(TD696) MTP-II Report

On

IMPLEMENTING CLIMATE RESILIENCE IN AGRICULTURE

Submitted in partial fulfillment of requirements

of the degree of

M.Tech. in *Technology and Development*

by

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Dissertation Approval

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Declaration

I hereby declare that this report titled "**Implementing Climate Resilience in Agriculture**" submitted for the partial fulfilment of the degree of Master of Technology to CTARA, IIT Bombay is a record of the MTP work which I have carried out under the supervision of Prof. Milind Sohoni, CTARA.

I further declare that this written submission represents my ideas in my own words and where other's ideas or words have been included, I have adequately cited and referenced the original sources. I affirm that I have adhered to all principles of academic honesty and integrity and have not misrepresented or falsified any idea/data/fact/source to the best of my knowledge. I understand that any violation of the above will cause for disciplinary action by the Institute and can also evoke penal action from the sources which have not been cited properly.

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Abstract

Climate Change is a major challenge and its impacts are being felt all over the world affecting vulnerable groups like agricultural / coastal communities, communities dependent on natural resources and those with constrained capacity to respond. Climate resilience is seen as the ability to prepare for and cope to changing climatic conditions. Climate resilience thus looks at identifying vulnerability to change and adopting techniques to mitigate and adapt to the change accordingly. Vulnerability due to climate change is used as a criteria to identify target beneficiaries and identify villages in most climate resilient projects. Vulnerability is very specific to the project area, local conditions and many other socio-economic and bio-physical factors. To understand vulnerability it is important to clearly understand the stress induced by changing climatic conditions and its impact on the community.

In the drought-prone villages of Maharashtra, climate change manifests through erratic monsoon. The reduction in number of rainy days and increase in heavy rainfall occurrences lead to crop loss and make irrigation all the more important. Access to protective irrigation to safeguard the kharif crop has become important in villages of Maharashtra. The decision of rabbi crop based on rainfall patterns and availability of data in the village to make an informed decision has also become important. These two parameters translate to economic returns through dependable yields.

PoCRA aims to improve climate resilience by improving access to protective irrigation, providing information regarding water availability before rabbi season while simultaneously working on improving water availability through watershed works and changing cropping patterns. This study tries to understand how climate change vulnerability specific to villages in Maharashtra can be studied and how these vulnerabilities can be mitigated through different engineering interventions and how PoCRA fares to do the same. The vulnerability is studied through a mixed approach of bio-physical and socio-economic vulnerability. The study relies heavily on primary data collected from the field. The study further looks at preparing a framework for beneficiary selection through a more detailed understanding of different benefits provided by the project and the requirements for each benefit individually, monitoring and evaluation for PoCRA. The monitoring and evaluation framework goes beyond the key performance indicators identified by World Bank and tries to extract maximum meaning from the Project Development Objectives.

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List of abbreviations

BEE	Bureau of Energy Efficiency
COP	Conference of Parties
CRF	Climate Resilience Framework
CRIDA	Central Research Institute of Dryland Agriculture
DFID	UK Department for International Development
DISCOM	State Electricity Distribution Company
ENVIS	Environmental Information Systems
FVO	Field Visit Observation
FYP	Five Year Plan
GHG	Green House Gases
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GoI	Government of India
GoM	Government of Maharashtra
GR	Government Resolution
ICAR	Indian Council of Agricultural Research
IPCC	Intergovernmental Panel on Climate Change
ISET	Institute of Social and Environmental Transformation
IWMP	Integrated Watershed Management Program
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Scheme
MNRE	Ministry of Non-Renewable Energy
MoA	Ministry of Agriculture
MoEFCC / MoEF	Ministry of Environment, Forests and Climate Change
MSAAPCC	Maharashtra's State Adaptation Action Plan on Climate Change
NAPCC	National Action Plan on Climate Change
NICRA	National Initiative on Climate Resilient Agriculture
NIRD	National Institute of Rural Development
NABARD	National Bank for Agriculture and Rural Development
OECD	Organisation for Economic Co-operation and Development
PMCCC	Prime Minister's Council on Climate Change
PDA	Project Development Objectives
PoCRA	Project on Climate Resilient Agriculture
SAPCC	State Action Plan on Climate Change
TERI	The Energy and Resources Institute

UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
WMO	World Meteorological Organisation
YASHADA	Yashwantrao Chavan Academy of Development Administration

Chapter 1 Introduction

India is already facing the impacts of climate change and has been ranked as highly vulnerable country by the recent Germanwatch Climate Risk Index 2018 in terms of the climate change vulnerability and probability of facing extreme weather events (Global Climate Risk Index, 2018) India's Economic Survey 2017-18 also notes that average rainfall in India has declined by 86 mm over the last three decades, where average kharif rainfall has declined by 26 mm and average rabbi rainfall has declined by 33 mm. Further, extreme rainfall shocks have resulted in 12.8% reduction in kharif yields and 6.7% reduction in rabi yields. Climate Change also has an impact on Indian agriculture which results in a GDP loss of 1.5% annually according to a report by Central Research Institute of Dryland Agriculture (CRIDA) based in Hyderabad (Down to Earth, 2017). in terms of the climate change vulnerability and probability of facing extreme weather events (Global Climate Risk Index, 2018). India's Economic Survey 2017-18 also notes that average rainfall in India has declined by 86 mm over the last three decades, where average kharif rainfall has declined by 26 mm and average rabbi rainfall has declined by 33 mm. Further, extreme rainfall shocks have resulted in 12.8% reduction in kharif yields and 6.7% reduction in rabi yields (MoF, 2018). Climate Change also has an impact on Indian agriculture which results in a GDP loss of 1.5% annually according to a report by Central Research Institute of Dryland Agriculture (CRIDA) based in Hyderabad (Down to Earth, 2013)

1.1 What is climate change?

The United Nations Framework Convention on Climate Change (UNFCCC, 2007), defines climate change as a "Change of climate that is attributed directly or indirectly to human activity that alters the composition of global atmosphere and that is in-addition to nature climate variability observed over comparable time periods". Not to be confused with one-off extreme weathers, climate change is said to occur when climatic conditions shift either higher or lower than the average over prolonged periods. Climate Change can also manifest as a change in the intensity and occurrence of extreme climatic events, like storms and strong winds, drought, floods etc. apart from the deviation from average climate conditions. Further, these continue for a protracted period, typically years or longer (UNFCCC, 2007). Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. (IPCC, 2013)

1.2 Climate change in the Indian context

India's carbon emissions per capita average to one quarter of the world's average and is below that of many developed countries. While India places a higher priority on development needs, policies driven by economic and environmental challenge have reduced growth in greenhouse gas (GHG) emissions. India ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1993 and the Kyoto Protocol in 2002. This situation will not change for several decades to come. Democracy is meant to maintain equa rights per capita to global environmental resources. The fifth Five-year Plan (1892-1897) included "Environment Protection" as its part but the Ninth Five-year Plan (1997-2002) recognized the need for environmental sustainability of the development process through social mobilization and participation of people at all levels (Planning Commission, 1997) as its core objective. The Tenth Five-year Plan linked economic development and poverty with environmental degradation and ecological disasters. India's carbon emissions have grown by 63% in the last decade. Climate change

1.2.1 The Global Climate Risk Index 2019

The Global Climate Risk Index 2019 analyses to what extent countries and regions have been affected by impacts of weather-related loss events (storms, floods, heat waves etc.). This year's 14th edition of the analysis reconfirms earlier results of the Climate Risk Index: less developed countries are generally more affected than industrialised countries. Regarding future climate change, the Climate Risk Index serves as a red flag for already existing vulnerability that may further increase in regions where extreme events will become more frequent or more severe due to climate change. The indicators analysed include the number of deaths, number of deaths per hundred thousand inhabitants, sum of losses in PPP and losses per unit in GDP. India ranked 14th in the Global Risk Index with the 2nd highest no. of fatalities.

1.2.2 Climate Change Action Plans in India

The Government of India constituted the Prime Minister's Council on Climate Change in 2007 as a response to the increase in occurrence of extreme weather events domestically and the IPCCs fourth assessment report and the Bali Action Plan released in the same year. The Council consisted of a multi-ministry Core Negotiating team, the MoEFCC for coordinating and implementing the NAPCC and Ministry of Science and Technology along with Principle Scientific Advisor to GoI for research support. The PMCCC supervised the formation of the National Action Plan on Climate Change (NAPCC).

1.2.2.1 India's National Action Plan on Climate Change

The NAPCC defined eight missions for sectors which were either vulnerable to climate change or resulted in advancing climate change.

The eight missions include:

1) National Solar Mission
2) National Mission for Enhanced Energy Efficiency
3) National Mission for Sustainable Habitat
4) National Water Mission
5) National Mission for Strategic Knowledge on Climate Change
6) National Mission for Sustainable Agriculture
7) National Mission for Green India
8) National Mission for Sustaining the Himalayan Ecosystem

There is no mechanism for monitoring and evaluation of these missions. Although the host ministries are supposed to update PMCCC, there are no reports which have been made public.

National Mission for Sustainable Agriculture

The National Mission on Sustainable Agriculture (NMSA) was initiated in 2013 focussing on soil and water conservation, water use efficiency, soil health management and rain-fed area development. Initially a large outlay of Rs. 1,08,000 Cr was budgeted for this mission through the 12th FYP (2012-17). (MoA, 2013)

The core components of this mission are as follows (MoA, 2013):

- Rain-fed Area Development – Emphasis on adoption of an area-based methodology for farming systems improvement along with preservation of natural resources. Focus on integrating agriculture components and income-generating activities
- On-Farm Water Management – Focus on promoting on-farm water management techniques (like drip, sprinkler) along with efficient water application and distribution systems, secondary storage and drainage development for enhancing water use efficiency
- Soil Health Management – Focus on organic farming practices, creating and linking soil fertility maps with nutrients present, land use based on land capability, appropriate use of fertilisers, minimising soil erosion and effective residue management

- Climate Change Sustainable Agriculture Monitoring, Modelling and Networking (CCSAMMN) – Focus on conception and propagation of climate change associated information and knowledge which is bi-directional (farmers to researchers and viceversa).

The mission does not focus much on climate adaptation aspects or coping mechanisms. There is a need for decentralised planning for agriculture as presently the States lack resources and competencies to come up with targets, resources and approaches for implementation of this mission. (Rattani, 2018)

1.2.2.2 Maharashtra's State Adaptation Action Plan on Climate Change

The MoEFCC was tasked with co-ordinating the states to prepare State Action Plans for Climate Change for which the MoEFCC released a common framework for the states. Various development agencies (UNDP, World Bank, GIZ and DFID) were also invited as a part of this exercise at the State level and to provide technical assistance (MoEFCC, 2010)

Government of Maharashtra appointed The Energy Resources Institute (TERI) in 2010 to carry out an assessment of climate vulnerability and designing adaptation strategies for Maharashtra. The outputs of this study have been utilised in formulating Maharashtra's State Adaptation Action Plan on Climate Change (MSAAPCC) (TERI, 2014).

Although the MSAAPCC was created in 2014, it was not until 2017 that the plan was officially approved the State Cabinet for operationalization. Since then, the Government of Maharashtra has come out with a government resolution outlining action items for key line departments and district administrations. Also, the coordination of implementing MSAAPCC has been given to Environmental Information Centre (ENVIS) in Department of Environment.

1.2.2.3 Government Resolution on District Action Plans for Climate Change

The GoM came out with a GR (GR# 201710251541019904) in October 2017 to approve the MSAAPCC and came out with the climate change policy of the state. This policy contained specific action items to various Line Departments to increase climate resilience and tasked District Administrations to prepare climate change adaptation action plans at the District levels. The GR then lays down specific recommendations for sectors like forests, water resources, agriculture, energy, health, public works, disaster management, rural development, urban development, finance and planning and environment. The rural development section talks about 'Climate Proof Village' where environmental conservation activities are being undertaken through participatory means and the village is self-reliant in it energy needs.

The GR also asks District Collectors of extremely vulnerable districts to come up with an adaptation action plan based on conditions of that district which includes actions and various funding mechanism in coordination with Climate Change Cell. This activity is to be coordinated by Planning and Environment departments.

While mentioning climate change measures, the GR does not detail out how it can be done. The measures associated to agriculture mainly include watershed activities, climate resilient seeds, weather monitoring etc.

1.3 Climate Change and Maharashtra

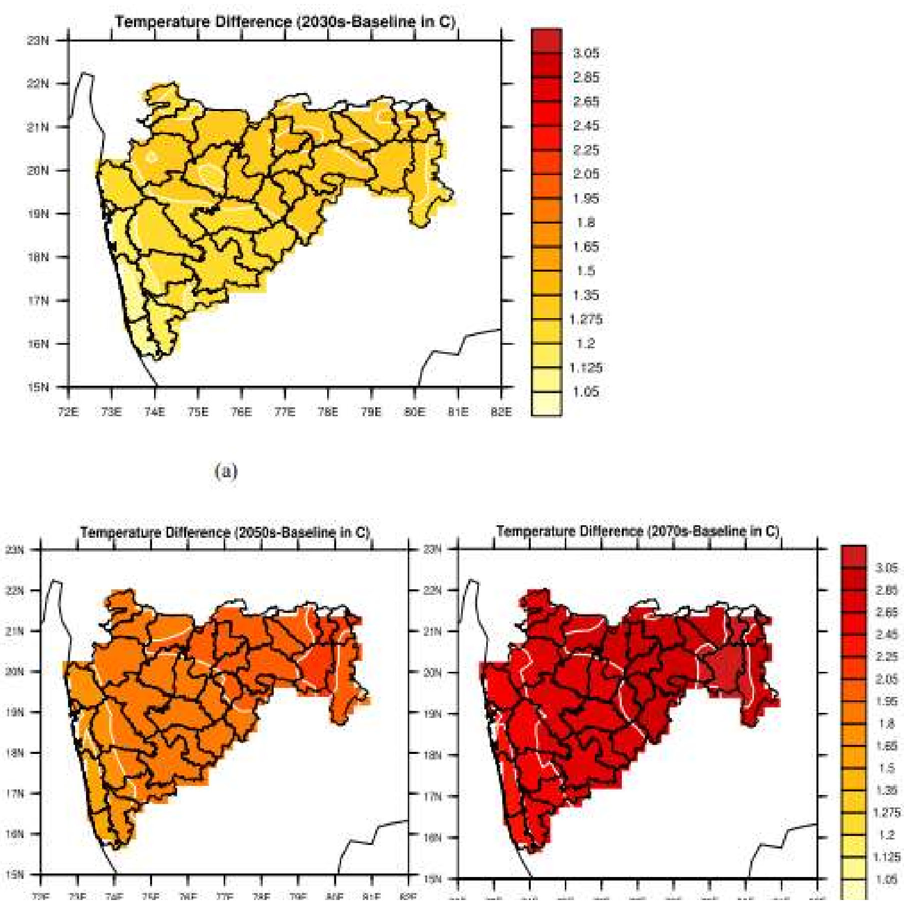
In Maharashtra, the climate variability is very high leading to high variability in rainfall pattern and agriculture production as seen to be increasing due to the increasing drought patterns seen in the state. In Maharashtra, increased temperatures and altered seasonal precipitation patterns by increased frequency and reduced time periods are affecting the hydrological and agriculture systems. Further, according to the study, increased risk of severe weather events may have a devastating impact on agriculture, water resources, forestry and the well-being of the population. Climate projections and impact assessments made for India show that Maharashtra, like the rest of India, is projected to experience an increase in rainfall variability, moisture stress, and occurrence of droughts, pests and diseases, a significant reduction in crop production and increased food production variability (Met, 2016).

A report by the National Bank for Agriculture and Rural Development (NABARD) recommends to the state government to initiate policies and measures to adapt to climatic changes, which would be detrimental to the agriculture sector in 14 districts affected by severe periodic droughts across Vidarbha and Marathwada. CRIDA (of ICAR) has concluded, “The districts in Marathwada and Vidarbha face very high risk to climate change”.

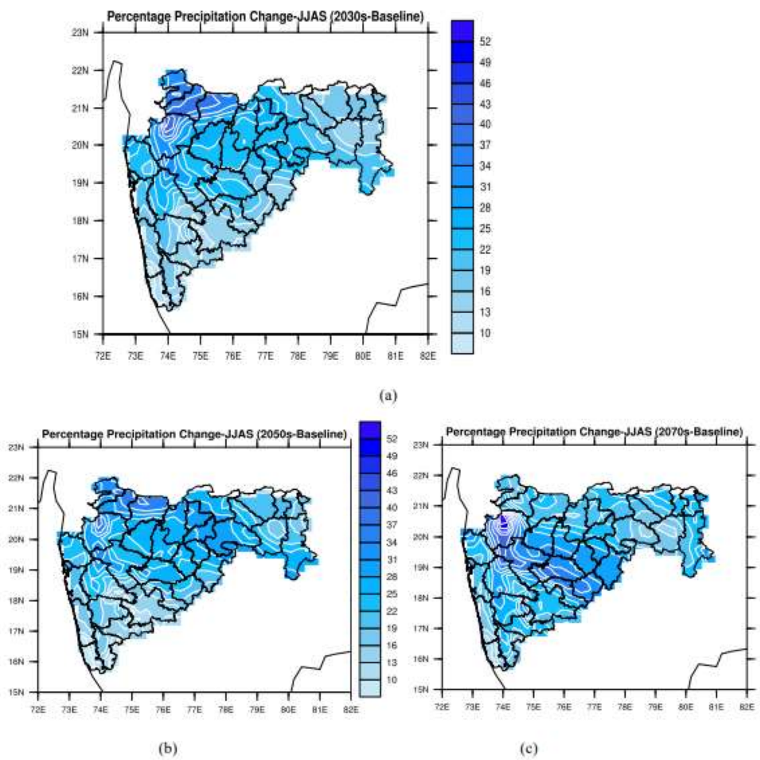
Thus, there is a need to promote resilience or adaptation to current climate variability and climate change, especially in the rain-fed Marathwada and Vidarbha region of Maharashtra. In the rain-fed Marathwada and Vidarbha region of Maharashtra, crop productivity and food production are highly variable / vulnerable to current climate variability and the on-going as well as long-term climate change. The crop productivity could decline and the variability of agriculture production could increase, due to climate variability and climate change. Thus, there is a need to develop climate resilient agriculture or cropping systems and agronomic practices to ensure higher and stable farm productivity. According to the study by NABARD, increased risk of severe weather events may have a devastating impact on agriculture, water resources, forestry and the well-being of the population. Climate projections and impact assessments made for India show that Maharashtra, like the rest of India, is projected to experience an increase in rainfall variability, moisture stress, and occurrence of droughts, pests and diseases, a significant reduction in crop production and increased food production variability (Met, 2016).

