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THE WORLD BANK

Impact Assessment Report

Project on Climate Resilient Agriculture (PoCRA)

Nanaji Deshmukh Krishi Sanjivani Prakalp

(Project of Government of Maharashtra in Partnership with the World Bank)

Submitted By

SAMBODHI teri NABCONS

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Key Abbreviations

AAP	Annual Action Plans
ATMA	Agriculture Technology Management Agency
BBF	Broad Bed Furrow
BEAMS	Budget Estimation, Allocation, and Monitoring System
CA	Cluster Assistant
CCT	Continuous Contour Trench
CHC	Custom Hiring Centre
CIC	Climate Innovation Centre
CNB	Cement Nala Bund
CRAT	Climate Resilient Agriculture Technology
CRIDA	Central Research Institute for Dryland Agriculture
CSAP	Climate Smart Agronomic Practices
DBT	Direct Beneficiary Transfer
DoA	Department of Agriculture
DPIU	District Project Implementation Unit
DSAO	District Superintending Agriculture Officer
FFS	Farmer Field School
FGD	Focus Group Discussion
FIG	Farmer Interest Group
FPO/FPC	Farmer Producer Organization/ Farmer Producer Company
GHG	Green House Gas
GIS	Geographic Information System
GKVS	Gram Krishi Vikas Samiti
GoI	Government of India
GoM	Government of Maharashtra
Ha	Hectares
HH	Household
ICAR	Indian Council of Agricultural Research
IDI	In-Depth Interview
INM	Integrated Nutrient Management
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
IRR	Internal Rate of Return
MDI	Minimum Detectable Impact
MIS	Management Information System
MSP	Minimum Support Price
NBSS-LUP	National Bureau of Soil Survey – Land Use Planning
NDKSP	Nanaji Deshmukh Krishi Sanjeevani Prakalp

NIPHT	National Institute of Post Harvest Technology
NPV	Net Present Value
NRM	Natural Resource Management
PAD	Project Appraisal Document
PDO	Project Development Objective
PMU	Project Management Unit
PoCRA	Project on Climate Resilient Agriculture
PSC	Project Steering Committee
RFID	Results Framework Indicators
SDAO	Sub-divisional Agriculture Officer
SHG	Self Help Group
SMART	State of Maharashtra Agribusiness and Rural Transformation
TAO	Taluka Agriculture Officer
TCM	Thousand Cubic Meters
VCRMC	Village Climate Resilient Management Committee

Acknowledgement

An analysis of the impact of climate change on agriculture in India presents us with a concerning challenge regarding the food security of more than a billion people. Global climatic changes, through increasing temperatures, varying rainfall, and changing land use among others, will affect agriculture through their direct and indirect effects on crops, soils, livestock, and pests.

The Government of Maharashtra (GoM) acknowledging these challenges and in vision with the Union Government's National Action Plan on Climate Change (NAPCC), pioneered the Maharashtra State Adaptation Action Plan on Climate Change (MSAAPCC) and sought to address the urgent need to integrate climate change concerns into the State's overall development strategy, aiming at building long term climate resilience and enabling adaptation to risks emanating from climate change.

In pursuit of the above objective, Sambodhi Research and Communications (P) Ltd., in association with The Energy and Resource Institute (TERI), and NABARD Consultancy Services (P) Ltd. (Nabcons) is thankful to the Project Management Unit (PMU), Project on Climate Resilient Agriculture (PoCRA) for awarding the assignment of "Monitoring & Evaluation (M & E) for Project on Climate Resilient Agriculture (PoCRA)" in the eight districts of the Marathwada area and seven districts of the Rest of Project Area (RoPA) of Maharashtra, respectively.

We would like to thank the Project Director and all the subject matter specialists from PMU for providing their guidance and continuous support to the M & E team for the successful execution of this assignment. Further, the project officials at the district and the sub-divisional level have been very supportive and helpful in the successful completion of the Impact Assessment of this project.

We would also like to acknowledge the support received from PoCRA's ground-level project staff comprising Agriculture Assistants, Agriculture Supervisors, Cluster Assistants, Technical Coordinators, Farmer Field School (FFS) Facilitators, Krishi Tais, Taluka Agriculture Officer (TAO), along with the Village Climate Resilience Management Committee (VCRMC) members.

We would also like to thank all the respondents and their families for agreeing to participate in the survey for the endline evaluation, patiently responding to the questions, and sharing their experiences. We are also thankful to members of project-supported Farmer Producer Companies (FPCs) and Self-Help Groups (SHGs) for their support in providing information on agri-business activities.

Executive Summary

Context

India continues to be the world's fastest growing large economy with its real Gross Domestic Product (GDP) rising from 5.5 percent in 2012-13 to 7.2 percent in 2022-23[1]. Maharashtra has the highest state GDP contributing nearly 14 percent to India's GDP (NITI Aayog)[2]. The agriculture sector in Maharashtra grew at 3.5 percent in 2022-23[3] contributes nearly 13 percent to the State's Gross Value Added (GVA) and employs nearly 50 percent of the State's working population[4]. However, it is characterized by small holder farmers who are dependent on rainfall for the cultivation of crops. This is coupled with climate change stresses like droughts, floods, delayed rains, etc. which have impacted their socio-economic well-being. Therefore, to develop climate-resilient agriculture, the Government of Maharashtra (GoM) was provided with loan assistance from the World Bank for the Nanaji Deshmukh Krishi Sanjeevani Prakalp (NDKSP), henceforth called the Project on Climate Resilient Agriculture (PoCRA) in 2018-19 to promote strategies for climate adaptation, mitigation and generate climate co-benefits for these smallholder farmers. PoCRA aimed to scale-up climate-smart technologies and practices at farm and (micro) watershed levels, that will contribute to drought-proofing and management of lands in the most drought and salinity/ sodicity-affected villages in the State.

About the Project

PoCRA has brought transformational changes in the agriculture sector by scaling up climate-smart technologies and practices at the farm and (micro) watershed levels, thus contributing to drought-proofing and management of lands in the State's most drought and salinity-affected villages. The project focuses on small landholders, especially those from vulnerable populations including female farmers whose livelihood is impacted by changing climate conditions and climatic uncertainties. The project has been implemented in 670 mini watershed clusters covering 5220 villages in 16 districts of Maharashtra, which include eight districts of Marathwada (Chatrapati Sambhaji Nagar, Nanded, Latur, Parbhani, Jalna, Beed, Hingoli, Dharashiv), six districts of Vidarbha (Akola, Amravati, Buldana, Yavatmal, Washim, Wardha), Jalgaon and Nashik district[5] of Nashik Division and approximately 932 salinity affected villages in the basin of Purna river spread across Akola, Amaravati, Buldana, and Jalgaon districts[6]. With the total project cost of Rs. 4696.35 Cr. the project development objectives were operationalized through four key components as follows:

Component A – Promoting climate-resilient agricultural systems

To enhance small-scale farmers' ability to adapt and alter their agricultural practices to mitigate the potential effects of climate change, this component constitutes nearly 83.29 percent of the total project cost.

Component A.1: Participatory development of mini watershed plans

For cluster development and investment plans, a total of 138 cluster development plans and 5043 Village Development Plans (VDPs) have been approved and implemented taking into consideration the social context and people's participation. The participatory village-level microplanning process is coordinated by 3959 fully functional Village Climate Resilience Management Committee (VCRMC).

Component A.2: On-farm climate-resilient technologies and agronomic practices

The project transferred matching grants for the on-farm technologies through the dedicated Direct Benefit Transfer (DBT) to around 485669 farmers. For extension, the project also conducted 37184 Farmer Field School (FFS) which is participatory and with interactive on-site learning approaches. The

[1] *Provisional estimates of national income 2022-23, NSS, MoSPI, Government of India (https://mospi.gov.in/sites/default/files/press_release/PressNoteQ4_FY2022-23_31may23.pdf)*
[2] *Arth NITI (https://niti.gov.in/sites/default/files/2023-03/ArthNITI_October_latest_09Nov2021.pdf)*
[3] *Economic Survey of Maharashtra 2022-23 (http://mls.org.in/PDF2023/BUDGET/ESM_2022_23_Eng_Book.pdf)*
[4] *District Strategic Plan, Planning department, GoM (https://mahasdb.maharashtra.gov.in/DSP/agriAllied)*
[5] *https://niti.gov.in/sites/default/files/2023-03/ArthNITI_October_latest_09Nov2021.pdf*
[6] *District Strategic Plan, Planning department, GoM (https://mahasdb.maharashtra.gov.in/DSP/agriAllied)*

interventions that were taken up by 485669 beneficiaries included (i) the development of micro-irrigation systems and construction of farm ponds for enhanced water-use efficiency, (ii) the adoption of climate resilient (drought and salinity tolerant) crop varieties, (iii) crop diversification (increased production of higher value horticulture products), and (iv) agronomic practices that improve soil health (increased organic soil content, reduced salinity, and sodicity, integrated nutrient management) and/or in-situ water conservation, and mitigate GHG emissions through carbon sequestration by, (i) planting trees in upper catchment areas and on contour lines (afforestation), (ii) growing fruit trees on small orchards, (iii) incorporating crop residues (biomass) into the soil, and (iv) adopting practices for conservation agriculture.

Component A.3: Climate-resilient development of catchment areas

The project implemented water security interventions like compartments and graded bunding on 59387 ha of land to hold around 26658 TCM of water in catchment areas. The project also complemented this by constructing 1884 water conservation works like cement nala bund and rejuvenation of old structures which helped in storing 6209 TCM of water. Additionally, the project was successful in generating a water storage capacity of around 30375 TCM through individual and community farm ponds across the project districts.

Component B – Post-harvest management and value chain promotion

With around 11.77 percent of the total project cost (Rs. 501.71 Cr), this intervention supported a total of 4701 agri-business proposals of 1698 Famer Producer Companies (FPCs), 1799 Farmer Interest Groups (FIGs) and 1204 Self Help Groups (SHGs). With the technical and financial support for business development and expansion, the project strengthened the supply and value chain of climate-resilient agricultural commodities while enhancing the capacity of various stakeholders involved. Agribusiness interventions also led to the reduction in wastage, nearby access to buyers for farmers, and processing facilities which helped farmers rise in the value chain.

Component B.1: Promoting Farmer Producer Organisations (FPOs)

The project has successfully implemented agri-business proposals to establish a climate-resilient agri-food system resulting in 218 farmer-producer companies reporting growth in annual profit. This has also enhanced the primary processing tasks for climate-resilient goods supported by the project while using eco-friendly technologies.

Component B.2: Strengthening emerging value-chains for climate-resilient commodities

With 2779 Custom Hiring Centres (CHCs), the project focuses on pre-and post-harvest farm activities by encouraging the use of fuel-efficient (less energy consuming) and technology-efficient (loss and time-reducing) farm machinery and equipment leading to reduced drudgery and labour cost. FPOs could cope with the climate and market variabilities by use of green technologies in the form of storage which was achieved through 960 godowns, processing capacities through 417 units, and 545 other agri-business activities implemented by the project.

Component B.3: Improving the performance of the supply chain for climate-resilient seeds

The farmers were encouraged through the project in the seed production program of climate-resilient varieties. Around 24205 farmers have successfully taken up seed production programs on nearly 58510 ha of cultivable land in the project area. This exercise led to the production of 50000 MT of certified seeds during the project period. This has improved the supply of climate-resilient seed varieties in the project and nearby regions.

Component C – Institutional development, knowledge, and policies for climate-resilient agriculture

PoCRA has successfully established VCRMC, an institution within the existing governance structure at the village level, nominated a female mobilizer known as “Krishi Tai” in every village, and developed a body of knowledge for comprehensive analysis and advanced climate, water, and crop modeling. The project has achieved this with just about 0.56 percent of the total project cost. The project invested in training and capacity building developed Strategic Research and Extension Plans (SREPs) and functioned as a mini-CIC.

Component C.1: Sustainability and institutional capacity development

Throughout the project timeline, nearly 76966 capacity-building events like training, webinars, and workshops were conducted for project beneficiaries. This has benefitted and strengthened nearly 1488567 project stakeholders including 72 percent male and 28 percent female participants. The project has developed the capacity of around 50000 VCRMC members and Krishi Tais on roles, skills, conservation, planning, inclusion, and technology. Apart from this, specialized training on protected cultivation benefiting more than 6000 farmers was conducted by the project. The project also conducted a total of 205 exposure visits on regenerative farming for 4218 farmers. The 15 SREPs, prepared in collaboration with the Project Director of the Agricultural Technology Management Agency (ATMA) and Krishi Vigyan Kendras (KVKs) incorporating scientific consultation with various project stakeholders from the district, have acted as a guide for the climate-resilient agriculture extension workers.

Component C.2: Maharashtra Climate Innovation Centre (CIC)

Over six years, the project has (i) used a large number of Application Programming Interfaces (APIs) from various agriculture and weather stakeholders, (ii) collaborated with institutions like the Indian Council of Agricultural Research (ICAR) agencies, State Agriculture Universities (SAUs), Indian Institute of Technology (IIT) Bombay, Groundwater Survey and Development Agency (GSDA), Yashada and Vanamati and (iii) developed various Information Technology (IT) based digital Apps including DBT, FFS, water budget etc., and services to streamline the implementation process. Given this backdrop, PoCRA can be visualized as a mini–CIC to engage public and private sector capacities to scale technologies for a climate-resilient agri-food system in Maharashtra.

Component C.3: Knowledge and Policies

The project activities have generated and disseminated cutting-edge knowledge on climate-resilient technologies, thus improving the policy and strategy framework required to further enhance resilience and sustenance in the agri-food system in Maharashtra. The consortia approach of the project helped develop robust partnerships with knowledge-based institutions in various fields such as water budgeting crop Kc values, soil parameter assessment, and many more.

Component D – Project management

The Project Management Unit (PMU) set up by the Department of Agriculture of the Government of Maharashtra has successfully ensured the efficient and effective overall management of the project throughout the timeline over the designated region. It has functioned on the back of a digital backbone which has helped it to bring efficiency and saving in management costs. The project's focus on collaboration and digitalization led to substantial financial efficiencies which helped keep the management cost as low as less than five percent of the project costs.

PoCRA – Final Evaluation

PoCRA was implemented between 2018 to 2024 in Maharashtra. This included about two years of the Covid-19 pandemic period. The report presents the evaluation of the Results Framework Indicators (RFID) targets, assesses the outputs and outcomes, and suggests a way forward to ensure the sustainability of the processes that were implemented as part of PoCRA over the said period. The final impacts are calculated by comparing the endline estimates with the baseline results while ensuring consistency and accuracy in data analysis. The comparison between the data of the project and control villages has also helped in identifying the determinants that have enabled or hindered the achievement of these targets and provides learnings for future initiatives aimed at enhancing climate resilience and agricultural productivity in Maharashtra. For assessment of the endline evaluation, data from a total of 7940 households (i.e., five each in the 898 project villages and 690 in the control villages) were collected and analyzed. The overarching framework adopted by the World Bank Group Evaluation Principles (2019)[7] noted in the OECD DAC Network on Development Evaluation (EvalNet) criteria defined as relevance, coherence, effectiveness, efficiency, impact, and sustainability.

7 https://ieg.worldbankgroup.org/sites/default/files/Data/reports/WorldBankEvaluationPrinciples.pdf

Digital approach

A robust Information and Communications Technology (ICT) system was at the heart of the climate-resilient strategy of the project. The project ushered in a remarkable revolution by training beneficiaries in an easy-to-use mobile app-based beneficiary system. The DBT system was exceptional as it promoted faceless contact and was an automatic Right-To-Information (RTI) approach enabled by removing the uncertainty in the minds of the beneficiaries regarding their proposal. PoCRA employed an innovative ICT system, including cloud, mobile, and Geographic Information System (GIS) technologies, facilitated by an in-house innovation lab. The ICT component reduced the efforts of project beneficiaries in accessing the project benefits. This system also delivered monetary and advisory services throughout the project tenure which includes the pandemic period as well, enhancing outreach and mainstreaming digital technologies in government programs. The DBT system, relied on an Aadhaar-enabled Payment System (AePS), and end-to-end digitization to ensure the practical abolition of physical files while streamlining the process to ensure transparency and efficiency. The project's success led to the establishment of the Maha DBT portal by the Agriculture Department. Real-time monitoring and proactive data disclosure ensured data integrity and timely corrective actions, improving overall project performance.

Efficient planning and social mobilization

The project has been successful in leveraging people-centric decentralized decision-making within existing Panchayati-Raj structures. Through 3959 Village Climate Resilient Agriculture Management Committees in 5220 villages, engaging around 50000 members, the project empowered communities to democratically identify beneficiaries, plan natural resource management, disseminate resilient techniques, and resolve disputes. The auto prioritization tool of social categories and first-in-first-out systems were an interesting mix of technology and social dimensions to deliver social justice.

Better dissemination of climate-resilient technologies

- **Farmer field schools:** The traditional extension system in agriculture is not without challenges. The project responded to this by creating an innovative structure of “barefoot” facilitators, trained in extension work, to focus on a massive extension outreach. FFS promoted under the project is a participatory and interactive on-site learning approach that emphasizes observation-based learning. The FFS focused on the transfer of Climate Resilient Agriculture Technologies (CRATs) through a total of 37184 schools and more than 2 lakh sessions that were conducted in 4800 villages. The number of host and guest farmers who participated in FFS is 15501 and 490780 respectively. The gender component of FFS was visible in the fact that 15 percent (2327) of the total host farmers and 14 percent (67644) of the total guest farmers trained were women.

- **Use of agro-advisory:** PoCRA is at the forefront of providing necessary information to farmers which helps them in efficient crop management. To improve their overall farm productivity, the project has provided specific advisory related to crops, weather, soil health, and local irrigation requirements apart from generic advisory which enhances the knowledge of farmers related to crops and their requirements. The project harnessed the power of digitization to unleash the use of agro-advisory by as many farmers as possible. On average, 60 percent of farmers are following the agro-advisory services delivered through various social media outreach platforms. The advisories are given in the context of climate vagaries, IPM, INM, and markets. It is observed that the popularity and usage of climate-friendly pesticides like neem extract, dashaparni, etc. are rising. Information about bird perches, pheromone traps, odor traps, etc. is disseminated and most farmers in the project region are found to be adopting climate-friendly pest management practices.

- **Integrated nutrient management practices:** PoCRA emphasizes good agronomic practices to improve soil fertility, and soil nutrient management, and promote soil carbon sequestration through compost units, treatment of saline and sodic soils, and broad bed furrow techniques. PoCRA facilitated an increase in the uptake of soil treatment measures at the end line, with 98 percent of the beneficiaries providing an affirmative response compared to a mere 2 percent at the baseline. It was observed that farmers are practicing integrated nutrient management including biofertilizers along with augmentation of pulse areas for nitrogen fixation for nutrient recycling to arrest nutrient loss, and reduce emission which is an example of adaptation with mitigation co-benefits.

- **Integrated pest management practices:** Integrated pest management guidelines of the project refer to a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks. One of the key areas of improvement is pest management. Specifically, 40 percent of farmers in the project group reported using these sustainable practices, compared to only 34 percent in the control group. This shift towards more eco-friendly pest management methods indicates a growing awareness and implementation of sustainable agriculture practices among project participants.

Increased implementation of climate-resilient technologies

- **Micro irrigation systems:** PoCRA assisted farmers in encouraging the uptake of drip and sprinkler irrigation systems to increase water saving and higher yield. This will ensure precise water application, reducing water wastage and increasing efficiency. PoCRA has 431328 beneficiaries of the micro-irrigation system. Based on the endline survey, out of the total sample of 1159 project farmers who adopted drip irrigation, 83 percent reported a reduction in water consumption and wastage. On the other hand, out of the 837 control farmers who adopted drip irrigation, 73 percent reported a reduction in water consumption and wastage. Farmers experienced 60-70 percent energy savings in comparison to traditional flood and furrow systems.

- **Protected irrigation:** Protective irrigation through PoCRA supported enhancing water security and agricultural resilience through the construction and rehabilitation of farm ponds. The farm ponds helped in the collection of excess runoff during rainy periods. The stored water has been used for supplemental irrigation to crops. The technology has been extremely useful as it makes water available for both humans and livestock during drought situations and helps conserve soil and moisture. The PoCRA project has facilitated the creation of 11120[8] new farm ponds thereby increasing surface water storage capacity 30375 TCM in the project region.

- **Protected cultivation:** Protected cultivation under the PoCRA leverages advanced agricultural technologies such as shade nets, polyhouses, and to create controlled environments that address microclimate variability. The project has implemented this activity on 1658.3 ha with a total assistance of Rs. 651.44 Cr to the farmers. The technology helped achieve optimum moisture, temperature, and humidity (controlled conditions) with a very low incidence of diseases and pests resulting in assured and high crop productivity of high-value crops in vegetables, flower production, and vegetable seed production. Farmers are using the technology for growing ornamental and high-value cash crops.

- **Plantation:** The project also emphasizes carbon sequestration by promoting horticulture and agroforestry plantations. This approach not only enhances agricultural productivity but also contributes to environmental sustainability. The project has supported the horticulture plantation on 29270 ha and agroforestry activity on 613 ha of land in project areas.

- **Integrated farming system:** Sericulture and livestock rearing have been promoted under PoCRA to help marginal and landless farmers develop resilience by diversifying their incomes. Silk production (or sericulture) represents a rare end-to-end sustainable industry with minimal ecological impact when care is taken with supply chain management. The project has promoted sericulture as a resilient practice through individual entrepreneurship under dryland conditions, which has generated an impressive response through 12361 applications from villages. The project has planned end-to-end handholding support to individual beneficiaries - from nursery raising to cocoon marketing – for all approved proposals. Activities like backyard poultry, rearing of small ruminants, apiculture, inland fishery, and sericulture have been highly useful to marginal as well as landless farmers helping them to increase and diversify their income. The adaptation strategy has enhanced the livelihood resilience among the 5391 beneficiaries of small ruminants, 2153 beneficiaries of inland fisheries, 362 beneficiaries of apiculture, and 234 beneficiaries of backyard poultry. Given that some of these beneficiaries were landless persons, it also serves as a testimony to the project's reach among the most vulnerable sections of society. The economic impact of these

[8] *Includes farm ponds built through project DBT portal, with inlet and outlet on e-class land and individual farm pond- MIS data*

measures is also visible, with more than 80 percent of project farmers who practiced integrated farming systems reporting an increase in income.

- **Good Agricultural Practices (GAPs) for improved management of saline and sodic soils:** Climate change affects soil salinity and sodicity. The project took a comprehensive view and attempted several initiatives as part of good agricultural practices to address the problem. Investment has been made in 932 villages in the areas like creation of farm ponds, micro-irrigation, seed treatment, adoption of intercropping, vermicomposting, growing legumes, mulching, etc.

Improved agricultural practices

- **High water use efficiency:** The key project impacts include improved water use efficiency due to an increase in number of farmers adopting improved irrigation practices. The number of farmers leveraging drip irrigation was reported as 15 percent and 16 percent among project and control farmers respectively during baseline, which increased to 25 percent for project farmers and 19 percent for control farmers during the endline. Similarly, the average use of sprinkler irrigation was reported by 14 percent of farmers at the time of baseline by both project and control farmers, which has now significantly increased to 31 percent among the project and 27 percent in control farmers thus highlighting the impact of the project in bringing more area under irrigation.

- **Crop productivity:** There has also been a secular increase in productivity in both project and control farmers as compared to baseline with project farmer yields being higher than control farmers. Further, the increase in productivity in project farmers for key crops is greater than control farmers. Project farmers growing soybean saw a 26 percent increase in productivity over baseline while control farmers reported only a 14 percent increase in Soybean productivity. Similarly, project farmers growing cotton reported an 84 percent increase in productivity over baseline while control farmers reported a 57 percent increase in cotton productivity. Additionally, there has been a remarkable improvement in the cropping intensity in the project areas as it is reported at 158 percent (as compared to 132 percent during baseline), and that in the control area is 144 percent (as compared to 137 percent during baseline).

- **Intercropping:** Intercropping system promotes the full use of cropland water by plant roots. It increases the water storage in the root zone, reduces the inter-row evaporation, and controls excessive transpiration. This creates a special microclimate advantageous to plant growth and development leading to an increase in the crop yield per unit area. This technology has reduced the likelihood of total crop failure due to adverse weather and has given diversification benefits (biological and financial) to the farmers in project areas.

- **Reduced cost of cultivation:** The project has also contributed to a reduction in the cost of cultivation for key kharif and rabi crops. Data shows that the gross farm cost for households in the control group is 10 percent higher than that of households involved in the project. This reduction in cultivation costs can be attributed to improved farming techniques and resource management promoted by the PoCRA project. Consequently, farmers in the project area can achieve better economic efficiency, enhancing their overall financial stability.

- **Contour cultivation:** The cultivation and interculture operations along the contours reduce soil loss, nutrient loss, weed infestation and enhance yields, and save time. With a more than 18 percent adoption rate, it was observed that there is a reduction in soil erosion in slopy land during heavy rains. With the reduction in fertilizer loss, farmers have experienced the adaptation benefit through an increase in crop yield in project areas including those affected by saline soils.

- **Land preparation and furrow opening:** With an adoption rate of more than 22 percent, furrow opening along gentle slopes for runoff management has accrued adaption benefits like ease in irrigation, drainage of excess water, maintenance of root zone soil moisture in prolonged dry spells resulting into higher crop productivity and assured crop production.

- **Broad Bed Furrow (BBF):** It is a good soil moisture management strategy It was observed that farmers have experienced in-situ moisture conservation during prolonged dry spells due to low rainfall and with effective drainage during high-intensity rainfall events resulting in 20-25 percent increase in crop yields as compared to flatbed sowing. 23 percent of farmers in the project are found to be adopting BBF.

- **Conservation tillage:** The project has promoted conservation agriculture practices focusing on Zero tillage cultivation techniques through farmer field schools. It was observed that zero/ minimum tillage with crop residue management helped in the effective conservation of soil moisture with effective energy management thereby reducing the cost of cultivation in light soil.

Better development of catchment areas

The project jurisdiction was in areas where climate volatility has been on display, especially in the past decade. Water security interventions have been, therefore, an important focus. The project created a large number of water conservation works (4315), leading to the creation of 32866 TCM surface water storage. Increasing water use efficiency is of utmost importance when water availability is at a premium. The project's focus on micro-irrigation as a means of increasing water-use efficiency was achieved through the creation of micro-irrigation over an area of 488747 ha area. This helped reduce costs, conserve soil, and increase productivity.

Innovative agribusiness interventions

Under PoCRA, various components are undertaken to strengthen agribusiness. This includes capacity development of Farmer Producer Organizations (FPOs), focusing on levers of FPO income and growth such as access to credit, sustainable agriculture practices, and infrastructure provision. There is also a focus on empowering women farmers by deepening their engagement across the agri-value chain and FPOs.

The project has established several Custom Hiring Centres (CHCs) to promote farm mechanization. CHCs make costly machines like tractors, trailers, combine harvesters, threshers, and disc ploughs available to small and marginal farmers at nominal rental sums. It is evident that by accessing CHCs, the farmers can reduce nearly 6 percent of the cost of renting farm machinery in the project villages and about 29 percent in the control villages. Apart from reduced hiring cost of farm machinery at CHC, the data shows that (i) 62 percent of the CHC users expressed a reduction in drudgery, (ii) 85 percent of them saved on labour costs, and (iii) 81 percent of them saved time on the critical farm operations.

The cumulative annual storage capacity assuming 60 percent of utilization rate by all supported FPOs for multiple usages throughout the year shows its effectiveness in managing and storing agricultural produce efficiently. Through the storage interventions, the project has strengthened these FPOs to handle different agricultural commodities effectively. The data implies that improving the storage facilities has effectively reduced wastage in the project area.

Also, through project support a substantial number of FPCs have created a robust seed infrastructure turning them into trusted suppliers of authentic and viable seeds of preferred varieties in the project area. These FPOs have been channelized for production, certification, distribution, registration, licensing, and accreditation by the project. With a substantial processing capacity created under the project, the farmers were able to value-add their produce resulting in reduced transportation costs and better bargaining power. It further helps farmers and FPOs to strengthen their value chains. Apart from the above the project interventions through other agribusiness activities like essential oil extraction units, neem oil extraction units, cattle feed units, sericulture units, vermicompost units, goat breeding units, and refrigerated/carrier vehicles have diversified the agribusiness scenario.

Positive effects

- **Increased farm incomes:** Farm incomes have shown considerable growth, with net farm income in project households being 46 percent higher than in control households. This substantial increase in income is a direct result of the improved agricultural practices and support mechanisms introduced by the project.

- **More inclusive uptake across social categories:** The survey reveals that farmers from all social categories including Scheduled Castes (SC), Scheduled Tribes (ST), Other Backward Castes (OBC), and Nomadic Tribes (NT) have accessed knowledge different different CRATs through FFS under PoCRA. Further, during the expert's visit, it was observed that indirect benefits in terms of improved water availability and agricultural productivity have been received by the pastoral community due to PoCRA intervention.

- **Increased resilience project beneficiaries:** Through expert's interaction with beneficiary farmers, it is observed that PoCRA has been successful in reducing yield variability, stabilizing income, generating employment opportunities for youth, and reducing seasonal migration to a certain extent, thereby improving the coping mechanism of vulnerable farmers resulting in increased resilience in project villages.

- **Increased GHG emission reduction:** The project though significantly focused on adaptation, also aimed at contributing to emission reduction through various management practices, with the introduction of horticulture crops, solar energy, and energy efficiency measures to create mitigation co-benefits. From the production side, the net GHG emission reduction in the project is from -233 to -3228 (in 000' tCO2eq/year).

Compliance with environment and social safeguards

- **Environment safeguards:** The project has focused on ensuring environmental safeguards compliance at the village level. The FFS dissemination of knowledge and practices on climate-resilient technologies and the application of pesticides (according to the integrated pest management plan) for various stages of crop growth has led to higher adoption of these technologies across the project region. More than 3566 environment safeguard-related trainings have been organized to generate awareness among 87110 farmers. These farmers are aware of integrated pest management practices for better crop production management. The project has also disseminated a climate-resilient agricultural technology handbook, and social media posters/ banners to create awareness among farmers.

- **Social safeguards:** The social management framework (SMF) of PoCRA was implemented in the project area. During implementation, social safeguard has been ensured by inbuilt inclusiveness criteria for prioritization of direct beneficiaries such as SC, ST, women, and physically challenged across small and marginal farmers. During microplanning in 5043 villages, SMF training has been imparted to ensure compliance with social safeguards in VDPs. The VCRMC executive committee consisted of 37556 marginalized farmers (80 percent) having below 1 ha. Land. This is evident from the fact that nearly 26 percent of project beneficiaries are women farmers who were provided with agricultural assets or services through the project. Additionally, around 5625 landless beneficiaries were supported with livelihood activities like backyard poultry, goat rearing, etc.

Economic and financial analysis

The Economic and Financial Analysis (EFA) compared the cost invested in the project and the financial implications of the interventions undertaken during the project implementation. EFA of the PoCRA analyzes activity-wise distribution of the resources and the economic impact generated by these activities. With the cost-benefit analysis approach, the analysis was based on a monetary valuation of the project's costs and benefits, focusing on the targeted crops and using 'with project' and 'without project' comparative variations. In a 'with project' scenario, smallholders increased production of their principal food crops by improving yields and access to markets. The calculations were done with a 15-year investment horizon, assuming that the financial benefit streams were transformed into economic values by adjusting for distortions and eliminating taxes, tariffs, transfers, and subsidies by a factor of 0.9. The project has obtained an Economic Internal Rate of Return (EIRR) of 45 percent as against 23 percent during the appraisal phase with a corresponding NPV of USD 4789 million as against the appraisal figures of USD 461 million. The updated Net Present Value (NPV) is estimated at USD 3995 Mn, at a 6 percent discount rate as per World Bank guidelines compared to USD 415 Mn at appraisal where a 6 percent discount rate was used. It is observed that the NPV becomes USD 1685 Mn when a discount rate of 10 percent is used for analysis. Hence, the sensitivity analysis indicates positive resilience to projected outcomes.

1. Introduction

1.1 Context

India continues to be the world's fastest-growing large economy, with real Gross Domestic Product (GDP) rising from 5.5 percent in 2012-13 to 7.2 percent in 2022-23[9]. Maharashtra has the highest state gross domestic product and contributes nearly 14 percent to India's GDP (NITI Aayog[10]). However, climate change is impeding socio-economic development within India, necessitating increased investment in adaptation measures to reduce vulnerability and maintain economic growth. Given that the agriculture sector accounts for nearly 15 percent of the national GDP, its growth is essential for achieving the country's target Sustainable Development Goals (SDGs).

The number of operational holdings during the Agriculture Census 2015-16[11] in Maharashtra for the year 2010-11 was 1.37 Cr which grew to 1.53 Cr in 2015-16 showing an 11.6 percent increase. However, operational holdings are dominated by small landholders characterized by low crop productivity and a high dependence on rainfall. As per the agricultural census 2015- 16, nearly 15 percent of the landholding is owned by women in Maharashtra. Most of the agricultural production is rain-fed, with less than 20 percent of the arable land under irrigation. Crop production is dominated by food grains, i.e. cereals (mostly rice, sorghum or jowar, maize) and pulses (chickpea or gram, pigeon pea or tur). For oilseed crops, soybeans remain a popular commodity.

In the past two decades, there has been a rapid shift towards growing cash crops, notably cotton and sugar cane, and high-value horticulture crops, including fruits (mango, citrus, grapes, pomegranate) and vegetables (onion and tomato). Though crop productivity has increased over time, it has remained at relatively low levels owing to extreme climate events like droughts, hailstorms, floods, delays in the onset of monsoons, and higher rainfall intensity. This called for concerted efforts in the agriculture sector to focus on improving:

- water use efficiency in irrigation systems,
- crop diversification in the farm production system,
- adoption of resilient crop varieties, and
- post-harvest value addition activities.

The Maharashtra State Adaptation Action Plan on Climate Change (MSAAPCC), 2014 formulated by the Government of Maharashtra (GoM) integrates climate change concerns into the State's overall development strategy and assists in building long-term climate resilience to enable adaptation to the risks from extreme climatic conditions. The GoM, with support from the World Bank, initiated the Nanaji Deshmukh Krishi Sanjeevani Prakalp (NDKSP), also known as Project on Climate Resilient Agriculture (PoCRA) in 2018-19, to promote strategies for climate adaptation, mitigation, and generate climate co-benefits for farmers.

1.2 About the Project

PoCRA has brought transformational changes in the agriculture sector by scaling up climate-smart technologies and practices at the farm and (micro) watershed levels, that will contribute to drought-proofing and management of lands in the most drought and salinity-affected villages in the state. The project focuses on small landholders, especially those from vulnerable populations whose livelihood is impacted by changing climate conditions and climatic uncertainties.

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[9] *Provisional estimates of national income 2022-23, NSS, MoSPI, Government of India https://mospi.gov.in/sites/default/files/press_release/PressNoteQ4_FY2022-23_31may23.pdf*
[10] *Arth NITI (https://niti.gov.in/sites/default/files/2023-03/ArthNITI_October_latest_09Nov2021.pdf)*
[11] *https://agcensus.da.gov.in/document/agcen1516/ac_1516_report_final-220221.pdf*

The project has been implemented in 670 mini watershed clusters covering 5220 villages in 16 districts in Maharashtra, which include eight districts of the Marathwada region (viz. Chatrapati Sambhaji Nagar (henceforth CSN), Nanded, Latur, Parbhani, Jalna, Beed, Hingoli, Dharashiv[12]), six districts of the Vidarbha region (viz. Akola, Amravati, Buldhana, Yavatmal, Washim, Wardha), Jalgaon and Nashik[13] district of Nashik Division, and approximately 932 salinity affected villages in the basin of Purna river spread across Akola, Amaravati, Buldhana and Jalgaon districts[14]. Conclusively, the project is active in eight districts of the Marathwada area and seven districts of the Vidharbha region also called the Rest of Project Area (RoPA).

The selection of the villages is based on a rigorous multicriteria analysis and considers the climate change vulnerability approach endorsed by the Intergovernmental Panel on Climate Change (IPCC), in which climate vulnerability is defined as a function of exposure, sensitivity, and adaptive capacity. The project has successfully set up a Program Management Unit (PMU) in Mumbai and 15 District Project Implementation Units (DPIUs) in the project districts in the Marathwada and Vidharba regions. Since its inception, the World Bank has appraised the project implementation and progress through its missions[15] at regular intervals over the project duration.

The project aims to make significant contributions in three key impact areas: water security, soil health, and farm productivity with crop diversification. These interventions are strategically designed to address the unique agro-climatic conditions of the region, ensuring a comprehensive approach to sustainable agriculture and resource management.

1.3 Project Development Objectives (PDOs)

In line with the context, PoCRA's Project Development Objective (PDO) is to enhance the climate resilience and profitability of smallholder farming systems in select districts of Maharashtra. The project is built around a comprehensive, multi-sector approach that focuses specifically on building climate resilience in agricultural production systems through scaling up the adoption of climate-resilient technologies and practices.

PoCRA is built around a comprehensive, multi-sector approach that focuses on building resilience in agricultural production systems while generating the following interdependent triple-win solutions:

- **Enhanced water security at the farm level** through the adoption of technologies for more productive and efficient use of water for agriculture, the increase in water storage capacity (surface and sub-surface), and improvement in water distribution structures to address on-farm water availability and reduce the risks associated with intra- and inter-seasonal climate variability.

- **Improved soil health t**hrough the adoption of good agricultural practices to improve soil fertility, soil nutrient management, and promote soil carbon sequestration.

- **Increased farm productivity and crop diversification** by adopting climate-resilient seed varieties (short maturity, drought, and heat resistant, salt-tolerant) and market-oriented crops with a clear potential for income security derived from the integration of smallholder Farmer Producer Companies (FPCs) in emerging value chains.

[12] *Aurangabad and Osmanabad renamed as Chhatrapati Sambhaji Nagar and Dharashiv, respectively.*
(Extra ordinary gazette released on 15 September 2023 under Central section, Part 4B, Ext No. 364 and 365)
[13] *Malegaon taluka from Nashik district was included in project in year 2022*
[14] *Source: PoCRA-Terms of Reference*
[15] *First Implementation Support and Review Mission: December 2-8, 2018; Second Implementation Support and Review Mission: September 16-October 4, 2019; Third Implementation Support and Review Mission: June 1-5, 2020; Mid Term Review Mission: April 18-26 and May 16-19, 2022*

1.4 Project Components

To achieve the above project development objective, the project is operationalized through four key components.

Component A: Promoting climate-resilient agricultural systems

This component's objective is to enhance small-scale farmers' ability to adapt and alter their agriculture practices to mitigate the potential effects of climate change. It enhances the resilience of agricultural production systems by implementing a range of activities at the farm level alongside interventions in drainage lines and catchment areas. A mini watershed plan serves as the foundation for a cluster development and investment plan, which outlines the project activities and investment priorities in the field.

Component A.1: Participatory development of mini watershed plans

The objective of this component is to guide the design and implementation of multi-sector project interventions aimed at enhancing climate resilience in the local agricultural systems. The mini watershed plans developed under this component consolidate information and data from the participatory village-level microplanning process. This process is coordinated by the Village Climate Resilience Management Committee (VCRMC) through participatory processes with the farming communities and other local stakeholders; village-level micro-plans are subsequently aggregated at the cluster level to form a mini watershed plan. Complementing the development of the micro watershed plan is a comprehensive water budgeting exercise addressing both spatial and temporal variations in groundwater and surface water availability.

Component A.2: On-farm climate-resilient technologies and agronomic practices

The objective of this component is to promote the transfer of on-farm technologies and agronomic practices that enhance climate resilience in the agricultural systems prevailing in the project area. This component significantly contributes to climate co-benefits by promoting a range of agricultural technologies and agronomic practices that:

- enhance the adaptation capacity of the various farming systems in the project area through, (i) the development of micro-irrigation systems and construction of farm ponds for enhanced water-use efficiency, (ii) the adoption of climate resilient (drought and salinity tolerant) crop varieties, (iii) crop diversification (increased production of higher value horticulture products), and (iv) agronomic practices that improve soil health (increased organic soil content, reduced salinity, and sodicity, integrated nutrient management) and/or in-situ water conservation, and

- mitigate GHG emissions through carbon sequestration by, (i) planting trees in upper catchment areas and on contour lines (afforestation), (ii) growing fruit trees on small orchards, (iii) incorporating crop residues (biomass) into the soil, and (iv) adopting practices for conservation agriculture.

For the demonstration of climate-resilient agricultural technologies and agronomic practices, the Farmer Field Schools (FFS), which is a participatory and interactive on-site learning approach that emphasizes problem-solving and discovery-based learning approach, is used in this component. FFS is operationalized at the village level under the coordination of the VCRMC and with the technical backstopping of the Agricultural Technology Management Agency (ATMA) extension staff and the KVK scientists.

To scale up and accelerate the adoption of the climate-resilient technologies and agronomic practices demonstrated in the PoCRA clusters, the project will provide financial assistance to eligible individual farmers through matching grants by following the government's Direct Beneficiary Transfer (DBT) mechanism.

Component A.3: Climate-resilient development of catchment areas

The objective of this component is to enhance the management of surface water and groundwater resources in the catchment areas of the project's mini watersheds to improve the performance of dryland farming during dry spells and lower-than-normal annual rainfalls. Under this component, the project focuses on the treatment of catchment areas (e.g. Continuous Contour Trenches (CCTs)), treatment of drainage lines (e.g. earthen/cement check dams and tanks), construction of new water harvesting structures (e.g. community ponds), rejuvenation of existing harvesting structures (including desilting), and aquifer recharge structures.

Component B – Post-harvest management and value chain promotion

The objective of this component is to assist small-scale farmers in their involvement with Farmer Producer Organizations (FPOs) and the integration of these FPOs into value chains for climate-relevant crops. Additionally, it aims to strengthen the supply chain for crop varieties that are resilient to climate change in the designated project area. This element will enhance the capacity of stakeholders in selected commodity value chains to effectively respond to and recover from adverse climate events. It will support initiatives that go beyond the farm gate to enhance climate resilience and provide comprehensive solutions within agricultural commodity value chains that promote climate-resilient farming practices.

Component B.1: Promoting FPOs

The objective of this component is to strengthen the capacity of FPOs to, (i) develop and successfully implement bankable proposals linked to climate-resilient agri-food systems and to be funded by financing institutions, (ii) operate as agribusiness entrepreneurs (FPCs) that generate sustainable profit for their members, and (iii) successfully carry out a variety of initial processing tasks for climate-resilient goods supported by the project, utilizing eco-friendly technologies when appropriate.

Component B.2: Strengthening emerging value-chains for climate-resilient commodities

The objective of this component is to promote the participation of FPOs in emerging value chains for climate-resilient commodities. Under this component, the project will provide co-financing (under the FPO Matching Grant scheme), (i) to implement growth-oriented sub-project proposals from eligible FPCs (and, where applicable, other FPOs as well) in the selected value chains, and (ii) to establish FPO-run custom-hiring centres (CHCs) for agricultural machinery. This component contributes to climate co-benefits by focusing on value chains for climate-resilient commodities, by promoting green technologies in primary processing (use of solar energy, including for storage), and by encouraging the selection of fuel-efficient (less energy) and technology efficient (loss reducing) farm machinery and equipment.

Component B.3: Improving the performance of the supply chain for climate-resilient seeds

The objective of this component is to improve the supply of seed varieties (volume, quality, availability, affordability, and access) with short duration cycle, drought-, salinity- or heat-tolerant features for crops produced by small and marginal farmers in the project area.

Component C – Institutional development, knowledge, and policies for a climate-resilient agriculture

This component is designed to improve organizations' and individuals' capacity to promote and adopt more climate-resilient agricultural practices. This will be achieved through the development of sector strategies and policies supported by comprehensive analysis and advanced climate, water, and crop modeling. By strengthening existing institutions, establishing a Climate Innovation Centre, and facilitating evidence-based policy discussions, this element will ensure the sustainability of the proposed approach to building climate resilience in agriculture, soil, and water resources.

Component C.1: Sustainability and institutional capacity development

The objective of this component is to strengthen the institutions associated with the project from the central to local level through capacity development to, (i) safeguard the sustainability of the project interventions beyond the project lifetime, (ii) promote spill-over impacts to villages and districts not covered by PoCRA, and (iii) mainstream climate-resilience in the agenda of institutions supporting agricultural growth and rural development in Maharashtra. Under this component, the project will finance, (i) the preparation of crop production contingency plans, (ii) the revision of Strategic Research and Extension Plans (SREPs), (iii) the implementation of an annual Knowledge Sharing and Learning Plan, and (iv) the design and implementation of a comprehensive ICT platform for the project.

Component C.2: Maharashtra Climate Innovation Centre

This component's objective is to establish a Climate Innovation Centre (CIC) to act as a knowledge hub, a climate-resilient incubator and to ensure strategic partnerships between government institutions, line departments, the private sector, and academia towards scaling up climate-resilient agriculture in Maharashtra.

Component C.3: Knowledge and Policies

The objective of this component is to (i) generate and disseminate cutting-edge knowledge on a range of issues related to climate-resilient agriculture and (ii) provide analytical underpinnings to improve the policy and strategy framework required to further enhance resilience in the agri-food system in Maharashtra (and beyond).

Component D: Project management

This component's objective is to ensure the efficient and effective overall management of the project through a PMU set up by the Department of Agriculture of the Government of Maharashtra.

1.5 Theory of Change

The Theory of Change (ToC) identifies the conditions that need to unfold for the project's long-term goals to be met. These conditions are arranged graphically in a causal framework. This creates a set of connected outcomes known as a “pathway of change,” which graphically represents the change process. It uses backward mapping from the long-term goal to the intermediate and then early-term changes that would be required to cause the desired change, as can be seen in Figure 1.

The project aims to enhance climate resilience and profitability of smallholder farming systems in selected districts of Maharashtra. This goal is pursued through a series of components that focus on promoting climate-resilient agriculture, ensuring efficient water use, strengthening post-harvest management, and developing institutional capacities and supportive policies.

Under Component A, the project focuses on the participatory development of mini watershed plans, which involves the preparation of cluster-level plans and the mobilization of farmer communities. This component also includes the demonstration of climate-resilient agriculture (CRA) practices through Farmer Field Schools (FFS), the enhancement of carbon sequestration, and the promotion of protected cultivation methods. Efficient and sustainable use of water for agriculture is promoted through catchment and drainage line treatments, the construction and rejuvenation of water harvesting structures, and the installation of micro and protective irrigation systems, leading to improved soil and water conservation.

Component B addresses post-harvest management by promoting Farmer Producer Companies (FPCs) and enhancing value chains. The project supports Farmer Interest Groups (FIGs), Farmer Producer Organizations (FPOs), and FPCs in establishing custom hiring centres and provides resources and support for product aggregation, handling, transformation, and marketing. This component also involves the intention of improving the performance of the seed supply chain by producing and distributing foundation and certified seeds of climate-resilient varieties, developing seed hubs, and providing infrastructural support.

Component C focuses on institutional development, knowledge enhancement, and policy support. This includes updating the SREPs to align with climate-resilient agriculture, providing agro-met advisory services, and preparing contingency plans and long-term climate change models. Apart from this, it also focuses on the development of a risk analysis framework, strategic partnerships, and capacity building for stakeholders as key initiatives. The component also includes the development of Management Information Systems (MIS), Information and Communication Technology (ICT) support systems, and Information, Education, and Communication (IEC) materials for project execution.

Outputs are the direct, tangible results generated from the completion of project activities. Activities in this section refer to the outputs of the three components. Component A has led to outputs like the development of 138 cluster-level plans (as well as 5043 village development plans), the engagement of Krishi Tais at the village level, the implementation of horticulture plantation on 29270 ha, agroforestry initiatives on 613 ha and the establishment of 5874 shade net houses, and 146 poly houses. Component B has resulted in support for 1799 FIGs, 1698 FPCs, and 1204 Self-Help Groups (SHGs). Other outputs include the production of climate-resilient seeds, enhanced seed processing capacity for 1,000 MT, skill development for seed-producing farmers, and strengthened seed quality testing facilities. Component C resulted in Institutional outputs like updated SREPs, developed agro-met services, prepared contingency plans, and strengthened capacity building and support systems for stakeholders.

Outcomes here refer to the short- to medium-term effects of the project outputs, indicating progress toward achieving the project's objectives. The project outcome, thus, includes improved soil and water conservation through micro watershed plans, increased adoption of improved agricultural technologies, enhanced agricultural productivity, increased carbon sequestration, and reduced greenhouse gas emissions. It has also led to improved water use efficiency at the farm level, the strengthening of financially sustainable FPCs, increased uptake of climate-resilient crop varieties, and the establishment of climate-resilient agriculture systems in the project area. Enhanced farm income, particularly for women-headed households and farmers from vulnerable communities, is also a significant outcome.

Impacts are the long-term effects and changes resulting from the outcomes, aligned with the project's overarching goal. The project aimed to contribute to enhanced climate resilience and profitability for smallholder farmers, leading to a more climate-resilient agriculture sector. It ensures household food and income security, promotes better gender and social equity in the agriculture sector, and supports India's Intended Nationally Determined Contribution (INDC) under COP 21 by advancing climate-resilient practices and systems.

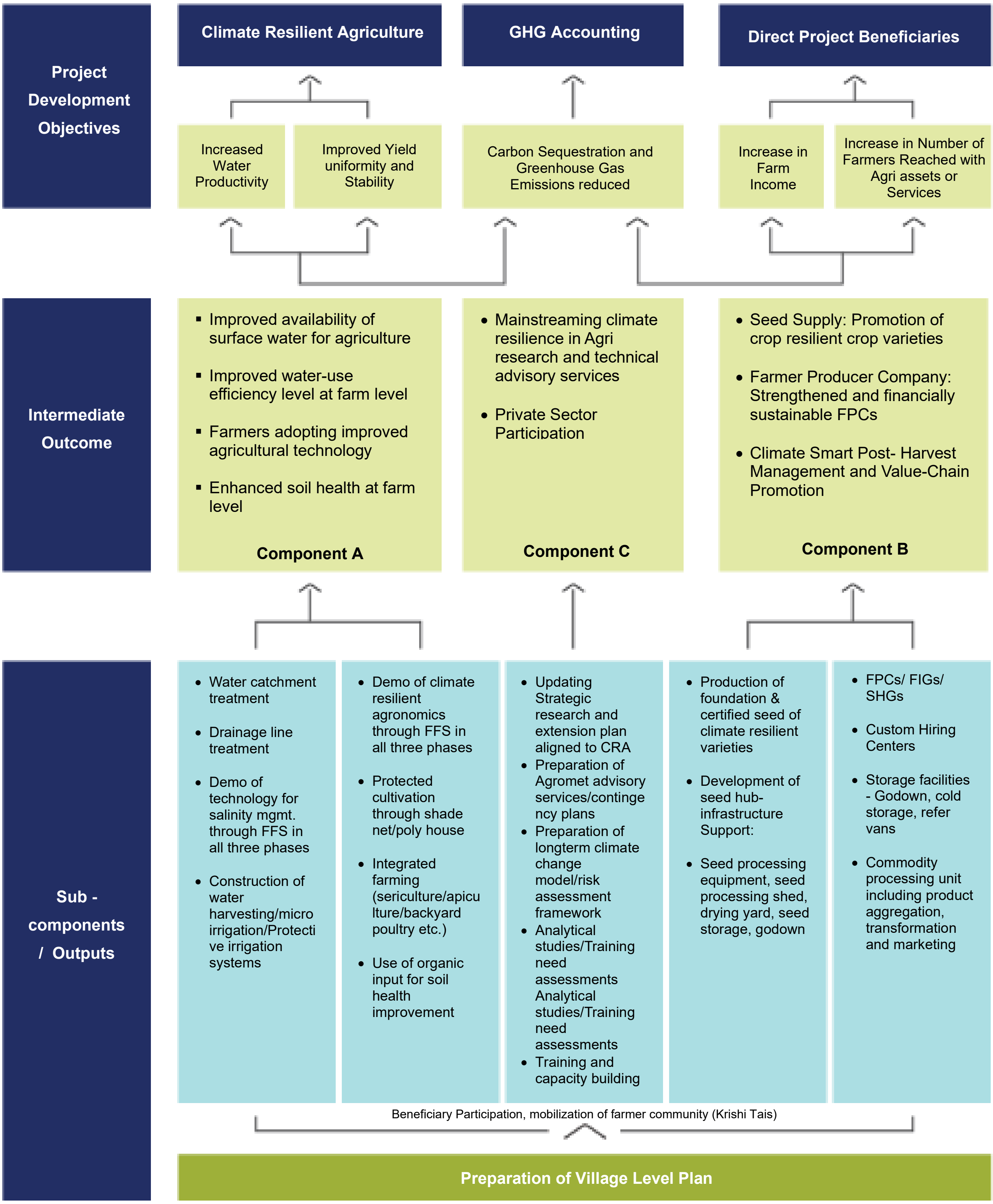

Figure 1: Theory of Change

1.6 Project Areas and Beneficiaries

The project has been implemented in 670 mini watershed clusters covering 5220 villages in 16 districts in Maharashtra, which include eight districts of the Marathwada region (viz. Chhatrapati Sambhaji Nagar (henceforth CSN), Nanded, Latur, Parbhani, Jalna, Beed, Hingoli, Dharashiv[16]), six districts of the Vidarbha region (viz. Akola, Amravati, Buldhana, Yavatmal, Washim, Wardha), Jalgaon and Nashik[17] district of Nashik Division, and approximately 932 salinity affected villages in the basin of Purna river spread across Akola, Amaravati, Buldhana and Jalgaon districts[18]. Effectively, the program is active in eight districts of the Marathwada area and seven districts of the Vidharbha region (Rest of Project Area (RoPA)) of Maharashtra.

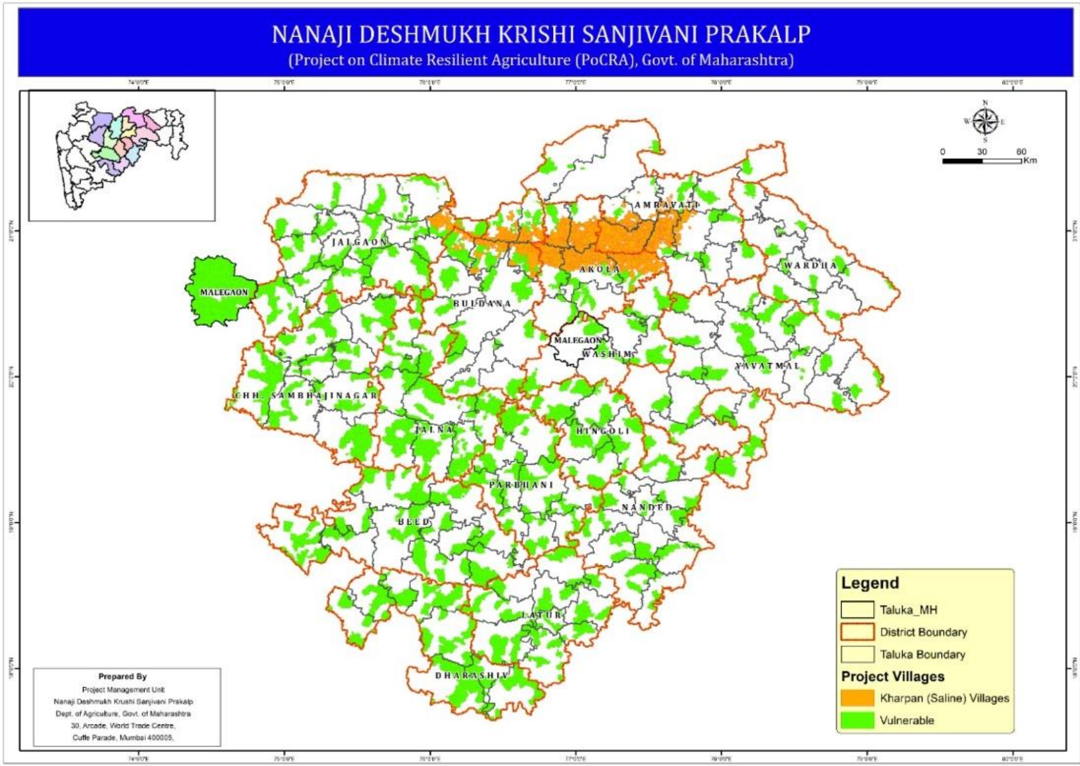

Figure 2: Transforming Maharashtra: Project Map for 5220 Villages in 16 Districts

Figure 2 highlights the villages where the project is implemented. This project was implemented over six years, from 2018 to 2024. About 40 percent of Maharashtra falls under the drought-prone area, with less than 750 mm of annual average rainfall[19]. In Maharashtra, the Marathwada region specifically has been periodically floundering under drought conditions since 2012. It also reported the highest rainfall deficit in the country at 48 percent in 2014. Marathwada region coincides with Chatrapati Sambhajinagar Division and consists of eight districts, namely, CSN, Beed, Latur, Dharashiv, Parbhani, Jalna, Nanded, and Hingoli.

However, given the harsh weather conditions, the region's agricultural system has been depleted significantly. Jalna district, famous for being the biggest producer of sweet lime, had been the worst hit by the drought.[20] The anticipated impact of climatic change and climate variability presumably led to increased pressure on already scarce water resources.

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[16] Aurangabad and Osmanabad renamed as Chhatrapati Sambhajinagar and Dharashiv, respectively. (Extra ordinary gazette released on 15 September 2023 under Central section, Part 4B, Ext No. 364 and 365)
[17] Malegaon taluka from Nashik district was included in project in year 2022.
[18] Source: PoCRA-Terms of Reference
[19] Hydrology and Water Resources Information System for India, National Institute of Hydrology, Roorkee http://nihroorkee.gov.in/rbis/India_Information/draught.htm
[20] Khetwani, Sagar and Singh, Ram Babu 2018- https://doi.org/10.9734/JGEESI/2018/43612

Vidarbha, located in the eastern part of Maharashtra, comprises 11 districts: Amravati, Akola, Yavatmal, Buldhana, Washim, Wardha, Nagpur, Bhandara, Gondia, Chandrapur, and Gadchiroli. Of these, the first six districts are included in the project. The region experiences diverse climatic conditions, with annual average rainfall ranging from 800 mm to 1400 mm, depending on the specific district. Vidarbha's agriculture is heavily dependent on monsoon rains, making it vulnerable to climate variability. Major crops in the region include cotton, soybean, tur (pigeon pea), and paddy, which are crucial for the local economy. However, frequent droughts and erratic rainfall patterns have severely impacted crop productivity. In particular, the western parts of Vidarbha, such as Akola and Yavatmal, face significant agricultural distress due to lower rainfall and higher temperatures. This variability has led to increased reliance on groundwater, further stressing the region's water resources.

The detailed area profile has been added in **Annexure -1**.

1.7 Budget Allocation

The total project cost was USD 600 million, including the World Bank's loan assistance of USD 420 million (70 percent) and the State Government's contribution of USD 180 million (30 percent). The component-wise expenditure report is provided below:

Table 1: Budget Allocation

Project Component	Project Cost		IBRD Finance		State Finance	
	Rs. (Cr)	%	Rs. (Cr)	%	Rs. (Cr)	%
Component A	3911.39	83.29	2737.97	83.29	1173.42	83.29
Component B	552.66	11.77	386.86	11.77	165.80	11.77
Component C	26.15	0.56	18.31	0.56	7.85	0.56
Component D	206.15	4.39	144.31	4.39	61.85	4.39
Total	**4696.35**	**100**	**3287.45**	**100**	**1408.91**	**100**

1.8 Implementation and Institutional Arrangements

The project is fully integrated into the GoM administration, and implementation is designed to capitalize on existing GoM departments at the state, district, sub-districts, and village levels. Overall project implementation is the responsibility of the Department of Agriculture, DoA (GoM). The Project Steering Committee (PSC), chaired by the Chief Secretary (GoM), provides strategic guidance for the implementation of the project, approves the annual work program and budget for the project, endorses the proposed renewal of Memorandum of Understanding (MoUs)/ contracts with strategic partners, and reviews the outcomes of implementation support.

The day-to-day management and operation of the project is the responsibility of the PMU, headed by a Project Director appointed by the GoM. The PMU is responsible for ensuring that:

- all project activities are planned, financed, and implemented as per the approved project annual work program and budget,
- project implementation is in line with the operational guidelines of the Project Implementation Plan (PIP),
- project procurement and financial management activities are carried out on time as per the World Bank's procurement guidelines for Investment Project Financing (IPF) borrowers (2016), the project fiduciary manuals and the procurement plan, and
- social and environmental safeguards applicable to the project are fully complied with.

