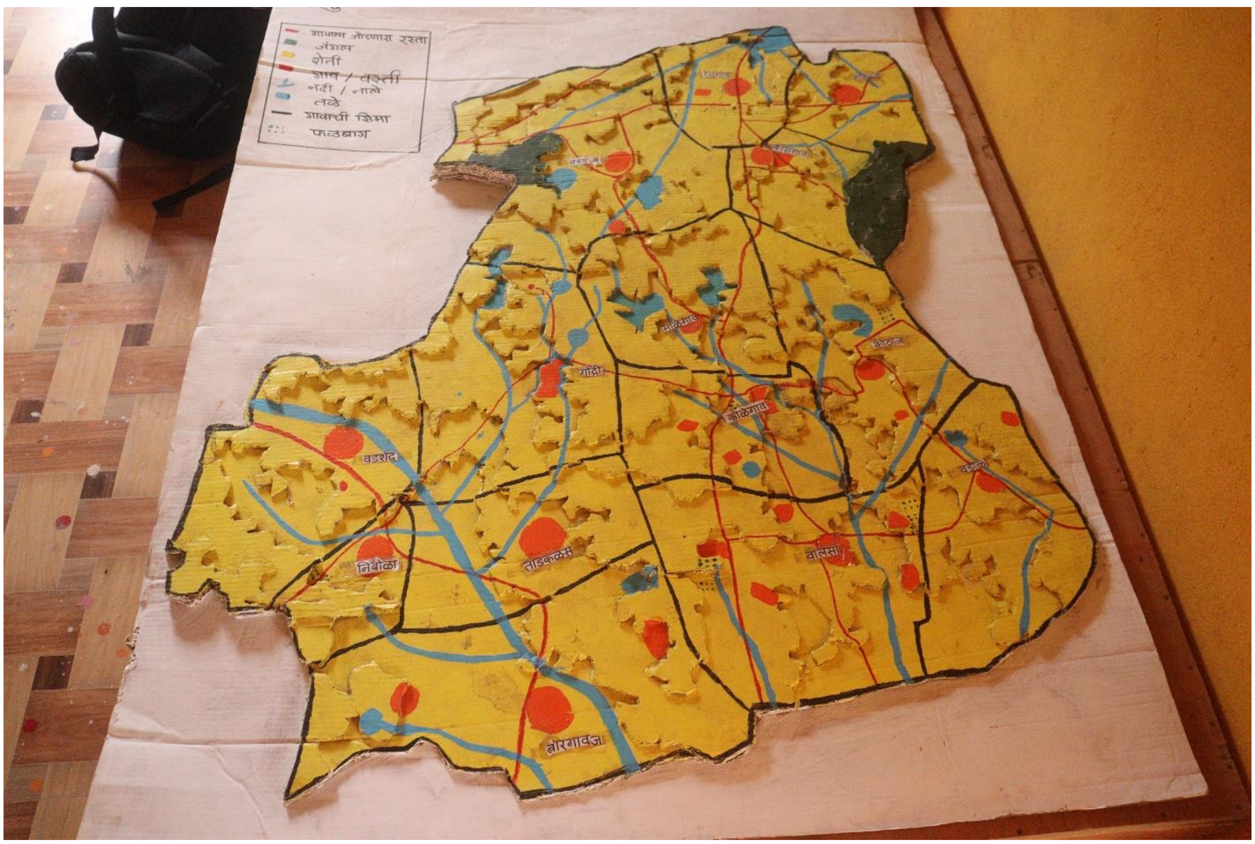
Table 13. FFS and its impact on Tupewadi and Tapovan villages

S.No.	Particulars	Tupewadi	Tapovan	Remarks/Impact
1.	No of FFS conducted till August 2022	03	03	
2.	No of FFS Host Farmers	03	03	One each for Cotton, Soybean, and Bengal gram for both villages
3.	No of gust farmers participated	90	90	(30 per FFS)
4.	Crops	Cotton, soybean and green gram	Cotton, soybean and green gram	-
5.	Major climate smart technologies and practices covered	Zero tillage, use of light traps against Pink Bollworm, use of climate resilient varieties in Bengal gram (Akash, BDNG 798), NH-615 (cotton variety suitable for High Density planting under rainfed condition), MAUS-12, 71 and JS-2029 (Soybean) BBF technique, IPM (Neem ark, sticky insect light trap), INM, drip/sprinkler irrigation	Zero tillage, use of light traps against Pink Bollworm, use of climate resilient varieties in Bengal gram (Akash, BDNG 798), NH-615 (Cotton), MAUS-12, 71 and JS-2029 (Soybean) BBF technique, IPM and INM.	About 25 farmers who grow soybean under rainfed conditions adopted BBF in Tupewadi village, 14 farmers in Tapovan,
6.	Coordinator			One coordinator from DoA covers 10 to 12 villages under PoCRA
7.	Honorarium to FFS Host Farmer	Rs.2800 per year	Rs.2800 per year	

Results also show that many farmers have adopted these climate smart varieties. Similarly, WOTR's FFS deals with the promotion of BBF technique in soybean, plastic mulching in Chilli, System of Crop Intensification (SCI) including IPM, INM, preparation of organic formulations etc. WOTR has conducted 24 FFSs till August 2022 covering all the farmers in Kotha Jahangir village. FFS is conducted by an agronomist from WOTR, unlike PoCRA, no honorarium is given to the farmer whose farm is selected for FFS. Though FFS was not the major extension approach of KVK, the promotion of most of the CSA interventions such as the BBF technique, improved seeds/varieties etc., is done through demonstrations, on-farm trials, field days etc.

3.6.5 Participatory Watershed approach

Watershed approach is emerging as one of the best options to offset the risks of climate change (Cohen and Davidson, 2011). Considering its role in climate change risks adaptation and mitigation in the agricultural sector, all three stakeholders followed the watershed approach. DoA under PoCRA identifies vulnerable mini watersheds or village clusters with indicators such as climate exposure, sensitivity, and adaptive capacity. Importance is given to micro-level watershed planning where gram panchayat-level project planning exercise is carried out with the effective participation of local communities such as marginal & small farmers, women, etc., and institutions such as gram panchayats. This planning helps in mapping available on and off resources (e.g. drainage pattern topography, hydrological units, available groundwater, road networks, agriculture land, season-wise cropping pattern, existing water harvesting structures, etc.,); identifying constraints; and possible CSA interventions at cluster level to adapt food systems to emerging climate change challenges. This process commences with cluster-level training, focus group discussions, meetings and water balance, technical verification by officials of PoCRA etc. Out of the 5142 villages, micro-planning has been completed in 3835 villages covering all 138 clusters under PoCRA as of September 2021.



Demarcation of watersheds on participatory mode, Kotha Jahangir village

Similarly, KVK under IGWDP has adopted a watershed approach in Kadwanchi by focusing on strengthening the supply side water management structures such as CCT, deep CCT, Check dams, gabion structures, Nala bunding, individual or community farm ponds etc., and in terms of demand side water management technologies, the drip and sprinkler irrigation received a higher priority. To effectively undertake the CSA interventions under watershed, KVK has created Kadwanchi watershed committee with 21 members by involving local farming communities. This has led to the effective adoption of on and off farm interventions. Similarly, WOTR's watershed approach includes the creation of check dams, composite gabion structures, Nala bunding, Nala deepening, installment of aquifer recharge system, etc. To further strengthen the effectiveness of watershed approach, WOTR constituted an Aquifer Committee in Kotha Jahangir village consisting of 14 members, which helps in mobilisation of farmers to ensure their participation in all activities related to water use for irrigation and household purposes and conservation efforts. Further, this committee monitors that no farmer in its jurisdiction digs bore well beyond 200 feet depth. This shows that the participatory watershed approach is essential while promoting CSA intervention and ensuring its adoption.