1.3.1 Future Climate Projections for the State

Climate change projections for Maharashtra were developed by TERI based on domain selection and checking the model outputs with observations. The domain having a higher



1.1 Figure 1-1 Temperature difference modelled for Maharashtra correlation with observations was then chosen for future projections. This methodology is unique for the state of Maharashtra and is said to provide better future projections than other models. Based on this unique domain selection method that sought to represent the regional climate over Maharashtra to a fairly good degree, rainfall and temperature changes have been projected for three time slices- 2030s, 2050s and 2070s by TERI.



2.1 Figure 1-2 Percentage precipitation change modelled for Maharashtra

A warmer atmosphere has a higher capacity to hold water. This is likely to produce more intense rainfall events with longer dry or low rainfall spells between these events. (TERI, 2014)

1.3.1.1 Agriculture sector specific impacts

The increasing trend in post monsoon season in Maharashtra may increase incidence of black mould in sorghum and of Heliothis in cotton and red gram, according to research by the Mahatma Phule Krishi Vidyapeeth. (TERI, 2014)

Research on impact due to climate change in the field of agriculture has been ongoing for the past two decades. However, the impacts cannot be clearly identified and there is a lot of uncertainty associated with it. Agriculture is fundamentally of an intertwined nature, involving agronomic, environmental and socio-economic dimensions. Studies set out to disentangle what is at stake from these points of views (Parry et al., 2007), but the estimates and the tools used to carry them out varied greatly. A combined approach to understand agriculture from a bio-physical, social and economic perspective is needed.

1.3.2 Impact of Climate Change on Agrarian societies in Maharashtra

1.4 Project on Climate Resilient Agriculture (PoCRA)

The Project aims to improve climate resilience in agriculture by maintaining an aggregate positive water balance in the village by improving access to water, enabling farmer level cropping pattern decisions and improving economic returns to farmers by stabilizing yields.

The Project Development Objective (PDO) is to enhance climate-resilience and profitability of smallholder farming systems in selected districts of Maharashtra. The project is built around a comprehensive, multi sector approach that focuses specifically on building climate resilience in agriculture through scaling up tested technologies and practices. PoCRA is a first of its kind climate resilience project undertaken in the agriculture sector in India. The project follows a unique triple-win strategy to address the twin objectives of enhancing climate resilience and enhancing farm productivity of small holders. This includes enhanced water security at farm level, improved soil health and increased farm productivity and crop diversification.

Major objectives of the project include:

1) Household food and income security through farmer’s adoption of climate-smart agriculture technologies aimed at improving land and water productivity; and through crop diversification is driven by on-farm risk ‑management and emerging market opportunities.

2) Water security at farm level through the upscaling of technologies geared towards a more efficient use of water for agriculture (e.g. micro-irrigation systems); and 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.

3) Improved soil health through the adoption by farmers of good agricultural practices that enhance soil fertility, soil nutrient management, soil carbon sequestration and soil water retention capacity.

Key performance indicators to be monitored are,

- Farmers adopting improved agricultural technology
- Improved water-use efficiency at farm level
- GHG Accounting
- Increase in farm income
- Direct project beneficiaries.

1.5 Motivation behind this study

More than 700 million Indians staying in rural areas are dependent on climate sensitive sectors like agriculture, forests and fisheries and allied biodiversity like water, mangroves, coastal zones and grasslands for their livelihoods (GoI, 2008). Additionally, as the adaptive capacity of these communities is very low, they are likely to be more vulnerable to adverse impacts of climate change.

All programs and projects working on Climate Resilient Agriculture use specific methodologies for selection of villages or regions to undertake projects and for identification of beneficiaries. These methodologies generally follow an approach which looks at macro scale indicators brought down to micro levels. These micro level indicators thus miss the mark and do not adequately represent the vulnerabilities and risks of the farmers.

Additionally, The GR on Climate Change contains action items to various Line Departments to increase climate resilience and tasked District Administrations to prepare climate change adaptation action plans.

The recommendations related to agriculture include:

- Agro-climate services need to be set up at the village level to provide village level information regarding climate, crop diseases, climate resilient crops, irrigation methods etc.

- Livelihood alternatives like animal husbandry, fisheries need to be promoted etc.

So while guidelines exist at the national and state level, they are not operationalized at the lower levels. Also, guidelines for the line departments on how to actually prepare action plans or match vulnerability to mitigation measures does not exist.

Concepts of climate change are very specific to the study area and in the drought-prone villages of Maharashtra the Project on Climate Resilient Agriculture understands climate change as the erratic monsoon patterns with reducing number of rainy days and increasing heavy rainfall occurrences. The climate resilience methodology followed by the Project is to maintain an aggregate positive water balance in the village by improving access to water, enabling farmer level cropping pattern decisions and improving economic returns to farmers by stabilizing yields.

This study aims to understand the concepts of climate change such as risk, vulnerability, adaptive capacity, climate resilient agriculture by different sources and link it with mitigation strategies.

1.6 Research Questions

1) Which climate change indicators can be used at the farm, village and regional levels?
2) How do these indicators translate to vulnerability and risk at the farm, village and regional levels?
3) How can the vulnerability be matched to mitigation measures?
4) How does PoCRA match vulnerability and mitigation?

Chapter 2 Research Methodology

2.1 Research design

Current climate resilient agriculture projects use specific methodologies and indicators for quantifying vulnerabilities, but these methodologies look at the macro level (district, state level). Current indices are associated mainly only with the changing climatic conditions and do not really quantify the risks faced by the farmers or the effect on crops due to the changing climatic conditions. This dilutes the meaning of the vulnerability as such and does not effectively select beneficiaries or vulnerable villages.

This study aims to understand climate resilience specific to farmers in drought-prone regions of Maharashtra. It aims to understand how climatic conditions affect vulnerability of a farmer, how this vulnerability be mitigated and the engineering interventions required for the same. Climate change affecting the drought pron.

The regions of Maharashtra mainly is due to the erratic rainfall patterns in the villages. It is necessary to identify clearly the stress induced due to changing rainfall patterns that a farmer faces as accurately as possible. This stress in turn affects the yields and economic returns of a farmer. Access to water to provide protective irrigation thus becomes important to increase climate resilience in farms. The vulnerability of the farmer is divided into two main categories- socio-economic vulnerability and the bio-physical vulnerability. The bio-physical vulnerability mainly looks at the stress faced by the crops. The stress faced by crops is calculated on the water budget principles.

PoCRA follows a certain methodology to improve access to water through individual benefits and community benefits. This study aims to understand hoe PoCRA aims to increase climate resilience in this frame of reference and resulting into a framework to identify beneficiaries and effectively monitor and evaluate the project.

2.2 Research methodology

1) Literature review
    i. Understanding what is climate change, vulnerability, risk etc.
    ii. Understanding the concepts of climate resilient agriculture
    iii. Tools of calculation of climate vulnerability
    iv. Understanding the objectives of PoCRA
    v. Understanding the implementation process of PoCRA

vi. Comparative analysis of concepts of climate change and PoCRA

2) Data collection

i. Questionnaire design

ii. Qualitative and quantitative data collection

3) Data analysis

4) Report Writing

Chapter 3 Literature Review

3.1 Concepts of Vulnerability and Risk in Climate Change

3.1.1 Vulnerability

'Vulnerability' is a cross-cutting multidisciplinary theme of research characterized by rapid changes in the environmental, economic and social systems. Vulnerability due to climate change has a complex relationship such that it covers an extensive sectors, parameters and involves a number of factors. Social scientists, geography scientists, hydrologists, engineers view vulnerability in a different light. Social scientists view vulnerability to involve socio-economic factors that influence people's ability to cope with environmental, economic and social hazards. In this context, vulnerability is a "state of the system before the hazard acts". It understands it as an external stimulus maintaining the stress on the system. Meanwhile, climate scientists generally regard vulnerability in terms of the probability of occurrence and impacts of the hazard. Thus, the concept is considered as the "likelihood and outcome of the hazard". This approach is based on risk analysis that emphasizes on the probability and size of the damage. It places an importance on the bio-geo-science factors that determine the hazard challenging the system, the frequency of its occurrence, and the natural factors influencing its effects (Maxim and Spangenberg, 2003; O'Brien et al., 2004). These two concepts are summarized into the types of vulnerability namely, the social (socio-economic) and the biophysical. Social vulnerability has also been defined as the "social and institutional capacities that determined both susceptibilities to, and the ability to cope with, hazards and environmental change." (Cutter, 1996) On the other hand, biophysical vulnerability refers to the "potential for loss from natural hazards, environmental variability, and change" (Cocklin, 1998). There are some researchers who treat the natural and socio-economic factors as interrelated concepts wherein one determines the other, i.e. natural vulnerability as one of the determinants of socio-economic vulnerability (Klein and Nicholls, 1999) or social vulnerability as one of the determinants of biophysical vulnerability (Brooks, 2003). Bio-physical and socio-economic vulnerability can be considered independent from each other. Clearly, there are variations on how vulnerability is conceptualized; these create the inconsistencies on each of the vulnerability factor's significance. By combining the different aspects of the conceptual structures, a new approach in viewing vulnerability was identified. Fussel (2005) identified four fundamental dimensions of a vulnerability assessment, namely:

(1) temporal reference (current vs future vs long-term);
(2) scale (internal vs external vs cross-scale – combinations of internal and external);

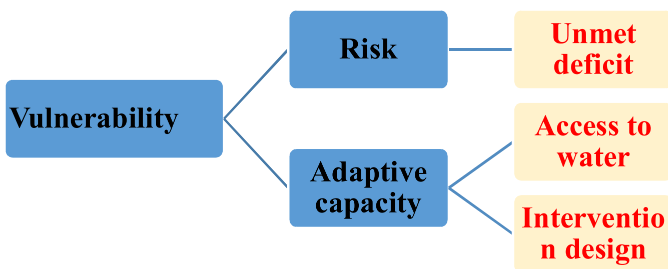
(3) disciplinary domain (socio-economic vs biophysical vs integrated – combinations of socio-economic and biophysical);
(4) vulnerable system;
(5) valued attribute; and
(6) hazards.

Socio-economic factors considered in vulnerability include economic resources, distribution of power, social institutions, cultural practices, and other characteristics of social groups. Bio-physical vulnerability factors are those related to system properties investigated by the physical sciences.

Vulnerability can be considered as,

Vulnerability = Risk –Adaptive Capacity

In the case of agriculture and in PoCRA, risk is understood as the unmet deficit and adaptive capacity is seen as the access to water and intervention design to improve the access to water.



3.1 Figure no. 1 Concept of vulnerability

3.1.2 Vulnerability to climate change

IPCC (2001) describes vulnerability as a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity. This definition expands vulnerability's linkages as it introduces concepts of sensitivity and adaptive capacity, in addition to exposure. The IPCC considers sensitivity as the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. These stimuli cover all the elements of climate change, including the mean climate characteristics, climate variability, and the frequency and magnitude of extremes. The effect may be direct – a change in crop yield in response to a change in the mean, range or variability of temperature – or indirect – damages caused by an increase in the frequency of coastal flooding due to sea-level rise. According to Smit and Wandel (2006), exposure and sensitivity are "almost inseparable properties of a system (or community) and are dependent on the interaction between the characteristics of the system and on the attributes of the climate stimulus."

3.1.3 Vulnerability indicators

Vulnerability is classified into social vulnerability and biophysical vulnerability and the indicators are categorized accordingly.

3.1.3.1 Social vulnerability

Social vulnerability influences how a unit will respond to the changing exposures and affects the degree by which the system will be affected by the said exposure (Ford, 2002). Social vulnerability is typically illustrated by the characteristics inherent to the system; it is the vulnerability which exists within, before it encounters a hazard event. The following factors have been identified by many authors to be causes for a high vulnerability: population growth, poverty, hunger, health, nutrition, low education levels, gender inequality, fragile and hazardous locations, lack of access to resources and services. These indicators have also been categorized as economic, health and nutrition, education, governance, agriculture, demographic, sanitation, political, and development indicators to compose social vulnerability.

1.1 Table 3-1 Different Socio-economic indicators used in India

Author	Indicators	Description
TERI	Agricultural dependency index: percent of district workers employed in agriculture; landless index: percent of landless laborers in agricultural workforce; education index: adult literacy rate (greater than seven years); female disadvantage index: "Missing girls", i.e. ,48.5 percent girls in 0-6 population; female literacy and child survival index: female literacy rate	Composite index: agricultural dependency, the vulnerability of the agricultural workforce, human capital, female disadvantage and female literacy and child survival chances

The concepts of social vulnerability focus on indicators of development to identify vulnerability. These indicators cannot be relied on to identify social vulnerability on a micro scale. While these can be the outcomes of changing vulnerability in the society, they cannot be used to identify vulnerable areas. Social vulnerability should be computed on the basis of direct social outcomes which can be observed which are much more complicated than those defined by TERI.

3.1.3.2 Biophysical vulnerability

This type of vulnerability involves the physical sciences, in terms of examining the natural characteristics of areas by which the hazards may affect. Meanwhile, Cutter et al. (2000) consider biophysical vulnerability in the geographic context. In this sense, the "geographic filter includes the site and situation of the place and its proximity to the hazard sources and events". Hence biophysical vulnerability is sometimes measured by the event frequency and the delineation of the hazard zones. The key parameters relating to agriculture vulnerability are temperature and precipitation. Both are undergoing rapid changes due to anthropogenic and climatic reasons. Other biophysical factors that affect productivity in agriculture are soil, water, topographical features.

Bio-physical vulnerability looked at mainly in most cases is only rainfall. The impact that the bio-physical parameters have in reality are not computed or estimated. The composite effect of all bio-physical parameters is very complicated and is not calculated currently to understand bio-physical vulnerability.

3.1.4 Risk

Risk is generally defined in relation to a hazard and is described to be probabilistic in nature. Risk is defined as the probability of occurrence of a hazard that acts to trigger a disaster or series of events with an undesirable outcome; or the probability of a disaster or outcome, combining the probability of the hazard event with a consideration of the likely consequences of the hazard (Brooks, 2003; Brooks et al., 2005; Sarewitz et al., 2003).

3.1.5 Climate change risks and impacts

Studies have been conducted to determine the kind of risks and impacts associated with climate change. The risks directly or indirectly affect people adversely. The changes in the intensity and frequency of rainfall and temperature and the occurrence of extreme weather events could trigger potentially dramatic increases in chronic poverty, hunger, disease, mortality, displacement, and violent conflict in many developing countries (Heltberg et al., 2008). Moreover, climate variability and change pose risks to ecosystems, social and cultural systems, and economic systems (Scheraga and Grambsch, 1998). It is perceived that these risks can only be mitigated by adaptation measures. In fact, others say that the only certain way of reducing risk is through a combination of adaptation and mitigation strategies, the purpose of the latter being to reduce hazards (Brooks, 2003).

3.2 Effect of Climate Change on agriculture

The impacts of climate change on agriculture have come under scientific scrutiny for more than two decades, but are still shadowed with uncertainty.

3.3 Socio-economic vulnerabilities in agriculture

The changing climate is exacerbating existing vulnerabilities of the poorest people. Barry Edison et al, 2006). The IPCC Fourth Assessment emphasizes that adaptation strategies are essential and these must be developed within the broader economic development policy context (IPCC, 2007). Addressing adaptation in the context of small-scale, raises special challenges that cannot be addressed adequately by the approaches taken thus far in most studies (Adger et al., 2003). Most of the existing research has focused on impacts of climate change and adaptation to climate change in the agricultures of industrialized countries. IPCC and some recent studies at the sub-continental scale for Africa indicate the importance of assessing the effects of climate change and possible adaptation strategies at the agricultural system and/or household level, rather than focusing on aggregated results that hide a large amount of variability (Burke et al., 2009; Nelson et al., 2009; Thornton et al., 2009a, 2010; Baethgen, 2010).

Chambers (1989) built his theory of vulnerability and adaptation on numerous case studies of poor small-scale farmers. He concluded that poor people usually seek to reduce vulnerability not by maximizing income, but by developing and diversifying their portfolio of capital assets. Chambers found that ‘‘most poor people do not choose to put all their eggs in one basket’’, and thus, tradeoffs exist between security and income (Chambers, 1989).

Actual farm yields, however, are also affected by other factors, such as pests and diseases, which depend on farm management and regional conditions. How these influence climate impacts is not well understood.

Millions of the rainfed smallholder farmers will experience immediate hardship and hunger as a consequence of climate change, since they will be less able to make adequate decisions about when to sow, what to grow, and how to time inputs along with having a low adaptive capacity. As climate change impacts are increasingly observed and felt by smallholder farmers, there is an urgent need to identify approaches which enhance the adaptive capacity of farmers, their households and communities. Indicator development is one of the methodologies to understand and capture complex reality of climate vulnerability for generating more scope and opportunities in terms of policy interventions. Moreover, indicators provide information on matters of wider significance than what is actually measured or what can be made perceptible as a trend or phenomenon that is not immediately detectable.

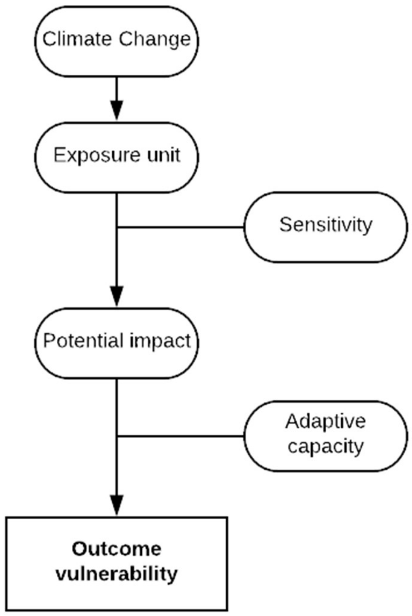
However, most methodologies focus on representative indicators for vulnerability which do not depict the actual vulnerability faced by farmers.