At the district level, project implementation is supported by technical and fiduciary specialists supervised by the District Superintending Agriculture Officer (DSAO) and the Project Director for ATMA. In each project district, a District Coordination Committee is established headed by a Collector, the DPIU, as the nodal implementing agency at the district level, and the associated line departments involved with the project are represented on the committee. At the sub-divisional level, project implementation is supported by specialists from the Sub-division Agriculture Office (SDAO). Project activities at the cluster level are coordinated by a Cluster Assistant supported by the local project person ("Krishi Tai") and technical specialists from other departments.

At the village level, the Village Climate Resilient Management Committee plays a key role in planning, community procurement, monitoring, and coordinating project implementation (e.g. watershed plans) and anchoring climate interventions at the community level. To that effect, the VCRMC liaises closely with the community institutions associated with the implementation of project activities, e.g. the water user associations, watershed development committees, as well as producer organizations including farmer interest groups. VCRMCs also play a pivotal role in the development of the mini watershed plans. The VCRMCs are headed by the head of Gram Panchayat (Sarpanch) and other members of the VCRMC are selected by the Gram Sabha and represent various stakeholders at the village level, including vulnerable groups.

Table 2: Number of Executive and Non-Executive Members

S.No.	Member's Name and Work	No. of Members	Post
Executive Members			
1.	Sarpanch	1	Ex-Officio President
2.	Deputy Sarpanch	1	Ex-Officio Member
3.	Gram Panchayat Members (Male1 & Female1)	2	Member
4.	Progressive Farmers (Gen–1, SC/ST/NT/VJNT-1)	2	Member
5.	Female Farmers (Gen–1, SC/ST/NT/VJNT-1)	3	Member
6.	Farmer Producer Groups/ FPO Representative	1	Member
7.	Women Self-Help Group Representative	1	Member
8.	Agri-allied Business Farmer	2	Member
	Total Executive Members	**13**	
Non-Executive Members			
9.	Agriculture Assistant	1	Ex-Officio Technical Member
10.	Gram Sewak/ Village Development Official	1	Member Secretary
11.	Cluster Assistant	1	Joint Secretary
12.	Krishi Tai/ Krishi Mitra	1	Extension worker
	Total Non-Executive Members	**4**	

To meet the project's need for highly specialized knowledge and technical skills, the PMU has reached out to strategic partners for planning and implementation. These are public institutions that have already assisted the PMU and other stakeholders during the project preparation phase. Detailed information is provided under the Component C section in the report below.

1.9 Monitoring and Evaluation Mechanism

The project has put in place a robust Monitoring and Evaluation (M&E) system to ensure that all project objectives are achieved. This system includes both internal and external monitoring mechanisms to consistently assess the progress of the project. Internally, the monitoring process uses performance indicators at the subdivision and taluka levels to evaluate and motivate project teams through fair benchmarking. Performance is measured against project activities, and the system is updated monthly. Key features of this system include graphical representations of results, breakdown into individual component-wise reports, and ease of analysis and monitoring. The system is dynamic and flexible, allowing for the inclusion of new parameters periodically, such as every quarter. The performance index has significant benefits, fostering healthy competition among subdivisions and talukas, leading to improved performance. Additionally, transparent analysis helps to identify areas needing attention, enabling necessary corrective actions.

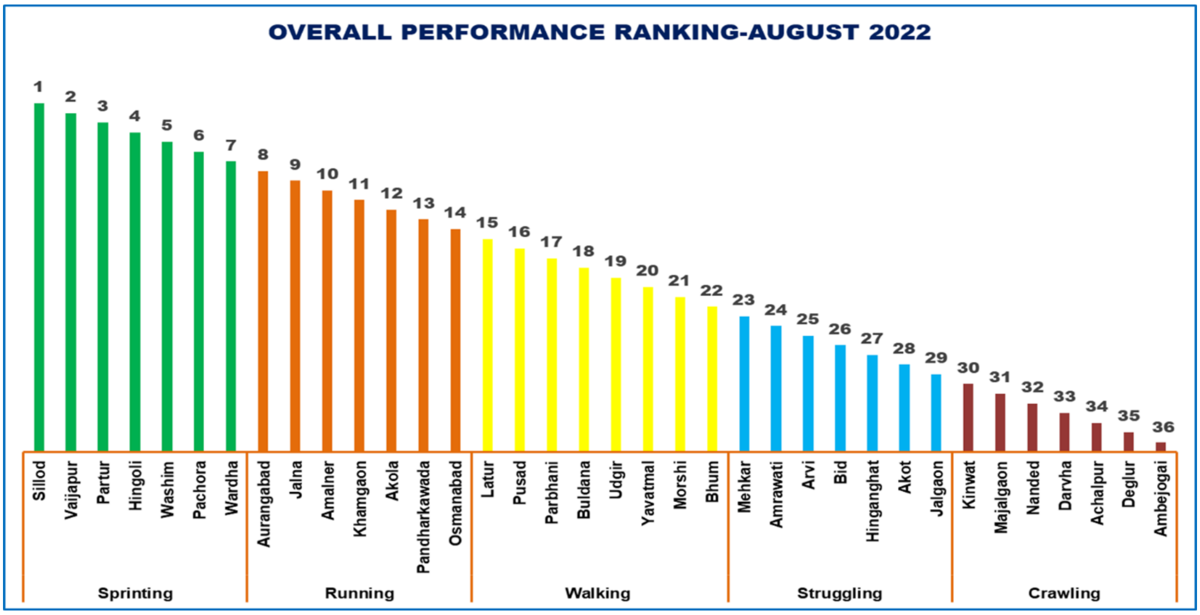

Figure 3: Snapshot of the Subdivision Performance Index

The integration of advanced ICT systems and advanced monitoring tools in the PoCRA significantly alleviates the data collection burden on field staff. This technology enables automatic, real-time data generation, streamlining the monitoring and tracking of project activities and objectives. As a result, the PMU can efficiently oversee progress without relying heavily on manual data collection. This automated system enhances accuracy and timeliness, ensuring that project goals are met effectively while freeing field staff to focus on more critical, hands-on tasks within the communities they serve.

This transparent and comprehensive monitoring system not only encourages healthy competition but also drives continuous improvement at the grassroots level. By providing an accessible and clear performance overview, the index supports informed decision-making and strategic planning, ultimately enhancing the overall effectiveness and impact of the PoCRA at the grassroots.

PoCRA has also established a robust external monitoring process to ensure comprehensive and objective assessments at various stages of the project lifecycle. The Project Management Unit (PMU) has engaged two specialized agencies- Sambodhi and Nabcons to conduct mandatory baseline, midline, and endline evaluations. These evaluations provide in-depth insights and assessments of the project's impact, effectiveness, and areas for improvement from inception through to completion.

In addition to these structured evaluations, PoCRA has implemented a concurrent monitoring system designed to oversee the project's implementation continuously. The primary objectives of concurrent monitoring are to assess progress against key performance parameters, identify effective components and process bottlenecks, and gather feedback from key stakeholders to refine and improve implementation strategies. This proactive approach ensures that any issues are identified and addressed promptly, facilitating smoother and more effective project execution.

The concurrent monitoring system requires the submission of detailed reports every six months, as stipulated in the Project Appraisal Document (PAD). These reports serve multiple purposes: they validate the accuracy of the management information system data by cross-checking it with on-ground realities and provide real-time insights into the project's progress. Nine concurrent monitoring reports for the Marathwada region and seven concurrent monitoring reports for the rest of the project area have been submitted. These reports are instrumental in providing evidence-based decision-making and ensuring that the project stays on track to achieve its objectives.

The concurrent monitoring process involves collecting data from various stakeholders, including farmers, local authorities, and project staff. This data is then analysed to identify trends, successes, and areas requiring improvement. By providing a continuous feedback loop, concurrent monitoring helps maintain the project's momentum and adapt strategies as needed to meet the evolving challenges and opportunities.

Moreover, this structured and ongoing monitoring process underscores the project's commitment to transparency and accountability. By regularly publishing detailed monitoring reports, the project ensures that all stakeholders are informed about its progress and challenges. This openness not only builds trust but also fosters a collaborative environment where feedback and suggestions are valued and acted upon. This commitment to continuous improvement and accountability is pivotal in achieving the long-term goals of sustainability and resilience in Maharashtra's agricultural sector.

1.10 Transparency and Grievance Redressal Mechanisms

The project emphasizes transparency, accountability, openness, and the disclosure of information to the community. A robust grievance redressal mechanism has been established to ensure that stakeholders' voices are heard and addressed promptly, enhancing the project's integrity and efficacy. This write-up outlines the multifaceted grievance redressal framework within the PoCRA project, highlighting citizen-focused engagement.

Social audit

Social auditing is a cornerstone of PoCRA's approach, serving as a tool for measuring, understanding, and improving the project's social and ethical performance. It aligns project objectives with reality, bolstering governance, transparency, and accountability. The social audit process involves various stakeholders, including marginalized groups, ensuring their voices are heard. This democratic exercise evaluates the distribution of benefits and community-created assets through participatory microplanning.

The Village Climate Resilient Management Committee coordinates social audits for benefits distributed via direct benefit transfer and community assets created under Natural Resource Management (NRM) activities. Out of 3959 VCRMCs, 3874 eligible gram panchayats conducted social audits, with 168457 stakeholders participating. This includes 124435 males (74 percent) and 44022 females (26 percent), highlighting active community engagement.

These audits, conducted during Gram Sabha meetings, are documented and signed by the Agriculture Assistant and the Sarpanch. The "Gram Krishi Sanjeevani Vikas Darshika", a live document available at mahapocra.gov.in, discloses village-level benefits. Physical verification of assets by VCRMC members ensures transparency and accountability.

Transparency measures

PoCRA ensures transparency through multiple channels. A dedicated website (mahapocra.gov.in) provides comprehensive information on the project's rationale, approach, manuals, implementation strategies, funding, and activities. Regular updates on the website maintain public awareness and engagement. At the administrative level, the Project Management Unit (PMU) in Mumbai oversees the documentation of all decisions, issuing guidelines and instructions digitally and physically.

At the district level, the District Superintendent Agriculture Officer (DSAO) coordinates project activities through a dedicated unit. Sub-Divisional Agriculture Officers (SDAO) replicate this structure, ensuring consistent implementation at the village level. The VCRMC discloses project activities, beneficiary selection, and water balance through public displays and awareness campaigns. Regular training and workshops at various levels enhance stakeholder capacity and project implementation.

Citizen engagement in grievance redressal mechanisms

The project offers multiple grievance redressal channels to ensure stakeholder concerns are addressed efficiently, focusing on citizen engagement and inclusivity:

1. **Project staff grievances**: All project staff-related matters and grievances are managed in accordance with their contracts and government rules. At the PMU level, the project director constitutes a grievance committee, including at least one female member, to address staff concerns.
2. **Village-level conflicts**: Efforts are made to resolve conflicts at the village level through the VCRMC, with facilitation by social mobilizers including Krishi Tai, and Cluster Assistants. If unresolved, conflicts are escalated to the Gram Sabha.
3. **SDAO-level arbitration**: For inter-village and service provider disputes, resolution is sought at the SDAO level. If formal arbitration is required, a five-member committee comprising the SDAO, a relevant technical member, and nominees from the concerned Gram Sabha is formed.
4. **DSAO appeals**: Dissatisfied parties can appeal to the DSAO, whose decision is final and binding.
5. **Service provider grievances**: Issues involving service providers and resource agencies are governed by World Bank procurement guidelines and contractual agreements.

Grievance redressal channels

The several accessible and citizen-friendly grievance redressal channels established by the project to address the concerns of the citizens are listed below:

1. **Email**: Stakeholders can email grievances to mahapocra@gmail.com, with the PMU ensuring appropriate action.
2. **Postal correspondence**: Complaints or suggestions can be mailed to the Office of the Project Director in Mumbai.
3. **CM helpline**: The toll-free number 1800 120 8040 operates 24/7, providing information and support.
4. **PMU telephone lines**: The telephone numbers +91 22 2216 3351 and +91 22 2216 3352 are available during working hours.
5. **District and subdivisional levels**: Grievances can be presented via email or phone to DSAO and SDAO offices.
6. **VCRMC level**: Local conflicts are resolved by VCRMC, with escalation to Gram Sabha if needed. Written grievances collected monthly in sealed boxes are resolved within 15 days.

This multi-layered grievance redressal mechanism ensures that the PoCRA maintains its commitment to transparency, accountability, and community engagement, fostering a climate-resilient and inclusive agricultural framework. By incorporating citizen-focused engagement, PoCRA enhances its responsiveness to stakeholder needs, promoting a participatory and equitable approach to climate-resilient agriculture.

1.11 Key Project Processes

Several key processes were followed during the project to ensure inclusivity, sustainability, and efficiency. A few of the key project processes that were instrumental in helping achieve the project objectives are described below:

Assessment based on climate vulnerability

During the project preparation phase, the GoM, with support from the PMU, completed the selection of the villages to be covered during project implementation based on a rigorous, science-based approach. GIS tools were used for the mapping of 1794 village clusters demarcated based on prevailing watersheds in the 15 project districts. Following a multi-criteria assessment, the clusters were then ranked according to their climate vulnerability; it is based on a rigorous multi-criteria analysis and takes into account the climate change vulnerability approach adopted by the Central Research Institute for Dryland Agriculture (CRIDA), a National Research Institute under the Indian Council of Agricultural Research (ICAR). Under this approach endorsed by the Intergovernmental Panel on Climate Change (IPCC), climate vulnerability is defined as a function of exposure, sensitivity, and adaptive capacity. Subsequently, 670 clusters were selected for PoCRA implementation, covering 4288 most climate-vulnerable villages including 932 which, in addition, are affected by high levels of soil salinity and sodicity. This data-driven approach ensured resources were allocated effectively, fostering long-term resilience and adaptive capacity. The inclusive nature of the mini watershed plans helped address local needs making the project more equitable and sustainable.

Village Climate Resilient Management Committee (VCRMC)

The Village Climate Resilience Management Committee, established under the PoCRA project in Maharashtra, plays a crucial role in enhancing climate resilience at the grassroots level. This committee, integrated into the local governance body, under the Panchayati Raj system is tasked with the approval and oversight of micro-plans developed by beneficiary households. These plans undergo a rigorous multi-stage process, ensuring thorough vetting and alignment with project goals before implementation. The VCRMC's integration into the local governance structure ensures that local knowledge and needs are adequately addressed, making the plans more effective and contextually relevant. By ensuring financial support is accessible through the DBT system and aligned with well-vetted plans, the VCRMC has made a substantial impact on the sustainability and success of the PoCRA project. The state government has adopted the VCRMC Model and has directed all Gram panchayats to constitute the Village Agriculture Development Committee (Gram Krishi Vikas Samiti) since 2020.

Microplanning

The village-level microplanning process has helped consolidate information and data to substantiate decision-making and implementation at the village level. The VCRMCs were leveraged to develop the mini watershed plan that was developed under Component A of the project. This process is coordinated by the VCRMC through participatory processes with the farming communities and other local stakeholders; village-level micro plans are subsequently aggregated at the cluster level to form a mini watershed plan. The mini watershed plan provides a detailed resource map for a given cluster of five to ten villages, generated through a comprehensive assessment of the prevailing social, economic, agricultural, ecological, hydrologic, and climatic features.

a. The preparation phase of microplanning includes the identification of clusters and villages, establishing stakeholder connections, preparation of resource material, and orientation of field officials and facilitators.
b. The participatory microplanning process was conducted at the village level over seven days initially. Later on, a more compact Micro planning process of four days was carried out. It begins with the introduction of the project and its objectives, the formation of the village resource group, and mobilization activities. The microplanning activities include activities such as social mapping, seasonality analysis, timeline analysis of climate change and natural resources, resource mapping, transect walk, targeted group discussions, and value chain analysis. The key component of resource mapping is the water balance assessment and identification of vulnerable zones. The field teams are equipped with maps that are the output of the hydrological model generated based on secondary data. The microplanning teams compute the demand for water considering the area under different crops and human and livestock populations to arrive at the total water requirement of the cluster. The PMU provides supply-side data (rainfall, runoff, soil moisture, deficit, and groundwater for different crops) with maps showing stream orders, soil details, land utility, habitats, and land details to the microplanning team. This data was used to compute the water balance of the cluster. The framework helped generate the current status (deficit/surplus) and scope for impounding more water. Based on the computed water budget and the upper limit for runoff, management decisions on the

quantity of additional engineering intervention structures (area treatment, drainage line treatment, farm ponds) in the cluster will be taken.

c. Integrated village development plans were developed based on stakeholder needs and were approved by the community through a gram sabha and women's gram sabha on the final day of the process. The Village Climate Resilient Agriculture Management Committee was formed, and the completion of the process is certified by the Gram Panchayat.
d. The post-microplanning process comprises a technical vetting process in which the plans approved in the gram sabha are vetted by a team of technical experts. The water balance computed using the hydrological model is useful in technical vetting. VDPs are approved by the district coordination committee headed by District Collector.

Direct Benefit Transfer (DBT)

To scale up and accelerate the adoption of the climate-resilient technologies and agronomic practices demonstrated in the PoCRA clusters, the project provides financial assistance to eligible individual farmers and FPO through the digital portal for end–to–end DBT, developed by the project in line with GoI directives. This DBT mechanism has ensured a seamless and paperless flow of transferring subsidies to the Aadhaar-linked bank account of the beneficiaries.

Maharashtra is one of the pioneer States in adopting DBT and several state-sponsored programs implemented by the Department of Agriculture (GoM) have adopted the DBT mechanism to provide financial assistance to farmers. The project is providing subsidies to individual farmers based on technical verification of the assets created by them. Basic selection criteria for subsidy recipients include: (i) being listed as an individual farmer in a PoCRA village; (ii) meeting the criteria for DBT; (iii) applying for subsidy support endorsed by VCRMC; and (iv) subsidy support sought for climate resilient on-farm activities. The beneficiary pays the full costs for the works and/or goods for his/her activities, and upon satisfactory completion of the same, the project disburses one installment grant into the beneficiary's bank account. The tools of auto-prioritization of social categories and FIFO systems were an interesting mix of technology and social dimensions to deliver social justice. The project's success led to the adoption of the MahaDBT portal by the Agriculture Department statewide from 2020-21.[21] The investment on individual activities and project support is presented below.

Investment on Individual activities and project support

Sr. No.	Activities	Farmers	Application	Disbursed Amount in Cr.
1	Agroforestry	1033	1060	1.31
2	Apiculture	362	362	5.23
3	Backyard poultry	234	234	0.26
4	Community farm pond	2695	2695	83.42
5	Compost (Vermicompost / NADEP / Organic input production unit)	3829	3858	1.88
6	Drip irrigation	227491	254487	1962.09
7	Farm mechanization	6784	7718	51.19
8	Farm pond lining	3158	3158	30.59
9	FFS Host farmer assistance	7808	11044	4.06
10	Horticulture plantation	44135	48086	203.39
11	Individual farm pond	5223	5231	60.98
12	Inland fisheries	2153	2154	5.45
13	Pipes	27633	27634	52.83
14	Planting material in Polytunnels / Polyhouse / Shadenet house	1140	1141	10.26
15	Polyhouse/ Poly tunnels	146	146	21.25

[21] *Department of Agriculture, State Government of Maharashtra adopted MAHADBT system vide G.R dated 4/11/2020. https://gr.maharashtra.gov.in/Site/Upload/Government%20Resolutions/Marathi/202011041210536101...pdf*

Sr. No.	Activities	Farmers	Application	Disbursed Amount in Cr.
16	Promotion for BBF technology	2055	2171	0.27
17	Recharge of open dug wells	588	588	0.69
18	Saline and Sodic lands (Farm ponds/ Sprinklers / Water pump/ FFS)	13847	14302	29.87
19	Seed production	24205	46666	49.39
20	Sericulture	5337	12361	89.01
21	Shadenet house	5874	5893	630.19
22	Small ruminants	5391	5391	19.77
23	Sprinkler irrigation	203837	206266	395.74
24	Water pumps	31373	31684	45.39
25	Well	1939	1939	44.77
Grand Total		**485669**	**696269**	**3799.29**

Extension services

Agricultural extension is the most common model used to transmit information to farmers. These traditional extension systems often use top-down approaches, like training and visits, and bottom-up approaches, like farmer field schools or peer farmer learning, to encourage the adoption of new technologies[22]. Adopting a similar approach, the project aided the establishment of farmer field schools to transfer climate-resilient technology to the clusters. These are all small plots of cultivated land, which serve as demonstration plots, which serve as informal "open-sky schools" and serve as a learning ground for small and marginal farmers under the project.[23] FFS was set up in the field of outstanding or achiever farmers identified by dedicated FFS facilitators and Agriculture Assistants and approved by VCRMC, to provide the vital link between these progressive / achiever farmers and others in a village. At FFS, the farmers learn about recent advances in science, hydrology, and crop productivity, and most importantly, learn how to adopt appropriate agricultural practices to help better adapt to climate change.

Besides the FFS medium, the knowledge and skills of selected trainee farmers were upgraded through training and exposure visits, etc. Special care was taken by VCRMC while selecting the trainee farmers, to ensure representation of small and marginal farmers and women farmers also.

In addition to these key processes, several processes contributed towards the success of the project in Maharashtra including real-time ICT systems for monitoring and tracking progress as well as engaging with beneficiaries, and the development of village development plans which have been described in detail in relevant sections below.

[22] *Improving agricultural information and extension services to increase small-scale farmer productivity, 2023, https://www.povertyactionlab.org/policy-insight/improving-agricultural-information-and-extension-services-increase-small-scale*
[23] *Ranjan Samantaray, 2021, https://blogs.worldbank.org/en/endpovertyinsouthasia/farmers-learn-climate-adaptation-open-sky-schools-india*

2. Approach and Methodology

2.1 Scope

The project's endline impact assessment report is designed to comprehensively assess the project's overall performance, impact, and sustainability. Building on the framework established by the mid-term review, the impact assessment evaluates the extent to which the project has achieved its intended targets and objectives. It measures the endline outcomes by comparing them with the baseline data, ensuring consistency and accuracy in data analysis.

The impact assessment identifies the determinants that have enabled or hindered the achievement of these targets and assesses the level of awareness among communities. It focuses on understanding the outcomes of project interventions and the effect of the same on the target population and compares these with the baseline situation to assess the effectiveness of the project in terms of physical infrastructure development, socio-economic changes, environmental impacts as well as institutional strengthening (of VCRMCs, FPOs/FPCs, SHGs, etc.) and participation within the community, and document key learnings from the project implementation. It also assesses the current situation on relevant variables mentioned in the results framework and on key Environment and Social Management Framework (ESMF) related indicators. This comprehensive evaluation highlights the achievements and challenges and offers actionable recommendations to inform future projects and initiatives aimed at enhancing climate resilience and agricultural productivity in Maharashtra.

2.2 Overarching Framework for Evaluation

As noted in the World Bank Group Evaluation Principles (2019)[24], the OECD DAC Network on Development Evaluation (EvalNet) introduces a normative framework comprising six evaluation criteria, namely: relevance, coherence, effectiveness, efficiency, impact, and sustainability. Additionally, the framework advocates for the incorporation of thoughtfulness and specificity as two fundamental guiding principles in the context of policy analysis. This framework serves as a valuable tool for delineating research inquiries, identifying potential data sources and stakeholders, and structuring the analytical plan.

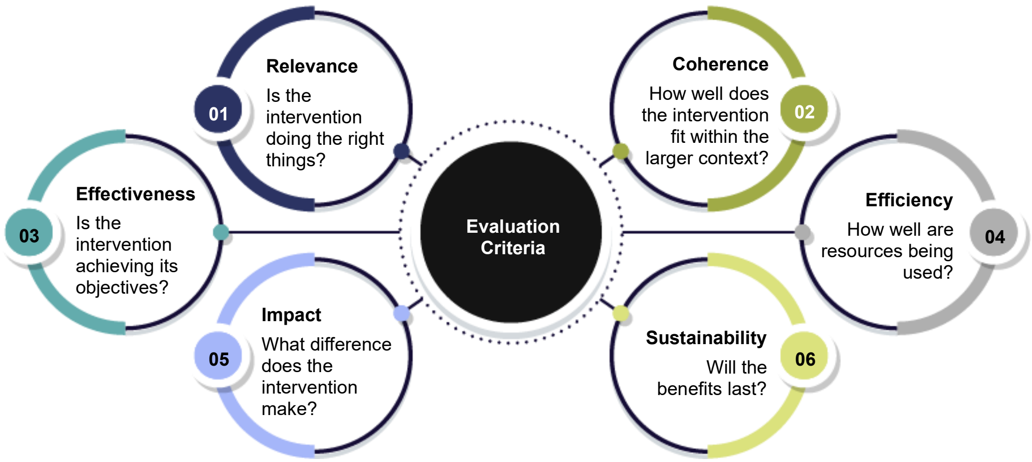

Figure 4: DAC Evaluation Criteria

(Source: https://www.oecd.org/dac/evaluation/daccriteriaforevaluatingdevelopmentassistance.htm)

[24] *World Bank Group Evaluation Principles, 2019, https://Ieg.Worldbankgroup.Org/Sites/Default/Files/Data/Reports/Worldbankevaluationprinciples.Pdf*

The M&E agencies have adopted the DAC framework to analyze the project's relevance in terms of achievements of its objectives; the project's effectiveness in terms of inputs and process of its implementation; project's efficiency in terms of its cost and benefits, fund utilization and capacity building, and output produced; project's impact on short, intermediate and long term outcomes, discuss project's coherence with other development programs through convergence; and project's sustainability in terms of the extent to which the benefits are likely to continue after the intervention. Using this framework, we have assessed PoCRA on each of these criteria through rigorous statistical analysis of primary and secondary collected data.

2.3 Evaluation Design

In line with the methodology mentioned in the inception report and that followed during the baseline and mid-term evaluation, a quasi-experimental design with a double difference method was adopted for the impact evaluation. A robust a-priori matching was used to match project and control clusters to ensure strong attribution of project results. Quasi-experimental designs assist in identifying a control group that is as similar as possible to the project group in terms of pre-intervention characteristics. The control group will, in turn, capture what would have been the outcomes if the program had not been implemented (i.e., the counterfactual). The ratio of the project to control is 1:1 in the case of the Marathwada region and 2:1 in the case of RoPA[25].

As the project is focused on climate resilience, the climate change vulnerability index (as defined by IPCC-2011) was used for matching and selection of control clusters, as the approach followed in the baseline as well as a mid-term survey. Villages were further selected from the matched clusters. A one-to-one matching technique was used to find the closest match to every project cluster in the same district. Finally, the control cluster corresponding to the sampled project cluster was selected for the survey. As shown in the figure below, the difference between ΔE, ΔM, and ΔB will give the net impact due to the project at this final stage. This double difference was used to estimate the impact between baseline-endline and mid-term-endline periods.

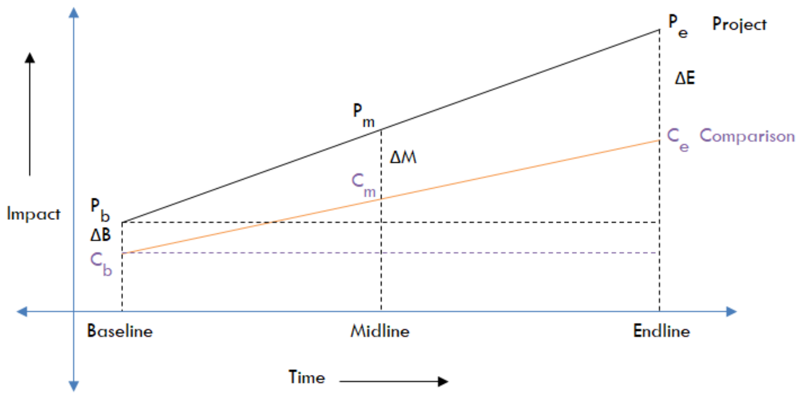

Figure 5: Illustration of Quasi-Experimental Design with Difference-in-Difference Method

2.4 Sampling Methodology

The project's endline survey employed a robust mixed-method design, integrating both quantitative and qualitative approaches to provide a comprehensive evaluation. The quantitative component involved a systematic sampling of farmer households, ensuring a representative distribution across clusters, villages, and household levels as specified in the Terms of Reference (ToR) by the PMU. This meticulous sampling strategy was designed to account for a Minimum Detectable Impact (MDI) at the project level, ensuring the reliability and validity of the findings.

[25] *As per Terms of Reference*

Concurrently, the qualitative component included in-depth interviews and focus group discussions with farmer-beneficiaries and other key stakeholders. This dual approach enabled the survey to capture a broad spectrum of data, encompassing measurable impacts and nuanced insights into the community's experiences and perceptions. By adhering to this comprehensive mixed-method design, the ETR survey provided a detailed and balanced assessment of the project's outcomes, effectiveness, and areas for improvement, ultimately contributing to the overarching goal of enhancing climate resilience and agricultural productivity in Maharashtra.

Sample size for household survey

The estimated sample size (number of households) covered in the project and control area is 2410 each in Marathwada (Sambodhi) and 2080 and 1040, respectively, in RoPA (Nabcons). A total of 4490 sample households each in the project and control area were analysed. The sample size is powered to have an MDI of 5 percent. Table below provides the overall sample for impact evaluation.

Table 3: Overall Household Sample for Impact Evaluation

Region	Number of talukas	Total number of mini watershed clusters	Total number of sampled project clusters	Total number of sampled control clusters	Total number of project villages	Total number of control villages	Total number of villages to be surveyed	Total households to be surveyed: 5 per village
Marathwada (8 districts)	76	347	241	241	482	482	964	4820
RoPA (7 districts)	79	320	208	208	416	208	624	3120
Total (15 districts)	**155**	**667**	**449**	**449**	**898**	**690**	**1588**	**7940**

Sample size for qualitative interviews

As in the baseline and mid-term surveys, along with the quantitative inquiry, qualitative surveys in the form of Focus Group Discussions (FGDs) and In-Depth Interviews (IDIs) were undertaken as part of the endline survey. The qualitative interviews that were conducted along with the sample size have been presented in the below matrix:

Table 4: Sample Size for Qualitative Interviews

Target Respondent	Sample	Enquiry Technique	Remarks
FGDs with beneficiaries i.e., farmers with more than 5 acres, farmers with less than 5 acres, landless	45 (30 in the project area and 15 in the control area. Distributed equally amongst the three categories of target respondents)	– FGD with community members	-Feedback on challenges faced in agriculture and the key challenges faced related to climate change and the coping mechanisms adopted -Feedback on the PoCRA intervention and the benefits accrued from the project
VCRMC/ Gram Krishi Vikas Samiti (GKVS) Representatives	45 (30 in the project area and 15 in the control area. Distributed equally in 15 districts)	– FGD with VCRMC/ GKVS	-Feedback about their participation, decision-making process, the effectiveness of the selection process, whether they could help the needy farmers, etc., challenges faced by target project beneficiaries i.e., farmers and landless people

Target Respondent	Sample	Enquiry Technique	Remarks
FPC/FPO Representatives	45 Project-supported FPCs	– IDI with FPC/FPO Representatives	Feedback on challenges faced by their FPC/FPO, on the support through PoCRA, and support that can help them in increasing the income of its member farmers
FGDs with Farmer Interest Group (FIG) members	30 (Two from each district in the project area)	– FGDs with members of Farmer Interest Groups	Feedback on the current activities and challenges faced by FIGs, on the support through PoCRA, and what can be done to strengthen them
FGD with Self-Help Group (SHG) members	30 (Two from each district in the project area)	– FGDs with members from Self Help Groups	Feedback on the current activities and challenges faced by SHGs, on the support through PoCRA, and what can be done to strengthen them

Field observations

Additionally, experts and research team members have conducted field observations to understand the status of project implementation in sampled project villages.

Asset verification

As a part of field observation activities, individual and community assets in 10 percent of the total number of project clusters, i.e., 67 in total, have been verified based on physical inspection and documentation. A checklist of technical specifications for physical verification and a list of documents to be verified for each type of asset was provided by PMU. In the case of community work, two assets in each cluster were randomly sampled from the list provided by PMU and verified during the endline survey. The individual assets were verified during the household survey.

The detailed sampling methodology adopted for the endline evaluation is presented in **Annexure 2**.

2.5 Sample Profile

The survey team analyzed the distribution of various socio-economic and demographic factors across the project and control study area to check if the respondents across the project and control arm are balanced. Below are the quantitative findings.

Distribution based on socio-economic categories

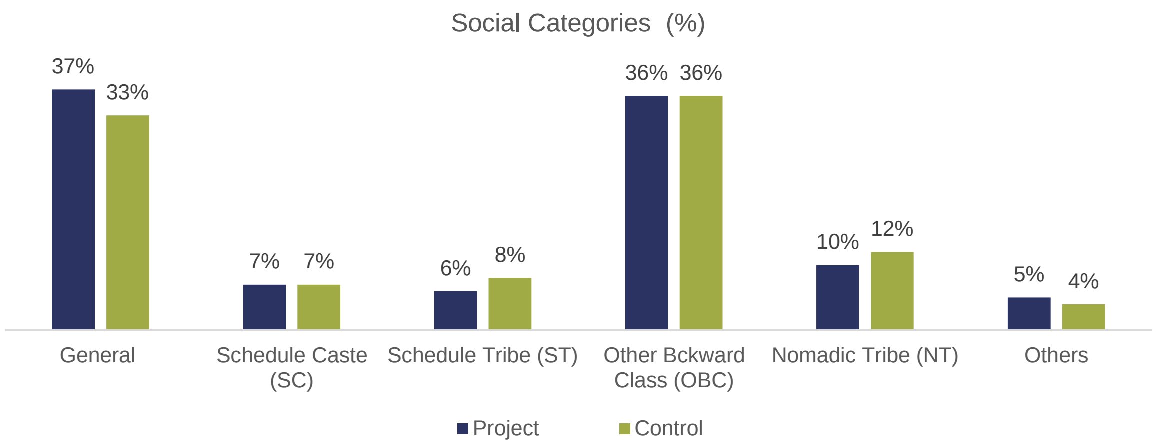

Figure 6: Distribution of Social Category

When enquired about their social category, nearly one-third of the respondents reported belonging to the general category (Project: 37%; Control: 33%), followed by Other Backward Classes (Project: 36%; Control: 36%), Scheduled Castes (Project: 7%; Control: 7%), Nomadic Tribes (Project: 10%; Control: 12%), and Scheduled Tribes (Project: 6%; Control: 8%). No significant difference has been observed across the project and control. The respondent profile based on the social category in the endline assessment is similar to that observed in the baseline respondent profile.

Distribution based on educational qualification

The respondents were asked about their educational qualifications and the highest qualification attained by any other member of their household. Nearly one-third of respondents in both areas were found to have completed secondary schooling (till 10th grade), and one-fifth of respondents have completed senior secondary (till 12th grade).

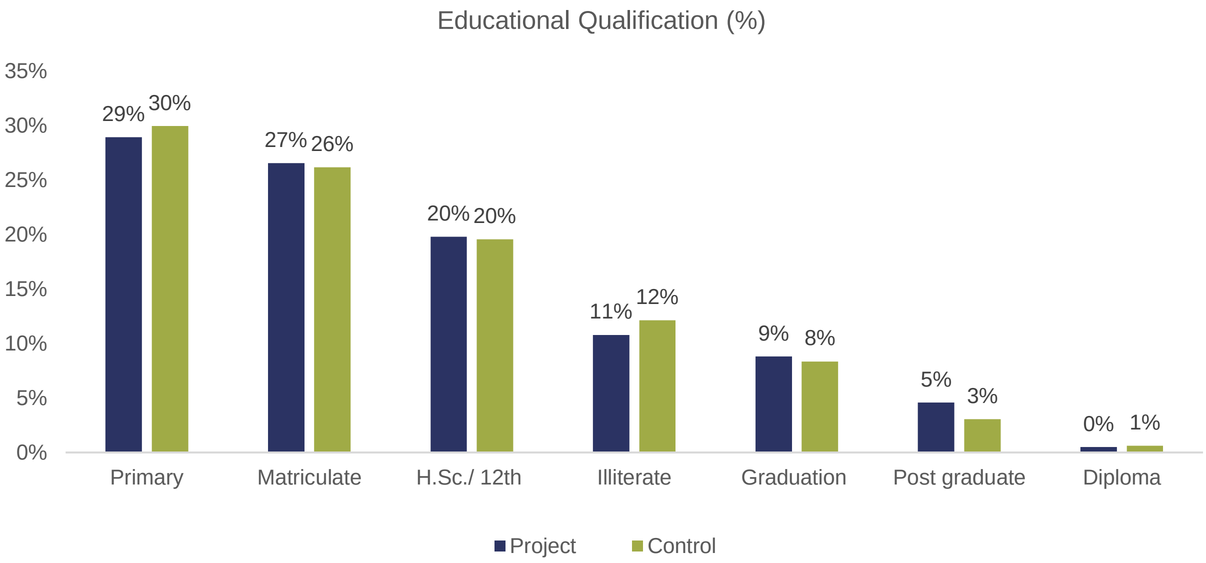

Figure 7: Distribution of Educational Qualification

In response to the question about the highest qualification attained by any other member of their household, around one-tenth of respondents in both areas reported graduation. About 5 percent reported post-graduation in the project area, and 3 percent reported graduation in the control area.

Distribution based on source of employment

When asked about employment in the endline, 72 percent of respondents in project areas and 74 percent of respondents in control areas reported that they are dependent on farming. Next to farming, agricultural laborer activity was found to be the second most important source of employment, with 8 percent of respondents in project areas and 10 percent of respondents in control areas reporting the same. This is in line with the findings from the latest trends in the Periodic Labour Force Survey (PLFS) 2022-23, which shows trends for the Labor Force Participation Rate (LFPR). In rural areas, LFPR increased from 48.9 percent in 2017-18 to 56.7 percent in 2022-23 while for urban areas it increased from 47.1 percent to 49.4 percent.[26]

Source of income

Apart from income from crop production, the respondents were also asked about their agricultural and non-agricultural income. The respondents across the project and control were asked if they were involved in agriculture-allied activities like dairy, honey, wool, etc. Overall, it was found that 19 percent (as compared to 16 percent in the midline) across the project and 16 percent (as compared to 14 percent

[26]*Periodic Labour Force Survey Annual Report 2022-23, MOSPI*
https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1966154

in the midline) across the control were engaged in dairy activity. About 5 percent (as compared to 11 percent in the midline) of respondents in the project area and 4 percent (as compared to 9 percent in the midline) of respondents in the control area reported being engaged in rearing livestock. The respondents were also asked about their income from different sources. Agriculture labor, other casual labor, and employment under Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) are the three prominent non-agri sources of income for the respondents apart from their income from agriculture.

Distribution of land ownership

As part of the endline impact assessment survey, the status of the land ownership across project and control areas was assessed. The respondents were asked if they owned or had leased land for cultivation.

Size of land owned and social category

Based on the size of their land ownership, the respondents were classified into three categories: small/ marginal farmers with land less than two hectares, medium farmers with land between two and five hectares, and large farmers with land more than five hectares. Those who did not own land or practice agriculture were categorized as landless. As can be seen from the table below, the respondent profile, more than 95 percent of respondent households in the project and control areas belonged to small/marginal farmers. Around 4 percent of respondent households owned more than five hectares of land, and the sample did not include a significant number of landless farmers. The average land owned by each respondent farmer in the project and control areas is approximately four acres.

Table 5: Size of Land Owned and Social Category

	Project				Control			
Land Size	**<2Ha**	**2-5Ha**	**>5Ha**	**Landless**	**<2Ha**	**2-5Ha**	**>5Ha**	**Landless**
Sample	3305	997	182	2	3254	1051	193	-
Percent	74	22	4	<1	73	23	4	-
Social group (%)								
General	39	36	6	-	35	31	12	-
OBC	35	39	36	50	35	41	34	-
SC	7	4	30	-	7	4	23	-
ST	5	6	13	50	7	8	19	-
NT	10	10	10	-	12	12	9	-
Others	4	5	5	-	4	4	3	-

Land ownership based on gender

For the land ownership profile of respondents by gender, it is observed that 17 percent of respondent households in the project and 15 percent in the control area had land owned only by female members. The land is in the name of both male and female members in nearly 5 percent of households in the project and 3 percent in the control area. Hence, it is evident that in the majority of households, i.e., 78 percent in the project and 82 percent in control, agriculture land is in the name of the only male member.

Beneficiaries of project

Under PoCRA, the project components benefit not only their primary target population but also other categories in the project villages. This is because besides providing matching subsidies to farmers, support was also provided to landless farmers for activities like ruminant rearing and Custom Hiring Centre (CHC). The project also aims to increase the groundwater level and water availability through community watershed interventions, like catchment treatment, drainage line treatment, and repair of old water harvesting structures, which benefit all farmers within the watershed area.

3. Achievement of Results Framework Indicators

3.1 Achievement of PDO Indicators

PDO Indicator #1: Increase in water productivity at the farm level

The concept of water productivity is mentioned by Kijne et al. (2003) as a robust measure of the ability of agricultural systems to convert water into produce. It is primarily used to evaluate the function of irrigation systems- as 'crop per drop'. It provides a diagnostic tool to identify low or high-water use efficiency in farming systems or sub-systems. Water productivity is computed on a range of scales and for different agriculture systems. Water productivity is a key project development objective indicator as part of the results framework of PoCRA.

Water productivity has been measured as yield in kg per cubic meter (kg/m3) of water provided to a particular crop based on the methodology developed by IIT- B[27]. Water productivity for different crops varies on different parameters such as per soil type, soil depth, number, and time of watering, etc. These have been considered while measuring the AET for the crops.

Water productivity has been calculated for the five main crops of the Kharif season, namely Cotton, Soybean, Pigeon Pea, Black Gram, and Green Gram. In the section below, the water productivity for each of these crops has been given for the study area. Outlier values have been excluded from the analysis by omitting the values which were outside two standard deviations. Furthermore, cases where farmers had reported no yield or crop loss have been excluded from the analysis (for both the project and control arm).

According to the PAD for this project, it is expected that the water productivity will increase by 20 percent with respect to the baseline value of 0.23 kg/m3 in the endline. However, the actual baseline value based on household survey data as estimated by M&E agencies is observed to be 0.379 kg/m3 and the actual endline value achieved was 0.41 kg/m3. Based on Table 6, we can conclude that the average water productivity in all five crops in the project area is more than in the control area with respect to the baseline survey. It was observed that the project intervention has resulted in an increase in crop production along with increased water availability and water use efficiency for irrigation which has resulted in the sustainable livelihoods of households in project areas. Since water productivity is the ratio of yield and water applied to the crops (both through rainfall and irrigation), the ratio is unlikely to record a significant change over the project period.

Table 6: Average Water Productivity (Kg/m3) for Key Crops in Kharif 2022-23

Crops	Baseline Survey		Endline Survey	
	Project	Control	Project	Control
Cotton	0.33	0.36	0.35	0.28
Pigeon Pea	0.31	0.34	0.39	0.32
Soybean	0.49	0.52	0.47	0.40
Green Gram	0.27	0.27	0.41	0.29
Black Gram	0.23	0.31	0.30	0.29
Overall	**0.38**	**0.41**	**0.41**	**0.34**

[27] *Detailed methodology presented in Annexure*

PDO Indicator #2: Improved yield uniformity and stability

Spatial yield variability of Soybean and Pigeon Pea

One of the key results framework project development objective indicators is the Coefficient of Variability (CV) which is an important indicator of climate variability. The lower the CV, the lower the variability of yield. The project aims to bring down the yield variability, thus giving stability to crop production and thereby reducing climate vulnerability. The baseline spatial variability was calculated at the start of the project. The total area under production for each crop grown by farmers and the total production from that crop has been recorded based on farmer responses during the household survey. To calculate the spatial variability of crop yield, the team calculated its productivity which is the ratio of total production (in quintal) to the total area under production (in acres).

Being Kharif and mostly rainfed, these crops are highly sensitive to variations in temperature and rainfall. As per the Maharashtra SAPCC, an increase of 1-4 °C temperature results in a reduction in soybean yield by 11 to 36 percent. In another study, it was reported that there was a significant decrease in soybean yield when the rainfall receded during the initiation of flowering to the maximum pod stage. The yield reduction was 56 percent when a drought spell of around 2 weeks occurred during the mid-vegetative stage. Similarly, the Pigeon pea is highly sensitive to temperature and rainfall variations, thereby requiring better irrigation and climate-resilient varieties. The PoCRA project is conceptualized in a robust manner considering the above factors and hence the activities have been designed to increase climate resilience through a holistic approach.

Spatial yield variability endline values for project and control villages have been calculated and reported in this section. Both spatial and temporal yield variations have been calculated. This indicator measures the coefficient of variation for yields of Soybean and Pigeon Pea across 15 project districts (spatial variability: CV-S). The coefficient of variation (CV) is defined as the ratio of the standard deviation to the mean:

$$\textbf{CV-S = SD}(\sigma) \textbf{ / Mean } (\mu)$$

The coefficient of variation has been calculated using yield data obtained from endline households survey using the CAPI application. Area (in acres) and production (in quintals) were recorded during the survey for major crops in the project and control area. Yield values for Soybean and Pigeon Pea have been calculated from the recorded data. The estimation is done on values of yield which are within one standard deviation thereby excluding outliers from our analysis.

The baseline during the project design phase was based on the secondary data available at a higher aggregate level i.e. at the district level. The revised methodology enabled us to collect yield data at a disaggregated level i.e. household level.

Table 7: Spatial Yield Variability of Soybean and Pigeon pea

Crop	Sample	Mean (Quintal/ Acre)	Std. Dev.	Coef. of Variation
Soybean				
Project	1780	6.30	1.87	**30**
Control	1756	5.35	2.15	**37**
Pigeon Pea				
Project	135	6.23	3.21	**52**
Control	133	5.63	3.02	**54**

The coefficient of variation for spatial yield variability is calculated using the data on the total area under production for each crop grown by farmers and the total production from that crop, based on farmer response. The productivity is calculated as the ratio of total production (in quintal) to the total area under production (in acres). Subsequently, the coefficient of variation was calculated by dividing the standard deviation of productivity by the mean of productivity (i.e., CV = standard deviation S/ mean X) for the specific crops. The survey methodology at baseline and endline enabled us to collect yield data at a disaggregated level i.e., household level. It is observed that the CV for Soybean and Pigeon Pea at the household level is 30 percent and 52 percent which is less than the baseline value of 36 percent and 66 percent, respectively, in the project village. This trend in CV reduction is close to the projected CV values of 29 percent for Soybean and 51 percent for Pigeon Pea as per RFID in the PAD.

a. Graphical representation of baseline to endline target and achievement of spatial variability of Soybean

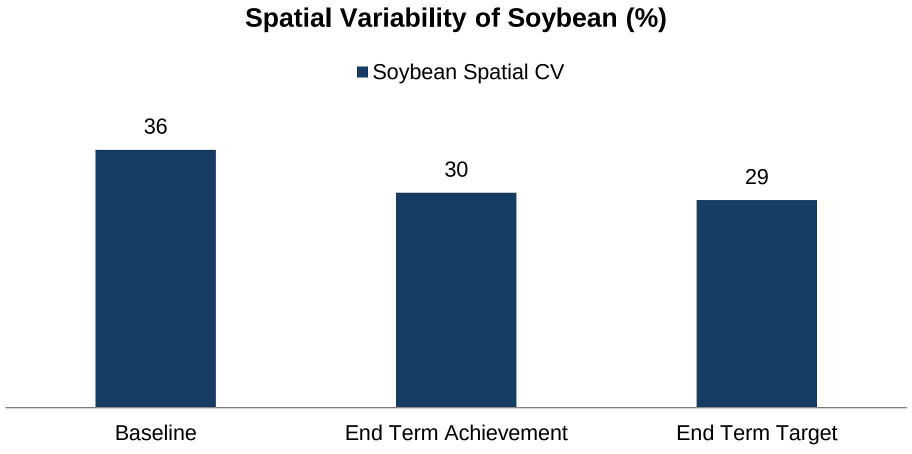

Figure 8: Spatial Variability of Soybean

b. Graphical representation of baseline to endline target and achievement of spatial variability of Pigeon pea

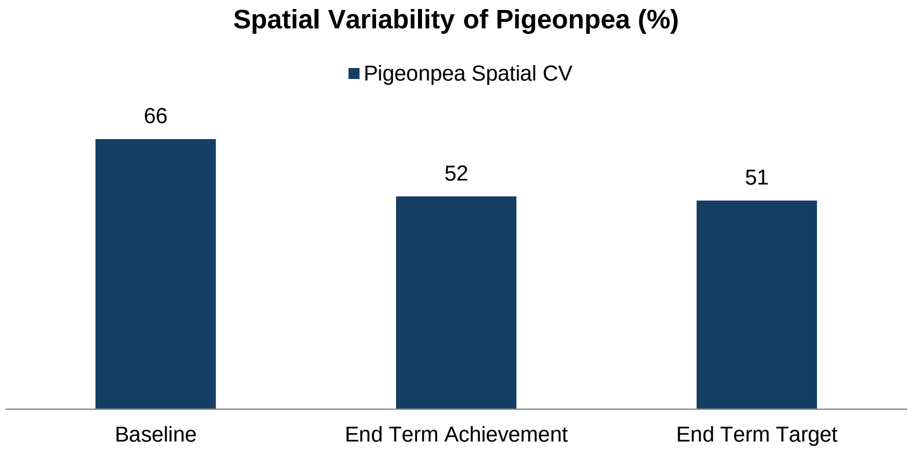

Figure 9: Spatial Variability of Pigeon Pea

Temporal yield variability of Soybean and Pigeon Pea

Temporal variability is determined by calculating the temporal coefficient of variance (CV T) for the crops of interest (Soybean and Pigeon Pea) using secondary production data. During the baseline as well, temporal variability has been calculated using the secondary productivity data available at the Maharashtra Department of Agriculture website (http://krishi.maharashtra.gov.in/1238/District-Level). The provisional values of CV T for Soybean and Pigeon Pea were estimated to be 37 and 48, respectively. These estimates are recalculated and finalized as presented in table below:

Table 8: Temporal Yield Variability of Soybean and Pigeon pea

Crop	Years for which CV T calculated	Mean	Std. Dev.	Coef. of Variation
Soybean	**2017-18 to 2023-24**	**1167**	**325**	**28**
Pigeon Pea	**2017-18 to 2023-24**	**843**	**353**	**42**

a. Graphical representation of baseline to endline target and achievement of temporal variability of Soybean

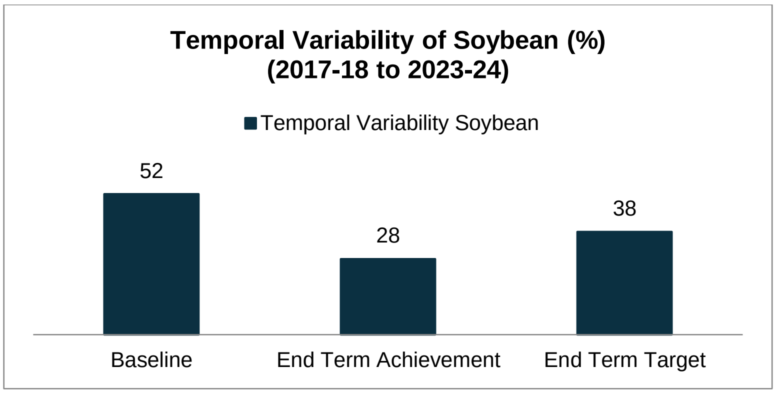

Figure 10: Temporal Variability of Soybean

b. Graphical representation of baseline to endline target and achievement of temporal variability of Pigeon Pea

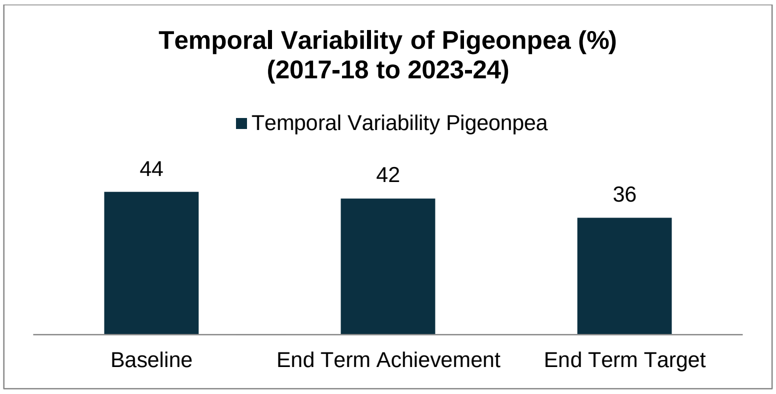

Figure 11: Temporal Variability of Pigeon Pea

The increase in variability in Pigeon pea (42 percent) as against the end target (36 percent) is attributed to the variation in rainfall distribution and temperature across the districts, incidences of diseases/pests, cultivation and management practices adopted by the farmers across the 15 districts of project implementation. In some of the districts, it is observed the amount of rainfall during September was low as compared to normal rainfall resulting in increased CV value at that location.

The detailed tables of the productivity of Soybean and Pigeon Pea are provided in **Annexure-3.**

PDO Indicator #3: Net greenhouse gas emissions

In the PoCRA project, the focus is largely on building resilience in agriculture and allied sectors to climate variability, droughts, and long-term climate change. The PoCRA project aims to enhance climate resilience and profitability of smallholder farming systems in the drought-prone semi-arid regions of Maharashtra. It is proposed to incorporate improved agronomic, water and nutrient management, agroforestry, etc. to build resilience in semi-arid agriculture while reducing GHG emissions and enhancing carbon stocks.

Results of the GHG balance analysis

The ex-ante carbon balance tool (ver 9.0) was used to estimate GHG emissions from the project area with different project activities. This tool quantifies the amount of greenhouse gas released or sequestered from agricultural production. The entire project area, which is around 3.8 million hectares distributed across 15 districts in Maharashtra, had its GHG emissions from project operations calculated.

A total of 14 years of project capitalization period, when project benefits will be continued, was taken into account during the GHG emission estimation. The impact of project activities on GHG balance including emissions from inputs in the form of fertilizers, pesticides, and energy use (electricity and diesel consumption) is summarized in Table 8. The ex-ante estimation of the GHG balance using tier 1 for the PoCRA project is shown to be negative, which means the project implementation will lead to a net carbon sequestration benefit. The main sources of GHG emissions are inputs such as electricity, diesel, and livestock-rearing activities under the project.

The total simulated project area is ~3.1 million ha (based on the input from land use change, cropland, and inland water bodies (exact value is 3124426 ha), which is within the total geographic area of project villages in 15 districts.

Table 9: Greenhouse Gas Balance of Project Activities under the PoCRA Project in Maharashtra

Project Components		GHG emission tCO2 e/yr		
		Control	Project	Balance
Land use changes	Deforestation	3645372	23,86,477	-12,58,895
	Afforestation	0	-5,77,151	-5,77,151
	Other land-use	-10406	-2,24,803	-2,14,397
Cropland	Annual	1128069	11,05,374	-22,695
	Perennial	-164981	-3,64,531	-1,99,550
	Livestock	342	1650	1308
	Inland wetlands	6222	20464	14242
	Inputs & Invest.	1,58,64,059	1,48,92,778	-9,71,280
Total GHG emission tCO2-e/yr		**20468676**	**17240258**	**-3228417**
Total emissions, tCO2-e/ha		**131.0**	**110.8**	**-20.7**
Total emissions, tCO2-e/ha/yr		**6.6**	**5.5**	**-1.0**

All other interventions are projected to contribute to increasing carbon stocks in soil and tree biomass. Achieving an increase in carbon sequestration is an important benefit of the PoCRA project. The net GHG benefit on a per-hectare basis for the project area is estimated to be 20.7 tCO2 over 20 years and 1.0 tCO2/ha/year.

During the baseline estimation CO2 eq GHG sequestration in the project area was estimated as 1.7 tCO2/ha/year and 34 tCO2 eq GHG sequestration per ha. However, a study reported annual CO2 sequestration per hectare in soil ranges between 0.5 to 1.28 t/ha.[28]

Thus, there will be an annual average CO2 sequestration of **3228 ('000 tonne/ annum)** in the project area during the 20 years as seen in Table 8.

The details of the assumptions and methodology are presented in **Annexure-4.**

PDO Indicator #4: Net Farm Income

Farm income is another key results framework project development objective (PDO) indicator to evaluate the impact of PoCRA. Farm income is defined as the net farm income calculated as the sum of net income from crops (gross income from all selling crops i.e., total quantity of each crop sold multiplied by the average price received minus the total cost incurred through the agriculture life cycle in production and selling of crops) and net income from agriculture-allied activities (gross income from sale of produce minus costs of production). The survey team and experts calculated the farm income for values lying within 3SD (99 percent) of the sample, thereby excluding outliers from our analysis.

During the Endline Evaluation, the Crop production cycle of FY 22-23 is considered to calculate the net farm income of the Households. All the major crops grown by the farmers and allied enterprises taken up by sampled farmers have been analyzed and the net farm income is described

The mean annual farm income in the project arm is Rs. 75395 (N = 3527), compared to Rs. 51701 (N = 3824) in the control arm. Overall, Net farm income is higher by 46 percent in project areas in contrast to the control area. The net farm income comparator was calculated as the ratio of the net farm income of the project area to the net farm income of the control area, which was 1.46. This shows that the project interventions led to a substantial increase in farm income in the project area.

Further, as required in the PAD document, farm income is also calculated separately for male and female-headed households at baseline, midline, and endline to see the impact of PoCRA on these different types of households. When the ETR survey team looked at the mean farm income of men and women-headed farmer households, it was found that the mean net farm income of women-headed households (N= 471) in project areas has significantly improved to Rs. 61001 in contrast to Rs. 44155/- (N = 390) in the control area. In contrast, the average net farm income of male-headed households was found to be Rs. 77084/- (N = 4,015) in the project area and Rs. 51468/- (N = 4,108) in the control area. Further, there has been an increase of 38 percent in net farm income in women-headed households and an increase of 50 percent in men-headed households in project areas.

Table 10: Increase in Net Farm Income of Male and Female-Headed HHs

Category	Income (Rs.) in Project	Income (Rs.) in Control	Comparator
Overall	75395	51701	1.46
Male-Headed	77084	51468	1.50
Female-Headed	61001	44155	1.38

[28] *(DOI, 10.1038/s41598-017-15794-8)*

PDO Indicator #5: Farmers reached with agricultural assets/ services

This indicator tracks the number of farmers who have benefitted from agricultural assets or services provided by the project. While assets encompass goods and works related to agricultural technology, agronomic practices, farm machinery, processing equipment as well as infrastructure, services are inclusive of research, extension, training, ICTs, inputs like fertilizers, pesticides, labor, Agro-met advisories, etc.

Efforts relating to improved production like soil and water testing alongside irrigation and drainage, enhanced market linkages, access to farm and post-harvest machinery, storage facilities, and finance further ensure holistic dissemination of services.

With respect to access to agricultural assets, equal emphasis has been laid on both pre-harvest as well as post-harvest structures and services. The project has established numerous custom hiring centres so that small and marginal farmers are able to access the costly machines on rent to achieve desired farm productivity without compromising soil health and water use efficiency. Efforts have been made to support the creation of seed hubs linking FPOs, universities, and other public sector players like Mahabeej and the private sector. Post-crop harvest, the project endeavored to not only support existing godowns/ warehouses for transit storage but also aid construction in the project area where the absence of such structures was keenly felt. A key instrument for the establishment of such godowns/ warehouses is the FPC/FIG/SHGs. These entities are also integral for the establishment of aggregation centres with sorting, grading, weighing, and packaging facilities available to the beneficiary farmers.

The MIS data highlights the fact that the indicator presents a robust implementation of the project's operations which reached out to 1365233[29] farmers at the endline. This included 354960 (26 percent) female farmers who were beneficiaries of assets and services.

3.2 Achievements of Intermediate Results Indicators

Farmers adopting improved agricultural technology

A set of 35 climate-resilient agriculture technologies were promoted through the PoCRA project, with a view to bringing efficiency, sustainability, and cost-effectiveness to agricultural operations. At the baseline, 25 percent of farmers from the project and 21 percent from control areas reportedly received training on any one of these technologies. On enquiring about the adoption status, 43 percent from the project area and 41 percent from the control area stated adopting at least one of these climate-resilient agriculture technologies.