Table 14. Impact of participatory watershed approach of all three stakeholders

S.No.	Particulars	Tupewadi and Tapovan – PoCRA by DoA			Kadwanchi – IGWDP by KVK			Kotha Jahangir by WoTR		
		BI	AF	%change	BI	AF	%change	BI	AF	%change
1.	Farm bunds (ha)	-	-	-	-	1432	+75%	-	416	+100
2.	CCT and deep CCT (ha)	-	-	-	-	408	+21%	-	-	-
3.	Loose Boulder and Gully Plug Structures (nos)	-	-	-	-	1298	-	-	-	-
4.	Check dams (nos)	-	-	-	-	-	-	-	06	+100 %
5.	Composite gabion structures	-	-	-	-	-	-	-	05	+100 %
6.	Nala bunding (nos)	-	-	-	-	-	-	-	03	+100
7.	Nala deepening (length in km)	-	-	-	-	-	-	-	5	-
8.	Farm ponds or community ponds	-	105	-	-	503	+100%	-	48	+100
9.	Cropped land (ha)	-	-	-	1365.95	1517.00	+10%	-	-	-

10.	Waste land	-	-	-	147.03	62.03	-58%	-	-	-
11.	Two season irrigation (ha)	-	-	-	505.00	897.00	+43%	-	-	-
12.	Perennial irrigation	-	-	-	174.4	617.00	+72	-	-	-
13.	No of open dug wells (nos)	-	-	-	206	806	+75	-	-	-
14.	Increase in groundwater table (metre)	-	-	-	6.03	11.97	+50	10.66	12.19	+12.55
15.	Area under drip irrigation (ha)	464	720		52	800	+93.5	20	520	+96%

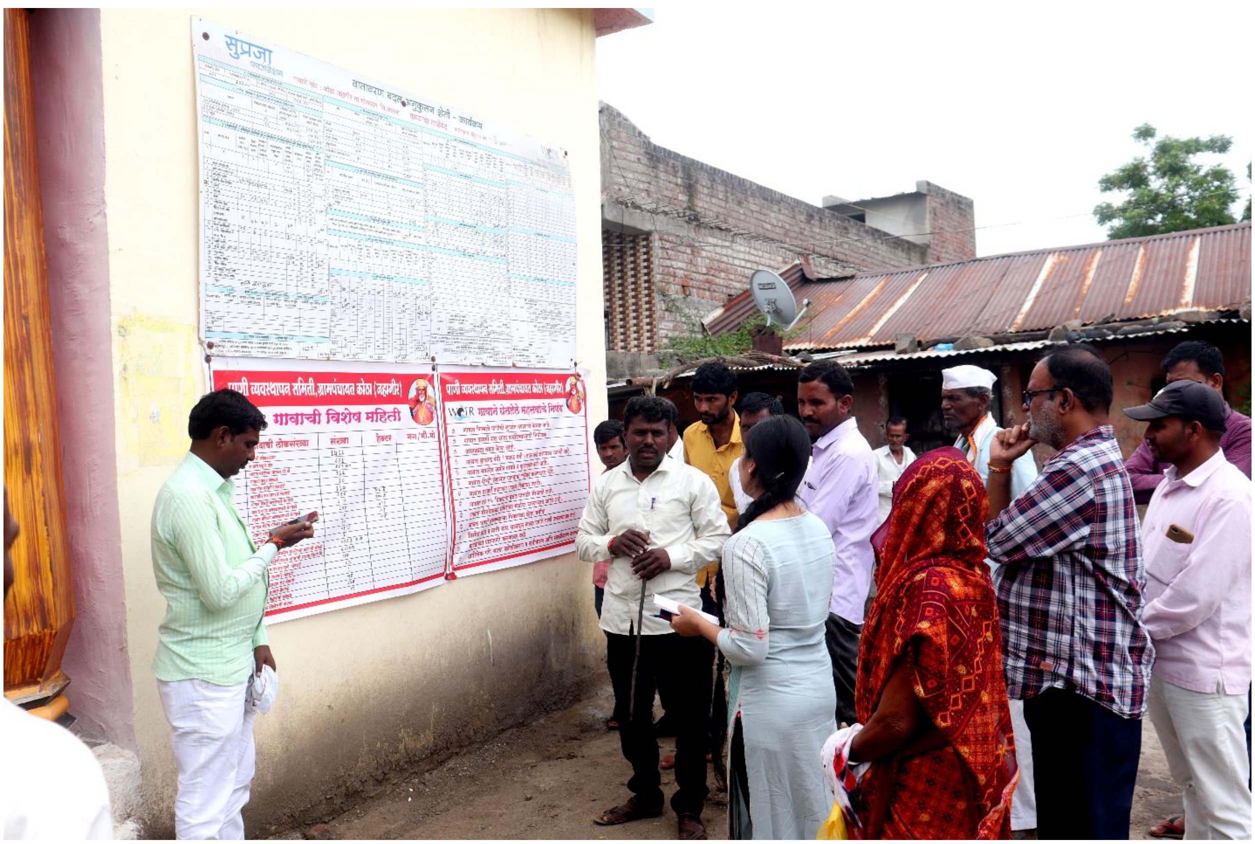
Before Interventions (BI), After Interventions (AI)

3.6.6 Participatory water budgeting

To decide the cropping pattern and the quantity of demand side water management structures, water budgeting or calculation of water balance has emerged as a major CSA model among the stakeholders. To ensure that the food system is CSA, DoA under PoCRA emphasises the need for water budgeting. It prioritises its focus on increasing the use of surface water, constructing more rainfall harvesting structures, enhancing the efficient use of soil moisture, recharge of groundwater aquifers and increasing crop water productivity. A mobile-based application is developed with the help of IIT, Bombay to assess the water balance framework for crop planning. It is calculated based on the excess runoff in the identified village by taking into account the soil type, land use, cropping pattern, existing water harvesting structures, human and animal population, groundwater recharge, and rainfall pattern. Based on the assessment, the members of VCRMC are made aware of the seasonal availability of water in the village for irrigation, suitable cropping pattern, efficient water use practices, technologies and other demand side water management activities to be undertaken. Similarly, water budgeting is the major CSA intervention prioritised by WOTR. Before introducing CSA technology and practices, WOTR calculates the availability of water for irrigation to the entire village including agriculture through the participation of all the members of VDC and Aquifer Committee. It assesses the amount of water available in the water harvesting structures such as check dams, gabion structures, community/individual farm ponds and availability of groundwater, based on such calculation, it recommends the suitable cropping pattern, judicious use of water for irrigation and other household activities. Results from Kotha Jahangir village show that farmers and the officials of WOTR have enumerated the data of available water for the year 2020-21.