3.4 Climate Resilient Agriculture

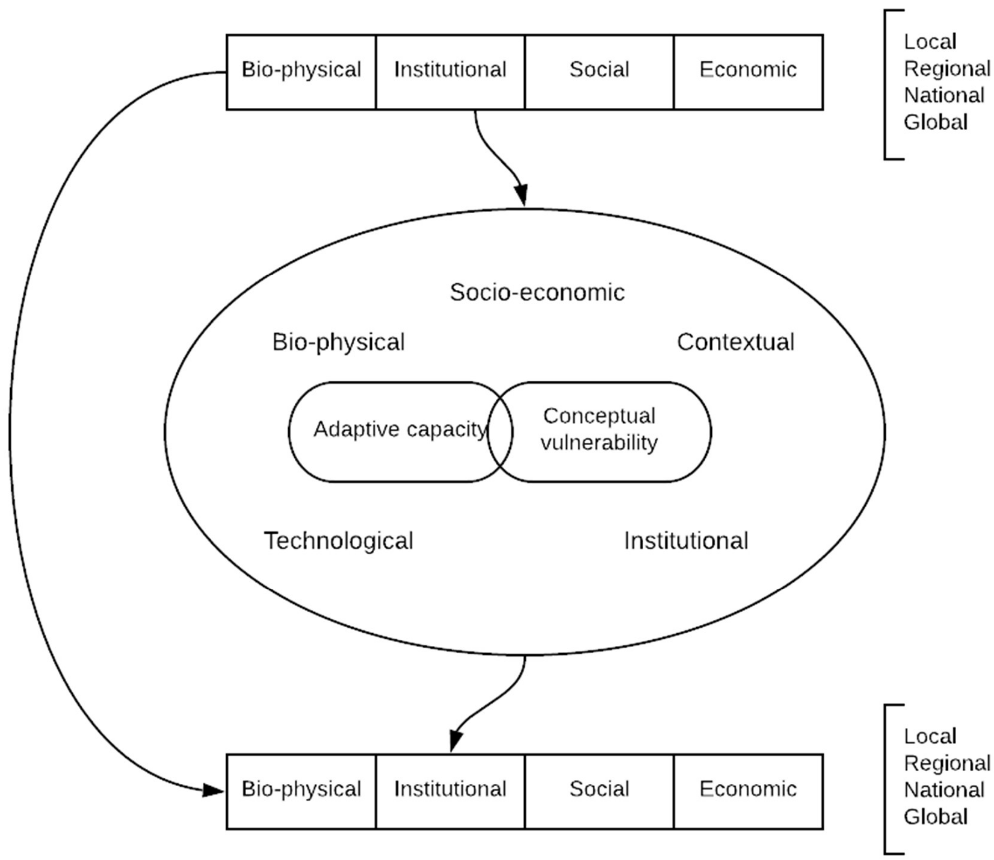
Keeping the need to make Indian agriculture more resilient to changing and increasingly variable climate, the Indian Council of Agricultural Research (ICAR) launched a megaproject "National Initiative on Climate Resilient Agriculture (NICRA)" during February 2011. This initiative, being coordinated by CRIDA, Hyderabad, is a collaborative and participatory effort by a number of institutes addressing the specific sub-sectors within agriculture. In order to develop and target appropriate adaptation measures, it is important to identify regions that are more affected by climate change. Hence, assessment of vulnerability of different regions was taken up as an important activity under NICRA. This publication presents the analysis of vulnerability of agriculture to climate change and variability at the district level considering the fact that most of the development planning and programme implementation is done at district level in India. Also, most of the non-climatic data that is integral to assessment of vulnerability to climate change and adaptation planning is also available at district level.

3.5 Contextual and Outcome Vulnerability

Contextual vulnerability (also known as starting-point interpretation or internal social vulnerability) is rooted in political economy. It is determined exclusively by internal characteristics of the vulnerable system or community that determine its propensity to harm for a wide range of hazards. Outcome vulnerability (also known as end-point interpretation or integrated cross-scale vulnerability) represents an integrated vulnerability concept that combines information on potential climate impacts and on the socio-economic capacity to cope and adapt (O'Brien, 2007).



4.1 Figure no. 2 Outcome vulnerability



5.1 Figure no. 3 Contextual vulnerability

Different interpretations of vulnerability do not only produce different rankings of vulnerable regions or systems; they also suggest different strategies for reducing vulnerability. 'Outcome studies' tend to focus on technological adaptation to minimize particular impacts of climate change whereas 'contextual studies' tend to focus on sustainable development strategies that increase the response capacity of human populations for dealing with a large variety of hazards (O'Brien, 2007).

Outcome vulnerability is characterised by the IPCC (2001) definition of 'the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes'. In contrast, contextual vulnerability assesses 'the susceptibility of a system to disturbances determined by exposure to perturbations, sensitivity to perturbations, and the capacity to adapt'. These two concepts of vulnerability vary in their: systems of interests; antecedents; conception of climate change; theoretical or disciplinary basis; range of impacts considered; and type of results provided. The outcome orientated approach works more effectively in more linear or bounded systems, whereas the contextual approach is more relevant to social and environment-linked open systems and traditionally uses more qualitative methods.

While contextual and outcome vulnerability produce different outputs and understanding of vulnerability, they both independently are not sufficient for understanding vulnerability entirely. Outcome vulnerability focusses on absolute climate changes such as temperature variation, rainfall variation etc. and has major contribution in modelling. Contextual vulnerability is able to capture the different reasons behind vulnerability however, the indicators used to define vulnerability in this case are not direct indicators of vulnerability and indicators of development are used in that case. This study focusses on understanding outcome indicators for contextual parameters such as social and economic paraeters.

3.6 Tools and Methodologies for vulnerability assessment and mitigation

Community-based Risk Screening Tool – Adaptation and Livelihoods (CRiSTAL) which according to its manual by Hammill et. al., (2007) is a tool for project planning which assists in designing activities at the community level which support adaptation to climate variability and change and as an output gives a) a list of livelihood resources highly impacted by climate events which are also highly important to the participants b) proposed modifications to existing projects and new activities which support climate adaptation c) list of desirable adaptation outcomes and influencing factors to be monitored.

Climate Vulnerability and Capacity Analysis (CVCA) which according to its manual by Daze et. al., (2009) is a methodology which assists in analysing vulnerability to climate change at national, state and local levels and adaptive capacity at community level through participatory research, questionnaires and analysis. It considers factors like climate resilient livelihoods, disaster risk reduction, capacity development and addressing underlying causes of vulnerability. There is a focus on participatory rural appraisal tools for the community level which has been designed by Dr. Robert Chambers.

Institute of Social and Environmental Transformation's (ISET) Climate Resilience Framework (CRF) stresses on roles of systems, institutions, agents and exposure in climate resilience and adaptation. It supports planning and strategic policy development using a concept known as shared learning techniques. The process involves analysis, identifying context-specific actions, prioritizing them, designing, implementation of interventions, monitoring and returns back to analysis.

3.7 Monitoring and Evaluation Framework

Monitoring for climate change programmes require specific consideration of large number of characteristics such as long timeframes, uncertainty about actual climate change patterns and their effects, shifting baseline data and changing contexts, inappropriateness of universal indicators, diversity in definitions and terms etc.

The different monitoring and evaluation frameworks prepared focus on different sectors, scales and categories. The different frameworks in use today include:

1) Evaluation of adaptation to climate change from a development perspective

This framework is prepared for the Global Environmental Facility Evaluation (GEF) Office and Department of International Development (DFID).

2) Tracking progress for effective action
3) Learning to ADAPT

This framework is prepared for the Institute of Development Studies, Christian Aid and Plan

4) Monitoring and Evaluation for Adaptation
5) Climate change adaptation monitoring and assessment tool (AMAT)
6) Participatory monitoring, evaluation, reflection and learning (PMERL) project for community-based adaptation

Prepared for International Institute for Sustainable Development

2.1 Table 3-2 Review of Climate Change Monitoring and Evaluation Frameworks

Framework	Type of data required	Method/ Approach	Content	Applicability/ Scale
Evaluation of adaptation to climate change from a	• Detailed conceptual framework /	Mixed Quantitative/ Qualitative method	Detailed list of suggested indicators	International, Natiol

development perspective	theoretical review • Literature review / summary of adaptation M&E approaches			
Tracking progress for effective action	• Detailed conceptual framework / theoretical review • Literature review / summary of adaptation M&E approaches	Mixed method	• Detailed list of suggested indicator • Guidance on indicator development • In-depth discussion / guidance on climate change adaptation programming	National, Rural Emphasis
Learning to ADAPT	• Detailed conceptual framework / theoretical review • Literature review / summary of adaptation M&E approaches	Mixed method emphasis	• Suggested indicators • Guidance on indicator development	International, National, Sub-National, Community, Rural emphasis

Monitoring and Evaluation for Adaptation	• Literature review	Mixed method	• Logframe/ Logic model • Theory of change • Detailed list of suggested indicators	International, National
Climate change adaptation monitoring and assessment tool (AMAT)	• Practical step-by-step guide	Quantitative method	• Detailed list of suggested indicators • Logframe/ Logic model • Theory of Change	International, National
Participatory monitoring, evaluation, reflection and learning (PMERL) project for community-based adaptation	• Practical step-by-step guide • Detailed conceptual framework • Literature review	Mixed method	• Theory of Change • Logframe • Indicators	Sub-national, community, rural emphasis

These monitoring and evaluation frameworks define different types of indicators such as progress and process monitoring indicators, progress validation and performance monitoring etc. All these methodologies for monitoring and evaluation focus on contextual indicators. They do not focus on robust methodologies specific to a particular cause but are more generic.

3.8 Progress and process monitoring

Process monitoring informs management and a donor about the actual implementation of project activities in the field. It is conducted using checklists and guidelines. Progress monitoring continually assesses the impact of the project activities on the target population. Monitoring both the positive and negative impacts, intended and un-intended impacts of the project/program becomes imperative.

Progress indicators focus on the key output of the project. Progress indicators can be qualitative or quantitative.

Chapter 4 Project on Climate Resilient Agriculture

The development objective of PoCRA for India is to enhance resilience and profitability of smallholder farming systems in selected districts of Maharashtra. This project has 3 main components:

1) PoCRA aims to strengthen the adaptive capacity of smallholder farmers to adjust and modify their production systems to moderate potential future impacts from climate events
2) Post-harvest management and Value Chain Promotion aims to support the participation of small holder farmers in Farmer Producer Organisations (FPOs) and their integration into value chains for relevant crops and to strengthen the supply chain for climate-resilient crop varieties in the project area.
3) Intuitional Development, Knowledge and Policies for Climate Resilient Agriculture aims to enhance the transformative capacity of institutions and stakeholders to promote and pursue a more climate resilient agriculture with sector strategies and policies based on strong analytical underpinnings and cutting-edge climate, water and crop modelling.

4.1 Objectives of the Project

The Project Development Objective (PDO) is to enhance climate-resilience and profitability of smallholder farming systems in selected districts of Maharashtra. The project is built around a comprehensive, multi-sector approach that focuses specifically on building climate resilience in agriculture through scaling up tested technologies and practices.

Major objectives of the project include:

1) **Household food and income security** through farmer's adoption of climate-smart agriculture technologies aimed at improving land and water productivity; and through crop diversification is driven by on-farm risk –management and emerging market opportunities.
2) **Water security at farm level** through the upscaling of technologies geared towards a more efficient use of water for agriculture (e.g. micro-irrigation systems); and 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.

3) **Improved soil health** through the adoption by farmers of good agricultural practices that enhance soil fertility, soil nutrient management, soil carbon sequestration and soil water retention capacity.

4.2 Project Components

The Project has three main components which are further detailed out into 9 major components.

A: Promoting Climate-resilient Agricultural Systems

- A.1: Participatory development of mini watershed plans.
- A.2: On-farm climate-resilient technologies and agronomic practices.
- A.3: Climate-resilient development of catchment areas

B: Climate-smart Post-harvest Management and Value Chain Promotion

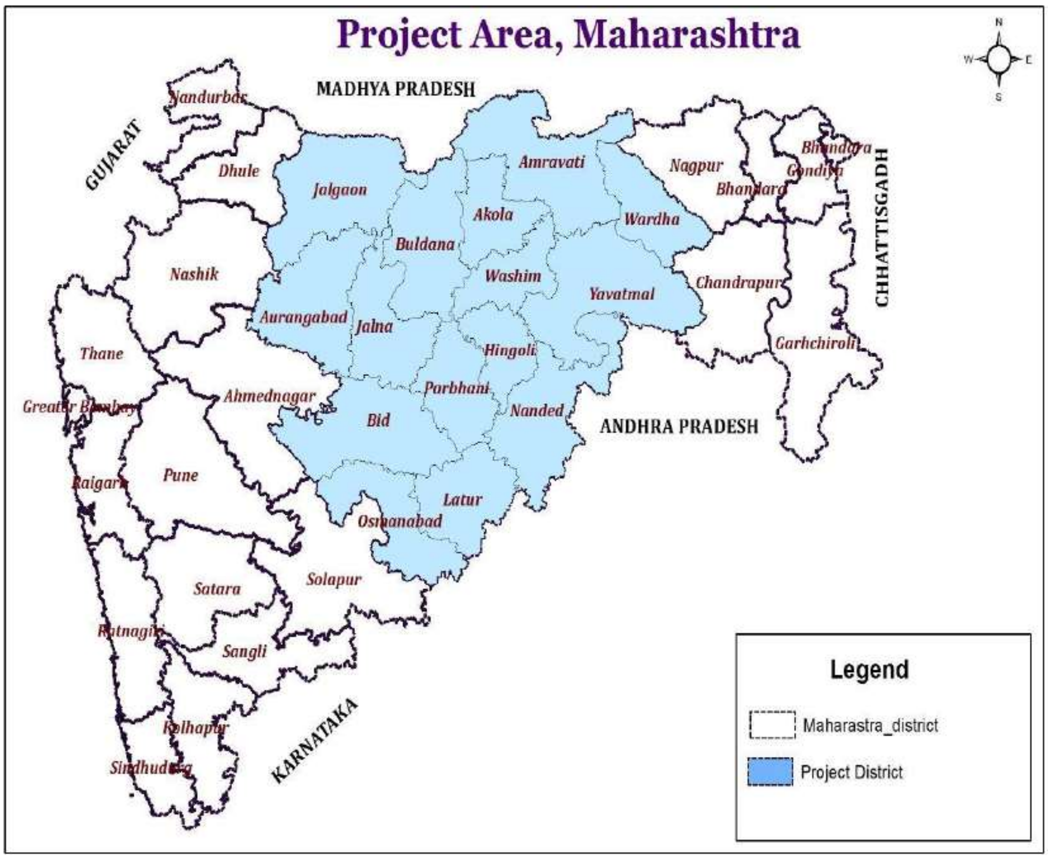
- B.1: Strengthening Farmer Producer Companies
- B.2: Strengthening emerging value-chains for climate-resilient commodities
- B.3: Improving the performance of the supply chain for climate-resilient seeds

C: Institutional Development, Knowledge and Policies for a Climate-resilient Agriculture

- C.1: Sustainability and institutional capacity development
- C.2: Maharashtra Climate Innovation Centre
- C.3: Knowledge and policies

4.3 Project Area

The proposed project will be implemented in the 15 districts in Marathwada (Aurangabad, Nanded, Latur, Parbhani, Jalna, Beed, Hingoli, and Osmanabad), Vidarbha (Akola, Amravati, Buldhana, Yavatmal, Washim, Wardha,) and Jalgaon district of Nashik Division. Out of a total of 18,768 villages in the districts selected, the project will cover about 4000 villages characterized by high climate vulnerability. The project will also include about 1,000 villages located in the Purna river basin and showing high levels of soil salinity and sodicity. These villages are spread over Akola, Amravati, Buldhana and Jalgaon.



6.1 Figure no. 4 PoCRA Project Districts

4.3.1 Biophysical Characteristics of the project area

Most of the bio-physical characteristics of the project districts are captured in three agro-climatic zones out of the nine zones of the state. The project areas lie mostly in scarcity zone, assured rainfall zone and moderate rainfall zone.

4.3.2 Climatic Conditions

The Project Area suffers from very low rainfall with uncertainty & ill distribution. Occurrence of drought is noted once in three years. Dry spell varies from 2-10 weeks. Water availability 60-140 days which is affected due to delayed monsoon. Temperatures of the range 33-41^{O} C maximum temperature and minimum temperature of 16-26^{O} C are observed.

4.3.3 Soil Type

Soil type in the entire project area varies highly and thus cannot be easily categorized. Soil ranges from black to red. The types of soils found are vertisols, Entisols and inceptisols with a pH value between the range of 7-7.5. Black soils found are derived from basalt rock. The soil is generally medium to heavy in texture.

4.3.4 Socio-economic characteristics of the project area

According to the Socio-Economic Caste Census (2012) estimates, in 73.13% of the households in the project districts, the monthly income of the highest earning member is less than INR 5000.

4.4 Village selection criteria in PoCRA

Vulnerability approach adopted by CRIDA (ICAR) has been considered for the selection of villages. The village selection criteria is based on the methodology prepared by TERI. The indicator is prepared based on the criteria mentioned in the Table 3.1.