During the endline, these figures grew appreciably, with 81 percent of farmers from the project and 63 percent from control geographies reporting that they received at least one training on any one of the 35 technologies. With respect to the adoption status, a significant change could be discerned with 82 percent of farmers from project areas and 69 percent from control regions reportedly adopting at least one of these climate-resilient agriculture technologies. Upon closer examination, data highlighted a significant improvement in CRAT technology adopters at the endline (82 percent) compared to baseline (43 percent), with a percentage change of 39 percent in favour of project farmers. In sharp contrast, among control farmers, the adoption rate increased by only 28 percent i.e., from 41 percent at baseline to 69 percent during the endline. Thus, a difference of 9 percent is recorded between the project and control areas, in terms of farmers trained and practicing CRAT technology, showcasing the project's vital intervention.

Crucially, the above figures do not elucidate the unique practitioners of CRAT i.e., individuals who started practicing CRAT technologies only after receiving training and extension services through the PoCRA project and adopted them during the project's implementation period i.e., owing to several farmers adopting multiple such technologies, testifying to the project's immense efforts. Further analysis

[29] *Based on MIS data*

revealed that about 61 percent of project farmers are uniquely trained adopters of CRAT technology during endline.

Treating this 61 percent of uniquely trained adopters of CRAT technology as a benchmark, extrapolation was undertaken to ascertain the total proportion of farmers adopting CRAT technology across all PoCRA regions, with exemplary results on display i.e., an exponential rise in CRAT adopters (1079700[30]) is evident at the endline.

Further, specifically among the women farmers in the project area, the adoption rate is found to be 56 percent. Of the beneficiaries who adopted CRAT technology, 153560 are women farmers, accounting for 14.22 percent of the total farmers adopting CRAT across all regions serviced by PoCRA. This is a momentous achievement in terms of CRAT adoption. The key reasons behind this success include the institutionalization of a demand-driven model whereby farmers voice their needs, and a robust supply mechanism ensures the provision of these need-based CRAT technologies. Also, frequent conduct of training and capacity-building sessions of high quality through farmer's field school demonstrations have popularized the adoption of climate-resilient practices among farmers. Farmers, on their part, have shown interest, enthusiasm, and a desire to evolve in trying to learn about these new-age, scientific technologies before adopting them wholeheartedly.

Table 11: Training and Adoption of at least one CRAT in Project and Control Areas during Endline

Parameter	Project	Control
Total Sample (N)	4486	4498
Sample with no CRAT Training	849	1661
Sample with no CRAT Adoption	804	1364
At least one CRAT Training	3637	2837
At least one CRAT Adopted	3682	3134
At least one CRAT Training – Endline	81 %	63 %
At least one CRAT Adopted – Endline	82 %	69 %
At least one CRAT trained and adopted	61 %	16 %
At least one CRAT Training – Baseline	25 %	21 %
At least one CRAT Adopted – Baseline	43 %	41 %
Percentage change from Baseline to Endline		
At least one CRAT Training	56 %	42 %
At least one CRAT Adopted	39 %	28 %

Area provided with new/ improved irrigation or drainage services

This indicator measures in hectares the total area of the land provided by the project with new or improved irrigation and drainage services. The information for this indicator is sourced from the project MIS-based data. The target area for this indicator at the end of the 6 years (endline) was 624000 hectares while the achieved area for the endline stood at 667902 hectares. In essence, the “area provided with new/ improved irrigation or drainage” indicator proved to create a high impact on the project and became a success.

[30] *Based on MIS data*

Improved availability of surface water for agriculture

This indicator measures the surface water storage capacity created due to the project-supported farm and community ponds. The indicator is reported in $1000m^3$ and information for this indicator is sourced from the project MIS data. The endline achievement is reported as 30375 TCM.

Area with GAPs for improved management of saline and sodic soils

This indicator tracks farm production area in hectares where Good Agricultural Practices (GAPs) are applied by farmers to improve the management of saline and sodic soil. This includes improved agronomic practices, water lifting devices, farm ponds, and micro irrigation systems. GAPs are demonstrated and support to farmers is given through various activities in project villages such as leveraging FFS, other project interventions, and individual benefits from project-supported activities. The total area under saline and sodic soils (Kharpan) across 932 villages is 362587 Ha. Of which, GAPs are adopted on 146826 Ha against the target of 127600 Ha based on the endline survey.

Regarding the adoption of GAPs in Kharpan villages, respondents were asked how they managed to overcome the soil salinity-related issues in their field. Out of 317 respondents, about 18 percent indicated the application of a balanced dose of Nitrogen, Phosphorus, and Potassium (NPK) as the most common approach to managing soil salinity as proper nutrient management helps plants withstand saline conditions better. It was followed by the adoption of micro irrigation such as drip and sprinklers (16 percent). Close to the balanced NPK application, 14 percent of respondents use micronutrients. Micronutrients are essential for plant health and help in stress tolerance. This method was quite popular, as micro irrigation helps in precise water delivery, reducing water logging and leaching of salts. Gypsum and fly ash are used by 12 percent of respondents to ameliorate soil salinity. These materials help in soil structure improvement and salt leaching.

Natural Resource Management (NRM) works were used by 7 percent of respondents. The area treatment like graded bunding has helped farmers to cope with the problem of salinity. Also, it is important to note that only 2 percent of respondents have not taken any measures to address soil salinity.

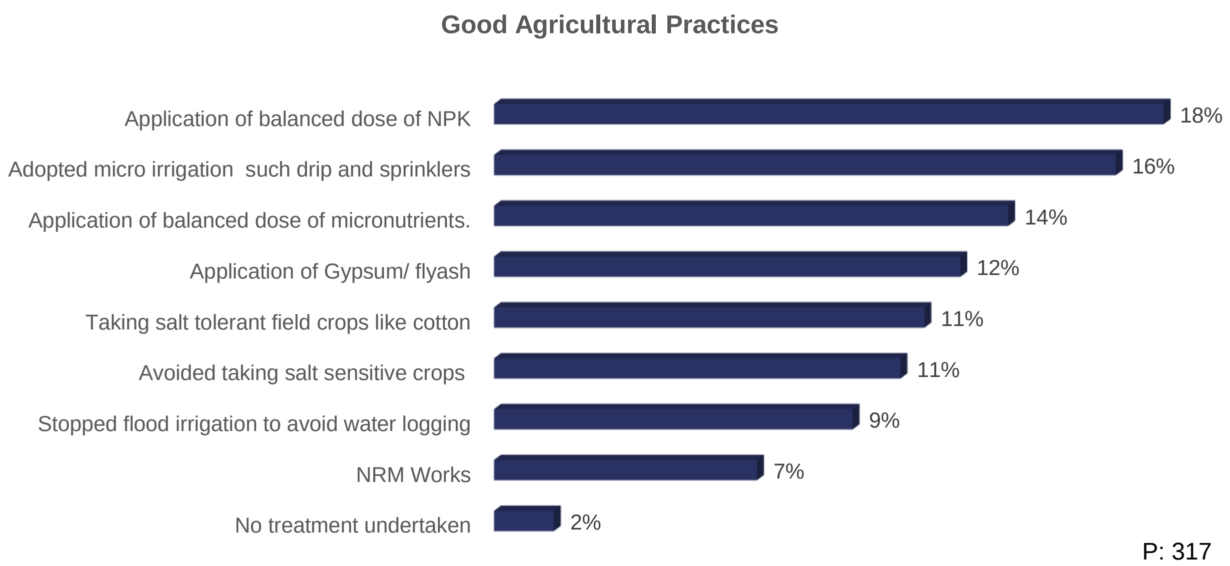

Figure 12: Good Agricultural Practices by Project Farmers during Endline

Seeds supply: Promotion of climate-resilient crop varieties

This indicator measures the share of production area in the project with oilseeds and pulses, that are cultivated using certified seeds of improved varieties. This indicator tracks the progress made on the use of these climate-resilient varieties, specifically for Soybean (Oilseeds), Pigeon Pea, and Chickpea (Pulses). This indicator is reported in percentage of the total area grown for these three crops.

As part of the endline survey farmers were asked about the certified seed of improved variety used currently for three major crops. A list of improved varieties with certified seeds was obtained from PMU and coded as part of the questionnaire being used for major crops grown in the study area across 15 districts. Further, farmers were also asked about the area under the improved certified seeds of climate-resilient variety and the total area under cultivation.

The values for three major crops, Soybean, Pigeon Pea, and Chickpea were calculated using the formula:

Area under Certified Seed of Improved Variety (%) =
Total Area (Crop-wise) under Certified Improved Seeds/ Total Area (For three crops)

It is essential to develop climate-resilient varieties of major crops to adapt to changing climates and weather variations. The endline target was 86 percent. This target has been surpassed with an achievement of 89 percent.

Farmers became more aware of the benefits of using certified varieties through project interventions. This led to sustainable yields despite the challenges of rainfed agriculture, such as late onset of rainfall, prolonged dry spells, intense rainfall, and pest and disease infestations. The improved varieties are superior in terms of yield, short maturity, drought tolerance, resistance to diseases and pests, and improved quality and nutritional aspects (e.g., bold seed, high oil content, high protein/vitamin content). These advantages encouraged farmers to adopt the certified seeds on a large scale from the beginning to the end of the project period.

Number of projects supported FPCs with growth in annual profit

As of date, 1187 unique Farmer Producer Companies (FPCs) were supported under the agribusiness component of PoCRA. All these FPCs had audit reports for at least one year before they were supported. However, to include the FPCs for the assessment of RFID which is the number of projects supported FPCs with growth in annual profit, their two consecutive years of audit reports were needed. Of the total 1187 unique FPCs, 345 FPCs received disbursement till FY 2021-22, 571 FPCs received disbursement in FY 2022-23, and 271 FPCs received disbursement in FY 2023-24.

As for the financial year 2023-24 audit reports will not be available before June- August 2024 and to measure the growth of FPCs two consecutive year audit reports after disbursement are needed. Hence, FPCs that received support in FY 2022-23 and 2023-24 have been excluded from the assessment. Those FPCs that were supported by the end of FY 2021-22 (i.e., by 31st March 2022) are eligible for inclusion in the assessment. Hence, the total number of FPCs that are eligible for scrutiny for assessment of RFID is 345. From the 345 eligible FPCs, audit reports of 108 FPCs were not received as of the date of the publication of the report. So, for the final analysis, the audit reports of 237 FPCs (out of 345 eligible FPCs) have been scrutinized for assessment.

The scrutiny of audit reports of 237 FPCs shows that 150 FPCs (nearly 63.29 percent) had registered growth in at least one financial year after the project support from PoCRA. Out of the 150 profitable FPCs, 124 are from the Marathwada region and 26 of them are from the RoPA region.

Given that 108 audit reports were not received at the time of writing this report, extrapolation has been done to arrive at the final figure for this indicator. Of the 237 FPCs, 150 FPCs have exhibited a growth in annual profits (63.29 percent). Thus, we have assumed that 63.29 percent (out of 108) of the audit would also show a growth in annual profits. Based on this, 68 FPCs would show a growth trend for which audit reports have not been received, when we add these 68 FPCs to the actual profit-making FPCs, the total is 218 FPCs reporting annual growth in profits.

Table 12: Assumption and Extrapolation for Estimate of Profitable FPCs

Particulars	Total FPC	Number of FPCs that showed growth in profit	Percentage of FPCs that showed profit growth
FPC for which Audit Reports was received	237	150	63.29
Remaining FPC	108	68	63.29
With Extrapolation	345	218	

Strategic Research and Extension Plans (SREPs) with internalized climate resilience agenda

With an internalized climate resilience agenda, the Strategic Research and Extension Plan (Climate Resilience Agriculture Supplement) for 15 districts has been meticulously prepared using science-based inputs from various technical institutions such as KVKs, universities, and CRIDA. This plan is enriched with the general and agricultural profiles of the districts, detailing the impacts of climate variability on agricultural production, coping measures, and climate resilience technologies developed and followed by farmers. It includes a comprehensive plan for weather-related contingencies, agro-meteorological advisories available at the district level, and an assessment of the status, constraints, and potential for developing commodity-wise agricultural value chains.

The plan also outlines extension strategies for climate change adaptation, encapsulated in the 'Village Adaptation Plan.' This includes detailed plans for water security, soil health, water budgeting, market demand, carbon sequestration, cost reduction in production, conservation and production of climate-resilient seed varieties, adoption of climate-resilient technologies, integrated pest management, integrated nutrient management, and integrated farming systems. Additionally, the plan addresses strategies to cope with weather-related contingencies, strengthen commodity value chains, and ensure the convergence of government programs with the extension plan. It includes a monitoring mechanism and strategies for periodic review and improvement. This comprehensive plan will be available online on the project website under the village profile, 'Gram Krishi Vikas Darshika,' to facilitate updates according to evolving strategies, research, and extension planning in the district for future use and necessary adjustments over time.

Clients receiving services for MH CIC

The purpose of the proposed CIC was to act as a knowledge hub, and climate-resilient incubator to ensure strategic partnerships between Government institutions, line departments, the private sector, and academia towards scaling up climate-resilient agriculture in Maharashtra.

PoCRA tied up with a knowledge partner and developed a draft feasibility report that examined various institutional arrangements, financial arrangements, and key offerings of CIC. Recognizing that a formal CIC would involve multi-disciplinary, multi-sectoral, and multi-departmental coordination, PoCRA has decided to refer the way forward to the Government to deliberate upon various options present in the report. However, while the project could not succeed in establishing a formal CIC, it may be noted that PoCRA functioned as a mini-CIC at the cross-section of agriculture and climate resilience by steering a robust consortia approach to help create and disseminate a large number of knowledge services.

PoCRA as a Mini- CIC

1) Use of a large number of APIs from weather, revenue / land, Agri Produce Market committees, warehouse authorities, etc. to provide weather advisories, price information, storage information, etc. to the farmers and other stakeholders.
2) Collaborating with ICAR agencies such as NBSS, CRIDA, IASRI to develop and disseminate various knowledge products based on needs of farmers.
   a. Engagement with ICAR-NBSS to create & disseminate knowledge and advisories about soil parameters & soil health
   b. Engagement with ICAR- IASRI to develop pest & disease detection service solution based on image recognition technologies using AIML tools
   c. Engagement with ICAR-CRIDA to determine climate vulnerability of the mini-watershed clusters in the project districts
3) Collaboration with SAUs to develop the crop coefficients (Kc) values of various crops by conducting Lysimetric studies
4) Developing and disseminating water budget tool through a technological partnership with IIT Mumbai to ensure better crop planning and Natural Resources Management.
5) Collaborating with start-ups such as Kheti Buddy to handhold the farmers for regenerative agriculture focusing on zero tillage farming.
6) Use of language learning models to try and develop a farmer's chatbot.
7) Engagement with progressive farms such as Saguna Bag for capacity building and exposure visits for farmers to understand the concept of reduced tillage and zero tillage.
8) Engagement with Farmer Producer Companies for establishment of agribusinesses and climate resilient farming systems.

Figure 13: PoCRA as Mini-CIC

Beneficiary participation and civic engagement: Approved participatory mini watershed plans implemented

A total of 138 Cluster development plans (CDPs) were prepared during the first phase of the project. It was later realized that village-level plans were more suited for execution. Hence the project focused on preparing village development plans. Accordingly, participatory micro-level planning was conducted at the village level and a total of 5043 Village Development Plans were prepared and duly approved by District Coordination Committee chaired by District Collector.

3.3 Results Framework Matrix

Following a baseline evaluation in October 2019 in Marathwada and October 2020 in the Rest of Project Area (RoPA) region, a midline evaluation was conducted in December 2021 to assess the project's impact. This evaluation measured progress on Results Framework (RF) indicators and identified areas for course correction. The RF indicators at the PDO level are largely on track, with some exceeding the projected mid-term review targets. Consequently, the endline target values of several PDO indicators, including water productivity, spatial yield variability of soybean and pigeon pea, and the area under certified seeds, have been revised. The same has been presented in the table below:

Table 13: Revised RFID Indicators and Targets

Indicator	Original baseline value (As per PAD)	Revised baseline value	Original endline target (As per PAD)	Revised endline target
Increase in Water Productivity at farm level in Percentage (Kg.m-3)	0.23	0.38	0.276	0.45
Improved yield uniformity and stability in Percentage (CV)-Spatial-Soybean	30	36	23	29
Improved yield uniformity and stability in Percentage (CV)-Spatial-Pigeon pea	39	66	30	51
Seed supply: Promotion of climate-resilient crop varieties (%)	28	64	35	86

Table 14: Result Framework Matrix

Result Framework Matrix					
Indicator Name	**Baseline Value**	**Midline Target**	**Midline Achievement**	**Endline Target**	**Endline Achievement**
PDO Level Indicators					
1. Climate Resilient Agriculture: Increased Water Productivity: Water Productivity - kg. m^{-3}: Ag. Production/ Water Consumption (Change relative to baseline: %)					
	0.38		0.382	0.45	0.41
2. CRA: Improved Yield Uniformity and Stability: Spatial and Temporal Yield Variability for Oilseeds and Pulses (%)					
Soybean	CV-S: 36 CV-T: 52		CV-S: 31 CV-T: 33[31]	CV-S: 29 CV-T: 38	CV-S: 30 CV-T: 28
Pigeon Pea	CV-S: 66 CV-T: 44		CV-S: 54 CV-T: 42	CV-S: 51 CV-T: 36	CV-S: 52 CV-T: 42
3. GHG Accounting: Carbon Sequestration and Greenhouse Gas Emissions Reduced: Net GHG Emissions (in '000 tCO_2eq/yr)					
	-233		-1971[32]	-4789	-3228
4. Annual farm income: Farm Income Comparator (Total; Male & Female landholders) (As ratio with/without project)					
Total	1.00	1.20	1.12	1.50	1.46
Male	1.00	1.20	1.17	1.50	1.50
Female	1.00	1.20	1.11	1.50	1.38
5. Direct Project Beneficiaries					
Number of Farmers reached with Agricultural Assets or Services (% Female)					
	0			1320000 (35%)	1365233 F- 354960 (26%)

[31] As per PAD, the temporal variability was to be estimated at endline, however midterm values for temporal yield variability of soybean and pigeon pea were calculated.
[32] As per PAD, GHG accounting was to be done only at the endline, however the midterm estimates were calculated.

Result Framework Matrix					
Indicator Name	**Baseline Value**	**Midline Target**	**Midline Achievement**	**Endline Target**	**Endline Achievement**
Intermediate Outcome Indicators- Component A: Promoting Climate-Resilient Agricultural Systems					
6. CRA: Farmers Adopting Improved Agricultural Technology					
Farmers adopting improved agricultural technology promoted (% female)	0	719800 F: 201000 (28%)	659205 F: 105911 (16%)	1272800 F: 446000 (35%)	1079700 F: 153560 (14%)
7. CRA: Improved Water Use Efficiency at Farm Level					
Area provided with new/ improved irrigation or drainage services (in ha)	0	200000	381157	624000	667902
8. CRA: Improved Availability of Surface Water for Agriculture					
Surface water storage capacity from new farm and community ponds (in $1000m^3$)	0	56000	23864	83900	30375
9. CRA: Enhanced Soil Health at the Farm Level					
Area with GAPs for improved management of saline and sodic soils (in ha)	0	66000	57699	127600	146826
Intermediate Outcome Indicators- Component B: Climate-Smart Post-Harvest Management and Value Chain Promotion					
10: Seed Supply: Promotion of Climate-Resilient Crop Varieties					
Production area under cultivation w/certified seeds for Oilseeds (Soybean), and Pulses (Pigeon Pea, and Chickpea) of improved varieties (share %)	64		86.40	86	89
11. Farmers Producer Companies: Strengthened and Financially Sustainable FPCs					
Number of project-supported FPCs with growth in annual profits	0	55	30	200	218

Result Framework Matrix					
Indicator Name	**Baseline Value**	**Midline Target**	**Midline Achievement**	**Endline Target**	**Endline Achievement**
Intermediate Outcome Indicators- Component C: Institutional Development, Service Delivery, and Knowledge for Climate-Resilient Agriculture					
12. Research and Extension: Mainstreaming Climate-Resilience in Agriculture Research and Technical Advisory Services.					
Number of updated districts SREPs with internalized climate resilience agenda (Out of 15)[33]	0			15	15
13. Climate Innovation Center: Private Sector Participation[34]					
Number of clients (FPOs, SMEs) receiving services from the CIC	0			200	
Cross-Cutting Indicators					
14. Beneficiary Participation and Civic Engagement					
Number of approved participatory mini watershed plans implemented/under implementation.	0	670	138	670	138 CDP (5043 VDP)[35]

The sections below offer an in-depth exploration of each project component, including their respective subcomponents. It provides concise descriptions of each component, highlighting the expected outputs and the resultant impacts. The readers will gain a comprehensive understanding of the project's multifaceted approach, appreciating the detailed planning and strategic implementation underpinning each element. By elucidating the interconnectedness of components and their contributions to the overarching goals, the following sections underscore the project's holistic vision.

[33] The document is prepared by the Project Director (ATMA) in consultation with the field functionary of the Department of Agriculture, State Agriculture Universities (SAUs), Krushi Vigyan Kendra's (KVKs), Farmers, Farmer Producer Organizations from the district. The SREP supplement contains an account of weather analysis, information about cropping pattern, impact of climate change on crop yields, coping mechanisms adopted by the farmers, adoption level of climate resilient technologies, constraints in marketing of agriculture produce and scope for value chain development. The SREP supplement ends with comprehensive template for village adaptation plan which will act as guide for the agricultural extension workers. It will be helpful carrying out extension of climate resilience technologies.

[34] PoCRA functioned as a mini- CIC and detailed explanation given in the above section.

[35] Total of 138 CDP was prepared during the first phase of the project. Participatory micro level planning conducted at village level and the total number of 5043 village development plans prepared, duly approved by District Coordination Committee chaired by District Collector.

4. Component A- Promoting Climate Resilient Agricultural systems

4.1 Participatory Development of Watershed Plans

The project embeds a decentralized, decision-making structure in the existing robust Panchayati-Raj structures. This ensured that decision-making was democratic, people-centric, and not department-centric. By giving the first right of beneficiary identification to the VCRMC, transparency mechanisms, and social audits were automatically triggered. The villages themselves were empowered to choose beneficiaries, plan for Natural Resource Management (NRM), disseminate resilient techniques, and resolve disputes.

The project has established 3959 fully functional VCRMCs (under the Maharashtra Village Panchayat Act, 1959) in 5220 villages, engaging around 50000 members in decision-making at the village level in project areas. The scale ensures the sustainability of the intervention, resulting in mobilizing the landless, and small and marginal farmers to participate. The VCRMCs are also involved in the social auditing function, ensuring better implementation and monitoring of the activities.

The project started by considering the social context and involving the community in planning. Micro-level plans were developed using statistics, evidence verification, and most importantly, input from the people. The plans considered demography, resources, mapping, water budget, analysis of constraints, resource and value chains, and contingency planning. Villagers focused on creating socially inclusive plans for individual farm interventions, agri-business interventions, and resource management interventions. These village-level plans were then combined into a mini watershed plan at the cluster level. In total, 138 cluster development plans and 5043 village development plans have been approved and carried out.

4.2 Demonstration of Climate-Smart Agronomic Practices (CSAP)

Farmer field schools for technology dissemination

The traditional extension system in agriculture is not without the challenges. The project responded to this by creating an innovative structure of "barefoot" facilitators, schooled in extension work, to focus on a massive extension outreach. Farmer field school has been one of the strategic and effective interventions of the project, which has brought significant improvement in the demand and adoption of climate-smart productivity-enhancing agronomic practices among farmers, resulting in the transformation of rainfed agriculture systems in project areas. FFS is a participatory and interactive on-site learning approach that emphasizes observation-based learning.

Figure 14: FFS in Progress

FFS has helped in capacitating farmers to analyze their production systems, identify issues, and adopt climate-resilient solutions most suitable to their farming systems. FFS was operationalized at the village level under the coordination of the VCRMC and with technical support from ATMA extension staff and the KVK scientists. The training for farmers through FFS mainly focused on (i) Intercropping practices, (ii) BBF and Zero tillage, (iii) Use of climate-resilient seed varieties, (iv) Integrated Pest Management (IPM), and (v) Integrated Nutrient Management (INM). To complement the FFS approach and build climate resilience in agriculture at the intended scale, the project developed an ICT strategy that centered around a common integrated platform that is easy to use (See Section C on ICT).

Farmer field school is an approach based on people-centered learning. It offers space for hands-on group learning, enhancing skills for critical analysis, and improved decision-making by local people. FFS activities are field-based, and include experimentation to solve problems, reflecting a specific local context. Participants learn how to improve skills through observing, analysing, and trying out new ideas in their fields, contributing to improved production and livelihoods.[36] It was found that the critical thinking, experimentation, and innovation skills of fellow farmers have improved. The farmers started questioning previous assumptions or cultural beliefs and reflected critically on the results of their observations and experimentation. For example, the farmers placed greater reliance on their empirical field observations of crop performance than on following the advice of village elders. It was also found that the farmers are changing their attitude towards conserving water and soil. The FFS helped farmers to gain confidence in their farming activities. The participating farmers became more motivated and proactive in their planning. All the farmers who followed FFS gained more confidence, demonstrated through interactions with others, including the outsiders. The farmers reported that they experience reduced shyness after the FFS, with a better ability to express themselves.

FFS leads to better knowledge about natural resources management. For instance, participating farmers' decision-making on pest management is based on field analysis and personal observations. Most of the farmers observed and monitored their farms more closely after attending FFS, making management decisions based on field observations. The FFS focused on the transfer of Climate Resilient Technologies through a total of 37184 Farmer Field Schools conducted across 4800 villages during the project period. The total number of host farmers who participated in FFS is 15501, of which 15 percent (2327) were female. The number of guest farmers who participated was 490780, of which 14 percent (67644) were female.

Enhancement in carbon sequestration

Agroforestry

Agroforestry under the PoCRA project in Maharashtra emphasizes integrating trees and shrubs with traditional farming practices to enhance biodiversity, improve soil health, and increase carbon sequestration. This sustainable land-use system combines agricultural crops with tree cultivation, providing multiple benefits such as improved soil fertility, reduced soil erosion, and enhanced water retention. By promoting agroforestry, PoCRA aims to create more resilient agricultural ecosystems that can better withstand climate variability. This approach not only boosts agricultural productivity but also contributes to climate change mitigation by capturing and storing carbon dioxide. Agroforestry practices help diversify farmers' income sources through the production of timber, fruits, and other tree-based products, thereby enhancing economic stability. Through these efforts, PoCRA fosters a sustainable agricultural landscape that benefits both the environment and farming communities. The total amount disbursed under this component was Rs. 1.31 Cr. The total number of beneficiaries supported through support for agroforestry during the project implementation period was 1033 covering the total land area of 613 hectares.

Practicing agroforestry will help recharge groundwater, avoid soil erosion and degradation, and lessen the impact of natural disasters. It will reduce poverty, provide food security, produce money, and empower tribal communities and rural populations. There is a growing demand for Ayurvedic medicine in India as the country attempts to enhance its forest cover from 23 percent to 33 percent. This would

[36] *Global Farmer Field School Platform, https://www.fao.org/farmer-field-schools/overview/en/*

help the country's commerce industry. Given its location, India's agricultural potential is greatly enhanced by agroforestry.[37]

The crops preferred by farmers in both project and control areas are teak and bamboo. The majority of farmers across both groups (56 percent in project and 67 percent in control) reported that they undertook agroforestry plantation activities on the bunds, however, 44 percent of project area respondents reported undertaking this within the field, which was significantly higher than the control areas at 33 percent. Nearly 56 percent of respondents from project areas reported a reduction in grazing in agro-forestry areas, while no respondent from the control reported the same.

Horticulture plantation

The promotion of horticulture plantations under the PoCRA project is a strategic initiative aimed at achieving agricultural diversification and providing a steady source of income for farmers. Over the past decade, Maharashtra has transitioned towards the production of high-value horticulture crops, establishing itself as one of India's leading producers of fruits such as mango, citrus, grapes, and pomegranate, as well as vegetables like onion and tomato[38]. This shift aligns with the Government of India's goal of achieving a 4 percent annual growth in agriculture, necessitating a move away from traditional food grain production towards high-value horticulture and livestock products.[39]

Figure 15: Horticulture Beneficiary with Plantation

The agroforestry and horticulture activities in the project accounted for about 2 million tonnes of CO_2 sequestration during the project implementation period. These measures not only enhance the adaptation capacity of farming systems but also support increased production of higher-value horticulture products. By fostering crop diversification and sustainable agricultural practices, the project aims to transform Maharashtra's agricultural sector into a modern, resilient, and economically viable food system.

Table 14: Key Facts – Horticulture Plantation

Number of Farmers	Area Cultivated (in Ha)	Disbursed Amount in Cr. (Rs.)
44135	29270	203.39

[37] *Agroforestry to Combat Global Challenges- Agroforestry: A Key Technique for Achieving the Sustainable Development Goals, 2024, https://link.springer.com/chapter/10.1007/978-981-99-7282-1_23*
[38] *PoCRA Project Appraisal Document (PAD), World Bank*
[39] *Same as Footnote 39*

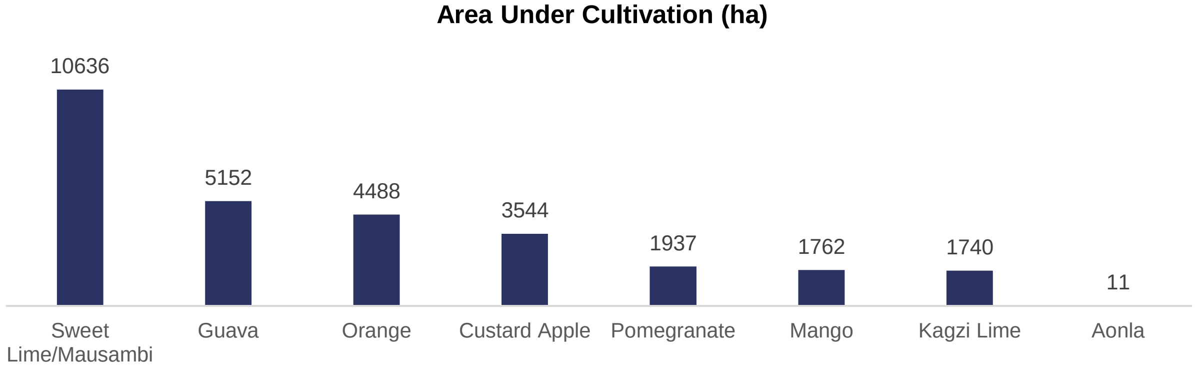

Figure 16: Area under Cultivation of Different Plant Species (Based on MIS data)

The table above highlights the significant strides made by the project in promoting horticulture, with a total of 44135 farmers cultivating an area of 29270 hectares, supported by a disbursed amount of Rs. 203.39 Cr. and supporting the carbon sequestration of 3228 ('000 tonne/ annum) in the project area. The distribution of beneficiaries and cultivated area spans various high-value horticulture crops. Notably, Sweet Lime (Mausambi) is cultivated on 10636 hectares, making it the most extensively cultivated crop under the project. Other significant crops include Guava, covering 5152 hectares, and Orange, cultivated on 4488.30 hectares. Additionally, Pomegranate and Mango are cultivated over areas of 1937 and 1762 hectares. These efforts highlight the project's focus on crop diversification and enhancing the economic resilience of farmers through the promotion of high-value horticulture.

Improvement of saline and sodic lands

Soil degradation is a significant issue in India, affecting 147 million hectares of land—an area roughly 1875 times the size of New York[40]. Soil salinity alone has degraded approximately 7 million hectares, with an additional 10 percent of this area becoming salinized each year. This degradation results in a loss of 16.8 million metric tons of crops annually, causing a financial loss of USD 276 million. Salt-affected soils are a major reason for poor plant growth, affecting crop production and reducing water use efficiency. Traditional treatments, such as applying gypsum to saline and sodic lands, have had limited success.

In response to this challenge, the PoCRA project introduced several initiatives to promote good agricultural practices and improve the resilience of salinity-affected (Kharpan) areas. The project supports farmers in enhancing water use efficiency through the deployment of micro-irrigation systems, water pumps for protective irrigation, and the construction of farm ponds to increase water availability in saline and sodic soil-affected villages. Recognizing that a lack of knowledge about soil salinity and sodicity exacerbates the problem, PoCRA also focused on education. Through farmer field school sessions and interactions with program officials, awareness about soil salinity and sodicity increased significantly. The following analysis is based on the 165 sampled Kharpan villages in the project area.

A significant improvement was observed in the uptake of soil treatment measures at the endline, with 98 percent of the beneficiaries providing a positive response compared to only 2 percent at the baseline. The treatments undertaken included the application of a balanced dose of NPK and micronutrients, gypsum, and fly ash. This also involved reducing the practice of flood irrigation to prevent waterlogging and introducing salt-tolerant field crops like cotton, among other measures.

The water in wells and rivers in the Kharpan area is unsuitable for irrigation, and its continuous use could accelerate the sodification process, jeopardizing future agricultural prospects. Farm ponds, canals, and borewells with lower salinity levels became the preferred sources for irrigation,

[40] *United Nations Office for Disaster Risk Reduction (https://www.preventionweb.net/news/soil-salinization-leaves-farmers-drastically-lower-crop-yields-india#:~:text=Soil%20on%20147%20million%20hectares,arable%20land%20will%20be%20salinized)*

demonstrating a marked improvement from the baseline. These efforts have been instrumental in mitigating the adverse effects of sodic water, thereby enhancing agricultural sustainability in the region.

Similar developments were observed in the methods used for irrigation, which varied significantly between the midline and the endline. However, with the project's emphasis on micro-irrigation, dissemination of agro-advisory services, and frequent training sessions, this conventional behavior was successfully altered with 36 percent of the farmers using drip irrigation during the endline. The endline survey revealed significant issues related to salinity among respondents in saline areas. Among the farmers in the project, 31 percent reported difficulty in land preparation, 27 percent experienced poor drainage, 23 percent faced poor aeration, and 18 percent noted poor crop growth, highlighting the widespread impact of salinity on agricultural productivity.

In the Kharpan areas, waterlogging emerged as a notable concern, though only 5 percent of respondents reported experiencing it in their fields. The duration of waterlogging ranged from 1 to 150 days, indicating varying degrees of severity. To address waterlogging, 67 percent of farmers reported removing excess water, 20 percent cultivated crops that could withstand waterlogging, and 13 percent undertook drainage line treatment.

Water salinity is a prevalent issue in the Kharpan area, with 64 percent (n=302) of respondents reporting problems with saline water. However, only 29 percent of these respondents treated the saline water, while 71 percent did not follow any treatment practices. Among the 194 valid responses about treatment methods for saline water used in irrigation, 44 percent reported using water sources with relatively low salinity levels. This practice helps prevent or mitigate soil salinization problems. Additionally, 34 percent employed leaching, a common practice that involves applying extra water to flush out excess salts from the root zone, thus managing soil salinity. The remaining 22 percent followed other practices, such as using salt-tolerant crop varieties, improving soil drainage, applying soil amendments like gypsum, or utilizing specialized irrigation methods.

These findings underscore the diverse strategies adopted by farmers to combat the challenges posed by salinity and waterlogging. The combination of these practices as part of an integrated salinity management strategy is crucial for mitigating the adverse effects on agricultural systems. By improving awareness and promoting effective salinity management practices, the PoCRA project aims to enhance agricultural sustainability and resilience in saline-affected areas.

Importance of good agricultural practices (GAPs) in saline soils

The dissemination of good agricultural practices, such as balanced NPK dosing, adoption of micro-irrigation systems (drip and sprinkler), balanced micronutrient application, gypsum application, salt-tolerant crop adoption, and improved drainage practices through natural resource management, has been a core focus of the project activities. These practices are promoted through farmer field schools to raise awareness and encourage adoption among farmers.

A primary concern for farmers regarding salinity is poor drainage and salt accumulation on the soil surface due to improper irrigation methods, such as flood irrigation. To address this, the project has promoted drip and sprinkler irrigation systems, which have been widely adopted by farmers in saline regions. The increased use of micro-irrigation systems has effectively prevented salt accumulation on the soil surface, leading to healthier crop growth.

Applying gypsum (hydrated calcium sulphate) to saline soils has proven effective in enhancing soil bulk density, aggregate stability, water infiltration, and overall soil physicochemical properties. This, in turn, improves biomass production and crop yields. Natural resource management initiatives facilitated through the project, have significantly impacted saline soil reclamation by ensuring effective excess water drainage. This reduces salinization rates, leaches out soluble salts, and prevents their accumulation in the crop root zone, promoting healthy crop growth.

The promotion of salt-tolerant crops, such as cotton and soybean, which limit salt uptake and maintain ionic and osmotic balance in roots and shoots, has significantly increased productivity in saline regions.

Different nutrients play crucial roles in enhancing crop productivity. For instance, nitrogen contributes to soft tissue formation, while potassium enhances disease resistance. Excessive nitrogen can lead to softer plants, making them more susceptible to fungal infections and insect infestations, while insufficient potassium reduces disease resistance. Micronutrient deficiencies, particularly in sulphur, zinc, and boron, can stunt plant growth and reduce photosynthetic potential, ultimately decreasing crop productivity.

Addressing these issues through the balanced application of NPK and micronutrients, promoted via farmer field schools and project interventions, has significantly improved crop productivity and farmers' net income in saline regions. These comprehensive efforts have led to sustainable agricultural practices and enhanced economic outcomes for farmers.

Protected cultivation

Protected cultivation under PoCRA leverages advanced agricultural technologies such as shade nets and polyhouses to create controlled environments that address microclimate variability. This method enables the cultivation of off-season vegetables and enhances farmers' adaptability to climate contingencies. Nearly 11 percent[41] of farmers reported having adopted this technology, significantly improving crop productivity by maintaining optimal moisture, temperature, and humidity levels. The controlled conditions result in fewer diseases and pests, ensuring higher yields of high-value crops, including vegetables and flowers. Additionally, farmers are utilizing protected cultivation for growing ornamental plants and high-value cash crops, further boosting their income potential.

In a study conducted by the Department of Agriculture, GoM has observed that the use of polyhouses can increase crop yields by up to 50 percent, providing farmers with a substantial increase in income. This method also reduces water usage by about 30-40 percent compared to open-field cultivation[42]. This approach offers several benefits, including the ability to grow crops throughout the year regardless of external weather conditions. The technology ensures stable and high-quality production, which is particularly beneficial for high-value crops that require specific growing conditions. By mitigating the effects of climate variability and reducing the incidence of pests and diseases, protected cultivation under the PoCRA project provides a reliable and sustainable agricultural practice. This method not only supports food security but also contributes to the economic resilience of farming communities, showcasing a successful adaptation strategy with significant mitigation co-benefits.

Shade net house

Perforated plastic shade nets are used to block the sun's radiation and stop the scorching or wilting of leaves brought on by rising temperatures.[43] By reducing the incidence of pests and diseases, shade nets help maintain optimal growing conditions, resulting in healthier plants and higher yields. Farmers use shade nets to grow a variety of crops, including vegetables, and seed production thereby enhancing their ability to produce high-quality produce year-round. This technology supports sustainable agriculture, provides impetus to crop diversification, and improves farmers' resilience to climate variability.

Table 16: Key Facts- Shade Net House

Shade Net House - Key Facts (Cumulative; Since Inception)		
Number of Farmers	**Area in Hectares**	**Disbursed Amount in Cr. (Rs.)**
5874	1623.70	630.19

The total disbursement for this initiative amounted to Rs. 630.19 Cr. and the above figures highlight the project's efforts to improve agricultural sustainability and productivity through the implementation of

[41] *As per mid-term review data.*
[42] *Maharashtra State Department of Agriculture, http://maharashtra.mahanhm.in/GuidLineDetail.aspx*
[43] *Protected Vegetable Crop Production for Long-term Sustainable Food Security, 2024, https://journaljsrr.com/index.php/JSRR/article/view/1984/3912*

shade net houses. The investment in shade net has led to a 21 percent increase in the production in project villages. Also, the farmers now benefit from the production throughout the year and can cultivate even in adverse weather conditions.

Figure 17: Shade Net in Beneficiary Farm in Chatrapati Sambhajinagar

Polyhouse

The project in Maharashtra promotes the use of polyhouses, which are greenhouse structures covered with polyethylene film. Polyhouses create a controlled microclimate, allowing for the cultivation of crops in optimal temperature, humidity, and light conditions. This technology enables farmers to grow high-value crops, such as vegetables, flowers, and exotic plants, throughout the year. Polyhouses reduce the risk of crop damage from adverse weather conditions and pests, leading to increased productivity and profitability. By adopting polyhouses, farmers can achieve consistent crop quality and quantity, contributing to the overall sustainability and economic stability of the agricultural sector.

Table 17: Key Facts- Polyhouse

Polyhouse – Key Facts (Cumulative; Since Inception)		
Number of Farmers	**Area in Hectares**	**Disbursed Amount in Cr. (Rs.)**
146	34.60	21.25

The table above highlights key statistics on Polyhouse interventions under the PoCRA project, aimed at enhancing climate resilience. Since the project's inception, a total of 146 farmers have benefited from the Polyhouse initiative, covering an area of 34.60 hectares. The total disbursement for this intervention amounted to Rs. 21.25 Cr. These figures underscore the project's commitment to promoting sustainable agricultural practices and improving productivity through the implementation of Polyhouses. Survey data further reveals that polyhouses have helped beneficiary farmers to increase their income by 25 percent in the project areas.

Blooming Innovations:

Vandana Jawahar Rathod's Path to Soilless Orchid Farming in Jawala, Yavatmal

In the traditional farming landscape of Yavatmal district, where cotton and soybean have long been the staple crops, unpredictable climatic conditions have posed significant challenges. These conditions have driven farmers to seek alternatives that promise better resilience and profitability. Vandana Jawahar Rathod, a progressive farmer from Jawala, responded to these challenges by embarking on an innovative project: soilless orchid cultivation in a polyhouse. With a substantial investment of Rs. 89.25 lakhs, supported by PoCRA with a subsidy of Rs. 41.29 lakhs and a bank loan, Vandana set up a polyhouse on her 1-acre farm. She used coconut shells as the growing medium, taking advantage of their high water-holding capacity and cost-effectiveness. The polyhouse accommodates 43000 orchid plants, which thrive in this soilless environment. Over a projected life cycle of 9 years, the project aims to produce around 15 Cr. flowers, potentially generating Rs. 3.5 Cr. in revenue.

Vandana's journey began with visits to successful soilless orchid farms in Pune, Palghar, and Hyderabad. These visits exposed her to modern techniques and inspired her to replicate these practices in her farm. Her willingness to adopt new agricultural methods reflects a commitment to innovation and sustainability in farming, setting a precedent for other farmers in the region.

The financial structure of Vandana's soilless orchid cultivation project, which includes the setup of a polyhouse on her 1-acre farm, outlines both fixed and working capital requirements. The total fixed cost of Rs. 89.25 lakhs encompasses several key elements like the polyhouse construction (Rs. 45 lakhs), a 2000-liter-per-hour RO water setup (Rs. 2 lakhs), plantation setup (Rs. 40 lakhs) etc. The project is projected to achieve a total net profit of around ₹62.34 lakhs by the end of five years, demonstrating its profitability and potential for generating substantial returns over its operational lifespan.

Vandana's soilless orchid cultivation project in a polyhouse represents a significant shift towards modern and resilient farming methods in Yavatmal. Her success story underscores the potential for innovation in agriculture to overcome climatic and economic challenges, offering a model for sustainable development in rural farming communities. Her efforts, supported by the PoCRA initiative, highlight the transformative power of integrating advanced agricultural techniques into traditional farming settings.

Figure 18: Case Study – Success via Adoption of Polyhouse

Integrated Farming Systems

Activities like backyard poultry, rearing of small ruminants, apiculture, inland fishery, and sericulture have been highly useful to marginal as well as landless farmers helping them to increase and diversify their income. The adaptation strategy during endline has enhanced the livelihood resilience among the 5000+ beneficiaries of small ruminants compared to only 2945 during midline, 2000+ beneficiaries of inland fisheries compared to only 890 during midline, 350+ beneficiaries of apiculture, and 200+ beneficiaries of backyard poultry under the project. This shows there has been a significant increase in the number of people adopting integrated farming systems.

Small ruminants

Small ruminant rearing is a longstanding tradition in Indian agriculture, with farmers raising various animals for diverse purposes such as agriculture support, manure production, and milk and meat supply. Small ruminant rearing, including goats, is a vital agri-allied activity in India, providing significant income to rural households, particularly in arid and semi-arid regions. This sector contributes to livelihoods, nutritional security, and employment, especially among the landless. Goats adapt well to diverse climatic conditions and require relatively low investment, making them ideal for small-scale farming.

Table 15: Key Facts- Small Ruminants

Small Ruminants – Key Facts (Cumulative; Since Inception)	
Number of Farmers	**Disbursed Amount in Cr. (Rs.)**
5391	19.77

The table above highlights key statistics on small ruminants under the project in Maharashtra, aimed at enhancing climate resilience and livelihood diversification. Since the project's inception, a total of 5391 farmers have benefited from this intervention. The total disbursement for supporting small ruminants amounted to Rs. 19.77 Cr. These figures reflect the project's commitment to promoting sustainable livestock practices and improving the economic resilience of the landless through the introduction of small ruminants. The small ruminant beneficiaries in the project have experienced a 35 percent increase in income whereas in control it is 22 percent.

Table 16: Benefits of Usage of Small Ruminants

Benefits	Project (%)	Control (%)
Increase in income from baseline	35	22
Increase in self-employment opportunity	31	35
Improvement in standard of living	24	13
Additional source of income	20	26
Other	5	4

Sericulture

Sericulture, the art of silk production, encompasses the cultivation of mulberry, silkworm rearing, and post-cocoon activities leading to the production of silk yarn. This industry not only supplies silk for clothing but also generates several valuable by-products beneficial to society. Consequently, the development of sericulture presents significant opportunities to enhance the living standards of people in rural areas of developing countries. By fostering sericulture, rural communities can achieve economic growth, create employment, and promote sustainable development, thereby improving overall quality of life.[44] Sericulture represents a rare end-to-end sustainable industry with minimal ecological impact when care is taken with supply chain management. The project has promoted sericulture as a resilient practice through individual entrepreneurship under dryland conditions, which has generated an impressive response through 12361[45] applications from villages. The project has planned end-to-end handholding support to individual beneficiaries - from nursery raising to cocoon marketing – for all approved proposals.

[44] *Conservation Status of Sericulture Germplasm Resources in the World - II. Conservation Status of Silkworm (Bombyx Mori) Genetic Resources in the World- 2, chapter 2-Conservation Status of Silkworm Genetic Resources In India, 2002* *https://www.fao.org/4/ad108e/ad108e0a.htm*

[45] *Sericulture activities promoted under PoCRA have 4 subcomponents thus any eligible individual can apply for multiple components, therefore there might be inflated number of applications.*

Table 17: Key Facts- Sericulture

Sericulture – Key Facts (Cumulative; Since Inception)		
Number of Farmers	**Area in Hectares**	**Disbursed Amount in Cr. (Rs.)**
5337	1860	89.01

The table above highlights key statistics on sericulture under the PoCRA project in Maharashtra, aimed at enhancing rural livelihoods and economic resilience. Since the project's inception, a total of 5337 farmers have benefited from sericulture initiatives, covering an area of 1860 hectares. The total disbursement for these activities amounted to Rs. 89.01 Cr. Due to sericulture intervention, 33 percent of farmers experienced an increase in income in project villages. These figures underscore the project's commitment to promoting sustainable sericulture practices, thereby improving the living standards and economic stability of rural communities in Maharashtra which has also been documented by several news and publication outlets.

Figure 19: Practice of Sericulture

Figure 20: Snap of Video of Sericulture Activities Promoted under PoCRA[46]

Additionally, PoCRA supports various agri-allied activities, including apiculture, backyard poultry, and inland fisheries, aimed at ensuring economic sustenance for farmers. Since the project's inception, apiculture, involving the cultivation of bees for honey production, has supported 362 farmers with a total disbursement of Rs. 5.23 Cr. This practice not only provides honey but also enhances crop pollination, leading to increased agricultural yields.

Backyard poultry, which involves raising chickens in small-scale household setups, has supported 234 farmers with Rs. 0.26 Cr. disbursed. This activity offers a steady source of income and nutrition through the production of eggs and meat. Inland fisheries, focusing on the breeding and harvesting of fish in inland water bodies, have benefited 2153 farmers with Rs. 5.45 Cr. disbursed. This practice ensures a reliable protein source and enhances the livelihood of rural communities. Collectively, these agri-allied activities, implemented throughout the project's duration, promote diversified income streams, enhancing the resilience and economic stability of farming households in Maharashtra.

[46] https://scroll.in/video/1054571/eco-india-how-sericulture-is-giving-cotton-farmers-a-new-lease-on-life-in-drought-prone-marathwada

Threads of Fortune:

Story of Eknath Talekar Practising Sericulture

Eknath Shrimant Talekar, a 48-year-old farmer from Rui (Dhanora) in the Georai Taluka of Beed District, Maharashtra transitioned from traditional agriculture to sericulture under PoCRA with just 1 hectare of land and a project support of Rs. 2.20 lakh.

Eknath had been cultivating conventional crops like Rabi Gram, Sorghum, and Soybean. Despite his hard work, the low income from these crops made it difficult to support his family. He began seeking alternatives to improve his livelihood and stabilize his income. The turning point came when Eknath learned about sericulture through the village climate resilient management committee. Visits to successful sericulture farmers in Latur and discussions with the department staff convinced him of the advantages of sericulture including low input costs, minimal water requirements, high potential returns, and reduced risks.

Motivated by his findings, Eknath developed a business plan aimed at expanding sericulture production, enhancing the quality of cocoons, improving productivity, and providing new employment opportunities. His focus shifted entirely to sericulture, with the goal of boosting the income for both him and the workers he employed. He recognized the potential for sericulture to offer a stable and higher income compared to traditional crops, providing better resilience against unpredictable weather conditions and other agricultural challenges. Sericulture emerged as a particularly attractive option for marginal and small farmers like Eknath. Unlike traditional crops such as soybean and wheat, which are vulnerable to market and climatic fluctuations, sericulture provided a more dependable source of income.

The sericulture process involves several stages, each adding value to the final product. It begins with the cultivation of mulberry, followed by the rearing of silkworms to produce raw silk. This silk is then reeled from the cocoons for further processing into finished products. Throughout this multi-fold activity, a significant amount of waste is generated at various stages. Eknath saw the potential in converting these by-products and waste materials into valuable co-products, enhancing the efficiency and sustainability of his sericulture operations.

To establish his sericulture venture, Eknath required an initial investment of Rs. 2.93 to Rs. 3.15 lakh. Recurring expenses are the cost of silkworm eggs, mulberry garden maintenance, labor, fertilizers, and irrigation. His annual cocoon yield amounted to 1093 kg, with market rates ranging from Rs. 390 to Rs. 805 per kg. Over the fiscal years from 2020 to 2023, he saw his net profit steadily increase from Rs. 3.6 lakhs in FY 2020 to Rs. 4 lakhs in FY 2021 and Rs. 4.5 lakhs in FY 2022, demonstrating the financial viability of sericulture as compared to his previous traditional farming methods. Eknath's was granted a subsidy of Rs. 2.2 lakh which helped him cover a substantial part of his initial investment and operating costs, making it easier to transition to sericulture and achieve early profitability.

Through sericulture, Eknath has achieved a consistent income stream, reduced recurring costs, and created new employment opportunities in his community. His successful venture into sericulture has not only improved his own financial stability but also contributed to the economic development of Rui village. Today, Rui (Dhanora), once known for its cotton production, has been transformed into a hub for sericulture, earning the nickname "Reshmachi Rui". The support and guidance from PoCRA and officials from other line departments have played a crucial role in this transformation, showcasing sericulture as a sustainable and profitable alternative to traditional agriculture.

Figure 21: Case Study - Success in Sericulture from Rui, Beed

Soil health improvement

Robust soil health is crucial for sustainable agriculture and climate resilience. With soil being impacted by a host of problems inclusive of erosion, loss of topsoil, lack of carbon capture, and accumulation of heavy materials[47], PoCRA stresses good agronomic practices to improve soil fertility, soil nutrient management, and promote soil carbon sequestration. The loss of topsoil, driven by erosion and unsustainable farming practices, reduces the soil's ability to retain water and nutrients, thereby directly affecting crop yields (Bera et al., 2020)[48]. Additionally, the decline in soil organic carbon, essential for soil fertility and structure, exacerbates the reduction in agricultural productivity (Patil et al., 2018)[49]. These issues not only undermine the agricultural potential of the region but also pose a threat to the livelihoods of farmers who rely on healthy soil for their crops.

Recognizing these challenges, the PoCRA project has prioritized improving soil health as a critical component of its strategy. PoCRA's interventions focus on promoting good agronomic practices that enhance soil fertility and nutrient management. By encouraging the use of organic amendments, protected cultivation, and crop rotation, the project aims to restore soil structure and increase soil organic matter content. Furthermore, PoCRA emphasizes soil carbon sequestration practices to combat soil degradation and improve soil health. This involves techniques such as agroforestry, conservation tillage, and in-situ soil moisture conservation which help capture and store carbon in the soil, thus improving its overall quality and resilience.

Optimum soil health reinforces climate resilience by sustaining agricultural productivity, safeguarding ecosystems, and securing farmer livelihoods in the face of climatic challenges. PoCRA's initiatives not only aim to restore soil health but also contribute to the long-term sustainability and resilience of agriculture in Maharashtra. These efforts ensure that farmers can continue to produce crops efficiently while maintaining the ecological balance necessary for future agricultural success.

Compost units (Vermi, NADEP, and Organic)

Composting is a process by which organic wastes are converted into organic fertiliser by means of biological activity under controlled conditions. There are various popular methods of composting and notable among these are aerobic composting, NADEP composting, vermicomposting, and biodynamic composting.[50] The intervention aims to promote extensive use of vermicompost/ NADEP compost units through FFS-led demonstrations for its benefits and adoption by the wider farming community and focuses on strengthening the capacities of farmers on organic farming systems.

NADEP composting is a natural process by which biomass wastes, soil wastes, and animal wastes are biologically degraded and decomposed into organic – compost.[51] The process involves placing select layers of different types of compostable materials in a simple, mud-sealed structure designed with brick and mud water. The unique efficacy of the system permits the conversion of approximately 1 kg of animal dung into 40 kg of rich compost, with suitable fields[52] to be applied[53]. The rationale behind promoting vermicompost and NADEP units is to help farmers become self-sufficient in terms of on-farm management of plant nutrients and avail good quality compost to aid crop cultivation.

During the endline survey it was found that after the uptake of the compost units, expenditure on chemical fertilizers reduced appreciably. This holds significance as approximately 80 percent of the farmers adopting these measures belonged to the vulnerable sections possessing limited purchasing power to procure costly inputs. Estimates show that applying only 6 tonnes per hectare of vermicompost

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[47] Singare, P. U., Lokhande, R. S., & Pathak, P. P. (2010). Soil pollution along Kalwa Bridge at Thane Creek of Maharashtra, India. Journal of Environmental Protection, 1(02), 121.

*48 Bera, S., et al. (2020). "Soil erosion and its impacts on agricultural productivity in Maharashtra." *Journal of Soil and Water Conservation*

*49 Patil, S. S., et al. (2018). "Soil organic carbon dynamics and its implications for agricultural productivity in Maharashtra." *Agricultural Research Journal*

[50] Package of Organic Practices from Maharashtra for Cotton Rice Red gram Sugarcane and Wheat Prepared by Maharashtra Organic Farming Federation (MOFF), 2006, https://cicr.org.in/wp-content/uploads/organic_input.pdf

[51] NADEP composting, https://megbrdc.nic.in/publications/fliers-Pamphlets/nadep-composting-english.pdf

[52] http://ecoursesonline.iasri.res.in/mod/page/view.php?id=149590

[53] http://ecoursesonline.iasri.res.in/mod/page/view.php?id=149590

instead of the recommended dose of NPK for cereal crop production, can reduce the cost of fertilizer by up to Rs. 4000/- (USD 55) per hectare and the cost of pesticides by 40 percent in the subsequent three to four years.[54]

Table 18: Key Facts- Compost Units

Compost Units- Vermicompost/NADEP/Organic inputs- Key Facts (Cumulative; since inception)	
Number of Farmers	**Disbursed Amount in Cr. (Rs.)**
3829	1.88

The construction of the NADEP compost units allowed a greater number of respondents in the project group to use their crop residue more judiciously (82 percent) compared to their counterparts in the control group (66 percent). In a similar vein, 70 percent (n=33) of the beneficiaries attested to improved soil health post-adoption of NADEP and vermicompost units compared to 48 percent (n=23) of the respondents in the control arm. The earthworm casts have certain features that complement soil health as they aerate the soil (8-30 percent) and have a high moisture-holding capacity,[31] they maintain soil temperature conditions and increase oxygen availability. It enhances activity beneath the soil, increasing the soil microbial diversity.[55]

Broad Bed Furrow (BBF) technique

The Broad Bed and Furrow (BBF) technique in agriculture involves creating raised beds (broad beds) separated by furrows. This method improves water management by allowing excess water to drain away, reducing waterlogging and soil erosion. It also enhances soil aeration and root growth, promoting healthier crops. BBF is particularly effective in areas prone to heavy rainfall as well as dryland conditions, thus fostering climate-resilient agriculture by increasing water efficiency, reducing runoff, and improving soil structure and fertility. BBF effectively diverts runoff water into field furrows which are blocked at the lower end. It is a good soil moisture management strategy assisting improved crop yields.

Recognizing these benefits, the PoCRA initiative in Maharashtra has actively promoted BBF to improve agricultural productivity and resilience. To facilitate the widespread adoption of BBF, PoCRA leverages the custom hiring centres established across the state. These CHCs provide farmers access to modern agricultural machinery and equipment at affordable rates, reducing the financial burden on individual farmers. By incorporating BBF equipment into the CHC inventory, PoCRA ensures that even small and marginal farmers can implement this advanced technique without substantial investment. This strategic move not only enhances the reach of BBF but also promotes sustainable agricultural practices. Through the CHC network, PoCRA enables farmers to adopt BBF, thereby improving water management, enhancing crop yields, and building resilience against climate variability at a low cost.

The adoption and practice of this method have grown manifold between baseline and endline. At the baseline, 3.5 percent of farmers had adopted this technology, whereas, during the endline survey, 23 percent of the farmers reportedly practiced it to ensure optimum soil moisture in their fields and better crop yields. BBF technology has proven particularly beneficial, with 59.43 percent of respondents reporting that it helped prevent crop damage during heavy rains. Additionally, 57.15 percent of the respondents noted that BBF technology aided in moisture conservation, and 56.96 percent observed improved crop production. This technology, which is widely popular in Maharashtra for sowing soybeans, has demonstrated significant yield increases. The adoption of BBF technology under the PoCRA project underscores its potential to enhance agricultural resilience and productivity, particularly in regions prone to erratic rainfall and water management challenges.

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[54] Council On Energy, Environment And Water, Vermicomposting in India, 2021, https://www.ceew.in/publications/sustainable-agriculture-india/vermicomposting
[55] Council On Energy, Environment And Water, Vermicomposting in India, 2021, https://www.ceew.in/publications/sustainable-agriculture-india/vermicomposting

Figure 22: BBF Technique Adopted by Beneficiary in Project Area

Best Practice – Broad Bed Furrow (BBF) Cultivation – Soybean & Pigeon Pea

Broad Bed Furrow cultivation refers to an in-situ water conservation practice that strengthens the farming system's capacity to cope with dry spells during rainy season. Main agronomic benefits expected from BBF include moisture storage in the soil profile, safe disposal of surplus surface runoff without causing erosion, presence of better drained and more cultivable soil and the possibility to re-use runoff water stored in small tanks.

PoCRA has taken initiative to promote BBF technology in villages through trainings and demonstrations provided via FFS. A key objective of this project is to encourage farmers to use BBF method in farms as well as provide subsidy based upon landholding for purchase of BBF Machine. BBF technique has proven to be instrumental in the cultivation of Soybean and Pigeon Pea. Soybean and Pigeon Pea crops were sown by BBF planter to enhance moisture conservation and ensure robust growth. A significant increase in yield was witnessed in the case of Soybean and Pigeon Pea's after the adoption of BBF system rather than the traditional method of sowing.

Owing to this exceptional result, officials of line departments, SAU personnel, members of KVKs and VCRMCs are engaging more frequently with farmers across project districts, encouraging them to adopt the technology on a larger scale. As a result, several farmers who have taken up this technology have benefitted in the following ways:

(a) helped to save their crops from heavy rains and water logging
(b) helped in root development by avoiding water stagnation; especially in the case of heavy soil, the aeration in BBF was better compared to traditional methods
(c) decreased their cost of cultivation as the expenditure incurred and the time required for sowing was also reduced considerably
(d) Fertilizer application has also reduced since it was placed within the cropped area and not in uncropped furrow area

Thus, going forward, BBF should be promoted and adopted on a much wider scale owing to its evident superiority over traditional methods like flatbed sowing. BBF is also a popular technique in restoring the quality of land marred by saline soils. For this very purpose, its adoption has soared in the Kharpan region in relation to the traditional methods like application of gypsum.