Water budgeting – A case of WOTR

Water budgeting is carried out by the Aquifer Committee consisting of farmers at the village level, two times a year i.e. before Kharif (May month) and Rabi season (October month). It is facilitated by the officials of WOTR. Aquifer Committee ensures the participation of all farmers and village people in the water budgeting. To carry out this, a participatory wall chart is placed representing the details of water budgeting at the nearby temple. This committee calculates the capacity of available water in storage structures such as check dams, gabion structures, Nalas, community/individual farm ponds, besides, groundwater availability, amount of rainfall and groundwater availability and recharge. After this, it calculates the water demand that ranges from household consumption to requirements for crops, livestock and poultry. While the water requirement for each crop is calculated based on the cropping pattern in the particular seasons (i.e. Kharif and Rabi). Then, the summation of water available and water intake is calculated. It helps the farmers to take decisions related to cropping patterns based on the calculation of whether the water is surplus or deficit. In case of deficit, they change crops that require less water e.g. Maize in Kharif and irrigation schedule, preferably during the critical stages of crops. For example, the water budgeting for Kharif season, 2022, the



Water budgeting carried out at Kotha Jahangir by WOTR Officials and farmers

Table 15. Water budgeting for Kharif season, 2022 in Kotha Jahangir village

S.No.	Particulars	Water availability in crore litres	Water utilised in cores litres	Balance in cores litres
1.	Different storage structures (e.g. check dams) after evaporation loss		-	
2.	Water for household purposes including water for livestock and other common uses	277.51 (277.51 - 3.8+0.98)	3.38	-
3.	Evaporation from forest, pasture and wastelands		0.98	
4.	Water for irrigation in kharif (for all crops in kharif season both under flood and micro irrigation)	273.15	245.37	**27.78**

3.6.7 Manpower support

> **"Farmers can sustain and invest by themselves in latest technology even after the withdrawal of PoCRA project, also SC/ST farmers are able to invest due to increased income due to the adoption of CSA intervention promoted by PoCRA"……Says A S Deshmukh, Assistant Agriculture Officer (AAO), Department of Agriculture, Jalna**

In terms of extension functionaries, DoA has utilised its own existing extension functionaries and from ATMA to organise FFS, village meetings, training and capacity development programmes. Further, DoA has recruited Cluster Resource Persons (CRPs) and Krishi Tai on a contractual basis to assist the extension functionaries in terms of mobilisation of farmers and ensuring participation. Concerning WOTR, there are three field-level trained master trainers in every adopted village to provide extension and advisory services to fellow farmers. They are mostly educated and progressive farmers selected from the village itself, in turn, they are trained and monitored by one technical officer having a minimum degree in Agriculture. The technical officer covers 10 to 12 villages. In addition to them, WOTR engages two taluk officers to train the cluster technical officer, master trainers and conduct village meetings at frequent intervals to disseminate the latest CSA interventions to farmers. However, KVK is the only stakeholder with very less manpower numbering just 5 Subject Matter Specialists (SMSs) with one Programme Coordinator (PC)-Head of KVK. It further dependent on progressive farmers to reach out their technologies to farmers of its adopted villages

3.6.8 Extension approaches of stakeholders and % of participation by sample beneficiary farmers

Results also show that the participation of farmers in village meetings, climate awareness programmes and climate farm field schools was more than 85%. Cent per cent farmers' participation was observed related to village meetings conducted by stakeholders. Similarly, cent per cent of the beneficiary sample farmers of PoCRA in Tupewadi and Tapovan used mobile apps (e.g. PoCRA DBT app) and also were the members of PoCRA WhatsApp group created by officials. Also, 90% of the beneficiary sample farmers of Kotha Jahangir were using FarmPrecise App developed by WOTR and 95% were members of WhatsApp group created by WOTR for sharing CSA information, followed by cent per cent of them were registered farmers for receiving the weather and crop advisory through SMS. However, not many beneficiary sample farmers (30%) of KVK use mobile apps as KVK-Jalna has not developed any App system for sharing CSA information. Also, 30% of them who use apps were found to have been using private apps such as *Shetkari Raja, SK croptech, Cropguru – Farmer App* etc. However, there is a greater implication in using these private apps. Though mobile apps help farmers to gather data on weather conditions, commodity prices, farm news etc, the use of multiple apps without any guidance from extension professionals may result in improper adoption. Therefore, farmers have to be guided to use recommended apps which can customise their farm information and deliver crop-specific recommendations. However, 65 and 60% of them were registered to receive weather advisory through SMS and members of WhatsApp group called Kadwanchi WhatsApp group, which pass on the CSA information developed by the scientists at KVK. In terms of participatory crop planning, 90% and cent per cent of the beneficiary sample farmers of PoCRA and WOTR benefited. However, only 5% of the beneficiary sample farmers participated in crop planning. Concerning water planning, cent per cent of the beneficiary farmers of WOTR participated. The higher participation rate is mainly due to that WOTR's CSA interventions are centred around water budgeting. Also, PoCRA and KVK emphasise the need for water planning, yet only 10 and 5% of the beneficiary sample farmers participated in such programmes. On the other hand, it can be observed that the scope for the use of electronic media such as TV and Radio for CSA is minimal. It might be that the agricultural information aired through radio or broadcast through TV is highly generic and a one-way of communication. Whereas, the smartphone-based app and WhatsApp groups helped the farmers to seek information which is specific to their farming systems.

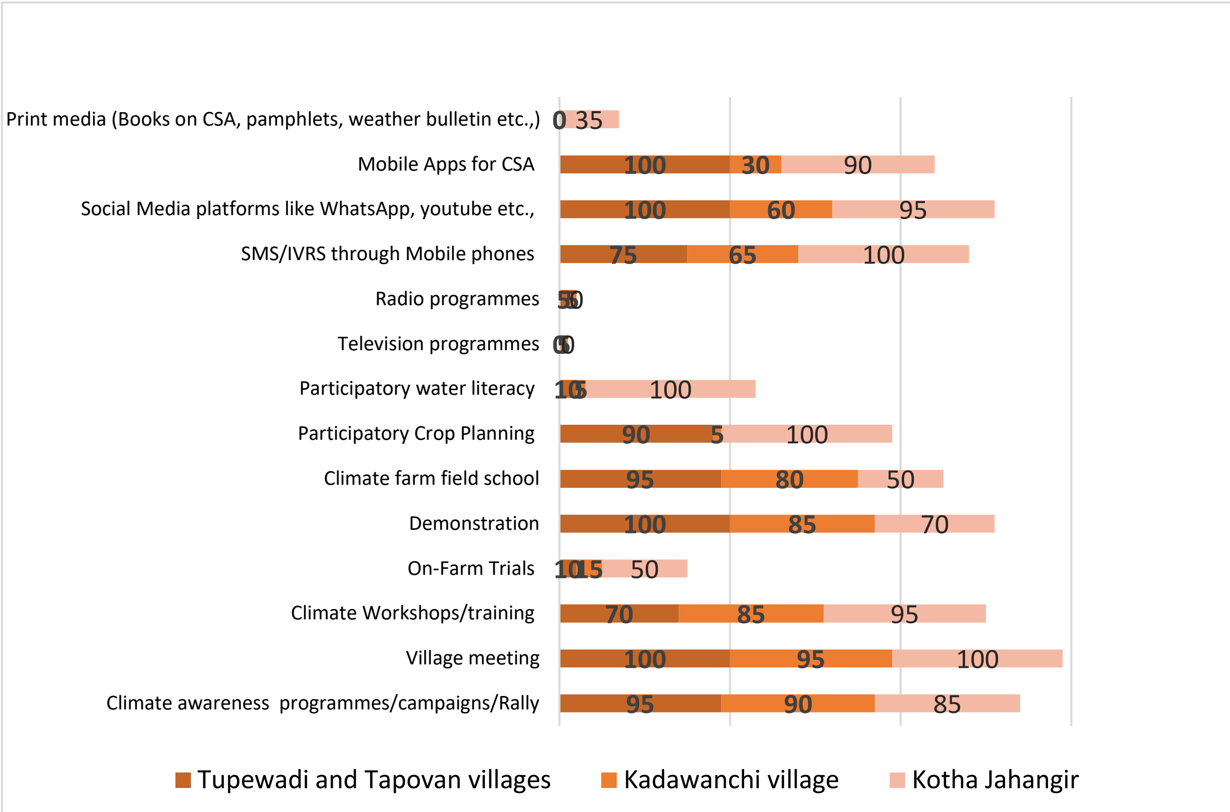


Figure 7. Extension approaches of stakeholders and % of participation by sample beneficiary farmers

3.7 Impact of CSA interventions

The present study has assessed the impacts of CSA interventions in terms of adaptation and resilience to droughts (the major climate change risks in Jalna district), changes in agricultural productivity and income. However, due to lack of scientific data on emissions reduction, the present study has not analysed the mitigation potential of CSA interventions in terms of quantity.