3.1 Table 4-1 PoCRA village selection criteria

Exposure (25% weightage)	**Sensitivity (40%)**	**Adaptive capacity (35%)**
Change in annual rainfall	Net sown area	Rural poor
Change in June/ July rainfall	Degraded land	SC/ST Population
Change in number of rainy days	Annual rainfall	Agriculture Workers
Change in min and max temperature	Cyclone proneness	Total literacy
Change in extreme hot/ cold day frequency	Flood proneness	Gender gap
Change in frost occurrence	Drought proneness	Access to markets
Change in drought proneness	AWC of soil	Road connectivity

Change in incidence of dry spells ≥ 14 days	Stage of GW development	Rural connectivity
99 percentile rainfall	Rural population density	Rural electrification
Change in number of events with >100 mm district domestic rainfall in 3 days	Area operated by small and marginal farmers	Irrigation
Change in maximum 5 rainfall in a single day as % to annual normal		Fertilizer consumption
		GW availability
		The share of agriculture in district domestic produce

The values of the climate exposure for the project districts were taken from CRIDA and were considered uniform throughout the district. For the indicators having direct relationships, the index for any indicator (n) of a cluster (i) was calculated as:

$$Index(n) = \{i(n) - Min(n)\}/\{Max(n) - Min(n)\}$$

For the indicators having inverse relationships, the index for any indicator (m) of a cluster (j) was calculated as:

$$Index(m) = \{Max(m) - j(m)\}/\{Max(m) - Min(m)\}$$

Combined vulnerability index for each of the clusters was calculated by aggregating individual indices after multiplying them with the weightage assigned to the respective indicators.

These indices look at climate change only and not the effects of climate change which actually increase the vulnerability of the farmers is not taken into consideration.

4.5 Beneficiary targeting

Most vulnerable farm households in a village to be identified by the village community for assistance under the project and the following categories will be given priority for project activities targeted to benefit individuals:

1) Marginal farmers
    a. ST/SC farmers
    b. Women farmers

    c. Disabled farmers
    d. Other farmers
2) Small farmers
    a. ST/SC farmers
    b. Women farmers
    c. Disabled farmers
    d. Other farmers

Beneficiary targeting tries to take into consideration the socio-economic vulnerability of farmers. However, whether the provided subsidy helps overcome this vulnerability or increases their vulnerability has not been studied. Also, does this methodology overlook other vulnerable farmers has not been looked at.

4.6 Project Execution at Village level

At the village level, after the village is selected in a phase, the project is executed in the following steps,

1) Village selected in a particular phase.
2) A VCRMC committee is set up in the village to help with the project execution in the village.
3) A seven day survey to prepare a village-level micro plan is conducted in the village by a selected NGO.
4) The NGO prepares the micro plan and submits it to the Sub-District Agriculture Officer (SDAO) for approval.
5) The *Krushi Sahayak* and *Krushi Mitra* begin collection of applications to different benefits provided by the scheme.
6) The *Krushi Sahayak* along with the VCRMC Committee approve and reject the applications based on the guidelines provided by PoCRA.
7) Technical approval is required for some individual benefits which is given by the *Krushi Adhikari* and *Krushi Adhikari.*
8) The beneficiary then receives the grant through the Direct Beneficiary Transfer.

4.7 Individual and Community benefits provided by the project

The project provides individual and community benefits. The individual benefits target access to water, crop management and livelihood alternatives. Thus some benefits manage the supply side of water and some manage the demand side of water.

4.7.1 Demand side benefits

Demand side benefits provide benefits to reduce and manage the water use, change certain cropping practices and adopt new crops entirely. The demand side benefits include:

1) Horticulture crops specific to area
2) Sericulture
3) Tree plantation along farm boundaries
4) Shade-net
5) Poly house
6) Poly tunnel

These benefits help reduce or manage the demand of water from the crops.

4.7.2 Supply side benefits

Supply side benefits provide benefits to manage the supply of water to the crop. The benefits include provision of a new source of water, devices for extraction of water, irrigation equipment for provision of water to crops etc. The benefits are thus provided in 4 stages. The supply side benefits include:

1) Well
2) Well Rehabilitation
3) Farm pond
4) Lining of farm pond
5) Electric/ Diesel pumps
6) Drip/ Sprinkler irrigation
7) Compartment bunding

The demand and supply benefits cover every aspect of crop water supply and demand.

4.7.3 Livelihood alternatives

The livelihood alternatives are provided to landless agriculture labourers in the village They include:

1) Goat rearing
2) Poultry
3) Honeybee rearing
4) Fishery
5) Vermicompost unit

4.7.4 Community benefits

Community benefits include watershed activities such as construction of Contour Nala Bunds, Contour Trenches, Percolation Tanks etc. These projects are undertaken in the village based on the water budget prepared.

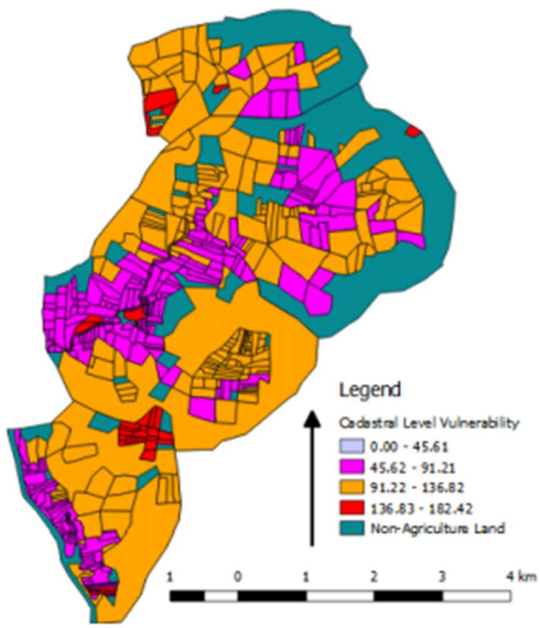
4.8 Water balance computation

Based on daily rainfall values, soil type, soil depth, and slope values the AET, PET, Run-off, Deficit and Groundwater Recharge for different crops is estimated. These values are estimated using the water budget app and plugin prepared for PoCRA. The deficit values are obtained by considering water requirement in different seasons, wilting point of crops, field capacity of soil etc. The graph below represents the seasonal deficit computation. The black lines represent the daily rainfall values. The area under yellow line represents the water requirement of the complete season. The area under the blue line represents the water taken up by the crop and the highlighted region depicts the deficit faced by the crop in terms of both quantity and time period.

7.1 Figure no. 5 Water balance computation

4.8.1 Farm level kharif vulnerability maps

Based on the deficit calculated for the different *gat* numbers, the kharif level vulnerability map is generated. The Kharif vulnerable zone model demarcates the stress zones by calculating the Kharif deficit at each point using inputs like LULC maps, soil, zones, cadastral maps, slope maps, daily rainfall data using a QGIS plugin. Back end inputs used in the plugin include reference crop properties like evapotranspiration, crop co-efficients, soil properties like percentage of sand, silt and clay, field capacity and saturation.The vulnerability maps are produced point wise, cadastral wise and zone wise.



4.1 Figure no. 6 Farm level kharif vulnerability map for Paradgaon for cotton crop

The map above represents the farmer level kharif vulnerability computation of the village Paradgaon. The colours represent different ranges of deficit for cotton. It is observed that there are some specific farms with very high deficit values for kharif crop.

4.9 Vulnerability, risk and climate resilience in the context of PoCRA

Vulnerability has been defined for by different uses based on the rapid changes in the environmental, economic and social systems. PoCRA focusses on the agriculture systems and views vulnerability as the chance of crop loss, reduced yield, lower return on investment etc. Vulnerability can be further divided into bio-physical and socio-economic vulnerability.

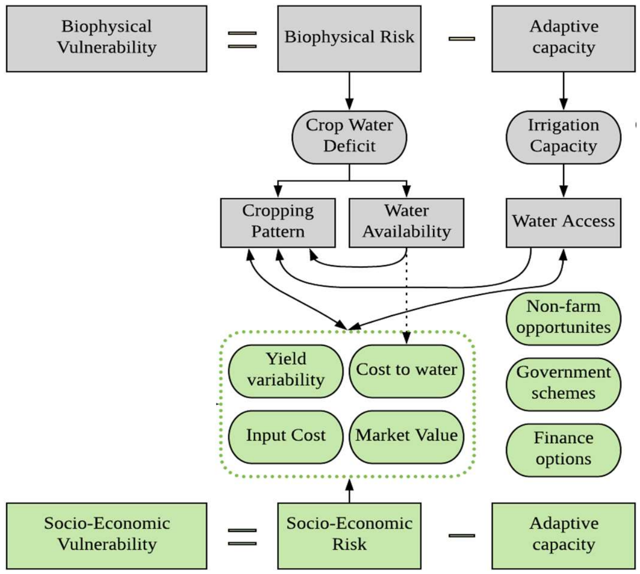
Reduced yield or crop loss is mainly due to the deficit faced by the crop. Bio-physical factors which lead to reduced yield or crop loss include soil type, soil depth, rainfall pattern, topographical features. While quantifying bio-physical vulnerability, it can thus be looked at as the deficit faced by the crop. Absolute effect of bio-physical parameters can be looked at as deficit. Deficit also provides an outcome based understanding of crop vulnerability.

While changing the scale from a crop to a farmer other than bio-physical parameters, various socio-economic parameters also come in play such as no. of family members, availability of loan, distance to market, distance to farm, level of education etc. Socio-economic vulnerability in the context of PoCRA affects crop choice, ability to irrigate crops, access to schemes etc. which in turn affect yield and economic returns. The economic returns of one crop cycle further change the economics of future crop cycles. Such an understanding of socio-economic vulnerability is more robust than the concepts used in literature. Socio-economic vulnerability is understood through real outcomes rather than on contextual indicators such as literacy rate, workforce participation ratio etc.

Vulnerability can be understood as the risk subtracted by the adaptive capacity of the system.

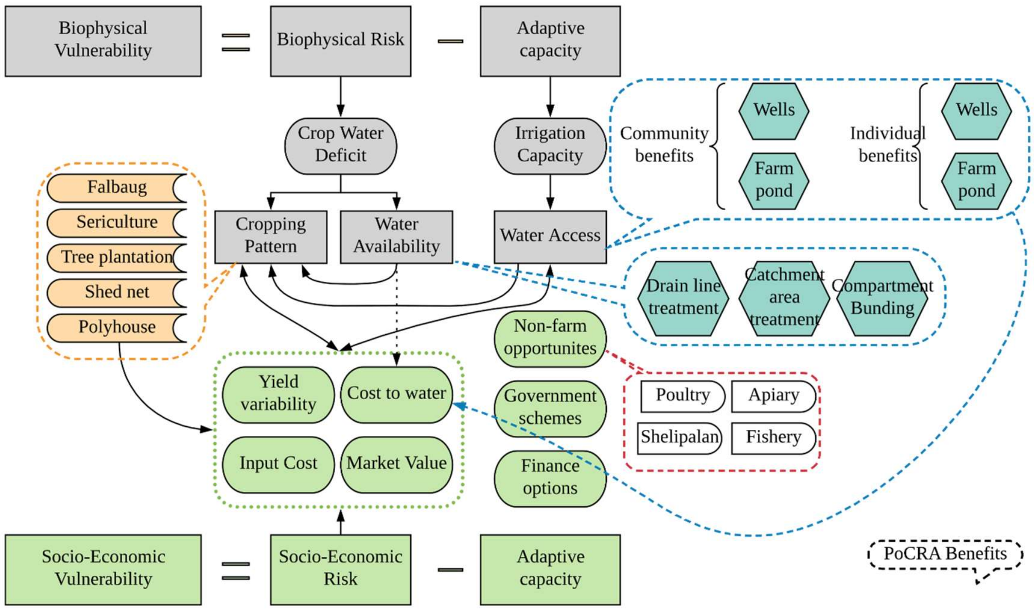
In this case, since vulnerability is understood in terms of bio-physical and socio-economic vulnerability, risk and adaptive capacity can also be understood separately.

Understanding bio-physical vulnerability as the deficit faced by the crop, the adaptive capacity will be the ability of the farmer to irrigate the crop. Understanding socio-economic risk as the varying economic returns, the adaptive capacity is the access to finance, non- farm employment opportunities, access to government schemes etc.



5.1 Figure no. 7 Vulnerability due to climate change

Climate resilience in the context of PoCRA is to reduce the bio-physical and socio-economic risks and increase the bio-physical and socio-economic adaptive capacity. PoCRA aims to increase bio-physical adaptive capacity through increased access to protective irrigation through provision of sources of water like well, farm pond etc. and through watershed activities. PoCRA aims to reduce bio-physical risk through changing cropping patterns using water balance prepared in the villages. PoCRA also aims at increasing socio-economic adaptive capacity through non-farm opportunities. PoCRA aims to reduce socio-economic risk by reducing input cost, cost to water, yield variability etc.



8.1 Figure no. 8 Climate resilience as per PoCRA

Chapter 5 Data Collection and Analysis

5.1 Field visits

Field visits were conducted as a part of this study to collect farmer data and to understand farmer vulnerability specific to the project area. Qualitative and quantitative interviews were conducted.

1) Paradgaon, Jalna – October, 2018

This visit was conducted to understand the execution of PoCRA in a village. A few farmer case studies were studied in detail. Data regarding cropping pattern was collected and a few qualitative interviews to understand different factors causing vulnerability were identified.

2) Yelda and Mamdapur, Beed – November, 2018

This visit was conducted to collect some socio-economic and cropping pattern data from farmers of different types in the villages. Interviews of PoCRA beneficiaries were also conducted. A VCRMC Committee meeting was attended to understand the functioning of the committee, *Krushi Mitra,* and *Krushi Sahayak.*

3) Pimpli Gavli and Janori, Buldhana – December 2018

Pilot survey for updated questionnaire including socio-economic information, cropping pattern, watering details, well details was conducted. Qualitative interviews of PoCRA employees and officials was conducted to understand the approval process for the different benefits provided in the project.

4) Yewati, Jalgaon - February, 2019

Data collection for monitoring and evaluation indicators and beneficiary prioritization. Hiware Bazaar was visited for a training program of *Krushi Sahayak*.

5) Dahigaon Purna, Amravati – April, 2019

Data collection for monitoring and evaluation indicators and beneficiary prioritization.

6) Warzadi and Divashi, Aurangabad – May, 2019

Visit to the NABARD Wadi cluster in Aurangabad to understand the functioning of the program 7 years after it was conducted.

7) Data from Wabgaon, Wardha; Tongaon, Aurangabad; Chapadgaon and Jalna; Tadmugli, Latur collected by TDSC students was used in computation of monitoring and evaluation indicators and beneficiary prioritization.

5.2 Data analysis

The data sources used in analysis are primary surveys conducted in field and village DPRs for water budget information. The data was used for different analysis mentioned below:

1) Crop level studies
    a. Understanding the effect of different parameters such as no. of irrigations, soil type, deficit faced by the crop, pest attacks on yield of different types of crops.
    b. Increase in marginal value of produce based on increasing yield different patterns such as no. of irrigations, soil type, pest attacks by studying input cost for different crops and their market value.

This helped understand the vulnerability associated with bio-physical parameters and crop choice as well.

2) Farm level studies
    a. Studying the different combinations of cropping patterns practiced, details regarding wells such as depth, temporal and quantitative availability of water, input cost for the entire farm, socio-economic information such as access to schemes, access to finance options, no. of family members, distance from farm etc.
    b. Budyko analysis to track and understand the movement of the farm over different years with respect to the cropping pattern and the rainfall in each year.
    c. Farmers were categorized into 3 types based on their cropping pattern and assessed separately.
3) Village level studies
    a. Budyko analysis based off data available from the village DPRs to understand the effect of the project on the village as a whole with respect to the changing cropping pattern, added watershed works and the rainfall in each year.
    b. Increase in different types of water storage.
    c. Variation in prices at the closest market for different crops.
    d. Beneficiary listing and associated problems

5.2.1 Questionnaire Design

The final questionnaire was based on pilot survey and qualitative interviews conducted. The data themes included in the questionnaire were:

1) Socio-economic information – total land, no. of family members, allied activities, loan information
2) Cropping pattern- watering information, yield data, market data, pest/ animal attacks, input costs
3) Asset information – Well/ borewell/ farm pond profiles
4) Sources of finance - loan details
5) PoCRA interventions

The collected data was analysed at farm and crop level. The questionnaire is attached in Annexure-1

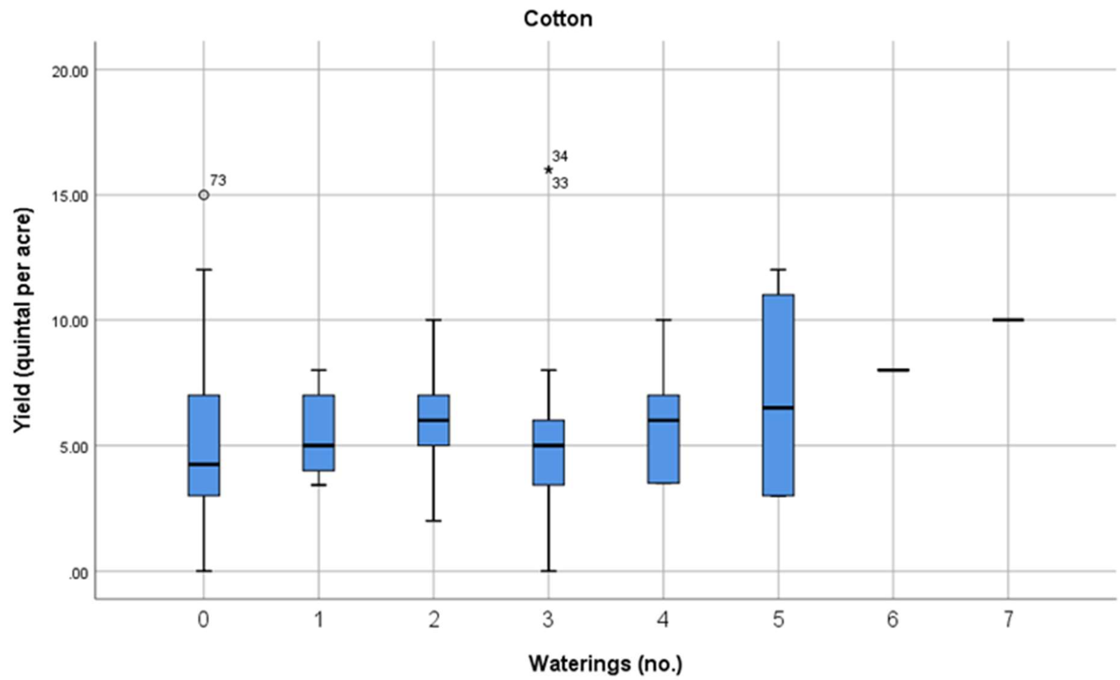
5.2.2 Crop level studies

5.2.2.1 Co-relation between socio-economic and bio-physical indicators

Bio-physical parameters affect the crop production in terms of yield generated. Yield fetches the market value and economical returns and is the connecting factor between bio-physical parameters and socio-economic parameters. Yield is dependent on many factors such deficit faced by crop, time and quantity of irrigation provided, pest attacks, animal attacks, crop variety etc.