Figure 23: Best Practice – Broad Bed Furrow (BBF) Technique

Regenerative Agriculture

Regenerative agriculture is an approach to farming that uses soil conservation as the entry point to regenerate and contribute to multiple provisioning, regulating, and supporting ecosystem services with the objective that this will enhance not only the environmental but also the social and economic dimensions of sustainable food production. Reducing soil disturbance due to tillage operations is an important feature of regenerative agriculture. The project has promoted zero tillage with an aim to reduce soil loss and reduce the production cost of cotton, Maize, and Soybean in the project districts. The Technology Coordinators have conducted dedicated FFS to promote zero tillage practice, which was later adopted by over 3000 farmers in project districts.

Figure 24: Regenerative Farming Adopted in Project Area

Figure 25: Field Visit to Observe Regenerative Agriculture

Cotton Chronicles: The Zero Tillage Revolution

Raosaheb Jaywanta Mohite, a dedicated farmer from Tapargaon, Kannad, in Chhatrapati Sambhajinagar district, has achieved remarkable success with Zero Tillage on his 4-hectare farm. Cultivating a variety of crops including cotton, sugarcane, bajra, wheat, and maize using well and drip irrigation systems, Raosaheb’s innovative approach has set a new standard for sustainable farming. His began in 2019 after attending a two-day workshop at the Saguna Rural Foundation Farm, led by Chandrashekhar Bhadsawale, a pioneer in Zero Tillage farming in rice crops. Motivated and guided by the project's Technology Coordinator through the farmer field school, Raosaheb prepared broad raised beds of 4.5 feet width in Kharif 2019 and cultivated cotton using the dibbling method.

Initially, Raosaheb faced challenges with weeds, but these turned into a boon as he managed them with weedicides, allowing the decomposed roots to enrich the soil's organic matter. He harvested cotton in three pickings, yielding 10 quintals per acre and shifting to marigolds. Over the past ten seasons, Raosaheb has consistently cultivated crops without disturbing the soil beds. He has observed significant improvements, including softened soil, increased water percolation, a higher water table in his well, and prevention of waterlogging during heavy rains. The farm has also experienced a natural rise in the earthworm population, enhanced soil organic carbon levels, decreased soil salinity, and increased microbial activity.

These benefits have translated into cost savings on labor and plant protection and reduced soil cracking in his black cotton soil. Raosaheb's yields have also improved significantly, with average cotton yields of 9 quintals per acre, 1.5 times his previous harvests, and increased yields of corn (20 quintals per acre) and pearl millet (12 quintals per acre). His farm has become a model for Zero Tillage, attracting over 1,500 farmers from 16 districts. Raosaheb has received numerous awards and appreciation, including from the Department of Agriculture, highlighting his success in promoting regenerative agricultural practices.

Figure 26: Success Story (Cotton Chronicles- The Zero Tillage Revolution)

4.3 Promoting an Efficient and Sustainable Use of Water for Agriculture

Water budgeting

Water budgeting is essentially a mass balance strategy that considers numerous water sources and sinks that affect water storage in soil. Water budgeting has three main components: inflow, outflow, and a change in soil moisture storage, which accounts for the volume of water that enters and leaves a closed space over a period[56]. Conscious efforts have been made by the project to develop an advanced water budgeting tool with the help of IIT-B which serves as a base for microplanning. A comprehensive water budgeting exercise supports the development of micro watershed plans. This exercise gathers updated information and modeled data on current groundwater and surface water availability, along with projected requirements for each village. Recognizing the need for seamless integration between surface and groundwater assessments, water framework toolkits have been developed and endorsed to facilitate accurate analyses.

At the micro watershed level, the water budgeting exercise includes hydrological analyses and calculations of crop evaporation based on prevailing cropping patterns, along with other sector water needs using village-level information. Water budgeting is an integral part of the mini-watershed plan, considering both spatial and temporal variations. This means the framework takes into account different land use patterns, slopes, soil types, and soil depths within a village, rather than providing an aggregated balance for the entire village. Additionally, it performs a seasonal water balance, differentiating between kharif and rabi seasons, in each cluster of villages within the project area.

A robust water budgeting framework is necessary for promoting efficient and sustainable use of water for agriculture. The water budget tool played an important role not only in measuring the trend of NRM activities but also in detecting soil moisture stress, dry spells, crop water deficits, groundwater recharge, crop water uptake, and protective irrigation requirements. Furthermore, the water budget tool was crucial for planning Kharif and Rabi crops. Based on the available surface water, groundwater, and soil moisture, we systematically planned which crops to sow in specific areas of the village. Proposed structures and cropping patterns were planned with the help of the water budget tool. This tool was utilized at village, taluka, and district levels. In this way, the water budget tool played an essential role in planning Kharif and Rabi crops based on the available water and soil resources.

Natural resource management works

For Natural Resource Management (NRM) to be sustainable, community ownership is essential. The initial step in NRM involves a comprehensive community mobilization exercise to ensure that the community is aware of key parameters such as precipitation, cropping patterns, water usage, and overall water balance. In each project village, a detailed micro-planning exercise was conducted, facilitating the clear identification of problems and potential solutions. This participatory approach ensured stakeholders' ownership of the executed projects.

Collaborations with other social organizations working in NRM and synergies with government projects like Jalyukt Shivar served as significant driving forces. Village potential treatment maps were developed and made available to the communities to disseminate knowledge about the potential of NRM works. Technical support for NRM initiatives was provided by the Agriculture Department and the Groundwater Surveys and Development Agency (GSDA).

NRM interventions included area treatments such as compartment bunding, graded bunding, continuous contour trenching, and deep continuous contour trenching. Drainage line treatment interventions encompassed structures like earthen nala bunds, cement nala bunds, and gabion structures. The project has executed a total of 4315 NRM works, encompassing area treatment over 59387 hectares and completing 1855 drainage line treatments, resulting in a storage capacity of 32866 TCM.

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[56] *Kumari, A., Upadhyaya, A., Jeet, P., Ahmad, A., & Prakash, V. (2021). Water budgeting and auditing for crop planning and management. Food and Scientific Reports, 2(8), 46-49.*

Table 19: Activity-wise Status of Soil and Water Conservation Works

Sr.No	Activity Name	No. of works	Area in Ha	Water Storage (TCM)	Disbursed amount in Rs. Cr
1	Compartment /graded bunding	2384	58567.72	26355.47	39.69
2	Continous contour trenches/Deep CCT	38	532.53	239.64	0.71
3	Trench cum mount	9	287.16	62.31	0.26
4	Composite gabian structure-RC Pardi	88	-	528	1.77
5	Cement nala bunds	239	-	1434.00	24.32
6	Earthen nala bunds	17	-	85.00	0.43
7	Loose bolder structures	31	-	3.10	0.16
8	Desilting of old water storage structure	852	-	3669.03	10.49
9	Gabian structure	15	-	7.50	0.03
10	Recharge shaft with recharge trench	437	-	255.95	4.64
11	Recharge shaft	176	-	92.27	1.15
12	Miscellaneous (Farm pond on e class land and BJS supported farm pond)	29	-	133.80	0.24
Total		**4315**	**59387.41**	**32866.08**	**83.89**

This integrated and participatory approach to NRM has not only addressed immediate environmental challenges but also empowered communities to take charge of their natural resources sustainably. The strategic partnerships and technical innovations have significantly enhanced the effectiveness and sustainability of the interventions, ensuring long-term benefits for the project villages.

Trend analysis of impounded runoff

The project aimed to measure the impact of natural resource management activities designed to develop climate resilience, implemented by the project using the water budget tool. The focus was on capturing the trend analysis in the form of impounded runoff as one of the indicators in various NRM structures developed by the project. From this, the change in storage capacity in some villages due to the project's NRM interventions was analyzed, comparing before (2018) and after (2023) scenarios at the district level covering a sample of 563 villages across 15 districts.

An exercise was carried out in 563 villages to assess the impounding of runoff due to the creation of NRM works post-2018. It was observed that the impounded runoff in 2018 was 5835.20 Cr litres (Figures derived from MLP exercise using the water budgeting tool). This impounded runoff increased to 8597.16 Cr litres in 2023 because of the creation of 3986 structures including farm ponds. Compared to 2018, the impounded runoff increased by 2761.96 Cr litres due to NRM works done by the project.

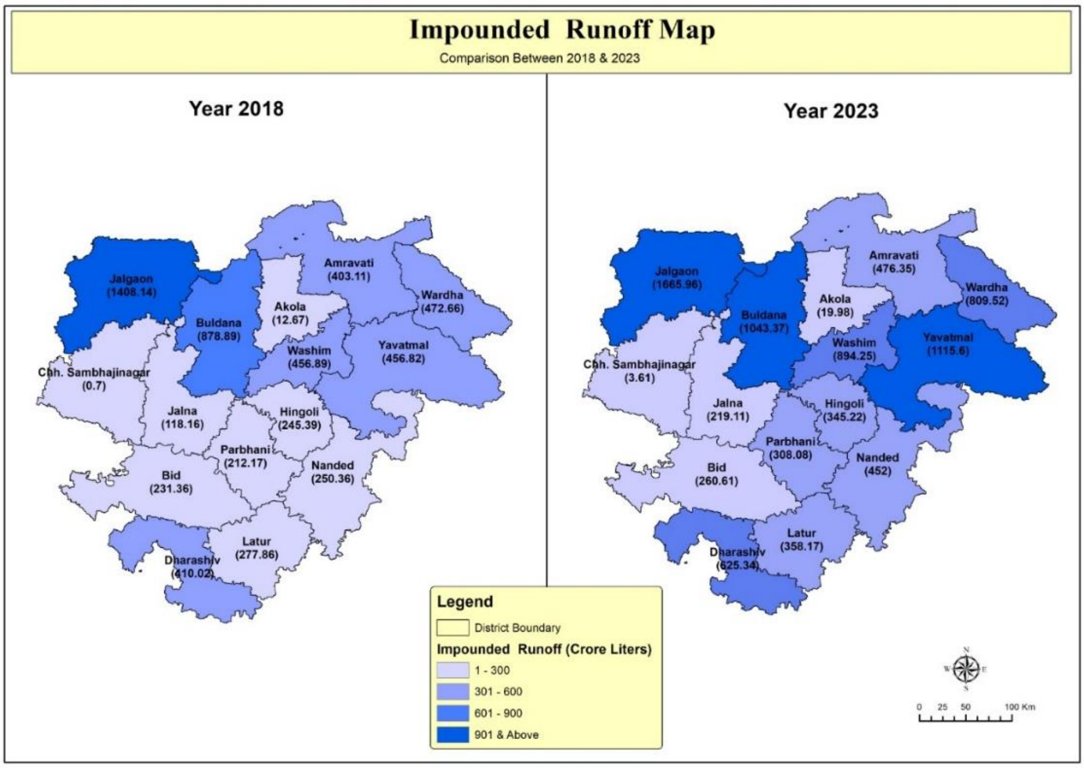

Figure 27: Impounded Runoff during Project Period from 2018 to 2023

Benefits observed through household survey

As observed, farmers were benefited from the construction of earthen nala bunds (54%), continuous contour trenches (43%), cement nala bunds (32%), desilting of old water structures (29%), loose boulder structures (27%), deep continuous contour trenches (24%), compartment/ graded bunding (13%), gabian structures (9%), e-class community farm ponds (2%), recharge shaft (2%) and recharge shaft with trench (1%). The benefits derived by the farmers through these NRM work implemented by the project as reported by the respondents was, increased groundwater level (68%), increase in yield (56%), increased availability of water for protective irrigation (52%), improved soil and water conservation (37%), crop diversification (30%), change in cropping pattern (20%), increased availability of water for livestock (16%), increased income (15%), availability of water during dry spell (12%), increase in area of cultivation during kharif (9%) and rabi (7%) seasons. Some (5%) of the farmers anticipate benefits in the near future.

Figure 28: Cement Nala Bund constructed in Walgud Village, Dharashiv

Around 88 percent of the 1943 farmers reported the NRM structure to be in good condition and providing benefits. It is observed that nearly one-third of the farmers are willing to extend their support for the maintenance of these NRM structures. NRM structure maintenance support as envisaged by the respondents was: willing to be part of the structure maintenance committee (71 percent), extend family labour for structure maintenance (34 percent), and willingness to pay for structure maintenance (25 percent). However, one-third of the farmers with the willingness to support also feel that the structure maintenance activities should be led by government institutions.

Farm pond

Individual and community farm pond

Under the project, individual farm ponds are designed to enhance water security for individual farmers. These small water bodies are created by excavating land on individual farms, allowing for the collection of excess runoffs during rainy periods. The stored water is used for supplemental irrigation during dry spells, ensuring crops receive sufficient moisture. Individual farm ponds also provide drinking water for livestock and are useful for pesticide application, thereby conserving soil and moisture. This initiative significantly boosts the resilience of small-scale farmers against water scarcity and climatic variations.

Table 20: Key Facts – Individual Farm Ponds

Individual Farm Pond - Key Facts (Cumulative; Since Inception)		
Number of Farmers	**Disbursed Amount in Cr. (Rs.)**	**Water Storage Capacity Created (TCM)**
5241	61.03	10130

The table above highlights key figures regarding the implementation of individual farm ponds since the inception of the project. A total of 5241 beneficiaries were supported, resulting in the creation of an overall water storage capacity of 10130 TCM. The total amount disbursed for the development of these individual farm ponds amounted to Rs. 61.03 Cr. at the end of the project implementation period. These figures underscore the project's commitment to enhancing water availability and improving irrigation infrastructure for farmers.

Figure 29: Farm Pond built on Beneficiary field in Project Area

PoCRA also emphasizes the development of community farm ponds to benefit multiple farmers. These larger water bodies are constructed through collective efforts and resources, facilitating the capture and storage of excess runoff during the monsoon season. Community farm ponds provide a shared source of water for supplemental irrigation, livestock drinking water, and pesticide spraying. By fostering communal participation, these ponds help manage water resources more efficiently and equitably, promoting sustainable agricultural practices and enhancing the overall resilience of farming communities against droughts and water shortages.

Table 21: Key Facts – Community Farm Ponds

Community Farm Pond - Key Facts (Cumulative; Since Inception)		
Number of Farmers	**Disbursed Amount in Cr. (Rs.)**	**Water Storage Capacity Created (TCM)**
2695	83.42	13942

Farm ponds can help ease water constraints caused by various factors, including climate change. This approach has the potential to increase the amount of water available for supplemental irrigation, while also increasing planted area and productivity, resulting in increased net crop yields. The table above highlights key statistics regarding the implementation of community farm ponds since the project's inception. A total of 2695 beneficiaries were supported, resulting in the creation of a cumulative water storage capacity of 13942 TCM. The total disbursement for the development of these community farm ponds amounted to Rs. 83.42 Cr. These figures reflect the project's significant efforts to enhance communal water resources and improve irrigation infrastructure for the farming community.

Farm pond lining

Under the project, support and technical knowledge are provided to farmers to adopt farm pond lining which involves the use of polythene to line the interiors of farm ponds, both new and rehabilitated ones. This technique prevents seepage, ensuring maximum retention of stored water. By lining 3158 existing ponds and numerous new ones, the project significantly increases the effectiveness of water storage, reducing losses and enhancing the availability of water for irrigation and other uses. Farm pond lining is a crucial adaptation strategy that helps maintain water reserves, thus supporting agricultural activities during dry periods and promoting efficient water use.

Table 22: Key Facts – Farm Pond Lining

Farm Pond Lining - Key Facts (Cumulative; Since Inception)		
Number of Farmers	**Disbursed Amount in Cr. (Rs.)**	**Water Storage Capacity Created (TCM)**
3158	30.59	6264

The table above showcases the key facts of Farm Pond Lining since the inception of the project. A total of 3158 beneficiaries were supported, resulting in a cumulative water storage capacity of 6264 TCM. The total disbursement for farm pond lining amounted to Rs. 30.59 Cr. These figures underscore the project's efforts to enhance water retention and irrigation efficiency through farm pond linings.

The Department of Agriculture, Government of Maharashtra has reported that lined farm ponds can reduce water losses by up to 40 percent, significantly improving water availability for agricultural purposes.[57] Additionally, 6 percent of project beneficiaries reported that they used the farm pond for inland fishing in comparison while no respondent from the control area reported the same. This highlights how the project has been instrumental in providing technical and financial inputs to increase water levels and diversify sources of income.

[57] *Maharashtra State Department of Agriculture, http://maharashtra.mahanhm.in/GuidLineDetail.aspx*

Open dug well

Irrigated agriculture accounts for about 87 percent of the total annual groundwater extracted in India. However, open-dug wells and borewells were seen drying up in certain areas where the use of water was more than usual, reflecting some consequences of irrigated agriculture[58]. This indicates a potential for further improvement in developing open-dug wells.

Open-dug wells are an integral component of the PoCRA project's strategy to improve groundwater access for farmers. These wells are manually excavated to reach groundwater tables, providing a reliable water source for irrigation and other agricultural needs. The PoCRA project supports the construction of open-dug wells, ensuring farmers have a dependable water supply even during drought conditions. These wells play a vital role in sustaining agricultural productivity, allowing farmers to irrigate crops, support livestock, and maintain overall farm operations despite fluctuations in rainfall and water availability.

Table 23: Key Facts – Open Dug Well

Well - Key Facts (Cumulative; Since Inception)	
Number of Farmers	**Disbursed Amount in Cr. (Rs.)**
1939	44.77

The table above highlights key statistics on open-dug wells under the PoCRA project implementation since its inception. The project has constructed open-dug wells only in safe watershed zones as prescribed by the GSDA. A total of 1939 farmers were supported, with a cumulative disbursement of Rs. 44.77 Cr. These figures reflect the project's commitment to improving water access and agricultural productivity through the development of open-dug wells.

Table 24: Benefits of Open Dug Well reported by Respondents during Endline

Benefits	Project (%)	Control (%)
Increased availability of water for protected irrigation	17	15
Change in cropping pattern	11	10
Improved availability of water during dry spells	9	9
Increased water availability for Rabi season	4	2

The table above highlights the benefits stemming from open-dug wells accruing to the respondents. The project areas have experienced a higher share of benefits, with respect to increased availability of water for protected irrigation and increased water availability during the Rabi season. Both these elements have augmented a change in cropping patterns in project regions which is expected to boost crop diversification, and soil health to ensure the sustainability of interventions undertaken.

[58] *Book -India's Water Future in the Changing Climate – chapter 4, 2014, https://link.springer.com/chapter/10.1007/978-981-97-1785-9_4* -

Figure 30: Open Dug Well in Project Area in Parbhani

During our interaction with VCRMC member in Sirsadevi (Beed) it was learnt that prior to PoCRA's implementation, vagaries of weather often wreaked havoc on cotton & wheat crops impacting farmer's sustenance. But after the coming in of PoCRA, farmers in the project regions have realized higher incomes due to adoption of polyhouse, fencing, lining and micro irrigation instruments among others. Dissemination of knowledge during FFS sessions relating to judicious use of water resources has also been well received and promptly adopted

Recharge of open dug well – Augmenting groundwater levels

The project includes initiatives to recharge open-dug wells, enhance groundwater levels, and ensure sustainable water availability. This involves techniques such as rainwater harvesting and directing surface runoff into wells, which replenish groundwater reserves. By focusing on well recharge, the project addresses the issue of groundwater depletion, promoting long-term water security for agriculture. This measure helps maintain a steady supply of water for irrigation, thus supporting continuous agricultural activities and reducing the adverse impacts of droughts and water scarcity on farming communities.

Table 25: Key Facts – Recharge of Open Dug Wells

Recharge of Open Dug Wells - Key Facts (Cumulative; Since Inception)	
Number of Farmers	**Disbursed Amount in Cr. (Rs.)**
588	0.69

In the project areas, the recharge of wells has significantly improved water availability, leading to enhanced crop yields and higher incomes for the beneficiaries. This intervention has substantially boosted both economic and agricultural outcomes, as evidenced by notable improvements in annual income and horticultural production in project areas compared to a control area. The recharge of open-dug wells has helped to increase water availability for protected irrigation as compared to control villages.

Based on endline survey data, 13 percent of farmers in the project village experienced water availability during dry spells. 5 percent of farmers noted the increased water availability for the Rabi season. It also contributed 8 percent of farmers in the project village to increase in area of cultivation during the kharif season. The recharge of open-dug wells has proven to be a critical component in enhancing agricultural resilience and productivity, showcasing the effectiveness of PoCRA's strategies in supporting sustainable agriculture and improving farmer livelihoods.

Micro irrigation systems

Micro-irrigation is a precise irrigation application technique that minimizes loss of water in traditional agricultural practices due to percolation, runoff, and soil evaporation and enhances water use efficiency. This helps in improving the productivity of dry land farming by reducing vulnerability to extended in-season dry spells and lower-than-normal rainfalls. The government through the “Per Drop More Crop” initiative is promoting micro-irrigation across the country.

Agricultural production in the project area is largely smallholder-based, rainfed, and highly vulnerable to vagaries in climate. Most of the project areas have experienced challenges due to unreliable monsoons which results in late planting of kharif crops and lower yields due to reduced availability of water in the season. Thereby reducing the scope for subsequent rabi and summer cultivation. Since these regions are drought-prone, improving water availability for farming, especially during dry periods is crucial to ensure sustainable crop production.

Through the project, a bouquet of services is offered to the beneficiaries to adopt diverse climate-resilient technologies for individual farmers, and financial assistance is provided for the adoption of micro-irrigation techniques. This constitutes nearly 62 percent of the total project expenditure. This reinforces the fact that before the project was implemented, there was significant latent demand for micro-irrigation in the project geography. The project has been instrumental in addressing the hitherto unmet need as seen in the table below.

Table 26: Key Facts – Micro Irrigation (Cumulative; Since Inception)

No. of Farmers	Area Covered (ha)	Disbursed Amount in Cr. (Rs.)
431328	488747	2357.83

A total of 431328 farmers have benefited directly from this initiative. The total area covered through micro-irrigation is 488747 ha, of which 282481 ha is for drip and 206266 ha is for sprinkler irrigation respectively. These interventions have not only optimized water management practices but have also significantly contributed to enhancing agricultural productivity and sustainability.

From the expert field visit, it was seen that regarding energy usage, since the overall number of pump operating hours have reduced significantly due to the adoption of sprinkler and drip irrigation, the energy saving was worked out ranging from 40 to 60 percent. Farmers reported an increase of 40 to 50 percent, both by sprinkler and drip irrigation. The greater area under irrigated cultivation has resulted in more yields and they are fully convinced of the benefits of drip and sprinkler irrigation

Figure 31: Drip Irrigation in Project Area

Drip irrigation systems

Drip Irrigation technology involves irrigating the root zone through emitters fitted on a lateral tube as well as inserted within the tubing as the emitting pipe. The use of different emitters will depend upon specific requirements, which may vary from crop to crop[59]. This method involves the slow release of water in droplets, minimizing evaporation and runoff, and ensuring precise moisture control for crops. Drip irrigation is particularly advantageous for conserving water, reducing soil erosion, and enhancing crop yield and quality by maintaining optimal soil moisture levels.

Under this sub-component, farmers are provided with financial subsidies to install these systems, making them accessible and affordable. Additionally, the project conducts extensive training and capacity-building programs to educate farmers on the benefits and proper implementation of drip irrigation.

Table 27: Impact of Drip Irrigation in PoCRA Region

S. No	Indicators	Pre	Post	Difference	% Difference
Drip Irrigation					
	Land Cultivated, Rabi (Acres)				
	Project	1.25	1.57	0.32	26
	Control	1.04	1.28	0.24	24

During the endline survey, when asked about irrigation during rabi season both pre and post-project implementation, the project group reported an increase in cultivated land from 1.25 to 1.57 acres, indicating a 26 percent rise, while the control group saw a 24 percent increase from 1.04 to 1.28 acres. In project areas, these results suggest that drip irrigation has contributed to higher land cultivation for the project group. Additionally, the project group experienced the advantages of adopting drip irrigation which reduced water wastage, optimized the use of fertilizer, and minimized the need for additional inputs with respect to the control group whose constituents were more habituated to using conventional irrigation methods.

Table 28: Key Facts- Drip Irrigation

Drip Irrigation – Key Facts (Cumulative; Since Inception)		
Number of Farmers	**Area in Hectares**	**Disbursed Amount in Cr. (Rs.)**
227491	282481	1962

Based on the table below, in terms of crop irrigation in the endline, the project group demonstrates a slightly higher average area irrigated for crops such as pigeon pea, chickpea, sorghum, maize, sugarcane, and turmeric. Specifically, the average area irrigated for pigeon pea by the project respondents is 3.31 acres compared to 3.14 acres for the control respondents. Similarly, chickpea shows a notable difference, with the project group averaging 3.23 acres against the control group's 2.93 acres. For sorghum, the project respondents have an average of 2.68 acres, which is higher than the 2.42 acres reported by the control group. Maize irrigation also shows a similar trend, with the project group averaging 3.4 acres compared to the control group's 3.1 acres. Turmeric has the most significant difference, with project respondents irrigating an average of 4.5 acres, while the control group averages 4.42 acres. However, the control group shows a marginally higher average for Soybean (3.73 acres vs. 3.71 acres).

[59] *Operational Guidelines of Per Drop More Crop (Micro Irrigation) Component of PMKSY, 2017, https://pmksy.gov.in/microirrigation/Archive/GuidelinesMIRevised250817.pdf*

Table 29: Area Irrigated using Drip for Different Crops (in acres)

Crop	Project	Control
Cotton	3.42	3.31
Pigeon pea	3.31	3.14
Soybean	3.71	3.73
Sugarcane	2.82	3.09
Chickpea (Rabi)	3.23	2.93
Sorghum (Rabi)	2.68	2.42
Maize (Rabi & Kharif)	3.4	3.1
Turmeric	4.5	4.42

These differences suggest that the project interventions might have been more effective in promoting efficient irrigation practices for certain crops. The higher irrigation averages for key crops like pigeon pea, chickpea, and maize indicate that the project group could potentially experience better crop yields and productivity, which are crucial for agrarian economies. The slight advantage seen in soybean for the control group might be due to specific local practices or soil conditions favoring soybean cultivation. Overall, the data underscores the positive impact of the project on enhancing irrigation efficiency, which can lead to improved agricultural outcomes and economic benefits for the participating farmers. The key benefits of drip irrigation observed in project villages are the increased availability of water for protected irrigation and increased water availability during the Rabi season.

Sprinkler irrigation system

Sprinkler irrigation is an agricultural irrigation method that mimics natural rainfall by distributing water through a system of pipes and sprinklers. This technique involves spraying water into the air, allowing it to fall evenly over crops, providing uniform coverage. Under sprinkler irrigation, water is discharged under pressure in the air through a set of nozzles attached to a network of High-Density Polyethylene (HDPE) pipes, simulating rainfall. Sprinkler irrigation systems are suitable for irrigating crops where the plant density is very high[60]. It is widely used for cereals, pulses, seeds, spices, and field crops.

Sprinkler systems can be permanent, semi-permanent, or portable, and they can be tailored to suit various types of terrain and crop requirements. This method is especially beneficial for areas with uneven land or where traditional irrigation methods are less effective. Under this component, the project helps optimize water use efficiency, reduce water wastage, and improve crop yields by providing farmers with financial subsidies for these systems. Additionally, training programs are conducted to educate farmers on the benefits and proper use of sprinkler irrigation.

The table below quantifies the positive impacts of adopting sprinklers as an irrigation technology through a difference-in-difference methodology. 1456 households in the project group and 1278 in the control group were used in this analysis. The increase in land area cultivated (Rabi) in the post-period was 9 percent higher than the control group i.e., we are thus able to isolate the effect of PoCRA intervention during the endline. These results are particularly encouraging as there is better water distribution, healthy crop growth, and higher yields facilitated by installing sprinkler systems.[61]

[60] *Operational Guidelines of Per Drop More Crop (Micro Irrigation) Component of PMKSY, 2017,* *https://pmksy.gov.in/microirrigation/Archive/GuidelinesMIRevised250817.pdf*
[61] *https://www.researchgate.net/publication/325844917_Sprinkler_irrigation*

Table 30: Impact of Sprinkler Irrigation in PoCRA Region

S. No	Indicators	Pre	Post	Difference	% Difference
Sprinkler Irrigation					
	Land Cultivated, Rabi (Acres)				
	Project	1.59	2.33	0.74	46
	Control	1.59	2.16	0.58	37

Table 31: Key Facts- Sprinkler Irrigation

Sprinkler Irrigation – Key Facts (Cumulative; Since Inception)		
Number of Farmers	**Area in Hectares**	**Disbursed Amount in Cr. (Rs.)**
203837	206266	395.74

This substantial investment as noted in the table above has facilitated widespread adoption of sprinkler irrigation, highlighting the project's significant impact on enhancing water-use efficiency in agriculture. By providing resources and support to a large number of farmers, the PoCRA project has effectively promoted sustainable agricultural practices, leading to improved crop yields and water conservation. In conclusion, the PoCRA project's emphasis on sprinkler irrigation has made significant strides in transforming agricultural practices in Maharashtra. By focusing on efficient water use and supporting farmers in the adoption of advanced irrigation methods, the project has not only enhanced crop productivity but also contributed to the sustainability and resilience of the agricultural sector.

Figure 32: Sprinkler in Beneficiary Farm in Project Area

Best Practice – Water Security and Management – Siras Devi, Beed

Water security & management is a key pillar to promote climate resilient agriculture under PoCRA. It supports activities aimed at achieving on-farm water security by maximizing the use of surface water for agriculture, managing groundwater resources in a sustainable manner, retaining and enhancing soil moisture, and enhancing water-use efficiency and water productivity.

The project's interventions played a very important role in improving the condition of water security and management in the village of Siras Devi, Beed. With respect to sources of water, prior to PoCRA's interventions, the situation in the village was abysmal. Despite 70 percent well availability, there was a universal absence of farm ponds, bore/tube wells were characterized by poor condition, and water levels in rivers and canals were low. PoCRA's implementation, however, brought about transformative changes. Fifty new farm ponds were created, leading to a substantial increase in groundwater levels, which also boosted water levels. Creation of farm ponds is in congruence with other schemes of the Government of Maharashtra catering to formation of individual farm pond. This had far reaching impact in the form of water now being available both the Kharif and Rabi seasons as farm ponds aid protective irrigation.

In terms of utilization of water in the fields, traditional practices of irrigation were prominent across Kharif, Rabi and summer seasons. The picture has changed significantly post-intervention, with several farmers adopting more modern techniques relating to micro irrigation practices such as drip and sprinkler irrigation. Such methods were prominently adopted during the Rabi season, indicating a proactive approach to optimize water usage. Moreover, in the summer season, there was an increase in crop cultivation, reflecting better water management practices and improved availability of water due to the PoCRA's activities.

Figure 33: Best Practice – Water Security and Management

Protected irrigation

The project has supported various water lifting and conveying devices to utilize water for irrigation created by various structures including pumps, pipes, etc.

Water pumps

Pumps are vital components of micro-irrigation systems, including drip and sprinkler irrigation. These are used to move water from its source through the irrigation system and to the crops. By providing the necessary pressure, pumps ensure a steady and controlled flow of water, which is crucial for the efficiency and effectiveness of micro-irrigation. The advantages of using pumps in micro-irrigation are significant: they facilitate precise water delivery, conserve water resources, enhance irrigation efficiency, and support the uniform application of water, which improves crop yield and quality.

Table 32: Key Facts- Water Pumps

Water Pumps – Key Facts (Cumulative; Since Inception)	
Number of Farmers	**Disbursed Amount in Cr. (Rs.)**
31373	45.39

Under the project, substantial support is provided to encourage the adoption of pumps. Farmers receive subsidies to purchase and install these pumps, making micro-irrigation more affordable and accessible. The water pumps benefit farmers better in increasing water availability for the Rabi season in the project area than the control. As seen above, there has been substantial investment made in supporting the use of water pumps by the farmers since the inception of the project.

Table 33: Impact of Pumps in PoCRA Region

S. No	Indicators	Pre	Post	Difference	% Difference
Pipes	**Land Cultivated, Rabi (Acres)**				
	Project	1.23	1.99	0.76	62
	Control	1.04	1.43	0.40	38

The above table shows the impact of the use of water pumps in project and control areas. In the Rabi season, the project area saw an exponential increase of 62 percent in the cultivated land area from 1.23 acres to 1.99 acres and an increase of 38 percent from 1.04 acres to 1.43 acres in the control area. These pumps ensure efficient water management through irrigation in drought-prone and rain-fed areas, thereby enhancing agricultural productivity and sustainability. By providing reliable water access, they help mitigate the impacts of erratic rainfall and water scarcity, enabling farmers to adopt practices like drip irrigation.

Pipes (HDPE/PVC)

Pipes are essential components to convey water from source to field while ensuring no loss during conveyance. The significant investment in pipes as seen in the table underscores the project's commitment to improving irrigation practices and reducing water wastage. By providing essential infrastructure, the PoCRA project has empowered farmers to optimize their water use, leading to increased agricultural productivity and sustainability.

Table 34: Key Facts- Pipes

Pipes – Key Facts (Cumulative; Since Inception)	
Number of Farmers	**Disbursed Amount in Cr. (Rs.)**
27633	52.83

The table below indicates the positive impacts of adopting pipes as an irrigation technology through a difference-in-difference. 242 households in the project area and 363 in the control area were used in this analysis. The increase in land area cultivated (Rabi) in the post-period was 18 percent higher than the control group—we are thus able to isolate the effect of the PoCRA intervention.

Table 35: Impact of Pipes in PoCRA Region

S. No	Indicators	Pre	Post	Difference	% Difference
Pipes	**Land Cultivated, Rabi (Acres)**				
	Project	1.40	2.04	0.64	46
	Control	1.17	1.49	0.32	28

These results underscore the effectiveness of pipe-based irrigation in boosting agricultural productivity, income, and resource management, supporting more sustainable and profitable farming practices. This has helped farmers in the project village to increase the availability of water for protected irrigation and efficient use of water. This intervention is part of a broader strategy to foster resilient farming communities, ensuring long-term benefits for the agricultural sector in Maharashtra. The positive impact on water management and crop yields highlights the effectiveness of these targeted interventions in supporting the farming community.

5. Component B- Climate Smart Post-Harvest Management and Value Chain Promotion

The project architecture for this component is based on three design principles. First, it focuses on developing the capacity of FPOs to enable them to reach more farmers and perform more effectively as aggregators. This involves providing services and building capacity, considering the regional context. The second principle is to align income and growth levers, such as training on sustainable agricultural practices, providing infrastructure, and facilitating access to credit. The third principle is to empower women farmers by involving them more in the agricultural value chain and FPOs.

Under the agribusiness component, the project promotes custom hiring centers (CHCs) as a major activity. The objective is to contribute to climate co-benefits by encouraging the use of fuel-efficient and technology-efficient farm machinery and equipment for pre- and post-harvest farm activities. The project also supports the construction of collection centers with cleaning, sorting, and packing facilities, as well as storage facilities. For FPCs targeting export markets and supply to retail chains, cooling facilities should be considered. Additionally, secondary processing units, such as flour milling, dal production, oil extraction, etc., are supported where there is a financially viable and sustainable business case.

The project has also financed the establishment of seed hubs and strengthened the capacity of key stakeholders in the seed supply chain to improve the supply of seed varieties with early maturity, drought, and salinity-resistant and heat-tolerant features.

5.1 Promoting Farmer Producer Companies

Small and marginal farmers (SMFs) constitute nearly 85 percent of all farmers in Maharashtra[62]. Owning 47 percent of the total operated area[63], the average landholding of this segment is just 1.48 acres[64]. The fragility of SMF livelihoods is exacerbated by risks of climate change, absence of timely crop advisory, limited access to inputs, credit, post-harvest services, and market linkages.

Within the SMF segment, women farmers face additional constraints of traditional gendered norms limiting their access to and control over land, information, finance, markets, and low participation in agriculture activities[65].

The aggregation of farmers into cooperatives, commodity groups, and interest groups has emerged as a model to mitigate the challenges of SMFs and improve women's participation in agri-value chains[66]. An aggregation model that has gained traction is the farmer-producer organization (FPO).

Reflective of a shift in understanding farming as a "value-led enterprise", it is believed that FPOs, through the provision of services such as bulk procurement of inputs, marketing of outputs, primary and secondary processing, and facilitating access to credit, can help SMF[67] avail of benefits of scale, thereby improving their incomes[68].

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[62] Marginal and small farmers are those with less than 1 hectare (2.47 acres) and between 1 and 2 hectares (2.47 to 4.94 acres) of land respectively.
[63] Operated area includes both cultivated and uncultivated area, provided part of it is put to Agricultural production during the reference period.
[64] Dept of Agriculture and Farmers Welfare, GoI. 10th Agricultural Census 2015-16 (provisional estimates)
[65] IFAD (2015). Promoting the leadership of women in producers' organizations. Lessons from the experience of FAO and IFAD
[66] National Association of Farmer Producer Organizations https://www.nafpo.in/wp-content/uploads/2021/12/NAFPO-Gender-Equitable-Transformation-of-Agriculture-_FPO-Guidelines.pdf
[67] Ministry of Agriculture and Farmer's Welfare. GoI. (2019) Report of the Committee on Doubling Farmers' Income
[68]NABARD (2015). Farmer Producer Organization. Frequently Asked Questions, 2015, https://www.nabard.org/demo/auth/writereaddata/File/FARMER%20PRODUCER%20ORGANISATIONS.pdf

Agribusiness interventions of PoCRA

The objective of this component is to support the participation of smallholder farmers in the Farmer Producer Organizations (FPOs) and integration of these FPOs in value chains for crops relevant to the climate agenda and strengthen the supply chain for climate-resilient crop varieties in the project area. The operational definition of FPO adopted by the project includes Farmer Producer Companies (FPCs) as well as other organizations at the sub-district or village level, such as Farmer Interest Groups (FIGs), and Self-Help Groups (SHGs), including women-led groups also.

FPCs are key stakeholders in GoI's strategy for agricultural growth and rural development. In 2019, the Government of India announced the formation of 10,000 new FPCs on a cluster basis under Central Sector Schemes. FPCs are organizations whose members are primary producers and usually result from the federation at the village cluster level of FIGs, SHGs, and other farmer groups. This intervention also has a focus on empowering women farmers – deepening their engagement across the agri-value chain and in FPOs.

Under the agribusiness component, Custom Hiring Centres (CHCs) are one of the major activities promoted under the project. Activities such as processing units for value chain development, storage godowns, and allied agriculture-based business activities are also supported under the project. The project also offers infrastructure support to improve the supply of climate-resilient seed varieties. The project has financed the setting-up of seed hubs and strengthened the capacity of key stakeholders in the seed supply chain. The agribusiness interventions of PoCRA are envisaged to have both short-term and long-term impacts on the overall livelihood sustainability and climate shock-proofing of the farming community in the project region.

Support to existing FPOs - Capacity building and training

Coverage and distribution

Various agribusiness activities were supported to strengthen the pre- and post-harvest management and value chain development of crops in project areas with a view to maintaining food security and livelihood security. Business Sustainability of FPOs was ensured by supporting agro-based businesses with a 60 percent (maximum Rs 60 lakhs) subsidy of total project value up to Rs. 1.00 Cr.

Initial assessment of registered FPCs

Initially, a survey conducted in the Dharashiv district by the Gokhale Institute of Politics and Economics in 2017, gave baseline information about the workings and aspirations of the FPCs that led to policy suggestions for designing the agribusiness component of PoCRA. Later, 1666 FPCs registered in the project districts till September 2020 were surveyed and evaluated by the project in the initial stage. The evaluation process for 1442 FPCs was completed, with 619 evaluated during Phase 1 and 823 during Phase 2. The FPC evaluation reports were disseminated to the relevant FPCs through the district functionaries. The in-house rating tool provided an unbiased assessment of the strengths and weaknesses of these FPCs based on the eight specified parameters that are organization and administration, governance, management, infrastructure, finance and market linkages, capacity building, and climate resilience.

FPO-DBT portal

The FPO-DBT portal was developed and commissioned in May 2021. The entire process of application, scrutiny, and disbursement of assistance was done through the portal and the subsidy was directly disbursed to the registered bank accounts of the FPOs, which has helped in creating a transparent, efficient, and credible system of funds disbursement. The feedback feature of the portal enables revisiting the supported business ventures and evaluating their progress. Due to the DBT feature the process time (average time taken from application till disbursement) which was 348 days before the DBT feature was reduced to 203 days post-launching the FPO DBT portal.

Robustness of financial, monitoring, and handholding structures

In addition to the FPO DBT portal, existing structures of the agriculture department in the state were buttressed with a dedicated field-level PoCRA staff for ensuring smooth, efficient, and robust structures for facilitating technical handholding, monitoring, and auditing the establishment of agri-businesses. Follow-up visits every six months by the district-level project staff ensured concurrent appraisal of the progress.

Financial support to FPOs (FPCs, Farmer Groups & SHGs supported under the project)

Every eligible FPO of the project area was entitled to submit applications for multiple projects within an overall subsidy limit of Rs. 60 lakhs. Out of the total 5830 proposals received for assistance, a total of 4701 eligible proposals of Farmer Producer Organizations (FPOs) were assisted under the project. They included 1698 Farmer Producer Companies (FPCs), 1799 proposals of Farmer groups (FGs), and proposals of 1204 Self-help groups (SHGs) as seen in the table below. The total amount of assistance provided was Rs. 501.71 Cr., which included 3235 unique entities, comprising 1187 FPCs,1173 Farmers Groups, and 875 SHGs.

Table 36: Agribusiness Proposals Activity-wise Disbursement Status

Activity Group	Farmers group		FPC		SHG		Total	
	Phy.	Disbursed Amount (Rs. Cr.)	Phy.	Disbursed Amount (Rs. Cr.)	Phy.	Disbursed Amount (Rs. Cr.)	Phy.	Disbursed Amount (Rs. Cr.)
Custom Hiring Centre (CHC)	1016	101.61	1063	114.66	700	66.35	2779	282.63
Godowns and Warehouses	438	45.87	263	37.87	259	28.39	960	112.14
Other Agribusiness Activities	195	18.13	228	31.03	122	11.71	545	60.87
Post-harvest/ Processing units	150	15.73	144	18.13	123	12.22	417	46.07
Total	**1799**	**181.34**	**1698**	**201.69**	**1204**	**118.68**	**4701**	**501.71**

Inclusion of women and vulnerable communities

Notably, 237 of the total project-supported FPOs were women-led. PoCRA's focus on gender and vulnerable farming communities is also evident through the survey of 335 households that have accessed the agribusiness services through these FPOs. It is observed that nearly 14 percent of women and 17 percent of vulnerable members including 13 percent of NT, 2 percent of SCs, and 2 percent of STs used these agribusiness services.

Capacity building

The project aimed to enhance the knowledge and skills of beneficiary participants across various aspects of agribusiness, including business development, project designing, warehouse management, and post-harvest technologies. Additionally, the exposure visits provided practical insights to FPOs and SHGs. The programs were aimed to build capacity across various aspects of agribusiness, from strategy development to practical implementation. More than 8250 diverse training programs catered to different stakeholders, fostering sustainable agribusiness practices.

Table 37: List of Training Institutes Partnered for Capacity Building for Agribusiness Training

S.No.	Subject	Training institutes
1	Business development strategies for SHGs, FPC members, and project officials	Vaikunth Mehta Institute of Co-operative Management (VAMNICOM)
2	Program on developing concepts for agri-business projects for officials	Bankers Institute of Rural Development - Mangalore (BIRD)
3	Training program on silage making (Online)	Animal husbandry
4	Warehouse management for FPOs	Maharashtra State Warehouse Corporation - Pune (MSWC) /VAMNICOM
5	Post-harvest onion storage technology	ICAR-Directorate of Onion And Garlic Research (DOGR), Rajgurunagar
6	Training conducted at PD ATMA / Field level	Various institutes like KVK/ Project officials conducted training as a master trainer
7	Exposure visits for FPCs/ SHGs	

The endline survey shows that on average three members of every FPC and eight members per SHG received some kind of training during the project period. The capacity building and skill enhancements of FPC and SHG members may have contributed to the empowerment and efficiency of agricultural practices and business operations. The member farmers of FPOs were trained on business proposals, financial transactions, market linkage, and the establishment of agribusiness activities like custom hiring centres, processing units, storage, and seed processing.

5.2 Strengthening existing value chain for climate-resilient communities

A total of 47 agribusiness activities have been supported under the project. These activities have been grouped under four major activity groups that are (a) Custom Hiring Centers (CHCs), (b) Godowns/ Warehouses/ Seed storage structures, (c) Post-harvest processing units, and (d) Other agribusiness activities.

Custom Hiring Centres (CHCs)

Agricultural Mechanization plays a vital role in increasing field efficiencies, higher productivity, and reduction of human drudgery in field operations.[69] Mechanization helps to overcome the challenges of shortage of labour, high labour cost, and diverse agricultural operations. For small & marginal farmers, access to implements and machinery is constrained by the high purchase cost of implements on an individual basis. Thus, FPO-owned CHCs are promoted to offset the adverse economies of scale arising due to small and marginal land holdings. CHCs are supported to enhance the productivity and timely cultivation of various crops grown in the project area by providing farm implements to small and marginal farmers on a rental basis.

A total of 2779 FPOs received support for establishing CHCs and the financial assistance provided to these CHCs amounted to Rs. 282.62 Cr. Assuming that every CHC caters to the cultivation of approximately 300 ha[70] of land, it can be extrapolated that CHCs created through the project could have led to mechanization of over 8 lakhs ha leading to reduced labour dependency in agricultural operations and improved efficiency of farm operations. During the endline survey, 106 respondents were asked about the business viability of CHCs, of which 40 percent of the respondents believed that CHC is a viable business. Proper management and strategic location of CHCs contribute to their viability as a sustainable business model.

[69] *Verma, S. R. (2006). Impact of agricultural mechanization on production, productivity, cropping intensity income generation and employment of labour. Status of farm mechanization in India, 2006, 133-53.*
[70] *Guidelines on sub-mission on mechanization in agriculture, GOI - https://agrimachinery.nic.in/Files/Guidelines/smam1819.pdf*

From the survey data of 52 households accessing CHCs, the total cost of hiring farm machinery for pre-sowing, sowing, interculture, harvesting, and threshing operations is estimated at around Rs. 3000/- per acre in project areas.

Figure 34: Sant Namdev FPC beneficiaries along with CHC Machineries Procured through Project

The average cost[71] invested on similar farm machinery by all the surveyed farmers of key crops for control villages is Rs. 3865/- per acre. This shows that renting farm machinery from the CHCs is beneficial for the farmers. It is evident that the CHCs can reduce nearly 23 percent of the cost of renting farm machinery in the project villages. Given the efficiency of project implementation for agribusiness interventions, it is observed that nearly 80 percent of these 52 households did not face any challenge in accessing the facilities from the CHCs, while the rest of them reported minor process-related problems.

Apart from reduced hiring cost of farm machinery at CHC, data shows that 62 percent of the CHC users expressed a reduction in drudgery, 85 percent of them saved on labour costs, and 81 percent of them saved time on the critical farm operations by utilizing the machinery available at CHCs.

From the above analysis, it is evident that Custom Hiring Centres (CHCs) have played a pivotal role in transforming agriculture in the project areas. The adoption of modern farm machinery through CHCs has significantly saved time for farmers, allowing for more efficient agricultural operations. Additionally, CHCs have contributed to a reduction in the cost of cultivation, making farming more economically viable. Moreover, there has been a notable behavioral shift among villagers towards adopting climate-resilient agricultural practices.

The widespread implementation of systems like the Broad Bed and Furrow (BBF) system, driven by the CHCs, highlights this change. This shift is crucial for enhancing the climate resilience and sustainability of these villages, ensuring long-term agricultural productivity and stability.

[71] Average cost is estimated from the rent of farm machinery in the cost of cultivation of Cotton, Soybean and Pigeon pea for both project and control villages.

Table 38: Types of Farm Machinery procured in PoCRA-supported CHCs

S.No.	Operation groups	Type of Equipment	Total Number of Equipment
1	Land preparation/ Pre-sowing equipment	Tractor, Power tiller (Range 20 BHP to 55 BHP), Rotavator, MB plough, Reversible plough	18028
2	Sowing equipment/ Inter cultivating equipment	BBF, Cultivator, Ridger, Seed cum fertilizer drill, V-pass, Sprayer, Power weeder, Mulcher, Spreader, Planter, Blower, Harrow, Leveller, Furrow opener, Bed maker, Pneumatic planter, Turmeric planter, Shredder, Potato digger, Potato planter, Turmeric bed maker	8649
3	Harvesting and post-harvest equipment	Thresher, Chaff cutter, Sorting/ Cleaning/ Grading machine, Turmeric polisher, Reaper, Turmeric cooker, Maize sheller, Combined harvester, Mower, Spiral separator, Trolly and Others	9656
Total			**36333**

The diversity of machines procured by the FPOs for running the custom hiring centres displays the bouquet of choices that the FPOs had in the project funding, leading to the farmers having a freedom of choice to select appropriate machines based on the diversity of the cropping pattern.

Godown/ Warehouses/ Seed storage structures:

The uncertainties of weather adversely affect the production of food grain & other commodities, while the demand for food is increasing due to the rise in population. Increased demand can be met by increasing the production & productivity of agricultural commodities while simultaneously reducing post-harvest losses during handling. It is estimated that about 10 percent of food grains and 35 percent of fruits & vegetables are lost in post-harvest handling[72]. These losses can be minimized by storing commodities in hygienic conditions. The climate-resilient seeds can also be stored to enhance the availability of seeds to the small & marginal farmers in the project area.

Under this subcomponent, support for storage infrastructure was provided to create storage facilities at the community level for storing various commodities (grain/seed). A total of 960 FPO proposals received support for establishing storage structures, drying yards, and seed processing units with financial assistance amounting to Rs. 112.13 Cr. A total of 180836 MT of storage capacity has been created to store Soybean, cotton, tur, and gram on a seasonal basis, serving as both seed and grain storage. The storage capacity created ranges from 80 MT to 1700 MT, averaging 180 MT per godown. Additionally, 11560 MT of storage capacity is specifically created for onions with an average capacity of 200 MT per open-ventilated onion storage structure.

Figure 35: Godowns Established in Project Area

[72] *Principles of agricultural engineering volume-1 by Am Michel and T. P. Ojha*

The cumulative annual storage capacity utilized by all supported FPOs was 257532.22 MT, assuming the full capacity utilization and multiple usages throughout the year. Even assuming that the full capacity may not have been achieved and even if the storage capacities were used at 60 percent utilization rates, we can safely conclude that at least 1.5 lakh MT capacity was utilized across the year for storing various commodities. This highlights that FPOs were able to leverage the additional storage capacity created under this project, thereby also reflecting their ability to manage and store agricultural produce efficiently. Also, the project's focus on creating storage infrastructure has enabled FPOs to handle different commodities effectively as 70 percent of FPCs agreed that better inventory management is achieved due to the availability of storage facilities during the endline survey.

Impact of storage on reduction of wastage

In agribusiness, understanding the determinants of farmer's income is crucial for policy formulation, strategic planning, and the implementation of effective interventions. One robust statistical approach to estimating the impact of various factors on income is through the calculation of the Average Treatment Effect (ATE) using regression analysis. The ATE provides a clear measure of the causal effect of a specific treatment or intervention, in this case, the impact of storage facilities on the reduction of farm waste. The results of this analysis significantly indicate that the storage facilities have a significant negative impact on the proportion of wastage. This means that improving storage facilities has effectively reduced wastage in the project area. The details of this model are presented in the **Annexure 5.**

This is in line with Manandhar et.al. (2018) who observed that smallholder farmers with limited farm mechanization have to manually conduct pre-harvest and post-harvest agricultural operations resulting in loss of produce up to 15 percent in the field, 13 - 20 percent while processing, and 15 - 25 percent in storage. A similar range of storage losses of 20 - 25 percent by the target farmers before good storage facilities are reported by the FPC operators to the agribusiness experts during their field visits. The experts observed that with proper storage facilities provided through godowns in the project-supported FPCs, the godown operators are now able to preserve the quality of agricultural produce and reduce spoilage due to pests, moisture, and environmental conditions. Thus, they can minimize the godown storage losses to around 4 - 6 percent.[73]

Post-harvest/ Processing units

Post-harvest processing units have been supported with an aim to create adequate infrastructure for primary/secondary processing in project areas to reduce wastage and to ensure a fair price for produce in project areas and value-added produce for consumers. Primary and Secondary processing activities have been undertaken by 417 FPOs with financial assistance of Rs 46.07 Cr. disbursed**.** This has helped in entrepreneurship development and value addition of various commodities in the project area.

- 82 FPOs were supported for the establishment of cleaning/ sorting/ grading units of grains and assistance of Rs 10.48 Cr was disbursed. These units are used for the primary processing of soybean, cotton, tur, and gram. The primary processing capacity created under the project is 30400 MT.
- 35 FPOs were supported for the establishment of secondary processing units (food processing units) with financial assistance of Rs. 3.12 Cr. A capacity of processing 10508 MT of food has been created in the project area.
- 140 pulse mills /dal mills have been erected with the financial assistance of Rs.14.68 Cr. with the creation of 42394 MT capacity for making processed pulses.
- 90 FPOs were supported to establish turmeric processing units and a subsidy of Rs. 10.52 Cr. was disbursed, creating a total processing capacity of 9696 MT of turmeric powder.
- Edible oil extraction units were established by 44 FPOs with financial assistance of Rs. 4.60 Cr. A total of 6076 Kg of edible oil can be extracted locally when the units are utilized at full capacity.

[73] Manandhar, A., Milindi, P., & Shah, A. (2018). An overview of the post-harvest grain storage practices of smallholder farmers in developing countries. Agriculture, 8(4), 57.

Other agribusiness activities

The project offered the flexibility of choices to the eligible FPOs which helped them in establishing diverse agribusiness activities. Apart from the processing units and the storage structures, the FPOs ventured into the establishment of innovative and allied agribusiness activities such as essential oil extraction units, neem oil extraction units, cattle feed units, sericulture units, vermicompost units, goat breeding units, and refrigerated/carrier vehicles among others. 545 FPOs were supported under this component and financial assistance of Rs. 60.86 Cr. was disbursed**.**

The Project has significantly enhanced agricultural value chains by supporting the procurement of 356 refrigerated vans and vegetable/fruit carrier vehicles, with a total carrying capacity of 550 metric tons of fresh produce. This logistical improvement has reduced transit wastage and increased the shelf life of agricultural products, enabling farmers and Farmer Producer Organizations (FPOs) to access more distant and remunerative markets. Additionally, the promotion of climate-resilient crops, such as Geranium, on degraded lands has led to the establishment of essential oil extraction units, producing niche high-value products. These efforts have not only fostered environmental sustainability but also bolstered local economies. The array of allied agribusiness activities catalyzed by the Project has effectively created unique micro-level business ventures, promoting employment generation, value addition, and improved earnings for rural communities. By integrating modern logistics, climate-resilient agriculture, and value-added processing, the Project has facilitated a holistic approach to rural development, ensuring both economic and environmental benefits.

Table 39: Capacities and Assets Created under Project

S.No.	Item	Unit	Total Capacities	Remarks
1	Construction of godown/ warehouse/ seed storage structures	MT	180836	Soybean, Cotton, Tur & Gram are stored on a seasonal basis
2	Establishment of custom hiring centres	Ha.	833700	Approximate mechanization achieved in ha
3	Food processing unit	MT	10508	Secondary processing capacity created for secondary processing of produce
5	Grain processing unit (Cleaning/ Sorting/ Grading unit)	MT	30488.	Soybean, Cotton, Tur & Gram are primarily processed on a seasonal basis
6	Medicinal/ Aromatic plants processing unit	kg	27532	Approximate output is utilized with full capacity
7	Oil extraction unit	Kg	6076	Approximate output is utilized with full capacity
8	Onion storage unit	MT	11560	Storage for Onion grown on area of approx. 230 Ha
9	Pulse mill (Dal mill)	MT	42393	Approximate dal output
10	Refrigerated van or Vegetable/ Fruit carrier vehicle	MT	550.	Transportation capacity
11	Seed processing unit	MT	35060	Drying shed & plant capacity included
12	Turmeric processing unit	MT	9696	Secondary processing capacity created for secondary processing of produce

Support to strengthen seed infrastructure

The objective of this component was to encourage the participation of smallholders in the seed supply chain. Accordingly, the project has strengthened the capacities of selected individual farmers (as described later) and FPOs to engage in seed production and seed multiplication in a sustainable and financially viable way. The project has supported production of foundation and certified seeds of climate resilient and locally popular varieties of soybean, pigeon pea and other commodities by providing 60 percent financial support for establishment of seed storage (11) seed processing equipment's (10), drying yards (134) with a total seed processing capacity of 35060 MT. There is a conscious effort to help key players in seed supply chain, overcome bottlenecks to improve the availability of seeds of climate resilient and highly productive varieties in the project area. The project has supported 157 FPOs with a 60 percent subsidy of Rs 19.40 Cr. for creating a robust seed infrastructure. The FPOs have emerged as trusted suppliers of authentic and viable seeds of preferred varieties in the project area. These FPOs have been integrated in the state structure of seed production, certification and distribution through proper registration, licencing and accreditation process.

Harvesting Prosperity:
The Geranium Distillation Unit Initiative

Overview

Ganorkar Aroma Farm Producer Co. Ltd., established in 2021 in Amravati, represents an innovative approach to agriculture in a district grappling with saline soils and declining water tables. The primary crops in this area, such as cotton, soybean, and Tur, face challenges due to resource depletion. To address these issues, the company has ventured into geranium cultivation, a drought-resistant crop that tolerates high salinity, providing a sustainable alternative. The company's shareholder base comprises 140 farmers who are pivotal in this transformation.

Initiative

Yash Ganorkar, a progressive young farmer and leader of Ganorkar Aroma FPC, spearheaded the establishment of a geranium distillation unit. Recognizing the lack of local processing facilities as a bottleneck for farmers, Ganorkar persuaded the Board of Directors (BOD) to invest Rs. 19.99 lakhs in a small-scale distillation unit with an 8-litre per day capacity. This strategic move was supported by a back-ended subsidy of Rs. 11.92 lakhs, which was disbursed to the company's account following the project's successful initiation. The entire seed investment was raised through self-contribution by the FPC members.

Cultivation and Supply Chain

To ensure a steady supply of raw materials, Ganorkar Aroma FPC encouraged local farmers to cultivate geranium, achieving a consistent supply of 161 metric tons per month. The company secured an assured market for the niche product, geranium oil, by establishing a partnership with a Mumbai-based firm, which promised consistent supply orders at lucrative rates. This created a robust supply chain ecosystem, facilitating efficient production, distribution, and market penetration for geranium oil.

Economic Impact and Performance

In its initial phase, Ganorkar Aroma FPC procured 30 metric tons of geranium from local farmers, leading to a commendable cash profit of nealy Rs. 5.6 lakhs within just six months. This success bolstered the morale of the BOD members and shareholders. The company also focuses on sustainability by recycling by-products into bio-fertilizers, ensuring optimal resource utilization. Additionally, the distillation unit has provided full-time employment to five farmers, enhancing local economic stability. The project also demonstrated significant financial success with an Internal Rate of Return (IRR) of 112 percent and a Net Present Value (NPV) of Rs. 29.99 lakhs in its very first year of operations.

Figure 36: Case Study - Success of Geranium Unit

Sustainability Impact

The impact analysis viewed FPO sustainability across the contexts of business and livelihood sustainability. The impact evaluation has that project interventions have contributed to strengthened FPO systems and processes. Project-supported FPOs have shown improvements across key parameters such as governance, administration, business planning, financial management, and the use of technology to ensure transparency and accountability of operations. The project's efforts in facilitating post-harvest support have resulted in FPOs providing a wide spectrum of advisories and services to farmers and greater connectivity to markets, underscoring the key design principle of the program. Through this, FPOs have developed a larger base for revenue generation and are on the way to emerging as profitable entities.

Diversification and convergence

Upon examining the access of all surveyed FPOs to sources of funding and credit under PoCRA, it was found that many have leveraged this support in conjunction with existing agribusiness schemes and services. This indicates that FPCs not only have future business plans but also believe in sustainable expansion through diversified credit systems. The additional access to credit and support from various sources is likely facilitated by their association with government projects such as PoCRA, SMART, and other agribusiness-related schemes. The project's integration of support and handholding structures within the existing departmental framework ensures that, even after the project's conclusion, structures like ATMA will continue to provide training, facilitation, and convergence services to the project FPOs.