3.7.1 Crop diversification

The climate smart interventions such as the adoption of drip/sprinkler irrigation and individual and community farm ponds have ensured the water availability for irrigation even during summer months i.e. February to April. Beneficiary farmers of PoCRA, KVK and WOTR indicated that they were able to grow crops in February, March and April due to the water availability in their farm ponds, also judicious use of water through drip/sprinkler irrigation. However, the most important impact of CSA interventions is crop diversification. Farmers were able to diversify their cropping pattern from dry land crops to garden land crops. For example, 191 and 213 beneficiary farmers of PoCRA in Tupewadi and Tapovan villages, respectively, were cultivating vegetables such as Chillies, tomato, cucumber, bitter gourd, sponge gourd, capsicum and floriculture like Gerbera in the open field condition and under shade net house. Vegetable crops cultivated under shade net houses are mostly for seed purposes. Data indicates that the gross cropped area of vegetables increased by 57% (from 256.88 to 600.21 acres) after the adoption of subsidised shade net houses coupled with drip irrigation under PoCRA. Results also show that 75% of beneficiary sample farmers in Tapovan and Tupewadi villages have constructed shade net houses with the subsidy received under PoCRA to their bank account linked with Aadhar number. On an average, about 0.25 to 0.50 acres of farm is allocated for shade net house, covering about 4% of the total cultivable area

Farm diversification to floriculture, Tapovan village

in Tupewadi village. These farmers have also adopted drip/sprinkler irrigation in shade net houses with the subsidy support of PoCRA. This implies that the provision of subsidy is an important factor in the adoption of shade net houses and installation of drip/sprinkler irrigation, which, in turn, facilitated the farmers to diversify their cropping pattern to high value commercial crops.

Similarly, In Kotha Jagangir village, all farmers diversified their cropping pattern towards chilli and soybean from cotton, Maize and sorghum due to the adoption of drip irrigation. The high adoption is linked to the advisory service role of WOTR as it has facilitated the farmers to get registered for drip irrigation subsidies given under various schemes such as NHM, PMKSY, MGNREGA etc. The area under drip irrigated chilli has increased by 85% i.e. from a mere 50 to 350 acres (Data, Gram Panchayat, 2021). Likewise, the role of KVK in the promotion of drip and individual farm ponds in Kadwanchi village encouraged the farmers to diversify their cropping pattern to perennial crops like grapes. The results also indicate that 95% of the sample farmers have diversified their cropping pattern from dryland crops like cotton to perennial crops like grapes and seasonal crops like vegetables due to the assured water supply from farm pond, besides drip irrigation systems in the grape orchard and vegetable gardens. Data shows that the percentage increase in area under grapes was 99.37% (it increased to 1185.6 from mere 7.41 acres) and increase in area under vegetables was 45% (it increased from 140.79 to 259.35 acres). The most important factors that the farmers attributed to the cultivation of grapes to the subsidy support received from the government for the construction of polythene sheet-lined farm ponds and the installation of drip or sprinkler irrigation, in addition to the creation of check dams and other water harvesting structures by KVK under IGWDP has resulted in throughout the year water availability for irrigation. Results also show that cent per cent of the sample beneficiary farmers (20 nos) constructed farm ponds and adopted drip irrigation in Kadwanchi village. This demonstrates that for farmers to shift to commercial crops under the changing climate conditions, especially during drought periods (as in the case of Jalna district) water smart interventions such as farm ponds, micro irrigation etc., are essential. This will also enhance productivity of crops and farm income. However, the results show that the subsidy component played a major role in paving a way for adaptation and enhancing the resilience of farmers. Without the subsidy support (e.g. PoCRA-Department of Agriculture-IGWDP, KVK and convergence with government schemes - WOTR), it could not have encouraged the farmers to adapt to high value commercial crops from their rainfed crops such as cotton, maize, sorghum etc. Therefore, there is a need for subsidy support for farmers to invest in high-cost CSA technologies such as shade net houses, drip/sprinkler irrigation systems, farm ponds etc., without such subsidy support, the probability of farmers adopting such high capital-intensive technologies in adapting agriculture to climate change risks is minimal.

Table 16. Cropping pattern in the select village before and after CSA interventions

S.No.	Particulars	Crops grown before CSA interventions	Source of irrigation	Crops grown after CSA interventions	Source of irrigation
1.	Tapovan and Tupewadi villages (PoCRA adopted villages)	Cotton, Maize, sorghum, wheat and soybean (to some extent) and vegetables in smaller areas	Precipitation and open well	Chilli, tomato, cucumber, bitter gourd, sponge gourd, capsicum, Gerbera, acid lime etc., under shade net conditions using drip irrigation for seed purpose, in addition to	Open well, farm ponds in addition to rainfall

				cotton, soybean, maize, sorghum, wheat in smaller areas	
2.	Kotha Jagangir (WOTR project village)	Cotton, Maize, Sorghum and a very less area under chilli as it is the traditional crop of Kotha Jagangir village	Precipitation and open well	Chillie (in more areas), soybean, cotton, tomato under drip irrigation, also sorghum, maize, horse gram and Bengal gram	Open well, farm ponds in addition to rainfall
3.	Kadwanchi (IGWDP)	Cotton, Maize, sorghum etc., under rainfed conditions and flood irrigation method	Precipitation and open well	Grape, vegetables, soybean, Maize, cotton, sorghum etc., under drip irrigation method	Open well, farm ponds in addition to rainfall

Box - 5. Shift from dryland to garden land agriculture – A case of Tapovan village under PoCRA

Mr Vasant Dhanpad Rao Madhoni, from Tapovan village located in Bhokardan tehsil of Jalna district, was growing cotton, Jowar or Maize in Kharif and entirely dependent on seasonal monsoon for irrigation. Therefore, many times he incurred loss due to drought conditions which is a frequent climatic risk in Jalna district. Various interventions such as providing subsidised drip irrigation systems and subsidy for creating farm ponds were undertaken by the Department of agriculture and other line departments, to overcome the risks of climate change in Jalna. Apart from this, the introduction of PoCRA scheme by the Department of Agriculture initiated subsidy support for the establishment of shade net houses which showed a sign of prosperity for farmers. Mr Vasant Dhanpad is one of the beneficiaries of PoCRA who constructed a shade net worth Rs. 21.61 lakh for an acre with the subsidy support of Rs. 13.36 lakhs under PoCRA. Shade net house has enabled him to cultivate Gerbera flowers, which yields him 1500 flowers per day. He says that he gets about Rs.5000 by selling these 1500 plants to the traders coming from Hyderabad, Jalna, Aurangabad, Amaravati and Nanded. He indicated that flowering starts from 3rd month from the planting and continues for about two years. On average, he gets a net income of Rs.1,00,000 per month. He further informed that he is providing assured employment opportunities to four of his village women daily, earning them an income of Rs.300 per day. Thus, the on-farm climate smart intervention such as shade net houses can improve the adaptive capacity of the individual farmer against the recognized drought and provide employment opportunities throughout the year.