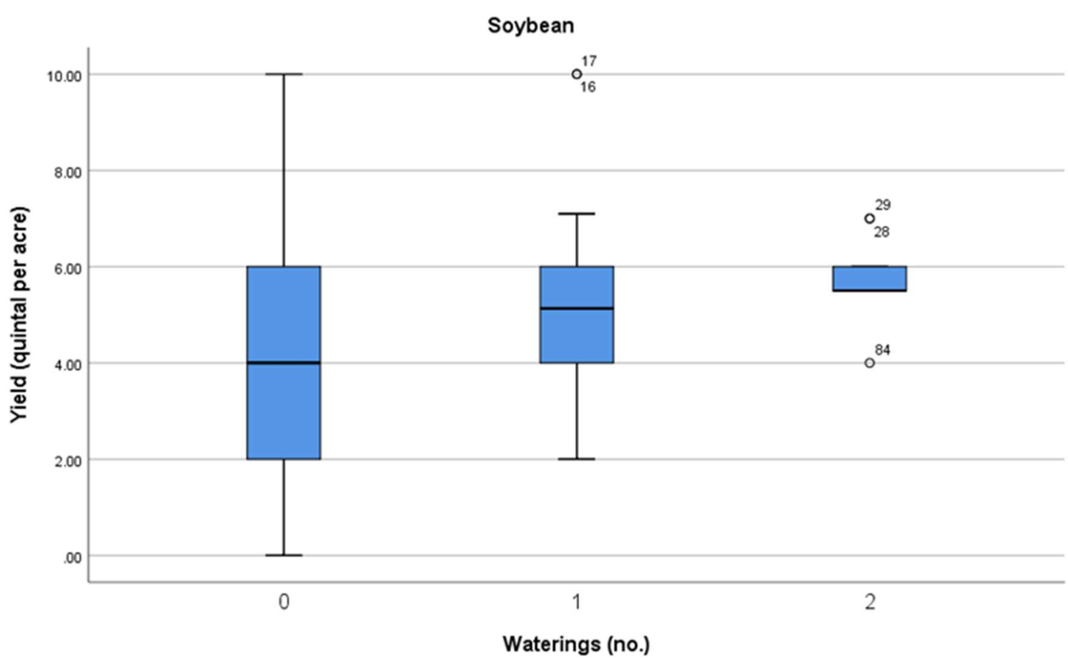
5.2.2.2 Variation of yield with number of irrigations

The yield of crops is seen to be varying with the number of irrigations. The box plot below depicts the changing yield in quintal per acre for cotton based on data collected from 6 villages for 81 respondents. A clear increase in the yield based on number of irrigations is not observed as the yield for cotton is also dependent on factors such cotton crop duration, number of pickings of the crop, pest attack on the crop etc.



6.1 Figure no. 9 Effect of yield on waterings - Cotton

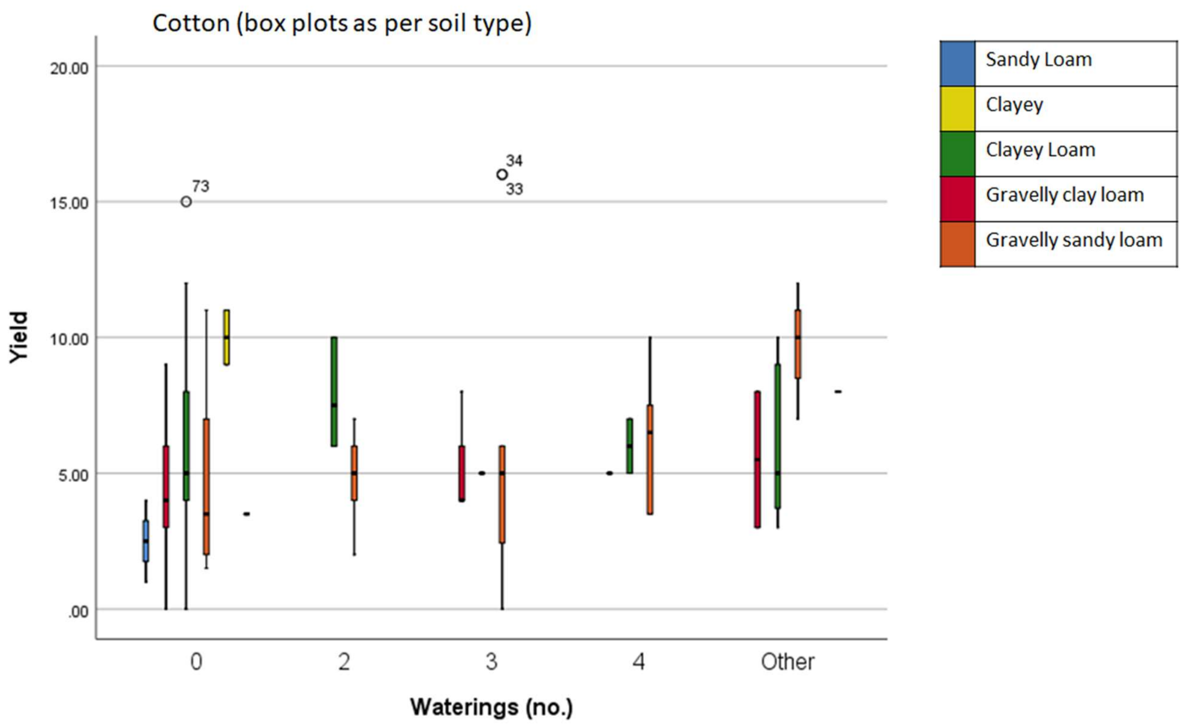
In the case of soybean, an increase in the average yield and a decrease in the variance of yield is clearly seen in the boxplot below. The box plot below depicts the changing yield in quintal per acre for cotton based on data collected from 8 villages for 121 respondents.



It is observed that the average yield is increasing with every irrigation and the range of yield reduces. Thus, the instances of crop loss can be seen to be reducing. Thus, a marginal value can be attributed to each irrigation provided to the crop.

5.2.2.3 Variation of yield with soil type

Soil type affects the deficit faced by crops. However, as the no. of irrigations increase, the effect of soil type on yield is seen to reduce as seen in the box plot below. The box plot is prepared for cotton based on data collected for 6 villages with 81 respondents.



Thus with the objective to increase farmer income it is necessary to ensure crop yields. Reducing variation in yield for different soil types and increased average yield can be observed with increasing no. of irrigations. Thus, making available protective irrigation during kharif is very essential.

5.2.2.4 Water productivity for different crops

Water productivity is measured as yield per cubic meter of water provided to particular crop. Water productivity for different crops is seen to be varying as per soil type, soil depth, number and time of waterings etc.

$$water\ productivity = \frac{yield\ (kg)}{Total\ water\ taken\ up\ by\ crop\ (Rainfall\ AET + watering\ AET)(m3)}$$

Where,

Yield in kg = weight of harvested grain in kilograms in 1 acre of land.

Water taken up by crop = water available to the plant as Actual Evapotranspiration due to rainfall computed through the water balance plugin + Extra watering provided to the plant as per irrigation type in m3.

Computation method:

Following are the inputs required for computation of water productivity through farmer survey:

1. Crop Name
2. Area under crop
3. Irrigation Type: rainfed/flood/drip/sprinkler
    a. For flood irrigation:
        i. Number of waterings provided
        ii. Date/ Month of watering
        iii. Approximate mm watering provided to farm
        iv. Number of days required to provide 1 watering
        v. Pumping time required in a day in hours

    Drip irrigation
        vi. Frequency of watering (number of times/days in a week)
        vii. Number of months irrigation is provided
        viii. Dripper flow rate
        ix. Number of drippers installed or spacing between drippers used to determine number of drippers in the area
        x. Number of hours of drip irrigation provided during one irrigation

    b. Sprinkler irrigation
        . Frequency of watering (number of times/days in a month)
        i. Number of months irrigation is provided
        ii. Number of sprinkler nozzles
        iii. Sprinkler flow rate

iv. Number of sprinklers installed or spacing between drippers used to determine number of sprinklers in the area
v. Number of hours per irrigation

Yield

Crop yield and watering information are the details required to compute water productivity. While some methodologies for yield computation look at biomass generated, and some others estimate yield based on harvest index of different crops, our proposed methodology looks at primary yield information. As yield is also affected by other factors like pest attack, animal attack which come into play on field and shift the measure. These factors need to be considered and adjusted for, while computation of water productivity index. This survey incorporates the inputs for external factors.

Calculation of extra watering provided

The amount of extra water given is computed in following manner for different irrigation types

1) Flood
2) Drip irrigation
3) Sprinkler irrigation

Watering given in mm:

Number of times soil was saturated with moisture through irrigation will be asked through questionnaire. This will then be used to estimate the total amount of watering given.

To elaborate further, number of times soil was saturated for that crop along with dates of irrigation will be fed into the farm level app to get the irrigation water consumed by plant that is its AET with watering.

2) Drip irrigation

The quantity of water provided to the crop is estimated by multiplying the number of drippers with the hours of use and the frequency of irrigation and number of months irrigation is provided. The water application efficiency for drip irrigation as recommended by FAO is 90% and is considered for calculations

$$\text{Watering (mm)} = \frac{(\text{Number of drippers} * \text{ flow rate of dripper (LPH)} * \text{ irrigation frequency (total no. of days)} * \text{irrigation hrs per day} * 90\%)}{\text{Total area(ha)} * 10\text{^}4}$$

Where -

Number of drippers = Total area (m^2) / Spacing between drippers (m^2)

If the farmer cannot provide details regarding the flow rate of the dripper, a flow rate of 8 lph is assumed.

3) Sprinkler irrigation

The quantity of water taken up by the crop is estimated through the number of sprinklers, sprinkler flow rate, hours of use, frequency of irrigation and number of months irrigation is provided. The water application efficiency for sprinkler irrigation as recommended by FAO is 75% which is considered for calculations

$$\text{Watering (mm)} = \frac{(\text{Number of sprinkler nozzels} * \text{ flow rate of sprinkler (LPH)} * \text{ irrigation frequency (total no. of days)} * \text{irrigation hrs per day} * 75\%)}{\text{Total area(ha)} * 10\text{^}4}$$

Where

Number of sprinklers = Total area(m^2) / Spacing between drippers (m^2)

If the farmer cannot provide details regarding the flow rate of the sprinkler, a flow rate of 715 LPH is assumed.

Example

The water productivity for different crops based on data collected from 5 different villages in Maharashtra Yelda, Mamdapur in Beed, Tadmugli, Latur, Yewati, Jalgaon and Wabgaon, Wardha is shown here. The total number of farmer samples collected were 192 and vilalges were visited during year 2018-19.

The results from the data are summarized in the table below

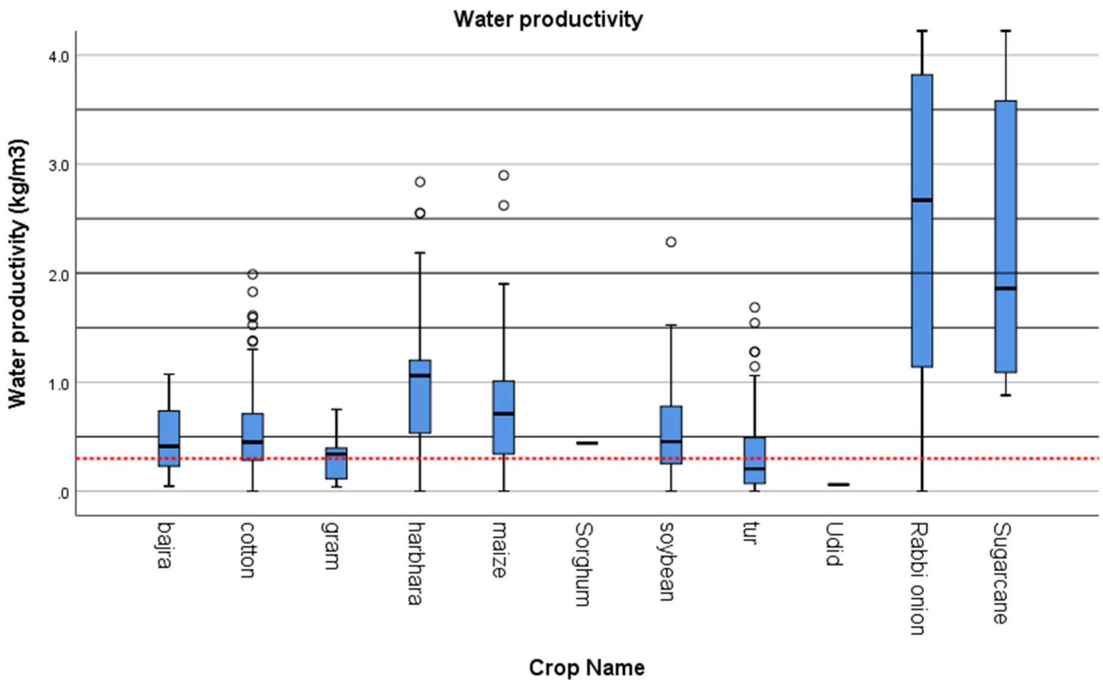
7.1 Table 5-1 Water productivity from primary survey of 5 villages

Crop Name	WP Range (kg/m^3)	WP Mean	WP std dev	Number of samples
Cotton	0.00-0.98	0.35	0.13	142
Tur	0.00-0.91	0.36	0.20	101
Sorghum	0.03-0.53	0.21	0.13	56
Soybean	0.00-0.80	0.36	0.17	85

The WP range is affected by the following parameters:

1) Soil type (primarily for rainfed agriculture)
2) Number of waterings
3) Pest/ Animal Attack (Based on the characteristics of the crop, ability to spray pesticide)
4) Last harvest (in case of crops like cotton)

The box plot below compares the water productivity for different crops and also shows the outliers. The red dotted line indicates the water productivity of 0.3 which was taken as a base value for comparison.



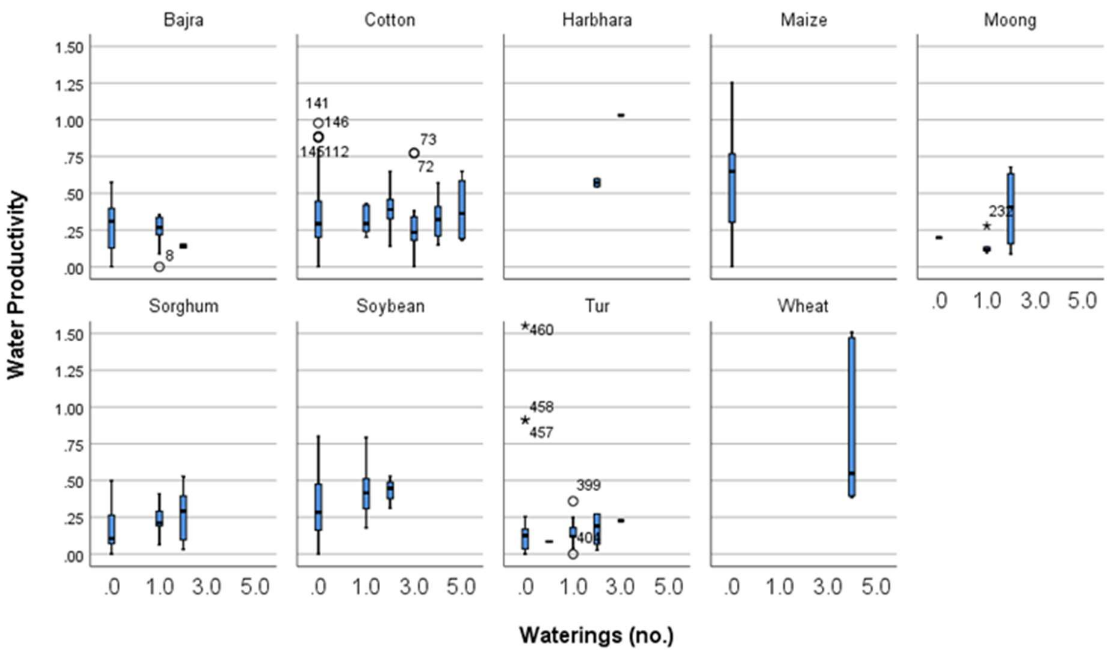
8.1 Figure no. 10 Water productivity for different crops

		Water productivity					
		Maximum	Mean	Minimum	Standard Deviation	Variance	Count
Crop_Name[b]	bajra	1.07	.48	.05	.34	.12	21
	cotton	1.29	.61	.00	.58	.34	173
	gram	.75	.29	.04	.22	.05	25
	harbhara	1.84	1.08	.00	.73	.54	82
	maize	2.90	.79	.00	.66	.43	79
	pomegranate	26.11	6.73	.00	6.84	46.74	15
	rabi_onion	5.32	2.67	.00	1.74	3.02	13
	rabi_wheat	4.36	.88	.00	1.10	1.20	35
	small_vegetables	26.30	7.85	.00	11.63	135.23	6
	sorghum	.74	.23	.07	.25	.06	22
	soybean	2.85	.80	.00	1.16	1.34	152
	Sugarcane	6.66	2.81	.88	2.40	5.75	5
	sweetlime	1.95	.22	.00	.65	.42	9
	tur	2.34	.74	.00	2.64	6.98	89
	udid	.20	.20	.20	.00	.00	8
	vegetables	3.88	1.03	.00	1.61	2.61	5

b. Analysis based on 2018 cropping pattern data for 6 villages namely Chapadgaon, Jalna, Dahigaon, Amravati, Tongaon, Aurangabad, Yewati, Jalgaon, Tadmugli, Latur and Wabgaon, Wardha

9.1 Figure no. 11 Water Productivity

The water productivity of the crops is seen to be varying with changing soil types and number of irrigations provided to the crop as is the case with yield. A slight increase in water productivity in most cases is observed. The graph below shows how the water productivity varies with varying number of irrigations for different crops.