Table 40: Convergence with other Govt Programs

Scheme	FPCs that availed subsidy from other schemes (N=32)	SHGs that availed subsidy from other schemes (N=20)	FIGs that availed subsidy from other schemes (N=21)
Loan waiver schemes	2	1	1
NABARD interest subvention scheme	1	1	-
Finance from Small Farmer Agribusiness Consortium (SFAC)	4	-	-
Training through various sources	8	10	6
Marketing training	13	1	1
Certification training	12	3	1
Branding support through varied sources	8	-	-

Note: The analysis presented in this table is based on qualitative data collected during the endline survey.

Business sustainability

Providing a spectrum of services to farmers by FPOs promotes income diversity and builds their capacities to earn revenue throughout the year. The business sustainability of the project FPCs is assessed by measuring if they are earning profits and re-rating the FPCs to see if they are showing growth on various parameters as measured by the rating tool.

Measurement of profitability of the supported FPOs

A total of 1187 unique Farmer Producer Companies (FPCs) have been supported under the agribusiness component of PoCRA. The scrutiny of audit reports of 237 FPCs that were made available shows that 150 FPCs (nearly 63.29 percent) had registered growth in at least one financial year after project support from PoCRA. The overall annual average profit per FPC stands at Rs. 75760. Out of 237 FPCs, 19 FPCs that had shown losses before the project support have shown a decrease in loss due to the project assistance.[74]

The data highlights several key insights into the operational and financial status of Farmer Producer Companies. The high percentage of FPCs showing profits reflects strong compliance and financial discipline within these organizations. Regular audits are crucial for maintaining transparency and building trust among stakeholders, including farmers, investors, and policymakers. This is a remarkable indicator of their financial success. This high rate suggests that most FPCs are not only surviving but thriving in their operations. Profits are a critical measure of success for FPCs as they directly impact the income and well-being of member farmers. Profitable FPCs can reinvest in their operations, improve services, and provide better returns to their members. For FPCs, consistent profit growth is vital for maintaining member confidence and ensuring continued support and participation.

It can be concluded that the data paints a positive picture of the financial health and operational effectiveness of Farmer Producer Companies. With a majority demonstrating compliance with audit requirements and achieving profitability, FPCs are well-positioned to contribute to the economic empowerment of farmers and the development of the agricultural sector. Continued focus on financial management, transparency, and strategic growth will further enhance the impact and sustainability of FPCs in the future.

Pre-and post-analysis of FPCs using rating tool

As discussed earlier, the project conducted a survey using a rating tool of nearly 1442 FPCs in the project region in January 2021. A few of these surveyed and rated FPCs were revisited during the endline survey. This was a purposive sample with the sole criteria of selection being, that the FPCs had received the project support. In the survey, data on various aspects of FPC specified in the rating tool was collected. To understand the changes that the FPCs have experienced, we have narrowed down eight indicators that would explain the same. The comparative table showing the pre-disbursement and post-disbursement ratings of the FPCs indicates that the FPCs have improved their performance after getting support through the project.

Table 41: Pre- Post Disbursement Rating of FPCs

S.No.	Sampled FPC Name	Pre- disbursement rating (Score out of 100)	Post- disbursement rating (Score out of 100)
1	Narwade Agro Farmer Producer Company, Palsap, Dharashiv	43	54
2	Dev Dhanora Agro Producer Company, Dev Dhanora, Dharashiv	37	53
3	Krishi Pariwartan Farmer Producer Company Ltd., Hingoli	57	61
4	Aadesh Seeds Agro Producer Company Ltd., Sakhare Borgaon, Beed	55	60
5	Greenozone Agro Producer Company Limited, Lonal, Nanded	65	70
6	Abhalmaya Agro Producuer Company, Buldhana	32	49
7	Krishidhan Agro Producer Company, Yavatmal	30	44

[74] *The detailed discussion is given in RFID section*

S.No.	Sampled FPC Name	Pre- disbursement rating (Score out of 100)	Post- disbursement rating (Score out of 100)
8	Wanashish Multicrop Farmer Producer Company Limited, Wardha	29	41
9	Krishi Vigyan Madhuratna Farmer Agro Producer Company Ltd., Akola	31	38
10	Rajanitai Deshmukh Farmers Producer Company Limited, Buldhana	32	43

Notably, project support has helped FPCs to improve their rating. The sample study of ten FPCs indicates that those supported by the project have gained beyond mere financial assistance. They have bettered in several axes such as business and market linkages, finance, organization, administration, and governance. This indicates a strong possibility of their long-term business sustenance indirectly impacting the livelihood betterment of the project area. They need further handholding to improve their capacities and skills.

Pre- Post Project Support Rating of
Narwade Agro Farmer Producer Company,
Palsap, Dharashiv

The FPC was established in 2018. Earlier to 2018, it hardly conducted any business activity. Now it is engaged in Ropvatika (Nursery). It sells saplings of various fruits and vegetables like tomato, brinjal, chillies, flowers etc. at reasonable rates. Before taking the benefits from project, there used to be 100 members in the FPC, now it has increased to 260, which also includes 67 women, and 30 members of SC category. It provides daily employment to 9 people in the village which includes 5 men and 4 women. The total project cost for the establishment of the plant nursery was Rs. 20 lakhs and the project has provided the subsidy of Rs. 11.96 lakhs. Before taking the benefits from the project, the FPC had no infrastructure while now it has its own office. It is observed that the post project support, the FPC has strongly improved its financial health and market linkage.

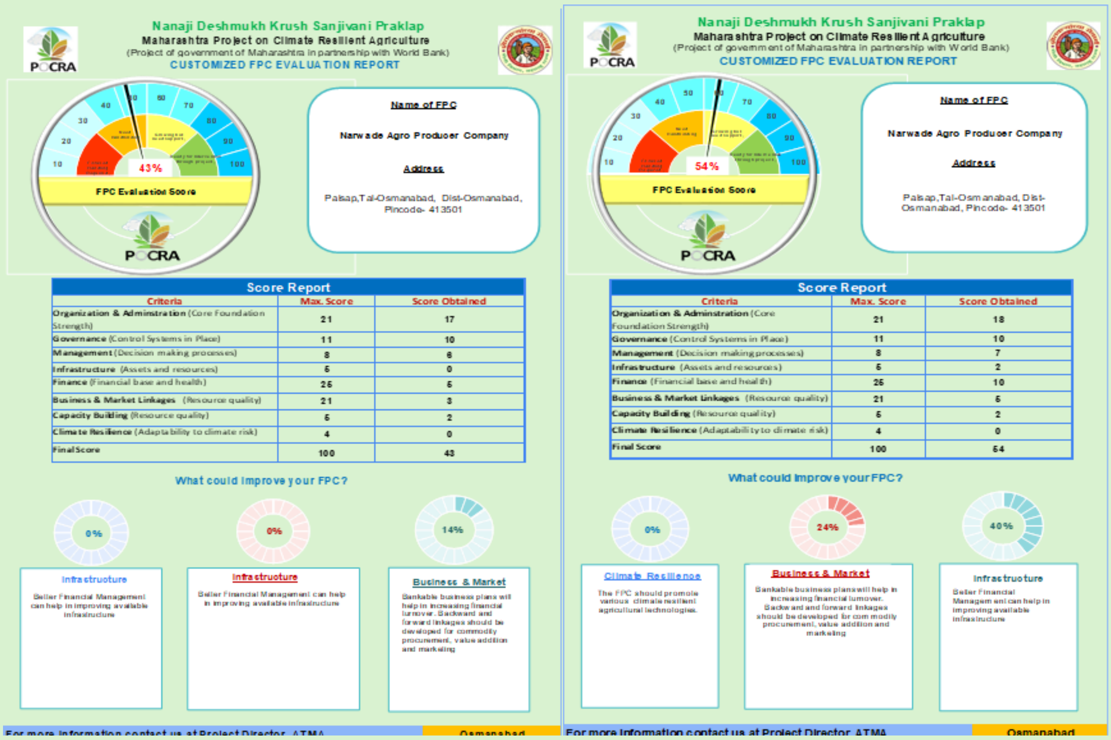

Figure 37: Snapshot of FPO Rating Tool – Change from Baseline to Endline

Livelihood sustainability

Livelihood sustainability can be achieved by changing the lives of people experiencing poverty and disadvantage. The project has supported many livelihood activities for the small and marginal farmers to increase their income through environmentally sustainable and appropriate management of natural resources. The number of farmers who directly or indirectly benefited through the agribusiness activities under the project was about 233976. The project has supported women farmers in participation in the agribusiness activities. The project has also leveraged the livelihood sustainability of the project farmers through agribusiness interventions.

Table 42: Composition of Membership in FPOs in Project Areas

S.No.	Membership Particulars	Membership in FPOs (%) (N = 335)
1	Marginal Farmers (<1 ha)	31
2	Small Farmers (1-2 ha)	46
3	Medium Farmers (2-5 ha)	18
4	Large Farmers (> 5ha)	5

The above composition of sampled FPCs shows that a large number (77 percent) of their member farmers belong to small and marginal groups of farmers. This is in congruence with the project policy of primarily supporting small and marginal farmers. It can be concluded that support given to community-based organizations effectively and indirectly helps the livelihoods of the most vulnerable sections of the farming community. Of the total 7940 unique households which include 4490 in the project and 3450 in control villages, the survey found 335 farmer households (nearly 4 percent of the total sample covered) with memberships in project-supported farmer producer companies (FPCs), self-help groups (SHGs) and farmer interest groups (FIGs). It is observed that within this membership in project districts nearly 15 percent, 55 percent, and 35 percent of farmers were respectively members of the project-supported FPCs (n = 50), SHGs (n = 186), and FIGs (n = 123). It is noteworthy that nearly one-fourth (25 percent) of the households belonged to control villages in these 335 households with farmer membership in this project-supported organizations. This highlights that this project supported organizations that undertake agribusiness activities and have member farmers in both project as well as control regions.

Use of project-supported agribusiness services:

Nearly 22 percent, i.e. 73 of the 335 households accessed various agribusiness and other activities in these FPCs, SHGs, and FIGs. These 73 member farmers include (i) 52 farmers using custom hiring centres for farm machineries, (iii) 16 farmers using storage/ godowns for storing their produce, (iii) eight farmers using processing units for the value chain, (iv) four farmers using refer vans for transportation, and (v) rest eighteen farmers for other services such as the purchase of farm inputs.

Impact on employment

The projects supported FPCs also created employment opportunities for locals through part-time and seasonal engagement as needed. The below table offers a detailed analysis of the impact on employment generation by the project, categorized by full-time, part-time, and seasonal employment for both men and women.

Table 43: Gender-wise Impact on Employment

Category of Employment	Number of FPOs	Total number of persons employed	Average number of days of employment per year	Person days generated	Average wage rate per day (Rs/ day)	Average per capita annual income (Rs./ year)
Full-Time Men	27	123	200	24600	400	80000
Full-Time Female	11	48	200	9600	280	56000
Part-Time Men	10	59	90	5310	400	36000
Part-Time Female	4	35	90	3150	280	25200
Seasonal Men	24	178	30	5340	400	12000
Seasonal Women	12	74	30	2220	280	8400

(**Source:** Endline qualitative interview data for FPCs)

The endline survey of 45 project-supported FPCs was conducted. Of these, 27 unique FPCs provided full-time employment to 171 persons including 123 men and 48 women. It is evident that an average of 6 persons were fully employed in a FPC. These 27 FPCs generate nearly 34200 person-days of full-time employment in FY 2022-23. The wage rates offered were well above the MGNREGA wage rate of Rs. 256/- for the year 2022-23 in Maharashtra.

Full-time employment

For full-time employment, 27 Farmer Producer Companies (FPCs) employed a total of 123 men, each working an average of 200 days per year. This resulted in 24600 person-days generated at an average wage rate of Rs. 400/- per day, leading to an average per capita annual income of Rs. 80000/-. Of these 11 FPCs employed 11 women full-time, generating 9600 person-days with an average wage rate of Rs. 280/- per day, and an average annual income of Rs. 56000/-. While full-time employment provides substantial income for both genders, men benefit from higher wage rates and greater representation.

Part-time employment

Part-time employment data shows that 10 FPCs employed 59 men part-time, with each person working 90 days per year. This results in 5310 person-days at a wage rate of Rs. 400/- per day, translating to an average annual income of Rs. 36000/-. Meanwhile, 4 FPCs employed 35 women part-time, generating 3150 person-days with a daily wage of Rs. 280/-, resulting in an annual income of Rs. 25200/-. Although part-time work offers moderate income levels, the disparity in wage rates between men and women highlights an area for potential improvement.

Seasonal employment

In seasonal employment, 24 FPCs engaged 178 men for 30 days annually, producing 5340 person-days at Rs. 400/- per day, leading to an annual income of Rs. 12000/-. Similarly, 12 FPCs employed 74 women seasonally, generating 2220 person-days with a daily wage of Rs. 280/-, yielding an average annual income of Rs. 8400/-. Seasonal employment provides essential income during specific periods but results in the lowest earnings among all employment types.

The person-days generated are highest in full-time roles (i.e., 34200 person-days), followed by part-time (i.e., 8460 person-days) and seasonal (i.e., 7560 person-days) roles. The average annual income is highest for full-time men (i.e., Rs. 80000/-) and lowest for seasonal women (i.e., Rs. 8400).

The project has successfully concluded, leaving valuable insights for enhancing the livelihood sustainability of FPOs. Increasing full-time employment opportunities, particularly for women, significantly boosts overall income. Policies aimed at equalizing wage rates between men and women effectively address gender income disparities. Furthermore, providing support to increase the number of working days for seasonal employees enhances their annual income. Implementing skill development programs for part-time and seasonal workers enhances their employability, potentially transitioning some into full-time roles. These measures have maximized the project's positive impact on employment generation and income distribution, ensuring long-term benefits for the community.

Impact on leveraging additional finance (FPO's own finance and institutional finance) through project agribusiness interventions:

- The total investment in agribusiness activities is Rs. 892 Cr of which, self-contribution by the FPOs is to the tune of Rs. 780 Cr and the institutional credit is Rs. 112 Cr. This indicates that considerable financial investment through own and institutional funding has been generated through the agribusiness interventions of the project. The project support to the FPOs, institutional support, and own finance helped all stakeholders to share the risk and helped bring the expertise of all stakeholders into the project. With institutional credit linkage, the task of due diligence on the project proposals became more robust.

- The total value of agribusiness projects for FPCs ranges from Rs. 1.5 lakhs to Rs. 1 Cr for 16 FPCs and Rs. 11.5 lakhs to Rs. 1 Cr for 21 FPCs. In comparison, SHGs have a narrower range, with projects valued between Rs. 2 lakhs to Rs. 40 lakhs for 9 SHGs and Rs. 6.2 lakhs to Rs. 20 lakhs for 16 SHGs. This indicated that FPCs typically manage larger and more variable project sizes compared to SHGs.

- Bank loans for FPCs vary widely, from Rs. 80000/- to Rs. 75 lakhs. However, for SHGs the bank loan ranges between Rs. 10 lakhs to Rs. 15 lakhs. This suggested that while FPCs have access to a broader range of loan amounts, SHGs tend to secure more uniform bank loan values.

The project's impact evaluation reveals several key insights into the operational dynamics of Farmer Producer Companies (FPCs) and Self-Help Groups (SHGs). FPCs manage larger and more variable agribusiness projects, showcasing their capacity to handle diverse and extensive operations. They also have access to a wider range of bank loan amounts, indicating better leverage and possibly more substantial collateral or creditworthiness compared to SHGs, which receive more standardized loan amounts. Additionally, FPCs demonstrate significant internal funding capabilities through a wide range of self-capital contributions, while SHGs, despite contributing less, show considerable commitment to self-funding within their capacity. The utilization of PoCRA grants further underscores the differences; FPCs receive higher grants in alignment with their larger project sizes and funding needs, whereas SHGs, though receiving smaller grants, effectively utilize these funds within their project scope. These insights highlight the strengths of FPCs in managing large-scale projects and leveraging diverse funding sources, as well as the effective grant utilization by both FPCs and SHGs, contributing to sustainable agribusiness development.

Other positive impacts

The agribusiness component of PoCRA, in coordination with the State Agriculture Department and other line departments focuses on strategy development, planning, and the exchange of experiences and technical know-how. State agencies like the Maharashtra State Warehouse Development Corporation, Mahila Arthik Vikas Mahamandal, and Khadi and Village Industries have partnered with the project for convergence, capacity building, and marketing of produce. Additionally, the project has signed an MoU with IIT Mumbai, which delivered detailed project reports (DPRs) for several business activities, including a 300 MT climate-agnostic onion storage structure, poultry feed manufacturing unit, soy milk/tofu processing unit, and turmeric powder unit. These DPRs were provided to interested FPOs in a workshop and are available on the PoCRA website for easy access.

Conclusion

The agribusiness interventions of PoCRA have been shown to have both short-term and long-term impacts on the overall livelihood sustainability and climate shock-proofing of the farming community in the project region. The tangible gains are in terms of improved farming efficiency, access to employment opportunities, access to better and advanced services, better price gains, better creditability, and profitability. The intangible yet significant gains in terms of enhanced capacities, skills, better decision-making capacities, reduced drudgery, and improvement in the socio-economic stature of small and marginal farmers and women farmers in the project area have been demonstrated effectively. The convergence and handholding with the larger state structures and government departments ensure the sustainability of these positive impacts post-project closure. As the project has created these agribusiness interventions recently, the anticipated benefits of participation in these organizations, the farmer's motivation for better market price realization through aggregation, storage, and processing to reflect at the desired level will need further effort by the State's agriculture department. Significant leveraging of public and community finance, in terms of the creation of long-lasting public infrastructure is an intervention that is likely to have a multiplying positive impact on the micro-level economic dynamics in the long run. The spill-over effects of agri-business interventions on climate resilience are evident through better adoption of CRTs (BBF through CHCs), creation of climate resilient seed hubs, and reduction in wastage and losses of food. To conclude, the agribusiness interventions of the project have helped in the achievement of the project development objective to enhance climate resilience and profitability of smallholder farming systems in the project area.

5.3 Improving the performance of the supply chain for climate-resilient seeds

The project has promoted the strengthening of a supply chain of seeds of the varieties having climate resilience features like short duration, drought resistant, and salinity tolerant. The project has leveraged the network of seed grower farmers connected with Maharashtra State Seed Corporation (MAHABEEJ) and farmer producer companies to produce foundation and certified seeds with such characteristics. The objective was to extend the cultivation of climate-resilient agriculture thereby improving the Seed Replacement Ration (SRR) of cereals, pulses & oilseed crops. The project has identified the varieties having the following resilient characteristics:

- Early maturity cycle
- Requires less irrigation with higher yield than other variety
- Moisture stress tolerant and hence suitable for rainfed condition
- Suitable for rainfed conditions in light to medium soil
- Escape terminal drought due to earliness
- Suitable for intercropping
- Tolerance to late heat stress
- Synchronized maturity
- Non-shattering pods
- Suitable for mechanical harvesting
- Moderately resistant to wilt
- Resistant to sterility mosaic
- Resistant to rust and leaf diseases
- Tolerant to Jassids

The farmers were encouraged through the project in the seed production program of climate-resilient varieties. 24205 farmers have successfully taken up seed production programs on nearly 58510 hectares of cultivable land in the project area. This exercise led to the production of 50000 MT of certified seeds during the project period. This has improved the supply of climate-resilient seed varieties in the project and nearby regions.

Figure 38: Seed Production Beneficiary in Project Area

6. Component C- Institutional Development, Service Delivery and Knowledge

6.1 Agro Advisory Services

The project on climate resilient agriculture is at the forefront of providing necessary information to farmers which helps them in efficient crop management. These advisories were made available to the farmers both through the website as well as SMS sent on the mobile number of all registered beneficiaries. The project leveraged its digital infrastructure to access a number of APIs from the weather department, marketing data, agriculture department, and revenue department to make relevant advisories available to the farmers.

Table 44: Access and Availability of Agro-advisory Services in Project Areas

Indicators	Project (N)	%	Control (N)	%
Access to Agro Advisory				
Yes	2797	62	1749	39
No	1550	35	2610	58
Source of Agro Advisory				
Agriculture department	2268	51	1435	32
PoCRA	1536	34	226	5
KVK	673	15	479	11
Gram panchayat	522	12	509	11
NGO	221	5	213	5
Pvt. company	383	9	244	5
FPC	61	1	15	0
Mode of Agro Advisory				
Friends/ Relatives	1686	38	1196	27
SMS	1697	38	979	22
Mobile application	1109	25	765	17
WhatsApp	1301	29	754	17
Interactive voice response	614	14	397	9
Radio	190	4	101	2
TV	807	18	590	13
Newspaper	555	12	357	8
E-Seva kendra	173	4	39	1

Indicators	Project (N)	%	Control (N)	%
M-Kisan	69	2	19	0
ITC e-Chaupal	93	2	16	0
Krishi king	86	2	38	1
Frequency of Access to Agro Advisory				
Daily	702	16	544	12
Weekly	1069	24	630	14
Fortnightly	531	12	303	7
Monthly	495	11	272	6
Quality of Agro-Advisory				
Useful and relevant	2022	45	1106	25
Not useful	71	2	63	1
General	509	11	456	10
Required additional information	190	4	119	3

Note: Percentage listed are proportion to the total sample

During the endline survey, 62 percent of the respondents had access to agro-advisory services in project areas, compared to only 39 percent in control areas. The agriculture department was the major source of agro advisory, benefiting 51 percent of respondents in project areas and 32 percent in control areas. Friends and relatives also constituted a significant source, with 38 percent of respondents in project areas and 27 percent in control regions relying on them. Other useful modes of advisory included SMS, mobile applications, and WhatsApp. Most respondents preferred to access agro-advisory weekly. The services were found useful and relevant by 45 percent of respondents in project areas vis-a-vis 25 percent in control areas.

The project leveraged the power of ICT and developed various APIs to give advisories to farmers on various issues. The advisories are given in the context of climate vagaries, IPM, INM and market prices, availability of godown space, etc. It is observed that the popularity and usage of climate-friendly pesticides like neem extract, Dhashaparni, etc. are rising. Information about bird perches, pheromone traps, odour traps, etc. is disseminated and most farmers in the project region are found to be adopting climate-friendly pest management practices.

In the project areas, 63 percent of the respondents received irrigation advisory, compared to 49 percent in control areas. Fertilizer advisory was provided to 68 percent of respondents in project areas and 55 percent in control areas. Pesticides advisory was received by 67 percent of respondents in project areas and by 55 percent in control areas. Crop pest advisory was received by 61 percent of respondents in project areas compared to 48 percent in control geographies. Lastly, crop residual disposal advisory was provided to 55 percent of respondents in project areas, while 45 percent in control areas. It is expected that all these advisories, cumulatively, result in the adoption of sustainable agriculture practices, improved planning and foresight with respect to farming operations, and enhanced resilience to adverse climatic conditions.

Table 45: Soil, Water, and Nutrient Management Agro-Advisories in Project Region

Nature of Agro-Advisories	Project (N)	%	Control (N)	%
Irrigation Advisory				
Yes, received	2849	63	2201	49
No, but expect to receive	1219	27	1831	41
No, don't expect	98	2	79	2
Don't know	181	4	248	6
Fertilizer (Chemical and Bio) Advisory				
Yes, received	3041	68	2481	55
No, but expect to receive	1053	23	1597	36
No, don't expect	93	2	52	1
Don't know	160	4	229	5
Pesticides (Chemical and Bio) Advisory				
Yes, received	3032	67	2489	55
No, but expect to receive	1063	24	1593	35
No, don't expect	90	2	50	1
Don't know	162	4	227	5
Crop Pest / Disease Advisory				
Yes, received	2739	61	2143	48
No, but expect to receive	1328	30	1889	42
No, don't expect	104	2	80	2
Don't know	176	4	247	5
Crop Residue Disposal Advisory				
Yes, received	2476	55	2010	45
No, but expect to receive	1561	35	2023	45
No, don't expect	106	2	74	2
Don't know	204	5	252	6

In terms of off-farm enterprises and agro-business advisories, organic farming advisories were received by 50 percent of respondents in project areas, compared to 38 percent in control areas. Horticulture advisories were received by 43 percent of respondents in project areas and 33 percent in control areas. Poultry/ Goatery/ Fishery advisories reached 37 percent of respondents in project areas and 32 percent in control areas.

In addition to water management, PoCRA provided several advisories to farmers. Markets for agricultural produce advisory reached 39 percent of respondents in project areas, compared to 33 percent in control areas. Environment Safeguard advisory was received by 42 percent in project areas, versus 35 percent in control areas. Credit advisory reached 41 percent in project areas, compared to 36 percent in control areas, and insurance advisory was provided to 41 percent in project areas, compared to 35 percent in control areas.

Table 46: Off-Farm Enterprises and Agri-Business Advisories in Project Region

Nature of Agro-Advisories	Project (N)	%	Control (N)	%
Organic Farming Advisory				
Yes, received	2229	50	1704	38
No, but expect to receive	1772	39	2254	50
No, don't expect	123	3	108	2
Don't know	223	5	293	7
Horticulture Advisory				
Yes, received	1913	43	1485	33
No, but expect to receive	2009	45	2389	53
No, don't expect	181	4	184	4
Don't know	244	5	301	7
Poultry/ Goatry/ Fishery Advisory				
Yes, received	1649	37	1445	32
No, but expect to receive	2145	48	2359	52
No, don't expect	294	7	255	6
Don't know	259	6	300	7

6.2 Training and Capacity Building

A total of nearly 75000 events (including online webinars and training) of training, workshops, symposiums, and exposure visits have been conducted for project stakeholders, benefitting more than 14 lakh stakeholders including 72 percent male and 28 percent female participants. The women's participation in various capacity-building events is 28 percent. Major activities in which women's participation is higher are women's farmer day, women FFS, microplanning, tribal area specific short micro planning, krishi sanjeevani saptah, kharif hangam planning, and festive events - raan bhaji mahotsav, biyane mahotsav (seed festival), etc.

Figure 39: VCRMC Meeting in Progress in Dasmegaon Village

The training, workshops, and exposure visits helped in building the capacity of nearly 50000 VCRMC members on their roles and responsibilities, skill enhancement and technical training, water and soil conservation, kharif planning, capacity building on inclusiveness and social safeguard inclusion in village development plans, microplanning for tribal people in tribal area VCRMC, krishi sanjeevani saptah, zero tillage, BBF technology, Krishi Tai's roles and responsibilities, digital training, etc.

The capacity building of Krishi Tai has been conducted on her roles and responsibilities, digital training under the augmentation of PMGDISHA, learning of SRT and BBF technology during FFS, etc. The project promotes the protected cultivation of high-value crops under shade net/ polyhouses. Farmers applying for these activities are exposed to high-tech practices through training at NIPHT, Pune, and KVK Baramati. So far, over 6000 farmers have been trained.

Figure 40: Exposure Visit Conducted as a Part of Project Intervention

Exposure visits are organized for farmers to gain knowledge about new climate-resilient technologies such as regenerative agriculture (zero tillage). A total of 205 exposure visits have been conducted for 4218 farmers. A Strategic Research and Extension Plan (SREP) with an internalized climate resilience agenda has been prepared with science-based inputs from the technical institution and has been enriched with crop-water budgeting, contingency planning, and crop-soil suitability and profitability.

6.3 Strategic Partnership and Consortia Approach

The project has consciously adopted the consortia approach to bring updated science-based knowledge into climate-resilient agriculture for the benefit of the farming community. The project at its inception had envisaged a robust consortia approach so as to ensure that cooperation is engendered in collaboration with a large number of technical partners who have been providing a number of solutions in the agricultural and social fields. The aim was to:

1. Generate and disseminate cutting-edge knowledge, and
2. Provide analytical underpinnings to improve policy and strategy framework

Accordingly, the project tied up with a number of partners to provide training, develop micro-plans, develop technical tools, carry out pilot studies, etc.

Some of the key partners and their roles have been described below:

Indian Institute of Technology (IIT) Bombay

The Project has partnered with the Indian Institute of Technology (IIT), Bombay with an objective to develop science-based tools for the benefit of farmers and the community at large. The thrust area of collaboration included primarily water budgeting and optimization of distributional networks in the energy used in agricultural operations. IIT-B also worked towards the development of some post-harvest technologies. Centre for Technology Alternatives for Rural Areas (CTARA) of IIT Bombay was actively involved in this engagement and with rigorous fieldwork and ground assessments, the collaboration yielded a robust Village Water Balance Assessment tool which was used by the project to plan Natural Resource Management activities. The tool also facilitated the community to arrive at an accurate assessment of soil moisture availability for post-monsoon crops. Real-time assessment of soil moisture status using the water balance tool is used in the advisories communicated to the farmers through the dashboard. The engagement also helped the project to understand the issues in energy usage at the farm level and the measures to overcome the deficit. One of the interventions was to create awareness about the use of capacitors in the electric motor set-up to reduce tripping and load consumption as well as to enhance the life of the motor. The food processing section in CTARA helped the project prepare the templates for the Detailed Project Report (DPR) for agribusiness activities focusing on value addition to the major commodities grown in the project area. The Water Balance Framework developed through the partnership is available for upscaling.

National Bureau Soil Survey (NBSS)

The project partnered with the NBSS-LUP (National Bureau of Soil Survey – Land Use Planning) to prepare a Land Resource Inventory (LRI) in different districts specific to various soil units for providing the finer scale soil layer information to be fed in the water balance tool.

The MoU achieved the following:

1. Creation of a land resource inventory of 5000 villages adopted under the project,
2. Performance of LULC analysis of the project villages, and
3. Provision of technical expertise to the project areas for providing soil health advisories at the granular level.

Currently, soil data of 4500 villages with seven parameters viz. Soil Depth, soil texture, pH, soil organic matter, cation exchange capacity, available water capacity, and bulk density are made available, and the remaining work on two parameters viz. EC and soil salinity are in progress.

The detailed note on Land Resource Inventory has been added in **Annexure- 11**

Indian Council of Agricultural Research (ICAR, New Delhi)

The Indian Council for Agricultural Research (ICAR), the apex research institution in the country's agricultural sector, collaborated with the project on several key activities through a comprehensive Memorandum of Understanding (MoU). These activities included:

1. **Identification of climate-vulnerable villages**: Utilizing a vulnerability atlas developed by ICAR's Central Research Institute for Dryland Agriculture (CRIDA) under the National Innovations in Climate Resilient Agriculture (NICRA) program.
2. **Selection of climate-resilient technologies**: Identifying suitable climate-resilient agricultural technologies developed through NICRA and the All India Coordinated Research Project for Dryland Agriculture (AICRPDA).
3. **On-farm demonstrations**: Conducting on-farm demonstrations of climate-resilient modules.
4. **Capacity building**: Enhancing the capacity of all stakeholders, including farmers.

The project collaborated with these organizations to adapt the climate vulnerability atlas, identifying the villages to be included in the project area.

State Agriculture Universities (SAUs)

The project partnered with the three SAUs within the project area – MPKV Rahuri, VNMKV Parbhani, and PD KV Akola – to determine the crop water coefficients (Kc) for the main crops under the project through lysimeter studies. As a result of the research engagement, localized Kc values for Cotton, Pigeon pea, Sesame, Gram, Bajra, Sorghum, Green gram, Soybean, Okra, and Groundnut are made available.

The detailed note on the determination of crop coefficient for key crops by lysimetric studies is given in **Annexure-12**

Gokhale Institute of Politics and Economics (GIPE)

The domain expertise of the Gokhale Institute of Politics and Economics (GIPE) significantly contributed to the project's Monitoring and Evaluation (M&E) strategy. GIPE's contributions included:

1. Developing the Terms of Reference (ToR) for the M&E agencies.
2. Providing guidelines for onboarding M&E agencies.
3. Offering strategic inputs in agribusiness promotion and water harvesting structures.

Groundwater Survey and Development Agency (GSDA)

Maharashtra's Groundwater Survey & Development Agency (GSDA), responsible for the exploration, development, and augmentation of groundwater resources, engaged with the project for two primary objectives:

1. **Cluster-wise groundwater recharge plans:** Preparing plans and estimates for groundwater recharge in 70 clusters.
2. **Technical backstopping**: Developing protocols for supervising groundwater recharge works and related training for field staff.

This technological partnership led to the introduction of effective engineering measures to enhance groundwater recharge, such as Recharge Shafts and Recharge Trenches, in project villages. These recharge plans helped prioritize potential sites for open-dug wells, and project staff received training to handle groundwater recharge initiatives, significantly enhancing their capacities.

Yashwantrao Chavan Academy of Development Administration (YASHADA), Pune

YASHADA, the apex training institute of the Government of Maharashtra (GoM), developed a protocol for participatory planning for rural development under the Grampanchayat Development Programme. The project engaged YASHADA to develop a customized protocol for microplanning in project villages, focusing on climate resilience. The institute trained Master Trainers to conduct microplanning and directly conducted participatory microplanning in 100 villages. This pilot initiative enabled the project to scale up microplanning efforts across other villages, involving Department of Agriculture field functionaries and Village Climate Resilient Management Committees (VCRMCs).

Kheti Buddy

Through Maharashtra State Innovation Society (MSIS) Kheti Buddy Agritech Pvt. Ltd has completed a pilot with 2000 farmers in the CSN district to study the impact of adopting zero tillage technology in farmers' fields on soil health and crop yield increase. The pilot aimed to increase the adoption of technology, improve soil health, maintain records, digitally record and monitor farmers, measure soil carbon fixation, etc. The project was carried out in 37 villages of 5 talukas in the district since March 2023 with the objective of (i) Increasing the use of augmented farming inputs/ techniques, (ii) Improving soil health and special focus on soil health to increase sustainability in agriculture (2000 farmers or 2500 acres) in the respective villages, (iii) Management and control, etc. through a dashboard in all the agricultural units in the respective villages to be commissioned or digitized (1092 farmers). (iv) To check the increase of carbon in the augmented farming in the respective villages and (v) To build climate-resilient farming practices that can adapt to the challenges posed by climatic changes.

Training Partners

The project identified several training institutes within and outside the state to provide specialized training. The training partners included:

1. **National Institute of Post Harvest Technology (NIPHT), Talegaon**: Training on polyhouse and shade-net cultivation.
2. **National Institute of Plant Health Management (NIPHM), Hyderabad**: Training on Farmer Field Schools (FFS) methodology and Integrated Pest Management (IPM).
3. **Vasantrao Naik State Agriculture Extension Management Training Institute (VANAMATI), Nagpur:** Induction training for project officials.
4. **Vaikunth Mehta National Institute of Cooperative Management (VAMNICOM), Pune:** Training Farmer Producer Organizations (FPOs) for agribusiness development.

This collaboration ensured comprehensive capacity building and knowledge dissemination, aligning with the project's goals of promoting climate-resilient agriculture and sustainable development.

6.4 Information and Communication Technology (ICT)

The project has deployed innovative ICT-based solutions to emerge as a robust mechanism to help in the implementation of all project components. There are several initiatives undertaken to help with monitoring and decision-making during the duration of the project. The project has established a Digital Innovation Lab to develop applications to help in the process of planning, implementation, and monitoring of the project activities. These applications aid the field and the PMU leverages ICT to engage with farmers, communities, and farmer groups and provide them need based services transparently and efficiently in real-time.

The application of new media technologies has paid rich dividends in reaching out to the beneficiaries during the unprecedented COVID-19 pandemic, laying the foundation for its mainstreaming in other government programs, now and in the future. The project ushered in a remarkable revolution by schooling beneficiaries in an easy-to-use mobile-based beneficiary system. The DBT system promoted faceless contact and was an automatic RTI enabler by removing the beneficiary's uncertainty regarding his proposal. The ICT component reduced to a minimum the efforts that beneficiaries must expend in many programs by chasing officials.

The PoCRA DBT system relied on an Aadhaar-enabled Payment System (AePS) and complete digitization to eliminate physical files. The success of the DBT PoCRA had a wider impact when inspired by it, the Agriculture Department launched the MahaDBT portal throughout the state. Additionally, the project incorporated numerous APIs from both internal and external sources to create an integrated platform that allowed seamless communication between various integrated applications. This ensured data integration, eliminated the tedium of repetitive data entry, and facilitated easy monitoring.

IT applications developed by PoCRA, like the Water Budget Model and Farmer Field School app, are path-breaking in providing farmers with IT-based capacity and capability building on climate-resilient farming practices. The involvement of village-level committees and field officials in the approval mechanism has helped increase the project's transparency and efficiency.

In addition to the field activities, PoCRA has developed reusable applications for approvals as well as monitoring at various levels, having leveraged the power of data and created 'Office on Mobile' for the extension functionaries. Easy access to required information, simplified business processes, and the ability to create and connect with a network of farmers have enhanced the efficiency and productivity of the workforce. The project-related information is captured at the point of its generation, which ensures data integrity. Information asymmetry has been removed through proactive disclosure of data and making it available in the public domain. Real-time monitoring of project activities at all levels has ensured timely corrective actions and improved performance.

Some of the key applications and portals developed for PoCRA include:

DBT farmer module

PoCRA DBT Portal is a pioneering initiative in Maharashtra to facilitate end- to-end automation of transfer of matching grants to individual farmers.

- DBT portal for farmers is developed for farmers to register and apply for financial assistance under the project
- This portal has a workflow-based system for the application, processing, and disbursement of assistance through Aadhaar enabled payment system
- Geo tagging of all the activities
- Real time tracking & monitoring

DBT community module

Village level communities can apply for financial assistance to carry out natural resource management works as per the Village Development Plan

- Activities approved under the Village Development Plan (VDP) can be undertaken and has the functionality to register village level communities
- Selection of vendors through e-tendering and has online system for inspections, recording of measurements and geotagging of assets.
- This helps in timely approvals with funds being disbursed directly to the bank accounts of the agency executing the work
- Real-time monitoring and mapping of each activity on integrated GIS platform

DBT FPC module

Portal for FPOs/FPCs/SHGs to apply for financial assistance to implement their business plans about post-harvest processing, seed supply chain, and custom hiring centre

- Workflow-based system for application, processing, inspection, approval, and disbursement of assistance
- Direct transfer to the bank account/loan account of FPC/FPO/SHG
- Geotagging of all the activities
- Realtime tracking & monitoring Direct benefit transfer

MLP app

MLP app is used for natural resource planning, computation of water balance, engagement with the community and assist in informed decision making

- Micro-level planning is a community-led initiative to plan for various activities under the project as per local needs.
- Easy to use application for the village level functionaries
- Calculate water balance of the village and suggest measures for optimum utilization of natural resources
- An automated engine at the backend to process the data and generate the village development plan

Farmer Field School (FFS) app

FFS app is used to take observations throughout the crop cycle, monitor dissemination of climate resilient technologies, yields of FFS and control plots etc.

- FFS app is designed to empower farmers to adopt the recommended package of practices for crop cultivation and to take own decisions based on experimental learning techniques
- The learning process takes place in the field and is normally designed to last for a full growing/cropping cycle
- Using the FFS app, PMU can monitor the session conducted at field levels across the PoCRA region
- Real-time documentation of field observations and photographs through a smartphone application
- Geo-referencing of FFS plots
- Monitoring adoption of climate-resilient technologies

Field Activities Supervision and Tracking System (FAST) (SMA) app

Staff monitoring app tracks day-to-day activities and progress of tasks assigned of the PoCRA staff.

- GIS-based application to mark attendance, manage leave and calculate salaries of PoCRA staff. It also allows data collection at the village level and information dissemination.

Training app

Training management app keeps track of all the capacity building activities

- Training app, also known as Capacity building management app, facilitates coordination & reporting of events. This application is used to plan, conduct and monitor all types of capacity building (CB) initiatives including training, workshops, exposure visits, and meetings.
- A single application to track all capacity building & training events
- Useful insights for training organizers
- Reduces communication gaps between organizers and trainees
- Promotes efficiency in CB efforts
- Real-time reports
- Creates repository of trainers, training topics, and trainees

6.5 Geographic Information System (GIS)

GIS (Geographic Information System) serves as a vital tool in the agriculture sector by integrating precise information into a mapping environment. When combined with remote sensing, GIS is used to create detailed maps of various aspects such as soils, groundwater potential zones, drainage, transport networks, settlements, land use, and land cover. It aids in the management and control of agricultural resources. For instance, in the selection of project villages, GIS platforms are used to calculate climate vulnerability for hydrological units (mini watersheds) by employing layers such as administrative boundaries and groundwater prospects maps. An important aspect of the project is village-level participatory planning for natural resource development and management, along with farm-level interventions to enhance resilience and productivity. This planning utilizes satellite data and GIS data on land use, land cover, groundwater assessment, soil properties, historical data, and current water storage structures. Various maps facilitate village-level planning: the Village Base Map provides information on drainage patterns, topography, hydrological units with cadastral boundaries, and road networks; the Village Land Use-Land Cover (LULC) Map gives details on agricultural land and seasonal cropland; the Village Watershed Potential Treatment Maps indicate existing structures and suitable locations for new soil and water conservation structures.

The project has also developed a GIS dashboard, offering a single-window solution for visualization, dissemination, monitoring, and decision-making regarding all project activities. This dashboard delivers near real-time geo-spatial information and weather forecasts, enabling stakeholders to access location-based weather information, project activity status, maps, crop water balance estimates, micro-level planning, Farmer Field School (FFS) information, and Soil Health Card (SHC) details, which assist in better implementation and provide analytical insights on critical indicators. Users can create maps tailored to their needs. The dashboard's features include a single platform to visualize all PoCRA activities, disseminate weather and crop health information, and provide an overview of parameters such as the spatial distribution of sowing dates, harvesting, storage, and crop yield. Intelligent queries on weather and crop health enhance decision-making, and the dashboard offers detailed updates on ongoing project activities. A real-time village profile called ‘Gram Krishi Vikas Darshika’ was made available online to all stakeholders to capture VCRMC details, village demography, and beneficiary details. This serves as a concurrent social audit tool as well as a knowledge dissemination instrument and de-facto Right to Information (RTI) tool.

The GIS dashboard can be accessed at http://gis.mahaPoCRA.gov.in/dashboard/

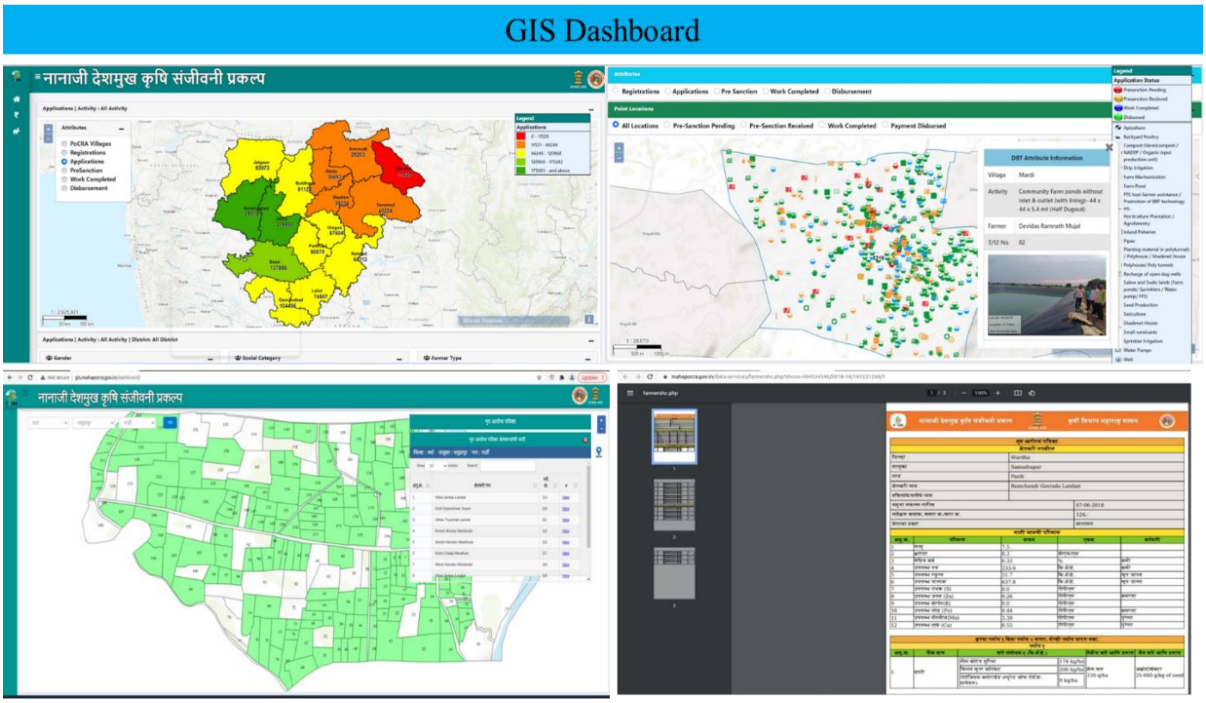

Figure 41: GIS Dashboard – Area under Project Region for Districts and Villages in Maharashtra

The GIS Dashboard has a powerful functionality that allows users to display detailed drill-down information from the state to village level. Users can see the project progress such as the number of registrations, applications, pre-sanctions received, work completed, and disbursement made across project regions as well as for district, taluka, and village levels as seen in the above figure.

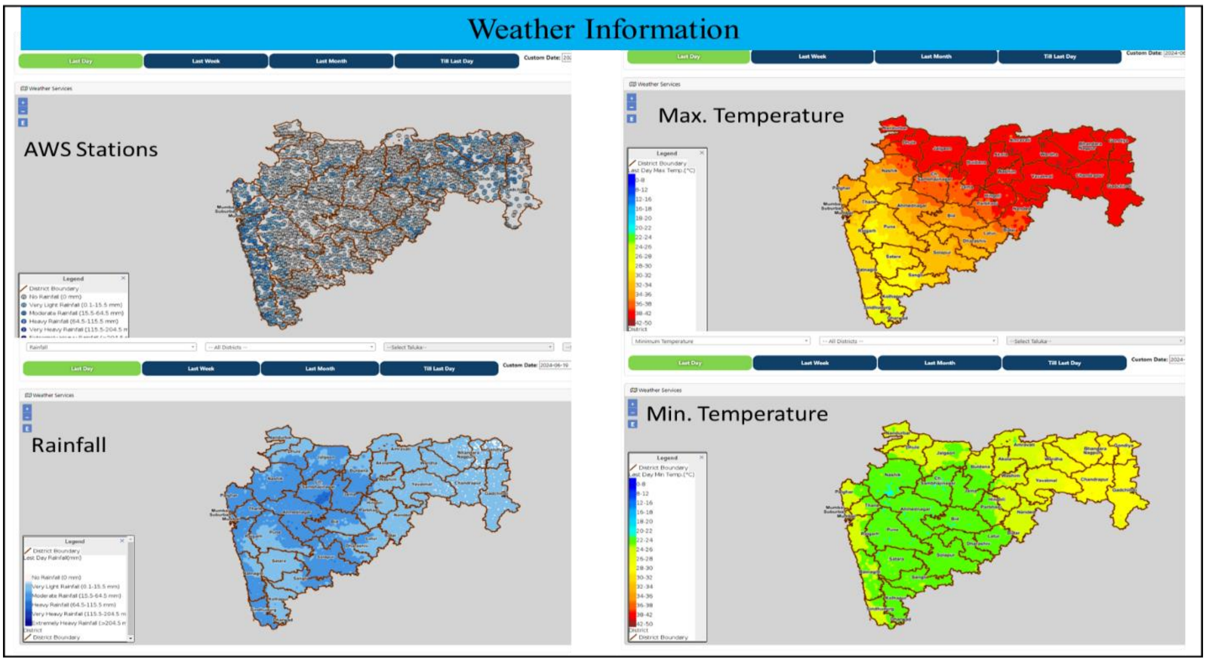

Figure 42: GIS Dashboard – Weather Information for Village and State Level across Maharashtra

The display of weather-related information is one of the core features of the GIS Dashboard as seen in the figure above. It displays information at a high level for the state and can be drilled down to the village level. The types of weather-related maps that can be generated from the dashboard are locations of AWS stations across Maharashtra, temperature range, and rainfall. All this information on the maps can be displayed for the last month, last week, last day, and custom range.

For better village-level planning, PoCRA has used natural resource mapping. Using geospatial technology, PoCRA prepared various village-wise maps which helped the project in achieving its objectives in Natural Resource Management (Village Base Map, Land Use Land Cover Map, Watershed Potential Map).

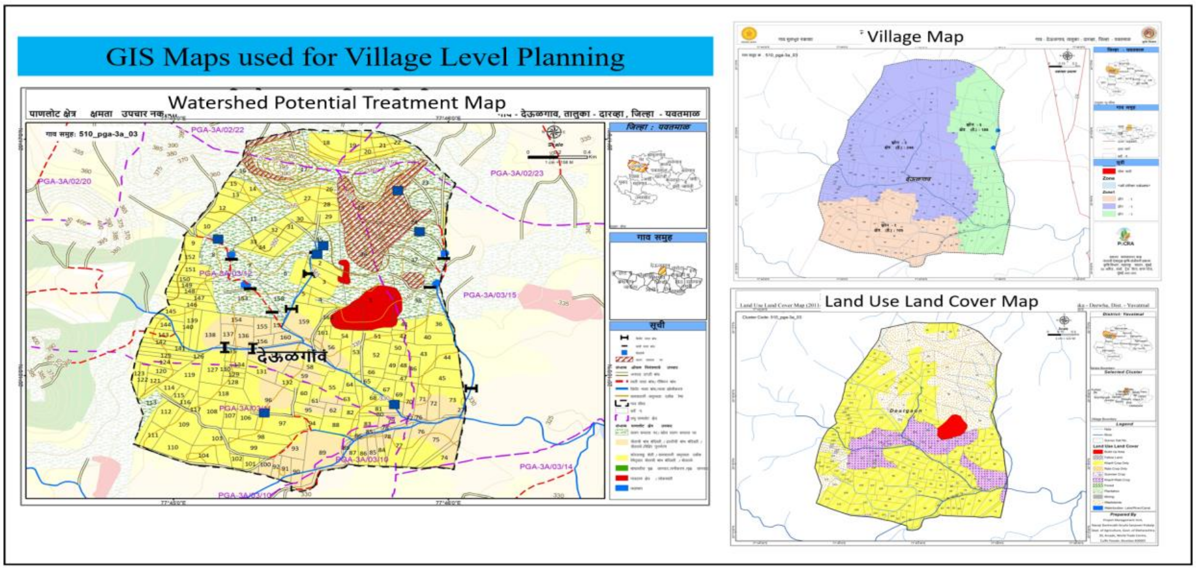

Figure 43: GIS Maps – Village-wise Maps for Achieving Natural Resource Management (NRM)

The generation of village profile documents is one of the key features available on the GIS Dashboard. This document displays all interventions of PoCRA that are implemented in the village. With its dynamic nature, the document is updated daily with activities implemented in the village every day.

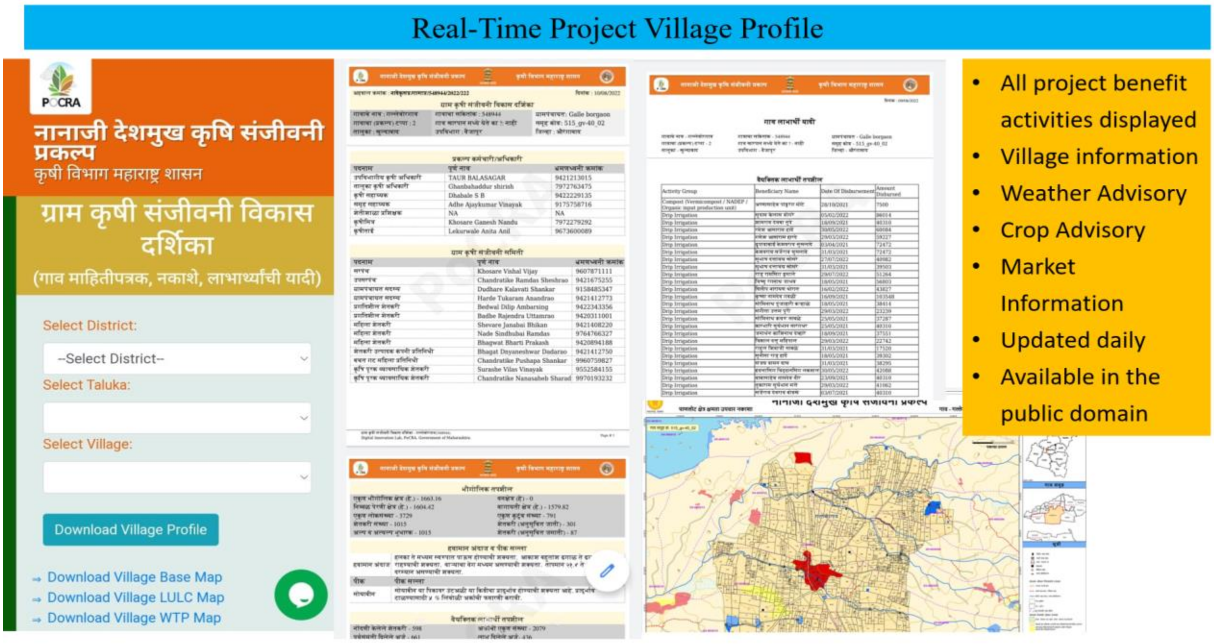

Figure 44: GIS Dashboard for all Interventions of PoCRA

Study- Change in Rabi Cropping Area in Nandar Cluster, Chhatrapati Sambhaji Nagar

A study using remoting sensing and GIS technology was conducted to analyze the change in rabi crop in the Nandar cluster in Chattrapati Sambhajinagar district. This cluster included four villages including Dera, Nandar, Agar Nandur, and Indegaon. Prior to the implementation of the project in the cluster region, there were 43 farm pond structures with WSC of 103 TCM whereas after project implementation there is a significant improvement in the WSC to 477 TCM with addition of 169 project structures.

Water Storage Capacity (WSC) in TCM					
Structures	**Existing Structures**	**Existing WSC**	**Project Structures**	**Project Structures WSC**	**Total**
Farm pond	43	103	169	374	477
Compartment bunding	132	53	602 (ha)	208	261
Total		**178**		**582**	**760**

Results revealed a significant increase in Rabi crop area, from 1084 hectares in 2016 to 2139 hectares in 2023. The most substantial growth occurred between 2019 and 2021. This demonstrates the project's positive impact through interventions like natural resource management and micro irrigation activities.

Activity Name	No. of Activities
Horticulture plantation	300
Pipes	207
Water pumps	133
Individual farm pond	150
Drip irrigation	99
Farm pond lining	27
Small ruminants	23
Sprinkler irrigation	17
FFS host farmer assistance	11
Sericulture	7
Total	**974**

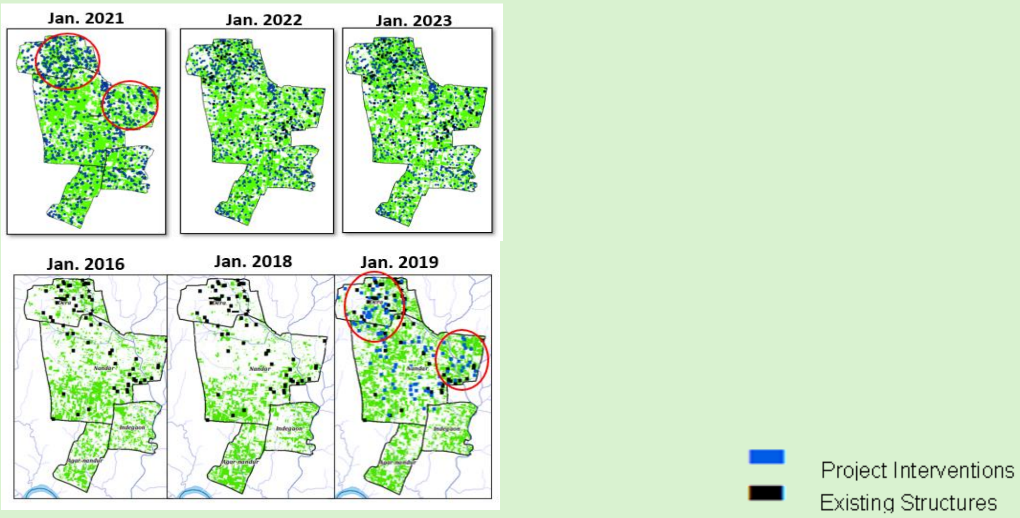

Figure 45: Study on Change in Rabi Cropping Area using GIS Technology

7. Component D- Project Management Support

This component encompasses the activities of the Project Management Unit (PMU)established by the Government of Maharashtra (GoM). Led by the Project Director appointed by the GoM, the PMU ensured that all PoCRA activities align with the provisions of the Project Financing Agreement, the Bank-approved project documents (including the Project Implementation Plan, PIP), the procurement regulations stipulated in the World Bank Procurement for IPF Borrowers (2016, revised November 2017), and the guidelines applicable to the project. The PMU is responsible for the day-to-day operations of the project, acting as the liaison between the Bank, the GoM, and the various agencies implementing project activities at the local level. This component includes a range of fiduciary activities, such as overall financial management, accounting, reporting, and auditing. It also involves the implementation of the Project Procurement Strategy for Development (PPSD) and the Bank-approved procurement plan, as well as the monitoring of environmental and social safeguards compliance.

Component D covers the comprehensive project Monitoring and Evaluation (M&E) and reporting activities which includes project impact evaluation. Additionally, the PMU is tasked with implementing all communication, public awareness, and outreach activities. This involves setting up and maintaining a comprehensive project website that accommodates an open space for lodging stakeholders' complaints as part of the project's Grievance Redress Mechanism (GRM). By ensuring robust management and oversight, the PMU played a critical role in the successful execution and sustainability of the PoCRA project, fostering a coordinated approach to climate-resilient agriculture in Maharashtra.

Information, Education, and Communication (IEC)

PoCRA's efforts towards Information, Education, and Communication (IEC) activities played a crucial role in the project's outreach and public relations efforts. During the unprecedented COVID-19 pandemic, PoCRA continued to reach out to farmers through various communication modes, demonstrating resilience and innovation. Since its inception, PoCRA has been at the forefront of digital transformation in farmers' lives, providing various digital solutions that have proven invaluable, especially during the pandemic. The project developed, launched, and upgraded five different applications over time, encouraging stakeholders to utilize these platforms. These efforts ensured efficient communication with end users, even during the coronavirus crisis. It has functioned on the back of a digital backbone which has helped it to bring efficiency and saving in management costs. The project's focus on collaboration and digitalization led to substantial financial efficiencies which helped keep the management cost as low as less than five percent of the project costs.

Figure 46: Project Review by Hon'ble Minister of Agriculture, GoM Shri. Dhananjay Munde

Digital outreach

During the COVID-19 pandemic, the digital preparedness and skills of PoCRA stakeholders developed gradually through multiple project interventions and proved invaluable. As the pandemic restricted physical movement, the reliance on the internet and online media surged. Thanks to their prior experience with various online tools, PoCRA stakeholders seamlessly transitioned to virtual communication. Project officials and farmers utilized platforms such as Microsoft Teams, Zoom, and Google Meet to conduct meetings, programs, and webinars. This digital outreach enabled timely and effective online processes, ensuring uninterrupted project operations. The seamless transition highlights the foresight and effectiveness of the PoCRA project's capacity-building initiatives, making it a model for resilience in times of crisis.

The PMU organized online events to launch new initiatives, including the village profile section on the project website inaugurated by the Hon’ble Minister of Agriculture, Government of Maharashtra. The village profile, also known as Gram Krishi Sanjivani Vikas Darshika, provides an overview of the progress of each village under the project. It offers detailed information, maps, VCRMC contacts, and beneficiary details accessible universally through the website.

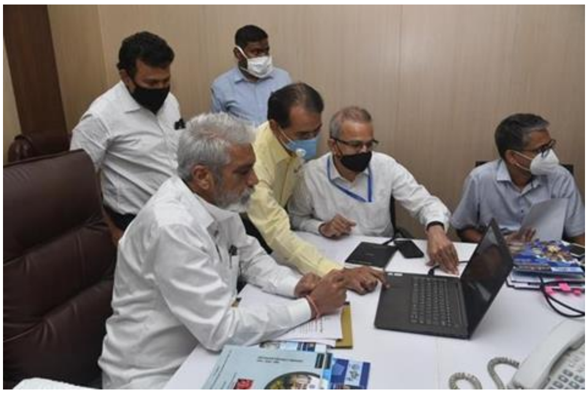

Figure 47: Online Launch of the Village Profile Section on Project Website by Hon’ble Minister of Agriculture, GoM Shri. Dadaji Bhuse

By leveraging digital tools and maintaining robust communication channels, PoCRA ensured continuous support and engagement with farmers, proving the effectiveness of its IEC component. These initiatives not only facilitated project execution during challenging times but also highlighted the project's commitment to digital innovation and stakeholder engagement.