Simpson Crop diversification Index

Simpson index of crop diversification (Sd) was used to assess the degree of crop diversification. The index was estimated using the following formula

$$\mathrm{Sd} = 1 - \sum_{i=1}^{n} p_i^2,$$

Where pi is the proportion of the ith crop/crop sector in gross cropped area. The diversification index ranged between 0 and 1, with higher values indicating a high degree of crop diversification

Table 17. Crop diversification

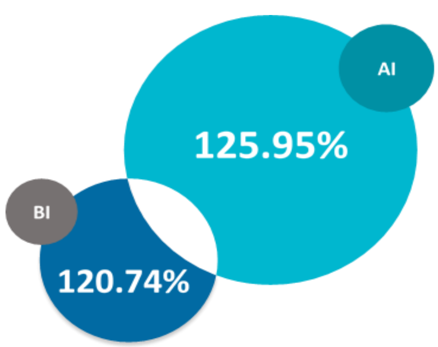
S.No.	Particulars	Tupewadi and Tapovan		Kadwanchi		Kotha Jahangir	
		BI	AI	BI	AI	BI	AI
1.	Simpson Crop Diversification Index	**0.68**	**0.74**	**NA**	**NA**	**0.65**	**0.65**

NA-Not Available

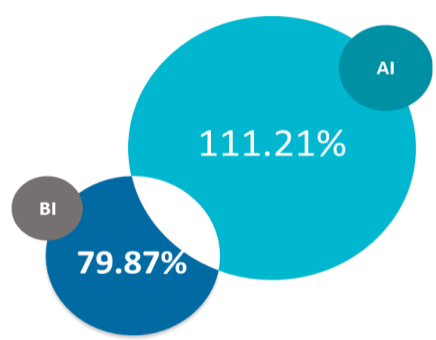
The CSA interventions have a conspicuous impact on crop diversification in all selected villages. In Kotha Jahangir village, though there is no change is observed in terms of index range. Results indicate that the area under vegetables has increased and the area under field crops decreased. This is the major reason for the no change in the index range. Similarly, in Tupewadi and Tapovan villages, the area brought under vegetables has increased, which resulted in more diversification.

3.7.2 Cropping intensity

Data shows that the CSA interventions have increased the crop ping intensity in Kotha Jajangir village, cropping intensity has increased to 111.21% due to the availability of water for irrigation to cultivate crops during the summer season. Whereas, the cropping intensity was 79.87% before the adoption of CSA interventions such as farm ponds, drip/sprinkler irrigation etc. In Tupewadi and Tapovan villages, cropping intensity increased from 120.74 to 125.95% due to the expansion of the gross cropped area under vegetables in open field conditions and under shade net houses.



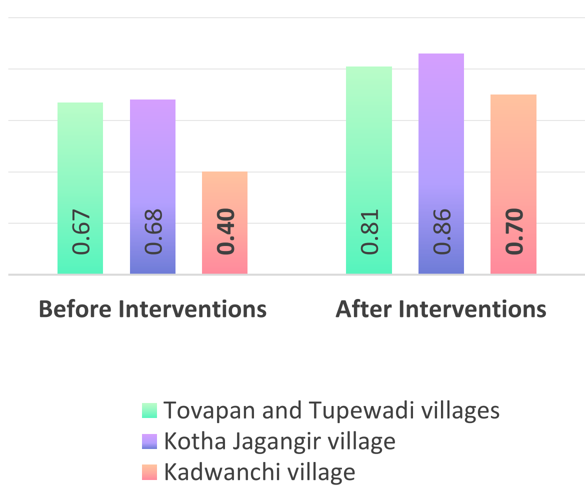
Cropping Intensity in Tupewadi and Tapovan villages - PoCRA
BI- Before Interventions
AI - After Interventions



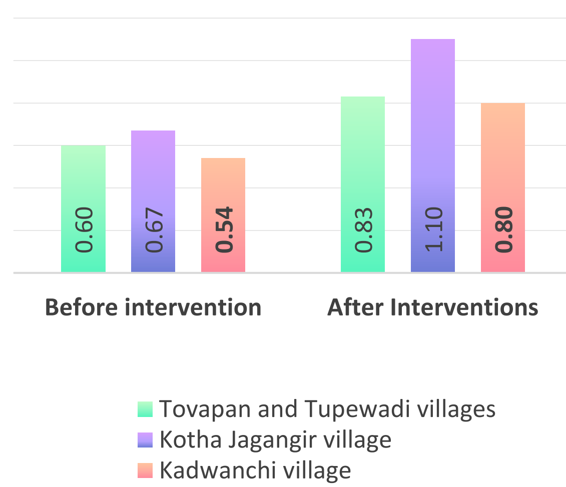
Cropping Intensity in Kotha Jajangir village - WOTR
BI- Before Interventions
AI - After Interventions

3.7.3 Crop yield

The first of the major three pillars of CSA as advocated by FAO is dealing with sustainably increasing productivity and income. All three stakeholders Department of Agriculture (PoCRA), KVK and WOTR are promoting CSA technologies and practices that can improve productivity and enhance the income of farmers. The study results indicate that there is a notable increase in the yield of crops due the interventions such as assured water supply sources i.e. farm ponds/community farm ponds and the adoption of conservation water technique drip/sprinkler irrigation. Farmers cultivating soybean in Tovapan and Tupewadi villages reported that the yield of soybean average 0.83 tonnes per acre due to the adoption of drip irrigation, which has increased from 0.60 tonnes per acre when cultivated under rainfed conditions. Also, farmers with cotton indicated that the lint yield (Without seeds), they were able to get yield of 0.81 tonnes per acre of lint on average. It has increased from 0.67 tonnes per acre when cultivated under rainfed conditions and flood irrigation depending on the water availability in open dug well. Similarly, farmers expressed that the yield of sorghum (Rabi crop) increased from 0.57 to 0.85 tonnes per acre. Farmers in Kotha Jagangir village have also reported an increase in the yield of soybean from 0.67 to 1.1 tonnes per acre with a maximum yield of 1.7 tonnes per acre. due to the judicious use of irrigation water through drip irrigation. Similarly, Maize yield of beneficiary sample farmers increased from 1.53 to 2.35 tonnes per acre on average with a maximum yield of 2.8 tonnes per acre. The yield of chilli increased to 9.07 from 5.92 tonnes per acre with a maximum chillie yield registering at 15 tonnes per acre (under shadenet conditions). Similarly, for cotton, the lint yield increased to 0.86 from 0.68 tonnes per acre. For wheat, the yield increased from 0.7 tonnes to 1.01 tonnes per acre. Also, farmers reported that the average yield of Bengal gram increased to 0.7 from 0.4 tonnes per acre, and for horse gram, it increased to 0.8 from 0.53 tonnes per acre. Farmers of Kadwanchi village have also reported a definite increase in the average yield of crops due to the adoption of CSA interventions such as farm ponds and drip irrigation. For grapes, the yield increased from 8 to 14 tonnes per acre and for soybean, from 0.54 to 0.80 tonne per acre. The Lint yield of cotton increased from 0.4 to 0.7 tonnes per acre. In addition to the above crops, farmers were growing red gram, green gram, black gram, pearl millet, coriander etc., but by very limited sample farmers and only for family consumption.



Cotton yield tones per acre as reported by sample farmers



Cotton yield (lint) tones per acre as reported by sample farmers

Farmer showing the quality yield of cucumber due to shade net houses, Tapovan village

Table 18. Major crops of selected villages for the last three years

S.No.	Crops	Selected villages		
		Tapovan and Tupewadi villages (PoCRA adopted villages	Kadwanchi (KVK adopted village)	Kotha Jagangir (WOTR project village)
I	**Major Kharif crops**			
1.	Cotton	✓	✓	✓
2.	Soybean	✓	✓	✓
3.	Maize	✓	✓	✓
4.	Sorghum	✓	✓	✓
5.	Pulses (Horse gram)			✓

6.	Chillie	✓		✓
II	**Major Rabi crops**			
1.	Wheat	✓	✓	✓
2.	Bengal gram	✓	✓	✓
III	**Perennials**			
1.	Grapes	-	✓	-
2.	Shade net house vegetables (Tomato, chilli, capsicum, cucumber etc.,)	✓	-	-

3.7.4 Employment opportunities

The foremost opportunity of CSA interventions promoted by all stakeholders is the minimisation of migration. Farmers of all four villages indicated that before CSA interventions, they had to go to other villages or regions as daily labourers in the lean season, particularly in February, March, April and May due to the non-availability of water for irrigation in their open dug wells. However, the adoption of various CSA interventions such as shade net houses, farm ponds and drip irrigation resulted in the continuous availability of man-days, thereby ensuring work in their fields or neighbouring farmer's fields throughout the year.