1.1 Figure 5-1 Water productivity variation with number of waterings

It is observed that the average water productivity is increasing with every irrigation and the range of water productivity reduces. Thus, the instances of crop loss etc. reduce drastically. Water productivity is also highly dependent on changing soil types. It is observed that increasing number of irrigations provided reduces the impact of the soil type on water productivity.

Current studies use Aquacrop to estimate water productivity. Aquacrop estimates the yield of the crop considering the harvest index and the irrigations provided. The range estimated by the model is much smaller than the range estimated through primary survey. Following table provides a comparison of water productivity from this study and that from Aquacrop model.

1.1 Table 5-2 Comparative study with existing models in use (Aquacrop)

Crop	**WP range (Aquacrop) (kg/m3)**	**WP range computed from primary survey (kg/m3)**

Wheat	1.0-1.2 kg/m3	0.2-1.5 kg/m3
Rice	0.2-1.2 kg/m3	-
Cotton	0.49 to 0.54 kg/m3	0-1.2 kg/m3
Soyabean	1.2-1.6 kg/m3	0-0.8 kg/m3

5.2.2.5 Economic Productivity

While the water productivity can tell us about the yield and how it changes with extra water provided to crops and soil texture, it does not cover the price fluctuations in local markets and input cost behind the different crops. Economic productivity thus looks at the profit per amount of water utilised. This makes it possible to compare productivity of different crops effectively.

Economic productivity is defined as profit per m3 of water utilised.

$$Economic\ productivity = \frac{Profit\ per\ acre\ in\ Rs.}{Water\ taken\ up\ by\ the\ plant\ in\ m^3}$$

Where,

Profit per acre is estimated through primary data regarding input cost and market price received and Water taken up by an acre of the crop in m3 (Total AET with watering is used)

This is estimated with the same methodology in which water productivity is estimated.

The definition for input cost varies from author to author depending on the kind of use being made of economic productivity. For the calculation of MSP in India, the following format is used for computing input cost. The input cost data collected through primary surveys is the actual cost incurred by the farmers and not computed cost.

2.1 Table 5-3 Input cost for MSP calculation

Sr.	Cost items	Considered during computation
1	Operational Cost	
1.1	Human Labour	
1.1.1	Casual	Yes

1.1.2	Attached	Yes
1.1.3	Family	
1.2	Bullock Labour	
1.2.1	Hired	Yes
1.2.2	Owned	
1.3	Machine Labour	
1.3.1	Hired	Yes
1.3.2	Owned	
2	Seed	Yes
3	Fertilisers	Yes
4	Manure	Yes
5	Pesticides/ Insecticides	Yes
6	Irrigation charges	Yes (if water purchased from elsewhere)
7	Interest on working capital	
8	Miscellanous	
9	Rental value of owned land	
10	Rent paid for leased-in land	
11	Land revenue, cesses and taxes	
12	Depreciation on implements and farm buildings	
13	Interest on fixed capital	

Additional parameters included are transport cost to market.

The economic productivity varies based on the following factors:

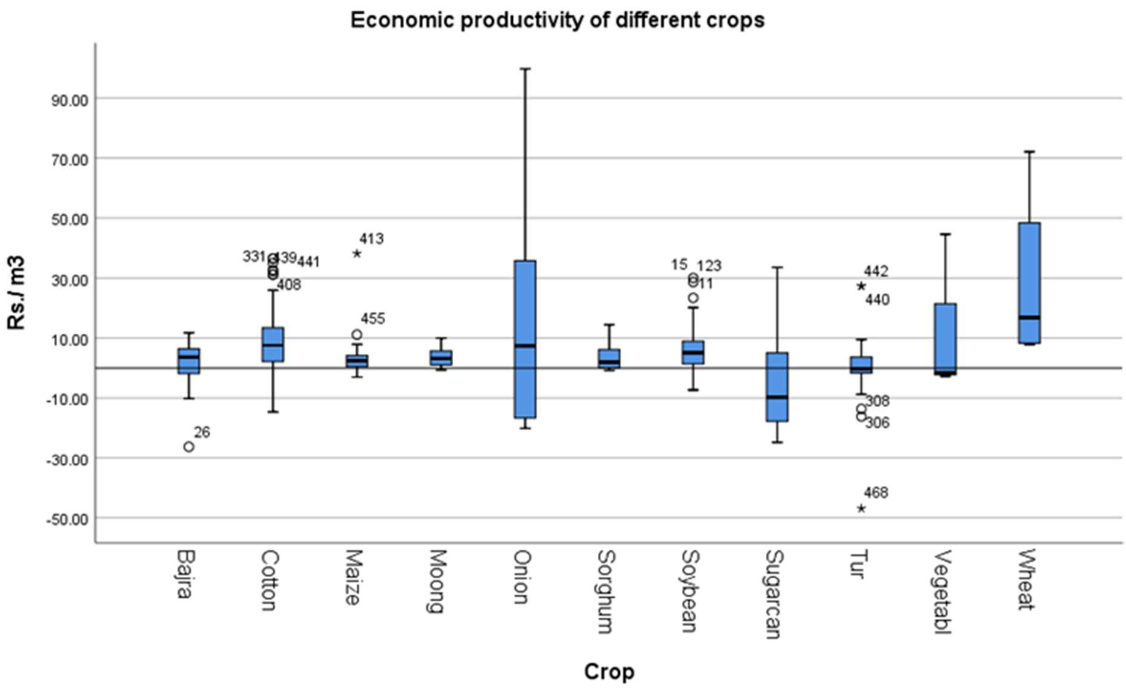
Fluctuating market prices

Water productivity

Varying input costs

The indicator is thus indicative of varying and rising input costs in different areas for different crops and fluctuating market prices for different crops.

The graph below shows the varying economic productivity of different crops.



1.1 Figure 5-2 Economic productivity for crops – study in 5 villages

The economic productivity of different crops shows that for crops such as onion and sugarcane the market prices are such that the crop is many times unviable. Whereas crops such as tur, soyabean, bajra, sorghum, maize etc. have stable yields and market rates with a smaller variation in the prices observed. The market values vary from place to place and on a daily basis highly.

5.2.3 Farmer case studies

Vulnerability that a farmer faces due to climate change can be attributed to certain bio-physical characteristics such as soil type, rainfall pattern, land slope, distance from stream, access to water etc. and certain socio-economic characteristics such as household income, family size, land holding, distance of home from farm, distance of market from farm etc. Farmer vulnerability affects cropping pattern decisions, yield of crops, market price received, availability of loans etc.

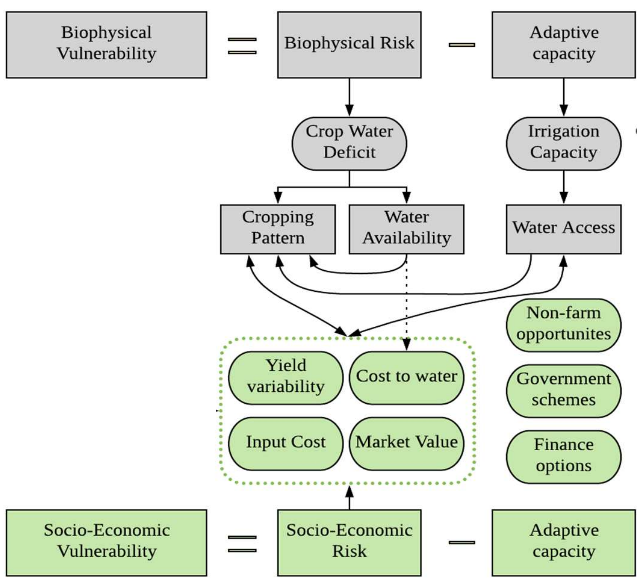
As per literature, vulnerability can be looked at as risk subtracted by the adaptive capacity.

Vulnerability = Risk – Adaptive capacity

Vulnerability can also be divided into two types; bio-physical vulnerability and socio-economic vulnerability. Bio-physical risk explains the risk faced by the farmer due to irregular rainfall, access to water, soil type, cropping pattern, land slope etc. These parameters are incorporated while calculating the deficit faced by the crop. Bio-physical risk is the deficit faced by the crop which explains the risk of crop loss due to only the bio-physical parameters.

The bio-physical adaptive capacity thus becomes the way to reduce deficit. This includes provision of protective irrigation and can be looked at as the capacity to meet deficit through irrigation.

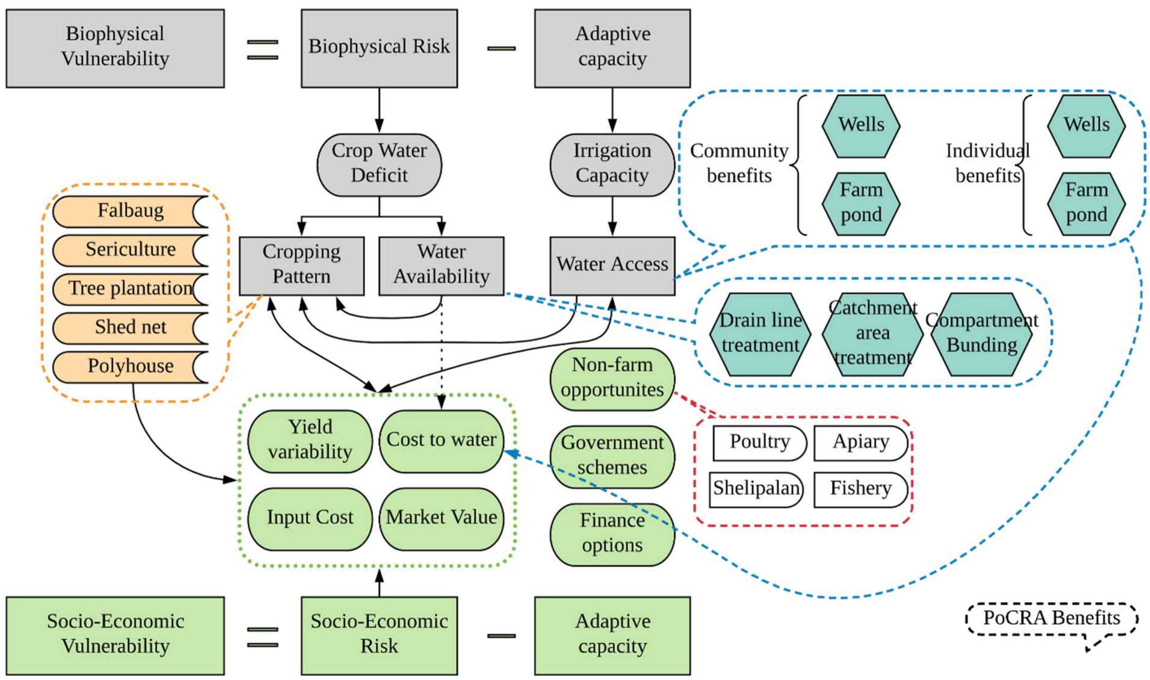
Socio-economic risk can be due to the input cost to the crop, varying market values available, varying yields, the cost of provision of additional water and other parameters which affect economic returns from the crop. The adaptive capacity in this case is through government schemes and programs, finance options, non-farm opportunities etc.



9.1 Figure no. 12 Bio-physical and Socio-economic Vulnerability

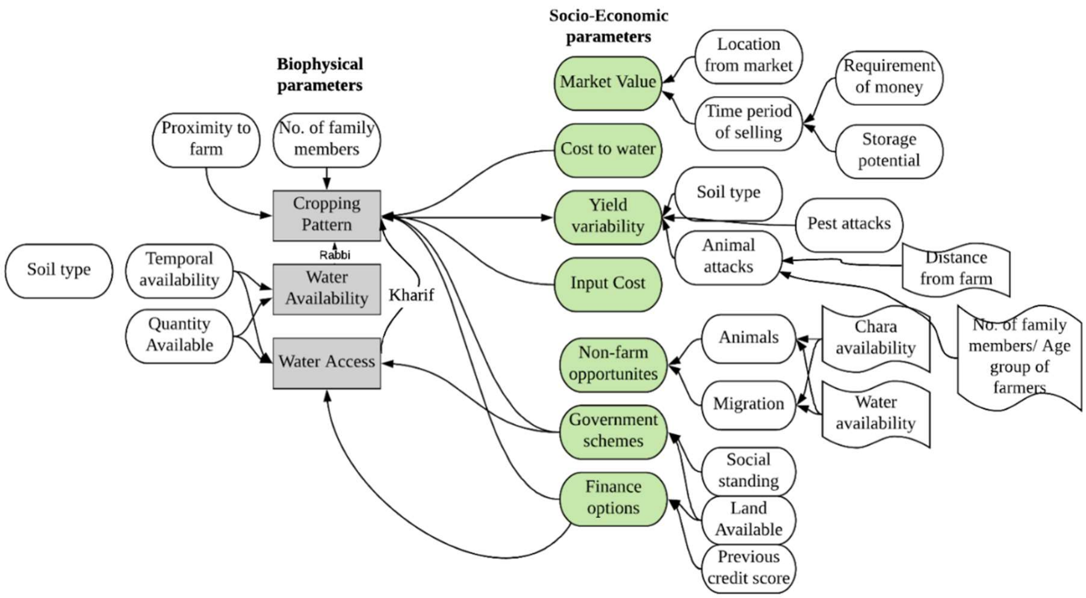
Further an interdependence is seen between the socio-economic and the bio-physical vulnerability. The bio-physical vulnerability is dependent on cropping pattern which is highly dependent on socio-economic vulnerability. The water availability is dependent on cost to water.

PoCRA addresses both the bio-physical and socio-economic vulnerability through various community interventions and individual benefits. It improves water availability through watershed development works in the village. It improves water access through provision of supply side benefits such as wells, farm ponds, irrigation systems etc. It aims to change cropping pattern by reducing the input cost to crops. It improves the adaptive capacity through subsidies and non-farm opportunities.



10.1 Figure no. 13 Vulnerability and PoCRA

The parameters affecting risk and adaptive capacity can further be divided into multiple parameters such as migration acting as an adaptive capacity during crop loss or yield variability depending on soil type, pest attacks, animal attacks, irrigation provided etc. The parameters affecting risk and adaptive capacity are mapped out as shown in the figure below.

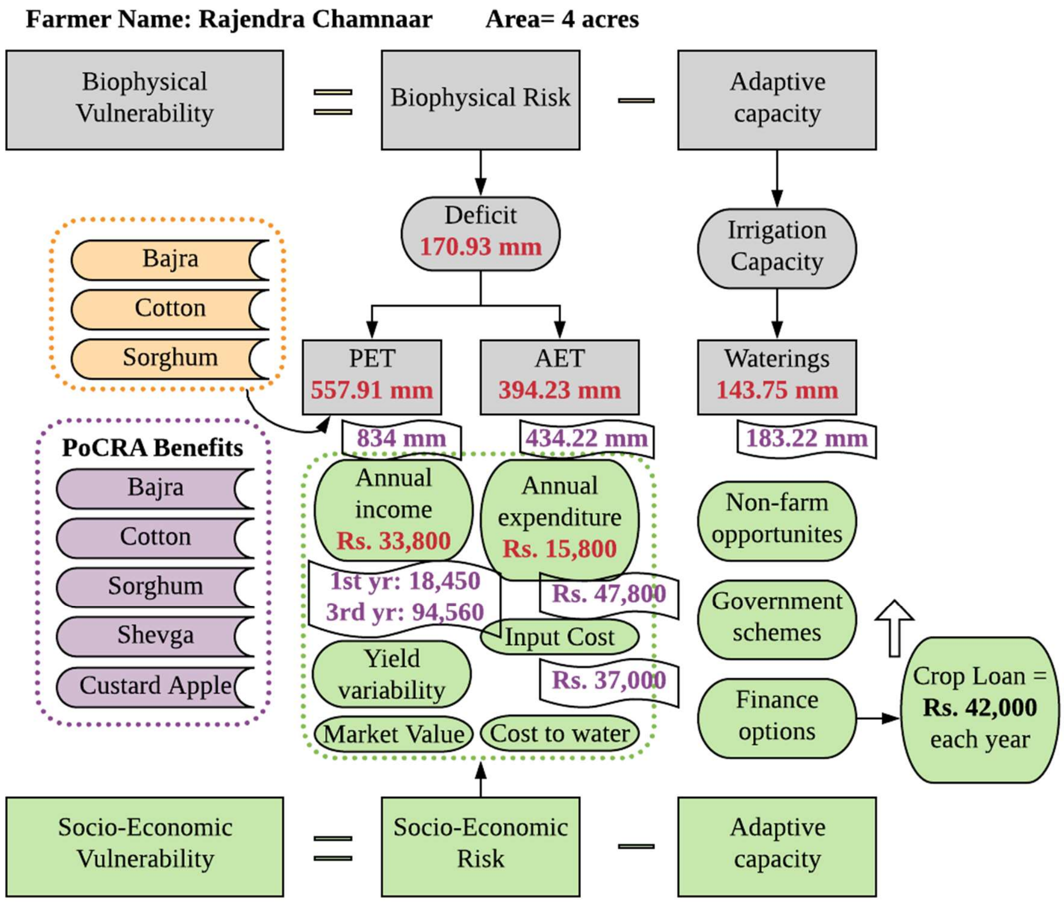


2.1 Figure no. 14 Parameters affecting bio-physical and socio-economic vulnerability

5.2.4 Farmer case studies

Data regarding current and previous year cropping patterns, irrigation details, socio-economic parameters used to define bio-physical risk and vulnerability were collected to build farmer case studies for different kinds of cropping patterns and different kinds of assets. This helped understand the pre-requisites for different cropping patterns and assets.