Harnessing social media

The PoCRA Project Management Unit has effectively utilized various social media platforms to maximize outreach to farmers, fostering awareness and engagement. The project publishes audiovisual content on its official YouTube channel to showcase project activities and share motivational case studies, encouraging farmer participation in the climate-resilient movement.

Regular updates on social media accounts, including Twitter, Instagram, and Facebook, have significantly increased PoCRA's visibility among the target audience. The project has garnered over 5400 followers on Facebook, more than 400 on Instagram, and a growing number on Twitter. Additionally, PoCRA has collaborated with organizations like Krishi Vigyan Kendra, to share valuable live sessions. These sessions were broadcast on Facebook and organized into a dedicated playlist on YouTube. Through strategic digital outreach, PoCRA ensures continuous farmer engagement and widespread dissemination of climate-resilient agricultural practices.

Dissemination of project implementation information

The PoCRA Project Management Unit employed a multi-faceted approach to publicize project initiatives across print, online, and electronic media. Information materials, such as booklets on Climate Resilient Technology for Kharif Planning, crop-based activities, and component-wise information were prepared under the guidance of key officials and subject experts. These materials, available in Marathi and digital formats, include leaflets and guidelines.

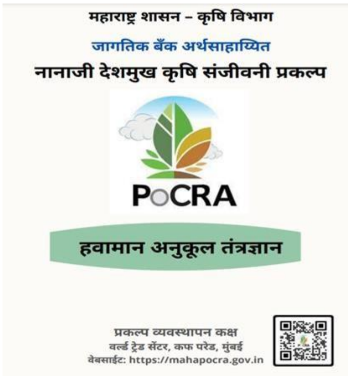

Figure 48: Booklet on Climate Resilient Technology for Kharif Planning

Field staff, including coordinators, contributed to the development of these resources, ensuring they are comprehensive and practical. The materials were distributed among field functionaries and stakeholders and publicized through social media channels. This strategic dissemination ensured that valuable information reached a broad audience, enhancing the project's impact on promoting climate-resilient agricultural practices.

Virtual training and workshops

Since February 2019, PoCRA has utilized live streaming tools for training programs, engaging various stakeholders, including VCRMC members. These sessions enable participants to interact directly with PMU officials, receiving immediate clarification and solutions to their issues. Numerous workshops have been conducted online, with live and recorded sessions uploaded on the project's YouTube channel for easy access. Notable events include a well-received workshop on silage manufacturing, held in collaboration with the Commissioner of Animal Husbandry, and a Kharif preparatory planning workshop featuring experts like Padmashri Popatrao Pawar and Satyajit Bhatkal, CEO of Paani Foundation.

8. Summary of Key Impacts

The following section provides a comprehensive summary of the key impacts of the PoCRA project. It highlights the significant outcomes and benefits achieved through the project's implementation. The detailed impacts presented below offer valuable insights into the effectiveness of the PoCRA project and its role in promoting sustainable and resilient agricultural practices. The project undertook substantial work in these fields and on account of them, significant impact was felt across the thematic areas.

8.1 Improved Water Use Efficiency

Since the area targeted by PoCRA is rainfall-dependent and drought-prone, irrigation plays a crucial role in agricultural production. This section presents the situational analysis of access to irrigation and irrigation practices of the farmers of the project area. This would help in understanding the ground situation in the project areas and improving project implementation. Estimates of baseline and endline surveys are also compared to understand if any change is observed over time.

During the endline assessment, farmers have been asked about the method of irrigation including improved irrigation sources such as drip and sprinkler irrigation. It is evident that the number of farmers using drip irrigation has increased from 15 percent during the baseline to 25 percent in the endline among the project samples. While, among control samples, the change in use of drip irrigation is only about 3 percent with 16 percent reported during baseline and 19 percent during Endline.

Regarding the adoption of sprinkler irrigation practices, a considerable increase in the number of farmers using sprinkler irrigation has been observed both among project and control farmers, but more among project farmers with a shift from 14 percent in baseline to 31 percent in endline. While it was 14 percent in baseline and 27 percent in endline among control farmers.

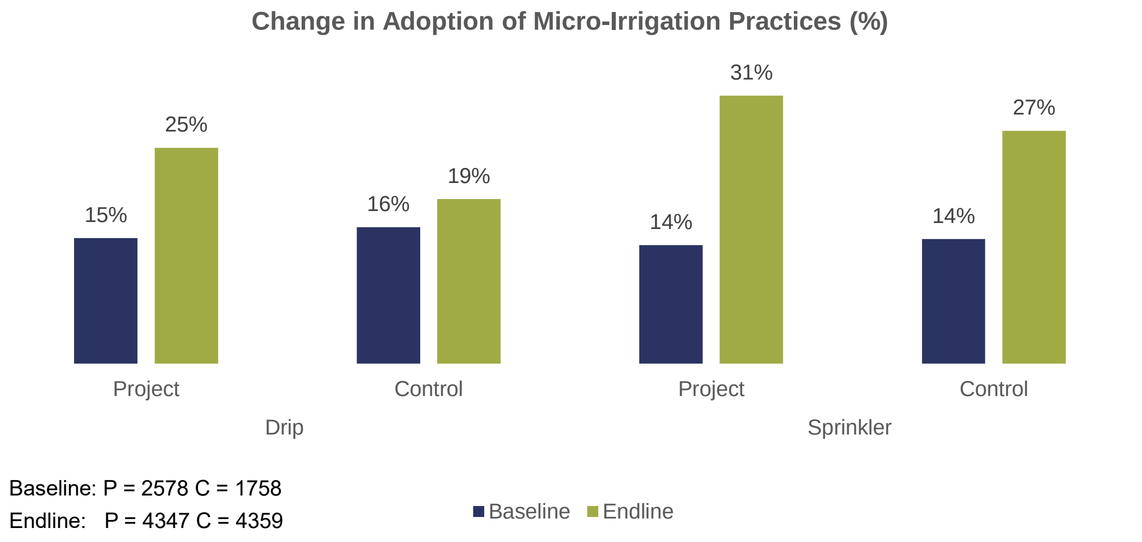

Figure 49: Change in Adoption of Micro-Irrigation Practices (%)

8.2 High Crop Diversification

Varied types of crops are being cultivated in project districts. The details of crops grown by farmers give an overview of the crop profile of sample farmers and the project's cropping pattern. The major crops cultivated by farmers are described in the table below.

Table 47: Major Crops Grown by Respondents in PoCRA Region

Season wise Crops	Cropping Pattern in PoCRA Region			
	Project		Control	
	Number of Farmers	Total Area (Hectare)	Number of Farmers	Total Area (Hectare)
Kharif				
Soybean	1779	3236	2061	3236
Cotton	1789	3102	1832	3198
Sorghum	5	5	324	481
Pigeon Pea	133	335	114	219
Maize	167	255	145	329
Green Gram	16	27	5	11
Black Gram	17	26	8	15
Cow Pea	1	2	4	5
Ground nut	9	9	39	61
Sunflower	2	2	2	4
Millets	17	19	14	21
Total	**3935**	**7018**	**4548**	**7580**
Rabi				
Chickpea	1081	1970	926	1548
Sorghum	276	400	313	322
Wheat	278	449	347	679
Onion	85	134	46	94
Total	**1720**	**2953**	**1632**	**2643**
Summer				
Sorghum (Fodder)	2	2	3	2
Total	**2**	**2**	**3**	**2**
Annual/ Horticulture				
Sugarcane	222	320	115	102
Turmeric	81	267	42	78
Sweet lime	114	185	35	52
Orange	91	165	100	56

Season wise Crops	Cropping Pattern in PoCRA Region			
	Project		Control	
	Number of Farmers	Total Area (Hectare)	Number of Farmers	Total Area (Hectare)
Banana	73	113	90	69
Guava	67	91	8	10
Lemon	44	70	20	38
Custard apple	44	69	-	-
Mango	43	50	37	41
Chilli	31	28	5	45
Capsicum	28	23	1	1
Pomegranate	16	22	8	10
Tomato	13	16	3	3
Other Fruits[1]	20	32	9	13
Other Vegetables[2]	89	10	11	11
Total	**976**	**1461**	**484**	**529**
Grand Total		**11434**		**10754**

Note: 1- Other Fruits include Grapes, Papaya and Watermelon. 2. Other Vegetables include- Cabbage, Bitter gourd, Ladies finger, Capsicum, Coriander.

Kharif Season: The most common Kharif crops cultivated (in both project and control clusters of the PoCRA region) were soybeans, cotton, and pigeon peas. Some of the other Kharif crops cultivated were sorghum, cowpea, maize, groundnut, sunflower, and millet.

Rabi Season: The most common Rabi crops cultivated (in both project and control clusters of the PoCRA region) were chickpeas, wheat, sorghum, and onion.

Summer Season: Apart from growing crops in the Kharif and Rabi seasons, Sorghum (fodder) is one of the major crops grown in Summer. Also, sample households in both Marathwada and RoPA regions were found growing summer and annual/ horticulture crops as follows:

Annual/ Horticulture Crops: PoCRA's interventions have increased water availability in the selected districts and as a result, several annual/horticulture crops like sugarcane, turmeric, sweet lime, orange, banana, guava, lemon, custard apple, mango, chili, capsicum, pomegranate, tomato, certain other fruits (papaya, grapes and watermelon) and other vegetables in the form of cabbage, bitter gourd, ladies finger, capsicum, and coriander are now being grown. The same is also evident from the area under cultivation with respect to annual/horticulture crops in the project geographies, which is significantly greater than those in the control regions.

Increased net cropped area and cropping intensity

The net cropped area is the total cultivated area of the farmers, irrespective of the number of times the land was used to cultivate crops. It is the cultivable land of the farmers, which includes the leased land for cultivation and excludes the cultivable land leased out by the farmers. Gross cropped area is the total area sown, even if it is sown more than once. Gross cropped area represents the total area sown once and/or more than once in a particular year, i.e. the area is counted as many times as there are sowings in the year. The cropped areas are measured in hectares. The table below presents the number of respondent farmers, net cropped area, and gross cropped area in both project and control regions during baseline, midline with the endline situation.

PoCRA, through its intervention, also aims to improve the cropping intensity in the project area. Cropping intensity is defined as gross cropped area divided by net sown area multiplied by hundred. The cropping intensity in the program area is 158 percent (as compared to 132 percent during baseline), and that in the control area is 144 percent (as compared to 137 percent during baseline). The cropping intensity increased by 26 percent among the project sample farmers between the baseline and the endline survey, while it improved only marginally to 7 percent among control farmers during the baseline and endline. The expansion of micro-irrigation facilities (drip irrigation and sprinkler focus) has had a tremendous impact on gross cropped area as well as cropping intensity. The main reason behind a significant increase in cropping intensity of project farmers is because of the changed cropping pattern in the Rabi Season and the increased growing of fruits and vegetables in rabi/ summer by use of improved irrigation practices. The improved irrigation practices allowed farmers to grow crops in more land areas along with efficient use of water resources, compared to traditional irrigation practices.

Table 48: Cropped Area of Land and Cropping Intensity in Project and Control Area

Particular	Baseline	Midline	Endline
Sample Size (n)			
Project	3591	3583	4486
Control	2809	2841	4498
Net Cropped Area (Hectares)			
Project	2822	5982	7204
Control	1509	4449	7449
Gross Cropped Area (Hectares)			
Project	3732	8233	11457
Control	2062	6161	10770
Cropping Intensity (Percentage)			
Project	132	138	158
Control	137	138	144

8.3 Improved Crop Yield/ Productivity

The productivity for the soybean, pigeon pea, cotton, wheat, chickpea, and sorghum has been calculated as the ratio of gross production (in quintal) to cultivated land under that specific crop (in hectares) based on household survey data and has been presented in the below table.

The improved productivity in the treatment areas is a testament to PoCRA's well-executed interventions on resilient practices which have brought great results to the beneficiary farmers. The project has significantly impacted the treatment areas through enhanced mechanization, improved irrigation techniques, adoption of drought-tolerant and climate-resilient, pest and disease-resistant seed varieties, and better-integrated nutrient management measures. Frequent interactions with officials from the Dept. of Agriculture, members of VCRMC, SAU personnel, and demonstrations received through farmer field schools have enabled farmers to realize such appreciable results.

Table 49: Productivity Comparison of Crops in Project and Control Area in PoCRA (Quintal per Hectare)

Crop	Mean Productivity (Quintal/ Hectare)*	Std. Err	95% Confidence Interval	
Soybean				
Project (n = 1779)	16.51 (13.09)	0.16	16.18	16.82
Control (n = 2061)	15.24 (13.34)	0.14	14.96	15.52
Cotton				
Project (n = 1788)	19.11(10.37)	0.20	18.72	19.51
Control (n = 1830)	17.84 (11.36)	0.17	17.50	18.17
Pigeon Pea				
Project (n = 823)	16.85 (10.13)	1.74	13.41	20.29
Control (n = 902)	14.52 (10.62)	0.86	12.81	16.21
Chickpea				
Project (n = 1080)	16.26 (9.14)	0.20	15.87	16.66
Control (n = 922)	13.95 (8.89)	0.20	13.57	14.33
Sorghum				
Project (n = 276)	13.36 (5.68)	0.49	12.40	14.32
Control (n = 324)	12.69 (6.67)	0.42	11.87	13.51
Wheat				
Project (n = 278)	20.90 (14.97)	0.54	19.85	21.96
Control (n = 347)	18.55 (14.97)	0.53	17.51	19.60

* Values in bracket are for baseline values

It is observed that the productivity of major crops is considerably improved and higher when compared to the estimates of the baseline survey, as seen in the table below:

Table 50: Change in Productivity of Major Crops during Project Period

Crops	Number of Farmers	Total area (Ha)	Productivity (Yield in Quintals/ Hectare)		% Change
			Endline	Baseline	
Soybean					
Project	1779	2558	16.50	13.09	26.04
Control	2061	2958	15.24	13.34	14.26
Cotton					
Project	1789	2421	19.12	10.37	84.29
Control	1832	2529	17.83	11.36	56.96
Pigeon Pea					
Project	129	126	16.97	10.13	67.56
Control	111	119	14.57	10.62	37.21

Crops	Number of Farmers	Total area (Ha)	Productivity (Yield in Quintals/ Hectare)		% Change
			Endline	Baseline	
Chick Pea					
Project	1081	1447	16.25	9.14	77.84
Control	925	1176	13.93	8.89	56.67
Sorghum					
Project	276	292	13.36	5.68	135.22
Control	324	331	12.70	6.67	90.37
Wheat					
Project	278	268	20.90	14.97	39.60
Control	347	326	18.55	14.97	23.93

Note: Wheat crop was not part of the main cropping pattern during baseline, and hence, the comparator for change in productivity to baseline for wheat is not available.

Major crops like Sorghum, Cotton, Pigeon, and Chickpea have performed admirably with respect to the magnitude of improvement in yield compared to the productivity reported during baseline and the endline. Factors like enhanced mechanization, better irrigation, adoption of certified seeds, and robust INM as well as IPM practices have delivered this transformative change. Improvement in yield, significantly higher in treatment areas compared to control geographies, has aided the project in realizing its key objective of enhancing the profitability of smallholder farming systems through decreased cost of cultivation and increased yield in project districts of Maharashtra.

Table 51: Yield Comparison across Project, Spillover, and Control Area Farmers in PoCRA region (Yield in Quintals/ Hectare)

Crops	Project	Spill Over	Control
Soybean	16.60	16.13	15.24
Cotton	19.34	17.83	17.56
Pigeon Pea	17.04	15.76	14.52
Sorghum	14.03	12.70	11.34
Wheat	21.54	18.55	17.39
Chickpea	16.62	14.05	13.96

Agricultural interventions have historically been characterized by the “spillover” effect[75]. The project sample is categorized as ‘Direct Project Beneficiaries’ and ‘spillover’ based on their involvement in PoCRA benefits. Farmers who have received direct benefits and part of their major interventions under PoCRA are identified as direct beneficiaries of the project. Those farmers who are residing in the project villages but have never participated in any training on interventions or practices nor are DBT transfer beneficiaries but have nevertheless observed/witnessed the PoCRA’s activities in their village are categorised as farmers with ‘Spillover’. These farmers are ‘indirect beneficiaries.

[75] *Angelucci, M., & Di Maro, V. (2010). Program evaluation and spillover effects: Impact-evaluation guidelines. Washington, DC: Inter-American Development Bank.*

The farmers selected from control villages are called control farmers. The above table on yield of major crops produced in the area clearly emphasizes that crop productivity is consistently high among direct project beneficiaries who have been part of training on climate resilient practices and practicing CRAT technologies compared to the yield reported among spillover farmers field and control farmers.

The intervention demonstrates a positive spillover effect. Not only are the direct beneficiaries experiencing significant improvements, but the surrounding farmers and families are also reaping benefits. This is further evidenced by the fact that farmers in the control group are performing worse than the spillover group. Not only the farmers in the ambit of the project are being benefitted by the intervention, but also the farmers who reside in the project villages. For example, if we compare the yield of Soybean across project, spillover, and control, we see productivity figures as 16.60, 16.13, and 15.24 quintal per ha. This shows us a pattern of spillover groups doing better than the control group.

8.4 Improved Pest Management

An important aspect of the project is integrated pest and disease management. The endline survey included questions for farmers regarding their behavior in this regard. Over the last decade, approximately 39 percent (1673) of farmers reported their crops being vulnerable to pest attacks, while 25 percent (1095) reported vulnerability to diseases in the project area. Interestingly, these numbers closely resemble those of the control region, indicating that the exposure to pest attacks and diseases does not differ significantly between the groups. This similarity suggests that any differences in the uptake levels for integrated management programs might not be skewed by this factor and should not pose a significant problem for our sample.

Limiting our purview to just the last 12 months during the endline survey, as many as 25 percent of farmers reported that pest attacks were the primary reason behind crop damage (across project and control groups). This indicates the significance of pest attacks, as a quarter of farmers claim it to be the main problem they face that harms their harvest.

The pink bollworm which afflicts cotton is by far the biggest pest—59 percent of sampled households in project areas and 65 percent in control areas report that their harvest is affected by it. The spotted bollworm, armyworm, aphids, thrips, and leaf hoppers all affect about 10 percent of farmers each. Coming to the adoption of pest/ insect management measures, pesticides are still the most common intervention (75 percent of farmers in Control, 85 percent in the Project), while local remedies such as Jeevamrut or Beejamrut extracts are utilized by just 4 percent of the sample. Trap crops were the second most common measure at around 15-20 percent. A notable difference is that 40 percent of farmers in the project group reported using some biological/ organic methods for pest management compared to 34 percent in the control group. This can be attributed to the learnings gained from numerous demonstrations carried out by over 37000 farmer's field schools. Both groups take considerable precautions while using fertilizer: approximately 90 percent bathe after spraying, while ~75 percent cover their nose and eyes with a face mask during spraying, which brings to the fore the thrust placed by the project implementation team to disseminate safety precautions in pesticides.

Whilst less common than pest attacks, diseases are also a significant reason behind crop damage: 13 percent and 11 percent in project and control areas report it as the main cause of crop damage. The main diseases that farmers are affected by include wilt (27 percent in project, 14 percent in control areas), leaf spot (20 percent in both areas), rust (15 percent in both areas), and mosaic (20 percent in project, 31 percent in control areas). Once again, the application of chemical agents is used by almost every farmer to counter diseases, while about 15 percent in both groups use organic/ biological methods in addition to chemicals.

Pest attacks are a major issue for agriculture in this region, with most pests attacking cotton and soybean crops. Farmers were asked about pest management in their fields, their practices, and their awareness related to pest management. Jeevamrut, Beejamrut, and neem extract are made from natural ingredients by farmers. Another method of mitigating pest attacks is the introduction of natural enemies of pests like spiders, ladybirds, and other insects in the crop. The farmers who acknowledged using pesticides were further enquired about the safety measures they adopt while spraying pesticides on the field.

The project's IPM and INM guidelines refer to a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks. It was observed that farmers are practicing INM along with biofertilizers along with augmentation of pulse areas for nitrogen fixation (better nutrient recycling arresting nutrient loss, reduced emission), which is an example of adaptation with mitigation co-benefits. The project established synergies with the Agriculture Department’s Crop Pest Surveillance and Advisory Project (CROPSAP) mechanism for pest surveillance to disseminate advisories based on the economic threshold level of pests so that the right mix of preventive and curative measures could be taken by the farmers.

8.5 Improved Nutrient Management

In addition to pest management, nutrient management is essential for improved crop productivity and reducing diseases in the crops. Soil testing is very important for understanding the nutrient composition and for nutrient management of the soil. Another way of ensuring the quality of soil is through intercropping, where complementary crops are sown alongside.

Table 52: Different INM measures used by farmers

INM Measures	Project		Control	
	N	%	N	%
Seed treatment	1150	25.64	1019	23.66
Vermicomposting	330	7.66	397	9.22
NADEP composting	230	5.34	243	5.64
Mulching	174	4.04	191	4.43
Green manuring	156	3.62	147	3.41
Inter-cropping	477	11.07	316	7.34
Farmyard manure	1761	40.87	1499	34.80
Legumes	288	6.68	211	4.90
Cover crops	105	2.44	87	2.02
No activity	1750	40.61	2059	47.80
Total	**4309**		**4307**	

Adoption of all such measures, specifically greater uptake of seed treatment, inter-cropping, and usage of farmyard manure and legumes in the project areas points to a greater absorption of knowledge by the farmers relating to integrated nutrient management. This information being disseminated through channels like FFS demonstrations, and visits by KVK personnel and SAU experts has led to minimal deterioration of soil, reduction in nutrient losses to ground and surface water bodies and atmosphere, and improved physical, chemical, and biological functioning of soil and provision of balanced nutrition to crops leading to enhanced crop yields.

8.6 Reduced Cost of Cultivation

As part of the endline study, the average per hectare cost of cultivation was computed for six key crops under the main seasons of Kharif and Rabi. These crops were selected based on their cropping patterns as well as cropping intensity across both treatment and control areas.

With respect to the Kharif season, 3701 farmers were engaged in the cultivation of cotton, soybean, and pigeon pea with a total cumulative area of approximately 6671 hectares in the programme areas. Concurrently, in the control region, 4007 farmers were engaged in the cultivation of these crops with a cumulative area of approximately 6651 hectares.

In terms of Rabi season, 1635 farmers were engaged in the cultivation of wheat, sorghum, and chickpea with a total cumulative area of approximately 2818 hectares in the program areas. Concurrently, in the control region, 1586 farmers were engaged in the cultivation of these crops with a cumulative area of approximately 2549 hectares.

The ETR team conducted an analysis of the cost of cultivation and derived C2plus50 for main crops grown in the treatment area using the formula of the MS Swaminathan Committee, constituted by the National Commission for Farmers[76]. While recommending MSPs, CACP considers important factors like cost of production, overall demand-supply conditions, domestic and international prices, inter-crop price parity, terms of trade between agricultural and non-agricultural sectors, the likely effect on the rest of the economy, besides ensuring rational utilization of land, water and other production resources and a minimum of 50 percent as the margin over cost of production in case of MSPs. Ever since the acceptance of the pre-determined principle to keep MSP at levels of one and half times the cost of production in the Union Budget for 2018-19, this practice has been followed regularly[77].

During the analysis, it was observed that most (91 percent) of the farmers received higher[78] prices than the MSP[79]. Hence, the income earned by the farmers is calculated based on the actual price realized by farmers instead of taking MSP. We used the price data reported by farmers during the endline survey. The price data reported by farmers is the price realized by farmers during sales for the crops grown in FY 22-23 under consideration for farm income analysis. Specifically, the price realized is computed for the major forms of sale of their produce such as i) Price received for the quantity sold in raw form, ii) Price received for the quantity sold in processed / value-added form, and iii) Price received after storage and sale of produce. Additionally, the Cost of Cultivation and Cost-Benefit (CB) Ratio calculated based on MSP are listed in **Annexure-9.**

[76] https://sansad.in/getFile/annex/262/AU677.pdf?source=pqars

[77] *The method used for evaluation of Cost of Cultivation of crops as per the Directorate of Economics & Statistics is detailed in the annexure.*

[78] *https://www.cuts-ccier.org/pdf/Minimum_Support_Price_and_Farmers_Income.pdf*

[79] *The average price realized by farmers as against MSP as follows- For cotton, the market price is Rs. 7247/- per quintal compared to an MSP of Rs. 6080/- per quintal received by 99 percent of sampled farmers. The average market received by 97 percent of farmers for Soybean is Rs. 4856/- per quintal against an MSP of Rs. 4300/- per quintal. About 88 percent of farmers received a market price of Rs. 7270 per quintal pigeon pea compared to an MSP of Rs. 6600/- per quintal. Sorghum is priced at Rs. 5839/- per quintal against an MSP of Rs. 2970/- per quintal, reported to be received by 85 percent of farmers. Wheat has an average market price of Rs. 3014 per quintal compared to an MSP of Rs. 2015/- per quintal, received by 82 percent of farmers. Lastly, chickpea is sold at Rs. 5927/- per quintal against an MSP of Rs. 5230/- per quintal with 97 percent of farmers receiving the market price.*

Table 53: Cost of Cultivation of Major Crops Cultivated in Kharif Season (Quintals/ Hectares)

Endline	Kharif Season Crops					
	Cotton		Soybean		Pigeon Pea	
	Project	Control	Project	Control	Project	Control
Sample N	1788	1830	1778	2061	133	114
Key heads - Cost of cultivation						
Labour (Rs./Ha) - Hired & family labour	23592	24196	12720	12878	7945	8485
Bullock labour charges (Rs./Ha) - Owned & hired	6082	5991	4128	4276	3843	5355
Rent of machinery (Rs./Ha)	4528	4478	7952	9671	11177	14490
Seeds (Rs./Ha)	4431	4305	5615	5560	1762	1827
Insecticides & pesticides (Rs./Ha)	5807	7076	5675	5400	8599	12908
Manures & fertilizers (Rs./Ha)	10251	10013	6564	6923	6298	5320
Irrigation (Rs./Ha)	998	1166	710	999	464	608
Miscellaneous (Transportation, Insurance, etc) (Rs./Ha)	2556	2503	2633	2405	1483	1214
Cost of cultivation (Rs./Ha)	58246	59728	45997	48111	41571	50206
Rental value of land (Rs./Ha)	30875	30875	30875	30875	30875	30875
Rental value of land for 1 crop (Rs./Ha)	10292	10292	10292	10292	10292	10292
Total cost of cultivation (Rs./Ha)	68538	70020	56289	58403	51863	60498
Yield (Quintal/Ha)	19.1	17.8	16.5	15.2	17.0	14.6
C2 (Cost of production including family labour and land rental value) (Rs./Quintal)	3585	3937	3412	3832	3056	4151
C2 plus 50 in project area (Rs./Quintal)	5378	5906	5117	5748	4585	6227
MSP declared by Govt (2022-23) [80] (https://farmer.gov.in/mspstatements.aspx)	6080	6080	4300	4300	6600	6600
Gross income (Rs/ Ha)*	131056	114275	74695	66626	69125	62859
BC ratio	1.91	1.63	1.33	1.14	1.33	1.04

* Note: Income received is calculated based on quantity sold in raw and its respective price received by farmers, and then the quantity processed, and its value-added price received

Table 54: Cost of Cultivation of Major Crops cultivated in Rabi Season (Quintals/ Ha)

Endline	Rabi Season Crops					
	Wheat		Chickpea		Sorghum	
	Project	Control	Project	Control	Project	Control
Sample N	278	347	1081	922	276	324
Key heads - Cost of cultivation						
Labour (Rs./Ha) - Hired & family labour	8323	9395	11207	11335	15864	15640
Bullock labour charges (Rs./Ha) - Owned & hired	3353	3570	3280	3583	5156	6107
Rent of machinery (Rs./Ha)	7805	10362	9182	9146	9521	8731

[80] *MSP Declared by Govt (2022-23) (https://pib.gov.in/PressReleasePage.aspx?PRID=1832172)*

Endline	Rabi Season Crops					
	Wheat		Chickpea		Sorghum	
	Project	Control	Project	Control	Project	Control
Seeds (Rs./Ha)	4093	5969	6335	6294	2719	2789
Insecticides & pesticides (Rs./Ha)	3064	4161	4322	5612	2220	4647
Manures & fertilizers (Rs./Ha)	5235	5935	3360	5606	3679	5340
Irrigation (Rs./Ha)	1152	1698	839	908	905	1130
Miscellaneous (Transportation, Insurance, etc) (Rs./Ha)	3159	3142	2500	2725	3459	3002
Cost of cultivation (Rs./Ha)	36185	44231	41025	45208	43523	47385
Rental value of land (Rs./Ha)	30875	30875	30875	30875	30875	30875
Rental value of land for 1 crop (Rs./Ha)	10292	10292	10292	10292	10292	10292
Total cost of cultivation (Rs./Ha)	46476	54523	51317	55500	53814	57677
Yield (Quintal/Ha)	20.9	18.3	16.3	13.9	13.3	12.7
C2 (Cost of production including family labour and land rental value) (Rs./Quintal)	2224	2979	3157	3984	4035	4552
C2 plus 50 in project area (Rs./Quintal)	3336	4468	4736	5976	6052	6828
MSP declared by Govt (2022-23) [81] (https://farmer.gov.in/mspstatements.aspx)	2015	2015	5230	5230	2970	2970
Gross income (Rs/ Ha)*	51971	49318	76343	66643	55689	52552
BC ratio	1.12	0.90	1.49	1.20	1.03	0.91

The above tables clearly show that the cost of cultivation during both the Kharif and Rabi seasons in the intervention areas is lower than in the control geographies. This aligns seamlessly with the project's key objective of increasing the profitability of farmers in the selected districts of Maharashtra. The benefit-to-cost ratio, which is superior for the aforementioned crops among the farmers in the project regions compared to control regions, further supports these findings.

Upon closer inspection, certain general trends were discovered and are detailed as follows. The project, as a key objective, has attempted to institutionalize the practice of renting out high-end farm machinery. As a result, several custom hiring centres have been established to promote farm mechanization whereby conventionally costly machines like tractors, trailers, combine harvesters, threshers, and disc ploughs, among others, are made available to small and marginal farmers at nominal rental sums. This has had a multi-pronged effect wherein project farmers have benefitted in the form of conservation of time, and effort, improved precision in agricultural operations yielding higher crop productivity and increasing overall production. Convergence with the national government's Sub Mission on Agricultural Mechanization (SMAM)[82], intended to promote inclusive growth of farm mechanization, is further expected to supplant human labour on the fields thereby reducing costs incurred on labour while concurrently promoting the cultivation of additional crops to strengthen resilience and enhancing the viability of primary livelihood practices.

[81] *MSP Declared by Govt (2022-23) (https://pib.gov.in/PressReleasePage.aspx?PRID=1832172)*
[82] *Chapter 7: Agriculture & Food Management, Economic Survey of India 2021-22; https://www.indiabudget.gov.in/budget2022-23/economicsurvey/doc/echapter.pdf*

We observe that encompassing several beneficiaries under the ambit of scientific irrigation, specifically the project's critical interventions like drip & sprinkler irrigation techniques, has proven to be both cost-effective and water-efficient compared to conventional practices like flood and rainfed irrigation. Reduction in flood irrigation is also important since, conventionally, it causes inefficient use of water and affects topsoil quality in the long run, which not only hinders further irrigation but also causes subsequent loss of water[83,84].

With respect to seeds, the project has been instrumental in promoting the adoption of certified seeds in the project geographies. In control areas, the practice of sowing informal and own seeds is still widely prevalent. The ubiquitous use of certified seeds by the project beneficiaries in producing all the major crops is vital in increasing crop productivity as also in serving the larger goal of ensuring food security. Another advantage of using certified seeds is that these seeds are resistant to many of the commonly occurring pests and diseases.Uptake of drought-tolerant and climate-resilient seed varieties of selected crops has led to reduced cost on pest management and withstanding of dry spells or climate shocks during cropping season while simultaneously safeguarding productivity as also improving crop yields. Thus, the expenses incurred in procuring certified seeds (including seed treatment cost) are offset to a considerable extent by the multiple benefits farmers draw from them during the production period in terms of effective pest and disease control, and drought tolerance.

Upon examining the application of fertilizers and manures[85], it must be appreciated that most of the project farmers adopt, a balanced application of organic manures, and fertilizers which includes judicious quantity of nitrogen, phosphorous, and potash along with micronutrients. While most of the control farmers also provide due importance to fertilizers, they do so with minimal use of organic fertilizers alongside irrational application of chemical fertilizers. Furthermore, in the case of control farmers, nitrogenous fertilizers are the most prominently adopted, with other essential elements restricted to a reduced role. This may lead to reduced costs on manure and fertilizers in the immediate future but it masks the deteriorating impact on soil fertility, sustainability, and crop productivity in the long run. Project farmers have weaned themselves away from traditional habits to shift to balanced and judicious application of manures and fertilizers and adopted improved integrated nutrient management practices such as fertigation under PoCRA.

Beneficiary farmers in the program areas are learning improved techniques of cultivation through regular participation in FFS and interactions with project staff as well as key experts from the Department of Agriculture, State Agriculture Universities, and members of KVKs and mainly from VCRMCs. All such changes signify a positive trend towards integrated nutrient management practices, promoting soil health while balancing environmental sustainability. The results highlight improved integrated pest management practices under PoCRA. The use of expensive chemical pesticides can make the land infertile and harm the environment. As a result, their use has decreased, and there has been a rise in the provision of biological and organic pesticides. Biological pesticides have displayed equal efficacy in controlling pests as their chemical counterparts. Thus, the widespread adoption of integrated pest management practices in project areas entails both an element of financial prudence and ecological harmony.

The above results for both kharif and rabi crops are highly encouraging from a cost point of view, and the project's multiple interventions and activities must be lauded for bringing about this transformative change. In the future, it is recommended to promote these crops in inter-cropping and agroforestry systems. As inter-crops, these crops can be grown together with vegetables (chili, onion, okra, capsicum) where water is available or with medicinal and aromatic plants like turmeric and ginger. As part of agroforestry, these crops can be grown together with papaya, guava, custard apple, and citrus. In conclusion, it is envisaged that both these avenues will further fortify farmer's incomes while simultaneously improving soil health and land productivity. The results presented below highlight the economic returns for major crops across two spectrums covering the reduced cost of cultivation as well as enhanced income, for project and control farmers during the endline survey based on the production period for the year 2022-23.

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[83] *Minhas P S. 1996. Saline water management in India. Agriculture Water Management 30: 1–24.*
[84] *Bundela, D. S., & Singh, O. P. (2021). Waterlogging and salinity problems in irrigation commands. Sustainable Agriculture, 74.*
[85] *K.V., Praveen & Singh, Alka. (2019). Realizing the potential of a low-cost technology to enhance crop yields: evidence from a meta-analysis of biofertilizers in India.*

Table 55: Reduced Cost and Added Returns for Major Crops Across Project & Control Areas of PoCRA Project

Crops (Season 2022-23)	Cost (Rs./ Ha)	Gross Crop Returns (Rs./ Ha)	Net Change in Income (Reduced Cost and Added Returns) (Rs./ Ha)
Soybean			
Project	45996	74695	
Control	48111	66626	
Reduced cost/ Added return for project farmers (w.r.t Control Areas)	-2114	8069	10184
Cotton			
Project	58245	131056	
Control	59727	114275	
Reduced cost/ Added return for project farmers (w.r.t Control Areas)	-1482	16781	18263
Pigeon Pea			
Project	41570	69125	
Control	50205	62859	
Reduced cost/ Added return for project farmers (w.r.t Control Areas)	-8635	6266	14902
Chickpea			
Project	41024	76343	
Control	45208	66643	
Reduced cost/ Added return for project farmers (w.r.t Control Areas)	-4184	9700	13884
Sorghum			
Project	42289	55689	
Control	48619	52552	
Reduced cost/ Added return for project farmers (w.r.t Control Areas)	-6331	3137	9468
Wheat			
Project	36186	51971	
Control	44230	49318	
Reduced cost/ Added return for project farmers (w.r.t Control Areas)	-8045	2653	10698

From the above table, we can ascertain the appreciable impact the project has had on the project farmers. With respect to all the selected crops, based upon their cropping patterns and cropping intensity, the project regions display significantly lower costs of cultivation vis-à-vis the control areas. This points to the considerable changes brought about by multiple interventions implemented by the project. The reduction in the cost of cultivation on one side and the increased yield on the other side are the dual benefits observed by farmers due to CRAT technologies adoption in project farmers compared to control farmers, which has resulted in a net increase in income to project farmers compared to control farmers. If farmers can sustain the CRAT adoption practice, it will further fortify their increase in farm income in the long run.

8.7 Increased Income

Farm income is defined as the net farm income calculated as the sum of net income from crops (gross income from all selling crops i.e., total quantity of each crop sold multiplied by the average price received minus the total cost incurred through the agriculture life cycle in production and selling of crops) and net income from agriculture-allied activities (gross income from sale of produce minus costs of production). The net farm includes the net income from agriculture and allied activities together.

Apart from a significant increase in crop and farm income, it is also visible that project farmers have observed a reduction in their cost of cultivation compared to control farmers, which can be attributed to the impact of climate-resilient practices. In terms of cost and income of households, PoCRA intervention has brought about significant changes. The gross farm cost of the households in the project geographies amounts to Rs. 69863/-, which is 10 percent lower than the same cost incurred by households in the control area at Rs. 75820/-. The gross farm income on the other hand has increased by 12 percent from around Rs. 129222/- in control areas to Rs. 145259/- in project areas. This shows that PoCRA has been successful in reducing farm costs while increasing farm income and ensuring the continued sustenance of farmers from their livelihood activity.

Table 56: Cost and Income of Households in PoCRA Project Region

Particulars	Project (Rs.)	Control (Rs.)	% Difference
Cost Details			
Gross crop cost	68011	75856	-10
Gross allied cost	1794	1665	8
Gross farm cost	69864	77521	-10
Income Details			
Gross crop income	138532	125099	11
Gross allied income	6727	4122	63
Gross farm income	145259	129222	12
Net Farm Income			
Overall	75395	51701	46
Women headed HH	61001	44155	38
Men headed HH	77084	51468	50

PoCRA has significantly impacted farmers' income. During the midline assessment, farmers in project areas experienced an approximate income increase of 51 percent, while control areas saw only a 17 percent increase. By the endline assessment, this trend continued, with project areas showing an approximate income increase of 52 percent compared to just 15 percent in control areas. These figures highlight the substantial economic benefits that the PoCRA project has delivered to participating farmers.

Table 57: Change in Income (Rs.) over Project Period in PoCRA

Project Period	Income (Rs.) in Project	% Change	Income (Rs.) in Control	% Change
Baseline*	33016	-	38422	-
Midline *	49736	50.64	44832	16.68
Endline	75395	51.59	51701	15.32

***Note:** 1) Change in income is calculated after inflating the baseline income figures to present value. 2) Baseline income was calculated based on the MSP price for the respective crops. While, the Endline income calculated based on the actual price realized (received) by farmers

While analyzing the basic descriptives of endline evaluation, it's been found that project, spillover, and control have been distinct in terms of cost of cultivation, crop productivity, cropping intensity, IPM and INM practices, and the adoption of different CRAT practices. Hence, it's been attempted to explore further to analyze the attributes differentiating the project farmers (Direct Beneficiaries) from Spillover (Indirect beneficiaries) and control farmers. The details of the analyses are in **Annexure-10**.

This might be due to the fact that higher net farm income significantly increases the likelihood of being in the project category, while it is not a significant predictor for the spill over category. The control underscores the critical role of CRAT training in promoting participation in projects and the spillover category of farmers, with varying degrees of influence across these categories when compared with the control farmers category. Further, the regression analysis indicates that participation in CRAT training, improved pest management methods and their aligned pesticide costs, nutrient management costs accruing cost of manure and fertilizer, and vital net farm income are significant factors that clearly inform whether farmers are in the project or spill over categories compared to control. Training programs (CRAT training) have a particularly strong influence, highlighting the importance of awareness-building interventions in agricultural projects.

9. Project Sustainability

PoCRA is a unique project distinguished by its efforts in raising awareness and disseminating climate-resilient technologies. The project executed over a period of six years, has been well served by a robust framework ever since its inception, featuring a well-thought-out approach, encompassing planning, design, and implementation, as well as thorough follow-ups, monitoring, and documentation of impacts. The project has established an adept institutional mechanism with vertical and horizontal linkages at various levels, building the capacity of farmers and grassroots-level organizations to adopt climate-resilient agriculture technology to achieve stability and enhanced agricultural productivity and income. These linkages pertaining to partnerships with district and block-level functionaries are expected to remain accessible and available to beneficiary farmers in the days ahead, ensuring the sustainability of the project’s wide-ranging interventions.

The project's impactful results highlight the importance of developing exit strategies to ensure the long-term sustainability of its objectives and focus. A few of these strategies are discussed below:

1) **Ownership by local institutions (VCRMC) and people’s participation in future decision-making, planning and implementation**

   At the village level, the Village Climate Resilient Management Committees (VCRMCs) played a key role within the community in planning, procurement, monitoring, and coordinating project implementation and anchoring climate interventions. The VCRMCs are headed by the Head of Gram Panchayat (Sarpanch) and other members of the committee are selected by the Gram Sabha and represent various stakeholders at the village level, including vulnerable groups. The VCRMCs, over the course of the project, have spearheaded the preparation of village micro-plans incorporating community inputs, implemented the projects within the approved annual action plan, overseen the upkeep of community assets, and approved more than two million applications. The capacities of VCRMC have been fortified through training, workshops, and exposure to execute these intricate yet expansive processes, which augurs well for the future with respect to the promotion and pursuit of climate-resilient practices even after the project’s impending exit.

   In the days ahead, it is envisioned that the VCRMC continues to liaison closely with the community institutions e.g. the water user associations, watershed development committees, as well as producer organizations (incl. farmer/common interest groups) existing in the village and synchronize their mandate with the aspirations of the people. This will lead to the implementation of activities that are demand-driven, technically sound, and climate-resilient, ensuring the sustainability of the project’s interventions and safeguarding the prosperity of the community.

2) **Organizational framework for project implementation and well-maintained MIS database**

   The Project Management Unit (PMU) has been central to planning and implementing the project’s interventions. It has effectively coordinated with various state-level departments and government bodies at district and block levels. Additionally, PMU has formed strategic partnerships with academia and research institutions, including universities (State Agricultural Universities) and NGOs, providing technical inputs and extending climate-resilient technological solutions to farmers. Integrating the project into the administration of the Government of Maharashtra through coordination and convergence at state, district, and block levels has fostered a sense of ownership and commitment among project functionaries as also its beneficiaries, which is critical for the sustenance of the project’s impact and enduring benefits.

   Another encouraging factor augmenting the sustainability of the project’s results is the presence of a robust database encompassing the project’s outreach and coverage, inclusive of all intervention disbursements, farmer requests, areas covered, participation in field activities, and training and awareness initiatives. This meticulously captured information is securely maintained in an MIS database, accessible to both the government and the public for any future actionable endeavours.

3) **Asset ownership at the community level**

The assets procured through the project period such as agricultural equipment of CHCs, godowns, and watershed structures are collectively owned by the community. It is expected that the baton of ownership and maintenance of these productive assets being passed on to these groups will foster a strong sense of ownership and ensure continued derivation of their benefits.

4) **GoM is in sync with PoCRA's priority in achieving "drought-proof" agriculture in Maharashtra**

Drought occurrences pose a significant challenge across various districts in Maharashtra, particularly within the Marathwada and Vidarbha regions. In response, the Government of Maharashtra (GoM) is proactively engaged in the deployment of multiple climate resilience initiatives designed to bolster support for farmers affected by these arid conditions, encompassing both project-designated and non-project areas. By adopting the infrastructure and institutional mechanisms established under PoCRA, the GoM can further its aim of drought-proofing agriculture in Maharashtra. This integration will ensure the continuation and expansion of climate resilience measures, fostering a sustainable agricultural ecosystem. Consequently, it is anticipated that beyond the conclusion of PoCRA, the government's sustained focus on fostering climate resilience within the agricultural community will facilitate the introduction of analogous initiatives, ensuring the continuation and extension of the benefits derived from such programs.

5) **Presence and expertise of line department staff in project implementation**

In the last six years, several functionaries from multiple line departments (Agriculture/ Watershed/ Water resources) have been deeply involved in project planning, implementation, impact assessment, and documentation. A predominant section of PoCRA's personnel in PMU and DPIUs, have been deputed from the Agriculture Department, GoM. These well-capacitated professionals, possessing high technical acumen are expected to continue providing their services and disseminating climate-resilient information knowledge to the community at large, thus securing the project's results and benefits. Further, the vital support of many national and state-level research institutes, extension officials, and the additional knowledge gained by the line departments will strengthen institutional memory and will remain an integral part of the action plans of relevant line departments ensuring long-term sustainability.

6) **Ownership and accountability stemming from a demand-driven approach**

Unlike several erstwhile projects that have traditionally followed a top-down approach, PoCRA has provided multiple benefits to the farmers following a participatory and demand-driven model. With a high level of awareness surrounding the project, it is envisaged that many non-beneficiary farmers who feel the need and have the resources will seek to gain the project's benefits from other sources and will be motivated to adopt other climate-resilient practices in agriculture. The beneficiary farmers along with the larger community are expected to continue to draw the benefits from the institutional mechanisms established by PoCRA.

7) **High-level adoption of CRAT practices by the farmers and its spill-over effect will reduce the emission of greenhouse gas**

The project has promoted numerous climate-resilient agricultural practices, reduced cultivation costs, and minimized greenhouse gas emissions through improved technology and equipment, thereby contributing to environmental sustainability. The adoption rate of these practices is admirable, with approximately 82 percent of farmers in the project geographies implementing at least one Climate-Resilient Agricultural Technology (CRAT) as the project nears its end. Further, 81 percent of farmers have received training on CRAT, enhancing their awareness and capacity to achieve climate resilience. This widespread adoption by trained farmers is a significant step towards sustainability. It is expected that these practices will have a spillover effect, extending to villages outside of project areas and accelerating the adoption of climate-resilient agricultural practices across Maharashtra.

8) Sustainability of project-supported FPOs

Upon evaluating the access of all surveyed Farmer Producer Organizations (FPOs) to various sources of funding and credit following their participation in the Project on Climate Resilient Agriculture (PoCRA), it has been observed that a significant proportion of these organizations have successfully leveraged additional agribusiness support through existing public mechanisms, beyond the direct interventions provided by PoCRA. Notably, more than 60 percent of the supported Farmer Producer Companies (FPCs) have reported profitability in their audit statements after receiving PoCRA support. This finding supports the inference that FPCs not only have future business strategies in place but also aspire to sustainable growth through a diversified system of credit access. The enhanced access to credit and support from various sources may also be attributed to their association with government-led projects such as PoCRA, SMART, and other relevant government schemes within the agribusiness sector. Importantly, the project's design includes the integration of all support and handholding frameworks within the existing departmental structures, ensuring that entities like the Agricultural Technology Management Agency (ATMA) will persist in delivering training, facilitation, and convergence services to the FPOs supported by the project, even after its completion.

10. Financial Management

The Financial Management (FM) arrangements of the project are designed to ensure transparency, accountability, and effective use of funds. These arrangements are deemed adequate to account for and report on project expenditures, meeting the fiduciary requirements within an agreed financial management framework. The key features of this framework include the following:

1. **Budgeting and planning**: The project's funds are routed through the Government of Maharashtra's (GoM) budget. The Department of Agriculture (DoA) prepares Annual Action Plans (AAP) following a bottom-up approach to project activities. These plans are facilitated by the online computerized Budget Estimation, Allocation, and Monitoring System (BEAMS), which aids in budget estimation, allocation of grants, and authorization of expenditures. The consolidated AAP is approved by the Project Steering Committee (PSC) and forwarded by the PMU to the Secretary of DoA for inclusion in the department’s estimates.

2. **Funds flow and accounting**: Payments are processed through existing treasury systems, seamlessly connected to the BEAMS system. Allocations to all accounting centres are made through BEAMS, except for ATMAs and Village Climate Resilient Management Committees (VCRMCs), for which funds are transferred through banking channels. The project includes 67 accounting centres, encompassing the PMU at the state level, DSAOs at the district level, ATMAs at the district level, and sub-divisional offices.

3. **Financial management guidelines and staffing**: The financial management framework is comprehensively documented in an FM Manual, which standardizes procedures and reporting formats for all implementing agencies. The FM supervision of the project is led by a Finance Specialist on deputation from the State Finance and Accounts Services to the PMU. This specialist is assisted by an Accounts Officer and Assistant Accounts Officers, also on deputation, ensuring a robust FM structure.

4. **External and internal audit**: The Comptroller and Auditor General of India (C&AG), through its offices in Mumbai and Nagpur, serves as the external auditor for the project. The audit report is submitted to the World Bank within nine months of the close of each financial year. Additionally, a firm of Chartered Accountants is appointed as internal auditors based on terms of reference and selection criteria agreed upon with the World Bank. The Project Audit Review Committee, chaired by the Project Director at the PMU and the DSAO at the district level, reviews key issues raised by the auditors and ensures timely resolution of observations by project management.

5. **Disbursement arrangements**: The World Bank finances 70 percent of the project costs, subject to a limit of USD 420 million. Funds from the Bank are made available to GoM through standard arrangements between the Government of India (GoI) and the States. Disbursements are made quarterly, based on the submission of Interim Unaudited Financial Reports.

The financial management framework ensures that financial resources are effectively managed, accurately accounted for, and transparently reported, supporting the project's goals of enhancing climate resilience and agricultural productivity in Maharashtra. By maintaining rigorous financial oversight and employing robust budgeting, accounting, and auditing practices, the PoCRA project upholds high standards of financial integrity and efficiency.

11. Procurement

The project ensures transparency, accountability, and equity through stringent norms and procedures for key project management activities, including procurement. Procurement for PoCRA is conducted in accordance with the World Bank's "Procurement Regulations for Borrowers under Investment Project Financing," dated July 1, 2016, and revised in November 2017. The project also adheres to the World Bank's anticorruption guidelines, ensuring all activities are conducted ethically and transparently.

A concise Project Procurement Strategy for Development (PPSD) has been meticulously prepared by the Government of Maharashtra (GoM). This PPSD provides an extensive overview of the project's operational context, prevailing market situations, the capacity of implementing agencies, and potential procurement risks. The procurement plan delineates the procurement selection method and sets forth prior and post-review thresholds to be followed by the borrower during project implementation in the procurement of goods, works, and non-consulting and consulting services.

Procurement activities are undertaken at various levels: state, district, sub-division, and community. At the State level, the procurement plan outlines the selection methods, prior and post-review thresholds, and procedures for procuring goods, works, and consulting services. The procurement manual guides the Project Management Unit (PMU) and communities to ensure compliance with the World Bank's procurement regulations.

At the community level, procurement is highly decentralized and demand-driven, primarily involving small-value activities. Community-level procurement follows Community Driven Development (CDD) arrangements as per the World Bank's regulations and the project's procurement manual. The manual includes a chapter on community procurement, which is translated into the local vernacular to ensure communities understand the procedures. The community procurement manual provides step-by-step instructions, forms, and formats for procurement, promoting a consistent approach to planning, execution, reporting, and monitoring.

The project includes various procurement activities to support the implementation of Cluster Development Plans (CDPs). These activities are managed by the PMU at the central level, District Superintendents of Agriculture (DSAO) and Agricultural Technology Management Agencies (ATMA) at the district level, and Sub-Divisional Agricultural Officers (SDAO) at the sub-division level. The procurement profile comprises both small-value procurements at the community level and high-value procurements at the PMU level. A large share of the project funds finances CDPs, individual farmer matching grants, and Farmer Producer Organization (FPO) matching grants.

To enhance procurement capacity, the PMU is staffed with a Procurement Specialist with experience in World Bank-funded projects. The PMU monitors and provides guidance on community-level procurement using a customized Management Information System (MIS). The PMU is responsible for ensuring compliance with procurement processes and procedures and for building the capacity of field offices and community procurement committees.

The project includes a complaint handling mechanism for procurement-related complaints, outlined in the procurement regulations and procurement manual. Fiduciary oversight and procurement review are conducted by the World Bank, with prior and post-reviews to ensure compliance. The PMU manages major consultancy contracts, monitors contractual performance, and ensures adherence to agreed procurement procedures. The PPSD for PoCRA, prepared by GoM, summarizes the procurement strategy and supports the project's objectives by ensuring efficient and effective procurement processes.

12. Economic and Financial Analysis

The Economic and Financial Analysis (EFA) is crucial to understand and compare the cost invested in the project and the financial implications of the interventions undertaken during the project implementation. It helps in assessing whether the project has achieved its intended goals and objectives. EFA of the PoCRA analyzes activity-wise distribution of the resources and the economic impact generated by these activities. This analysis broadly considers factors like cost invested, benefits, and financial value.

During endline, based on project objectives and scope of work, all the major interventions are added, such as shown in the table:

Table 58: List of Major Interventions in Project

List of Major Interventions	
Agroforestry	Community farm pond
Horticulture plantation	Farm pond lining
Seed production	Individual farm pond
Compost (Vermicompost / NADEP / Organic input production unit)	Sericulture
Drip irrigation	Farm mechanization
Sprinkler irrigation	Pipes
Planting material in Polyhouse / Shade net house	Water pumps
Polyhouse	Recharge of open-dug wells
Shade net house	Well
Apiculture	FFS Host farmer assistance
Backyard poultry	Small ruminants
Saline and sodic lands (Farm ponds/ Sprinklers / Water pump/ FFS)	Promotion for BBF technology
Inland fisheries	NRM interventions
Strengthening of value chains by supporting FPOs	

The assessment of the project's projected financial and economic impact was updated using a cost-benefit analysis approach. The analysis was based on a monetary valuation of the project's costs and projected benefits, focusing on the targeted crops and using a 'with project' and 'without project' control. In a 'with project' scenario, smallholders increased production of their principal food crops by improving yields and access to markets.

The economic analysis was conducted under the following assumptions. Financial benefit streams were transformed into economic values by adjusting for distortions and eliminating taxes, tariffs, transfers, and subsidies by a factor of 0.9. A 15-year investment horizon was assumed with an opportunity cost of capital at 6 percent. The farm model analyses show substantial increases in net household income. It increased from about Rs. 51701/ - per year in the 'without project' situation to about Rs. 75395/- per year in the project year.

Project Internal Rate of Return (IRR) and Net Present Value (NPV):

Based on the above background and assumptions, the project's Internal Rate of Return (IRR) is estimated at 45 percent with a corresponding Net Present Value (NPV) of USD 4789 million as against the appraisal figures of 23 percent and USD 461 million respectively.

Economic Rate of Return (ERR):

The financial benefit streams were transformed into economic values by adjusting for distortions and eliminating taxes, tariffs, transfers, and subsidies by a factor of 0.9. The project has obtained an Economic Rate of Return (ERR) of 35 percent as against 22 percent during the appraisal phase. In the base case scenario, the project yields an updated ERR of 35 percent, against the appraisal estimate of 22 percent during the appraisal phase. The updated net present value (NPV) is estimated at USD 3995 Million, at a 6 percent discount rate as per World Bank Guidelines compared to USD 415 Million at appraisal where a 6 percent discount rate was used (when a similar 10 percent discount rate is used at ICR, the NPV becomes USD 1685 Million).

Table 59: Overview of Economic and Financial Analysis of PoCRA Project

Financial Indicators	Endline Assessment	Baseline Estimate
IRR[86]	45%	23%
NPV USD Million	4789	461
ERR[87] **(6 % Discount Rate)**	35%	22%
NPV USD Million	3995	415

Sensitivity analysis of financial indicators

The above-calculated NPV, IRR, and ERR values were tested for sensitivity. It helps to assess the impact on indicators, in case there is an issue with an increase in investment cost or decrease in benefit. The sensitivity analysis indicates resilience to projected outcomes, and robustness of the PoCRA project under various adverse conditions. A series of sensitivity analyses were performed to assess the impact of a possible 30 percent fall in expected benefits, a possible 30 percent cost overrun, or a combination of both. The project remains financially and economically viable with either a 30 percent reduction in benefits or a 30 percent overrun in investment costs. However, when both benefits are reduced and costs are increased by 30 percent, the project's attractiveness diminishes significantly, with IRR and ERR dropping to 9 percent and 5 percent, respectively, and NPVs showing substantial declines. Yet, results show that the return on the project's investment would remain above the opportunity cost of capital in the simulated scenarios.

Table 60: Sensitivity Analysis for Economic and Financial Analysis of PoCRA Project

Financial indicators	Benefits Down by 30%	Investment Costs Up by 30%	Benefits Down & Costs Up by 30%
IRR	19%	24%	9%
NPV USD Million	2406	3843	1461
ERR	14%	19%	5%
NPV USD Million	1850	3049	905

[86] IRR - Internal Rate of Return informs the financial perspective of the project and does not distinguish between economic and financial impacts.
[87] ERR - Economic Rate of Return indicates substantial overall benefits relative to costs. It has broader economic perspective, includes social, environmental, and indirect economic benefits and costs.

Greenhouse gas accounting

The Ex-Ante Carbon Balance Tool (EX-ACT)[88] tool was used to assess the project's environmental benefits by incorporating the social value of carbon. Sources of environmental benefits included carbon sequestered because of increased productivity coupled with retention of the resulting crop residues in the field, and adoption of other climate resilient agricultural practices. The assessment found that the annual sequestration capacity net balance is estimated to be -3228 '000 tCO2-eq, achieved by the project, and a social value of carbon starting at USD 34.2 per ton in 2018, the ERR was estimated at 54 percent. This increases to 67 percent when the net GHG balance of -4789 '000tCO2 eq is achieved as per the project target.

ERR including outcomes of greenhouse gas accounting

Net GHG Balance	Social Value of Carbon (2018) *	ERR
Project scenario (-3228 '000tCO2eq)	USD 34.2 per ton	54%
Sensitivity scenario (-4789 '000tCO2eq)	USD 34.2 per ton	67%

**To account for greenhouse gas emissions in economic analysis, the World Bank Group uses a carbon price, or social value of carbon, starting at USD 30 per ton in 2015 and rising to USD 80 by 2050. This corresponds to USD 34.2 per ton equivalent in 2018 and increasing annually at USD 1.43 per ton till the end of the 15-year investment horizon.*

[88] The Ex-Ante Carbon Balance Tool (Ver 9.0)[88] was used to estimate GHG emission from the project area with different project activities. This tool quantifies the amount of greenhouse gas released or sequestered from agricultural production. More details of the tool and its modulation to project context is explained under section 3.1.3.

13. Key Recommendations and Way Forward

PoCRA has significantly improved the profitability of small-scale farming operations in selected districts of Maharashtra by enhancing their resilience to climate challenges. The project leveraged a comprehensive, multi-sectoral strategy that emphasizes enhancing climate resilience in agricultural production systems through the expansion of adoption and use of climate-resilient technologies and agronomic practices. The project has focused on the development of mini watersheds through comprehensive micro-level village development plans. Using these plans, the project promoted climate-smart agriculture and resilient farming systems that improved water security, the use of certified seeds, and soil health. This is evident from the better adoption rate of micro-irrigation system, treatment of catchment areas for water security, use of drought-tolerant varieties of seeds, crop diversification, agronomic practices including both pest and nutrient management and carbon that is sequestrated in the project region. Apart from farmers, landless households also benefited from the project through the activities under integrated farming systems. Furthermore, the project strengthened post-harvest management and promoted value chain agribusiness activities in the farmers' producer organizations involving small and marginalized farmers. Through this intervention, the project facilitated access to farm machinery through custom hiring centres at affordable rates, the establishment of storage and processing units for agricultural produce, production and use of certified seeds, and other relevant agribusiness activities with an emphasis on climate resilient. Stakeholders including project staff, VCRMC members, Krishi Tais, etc., were capacitated through training, workshops, and exposure visits to promote a climate-resilient agricultural system. Strategic partnerships have been formed with both state and academia and research institutions to promote technological solutions for farmers. While these components have yielded positive results, implementing certain recommendations related to them will have an even greater impact on the ground. These recommendations are as follows:

- **Strengthening institutional and individual capacity for sustainability:** The administrative capacity of Village Climate Resilient Management Committees (VCRMCs) must be further enhanced to plan, implement, monitor, and strengthen the project. Their collaboration with block and district-level offices will enable efficient local resource allocation, support to communities, streamline communication, and informed decision-making processes at the village level. Empowering farmers with the knowledge and skills of sustainable agricultural practices will contribute towards improvement in their climate resilience and livelihoods. Krishi Tais or female farmer friends who mobilize women farmers on vital information about climate-resilient agricultural practices to increase their participation in project activities need further attention on their roles, punctuality, and honorarium. Farmers Producer Companies (FPCs), Self-Help Groups (SHGs), and Farmer Interest Groups (FIGs) are other key institutions that must be encouraged to access and implement agribusiness activities. Regular and refresher training sessions should be conducted to ensure that the above stakeholders are up to date with the latest techniques and best practices. By focusing on exposure visits, social relationship-building, weather advisory, and market information, farmers can be better prepared to face the changing climate. By staying responsive to the evolving needs of stakeholders, we can ensure building institutional and individual capacity for sustainability.