Skilled women labourers pollinating Capsicum grown for seed purpose, Tapovan village

3.7.5 Income

All the beneficiary farmers reported that their income has increased substantially. For example, the sample beneficiary farmers of PoCRA of Tapovan and Tupewadi villages reported that on average they were able to earn Rs.4.07 lakh per ha in a year due to growing commercial crops cultivated under shade net houses coupled with drip irrigation for seed purposes, also increased yield of their major field crops such as cotton, soybean and bengal gram. It has increased from Rs. 2 lakhs per ha/year before PoCRA interventions. It shows that the income level of beneficiary farmers has nearly doubled. The same farmers reported that before adapting to shade net houses with drip irrigation, they even had a season of net income loss during severe drought periods. The net income from crop and animal husbandry was not exceeding more than Rs. 1 lakh a year due to rainfed conditions. Further, they reported that before PoCRA, Bamboo structure was constructed for vegetable seed production, but they succumbed to disasters such as heavy wind and precipitation. Hence, the subsidy support for the establishment of shade net houses enabled them to convert their disaster prone bamboo shade net to permanent GV pipe based shade net, resulting in assured quality seed production of vegetables and selling them at high prices. For example, the data shows that in Tupewadi village, there were 115 bamboo-based shade net houses before PoCRA and it has

> "Beneficiary farmers of PoCRA in Tupewadi village indicated that they have become self sufficient and need not take loans from bank hereafter"

reduced to a mere 22. Further, efforts are underway to replace the remaining bamboo structures with GV pipe based permanent structures. This on-farm infrastructure has further encouraged private seed companies to enter into contracts with these farmers for vegetable seed production, in turn, providing them with a lucrative price.

Also, beneficiary sample farmers of KVK reported that on average their annual income from crop and animal husbandry goes up to Rs.7.87 lakhs, compared to Rs.2.56 lakhs per ha before IGWDP. However, most of them were medium and large farmers. The beneficiary sample farmers of WOTR in Kotha Jagangir village were also able to get near about Rs.2 lakhs per ha in a year from crop and animal husbandry combined. The same farmers were not getting more than Rs. 1.25 lakh per ha before adapting to CSA interventions. It is evident from the results that the income of beneficiary farmers of PoCRA nearly doubled. It is mainly attributed to the provision of subsidy support under PoCRA for the adoption of on-farm infrastructure i.e. Shade net houses. This unique intervention enables the farmers not only to enhance the resilience of food systems but also to improve their food security in terms of higher productivity and income.

However, the major reason for WOTR to focus on the promotion of CSA practices, rather than high capital-intensive technologies is its funding supports come from donor agencies. Hence, they mostly play a facilitating role in the promotion of CSA practices, alongside providing advisory services regularly. WOTR did not provide direct funding or subsidy support for farmers to adopt capital-intensive CSA technology. Field evidence illustrates that the adoption of CSA interventions is directly proportionate to the increase in crop yield and income level of farmers. However, their adoption is linked to huge subsidy support and linkages to loans.

Case 5. Venturing into seeds production through shade net houses – A way of increasing farmers' income against climate change risks

Mr Ganesh Bhandudas family in his Gerbera plantation, Tapovan village

Mr Ganesh Bhandudas Tuke was like any other farmer who was majorly growing soybean and cotton under rainfed conditions. In this context, many of his village farmers were adopting shade net houses with subsidy support under PoCRA and diversifying their cropping pattern to vegetables for seed purposes. This has also encouraged him to avail of the subsidy and establish shade net house on 0.5 of his 3 acres of land. The shade net house has further enhanced his access to private seeds companies, which enabled him to grow vegetable crops such as tomato, capsicum, cucumber and chilli for seed production in a year. He stated that his income has drastically increased after his venturing into seed production under shade net houses.

Table 19. Income of Mr Ganesh Bhandudas Tuke from just a half acre of shade net house in a year

S.No.	Name of crops	Seed yield in kg	Price per kg	Total price (Rs.)
1.	Tomato	20	10000	200000
2.	Chilli	35	7000	245000
3.	Capsicum	15	12000	180000
4.	Cucumber	40	2200	88000
			Total	**713000**

In addition to this, shade net houses have resulted in private companies voluntarily training the people including women in the pollination of vegetable crops. These skilled people are employed in vegetable seed production at a daily wage rate of Rs.400. This has created more employment opportunities and stopped the migration to faraway villages or nearby cities in search of daily wage jobs. Mr Ganesh Bhandudas indicated that he provides employment opportunities to about six skilled labour in seed production.

Officials of PoCRA and MANAGE Team in Gerbera farm

Summary & Conclusion

CHAPTER – IV

Summary and conclusion

4.1 CSA prioritisation by stakeholders

Water and Soil Smart Interventions have received the top priority among all three stakeholders, followed by agronomic interventions. Within water and soil smart interventions, more emphasis is on the promotion of farm ponds and micro irrigation

The prioritization of CSA interventions by stakeholders was ranked based on the percentage share of investment in individual CSA thematic areas such as agronomic, water and soil, allied sector, infrastructure, institutions and extension to the total cost/budget spent on the total CSA themes, as well as extension and support services that the particular technology received while promoting. Findings show that water & soil smart interventions have received the top priority among all three stakeholders as more than 60% of the total PoCRA project cost and more than 50% of the total IGWDP project cost (KVK) were invested in ensuring water security and soil conservation. Likewise, more than 90% of WOTR's activities are related to water security as its interventions are aiming to provide water security through check dams, gully plugs, compartmental bunding, BBF technique, drip or sprinkler irrigation etc. This CSA prioritisation towards ensuring assured water for irrigation has resulted in crop diversification towards commercial crops, judicious use of water through micro irrigation systems, increase in groundwater table, etc. The benefits and co-benefits of water smart interventions have also enhanced the adaptive capacity of farmers of Tupewadi & Tapovan, Kadwanchi and Kotha Jahangir villages to drought and doubled the income of farmers. Agronomic smart interventions have received the second most priority among all three stakeholders. About 11% (Rs.243.87 crores) of PoCRA total cost invested was spent on promoting agronomic interventions such as IFS, IPM, INM, CSA varieties, etc., and 34% of IGWDP project cost was spent on agronomic interventions such as improved crop varieties and promotion of other crop cultivation practices.

However, there existed both commonalities and differences among stakeholders in the promotion of agronomic interventions. Promotion of organic agriculture, IFS, IPM, INM, intercropping, BBF technique have received equal importance among stakeholders. However, concerning zero tillage (no tilling of soil), only DoA under PoCRA has promoted zero tillage. Whereas, WOTR and KVK's prioritisation was limited to minimum tillage (ploughing the field up to 15 cm). Similarly, DoA has emphasised more need for CSA varieties than WOTR and KVK to improve the adaptation of food systems to climate vulnerabilities. Results also show that about 50% and 10% of farmers in Tapovan and Tupewadi villages have adopted CSA varieties of soybean, Bengal gram and cotton. However, none of the sample beneficiary farmers in Kadwanchi village was using CSA varieties of SAUs or ICAR research stations. Contrarily, WOTR is focusing on the conservation of local cultivars with its extension advisory service largely limited to creating awareness of government-approved varieties. However, none of the sample farmers used local cultivars. Relating to allied smart interventions, about 2.56% of the total cost of PoCRA spent on CSA earmarked to the allied sector activities such as promotion of sericulture, apiculture, agroforestry, backyard poultry, goatery, etc. Contrarily, more than 10% of the IGWDP fund of KVK was spent on allied sector interventions such as increasing the area under fodder crops, introduction of crossbreeds, promotion of backyard poultry, integration of horticulture and agroforestry with field crops.