1) Case study 1



3.1 Figure no. 15 Case Study Rajendra Chamnaar

The diagram above depicts the case of Rajendra Chamnaar. The values in red are the deficit, income and expenditure values of the farmer before the PoCRA intervention. The PoCRA intervention led to the farmer changing his cropping pattern and adding horticulture crops like *Shevga* and Custard Apple. The annual expenditure increased from Rs. 15,800 to Rs. 47,800 of which Rs. 37,000 was the cost of the additional water required. The income in the first two years after the crop change reduced to almost half the original income but in third year was close to Rs. 1 lakh. The farmer was able to take up this bio-physical risk of increasing deficit due to his higher socio-economic adaptive capacity.

2) Case study 2

Farmer name: Yamunabai Dhawale

Location: Away from stream

Family size: 9

Alternate sources of income: None

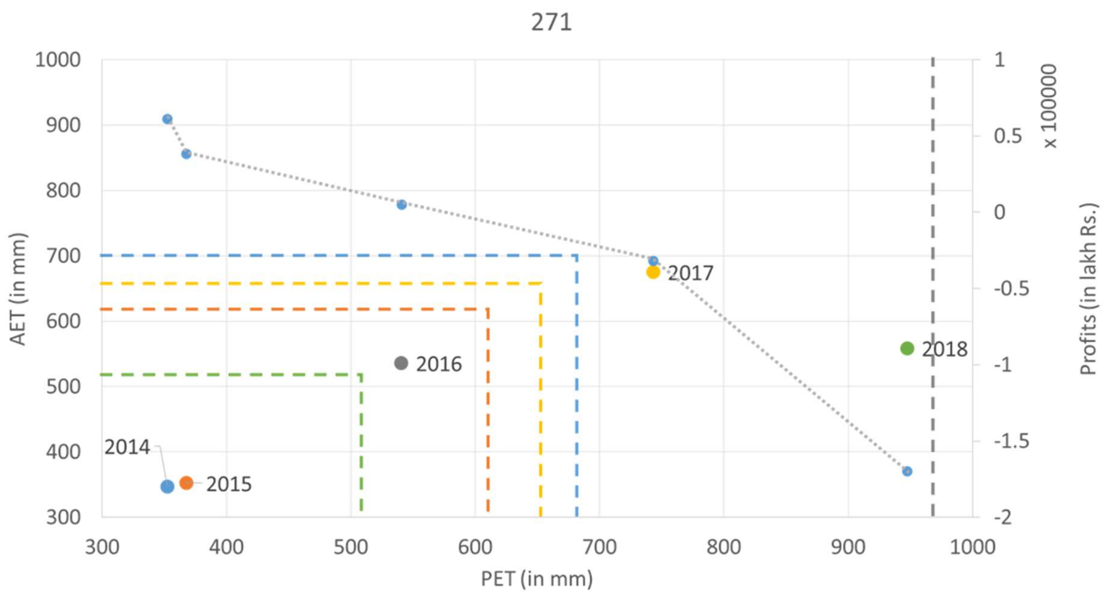
1.1 Table 5-4 Case study

	2017	**2018**	**Cropping pattern in 2017**				**Cropping pattern in 2018**			
Assets	**Well water available**	**Well water available**	**P1 requirement**	**P2 requirement**	**P3 requirement**	**Deficit**	**P1 requirement**	**P2 requirement**	**P3 requirement**	**Deficit**
1 well	162.07	89.03	141.83	353.37		**32.54**	564.47	110.32		**388.61**

Asset details: Well which generally lasts all year. In October 2018, the well depth was 3 feet and was expected to dry up by November end.

Cropping pattern: Soyabean and Lemon taken in 2017. Soyabean, Custard Apple, Lemon and Jaam taken in 2018. Lemon was planted in 2016. Before 2016, Soyabean, Tur, Cotton were the common crops.

The farmer had a deficit of 32.54 mm in 2017. The change in cropping pattern in 2018 caused the deficit to increase to 388.61 mm. The cropping pattern has been changed to include a lot of area under P1 crops. The farmer aims to water atleast the Custard Apple and Lemon using a tanker. Considering the deficit requirement of Custard Apple and Lemon, atleast 102 tankers of 10,000 litre capacity over 6 months. Each tanker costs Rs. 400-500 in the earlier months and the cost goes on increasing to Rs. 700 in the summer months.



The dotted line represents the rainfall and the natural limit for AET and PET in different years. The point of the same colour represents the cropping pattern sown. It was observed that in 2017 and 2018, the cropping pattern change increased the PET much more than the natural limit of rain. While some of it was met through irrigations, PET was not met. The blue points represent the profits in different years on the right axis. It can be seen that with changing cropping patterns and increased bio-physical risks, socio-economic risk also increases.

5.2.4.5 Farmer category based income variability

Annual farm income is computed for the farmers based on input cost and market price for different crops as reported by the farmers.

1.1 Table 5-5 Range of farm income in surveyed villages

Range	Yewati	Tadmugli	Wabgaon	Dahigaon	Tongaon	Chapadgaon
<-10000	3	0	6	0	2	4
-10000-(-5000)	4	0	7	1	1	3
-5000-0	2	2	4	5	2	3
0-5000	8	3	8	5	2	5
5000-10000	2	3	4	4	5	5
10000-20000	1	3	2	6	4	2

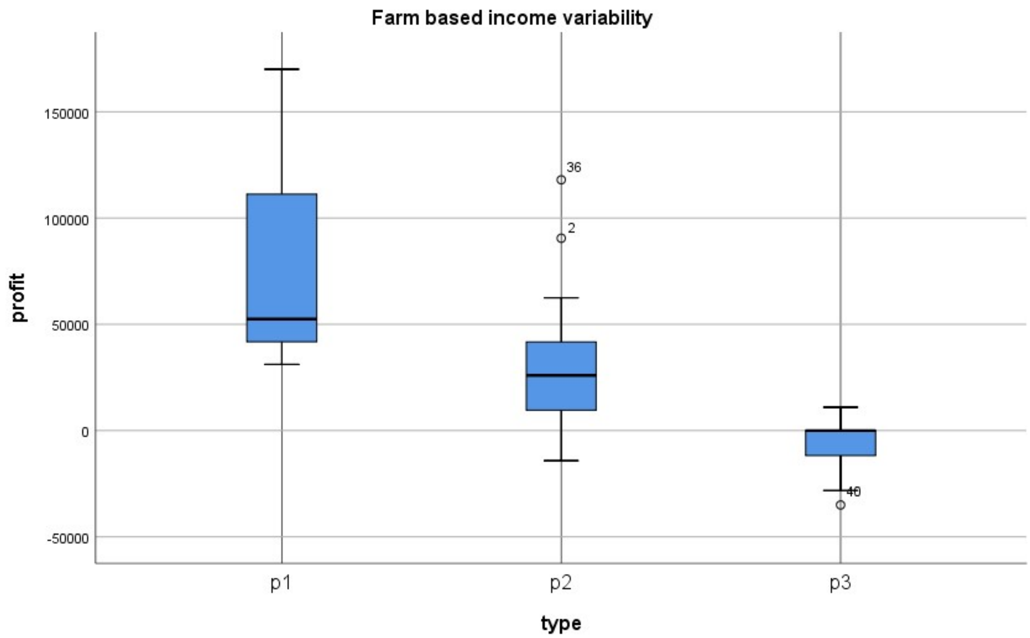
Range	Yewati	Tadmugli	Wabgaon	Dahigaon	Tongaon	Chapadgaon
>20000	1	2	1	6	2	4

The table above shows the range of annual farm income for different farmers in 6 villages. It can be seen that the range is highly varying. The loss-making farmers are due to crop loss and also due to annual horticulture crops. It is necessary to distinguish between the two and thus farmer category needs to be looked at.

Farmers were categorized into 3 types based on their cropping pattern.

1) P1 category farmers- Farmers with annual crops such as pomegranate, sweetlime etc. These are the crops which receive the first priority while providing irrigation. These farmers would generally have access to water through multiple sources all year round. Most of the farmers in this category were observed to rely on tanker water provision during the summer months.
2) P2 category farmers- Farmers with crops which were irrigated atleast a few times. This includes crops like cotton, tur, soybean etc.
3) P3 category farmers- Rainfed farmers were included in this category. These farmers do not have any source of irrigation. These farmers generally sowed crops like sorghum, soybean, cotton, tur, maize etc.

The reason to study the 3 types of farmers separately is because the reasons for vulnerability and losses are different for each category. P1 farmers need to provide irrigation all year long, require heavy investments and do not earn profits till the fruit bearing period begins which induces a huge amount of risk. P2 farmers are able to provide irrigation but may not be able to meet the deficit faced by the crops. They face risks due to pests and animal attacks and



11.1 Figure no. 16 Farm based income for different farmer categories

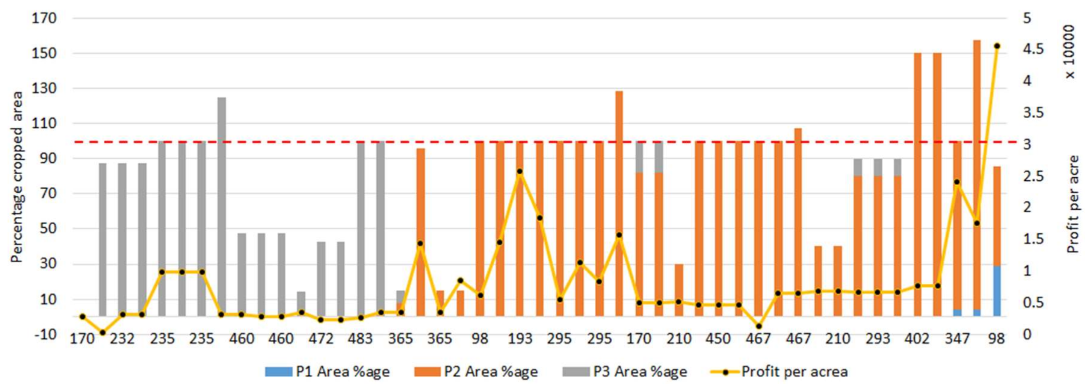
fluctuation of market prices. P1 farmers are not able to provide protective irrigation and are entirely dependent on the rainfall patterns in the area.

1.1 Table 5-6 Average profit across categories for study in 6 villages

Farmer category	Tadmugli	Wabgaon	Yewati	Dahigaon	Tongaon	Chapadgaon
P1		-6179	-8666	-2425		-3524
P2	3834	2132	8236	6123	7542	8348
P3	1277	2283	7222	3425	1253	3521

5.2.4.6 Reflection of cropping pattern in economic stability of farmers

The percentage area under P1, P2 and P3 crops affects he profit per acre of farmers substantially. The graph below shows the profit per acre for different farmers with different proportions of area under different cropping pattern.



2.1 Figure no. 17 Profit per acre versus crop type

5.2.4.7 Water Access on Farms

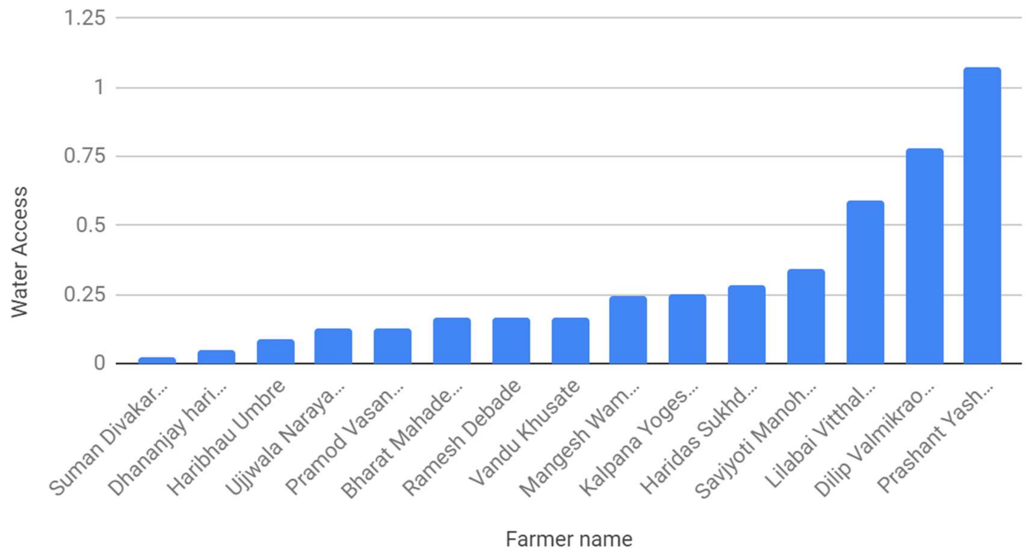
The ratio of water access on farm in mm to total deficit in mm gives an idea about the amount of deficit the farmer could cover through irrigation. It is dependent on both cropping pattern, rainfall pattern and capacity of well.

The total deficit is computed using the plugin deficit values for the particular gat number collected through the farmer survey for different crops multiplied with respective crop areas.

$$Total\ deficit\ in\ mm = \frac{Crop\ 1\ Area \times Deficit\ for\ crop\ 1 + Cro\ \ 2\ Area\ \times Deficit\ for\ crop\ 2 \ldots + Crop\ n\ Area \times Deficit\ for\ crop\ n)}{Total\ Crop\ Area}$$

The water access on farm is computed through irrigation information collected through the farmer survey and AET as per the plugin.

The graph below shows the comparison between farmers of Wabgaon, Wardha on ratio of water access to total deficit. The farmers with low ratio have a high water consuming cropping pattern



1.1 Figure 5-3 Water access ratio – Farmerwise

5.2.5 Village level studies

5.2.5.1 Analysis of village DPR

The village DPRs contain information regarding the village cropping pattern, storage potential of the village, proposed new structures in the village, water budget and proposed cropping pattern based on the water budget. The DPR also has other general information such as demographic information, details regarding FPOs, maps etc.

1.1 Table 5-7 Paradgaon Water Balance

	Rainfall - 435 mm	**2016**	**2017**	**2018**
Monsoon Water Balance (TCM)	Protective Irrigation Requirement	**5136**	**5122**	**5602**
	Impounded Run-off	429	429	429
	Ground Water Available for Kharif	35.5	37	37
	Monsoon Water Balance	**-4528**	**-4536**	**-5136**
Post-monsoon Water Balance	Post-monsoon requirement	**7356**	**7501**	**8061**
	Drinking Water requirement	159	159	159
	Impounded Run-off available after monsoon	112	122	102

	Ground Water Available Post Monsoon	45	42	74
	Soil Moisture	352	368	354
	Post-monsoon water balance	**-6985**	**-7132**	**-7362**

The current water balance is seen to be aggregate negative for all three years with the deficit increasing due to changing cropping pattern to annual crops.

5.2.5.2 Market prices study for Partur and Jalna APMC

2.1 *Table 5-8* Market prices for Partur and Jalna APMC

Crop	Average modal wholesale market rate in Partur / Jalna APMC	Std dev of modal price distribution	Mean of daily price spread	Mean price spread as % of mean price	Crop water requirement (mm)	Output (Rs. Per cu.m.)
Cotton	Rs. 4367	16%	Rs. 1108	25%	700-800	Rs. 10
Tur	Rs. 3894	7%	Rs. 477	12%	575-625	Rs. 7.5
Soyabean	Rs. 3227	8%	Rs. 315	9%	350-400	Rs. 14
Wheat	Rs. 1670	14%	Rs. 171	10%	500-525	Rs. 9
Jowar	Rs. 1674.90	20%	Rs. 233	14%	400-450	Rs. 5
Sweetlime	Rs. 3125	21%	Rs. 1875	60%	1600-1800	Rs. 38

The table above shows the variation in prices temporally for different crops in Jalna or Partur APMC. The variation is seen based on the crop season and the time period during which the amount of crop coming to the APMCs is the most. The price spread for cotton is high due to the difference in cotton grade and also due to pest attacks. If a pest attacks all the farms in a particular area a higher price is seen in that year/ season. The price spread for sweetlime is very high due to the crop season in which the crop is taken to market. In many cases, the sweetlime does not even reach the farms due to unavailability of irrigation water.

5.2.6 Dependencies of different PoCRA benefits

Different PoCRA benefits have different requirement to function as intended on field. The table below lists the different dependencies of different benefits in the project.

3.1 Table 5-9 Dependencies of different PoCRA benefits

Sr.	PoCRA benefits	Dependencies
1.	Horticulture	Availability of water, shorter distance to farm, larger family sizes
2.	Sericulture	Availability of water, shorter distance to farm, larger family sizes, ability to have a large initial investment
3.	Tree plantation	Ability to maintain the trees from animals in the beginning- distance from farm
4.	Shade-net	Availability of water, large initial investment required
5.	Polyhouse/ Polytunnel	Availability of water, large initial investment required
6.	Well	-
7.	Well rehabilitation	Well
8.	Farm pond (Run-off based)	Land availability, certain soil types are ideal for run-off based farm ponds such as yellow soil in the saline belt of PoCRA
9.	Groundwater based farm pond	Well
10.	Lining of farm ponds	Large initial investment required
11.	Drip/ Sprinkler irrigation	Well
12.	Electric/ Diesel Pumps/ Pipes	Well

Chapter 6 Monitoring and Evaluation Framework

The M&E framework has been carefully designed to cater to critical requirements such as longitudinal tracking of project outcomes, fair representation of ground conditions and, even and equitable coverage at taluka and revenue circle level. The indicators defined are mainly outcome based progress indicators to monitor the project.

6.1 Project Outcomes and Key Performance Indicators

The main purpose of M&E framework is to measure the impact of project activities through various crop, farmer and village level indices. PoCRA has defined a Result Management Framework for same which provides a list of indicators at various levels. Five of these have been identified as Key performance indicators for the project. The table below provides a mapping of these KPI's with Result Framework indicators (RFI) along with measurement level and tools used for measurement in our M&E framework. This framework caters to the limited water budget related Result Framework indicators which are illustrated in the table below.