- **Leveraging digital technology for farmer outreach:** Farmer Field Schools (FFS) held at the village level helps in the transfer of knowledge and technical know-how related to climate-resilient technologies from progressive farmers to the wider farming community. This purpose is hindered by the low participation and enthusiasm of guest farmers including women as well as vulnerable categories to learn in the FFS session. To mobilize the guest farmers to participate in FFS sessions, more focus is needed to be given to trainers, content, schedule, venue, and remuneration. Further, considering the increased accessibility and digital literacy of farmers, it is recommended to craft digital modules/ approaches to reach out to farmers to disseminate information and create awareness on specific technology availability, application methods, and their benefits on social, economic, and environmental benefits.

- **Following agro-advisory services:** With the goal to improve farmer's plans for their agricultural activities by adapting to the changing climate conditions, it is recommended that the relevant line departments along the Indian Meteorological Department (IMD) and Krishi Vigyan Kendra (KVK) offer tailored weather forecasts, data related to management of crops, irrigation, pests, nutrients, soil and water conservation, agribusiness, market, finance and contingencies through the project's website, as well as via various information technology (IT) systems like SMS, WhatsApp, mobile apps, and a phone-in help provision. Apart from the generalized location-specific and crop-specific agro-advisories, there is also scope to explore possibilities to provide customized/ need-based and farmers-specific agro-advisory services through different digital modes such as mobile/web applications, WhatsApp, Subject matter experts E-consultations using advanced technologies such as Artificial Intelligence and Machine Learning which are still in the nascent stage in the agro-advisory sector in India.

- **Ensuring sustainability of CRATs adoption:** It is evident that the project region has improved impacts on cost of cultivation, cropping intensity, and yields than the control region. To sustain the same in the long run, the Government needs to ensure the scale-up of CRATs to other districts and the continuation of dissemination of CRATs as a Market-oriented Package of Practices (MoPoP) through capacity-building activities in the near future. Given a longer gestation period, it can lead to behavior changes among farmers on their agronomic practices for sustenance of CRATs adoption. Additionally, GoM must review the adoption of interventions with low adoption rates, such as backyard poultry, apiculture, agroforestry, and protected cultivation techniques. By providing more technical and financial support and increasing capacity building for CRAT adoption, they can help increase their uptake. These steps will enhance the climate resilience of farmers by diversifying their income sources and reducing their dependency on traditional cropping systems.

- **Promote renewable energy initiatives:** Farmers have reported concerns about the inconsistent and insufficient electricity supply, which restricts pumping hours and negatively affects crop production. This irregular power supply hinders timely water application from available wells, leading to inefficiencies. Additionally, electricity being supplied during nighttime in certain weeks proves inconvenient for optimal system operation and poses safety risks for farmers. Considering these challenges, it is recommended to explore the use of renewable sources of electrical energy such as solar pumps by the farmers.

- **Fostering community-driven sustainability:** PoCRA's long-term success relies on a strong focus on community-driven sustainability. Prioritizing community-based Natural Resource Management (NRM) along with individual efforts is crucial for a balanced approach to water resource management. A village-level micro-plan of the water balance defines the need for the development of community-based NRM works in that region. Farmers can become self-reliant and climate resilient through these soil and water conservation works. In the future, it is critical that the GoM adopts an approach that focuses on community-based NRM works that improve the region's water balance to ensure the availability of surface and sub-surface water, drainage, and soil health including treatment of saline and sodic soils.

- **Improve focus on farmer producer organizations:** With an augmented smallholders' participation, the project strives to integrate these FPOs in the input supply and commodity value chains and strengthen the supply chain for seeds inputs and then climate-resilient crops produced. It is recommended that GoM supports the supported FPOs to pay stringent attention to environmental and social guidelines, participation of women farmers, and expansions in their market-oriented agribusiness activities. It is also recommended that FPOs and extension activities focus on the use of resilient inputs and emphasize more on market-oriented production, strengthening value chains establishing sustainable and efficient market linkages, and making quality produce available for consumers at a fair price.

- **Enhancing financial linkages:** To overcome the issue of capital investments and high interest rates from private investors which are faced by FPOs, it is imperative that support from the relevant line departments is crucial to establish strong linkages between their member farmers and formal financial institutions. By facilitating access to loans with lower interest rates, the member farmers can secure the necessary funds to invest in their FPOs and ensure sustainable growth. Financial constraints faced by small and marginal farmers in investing upfront cost for project benefits is a continuous challenge. The paucity of credit availability to the vulnerable sections on account of their limited asset ownership, lack of formal documents, and mortgageable properties requires project support to access institutional finance. By partnering with financial institutions, GoM can facilitate easier access to essential resources, such as seeds, fertilizers, and credit. These measures will not only support farmers in their immediate needs but also promote long-term financial stability and resilience.

- **Enhancing market linkages including digital marketplaces:** In wholesale markets, FPOs struggle to compete on pricing due to a lack of scale, while in retail markets, brand image and visibility pose significant hurdles. Moreover, the lack of demand creation for the core products of FPOs further hinders their market penetration. To overcome these obstacles, it is essential that the project helps FPOs develop robust institutional mechanisms that support efficient marketing strategies. One effective approach is to leverage emerging marketplaces such as the Open Network for Digital Commerce (ONDC) to make these platforms accessible to FPOs. By integrating FPOs into ONDC and similar digital marketplaces, we can enhance their visibility, expand their reach, and create demand for their products. This integration will allow FPOs to benefit from the scale and efficiency of digital commerce, leveling the playing field in both wholesale and retail markets. Furthermore, project-supported FPOs should be encouraged to collaborate and synergize their efforts, rather than compete against each other. Collaborative efforts can lead to the development of collective brands, shared resources, and unified marketing strategies, ultimately strengthening their market presence and improving competitiveness. By fostering a cooperative environment, FPOs can achieve greater economies of scale, enhance their bargaining power, and effectively penetrate new markets**.**

- **Achieving net zero:** To align with India's Nationally Determined Contributions (NDCs) and achieve the ambitious goal of net-zero, the project must emphasize raising awareness about carbon emissions and the opportunities within carbon credit markets. By incentivizing sustainable practices, GoM can enhance both environmental sustainability and the income of beneficiary farmers. Encouraging farmers to adopt sustainable agricultural practices is crucial. The project should educate them on the benefits of carbon sequestration, which can open up carbon credit markets and provide an additional income stream. Integrating these environmental initiatives into PoCRA will not only promote agricultural sustainability but also contribute significantly to India's broader environmental conservation goals and NDC commitments. It is necessary that awareness about carbon emissions and carbon credit opportunities to incentivize is raised among farmers.

- **Convergence with other government schemes:** GoM is recommended to explore the convergence with other government schemes which can lead to a multiplier effect towards the target. Through convergence, they can achieve financial efficiency, integrated approach, and enhanced impact. By aligning efforts and pooling resources along with diverse initiatives, various stakeholders can work together towards a common goal of enhancing resilience and sustainability in agriculture.

- **Strengthening partnerships and collaborations:** GoM is recommended to enhance the strengthening of partnerships with various stakeholders, including government agencies, non-governmental organizations (NGOs), research institutions, and the private sector including startups to facilitate the transfer of knowledge and innovations to farmers. Engaging with NGOs and community-based organizations can enhance the reach and impact of project interventions at the grassroots level. Private sector partners can provide access to advanced technologies, financial resources, and market linkages.

- **Enhancing policy support and advocacy:** Advocacy for supportive policies and regulations is essential to create an enabling environment for climate-resilient initiatives under PoCRA. Engaging with policymakers to promote policies that support sustainable agriculture, climate resilience, and farmer welfare can drive long-term change. This includes advocating for policies that provide financial incentives for sustainable practices, ensure fair market access, and support the development of rural infrastructure. Furthermore, promoting the inclusion of climate resilience and sustainability in agricultural education and extension services can ensure that future generations of farmers are well-equipped to face the challenges of climate change. By enhancing policy support and advocacy, GoM can create a conducive environment for sustainable agricultural development.

Thus, PoCRA has made significant strides in improving climate resilience and farmer livelihoods in Maharashtra. Building on these successes requires a comprehensive and strategic approach that includes strengthening information dissemination, fostering community-driven sustainability, empowering stakeholders, revisiting low-adoption interventions, promoting environmental consciousness, leveraging technology, strengthening partnerships, and enhancing policy support. By implementing these strategies, GoM can continue to drive positive change and contribute to the long-term resilience and prosperity of Maharashtra's agrarian community. The commitment to transparency, accountability, and continuous improvement will ensure that the project remains responsive to the needs of farmers and the challenges posed by climate change, ultimately leading to a more sustainable and resilient agricultural sector in Maharashtra.

Annexures

Annexure 1: Detailed Area Profile

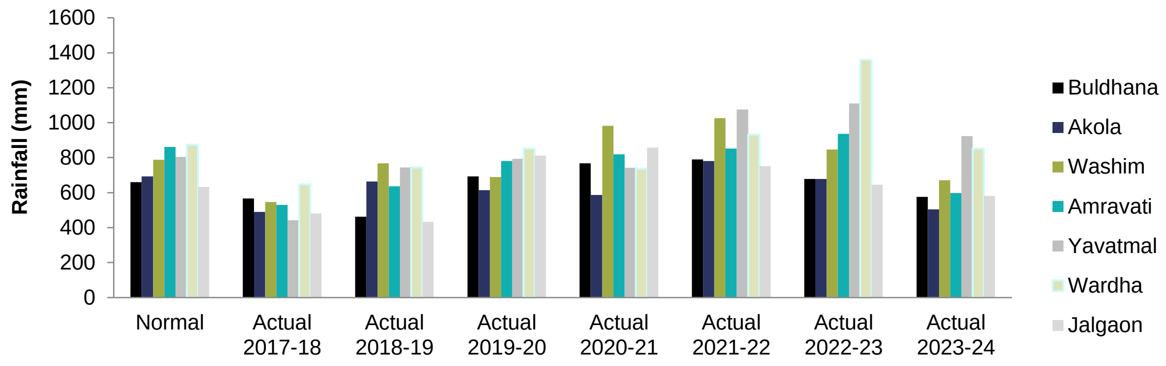
Agroclimatic features of project area

The project area covering the 15 districts across the Vidarbha and Marathwada regions of Maharashtra is mostly characterized by rainfed farming. The climatic conditions of this region can be broadly described as semi-arid. The unique feature of this zone is that it is characterized by a single rainfall pattern. The average annual rainfall is mostly from southwest monsoon winds. About 70 percent of the rainfall is received during June to September, i.e. monsoon season. The total number of rainy days ranges from 42 to 54. Monsoon rains (June-September) amounting to 704 mm account for 87 percent of annual rainfall, winter (October-January) 7.3 percent, and summer (February-May) 5.7 percent. The mean maximum temperatures for the monsoon, winter, and summer seasons are 33.0, 31.2, and 37.9 ^{o}C, respectively. The corresponding values of mean minimum temperature are 24.0, 16.0, and 20.0^{o}C. The records of extreme highest and lowest temperatures are 48.5 ^{o}C and 1.0^{o}C, respectively. The historical rainfall data indicated that rainfall during the southwest monsoon season is in deficit by 16 percent of the average rainfall. The dry spells were experienced during July, August, and September, coinciding with the vegetative or reproductive stages of the major rainfed crops and coupled with some of the high rainfall events. (Source: AICRP on Agrometeorology, Dr. PDKV, Akola, and Dr. VNMKV Parbhani).

Table 61: District-wise Actual and Normal Rainfall in mm (June-September) for 2017-18 to 2023-24

District	Normal	Actual 2017-18	Actual 2018-19	Actual 2019-20	Actual 2020-21	Actual 2021-22	Actual 2022-23	Actual 2023-24
Chhatrapati Sambhaji Nagar	632.6	505.1	352	628.7	970.6	930.9	661.7	523.3
Jalna	581.7	603.3	418	586.7	949.5	1104.9	782.9	486.1
Beed	566.1	600.5	320.5	459.2	698.8	989.6	637.4	449.1
Latur	795.3	671.8	464.1	516	736.9	907.8	737.8	512.6
Dharashiv	603.1	726	422	448	611.7	829.1	664	428.7
Nanded	706	574.6	749.4	821.9	820.2	1167	1046.3	883.1
Parabhani	603.1	480.6	494.2	595.9	824	1100.8	650.4	522.5
Hingoli	761.3	572.4	684.3	748.1	960.7	1078.5	885.6	740
Buldhana	659.4	567	462.7	693.5	768.3	790.1	678.2	576.4
Akola	693.7	490.1	663.6	614.7	587.2	780.6	679	503.7
Washim	789	546.2	768.5	688.6	981.9	1025.6	845.9	670.8
Amravati	862	529.3	636.6	780.6	819.3	851.3	936.6	597.4
Yavatmal	805	442.8	744.7	793.8	741.5	1075.1	1109.9	922.9
Wardha	874.5	647.5	744.7	853	737.1	932.6	1361.5	852.9
Jalgaon	632.6	480.4	432.3	812	857.8	752	645.5	581.6

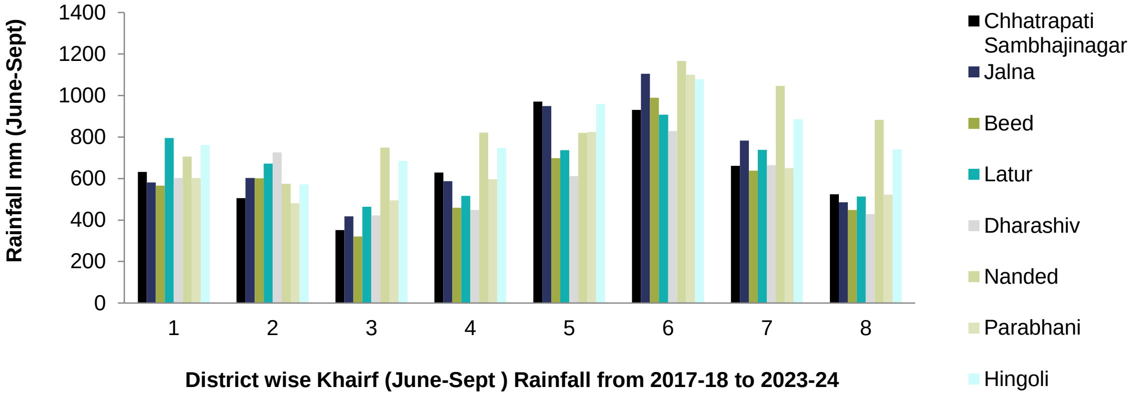
a. Graphical representation of normal and actual rainfall across project districts from June-September for 2017-18 to 2023-24.



District wise Khairf (June-Sept) Rainfall from 2017-18 to 2023-24 for (RoPA)

(Source: Maharain rainfall recording and analysis, Dept of Agriculture, Maharashtra)

b. Graphical representation of normal and actual rainfall across project districts from June-September for 2017-18 to 2023-24



District wise Khairf (June-Sept) Rainfall from 2017-18 to 2023-24

(Source: Maharain rainfall recording and analysis, Dept of Agriculture, Maharashtra)

Topography

Land utilization pattern

The land utilization pattern of the project area indicates that the Yavatmal district, followed by Amravati and Jalgaon districts, is the largest geographically, while the Hingoli district has the smallest geographical area. The maximum forest area is in the Amravati district, followed by Yavatmal and Jalgaon. Regarding the gross cropped area, it is highest in Chatrapati Sambhaji Nagar, followed by Yavatmal and Buldhana, whereas the net sown area is largest in Jalgaon, followed by Yavatmal and Amravati.

Table 62: Land Use Pattern in Project Area (00’ ha)

SN	District	Forest	Barren/ Uncult. Land	Land Under Non-Agri Use	Cult. Waste Land	Perm. Pasture	Misc. Trees/ Groves	Current Fallow	Other Fallow	Net Area Sown	Area Sown more than once	Gross Cropped Area	Geo. Area	Crop intensity	Cult. Area
1	Buldhana	1226	585	677	275	423	7	283	216	5978	4272	10250	9671	171	6759
2	Akola	297	109	377	22	166	10	108	62	4278	3693	7971	5429	186	4480
3	Washim	370	74	326	90	284	6	213	109	3659	1651	5310	5131	145	4077
4	Amravati	2936	191	457	93	331	60	349	183	7617	2328	9945	12217	131	8301
5	Yavatmal	2365	437	678	210	992	123	388	247	8078	2370	10448	13519	129	9047
6	Wardha	575	94	380	217	632	93	653	188	3459	1366	4825	6289	139	4610
7	Jalgaon	1559	1046	163	63	388	28	93	52	8246	5627	13873	11639	168	8483
8	Chatrapati Sambhaji Nagar	867	215	611	147	326	82	401	104	7323	6566	13889	10076	190	8056
9	Jalna	49	72	203	186	271	115	959	221	5650	3590	9240	7726	164	7132
10	Beed	226	348	598	372	289	14	820	452	7567	2648	10214	10686	135	9225
11	Latur	18	193	267	425	222	177	427	347	5080	2242	7321	7157	144	6456
12	Dharashiv	44	76	219	495	224	22	1074	1283	4049	3389	7438	7485	184	6922
13	Nanded	808	186	521	442	275	70	810	192	7027	2774	9801	10331	139	8541
14	Parbhani	64	81	289	233	130	13	388	265	4847	4300	9147	6311	189	5746
15	Hingoli	229	65	102	115	156	1	405	127	3461	2863	6324	4661	183	4110

Source: *Land Utilization statistics (2022), Mahaagri, Department of Agriculture, Govt. of Maharashtra

Source: *Land Utilization statistics (2022), Mahaagri, Department of Agriculture, Govt. of Maharashtra

Soil resources

The soils in the project area range from shallow (Entisols) to deep black (Vertisols), and they have a neutral to alkaline pH. They are low in available nitrogen and phosphorus but high to very high in available potassium. The soils are derived from basalt rock, are black, and have varying depths depending on their physiography, ranging from shallow to deep. They are medium to heavy in texture and high in lime content, with high base saturation. The predominant Vertisols in the zone contains montmorillonite/ smectite clay, which results in swelling after wetting and shrinkage following drying, leading to deep and wide cracks. Most of the soils are calcareous, highly base-saturated, well-drained, well-supplied with potash, moderate to low in phosphate, but low in organic matter content, and slightly alkaline. Soils deeper than 1.5 m and clay in texture pose the problem of waterlogging, as they are poor in infiltration and permeability. Moving beyond the project area, some districts have salinity-affected areas, such as Akola, Amravati, Buldana, and Jalgaon. Some villages in these districts fall under the vertisols of the Purna Valley, which has a saline tract. Salinity refers to the harmful presence of various electrolytic mineral solutes in soil and water. The specific areas under these districts are detailed in the table below.

Table 63: Soil Affected Soils in Rest of Project Area

District	Area of Salt Affected Soil (lakh ha)
Akola	1.68
Amravati	0.61
Buldana	0.45
Jalgaon	0.24

(Source: National Bureau of Soil Survey and Land Use Planning, Nagpur)

Demography

Population, religion, and gender aspects

The project area has a total population of 16789618, according to the 2011 India census. Hinduism is the predominant religion, followed by Buddhism and Islam. This is unusual compared to the rest of Maharashtra and most north Indian states, where Islam is the second-most-followed religion. Marathi is the predominant language spoken in the project area of Maharashtra, followed by Hindi. The district-wise population of males and females for all the seven districts where the baseline survey was conducted is presented in the table below.

Table 64: District-wise Population in Project Area

District	Male (Number)	Female (Number)	Total (Number)
Akola	936226	882391	1818617
Amravati	1482845	1404981	2887826
Buldana	1342152	1245887	2588039
Washim	621228	575486	1196714
Yavatmal	1419965	1352383	2772348
Wardha	665925	630232	1296157
Jalgaon	2197365	2032552	4229917
Chatrapati Samabhaji Nagar	3701282	1924469	1776813
Jalna	1959046	1011473	947573
Beed	2585049	1349106	1235943

District	Male (Number)	Female (Number)	Total (Number)
Latur	2454196	1273140	1181056
Dharashiv	1657576	861535	796041
Nanded	3361292	1730075	1631217
Parbhani	1836086	942870	893216
Hingoli	1177345	606294	571051

(Source: Population census 2011)

Area, production, and productivity of major crops grown

Oilseeds and fiber crop (Kharif)

The major oilseed crop grown in the project area is soybean and the dominant fibre crop of the project area is cotton. Both crops play a vital role in the economy of the region, being the major cash crops covering almost 80 percent of the area under cultivation during the kharif season. The area under soybean crop was recorded maximum in Latur and Buldana district followed by Dharashiv. The productivity was observed highest in Buldhana district which was followed by Jalna and Akola. In the case of Cotton, the largest area was occupied by Jalgaon district, followed by Yavatmal and Chatrapati Sambhaji Nagar; however, the productivity was leading in Latur, followed by Parbhnai and Buldhana districts**.**

Table 65: Area, Production, and Yield for Major Oilseed and Fibre Crops in Project Area

Particulars		Soybean			Cotton (lint)		
Sr.	District	A ('00ha)	P ('00 ton)	Py (Kg/ha)	A ('00ha)	P ('00 ton)	Py (Kg/ha)
1	Akola	2427.17	3876.67	1597.20	1498.69	3624.89	411.18
2	Amravati	2564.38	1810.20	705.90	2728.90	3874.77	241.38
3	Buldana	4446.49	7916.52	1780.40	2122.20	5425.18	434.59
4	Washim	3081.98	4227.55	1371.70	195.18	413.27	359.95
5	Yavatmal	2819.07	2300.92	816.20	4676.08	5698.36	207.16
6	Wardha	1385.20	1650.05	1191.20	2543.71	6256.18	418.11
7	Jalgaon	244.34	355.81	1456.20	5310.77	12949.19	414.51
8	Chatrapati Samabhaji Nagar	304.17	239.32	786.80	4004.05	4526.31	192.17
9	Jalna	2053.62	3535.93	1721.80	3031.29	6877.86	385.72
10	Beed	3447.32	5075.14	1472.20	2731.18	4757.09	296.10
11	Latur	4867.02	5343.98	1098.00	72.84	272.21	635.32
12	Dharashiv	4377.75	5002.01	1142.60	20.27	30.26	253.75
13	Nanded	4268.25	5283.24	1237.80	1972.91	3330.34	286.97
14	Parbhani	2633.96	4103.18	1557.80	1822.93	5331.58	497.20
15	Hingoli	2495.07	3874.09	1552.70	324.76	782.15	409.43
State Total		48927.02	66799.07	1365.28	42400.07	85909.47	344.45

(Source: Maha-agri, Department of Agriculture, Govt. of Maharashtra, 2022-23)

Pulses (Kharif)

Among the pulse crops, majorly grown in the kharif season were Pigeon pea (Tur), Greegram (Mung), and Blackgram (Udid). The area under pulses crops, especially pigeon pea, is observed to be increasing significantly because pigeon pea is a prominent intercrop grown with the major cash crops of the region, i.e. soybean and cotton. The most popular intercropping system adopted by the farmers in the study area is Soybean + Pigeon pea in a row proportion of 6:1/5:1 and secondly Cotton + Pigeon pea in a row proportion of 7:1/8:1/:9/1. In the case of pigeon peas, the area was found highest under the Yavatmal district, followed by Amravati and Buldhana districts. However, Jalna is the leading district as regards productivity, followed by Nanded and Parbhani. Nanded, Jalgaon, and Parbhani districts have the largest area under Greengram, and the highest productivity was observed in Parbhani, Beed, and Jalna, respectively. As regards the Blackgram area, it is maximum in Beed, followed by Dharashiv and Jalgaon, whereas productivity is leading in Parbhani, followed by Beed and Buldhana districts.

Table 66: Area, Production, and Yield for Major Pulses Crops in Project Area

Particulars		Pigeon pea			Green gram			Black gram		
Sr.	District	A (‘00ha)	P (‘00 ton)	Py (Kg/ha)	A (‘00ha)	P (‘00 ton)	Py (Kg/ha)	A (‘00ha)	P (‘00 ton)	Py (Kg/ha)
1	Akola	558.36	422.68	757.00	102.90	27.06	263.00	118.91	36.79	309.40
2	Amravati	1168.35	396.30	339.20	81.60	1.60	19.60	30.97	0.81	26.00
3	Buldana	789.74	689.44	873.00	140.23	95.23	679.10	178.79	117.80	658.90
4	Washim	636.28	396.66	623.40	25.53	12.30	481.80	61.17	33.50	547.70
5	Yavatmal	1330.03	542.79	408.10	81.60	1.60	19.60	61.35	19.12	311.60
6	Wardha	768.63	501.53	652.50	0.02	0.01	378.50	0.17	0.08	461.05
7	Jalgaon	119.16	90.23	757.20	181.52	103.43	569.80	318.79	173.81	545.20
8	Chatrapati Samabhaji Nagar	326.05	196.74	603.40	111.37	54.77	491.80	28.80	12.34	428.50
9	Jalna	489.35	561.14	1146.70	183.08	127.09	694.20	102.16	62.53	612.10
10	Beed	485.20	417.95	861.40	155.14	125.17	806.80	462.99	388.49	839.10
11	Latur	686.15	235.21	342.80	71.70	40.59	566.10	53.78	34.90	648.90
12	Dharashiv	419.72	260.94	621.70	134.83	90.95	674.50	409.74	257.60	628.70
13	Nanded	641.33	582.78	908.70	236.58	107.27	453.40	194.05	110.18	567.80
14	Parbhani	470.85	425.89	904.50	155.92	125.80	806.80	85.76	73.90	861.70
15	Hingoli	444.59	273.11	614.30	98.53	57.83	586.90	274.98	165.13	600.50
State Total		2859.64	1784.76	624.12	2859.64	1784.76	624.12	3672.52	2334.22	635.59

(Source: Maha-agri, Department of Agriculture, Govt. of Maharashtra, 2022-23)

Rabi crops

In the study area, the most important rabi crops are Wheat, Sorghum, and Chickpea. The largest area is dedicated to Chickpea (Gram), followed by Wheat and Rabi Sorghum. For Wheat, Amravati has the highest area, followed by Jalgaon and Buldhana, with the highest productivity in Washim, Beed, and Jalgaon. For Sorghum, Beed has the highest area, followed by Dharashiv and Parbhani. The highest productivity for Rabi Sorghum is in Jalgaon, Buldhana, and Akola. In the case of Chickpeas, the maximum area is in Latur, followed by Nanded and Dharashiv districts, with higher productivity in Wardha, Hingoli, and Parbhani.

Table 67: Area, Production, and Yield for Major Rabi Cereal Crops in Project Area

Particulars		Wheat			Sorghum			Chickpea		
Sr.	District	A ('00ha)	P ('00 ton)	Py (Kg/ha)	A ('00ha)	P ('00 ton)	Py (Kg/ha)	A ('00ha)	P ('00 ton)	Py (Kg/ha)
1	Akola	324.83	568.22	1749.30	9.69	11.93	1230.93	1205.23	1340.40	1112.15
2	Amravati	1230.93	446.65	712.45	4.39	5.40	1230.98	1262.17	1149.80	910.97
3	Buldana	707.73	1331.88	1881.90	101.66	141.27	1389.57	2081.51	2067.10	993.08
4	Washim	386.54	907.83	2348.60	4.39	5.40	1230.98	837.21	967.30	1155.38
5	Yavatmal	546.35	553.40	1012.90	23.86	29.37	1230.88	1413.25	964.10	682.19
6	Wardha	164.24	270.83	1649.00	10.05	8.42	837.75	857.92	1181.50	1377.17
7	Jalgaon	798.88	1667.73	2087.60	387.51	706.00	1821.88	866.56	919.50	1061.09
8	Chatrapati Samabhaji Nagar	449.24	706.17	1571.90	283.89	196.00	690.40	647.82	445.30	687.38
9	Jalna	266.98	544.69	2040.20	766.63	924.90	1206.45	1058.75	1277.00	1206.14
10	Beed	579.83	1240.72	2139.80	1455.23	1686.60	1158.99	1734.60	1782.60	1027.67
11	Latur	159.86	216.96	1357.20	319.45	309.50	968.86	3144.09	2694.29	856.94
12	Dharashiv	334.48	519.88	1554.30	1393.98	1715.40	1230.58	2569.07	2373.80	923.99
13	Nanded	269.62	378.62	1404.30	268.44	271.20	1010.26	2757.55	2904.91	1053.44
14	Parbhani	331.26	610.41	1842.70	857.22	1116.90	1302.93	1727.93	2100.90	1215.85
15	Hingoli	299.67	513.12	1712.30	75.35	57.80	767.04	1372.66	1701.71	1239.71
State Total		12036.23	23010.23	1911.75	13382.11	13953.50	1042.70	29348.22	29741.49	1013.40

(Source: Maha-agri, Department of Agriculture, Govt. of Maharashtra, 2023-23)

Annexure 2: Detailed Sampling Methodology

To conform to the sample proposed and ascertain MDI, we accounted for intra-class correlation and estimated the design effect equalling ρ (m – 1) + 1, where ρ is the intra-class correlation coefficient (ICC) and m is the average number of observations per cluster. The sample thus, provides 80 percent power to detect the minimum change at a 0.05 level of statistical significance[89]. The sample size estimation has been done using the below-mentioned formula:

$$MDI = 2.8 * \sqrt{(b(1-b)} * \sqrt{\frac{1}{P(1-P)}(\frac{\rho_C(1-R_C^2)}{N} + \frac{(1-\rho_C)(1-R_I^2)}{rN})}$$

1. b is the baseline prevalence rate of a binary outcome (0.5[90])
2. P is the fraction of the sample in the treatment group (0.5)
3. ρc is the intra-class correlation (ICC) i.e., the proportion of variance among catchment areas (0.02)
4. RC^2 and RI^2 are the regression R-squared values at the cluster and individual level respectively (0.3)
5. N is the total number of catchment areas selected
6. r is the total number of respondents in each catchment area

The estimated sample size (number of households) to be covered in the project and control area is 2410 each in Marathwada (Sambodhi), and 2080 and 1040 respectively in ROPA (Nabcons). The proposed sample size is powered to have an MDI of 5 percent. Table 66 below provides the overall sample for impact evaluation.

Table 68: Total Sample for Impact Evaluation

Phase	Cluster		Villages		Households	
	Project	Control	Project	Control	Project	Control
Endline	449	449	898	690	4490	3450
Total	**898**		**1588**		**7940**	

Total sample size considering both regions: The total sample size (number of households) to be covered in the project and control area is 4490 and 3450, respectively.

Sampling distribution for household survey

A multi-stage sampling method has been proposed. Table 69 details the rolling sampling approach that will be used for impact evaluation.

Table 69: Sampling Approach for Impact Evaluation

Total Project Cluster	Baseline	Mid-term	Endline
	449 out of 667	225 fixed out of 449 baseline clusters	225 fixed out of 449 baseline & mid-term clusters
	Random Selection	224 out of the remaining 442 project clusters	224 out of the remaining 442 project clusters
		Total of 449 out of 667 clusters	Total of 449 out of 667 clusters

[89] The sample size reflects 95% confidence and 10% margin of error (ToR, Page 84)
[90] Maximum rate of prevalence

The steps to be adopted for multi-stage sampling (during the endline survey) are as follows:

A. Selection of district:

All the 15 project districts namely: Chatrapati Sambhaji Nagar (previously Aurangabad), Beed, Jalna, Latur, Dharashiv (previously Osmanabad), Nanded, Parbhani, and Hingoli in Marathwada region and Amravati, Buldhana, Akola, Washim, Yavatmal, Wardha, and Jalgaon in RoPA region will be covered in endline evaluation.

B. Selection of clusters

The project clusters will be selected proportionately from each district using the method proposed in ToR. Table 70 presents the number of project clusters to be covered in each district. Non-PoCRA (Control) clusters will be matched with the PoCRA clusters based on the climate vulnerability index in each district. Subsequently, the clusters to be sampled will be chosen from the total number of clusters in each district using the approach presented in the below Table.

Table 70: Number of Project Clusters to be Covered in each District.

Region	Number of talukas	Total number of mini watershed clusters	Total number of sampled project clusters	Total number of sampled control clusters	Total number of project villages	Total number of control villages	Total number of villages to be surveyed	Total households to be surveyed: 5 per village
Marathwada (8 districts)	76	347	241	241	482	482	964	4820
RoPA (7 districts)	79	320	208	208	416	208	624	3120
Total (15 districts)	**155**	**667**	**449**	**449**	**898**	**690**	**1588**	**7940**

D. Selection of Villages

In the case of the Marathwada region, from each cluster, two villages will be selected on a random basis. Therefore, a total of 482 villages in project clusters and 482 villages in control clusters would be selected for evaluation. In the case of the RoPA region, from each project cluster, two villages will be selected on a random basis. Therefore, a total of 416 villages in project clusters would be selected for evaluation. However, in the case of a control cluster, one village will be selected on a random basis. Therefore, a total of 208 villages in control clusters would be selected for evaluation. Hence, a total of 898 villages will be sampled in project clusters and 690 villages will be sampled in control clusters. In case a sampled village is reported to be inhabited or has any other unforeseen issue due to which a survey cannot be conducted in the same, it will be replaced by another village that is randomly selected too. Also, in case a sampled cluster has only one village, a sample of ten instead of five will be taken from that village. It is to be noted that for the clusters which are fixed from the baseline and mid-term, the same villages will be selected from them during the endline survey.

E. Selection of Households

For the selection of households, we needed to find a sampling frame with an accurate list of households for the selected villages to select five households per village. Therefore, we propose the use of an electorate list, that is uniform, accurate, updated from time to time, and available for download from the Election Commission's website. However, one limitation of the electoral list is that it gives the list of electorates (persons aged 18 and above) and not the list of households as such. However, we can assume that the household of the selected electorate is the selected household for our purpose. Though we need to cover five households per village, there might be a non-coverage of households due to non-treatability, not being available for interview, refusal, and so on. To compensate for these factors, we propose to select 10 households (electorates) from each selected village and interview 5 households from that list. From the electoral/household list so obtained, a sample of 10 electorates/households will be selected by applying the Systematic Random Sampling method. Of the 10 selected households, consultation will be made with the Village Sarpanch/VCRMC members to exclude those electorate who are landless and select only one if two or more electorate belong to one household. Five households will be selected and interviewed depending on their availability for interview. Thus, the proposed sampling design will ensure that the selected households will adequately represent the project area and control area, besides ensuring coverage of the predetermined 7940 households (4820 in Marathwada and 3120 in RoPA) in the sample.

F. Combining data of Marathwada and RoPA (Case-Weighting)

As per the ToR, the number of project and control area clusters to be sampled is 1:1 in the Marathwada area but it is 2:1 in RoPA. As such, data processing of the combined data needs case-weighting for the disproportionate sample cases in the control area of RoPA. For this, a weight variable will be created and added to the combined dataset with the value of the weight variable 1 for the cases of Marathwada (both project and control areas) and Project area of RoPA and the value 2 for control area of RoPA. This weight variable will be used while processing the data and all statistical software including SPSS have provisions to weigh the cases based on the weight variable. All the statistical analyses.

Sample size for qualitative interviews

Like baseline and mid-term surveys, and along with the quantitative inquiry, qualitative surveys in the form of Focused Group Discussions (FGDs) and In-Depth Interviews (IDIs) were undertaken as part of the endline survey. Table 71 presents the sample size for the qualitative interviews that will be conducted.

Table 71: Sample Size for Qualitative Interviews

Target Respondent	Sample	Enquiry Technique	Remarks
FGDs with beneficiaries i.e., farmers with more than 5 acres, farmers with less than 5 acres, landless	45 (30 in the project area and 15 in the control area. Distributed equally amongst the three categories of target respondents)	FGD with community members	-Feedback on challenges faced in agriculture and the key challenges faced related to climate change and the coping mechanisms adopted -Feedback on the PoCRA intervention and the benefits accrued from the project
VCRMC/ Gram Krishi Vikas Samiti (GKVS)Representatives	45 (30 in the project area and 15 in control area. Distributed equally in 15 districts)	FGD with VCRMC/ Gram Krishi Vikas Samiti (GKVS)	-Feedback about their participation, decision-making process, the effectiveness of the selection process, whether they could help the needy farmers, etc, challenges faced by target project beneficiaries i.e., farmers and landless people
FPC/FPO Representatives	45 Project-supported FPCs	IDI with FPC/FPO Representatives	Feedback on challenges faced by their FPC/FPO, on the support through PoCRA, and support that can help them in increasing the income of its member farmers
FGDs with Farmer Interest Group (FIG) members	30 (Two from each district in the project area)	FGDs with members of Farmer Interest Groups	Feedback on the current activities and challenges faced by FIGs, on the support through PoCRA, and what can be done to strengthen them
FGD with Self-Help Group (SHG) members	30 (Two from each district in the project area)	FGDs with members from Self Help Groups	Feedback on the current activities and challenges faced by SHGs, on the support through PoCRA, and what can be done to strengthen them

Annexure 3: Detailed Information on Yield of Soybean and Pigeon pea in Project Districts

District-wise and year-wise yield (kg/ha) of Soybean for 2017-18 to 2023-24

Year	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24
Jalgaon	1639.00	1452.70	548.97	1192.00	590.72	1457.32	991.11
Chatrapati Sambaji Nagar	439.00	645.70	817.41	1240.00	721.00	785.01	721.59
Jalna	698.00	899.49	1713.71	1999.00	1312.30	1713.85	1302.44
Beed	708.00	242.27	775.34	1980.00	901.10	1470.10	1323.44
Latur	1184.00	1021.82	1103.03	1750.00	1228.66	1097.79	1551.64
Dharashiv	688.00	550.00	1205.11	1686.00	1060.09	1141.23	1227.20
Nanded	696.00	1389.70	1356.62	1375.00	789.67	1231.88	1439.29
Parbhani	878.00	1110.80	1027.21	1376.00	422.92	1539.78	1179.81
Hingoli	1134.00	1393.60	1979.28	1081.00	974.86	1533.35	1302.17
Buldhana	1187.00	1109.40	1351.73	1672.00	1572.17	1776.94	1477.80
Akola	704.00	1404.10	907.78	1226.00	1092.69	1597.04	1378.90
Washim	757.00	1369.08	1090.59	1751.00	1641.40	1370.83	1593.21
Amravati	924.00	1205.66	833.34	923.00	941.22	705.84	1629.20
Yavatmal	811.00	1179.10	822.49	1000.00	1031.07	815.61	1299.22
Wardha	1528.00	1309.35	1304.19	541.00	1621.95	1189.14	925.56

Temporal yield variability (Estimate) of Soybean for 2017-18 to 2023-24

2017-18	Mean	931.67	**2021-22**	Mean	1060.12
	STdv	336.77		STdv	365.56
	Percentage	36%		Percentage	34%
2018-19	Mean	1085.52	**2022-23**	Mean	1295.05
	STdv	359.43		STdv	337.34
	Percentage	33%		Percentage	26%
2019-20	Mean	1122.45	**2023-24**	Mean	1289.51
	STdv	378.30		STdv	254.07
	Percentage	34%		Percentage	20%
2020-21	Mean	1386.13	**Average**	Mean	1167
	STdv	415.87		STdv	325
	Percentage	30%		Percentage	28%

District-wise and year-wise yield of Pigeon Pea for 2017-18 to 2023-2024

Year	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24
Jalgaon	741.00	503.37	508.77	812.00	538.08	757.20	581.81
Chatrapati Sambhaji Nagar	823.00	259.50	768.61	693.00	662.02	196.74	634.04
Jalna	782.00	354.53	1275.37	1232.00	1203.10	561.14	977.96
Beed	563.00	109.72	754.76	1440.00	900.03	417.95	930.06
Latur	1180.00	477.00	1222.58	1478.00	637.08	235.21	795.57
Dharashiv	826.00	230.00	372.01	937.00	665.59	260.94	664.34
Nanded	880.00	924.20	707.17	1069.00	762.47	582.78	969.98
Parbhani	1502.00	451.33	1147.94	1288.00	1581.56	425.89	1145.57
Hingoli	804.00	385.80	924.62	283.00	504.12	273.11	601.16
Buldhana	627.00	513.69	1195.22	1502.00	3135.92	873.00	718.83
Akola	1018.00	605.30	2268.86	931.00	1835.83	757.00	1169.53
Washim	346.00	602.93	629.33	854.00	507.15	623.40	668.03
Amravati	989.00	1112.81	819.75	919.00	1001.70	339.20	997.75
Yavatmal	971.00	1112.28	314.94	581.00	713.78	408.10	1108.16
Wardha	1137.00	1112.70	1352.38	1855.00	1427.61	652.50	1045.75

Temporal yield variability (Estimate) of Pigeon Pea for 2017-18 to 2023-24

2017-18	Mean	879.27	2021-22	Mean	1071.74
	STdv	276.80		STdv	704.79
	Percentage	31%		Percentage	66%
2018-19	Mean	583.68	2022-23	Mean	490.94
	STdv	331.96		STdv	213.21
	Percentage	57%		Percentage	43%
2019-20	Mean	950.82	2023-24	Mean	867.24
	STdv	490.14		STdv	209.97
	Percentage	52%		Percentage	24%
2020-21	Mean	1058.27	Average	Mean	843
	STdv	409.84		STdv	353
	Percentage	39%		Percentage	42%

Annexure 4: Assumptions and Details for GHG Balance Estimation Methodology

Accounting methodology

The World Bank has adopted the Ex-Ante Carbon-balance Tool (EX-ACT), developed by FAO in 2010, to estimate the impact of agricultural investment lending on GHG emissions and carbon sequestration in the project area. EX-ACT is a land-based appraisal system that allows the assessment of a project's net carbon balance, defined as the net balance of CO2 equivalent GHG that is emitted or sequestered because of project implementation compared to a no project or without project scenario. EX-ACT captures project activities in the following five modules: land use change, crop production, livestock and grassland, land degradation, inputs, and investment. Agriculture development and natural resource management projects are normally expected to contribute to net GHG (CO2 equivalent) sequestration, as a co-benefit to the resilience-building objectives.

Project activities relevant to the analysis of the project area

In the PoCRA project, the cropping pattern in the selected districts is dominated by Tur, cereals (Jowar, Bajra, Maize), cotton, pulses, and oilseeds (soybean, mustard). This study was carried out following the baseline survey in 15 PoCRA project districts. The project area (Pa) in these 15 districts covers 3.8 million ha of nearly 13 million ha of total geographical area in these districts.

Project activities

Throughout the PoCRA project's six-year implementation phase, several interventions have been made to enhance climate resilience to agriculture in the project area. Most of the practices or interventions are likely to have implications for carbon stocks. Considering the trend of forest land area in different districts from 2011 to 2019, it was estimated that about 2.4 million ha of forest land was in the project area during 2017. District wise most recent change in forest cover in different districts of the project area was taken from the Forest Survey of India report (2019). Following the annual growth of the forest area, the forest cover in different districts of the project area was estimated for the year 2023 (Table 1). Based on the project activities (like microplanning etc.) and field observation and land use change in sample project clusters, it was estimated 98 th ha of forest land in the "Control" area and 147 th ha in the "Project area" during 2023.

Table 72: Estimated Forest Area in Project Area of Different Districts during 2023

District	Total Forest Area (ha) in 2017	Total Forest Area (ha) in 2019	Estimated Forest Area (ha) in 2023	Estimated Forest in Project Area (ha) in 2023
Akola	33571	34037	34976	16774
Amravati	316048	316777	315322	70417
Aurangabad	55617	56793	54466	17514
Beed	14604	16403	13002	4024
Buldhana	57178	59190	55234	16244
Hingoli	10892	11001	10784	3841
Jalgaon	111427	114684	121291	35385
Jalna	3593	3648	3538	1432
Latur	1289	1302	1329	411
Nanded	91052	93636	98876	23693
Dharashiv	4834	4966	5234	2088
Parbhani	3728	4033	3446	1246
Wardha	88258	89195	87332	8152

District	Total Forest Area (ha) in 2017	Total Forest Area (ha) in 2019	Estimated Forest Area (ha) in 2023	Estimated Forest in Project Area (ha) in 2023
Washim	29011	29676	28361	4917
Yavatmal	257290	260732	267661	39740

The improved and climate-resilient practices proposed under the project and considered for GHG accounting, considering the EX-ACT modules, include:

i. No-tillage and residue retention nutrient management
ii. Improved agronomic practices
iii. Improved water management
iv. Manure application
v. Crop residue management

The Cropland Area (CA) of a particular crop under the 'project' and 'control' areas was estimated with the following equation.

$$[CA]_i = (S[CA]_i / S[CA]) \times Pa$$

Where $[CA]_i$ is the area of a particular crop (i) in the project area in ha; $S[CA]_i$ is the area (ha) of a particular crop (i) in the endline household survey S[CA] is the total land area (ha) of surveyed households. Similarly, the area under a particular crop in the control area was also calculated based on the endline household survey data. Pa is the project area in ha.

The survey data was also used to calculate the total amount of fertilizer application, electricity consumption, crop production, etc. in both 'with project' and 'without project' areas. Different perennial horticulture crops were promoted in the project area during the implementation period. Household survey data of endline was used to estimate the area of horticulture cropping in the project area. District-level horticulture cropping area and yield data (Department of Agriculture, Government of Maharashtra 2023) were used to estimate the horticulture crop yield in the control area. Guava, Custard Apple, Lime, Pomegranate, and grapes are the main fruit crops in the project districts.

Annexure 5: Agribusiness

Model: Impact of storage facilities on proportion of wastage

```
Model 2 Summary:
                              OLS Regression Results
==============================================================================
Dep. Variable:     Proportion_of_Wastage   R-squared:                       0.880
Model:                               OLS   Adj. R-squared:                  0.880
Method:                    Least Squares   F-statistic:                 3.287e+04
Date:                   Wed, 12 Jun 2024   Prob (F-statistic):               0.00
Time:                           09:44:48   Log-Likelihood:                 13976.
No. Observations:                   4485   AIC:                        -2.795e+04
Df Residuals:                       4483   BIC:                        -2.793e+04
Df Model:                              1
Covariance Type:               nonrobust
=====================================================================================
                        coef    std err          t      P>|t|      [0.025      0.975]
-------------------------------------------------------------------------------------
const                 0.4003      0.000   2486.291      0.000       0.400       0.401
Storage_Facilites    -0.2914      0.002   -181.302      0.000      -0.295      -0.288
==============================================================================
Omnibus:                     6638.416   Durbin-Watson:                   1.033
Prob(Omnibus):                  0.000   Jarque-Bera (JB):          9351361.101
Skew:                           8.409   Prob(JB):                         0.00
Kurtosis:                     226.065   Cond. No.                         10.0
==============================================================================
```

Annexure 6: Expert Field Visit Reports

This annexure contains detailed field visit reports compiled by experts in the Marathwada and Vidarbha regions. The first set of reports is by experts engaged by Sambodhi for the Marathwada region, followed by reports from experts engaged by Nabcons covering the Vidarbha (RoPA) region.

Findings from field visits by experts engaged for the Marathwada Region

Team Leader cum Monitoring and Evaluation Expert

Team leader cum M&E expert Biswaranjan Baraj visited Sidhanath Wadgaon village in Gangapur tehsil and Golegaon village in Sillod tehsil under Chhatrapati Sambhajinagar district. He also visited Tupewadi and Asarkheda villages in Badnapur tehsil under Jalna district from 6th to 8th May 2024. The visit comprised interaction with beneficiary farmers, and FPCs of the PoCRA project. The Shraddha Farmer Producer Company (FPC), Samar Agro Farmer Producer Company Limited, and Chhatrapati Shivaji Maharaj Shetkari Gat in Sidhanath Wadgaon village, Samruddhi Swayam Sahayata Gat in Tupewadi village and Krushiratna Shetkari Gat in Asarkheda village were visited to understand the current functioning of FPCs and how it helped achieving better income of the farmers and climate resilient agriculture in PoCRA region.

Key Insights:

- **Infrastructural assets and resultant benefits:** All groups had invested significantly in infrastructure, such as godowns and Custom Hiring Centres (CHCs), with substantial subsidies from the project. Godowns and CHCs improved the storage and timely availability of machinery, reducing post-harvest losses and cultivation costs. Their presence allowed farmers to sell their produce at higher market prices. The availability of critical machinery at lower costs not only increased agricultural efficiency but also reduced expenses. Vehicles like pickup vans aid in transporting the produce and lend further support to logistical needs.

- **Financial impact:** The initiatives have led to significant cost reductions and income increases for the farmers. For example, through the use of CHC equipment, farmers reported increased production and a reduction of cultivation costs by around 20 percent because of the reduction of rentals of agricultural equipment and the timely availability of agricultural operations. The storage helped in the reduction of wastage of crops and helped get better prices of produce as they stored the crop produce in godowns and sold in the market at a time when the price of the agricultural item was higher. Profits from FPC activities are distributed among members, contributing to improved financial stability of the farmers. The cropping pattern has changed in many villages after PoCRA support. Farmers are giving up their traditional crops and shifting their focus to new crops like horticulture, and vegetable production using Shadenet to increase their income.

- **Climate resilience:** Enhanced storage capacity and timely access to machinery have made the groups more resilient to absorb climate-related shocks and disruptions. The transportation van helped farmers do reliable transportation of crops, especially during adverse weather conditions. Farmers could protect and store their crops during adverse weather conditions, reducing wastage and financial losses. All these helped farmers achieve climate resilience.

Some of the major recommendations based on field visits are

- **Enhanced utilization of assets:**
  Increased CHC utilization: After use by member farmers, the farm machinery of CHCs should be provided to external farmers charging a reasonable fee increasing utilization rates and income of the farmers. Currently, it is happening in many CHCs, but there is further scope for more usage of machinery by non-farmers.
  Optimization of godown usage: Better planning and coordination among FPC members to fully utilize godown capacity should be encouraged and non-member farmers should also be

allowed to store their produce if storage is available after storing agricultural produce of member farmers charging a reasonable fee.

- **Training and awareness:** The training for FPC members on efficient management practices and maintenance of machinery should be conducted to maximize the benefits of storage and farm equipment. There should be proper monitoring of the usage of godowns, vans, and farm equipment by district and block-level PoCRA officials

- **Marketing and sales strategy:** There should be collective marketing strategies to sell stored produce at peak prices, ensuring members get the best possible returns.

- **Financial management and planning:** By implementing financial planning and management workshops, the capacity of the FPCs should be enhanced to better allocate funds, manage subsidies, and plan for future investments. The farmers should be encouraged to invest a portion of the profits in the creation of more farm assets.

Agri Engineering Expert

Agri engineering expert Vijay Agarwal visited Palkhed and Bhagur villages in Vaijapur taluka of Chhatrapati Sambhaji Nagar district in February 2024. The visit assessed the change in land use and cropping pattern, pre-and post-PoCRA works, creation of assets, and challenges faced under different activities.

Key Insights:

- **Cropping pattern:** The cropping pattern in the village earlier comprised Cotton, Sorghum (Jowar), Pigeon Pea, and Gram (Channa) which has now changed to Ginger, Tomato, Chilli, Onion promoting crop diversification and encouraging intercropping which caters to enhanced climate resilience and improved income drawn from livelihood activity.

- **Drip and sprinkler irrigation:** It was found that the beneficiary farmers largely used PoCRA's assistance for drip and sprinkler irrigation systems. The farmers pointed out that before PoCRA, they faced a shortage of water, particularly during winter (Rabi season), which has now ameliorated due to water-saving drip irrigation and storing facilities through PoCRA-assisted pond facilities in their farms. This has led to comparatively higher crop yields than before and augurs well for their future.

Hydrology Expert

Hydrology expert Suresh Kulkarni visited Dharashiv (Dindori, Deolali and Tambewadi in Bhum taluka) and Latur (Murud Bk in Latur, Nagarsiga in Ausa taluka and Yerol in Shirur taluka) in January 2024. Certain key interventions were assessed for their impacts on increasing crop productivity, enhancing surface water and groundwater availability at farmers' fields, increasing water use efficiency, and soil and water conservation in the project villages.

Key Insights:

The major impacts and challenges of the structural interventions as observed during the field survey areas as follows:

Drip and sprinkler irrigation

- **Area under cultivation**: Water savings to the tune of 40 percent to 50 percent in the case of sprinklers and 60 percent to 80 percent in the case of drips were achieved. The water saving has been reflected in terms of the expansion of irrigated areas in the project villages. The area under irrigation in the Rabi season and under cultivation of Sugarcane have shown considerable growth. Overall, farmers could expand their area under irrigation and cultivate cash crops due to sprinkler/ drip irrigation intervention.

- **Energy Usage**: As the overall number of pump operating hours are reduced due to sprinkler and drip irrigation, the energy saving was worked out, ranging from 40 percent to 60 percent.

- **Increased crop yield**: Farmers reported an increase of 40 percent to 50 percent, both by sprinkler and drip irrigation. The greater area under irrigated cultivation has resulted in more yields and eventually will translate into enhanced income.

It was heartening to witness that out of the multiple interventions under PoCRA, the maximum number of farmers showed a preference for sprinkler and drip irrigation systems and seemed wholly convinced of the benefits of these techniques.

Cement Nala Bund

- **Increase in water availability:** Due to the construction of CNB, farmers in the adjoining area have erected new wells along its upstream and downstream stretches. An increase in the water recharge during the rainy season from the Nala on which the CNB is constructed was witnessed thereby leading to an increase of almost four to five-fold the water capacity of their dug wells.

- **Greater cropping intensity:** Before CNB, only two irrigation rotations could be given, but after its construction, four to five rotations were given to crops. The overall cropping intensity has increased significantly as more area can be irrigated in the Rabi season than earlier.

Farm ponds

- **Water security and management:** Farm ponds have provided water security and a reliable source of water supply. Farmers used the stored water to irrigate crops during the dry spells as a protective irrigation. Almost all farm ponds are lined with plastic sheets to prevent seepage losses. Beneficiary farmers expressed great satisfaction with the provision of liberal subsidies obtained through PoCRA.

Compartment bunding

- **Improved soil moisture and crop production:** Compartment bunding (CB) retains the rainwater in the field for a longer period, thereby contributing to an increase in soil moisture. The CB enhances recharge to groundwater, thereby increasing water levels in nearby dug wells. This has helped farmers to grow crops like wheat/gram in the Rabi season, culminating in an increase in the farmers' income.

- **Enhanced soil health:** CB has proven to prevent soil erosion due to runoff during high-intensity rainfall. There has also been an improvement in the soil texture. The CB also retains nutrients in the soil, thereby preserving the soil fertility.

Challenges to overcome

Through PoCRA, several climate-smart technologies and natural resources management (NRM) structures were promoted by providing financial and technical support to farmers. Nevertheless, there are some weaknesses and threats in the adoption of these technologies and NRM structures, which are as follows:

- **Erratic power supply**: With respect to sprinkler and drip irrigation technologies, looming threats include declining groundwater availability and an erratic power supply. On account of the erratic power supply, farmers are required to adjust irrigation hours according to the availability of power supply.

- **Improved guidance:** Farmers could benefit from greater handholding and more frequent guidance from irrigation system suppliers and agricultural department field staff regarding the operation and maintenance of sprinkler and drip systems.
- **Maintenance of systems and role of Gram Panchayat:** A few CNBs were found silted and full of vegetation, impacting their harvesting and retaining capacity and reducing the recharge to groundwater. The Gram Panchayat Committee needs to act as a steward to maintain these structures.

GIS Expert

GIS expert Sreeja Nair visited Sawana village and Goregoan village of the Hingoli district and Bitnal village and Dhanora village of the Nanded district in January 2024. The visit was to understand the NRM-related interventions, modernization of farming, diversification of agriculture, and overall impacts as seen under the project.

Key Insights:

Sawana Village:

- **Benefits stemming from NRM activities:** NRM-related structural or non-structural interventions have been carried out in this village. Prior to the project, there was a water shortage during the summer season, and traditional crops, such as soybean, cotton, Chickpeas, etc, were grown by the farmers. Since 2021, many farmers have benefited from drip and sprinkler irrigation systems and have transitioned to growing horticultural crops. Farmers have also started multi-cropping instead of practicing monoculture.

- **Construction of warehouse for storing grains:** A number of warehouses are run by multiple farmer’s groups. Seed Production and subsidies have benefitted multiple farmers. However, it is advised to expand the usage of the Warehouse tractor, crusher, and other equipment under the project, which is at present primarily used by the members of the Farmer's Group only. Refrigerator vans are also provided to the farmer’s group for the transportation of agricultural produce, improving profit margins and connectivity with local markets.

- **Cropping pattern**: The cropping pattern has been evolving over the last two years, with the introduction of horticulture plantations like orange, custard apple, and guava. Some farms have also seen an increase in multiple cropping due to the rise in bore wells. Agroforestry areas have shown growth in the last three years, although farmers will only be able to produce in two years from now.

- **Recommendations and limitations:** To ensure the sustainability of the project’s interventions and continued accrual of its benefits, it is important to further expand the coverage of the project through its institutional mechanisms, in particular the VCRMC, to include marginal farmers who have thus far been unable to draw the benefits owing to lack of affordability of initial investments.

Goregaon Village

- **Dug wells and check dams:** Construction of dug wells has been a boon under PoCRA, providing irrigation during the lean season. The availability of water from Dug wells and drip irrigation systems has enabled farmers to cultivate horticulture plants, which has increased their income. Check dams have helped store excess water and recharge groundwater. As a result, fruits and vegetables are also now grown throughout the year.

Sociology Expert

Sociology expert Mini Govindan visited Sawana and Goregaon villages from the Hingoli district, and Bitnal, and Dhanoara villages from the Nanded district in January 2024. The visit was to understand climate smart post-harvest management and value chain promotion as well as report the overall benefits, impacts, and challenges experienced.

Key Insights:

Discussions with SHGs

- Despite PoCRA's commendable interventions in the promotion of activities such as sericulture, fishery, and apiculture, among others, to achieve the objective of enhancing profitability through the SHG collective approach, it was found that a few of these collectives had not shaped up as desired.
- Frequent internal conflicts and differences among the members, in operating a Dal Mill in the village of Goregaon had impeded its functioning, despite receiving 60 percent of the amount from PoCRA (Rs. 12 lakhs out of Rs. 20 lakhs) for initiating the operations.
- Thus, going forward, it would be advisable for VCRMC to pay attention to aspects of trust, solidarity, and leadership within such groups, before processing applications and thereby ensuring streamlined operations.

Discussions with VCRMC

- VCRMC is envisaged as the building block of PoCRA. Members of this committee, which plays a key role in planning, community procurement, monitoring and coordinating project implementation (e.g. watershed plans), and anchoring climate interventions at the community level, have been selected by the Gram Sabha. Special emphasis has been levied on the representation of different interest groups, in particular the presence of vulnerable sections.
- With the project coming to its imminent conclusion, it is critical to maintain the motivation levels of VCRMC members to take responsibility for the project's many interventions and ensure the benefits accrued thus far, continue to be enjoyed by people of the village.
- VCRMC's greater thrust on organizing exposure visits for their members, collaborations with financial institutions for enhanced credit availability to farmers, partnerships with nurseries to ensure a seamless supply of quality planting material, support for the cultivation of fodder crops and improving livestock feed, and most importantly, assessing the specific needs of the landless in each region and designing exclusive interventions for them would aid the above-stated endeavor.

Discussions with FPCs

- PoCRA's most impactful intervention was witnessed in the form of propelling the existing Farmer Producer Companies (FPC) and Farmer Interest Groups (FIG) as enablers of change, to promote practices and technologies in post-harvest management and value addition that support climate adaptation and/or mitigation.
- The benefits availed by FIG cater to supporting the establishment of a godown (warehouse), procurement of a cleaning and grading machine, and acquiring a vehicle. These benefits have cumulatively resulted in reduced post-harvest losses for farmers due to spoilage or pest infestation, aided price stabilization by adjusting demand and supply, and fostered seamless transportation to the main vegetable/fruit/grain markets to sell the produce. Post the installation of grading & cleaning machines and undertaking grading processes, the farmers earned an

increased income of 10 percent to 25 percent as compared to selling their produce without grading.