NA However, infrastructure smart interventions such as the creation of processing units, godowns and cold storage units received less priority among all three stakeholders. The water, soil and agronomic interventions are directly benefiting farmers in terms of improved irrigation, water use efficiency, soil health maintenance, which in turn help them to get more crop yield and remunerative income. Therefore, prioritising infrastructure interventions will further help the farmers to improve post harvest management of crops including minimal post harvest wastage. Therefore, stakeholders have to strengthen their focus on farm gate infrastructure including cold storage as the area under vegetables and fruit crops is mushrooming due to improved access to, and availability of water for irrigation. However, relating to on-farm infrastructure, DoA aimed to promote capital intensive advanced technologies such as shade net houses to make food systems more drought proof. Whereas, KVK and WOTR have not focused on such technology due to their huge capital requirement. Results show that the construction of shade net houses on a half acre of farm requires about Rs. 10 to 12 lakhs. Therefore, the promotion of these technologies is dependent on the availability of funding options. As being funded by donor agencies, the promotion of shade net houses may not be financially feasible option for WOTR. However, the scope for NGOs like WOTR to foster convergence with PoCRA and promote such capital intensive technology in thier projects sits. Also, KVK's mandate in CSA is limited to on-farm trials and demonstrations of new/improved varieties, awareness and capacity building on technology and facilitating farmers to adopt advanced technology through convergence with ongoing government schemes and programmes. The beneficiary farmers of PoCRA with shade net houses in Tupewadi and Tapovan villages have shown more resilience to drought as it helps farmers in cultivating commercial crops for seed purposes under controlled atmosphere, despite rising risks of drought.

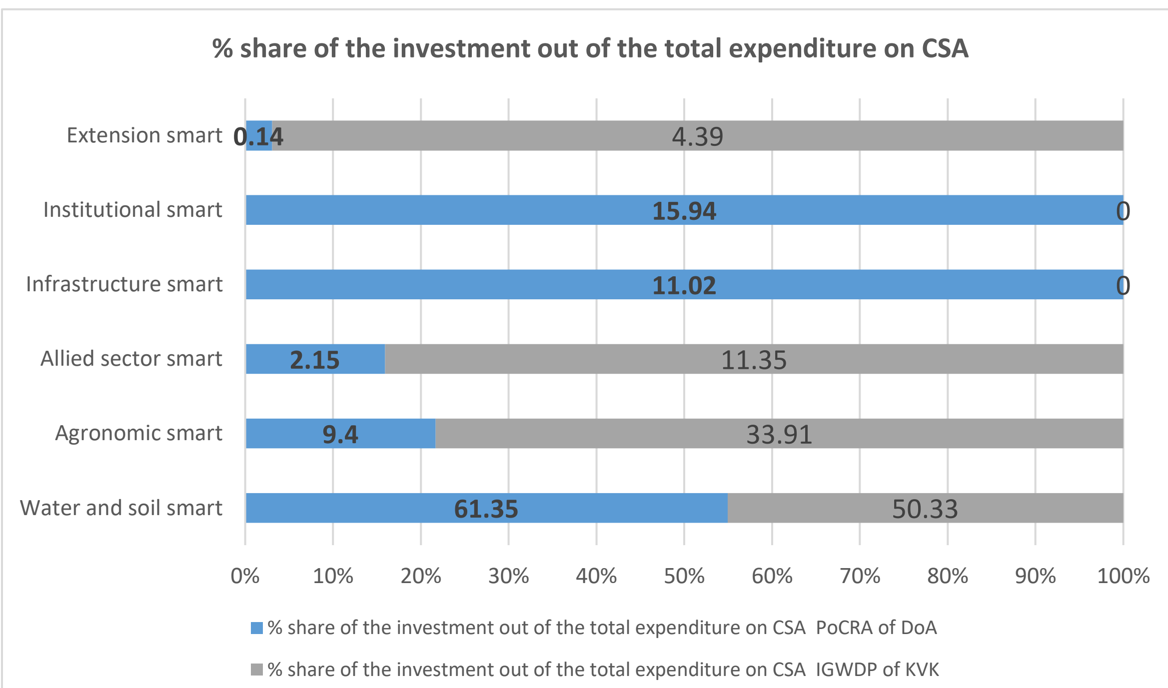


Figure 8. % share of the investment on individual CSA to the total expenditure on CSA combined

Farmer in his field, Jalna district

Results show that the adoption of CSA interventions by farmers is more. Such an adoption rate is possible due to the various extension models that the stakeholders followed. All three stakeholders have followed a participatory watershed approach, created local community institutions as their major extension system to promote CSA interventions, followed by FFS played a major role in creating knowledge and skill among beneficiary farmers of DoA under PoCRA and WOTR on various CSA technologies and practices. However, for KVK, demonstrations and on-farm trails were the major extension models for promoting CSA interventions. Also, the use of ICT interventions has emerged as one of the major large-scale reach tools for both PoCRA and WOTR. Both of them have developed mobile apps to benefit the farmers in real time and solve the farm-level challenges resulting from the risks of climate change. Hence, along with CSA technology and practices, extension support services are equally important in enabling farmers to be aware of the existing challenges, and possible CSA interventions, motivating them to adopt incentives and subsidies and enhancing the resilience of the farming systems to various climate vagaries.

4.2 Major learning from the study

- Irrespective of the CSA prioritisation of stakeholders, each had its own CSA pathways to enable the food systems to be more resilient to climate change risks and improve food system adaptation. For example, the benefits and co-benefits emerging from the adoption of drip irrigation, farm ponds, BBF technique, plastic mulching, IPM, INM, crop rotation, climate smart varieties etc., have improved the adaptive capacity of beneficiary sample farmers of all three stakeholders namely DoA, KVK and WOTR. Nevertheless, DoA under PoCRA has shown relatively more adaptation due to its huge funding support from World Bank. For example, the increased adoption of shade net houses has almost doubled the income of farmers, while serving as a great risk aversion mechanism to drought and other climate change vulnerabilities. However, it requires huge capital for the construction of shade net houses. Therefore, the subsidy support has enabled marginal and small farmers to adopt such high-cost technology.
- Further, DoA under PoCRA has narrowed down the creation of CHC to a village or cluster of villages. This shows that the possibility of ensuring CSA is highly dependent on huge funding requirements, also, it is sustainable as the capital investment spent will remain the same even after the withdrawal of the project with its rippling effect spreading from project villages to nearby non-project villages.

- CSA interventions of PoCRA are high-cost technology-oriented due to its own funding support with a large-scale operation. WOTR's interventions are low-cost technology and good agricultural practices oriented interventions as its funding support is from donor agencies but have its adopted villages across the country. On the other hand, KVK's interventions are model based such as watershed model, implemented through Projects like IGWDP on a small scale.
- In terms of manpower support, PoCRA is dependent on the officials of DoA, facilitated by local communities and institutions. WOTR is dependent on the communities and local institutions and hand holding by technical officers engaged by WOTR and KVK has the expertise of Subject Matter Specialists (SMS) and is supported by farming communities and local community institutions in their adopted villages. Each stakeholder has its own merits and demerits in determining the adaptation in agriculture and mitigation of GHGs emissions from agriculture.
- In terms of sustainability, the capital-intensive CSA interventions like shade net house is likely to be continued by farmers, hence, the continuity in the adaptation of the farming systems to droughts can be ensured in long run. Further, the adoption of micro irrigation and ensured water availability through farm ponds at farmers' levels and community levels and other structures will continue as the benefits and co-benefits rendered by these CSA interventions can be seen from increased crop diversification, higher yield, income and employment generations.

4.3 Recommendation

- ✓ Along with CSA priorities towards the promotion of soil and water smart interventions, stakeholders have to strengthen its convergence with state and central government schemes to promote agroforestry both in farmer's lands and wastelands.
- ✓ Need for mass-scale awareness among farmers to adopt agroforestry, create access to authorised quality tree nurseries and linkages to private firms and international carbon markets to realise the full potential of agroforestry.
- ✓ Before the implementation of any CSA project and promotion of CSA technologies and practices, the stakeholder may take into account the GHG emissions with a baseline survey and adopt an internationally accepted standardised methodology to measure the reduction in GHG emissions at farm levels compared with previous practices. Such reduction measures will help the stakeholders to facilitate earning carbon credits for farmers by linking them to international carbon markets.
- ✓ Convergence needs to be developed for promoting capital-intensive CSA interventions such as shade net houses. Stakeholders like WOTR being NGO may make convergence with PoCRA and NHM for funding shade net houses to promote in their adopted villages.
- ✓ Solar pump is becoming a major energy smart CSA intervention, particularly in minimising CO_2, yet there was less priority among stakeholders in the promotion of solar pumps. Hence, prioritisation of extension efforts towards the promotion of solar pumps will be an additional boost to farmers to adaptation and mitigation.
- ✓ Along with a focus on technological interventions, concerted efforts have to be made to improve entrepreneurship, which will facilitate the likely enhancement in continued sustainability of the CSA interventions in dryland agriculture, even after the withdrawal of projects.

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ANNEXURE- I

Districts covered under PoCRA in Maharashtra state

S.No.	Districts	Region
1.	Aurangabad	**Marathwada**
2.	Beed	
3.	Hingoli	
4.	Jalna	
5.	Latur	
6.	Nanded	
7.	Osmanabad	
8.	Parbhani	
9.	Akola	**Vidarbha**
10.	Amravati	
11.	Buldana	
12.	Yavatmal	
13.	Washim	
14.	Wardh	
15.	Jalgaon	**Nashik**

ANNEXURE -II

Farm holding category in the selected villages of the study

N=60

S.No.	Particulars	Farmers category							
		Marginal (<2.5 acres)		Small (2.51-5 acres)		Medium (5.01-10 acres)		Large (>10 acres)	
		No	%	No	%	No	%	No	%
1.	Tapovan and Tupewadi villages (PoCRA adopted villages)	14	**70**	05	**25**	00	**00**	01	**05**
2.	Kotha Jagangir (WOTR project village)	09	**45**	07	**35**	04	**20**	00	**00**
3.	Kadwanchi (KVK adopted village)	03	**15**	04	**20**	06	**30**	07	**35**
	Total	26	**43.33**	16	**26.67**	10	**16.67**	08	**13.33**

ANNEXURE -III

Profile of selected villages (In acre)

S.No.	Villages	Tupewadi and Tapovan	Kadwanchi	Kotha Jahangir
1.	Total cultivable areas (in acre)	6628.12	3433.72	1627.5
2.	Cropping Intensity (BI/AI)	132.47/134.11	NA	79.87/111.21
3.	No of farmers	1814 (1450 and 364)	NA	290

BI-Before Intervention and AI – After Intervention

ANNEXURE -IV

Gross cropped area under different crops in the selected villages (In acre)

S.No.	Name of crops	Tupewadi and Tapovan		Kadwanchi		Kotha Jahangir	
		Before PoCRA intervention	After PoCRA interventions	Before IGWDP intervention	After IGWDP intervention	Before WOTR intervention	After WOTR intervention
I	**Field crops**						
	Cotton	4549.74	3979.17	492.65	-	700.00	300.00
	Wheat	350.74	498.94	68.41	-	-	90.00
	Maize	125.97	98.8	-	-	400.00	70
	Sorghum	1741.35	1496.82	923.65	NA	70.00	70.00
	Pearl millet	-	-	1300.23	-		
	Redgram	NA	370.5	NA	NA	30.00	30.00
	Greengram	NA	NA	316.92	NA	25.00	25.00
	Blackgram	177.84	192.66	03.45	NA	-	-
	Soybean	711.36	1015.17	NA	NA	25.00	600.00
	Bengal Gram	728.65	634.79	11.85	NA	1300.00	1810.00
	Total field crops	**8385.65**	**8286.85**	**3117.16**		**2550.00**	**2995.00**
	Vegetables						
	Chillies	71.63	177.84	**	**	50	350
	Tomato	39.52	51.87	**	**	0	5
	Brinjal	66.69	101.27	**	**	-	-
	Bhendi	17.29	00.00	**	**	-	-
	Capsicum	4.94	69.16	**	**	-	-
	Bitter Gourd	24.70	108.68	**	**	-	-
	Ridge Gourd	32.11	91.39	**	**	-	-
II.	**Total Vegetables**	**256.88**	**600.21**	**140.79**	**259.35**	**50**	**355**
	Grape	-	-	7.41	1185.6	-	-
	Pomegranate	-	-	-	49.4	-	-
	Ginger	-	-	4.94	29.64	-	-
III.	**Oil Crops**						
	Groundnut	138.32	-	-	-	-	-

	Total oil crops	**138.32**	-	-	-	-	-
IV.	Floriculture						
	Gerbera	-	02.00				
	Total floriculture		**02.00**				
	Total Gross Cropped area	**8780.85**	**8889.06**		**1523.99**	**2600.00**	**3350.00**

The area before interventions refers to the gross cropped area of different crops in the particular village a year before interventions and after interventions refer to the gross cropped area of different crops in the particular villages during 2020-21

** Individual crop data is not available

- refers to the crop not cultivated in the chosen village

ANNEXURE - V

Percentage share of investment to the total budget on CSA utilised by stakeholders

S.No.	**Particulars**	**DoA (PoCRA)**		**KVK (IGWDP)**		**WOTR**	
		Rs. in crores	%	Rs. in crores No	%	Rs. in crores	%
1.	Water and soil smart	1592.08	**61.35**	0.53	**50.33**	NA	NA
2.	Agronomic smart	243.87	**09.40**	0.36	**33.91**	NA	NA
3.	Allied sector smart	55.94	**02.15**	0.12	**11.35**	NA	NA
4.	Infrastructure smart	286.01	**11.02**	0.00	**-**	NA	NA
5.	Institutional smart	413.48	**15.94**	0.00	**-**	NA	NA
6.	Extension smart	3.51	**0.14**	0.04	**4.39**	NA	NA
	Total	2594.89	**100**	1.05	**4.43**	NA	NA

ANNEXURE – VI

Average yield of major crops of the sample farmers

S. No.	Particulars	Yield of Major crops (MT per acre)																	
		Soybean		Cotton		Grapes		Sorghum		Chillie		Horse gram		Redgram		Bengal gram		Wheat	
		BI	AF	BI	AF	BI	AF	BI	AF	BI	AF	BI	AF	BI	AF	BI	AF	BI	AF
1.	Tapovan and Tupewadi villages (PoCRA adopted villages)	0.60	0.83	0.61	0.81	-	-	0.57	0.85	-	-	-	-	-	-	-	-	-	-
2.	Kotha Jagangir (WOTR project village)	0.67	1.1	0.68	0.86	-	-	0.8	1.0	5.92	9.07	0.53	0.8	-	-	0.4	0.7	0.69	1.01
3.	Kadwanchi (KVK adopted village)	0.54	0.80	0.4	0.7	8.33	13.84	0.68	1.08	-	-	-	-	0.44	0.86	-	-	0.4	0.75

BI-Before CSA Interventions; **AI-**After CSA interventions