- A common denominator observed in all the FIG/ FPC is the increased confidence of member farmers in handling post-harvest management and value chain promotion. A noteworthy aspect is that the FIGs have employed landless workers to clean and maintain the physical infrastructure and machinery/ equipment. Most crucially, they took immense pride in benefiting the small and marginal farmers of the village, stating that the living standards of the vulnerable groups have increased with better income and savings.

Agri-Business Expert

Agri-business expert Deodatt Singh visited CSN (Sidhanath Wadgaon in Gangapur taluka and Golegaon Bk in Sillod taluka) and Jalna (Tupewadi and Asarkheda in Badnapur taluka) districts in May 2024. The visit centred around evaluation of the Storage and Carrier Van Activity of FPCs being implemented by PoCRA.

Key Insights:

- **Custom Hiring Centres (CHCs):** CHCs provided farmers with access to expensive agricultural machinery at affordable rental rates, eliminating the need for significant equipment investments and thereby reducing the overall cost of cultivation. The availability of machinery decreased the requirement for manual labor making tasks such as ploughing, sowing, and harvesting more efficient. Access to machinery encouraged the adoption of climate-smart agricultural practices, increasing the community's resilience to climate change. CHCs also created direct employment opportunities for individuals managing and maintaining the machinery. Access to specialized machinery encourages the adoption of climate-smart agricultural practices, increasing the community's resilience to climate change.

- **Storage and carrier van activity:** Proper storage facilities such as godowns have helped preserve the quality of agricultural produce, reducing spoilage caused by pests, moisture, and environmental conditions. Such storage units have aided better price realization by the farmers by optimizing the timing of selling their produce and improving inventory control. FPC operators reported that losses had been minimized to around 4-6 percent from the earlier 20-25 percent. The storage facilities and carrier vans generated both direct and indirect employment opportunities like logistics, packaging, transportation, and quality control.

Environment Expert

Environment expert Arindam Datta visited CSN (Karanjkeda and Pishor in Kannad taluka) and Jalna (Sonal Pimpalgaon in Ambad and Tapovan in Bhokardan taluka) districts in January 2024. The visit was conducted to evaluate the impacts that PoCRA has brought about from an environmental lens.

Key Insights:

- **Pest management through stick pads:** The poly house is equipped with sticky pads to detect pest infestation. While there are some instances when the farmer lacks the knowledge on how to effectively use the sticky pads as pesticides, on the whole, most farmers have greatly benefitted from it.

- **Chikoo-specific intervention:** Chikoo is taken up by a lot of farmers in this region. Local-level storage and processing units for Chikoos could benefit the farmers significantly who are currently forced to auction their orchards annually to large businessmen due to difficulties in storing the fruits. Following a model, inspired by the local onion storage facility, could bring much-desired prosperity to the Chikoo growers along with employment, inventory management, and improved price realization.

- **Drip irrigation:** Drip irrigation has received immense support from PoCRA. This has resulted in increased production of tomatoes in Pishor village.

- **Crop residue burning and other challenges:** Crop residue burning is one of the major environmental problems in many villages, particularly in cotton and tur. It is also critical to monitor the number of pesticides being applied in shade nets while concurrently ensuring the prevention of frequent water logging and the development of highly humid conditions which can adversely affect the produce being cultivated.

Agronomy Expert

Agronomy expert Ramlal Singandhupe visited CSN (Karanjkheda and Pishor in Kannad) and Jalna (Sonal Pimpalgaon in Ambad and Tapovan in Bhokardan) districts in January 2024. The visit comprised an evaluation adoption of Climate Resilient Agricultural Technologies and agronomic practices which included improved seed varieties, contour furrow and bund cultivation, BBF cultivation, inter-cropping, Integrated pest and nutrient management, mulching, conservation tillage, protected cultivation (shadenet and polyhouse), and micro-irrigation techniques (drip and sprinkler) as well as farm ponds.

Key Insights:

- **Tapovan – Shadenets and farm ponds:** Shade net houses have been a major intervention in Tapovan. For irrigation of shade net crops and field crops, farm ponds have been constructed by individual farmers and are being used extensively.

- **Pishor – Pressurized irrigation systems:** The farmers of Pishor village have received maximum benefits in Apiculture, shadenet, drip irrigation systems, sprinklers, and pipes. In this Gram Panchayat, a significant area has been brought under irrigation due to the availability of water from the medium irrigation projects. While all technologies have contributed positively, the impact of pressurized irrigation systems, shade nets, and seed multiplication stands out as highly profitable. A key learning was the presence of widespread enthusiasm and proactiveness among the farmers in adopting these sustainable practices.

- **Karanjkheda Jahagir – Improved maize production and better market linkage:** While the area and production of maize crops increased across both Kharif and Rabi seasons, the associated economic benefits were hindered by the existing marketing network. Better market linkage would help the farmers significantly, reducing their involvement in heavy value chain practices like drying, processing, cleaning, transportation, etc.

- **Recommendation(s)**: Important to regularize and stabilize the power supply for operating the irrigation pumps. This will not only aid in optimum water supply but also ensure that farmers are not required to adjust irrigation hours according to the availability of power supply. In the short term, greater encouragement to adopt solar pumps would prove beneficial.

Insight on Climate Resilient (CR) Technologies:

- **BBF:** Implemented in ginger, rabi maize, and soybean cultivation. This has led to enhanced drainage and prevented waterlogging, promoting better crop growth and yield. BBF has also reduced soil erosion and enhanced the soil structure.

- **Improved seed varieties and seed multiplication:** Farmers have adopted high-quality seeds for soybean and other crops. Seed multiplication ensured the availability of quality seeds locally.

- **Individual farm ponds and lining:** Rainwater harvesting and storage for irrigation. Lining prevented seepage and ensured water availability.

- **Sericulture and mulching**: Sericulture (silk production) provided an additional income source. Mulching conserved soil moisture and suppressed weeds. The balanced use of fertilizers and pest control measures improved soil health and minimized chemical inputs.

Agricultural Economist

Agri-economy expert Dalbir Singh visited CSN (Sidhanath Wadgaon and Wajnapur in Gangapur), Beed (Ardhmasla, Nipani Jwalka, and Ranjani in Georai), and Parbhani (Devnandra, Kherda and Pathargav in Pathri) districts in February 2024. The key objectives of his visits were to assess the resilience built within the community through a host of measures. The group discussions were conducted while interacting with the project implementation staff deployed on the field and primary stakeholders such as farmers belonging to various socio-economic categories, to collect information regarding the impact of project activities at the farm and household levels respectively

Key Insights:

- **Changes in cropping pattern:** During the field investigation, it was noted that there were substantial changes in cropping pattern after the implementation of various project activities. New crops emerged such as horticulture crops like citrus, mangoes, guava, pomegranate, and other vegetable crops. Thus, it can be inferred that the emergence of such crops has given more room to farmers to absorb shocks from one crop loss/ damage while fortifying their income avenues.

- **Crop productivity:** Crop productivity is one of the major indicators of agricultural development. After the project intervention, there was a substantial increase in the productivity of major crops grown by the farmers in project villages. PoCRA must be commended for focussing on diverse interventions to build a holistic ecosystem to ensure long-term sustainable results. Thus, expansion in crop productivity stems from the installation of micro-irrigation technologies and farmers following a whole gamut of water management practices indicating institutional reforms.

- **Adoption of technology:** In the selected project villages, electronic devices such as computers, mobiles, and modern farm implements have improved the farmer's skills in dealing with emerging issues in farm activities. Some of them were visible while accessing market information and other farming-related information by using the internet facilities in the computer sets installed at the farm shed at the site. Farmers also regularly used applications to gain agro-advisory services. They also harnessed mobile technology in marketing their farm products and inputs. Farming communities realized the importance of leveraging modern technologies in resolving problems relating to farms and farm production.

- **Development of youth entrepreneurship:** Agri-based entrepreneurship has a substantial potential to create new employment opportunities for rural youth and halt their migration from villages. This has improved the living conditions of farmers by providing alternative sources of livelihood including several youths involved in various agricultural-oriented businesses including transport facilities, farm inputs business, and farm implements-based supply and repair centres. PoCRA's institutional mechanisms are encouraged to foster greater farm management and entrepreneurial skills within the farming community after the project's exit.

Findings from field visits by experts engaged for the RoPA Region

Agri-Business Expert

Agri-business expert Sohan Premi visited the villages of Shelu Bk., Ambhora, and Kodori in the districts of Washim, Akola, and Amravati in February 2024.

Key Insights:

- **Market access and value addition** – The establishment of small and medium-sized agro-processing units added value to raw agricultural products through processes such as drying, canning, and packaging. These resulted in increased farmer incomes. Apart from that, the development of cold storage facilities as well as warehouses led to a reduction in post-harvest losses and maintained the quality of produce.

- **Capacity building and training** – It was observed that training sessions, and workshops for farmers on topics of climate-resilient agricultural practices, financial literacy, and business management were conducted regularly. Important to strengthen agricultural extension services to provide ongoing technical support, information dissemination, and advisory services to farmers.

- **Financial and risk management** – It was encouraging to observe the implementation of crop insurance. Equally important was the dissemination of information relating to schemes to protect farmers from losses due to extreme weather events and other climate-related risks. Farmers had access to microfinance and credit. The provision of subsidies and financial incentives for adopting climate-smart agricultural practices and technologies were attested to by farmer respondents.

- **Supply chain optimization** – On this front, the project must be appreciated for the implementation of logistics and supply chain systems that reduce transportation costs, minimize losses, and ensure timely delivery of agricultural products to markets.

- **Policy advocacy and government support** – Institutional mechanisms should engage in advocacy for supportive policies and frameworks that promote climate-resilient agriculture and provide the necessary infrastructure and resources to further augment the project's objectives.

Agri- Engineer Expert

Agri-engineering expert Syed Ismail visited Algaon, Warkhed, Vinchori, and Surwadi villages of Wardha and Amravati districts in February 2024. The visit aimed to investigate the progress accomplished against the activities covering environment and climate change-related perspectives.

Key Insights:

- **Water management technologies:** Drip irrigation has ensured efficient water usage. Sprinkler Irrigation Systems have ensured even water distribution, and farm ponds and check dams have ensured higher storage of rainwater during dry periods. Contour bunding has enabled a reduction in soil erosion. Graded bunds have improved soil moisture conservation.

- **Farm mechanization:** Precision Farming tools like GPS and GIS have optimized field operations and ensured the precise application of inputs thereby enhancing efficiency and reducing both wastage and costs.

- **Renewable energy integration:** Solar-powered pumps have reduced dependence on unreliable power sources leading to a timely supply of water and promoting sustainable energy use.
- **Protected cultivation:** Widespread adoption of shade nets, and polyhouses have protected crops from extreme weather conditions and extended growing seasons.

- **Post-harvest technology:** Cold storage facilities have reduced post-harvest losses and preserved the quality of produce. Value addition units have increased the shelf life and market value of the produce.

Agronomy Expert

Agronomy expert Ravikiran Mali visit was undertaken along with a group of officials from the Department of Agriculture. Visits were made to the villages Anbhora, Shelu Bk, Kodori, and Shirala in the districts of Akola, Washim, and Amravati.

- **Anbhora, Akola:** Water resources such as drip and sprinkler irrigation systems have been developed significantly in the Akola taluka, bringing more area under cultivation, especially in the Rabi season, and thereby increasing the cropping intensity with more income over the year for farmers. It was observed that the productivity of major Kharif and Rabi crops has improved significantly in Anbhora due to the introduction of project interventions and the adoption of improved technologies and cultivars by the farmers.

- **Shelu Bk, Washim:** Integrated disease and pest management have resulted in a significant decline in wilt, leading to optimum plant population and a significant increase in crop productivity. Farmers reported the application of biopesticides like Neemark (Nimboli) with appropriate dosage to control these pests, resulting in reduced number of sprays and cost of cultivation. Farm operations such as land preparation, sowing, hoeing, and spraying have become more streamlined and punctual, and there are substantial yield benefits now accruing to the farmers. Farmers experienced an increase in yield to the tune of about 40-45 percent in Soybean crops due to the availability of protective irrigation through sprinklers.

- **Kodori, Amravati:** Farmers experienced an increase in yield amounting to 40-45 percent in Soybean and Cotton owing to the adoption of sprinklers. Not just enhanced yield, but water conservation to the extent of 16 percent to 70 percent was also brought about through the usage of sprinklers. The practice of goat rearing was found to be very useful for several landless laborers and served as a key source of income.

- **Shirala, Amravati:** Post the implementation of seed production, farmers have received 15-20 percent higher rates by selling seed instead of selling their produce as raw grain. The average rate received for the grain soybean is around Rs. 4500/- to Rs. 5500/- per quintal. Due to drip irrigation, a yield increase of around 50-70 percent was observed as compared to the un-irrigated. The fertigation method has reduced fertilizer consumption and proven to be very cost-effective. Farmers expressed keen interest in various types of newly developed farm implements, which curtail labor requirements and therefore are in high demand.

Agri-Economy Expert

Agri-economy expert K. U. Viswanathan visited the villages Maharkhed, Tandulwadi, Ancharwadi, Vasantnagar, Shelwad, and Rotwad located in Buldhana and Jalgaon districts in March 2024. The visit included conducting meetings with the field-level implementers of the PoCRA project as well as its beneficiaries.

Key Insights:

- **Discussions with farmer households:** PoCRA has made an impact on farming operations, especially on those who had DBT. The awareness surrounding PoCRA was found to be very high in the villages. Nearly all farmers visited had registered under the scheme. Importantly, 20-30 percent of DBT beneficiaries were women. Farmers cultivating tomatoes and chilies for private seed companies were generating more income in shade net cultivation. The godown constructed under the scheme was generating an incremental income for the beneficiaries. The formation of FPOs under the project villages has demonstrated increased selling prices for the produce of member farmers. Post the project's exit, awareness around climate change could be an area to be worked on as it seemed inadequate at the time of the visit.

- **Discussions with SHGs and FPCs**: CHCs sanctioned to SHGs were generating incremental income. CHCs need to be promoted on account of their labor savings, timely completion of sowing/harvest in peak labor short seasons, and incremental effect on yield. New FPCs need to be promoted under PoCRA villages as there is already a forum like VCMRC, which can anchor group formation and registration.

- **Discussions with VCRMC committees and farmer field school:** VCRMCs were formed in all the sample villages as per the scheme and ensured that PoCRA's numerous undertakings were well coordinated. Going ahead, VCRMCs are encouraged to converge various government schemes in PoCRA villages. The FFS concept needs to be continued as its impact is reflected in the improved cropping pattern and yield level of crops.

- **Feedback on PoCRA project:** The possibility of accessing more than one subsidized component and the seamless working of DBT, ensuring the fast release of subsidies, has made the scheme popular. Farmers need a continuation of the scheme, including non-covered villages.

Environment Expert

Environment expert Suraj Pandey visited three (Sawkhed Tejan, Varad Bk, and Palas Kheda Kakar) villages from the Buldhana and Jalgaon districts in February 2024. The visit aimed to ascertain the progress accomplished against the activities covering environmental and climate change-related issues.

Key Insights:

- **Adopting climate-resilient crops and varieties:** Planting drought-resistant varieties of traditional crops like millets, sorghum, and certain pulses can help mitigate the impact of water scarcity. Using short-duration crop varieties that mature quickly can help farmers avoid the risk of crop failure due to late or insufficient rainfall.

- **Efficient water management:** Continuation of drip and sprinkler irrigation to implement efficient irrigation techniques thereby reducing water wastage and ensuring precise water delivery to crops. Promotion of Mulching through the use of organic mulches is recommended to retain soil moisture and reduce evaporation.

- **Soil health/ Kharpan region/Saline affected area:** Further, promote organic farming practices to enhance soil health and resilience against climate extremes alongside crop rotation and intercropping to improve soil fertility and reduce pest and disease incidence. Critically, the addition of Biochar is recommended to soil to improve water retention and soil structure.

- **Agroforestry and crop diversification** – Integrating trees with crops and livestock farming creates more resilient farming systems that can withstand climate variability. Similarly, diversifying crops to spread the risk and ensure income even if one crop fails due to adverse weather conditions, is critical going ahead.

- **Community-Based Approaches** – As its mandate, the project has consistently strived towards the formation of farmer cooperatives to facilitate knowledge sharing, collective action, and access to resources. Post its imminent conclusion, participatory planning should be encouraged by involving farmers in processes to develop locally appropriate climate adaptation strategies.

GIS Expert

GIS expert Praveen Mishra visited the villages of Sawkheda Tejan, and Bhorsa in Buldhana district and Varad Bk and Palas Kheda Kakar in Jalgaon districts.

Key Insights:

- **Soil and water conservation:** Advised conducting extensive geological surveys to map soil types, water tables, and rock formations in order to capture data that can guide soil management and water conservation practices. Similarly, implementing soil conservation techniques based on a region's topography and geology, such as terracing, contour bunding, and check dams can prove highly effective in reducing erosion and retaining soil fertility.

- **Groundwater management:** With respect to Aquifer recharge, it is important to identify potential sites for artificial aquifer recharge using structures like percolation tanks, recharge wells, and check dams. Geological mapping can pinpoint areas with high recharge potential. Similarly, it is imperative to establish a network of groundwater monitoring wells to track water levels and quality, ensuring sustainable use of this vital resource.

- **Water resource management:** Rainwater harvesting structures should be designed taking into account geological conditions; for example, rooftop harvesting in rocky areas and farm ponds in alluvial soils are most suited.

- **Soil health and fertility:** Prior to undertaking fertilizer application and soil amendment practices, it is essential to create soil maps. Comprehensive soil testing also enables the determination of nutrient levels, pH, and texture. In a similar vein, based on a region's geological composition, utilization of mineral resources like gypsum or lime to correct soil deficiencies and improve structure can prove to be highly beneficial.

- **Adaptation to climate extremes** – Important to plan mitigation measures based on the mapping of areas prone to geological hazards such as landslides, floods, and soil erosion. Of equal importance is the design and construction of agricultural infrastructure like storage facilities, irrigation systems, and shelters, taking into consideration the geological stability of the region.

- **Geospatial technologies –** In the days ahead, synchronization of GIS and Remote Sensing technologies will prove critical to monitor land use changes, soil erosion patterns, and water resource distribution in the course of planning and decision-making.

Sociology Expert

Sociology expert Raghuraja J visited the villages of Maharkhed, Tandulwadi, Ancharwadi, Vasantnagar, Shelwad, and Rotwad spanning the districts of Buldana and Jalgaon. The visit entailed discussions with beneficiary groups such as VCRMC members, women SHGs members, and elected members of Panchayat, and learning the opinion of the village leaders. Topics ranged from cropping patterns across seasons, adoption of PoCRA-led interventions, water availability, and farmer's income among a host of other topics. The field staff, Agriculture Department officials, Sarpanch, SHG group Members, and Krishi Tais wholly participated in the interactions.

Key Insights:

- **Role of VCRMC and Agri. Officials:** PoCRA-supported technologies have led to a considerable improvement in cultivation during the Rabi season. In comparison with the Kharif area, 90 percent of the Rabi area was sown due to CRA technologies. The long-term interventions need to be followed up for vertical and horizontal spread of technologies. This monitoring system can be implemented by VCRMC and Agriculture Department officials in the coming days.

- **Access to agriculture technology/ services:** FFS knowledge should be disseminated horizontally and vertically. Agricultural technology/services should be made available to farmers through Krishi Tai and Agriculture Department personnel for at least the next two to three years. The CHCs at the village level can be service-provider centres.

- **Participation of vulnerable sections:** While information regarding the project was widely available, in some instances, the participation of Scheduled Caste and Scheduled Tribe was found to be low due to marginal holdings/landlessness/low education level and lack of irrigation facilities. In these situations, a noteworthy climate-resilient technology, i.e. introduction of small ruminants has benefitted in providing income and employment for this section of farmers.

- **Discussions with VCRMC/ TAO/ Project officials:** VCRMC members are meeting regularly and in particular, the participation of SC/ST individuals and women is optimum. Strengthening and continuation of these VCRMCs after the project needs to be ensured. Participation of technical experts and specialists in VCRMC meetings could help in planning objective-oriented activities.

- **Gender aspect:** To ensure the robust sustainability of the intervention, it is important to include more and more women within the fold of CRA activities and expose them to CRA technologies. There is a requirement of 10-15 percent of land being in women's names, in the absence of which their participation in CRA activities is hindered. This criterion needs to be reviewed to ensure women's continued participation in VCRMC gatherings and to promote women farmer SHGs.

- **Social aspect:** FFS for women beneficiaries is the highlight of the project. The majority of the beneficiaries are included in FFS activity. It is a powerful extension methodology for the dissemination of agricultural information. There is a knowledge sharing horizontally between farmers. Going ahead, it would be advisable to assess the impact realized by SC/ ST/ Women beneficiaries to promote and generate improved social participation.

Hydrology Expert

Hydrology expert Anand Kumar Ojha visited the villages of Algaon, Bhidi of Wardha district, Surwadi Kh, Vinchori, and Warkhed in the district of Amravati.

Key Insights:

- **Water resource management and soil health:** Water resources in the villages were primarily managed through dug wells, borewells, and canal systems, with fresh groundwater available at varying depths. Groundwater recharge was supported by excess water from weirs and ponds, enhancing irrigation capabilities.

- **Benefit to the farmers:** Across all the villages, farmers benefited immensely from various subsidies aimed at enhancing agricultural productivity. Commonly subsidized items included drip and sprinkler irrigation sets, water pumps, farm machinery, horticulture plantations, and seed production. The sustainability of the interventions could be extended if the differing levels of support and implementation efficiency could be brought to a uniform level.

- **NRM activities:** In the villages visited, NRM activities like nala deepening, cement nala bunds, and graded bunding have been implemented. Nala deepening has widened and deepened the waterway, but issues such as bank scouring, silt deposition, and rainwater-induced erosion continue to mar its potential. Recommendations include creating small drains along the banks, providing suitable inlets, and planting vegetation to protect against erosion.

- **Recharge shafts:** In some villages, recharge shafts were constructed in the drain beds, to enhance groundwater recharge, using deep perforated pipes encased in boulders and wire mesh. However, heavy rainfall damaged many such structures, and their remnants have obstructed the flow of water, causing further damage. It is thus recommended, to increase the width of the nala and avoid the placement of structures at the centre, to mitigate these issues.

Annexure 7: Methodology Note on Water Productivity by IIT-B

Description

This indicator measures the annual increase in water productivity at the sub-district level (taluka); it is expressed as a ratio of agricultural production (in kg) over evapotranspiration (in m3). It is measured from Year 3 onwards and for the Kharif season only. It is expressed as a percentage change relative to a baseline value of 0.23 kg percubic meter.

As per the PAD, the values are calculated based on the secondary data. The current analysis for calculations of Water Productivity has been done based on the AET calculations done by the Indian Institute of Technology, Bombay. IIT Bombay, being the knowledge partner of the PMU and the leading research institution in the country has calculated the AET values for both rainfall as well as irrigation. For irrigation calculations, primary data from surveys like geographical location, irrigation method, pump capacity, number of watering, crop type, etc. has been used.

Methodology used

Farm-level water productivity has been calculated using the methodology developed by IIT Bombay as follows:

$$Water\ Productivity = \frac{Yield\ of\ crop\ (kg)}{Total\ water\ taken\ up\ by\ crop\ (Rainfall\ AET + Irrigation\ AET)(m3)}$$

1. For the calculation of water productivity, farm-level data related to the yield and irrigations applied has been taken based on the response from farming households during the baseline and mid-term survey. The following information related to crop and irrigation was collected as part of the baseline and mid-term household survey for estimation of water productivity:

    a. Crop name
    b. Crop area in acre
    c. Crop sowing date
    d. Crop harvesting date
    e. Crop yield
    f. Number of irrigations
    g. Type of irrigation
    h. Flow rate of dripper system in litres per hour (lph)
    i. Flow rate of sprinkler system in litres per hour (lph)
    j. Spacing between installed drip in feet
    k. Spacing between sprinkler in feet
    l. Serial number of irrigations
    m. Month and week of irrigation
    n. Days per watering
    o. Hours per watering
    p. Depth of soil (For estimating rainfall AET)
    q. Type of soil (For estimating rainfall AET)
    r. Gat number of plots (For estimating rainfall AET)

2. For **sprinkler irrigation,** the flow rate was calculated using the technical specifications provided in the water productivity note of IIT Bombay. Sprinkler spacing (in feet) to be converted to meter: Suppose the sprinkler nozzle spacing is 40x40 feet (around 12x12 meters), then look for this spacing in the top row of Table 73. All values under this spacing denote the flow rate in mm/hr. We have selected the average or middle value under this spacing i.e., 10.2 mm/hour (marked by the red circle) for computation. This method is used for the selection of sprinkler flow rate.

Table 73: Technical Specifications for Sprinklers[91]

Technical Specifications

Single Nozzle **(Trajectory 25°)**

Precipitation rates (mm/hr) & uniformity (CU) at various spacing

Nozzle (mm)	P (Kg/cm²)	Q (lpm)	D (m)	Spacing (m) 12x8	12x9	12x10	12x11	12x12	13x12	18x9	14x12
4.3	2.0	17.23	28	10.8	9.6	8.6	7.8	7.2	6.6	6.4	6.2
	2.5	19.40	28	12.1	10.8	9.7	8.8	8.1	7.5	7.2	6.9
	3.0	21.55	28	13.5	12.0	10.8	9.8	9.0	8.3	8.0	7.7
	3.5	23.31	28	14.6	13.0	11.7	10.6	9.7	9.0	8.6	8.3
	4.0	24.60	28	15.4	13.7	12.3	11.2	10.3	9.5	9.1	8.8
4.7	2.0	20.05	26	12.5	11.1	10.0	9.1	8.4	7.7	7.4	7.2
	2.5	22.21	28	13.9	12.3	11.1	10.1	9.3	8.5	8.2	7.9
	3.0	24.40	28	15.3	13.6	12.2	11.1	10.2	9.4	9.0	8.7
	3.5	26.32	28	16.5	14.6	13.2	12.0	11.0	10.1	9.7	9.4
	4.0	27.12	26	17.0	15.1	13.6	12.3	11.3	10.4	10.0	9.7
5.1	2.0	22.92	28	14.3	12.7	11.5	10.4	9.6	8.8	8.5	8.2
	2.5	24.96	28	15.6	13.9	12.5	11.3	10.4	9.6	9.2	8.9
	3.0	27.71	28	17.3	15.4	13.9	12.6	11.5	10.7	10.3	9.9
	3.5	29.63	28	18.5	16.5	14.8	13.5	12.3	11.4	11.0	10.6
	4.0	31.89	30	19.9	17.7	15.9	14.5	13.3	12.3	11.8	11.4

Note:
- Sprinklers are tested under standard test conditions.
- P= Pressure; Q= Discharge; D = Diameter
- Colour code - Distribution uniformity

CU < 85%	CU - 85-88%	CU - 88-92%	CU > 92%

Irrigation water in mm = (value as specified)

3. For **drip irrigation**, watering in mm was calculated by using the formulae:

   a. Number of drippers in crop area = Crop area in acre * 4046 (sq-m)/ Dripper spacing in feet * 0.09 (sq-m)
   b. Irrigation water in mm = (Number of drippers in crop area * Dripper flow rate in lph * Pumping hours per irrigation)/ Crop area in acre * 4046

4. For **flood irrigation**, watering in mm was assumed to be 50.

The above data is shared with the IIT Bombay team. IIT-B then used the farm-level plug-in model developed by them to calculate the AET values for each crop. The total AET included the rainfed AET and the watering AET which was calculated based on the irrigation information shared by the farmers.

[91] Source:https://www.jains.com/PDF/Catalogue_2015/sprinkler/overhead_sprinkler/metal_impact_sprinkler/JI_2_sprinkl er.pdf

Annexure 8: Estimated Yield of Crops in Project and Control Areas

Table 74: Productivity of Crops (Quintal/Hectare) in Project Area

District	Cotton	Soybean	Chickpea	Pigeon pea	Sorghum	Wheat
CSN	17	17	15	14	11	25
	(n = 248)	(n = 33)	(n = 24)	(n = 3)	(n = 8)	(n = 41)
Beed	15	16	13	16	12	17
	(n = 111)	(n = 82)	(n = 31)	(n = 4)	(n = 46)	(n = 18)
Jalna	17	16	14	16	10	19
	(n = 199)	(n = 114)	(n = 51)	(n = 5)	(n = 31)	(n = 18)
Latur	20	16	14	-	17	15
	(n = 11)	(n = 205)	(n = 132)	-	(n = 26)	(n = 3)
Dharashiv	25	16	14	16	14	18
	(n = 1)	(n = 243)	(n = 83)	(n = 2)	(n = 100)	(n = 11)
Nanded	15	15	14	16	14	21
	(n = 98)	(n = 125)	(n = 79)	(n = 5)	(n = 16)	(n = 25)
Parbhani	17	15	13	14	10	19
	(n = 118)	(n = 147)	(n = 87)	(n = 2)	(n = 29)	(n = 27)
Hingoli	20	16	15	17	9	16
	(n = 38)	(n = 155)	(n = 85)	(n = 1)	(n = 6)	(n = 27)
Akola	20	18	18	25	31	23
	(n = 136)	(n = 351)	(n = 206)	(n = 20)	(n = 1)	(n = 37)
Amaravati	21	16	17	16	5	16
	(n = 140)	(n = 102)	(n = 51)	(n = 35)	(n = 2)	(n = 20)
Buldhana	21	18	21	38	26	27
	(n = 274)	(n = 108)	(n = 159)	(n = 8)	(n = 6)	(n = 22)
Jalgaon	24	27	23	-	31	31
	(n = 205)	(n = 7)	(n = 13)		(n = 5)	(n = 12)
Wardha	15	11	12	8	-	13
	(n = 64)	(n = 35)	(n = 23)	(n = 16)		(n = 6)
Washim	21	18	18	17	-	19
	(n = 29)	(n = 148)	(n = 46)	(n =16)		(n = 8)
Yavatmal	21	16	15	7	-	12
	(n = 117)	(n = 23)	(n = 10)	(n = 16)		(n = 3)

Table 75: Productivity of Crops (Quintal/Hectare) in Control Area

District	Cotton	Soybean	Chickpea	Pigeon pea	Sorghum	Wheat
CSN	14.7	14.2	12.1	11.4	13.0	21.8
	(n = 266)	(n = 36)	(n = 37)	(n=4)	(n = 11)	(n = 60)
Beed	13.9	14.2	12.4	13.6	10.5	18.2
	(n = 199)	(n = 99)	(n = 39)	(n = 3)	(n = 50)	(n = 23)
Jalna	15.7	16.3	14.4	11.1	12.2	21.6
	(n = 224)	(n = 106)	(n = 37)	(n = 2)	(n = 25)	(n = 29)
Latur	14.7	14.1	11.7	14.8	14.1	13.9
	(n = 10)	(n = 257)	(n = 126)	(n = 2)	(n = 20)	(n = 9)
Dharashiv	13.2	14.3	10.5	9.9	13.0	14.5
	(n = 1)	(n = 328)	(n = 96)	(n = 1)	(n = 100)	(n = 9)
Nanded	15.1	13.7	13.0	11.9	13.8	12.0
	(n = 102)	(n = 154)	(n = 95)	(n = 1)	(n = 35)	(n = 16)
Parbhani	16.3	13.6	11.1	13.2	8.8	13.1
	(n = 106)	(n = 182)	(n = 52)	(n = 3)	(n = 58)	(n = 40)
Hingoli	15.1	13.0	11.7	9.8	9.9	14.0
	(n = 34)	(n = 171)	(n = 88)	(n = 8)	(n = 5)	(n = 43)
Akola	17.6	16.4	15.6	12.2	30.5	21.3
	(n = 88)	(n = 298)	(n = 182)	(n = 22)	(n = 6)	(n = 78)
Amaravati	20.6	16.1	18.7	21.1	8.2	15.4
	(n = 114)	(n = 74)	(n = 42)	(n = 30)	(n = 4)	(n = 22)
Buldhana	21.2	19.0	21.2	22.3	31.0	31.8
	(n = 262)	(n = 138)	(n = 70)	(n = 8)	(n = 6)	(n = 14)
Jalgaon	22.6	17.3	18.4	-	28.4	-
	(n = 256)	(n = 2)	(n = 10)		(n = 4)	
Wardha	22.6	9.9	10.4	10.5	-	16.1
	(n = 66)	(n = 26)	(n = 10)	(n = 10)		(n = 4)
Washim	20.3	20.2	17.7	11.4	-	-
	(n = 12)	(n = 162)	(n = 36)	(n = 8)		
Yavatmal	20.0	13.8	22.6	8.4	-	-
	(n = 130)	(n = 28)	(n = 2)	(n = 12)		

Annexure 9: Methodology for Cost of Cultivation

The results presented capturing the cost of cultivation are based on the data collected from farmer households in the project and control farmers during the endline survey and for the crop production year 2022-23. The BC Ratio calculated based on the Minimum Support Price (MSP) is presented below. The details of key headings considered during the estimation of the cost of cultivation are as follows:

1. Cost A1: It includes all actual expenses in cash and kind incurred in the production by a farmer
   a. Labour charges (Hired + Family) covering aspects of land preparation, sowing, intercultural operations, harvesting, and threshing
   b. Bullock labour charges (owned + rented) inclusive of practices like land preparation, sowing, and intercultural operations
   c. Machinery charges (owned + rented) encompassing deployment of machinery for land preparation, sowing, intercultural operations, harvesting, and threshing as well as maintenance of the concerned machinery
   d. Seed cost including both purchase and treatment of seeds
   e. Insecticides/ Pesticides, fertilizers/ manure, and irrigation charges
   f. Miscellaneous expenses like electricity charges, fuel charges, premium for crop insurance, etc.
2. Cost A2: Cost A1 + Rent paid for leased land
3. Cost B2: Cost A2 + Rent value of owned land
4. Cost C2: Cost B2 + Imputed value of family labour

Table 76: Cost of Cultivation for Major Crops of Kharif Season in PoCRA Region

Endline	Kharif Season Crops					
	Cotton		Soybean		Pigeon Pea	
	Project	Control	Project	Control	Project	Control
Sample N	1788	1830	1778	2061	133	114
Key heads - Cost of cultivation						
Labour (Rs./Ha) - Hired and family labour	23592	24196	12720	12878	7945	8485
Bullock labour charges (Rs./Ha) - Owned & hired	6082	5991	4128	4276	3843	5355
Rent of machinery (Rs./Ha)	4528	4478	7952	9671	11177	14490
Seeds (Rs./Ha)	4431	4305	5615	5560	1762	1827
Insecticides & pesticides (Rs./Ha)	5807	7076	5675	5400	8599	12908
Manures & fertilizers (Rs./Ha)	10251	10013	6564	6923	6298	5320
Irrigation (Rs./Ha)	998	1166	710	999	464	608
Miscellaneous (Transportation, Insurance, etc) (Rs./Ha)	2556	2503	2633	2405	1483	1214
Cost of cultivation (Rs./Ha)	58246	59728	45997	48111	41571	50206
Rental value of land (Rs./Ha)	30875	30875	30875	30875	30875	30875
Rental value of land for 1 crop (Rs./Ha)	10292	10292	10292	10292	10292	10292
Total cost of cultivation (Rs/Ha)	68538	70020	56289	58403	51863	60498
Yield (Quintal/Ha)	19.1	17.8	16.5	15.2	17.0	14.6
C2 (Cost of production including family labour and land rental value) (Rs./Quintal)	3585	3937	3412	3832	3056	4151
C2 plus 50 in project area (Rs./Quintal)	5378	5906	5117	5748	4585	6227

Endline	Kharif Season Crops					
	Cotton		Soybean		Pigeon Pea	
	Project	Control	Project	Control	Project	Control
MSP declared by Govt (2022-23) (https://farmer.gov.in/mspstatements.aspx)	6080	6080	4300	4300	6600	6600
Margin to farmers over MSP	702	174	-817	-1448	2015	372.93
Percentage	13%	3%	-16%	-25%	44%	6%
Gross income (Rs./Ha)	116236	108127	70948	65532	111995	96182
BC ratio	1.70	1.54	1.26	1.12	2.16	1.59

Table 77: Cost of Cultivation for Major Crops of Rabi Season in PoCRA Region

Endterm	Rabi Season Crops					
	Wheat		Chickpea		Sorghum	
	Project	Control	Project	Control	Project	Control
Sample N	278	347	1081	922	276	324
Key heads - Cost of cultivation						
Labour (Rs./Ha) - Hired and family labour	8323	9395	11207	11335	15864	15640
Bullock labour charges (Rs./Ha) - Owned & hired	3353	3570	3280	3583	5156	6107
Rent of machinery (Rs./Ha)	7805	10362	9182	9146	9521	8731
Seeds (Rs./Ha)	4093	5969	6335	6294	2719	2789
Insecticides & pesticides (Rs./Ha)	3064	4161	4322	5612	2220	4647
Manures & fertilizers (Rs./Ha)	5235	5935	3360	5606	3679	5340
Irrigation (Rs./Ha)	1152	1698	839	908	905	1130
Miscellaneous (Transportation, Insurance, etc) (Rs./Ha)	3159	3142	2500	2725	3459	3002
Cost of cultivation (Rs./Ha)	36185	44231	41025	45208	43523	47385
Rental value of land (Rs./Ha)	30875	30875	30875	30875	30875	30875
Rental value of land for 1 crop (Rs./Ha)	10292	10292	10292	10292	10292	10292
Total cost of cultivation (Rs/Ha)	46476	54523	51317	55500	53814	57677
Yield (Quintal/Ha)	20.9	18.3	16.3	13.9	13.3	12.7
C2 (Cost of production including family labour and land rental value) (Rs./Quintal)	2224	2979	3157	3984	4035	4552
C2 plus 50 in project area (Rs./Quintal)	3336	4468	4736	5976	6052	6828
MSP declared by Govt (2022-23) (https://farmer.gov.in/mspstatements.aspx)	2015	2015	5230	5230	2970	2970
Margin to farmers over MSP	-1321	-2453	494	-746	-3082	-3858
Percentage	-40%	-55%	10%	-12%	-51%	-57%
Gross income (Rs./Ha)	42106	36880	85001	72858	39614	37633
BC ratio	0.91	0.68	1.66	1.31	0.74	0.65

Annexure 10: Attributes for Project, Spillover, and Control Farmers

While analyzing the basic descriptives of endline evaluation, it's been found that project, spillover, and control have been distinct in terms of cost of cultivation, crop productivity, cropping intensity, IPM and INM practices, and the adoption of different CRAT practices. Hence, it's been attempted to explore further to analyze the attributes differentiating the project farmers (direct beneficiaries) from spillover (indirect beneficiaries) and control farmers.

The farmer's category is considered a dependent variable (Yi), having three categories of farmers direct, spillover, and control farmers. Hence, multi nominal Logistic regression is employed and factors driving these categories of farmers have been shortlisted and fit in the model. The details of selected independent variables used to fit in the model are as follows:

Dependent Variable => Y = Farmers category (Project, Spillover, Control)

Independent Variable => X1 = Cultivable land, X2 = Gender, X3 = CRAT training and adoption, X4 = Insecticide and pesticide cost (Kharif), X5 = Manure and fertilizer cost (Kharif), X6 = Seed cost (Kharif), X7 = Machinery cost (Kharif), X8 = Labor cost (Kharif) and X9 = Net farm income

Factors driving farmers under project, spillover, and control category

Table 78: Factors Driving Farmers under Project, Spillover, and Control Category

	Pseudo R2					**0.2238**
	Number of observations					**7266**
	Wald chi2(18)					**1617.09**
	Prob > chi2					**0.0000**
	Log pseudolikelihood					**-5060.63**
Control	**(base outcome)**					
		Project			**Spill Over**	
Variables considered	**Coef. Std. Err.**	**z**	**P>z**	**Coef. Std. Err.**	**Z**	**P>z**
Cultivable land	-0.0156 (-1.21)	-1.21	0.226	-0.0297 (-1.00)	-1.00	0.318
Gender	0.230** (2.61)	2.61	0.009	0.0337 (0.25)	0.25	0.806
CRAT training and adoption	3.634*** (37.52)	37.52	0.000	2.028*** (14.48)	14.48	0.000
Insecticide and pesticide cost (Kharif)	-0.00407*** (-6.03)	-6.03	0.000	-0.00629*** (-5.20)	-5.20	0.000
Manure and fertilizer cost (Kharif)	0.00145*** (3.89)	3.89	0.000	0.00174*** (3.63)	3.63	0.000
Seed cost (Kharif)	0.000145 (0.02)	0.02	0.981	-0.000785 (-0.98)	-0.98	0.328
Machinery cost (Kharif)	-0.000625 (-0.15)	-0.15	0.883	0.000335 (0.95)	0.95	0.341
Labor cost (Kharif)	0.000729 (0.67)	0.67	0.500	-0.000518 (-1.87)	-1.87	0.062
Net farm income	0.000141*** (4.99)	4.99	0.000	0.000616 (1.30)	1.30	0.194
Constant	-1.335*** (-10.85)	-10.85	0.000	-1.846*** (-9.72)	-9.72	0.000

The multi-nominal regression analysis undertaken for the selected variables as seen in the above table shows a better model fit (log pseudolikelihood of -5060.63) with higher (less negative) values indicating a better fit. The Pseudo R^2 suggests that approximately 22.38 percent of the variance in the dependent variable is explained by the model, indicating a moderate level of explanatory power. The Wald Chi^2 (18) statistic of 1617.09, confirms that the fitted model is statistically significant, meaning the predictors collectively have a substantial impact on the outcome variable. Impact of various factors on farmers being classified into project (Y=1) or spillover (Y=2) and Control (Y=3) categories.

The control farmers group is taken as the base outcome/ default outcome. Further, among the project category of farmers, participation of farmers in CRAT training significantly increases the likelihood of being in this group. Similarly, for the spillover category, CRAT training also has a strong positive effect, though the impact is less pronounced compared to the project category. In both categories, higher insecticide and pesticide costs are associated with a lower likelihood of inclusion of project farmers and control farmers. Additionally, manure and fertilizer costs positively influence the likelihood of being in both categories (project and spillover). Notably, higher net farm income significantly increases the likelihood of being in the project category, while it is not a significant predictor for the spillover category. The control underscores the critical role of CRAT training in promoting participation in projects and the spillover category of farmers, with varying degrees of influence across these categories when compared with the control farmers category.

Thus, the regression analysis indicates that participation in CRAT training, improved pest management methods and their aligned pesticide costs, nutrient management costs accruing cost of manure and fertilizer, and vital net farm income are significant factors that inform whether farmers are in the project or spill over categories compared to control. Training programs (CRAT training) have a particularly strong influence, highlighting the importance of awareness-building interventions in agricultural projects.

Annexure 11: Land Resource Inventory-based Advisories for Climate-Resilient Agriculture

PoCRA aims to enhance agriculture productivity and climate resilience of farmers through the adoption of improved production technology, on-farm, and community-based water management, and improved soil health and water use efficiency. Land Resource Inventory mapping plays a vital role in natural resource management. It assists in the planning for future land use/agriculture, as it assesses the land resource and its potential for sustainable agriculture. Farm-level water budget, soil moisture status, crop suitability, and contingency planning are all strongly influenced by soil characteristics. Integrated with climate and crop information, the land resource inventory has the potential to manage rainfed agriculture for sustainable crop yields. The project has identified ICAR-NBSS&LUP as a technological partner to assess land resources which will help for inventory mapping of land resources of selected villages in 15 project districts to facilitate optimum utilization of soil and water resources.

ICAR-NBSS&LUP conducted a conventional/detailed soil survey of selected 500 villages to build a land resource inventory during 2019-22 to study 725 soil profiles (about 1700 soil samples) in 53 clusters located in 16 districts. This data provided insight into the soil variations in each of the districts/geographies and is adequately representative of the possible soil variations in each district. A soil-landform relationship has been established and standard methods to derive soil information using remote sensing data combined with existing laboratory data of 725 profiles used for building prediction models.

Digital Soil Mapping (DSM) was used as a tool for conventional/detailed soil surveys to map soil properties. It is a very fast method of acquiring soil information but has limitations as only surface features of the soils are captured through environmental co-variates. However, combined with existing data, DSM was effectively harnessed for quick acquisition of soil information. The primary and secondary derivatives of the Digital Elevation Model (DEM) like elevation, slope, aspect, curvatures (plan and profile), topographic wetness index (TWI) and topographic position index (TPI), LS factor, Multi-resolution Ridge Top Flatness (MrRTF), and Multi-resolution Index of Valley Bottom Flatness (MrVBF) were used in the modeling. Along with DEM attributes, all the bands of sentinel imagery, Normalized Difference Vegetation Index (NDVI), and Enhanced vegetation index (EVI) were used as covariates for the prediction of soil properties. The prediction maps have been produced with 30 m spatial resolution using the nearest neighbor resampling method.

The conditional Latin Hypercube Sampling (cLHS) model was adopted by considering covariates as strata that work well in capturing environmental variables while minimizing soil sampling sites. The model requires pre-identified sample locations as the population from which proposed samples are to be chosen. The objects-based segments making up the TMUs were to be considered as the initial population. The model works on the principle of resembling individual characteristics or attributes of the population with that of the sample. Here the population indicates the spatial variability at the segment level in the study area while the sample constitutes the modeled sampling sites. The minimum sample size which satisfactorily retains the maximum variability of input parameters resembling the population distribution as evaluated through the interquartile range matching technique was considered optimum. cLHS model-based minimum sampling framework preserves the accuracy of soil maps while reasonably reducing the sampling sites at morphometric properties based on the preliminary level soil series identified.

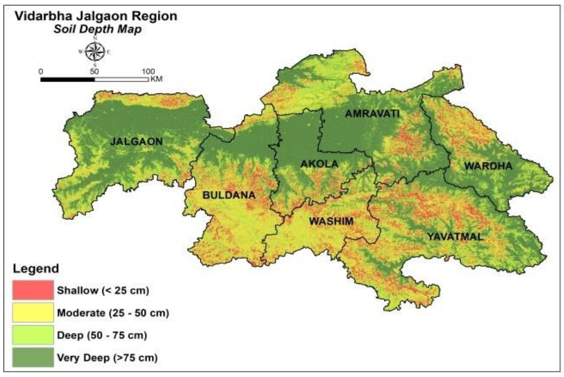
The study area was traversed to recognize and validate landform classes to comprehend the soil heterogeneity and the current land use land cover units. Depending on the change in surface texture, slope, erosion, and stoniness, representative areas on landform units inside the location were selected for detailed soil profile studies. The soil profile 1.5m long, 1.0 m wide, and 1.5 m deep or till weathered layer was dug for the study of various morphological features and soil variability as suggested in the USDA Soil Survey Manual (Soil Survey Staff, 1998). Special observations regarding the depth and width of cracking and the extent of slicken sides were also recorded. The horizon-wise soil samples were collected, processed, and brought to the laboratory for soil analysis using standard procedures. A total of 2576 samples were taken from 864 soil profiles from 163 project clusters in 16 project districts.

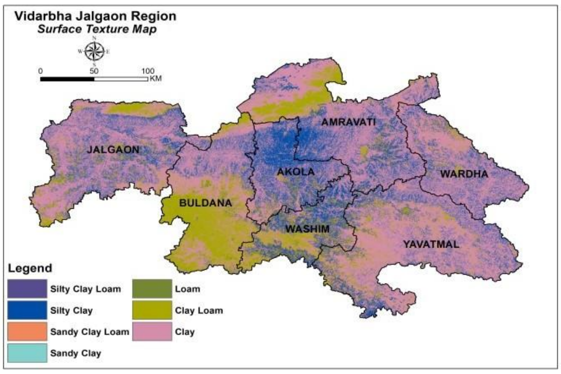
Thematic mapping is operationalized based on the logical evaluation of attributes. All the laboratory-measured data were compiled and processed in the GIS platform. The spatial database was generated using the ArcMap module of ArcGIS software to generate several thematic maps. These maps assist us in understanding the spatial distribution and nature of a selected theme (soil parameter) character, which serves as diagnostics of land use planning parameters. The non-spatial (attribute) data are connected to soil layers to gain various thematic maps like soil drainage, soil depth, slope, etc.

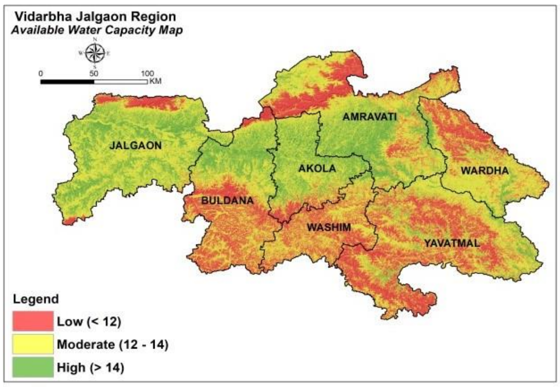
Vidharbha and Jalgaon region

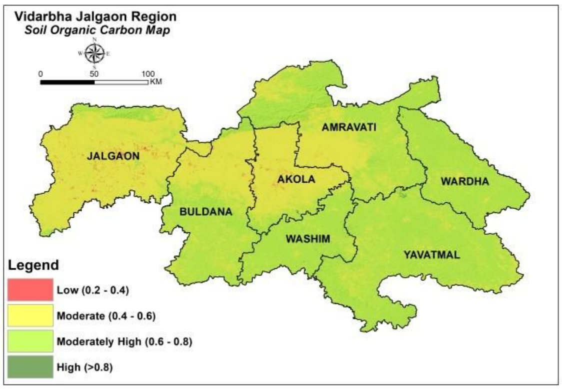
In the Vidarbha region, the project on climate-resilient agriculture covers six districts namely Buldhana, Akola, Amarvati, Washim, Yavatmal, and Wardha. This region falls in the semi-aridic dry climate with Deccan basalt as a broad physiographic region. The land use/ land cover analysis showed that agriculture is the dominant land use in the region. It covers 72.6 percent of the area of the region followed by waste land (20.4 percent). The study reveals that around 10 percent of the TGA of the six districts under the project falls in the shallow soils category having less than 25 cm soil depth and around 31.5 percent area has a moderate soil depth of 25 to 50 cm. Deep and very deep soils occupied 17.2 and 41.75 percent TGA of the region respectively. The dominant soil texture in the region is “clay” covering 61 percent of the TGA. All the soils are mild to moderately alkaline in reaction. Soil Organic Carbon (SOC) is a key parameter as far as the soil quality is concerned and most of the soils of the Vidarbha region are impoverished in SOC. Around 42.7 percent area of the TGA under the project in Vidarbha region is moderate (0.4-0.6 percent) in SOC whereas 56.7 percent area is moderately high (0.6-0.8 percent) in SOC content. The soil fertility status of the region is poor as the available nitrogen content in the area is low (<250kg/ha). Almost 92 percent of the area of the TGA is low in available phosphorous content. The available potassium content in the region is high. The study indicates that there is an immense need to adopt soil and water conservation measures in shallow soils with low AWC regions. To improve the soil's health in terms of SOC, available N and P through the addition of FYM and green manuring is essential.

Results:



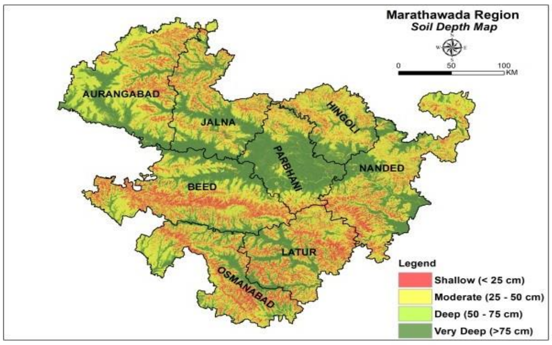


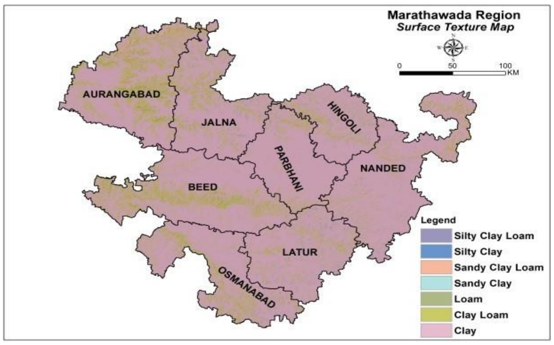


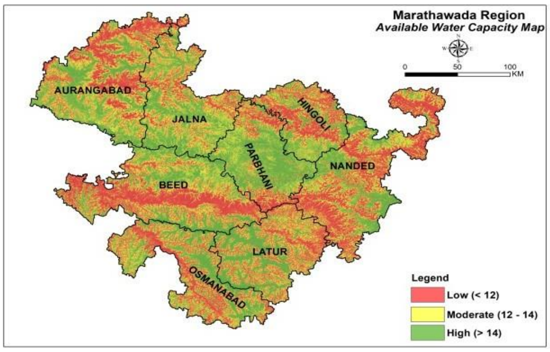


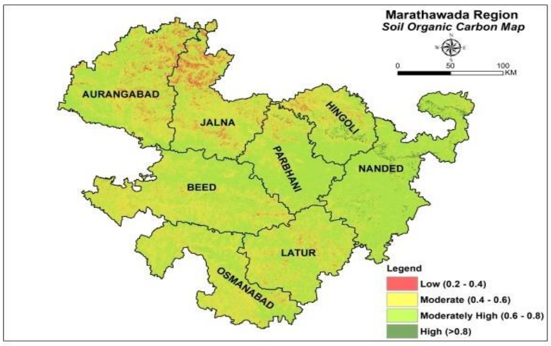
Marathwada region

The project on climate-resilient agriculture covers all the districts of the Marathwada region. This region falls in the semi-aridic dry climate with Deccan basalt as a broad physiographic region. The land use/land cover analysis showed that agriculture is the dominant land use in the region. It covers 83.2 percent of the area of the region followed by bushland (11.7 percent). The study reveals that 16 percent of the TGA of the region is under the shallow soils category having less than 25 cm soil depth and more than 40 percent area of the TGA of Marathwada is in the deep to very deep category. However, more than 43 percent of the area of the TGA is under moderately deep soils with a soil depth of 25 to 50 cm indicating soil depth as one of the major constraints. The dominant soil texture in the region is clay occupying more than 85 percent of the TGA of the region. All the soils are mild to moderately alkaline in reaction and the pH varies from 7.5 to 9.0. The soil of the Marathwada region is impoverished in SOC. Its content varies from 0. 4 to 0.8 percent. More than 95 percent area of the TGA under the project is moderate to moderately high in the SOC category. The soil fertility status of the region is poor as the available N content in more than 98 percent of the area is low (<250kg/ha). The available P content in 82.5 percent area is moderate and 17 percent area is under high category. There is a good reserve of available K content in the region. More than 95 percent of the area of the region is high in available K content. More than 68 percent of the area of the region is low to moderate in AWC content. The study indicates that there is an immense need to adopt soil and water conservation measures in shallow soils with low AWC and light texture regions.









The main project outputs delivered by ICAR-NBSS&LUP are in the form of different thematic maps viz. soil depth, surface texture, bulk density (BD), available water capacity (AWC), soil reaction (pH), Electrical conductivity (EC), organic carbon (OC), nitrogen (N), phosphorus (P), potassium (K), zinc (Zn), copper (Cu), iron (Fe) and manganese (Mn) content in the soil. These outputs aided in generating land parcel-specific advisory for individual farmers for selecting best management practices in terms of agronomic and nutrient application. Water budgeting, identification of hotspots for disease and pest vulnerability, and land shaping were some of the other aspects that can also be addressed using the above outputs. Advisory on land shaping and the choice of crops can easily be done using the outputs that are generated in this project. The project, in technical partnership with IIT Bombay, has developed a framework to assess the water balance in the project villages. Land resource inventory includes soil parameters namely depth, texture, pH, EC, soil salinity, soil organic matter, cation exchange capacity, AWC, and BD along with other data like weather parameters, and crop characteristics. forms the core database for calculating the water balance, crop interventions, soil management, and subsequent project planning.

Annexure 12: Determination Of Crop Coefficients for Key Crops by Lysimetric Studies

Crop evapotranspiration, which encompasses both soil evaporation and plant transpiration, represents the total water consumed by crops during their growth cycle. Accurate estimation of crop evapotranspiration is essential for efficient irrigation management. Crop coefficient (Kc) adjusts reference evapotranspiration to estimate actual crop evapotranspiration, varying with crop growth stages. Currently, reliance on global average Kc values from FAO may lead to under or over-estimation of crop water requirement. To address this issue, locally measured Kc values are crucial, as they reflect specific regional conditions, ensuring accurate crop water requirement estimations. Weighing Lysimeters, widely utilized to measure crop water usage patterns, facilitates the standardization of localized reference evapotranspiration models. By integrating locally derived Kc values and leveraging weighing Lysimeters, PoCRA aimed to empower farmers with accurate crop water requirement estimates, thereby enhancing agricultural productivity per unit of water. This localized approach fosters confidence among users and promotes sustainable agricultural practices tailored to Maharashtra's climatic conditions and crop profiles. Mahatma Phule Krishi Vidyapeeth (MPKV) Rahuri, Vasantrao Naik Marathwada Agriculture University (VNMAU) Parbhani and Dr. Punjabrao Deshmukh Krishi Vidyapeeth (PDKV) Akola were appointed as the technological partners to conduct the study.

Crop coefficients

Crop coefficients for cotton, soybean, groundnut, pigeon pea, sorghum, green gram, sesame, gram, and fodder bajra are scientifically developed for daily, weekly, and stage-wise intervals which are given in the below table.

Table 79: Kc Values by Lysimetric Studies

University	Crops	Physiological stage of the crops							
		Initial stage		Develop Stage		Mid Stage		End Stage	
		Lysimet Kc values	FAO values	Lysimet Kc values	FAO values	Lysimet Kc values	FAO values	Lysimet Kc values	FAO values
VNMKV, Parbhani	**Rabi Sorghum**	0.49	0.44	0.755	0.8	1.17	1.25	0.74	0.88
	Kharif Soybean	0.545	0.57	0.65	0.75	1.02	0.99	0.61	0.54
	Okra	0.655	0.6	1.085	0.6 - 1.10	1.34	1.1	0.78	1.10 - 0.90
	Kharif Green Gram	0.525	0.6	0.98	0.9	0.85	1.14	0.5	0.64
	Summer Groundnut	0.555	0.38 - 0.56	0.735	0.68 - 1.03	1.155	1.11 - 1.04	0.655	0.94 - 0.81
Dr. PDKV, Akola	**Summer Sesame**	0.545	0.61	1.005	0.9	1.22	1.21	0.68	0.74
	Kharif Cotton	0.555	0.35	0.84	0	1.13	1.15	0.86	0.85
	Kharif Pigeon pea	0.525	0.4	0.81	0	1.1	1.15	0.785	0.55
	Summer Green Gram	0.585	0.56	0.97	0.96	1.165	1.085	0.795	0.83
MPKV, Rahuri	**Kharif Sesame**	0.475	0.35	0.785	0.74	0.96	1.1	0.495	0.25
	Rabi Gram	0.5	0.4	0.93	0.7	1.145	1	0.48	0.505

University	Crops	Physiological stage of the crops							
		Initial stage		Develop Stage		Mid Stage		End Stage	
		Lysimet Kc values	FAO values	Lysimet Kc values	FAO values	Lysimet Kc values	FAO values	Lysimet Kc values	FAO values
	Summer Fodder Bajara	0.505	0.3	1.34 - 0.77	0.64	1.195	1.01		0.64

Crop water requirement

The seasonal and weekly crop water requirements of cotton, soybean, groundnut, pigeon pea, sorghum, green gram, sesame, gram, and fodder bajra were computed using crop coefficients developed under the Lysimetric studies project. Accordingly, irrigation water requirements were estimated for different irrigation methods, including surface irrigation with 40 percent, 50 percent, and 60 percent efficiency, sprinkler irrigation with 80 percent and 85 percent efficiency, and drip irrigation with 90 percent and 95 percent efficiency. The compilation of taluka-wise crops and irrigation water requirements is provided for 29 districts in Maharashtra. The project has embedded the localized Kc values in the PoCRA Water Balance computation model which is yielding improved results over the earlier method. Also, these outcomes are being incorporated into the farmer advisory modules of the project. The universities are advised to incorporate the new Kc values in the recommendations for their wider acceptance and use while designing natural resource management interventions and irrigation management.

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