1.1 Table 6-1 Monitoring and Evaluation Indicators and Result Framework Indicator

Sr. number	Selected Result Framework indicator (RFI)	Key Performance Indicators	M&E indicator level	Tools used
1	RFI1: Climate Resilient Agriculture: Farmers adopting improved Agricultural technology	KPI5: Farmers reached with agricultural assets or services by gender	Village Level	DBT database
2	RFI2: Improved water use efficiency at Farm level	KPI1: increased water productivity at Farm level	Crop level for 3 main kharif crops	Farmer survey

3	RFI4: Profitability – Annual Farm Income	KPI4: Farm income by Gender	Farm level	Farmer survey
4	RFI5: Direct Project Beneficiaries	KPI5: Farmers reached with agricultural assets or services by gender	Village Level	DBT database
5	RFI6: Climate Resilient Agriculture – improved yield uniformity and stability	KPI2: Improved yield stability across space and time	Crop Level and Village Level	Farmer Survey
6	RFI7: Climate resilient Agriculture – Improved Availability of water for Agriculture	Storage capacity at Village level Water Access at farm Level	Village Level and Farm Level	MLP water Budget dataset DPR dataset

Source: PoCRA PIP Manual, PoCRA PAD Manual

6.2 Key Performance Indicators

Project on Climate Resilient Agriculture was envisaged with an objective to enhance climate resilience and profitability of smallholder farming systems in project area. With this in view, a concrete village level micro planning process was designed and implemented to address on farm water security and reduce risks associated with inter and intra seasonal climate variability. Water balance played a critical role in this process by allowing estimation of farm level vulnerability and climate stress based on geo-physical and agricultural characteristics of village.

The project strategized increasing the surface water storage capacity, ground water recharge and in situ water conservation to increase farm productivity and income. Based on these objectives and strategies it became imperative to measure the benefits of project that it targeted to achieve. These project outcomes are to be estimated at-

1) Crop level
2) Farm level
3) Village level

Key performance indicators (KPI) to be monitored for outcome assessment have been identified for this purpose which include –

1) Increased water productivity at farm level
2) Improved yield stability across space and time
3) Net greenhouse gas emissions
4) Farm income by Gender
5) Farmers reached with agricultural assets or services by gender

The indicators identified by World Bank to monitor the project are shown in the table below. However, these indicators are not comprehensive and a few indicators need to be added to bring greater meaning to the KPI. The indicators suggested are illustrated in the table below. The indicators suggested in the document cater to the water related project development objectives. The data requirement for the proposed indicators is also mentioned in the table below.

1.1 Table 6-2 PDO level indicators, proposed indicators and data source

PDO Level Indicator	**Proposed indicators**	**Data source**
PDO 2) Climate resilient agriculture: Improved water use efficiency at farm level (Area provided with new/improved irrigation or drainage services (in ha)) **KPI 1**	Water productivity (crop level)	Farmer survey
	Economic productivity (crop and farm level)	Farmer survey
	Budyko point	Farmer survey

PDO 4) Profitability: Annual farm income (Farm income comparator (as ratio with/ without farm income) between beneficiaries and non-beneficiaries) **KPI 4**	Annual farm income for P1 category farmers (beneficiary and non-beneficiary)	Farmer survey
	Annual farm income for P2 category farmers (beneficiary and non-beneficiary)	Farmer survey
	Annual farm income for P3 category farmers (beneficiary and non-beneficiary)	Farmer survey
PDO 5) Direct project beneficiaries (Number of farmers reached with agricultural assets or services (% of female)) **KPI 5**	Number of farmers using drip/ sprinkler for the first time.	Farmer survey
	Number of farmers provided horticulture benefit upto year 1, year 2 and year 3.	DBT (Village level)
	Number of farmers provided with polyhouse/ polytunnel	DBT (Village level)
	Number of farmers provided with farm pond- GW based/ run-off based	DBT (Village level)
	Number of farmers provided with plastic sheet for farm pond	DBT (Village level)
	Number of farmers going for sericulture	DBT (Village level)
	Number of villages covered amongst number of villages where provision of wells is possible.	
PDO 6) Climate resilient agriculture: improved yield uniformity and stability (Spatial and temporal yield variability for crop A (std. deviation of avg. yield in kg/ha))	CV for yields of different crops for rainfed and irrigated	Farmer survey, Plugin output

KPI 2		
PDO 7) Climate resilient agriculture: Improved availability of water for agriculture (Surface water storage capacity from new farm ponds (in 1,000 m3)) **(KPI 1 and 2)**	Ratio of water access on farm in mm to total deficit in mm Ratio for water access on farm in mm to total deficit for P1, P2 and P3 category crops Area under P1/ P2/ P3 crops	Farmer survey Village level (DPR)
	W1/ W2/ W3 water access in mm	Farmer survey (farm level), DPR (village level)
	Last watering month	Farmer survey

The bio-physical productivity indices are mapped to PDO 2 or KPI 1 concerning water use efficiency. Economic indicators are mapped to PDO 4 and KPI 4 consisting of profitability. PDO 5 and KPI 5 are linked to project benefits. Climate resilience indicators on yield variability become a part of PDO6 or KPI 2 whereas water access indicators become part of PDO 7 and, KPI 1 and KPI 2.

Each of these indicators has a different measurement mechanism depending on scale of indicator – Village, Farm or Crop. Farmer survey in selected villages at baseline, midline and endline will be required to estimate crop and farm level indicators whereas the village level indicators may be computed based on the DBT, water budget and DPR datasets. The list of the village, farm and crop level indicators, the PDO and KPI they cater to and data source is given in the table below.

1.1 Table 6-3 List of indicators

Indicator Code	Indicator	PDO	KPI	Data Source	Frequency
Village Level Indicators					
V1.	Number of farmers using drip/ sprinkler for the first time.	5	5	MIS/DBT	Annual
V2.	Number of farmers provided horticulture benefit upto year 1, year 2 and year 3.	5	5	MIS/DBT	Annual
V3.	Number of farmers provided with polyhouse / polytunnel.	5	5	MIS/DBT	Annual
V4.	Number of farmers provided with farm pond-GW based/ run-off based	5	5	MIS/DBT	Annual
V5.	Number of farmers provided with plastic sheet for farm pond	5	5	MIS/DBT	Annual
V6.	Number of farmers going for sericulture	5	5	MIS/DBT	Annual
V7.	Budyko point*	2	1	DPR	Annual
V8	W1/ W2/ W3 water access in mm*	7	1&2	DPR	Annual
V9	Area under P1/ P2/ P3 crops*	7	1&2	DPR	Annual
Farm Level indicators					
F1	Economic productivity*	2	1	Fixed frame and variable frame farmer survey for beneficiary and non-beneficiary	Annual

Indicator Code	Indicator	PDO	KPI	Data Source	Frequency
F2.	Budyko point*	2	1	Fixed frame and variable frame farmer survey for beneficiary and non-beneficiary	Annual
F3	Ratio of water access on farm in mm to total deficit in mm*	7	1&2	Fixed frame survey for beneficiary	Annual
F4	Annual farm income for P1 category*	4	4	Fixed frame survey for beneficiary and non-beneficiary	Annual
F5	Annual farm income for P2 category farmers*	4	4	Fixed frame survey for beneficiary and non-beneficiary	Annual
F6	Annual farm income for P3 category farmers*	4	4	Fixed frame survey for beneficiary and non-beneficiary	Annual
F7	Ratio for water access on farm in mm to total deficit for P1, P2 and P3 category crops*	7	1&2	Fixed frame survey for beneficiary	Annual
F8	Last watering month*	7	1&2	Fixed frame and variable frame farmer survey for beneficiary and non-beneficiary	Annual
F9.	W1/ W2/ W3 water access in mm*	7	1&2	Fixed frame and variable frame farmer survey for beneficiary and non-beneficiary	Annual
F10.	Area under P1/ P2/ P3 crops*	7	1&2	Fixed frame farmer survey for beneficiary and non-beneficiary	Annual
Crop Level Indicators					

Indicator Code	Indicator	PDO	KPI	Data Source	Frequency
C1	Water productivity	2	1	Fixed frame and variable frame farmer survey for beneficiary and non-beneficiary	Annual
C2	Economic productivity	2	1	Fixed frame and variable frame farmer survey for beneficiary and non-beneficiary	Annual
C3	CV for yields for rainfed soybean, tur	6	2	Fixed frame and variable frame farmer survey for beneficiary and non-beneficiary	Annual
C4	CV for yields of irrigated soybean, tur	6	2	Fixed frame and variable frame farmer survey for beneficiary and non-beneficiary	Annual

6.3 Measurement of indicators

The necessity of the indicator, frequency of data collection, data source and level is mentioned in this section for each PDO.

6.3.1 PDO 5) Direct Project Beneficiaries

PDO 5 looks at the direct project beneficiaries of the project. The table below illustrates the proposed changes to include detailed understanding of project beneficiaries.

1.1 Table 6-4 PDO 5 proposed indicators

PDO Level Indicator 5) Direct project beneficiaries		
Number of farmers reached with agricultural assets or services (% of female)		
Frequency: Annual	Unit of measure: Number	End Target: 12,72,800
The number of farmers adopting improved agricultural technologies need to be looked at separately for different technologies and benefits provided under PoCRA. Farmers in many		

villages are already using drip and sprinklers for irrigation and are provided a new set through PoCRA. The number of farmers adopting improved agriculture technologies for the first time need to be considered.

Sr.	Indicator	unit	Level	Frequency	Data source	Remarks
V1.	Number of farmers using drip/ sprinkler for the first time.	Number	Village, district, project area	Annual	Primary survey (Variable frame farmer survey) and PoCRA MIS	The percentage of farmers using drip or sprinkler irrigation for the first time needs to be considered.
V2.	Number of farmers provided horticulture benefit upto year 1, year 2 and year 3.	Number	Village, district, project area	Annual	Primary survey and PoCRA MIS	The benefit for horticulture is provided over a period of 3 years. The farmers receiving the benefit in year 2 and 3 are the farmers who could maintain the trees for the 3 years. It is important to look at all 3 Numbers to understand whether or not the Number is reducing and the kind of economic implications is has on the farmers.
V3.	Number of farmers provided with polyhouse/ polytunnel	Number	Village, district, project area	Annual	PoCRA MIS	

V4.	Number of farmers provided with farm pond- GW based/ run-off based	Number	Village, district, project area	Annual	PoCRA MIS	
V5.	Number of farmers provided with plastic sheet for farm pond	Number	Village, district, project area	Annual	PoCRA MIS	This will provide an idea of the Number of farmers with a farm pond before the project in the project area.
V6.	Number of farmers going for sericulture	Number	Village, district, project area	Annual	PoCRA MIS	

6.3.2 PDO 2) Improved water-use efficiency at farm level

Improved water use efficiency at farm level depends on various parameters such as crop type, soil type, soil depth, land topography, nearby interventions, irrigation method etc. The indicator should thus do justice to depicting differences due to all these parameters.

1.1 Table 6-5 PDO 2- List of indicators

PDO Level Indicator 2) Climate resilient agriculture: Improved water-use efficiency at farm level
Area provided with new/improved irrigation or drainage services (in ha)
Frequency: Annual   Unit of measure: Number   End Target: 6,24,000
The area provided with new irrigation or drainage services (ha); and the area provided with improved irrigation or drainage services (ha). Irrigation or drainage services refers to the better delivery of water to, and drainage of water from, arable land, including better timing, quantity, quality, and cost-effectiveness for the water users. New irrigation or drainage services refers to the provision of irrigation and drainage services in an area that has not had these services before. The area is not necessarily newly cropped or newly productive land, but is newly provided with irrigation and drainage services, and may have been rain-fed land

before. Improved irrigation or drainage services refers to the upgrading, rehabilitation, and/or modernization of irrigation or drainage services in an area with existing irrigation and drainage services. This indicator looks at the area to which irrigation and drainage services are provided but does not look at the number of farmers reached with the service. Watershed works are conducted in most of the works and the area provided with new irrigation does not capture the concept of water use efficiency. Water use efficiency should be looked at as the output obtained from water.						
Sr. Number	Indicator	unit	Level	Frequency	Data source	Remarks
C1.	Water productivity	Number	Crop	Annual	Farmer survey (Fixed frame-beneficiary, non-beneficiary and variable frame-beneficiary non-beneficiary.	Crop water productivity differs from region to region and the reasons for variation in crop water productivity are various and numerous such as insufficient irrigation, animal and pest attacks etc. Thus it is important to study crop water productivity through actual primary data and not through yield estimation techniques.
C2, F1.	Economic productivity	Number	Crop, farm	Annual	Farmer survey (Fixed frame and variable frame beneficiary, non-beneficiary)	Economic productivity looks at the kind of monetary value farmers are able to convert their water into. Economic productivity will be able to aggregate the different crops a farmer has and help provide an

						overall understanding of water productivity for the farmer.
F2.	Budyko point	Number	Farm, Village	Annual	Fixed frame farmer survey and DPR	Budyko point will be able to map a farmer and his trajectory over the different years over which data will be collected through fixed frame farmer survey. It will show that with changing rainfalls how has the farmer/ villages cropping pattern managed to adjust to the changing rainfall patterns.

6.3.3 PDO 4) Annual farm income

Profitability is measured at farm level taking into account the cropping pattern of farmer, as different crops have different propensity to profit and investment risk. For example, there is higher fluctuation in prices of annual crops as compared to kharif and long kharif crops like Soybean, Tur, Cotton which also have comparatively lower investment risks. But the annual crops with higher investment risks have more market value compared to the kharif or long kharif crops and so lie in a different profit margin. Considering this and based on the cropping pattern, farmers are classified as rainfed (P3), irrigated (P2) and those having annual crops (P1) and their profit indices are measured accordingly in these three categories. These indices are determined only for fixed frame farmers so that the increase in profit can be gauged over time.

1.1 Table 6-6 PDO 4- List of Indicators

PDO Level Indicator 4: Profitability: Annual farm income

(Farm income comparator (as ratio with/ without farm income) between beneficiaries and non-beneficiaries)						
Frequency: Annual Unit of measure: Number End target : 1.5 times existing						
This indicator tracks the annual farm income of project beneficiaries. It measures how the income of landholders evolves with project activities, compared to the income of landholders that do not benefit from project interventions. It is necessary to track the annual farm income for the different types of cropping patterns being adopted based on the type of benefit provided by PoCRA. The changing annual farm income of a farmer with horticulture and a farmer moving from rainfed cropping pattern to irrigated cropping needs to be tracked separately.						
Sr.	Indicator	unit	Level	Frequency	Data source	Remarks
F4.	Annual farm income for P1 category	Number	Farmer survey	Annual	Farmer survey- fixed frame- beneficiary and non-beneficiary.	The annual income from farm activities needs to be assessed every year for the same farmers to understand clearly the impact of the project.
F5	Annual farm income for P2 category farmers	Number	Farmer	Annual	Farmer survey- fixed frame- beneficiary and non-beneficiary.	The annual income from farm activities needs to be assessed every year for the same farmers to understand clearly the impact of the project.
F6	Annual farm income for P3 category farmers	Number	Farmer	Annual	Farmer survey- fixed frame- beneficiary and non-beneficiary.	The annual income from farm activities needs to be assessed every year for the same farmers to understand clearly the impact of the project.

6.3.4 PDO 6) Improved yield uniformity and stability

Yield uniformity is a function of water access at farm level along with various other parameters. So, this is proposed to be measured spatially and temporally through coefficient of variability of yield for major crops in village for consecutive years.

2.1 Table 6-7 Improved yield uniformity and stability

PDO Level Indicator 6: Climate resilient agriculture: improved yield uniformity and stability						
(Spatial and temporal yield variability for crops (std. deviation of avg. yield in kg/ha))						
Frequency: Mid Term, End Term Unit of measure: Percentage Soyabean spatial yield variability: Baseline =30 End target = 23 Soyabean temporal yield variability: Baseline 52 End target= 38 Pigeon pea spatial yield variability: Baseline =39 End target = 30 Pigeon pea temporal yield variability: Baseline 44 End target= 36						
The yield for crops needs to be studied separately for rainfed and irrigated crops as the yield variability defers greatly with changing number of irrigations provided and soil type in rainfed crops.						
Sr.	Indicator	unit	Level	Frequency	Data source	Remarks
C3.	CV for yields of soybean, tur for rainfed	Number	Crop	Annual	Farmer survey- fixed frame and variable frame-beneficiary and non-beneficiary.	
C4.	CV for yields of soybean, tur for irrigated	Number	Crop	Annual	Farmer survey- fixed frame and variable frame-beneficiary and non-beneficiary.	

6.3.5 PDO 7) Improved availability of water for agriculture

The objective of the project is to provide access to protective irrigation to the kharif crop to help improve the climate resilience and profitability of small landholding farmers. Improved availability of water needs to be looked at as measuring access to water in both supply and demand terms. The table below illustrates the required indicators for the same.

1.1 Table 6-8 PDO 7- List of Indicators

PDO Level Indicator 7) Climate resilient agriculture: Improved availability of water for agriculture						
Surface water storage capacity from new farm ponds (in 1,000 m3)						
Frequency: Semi-annually Unit of measure: Number End target : 8,39,00,000						
Looking at improved water availability only through surface water is not sufficient. Water availability will increase through PoCRA interventions as surface water availability, ground water availability and improved soil moisture as well. It will primarily reflect through shifting farmers from rainfed to irrigated and also shifting farmers from seasonal crops to annual horticulture crops. While the proposed frequency is semi annual, for the proposed indicators the frequency chosen is annual since water available to crops based on number of irrigations can be taken for a farmer in the entire year.						
Sr.	Indicator	unit	Level	Frequency	Data source	Remarks
F3, F7.	Ratio of water access on farm in mm to total deficit in mm Ratio for water access on farm in mm to total deficit for P1, P2 and P3 category crops	Number	Farm	Annual	Fixed frame and variable frame farmer survey for beneficiary and non-beneficiary	Non beneficiary fixed farmer survey will help evaluate the watershed development works undertaken in the village. Beneficiary will help evaluate the individual benefits provided by the scheme.
F9.	W1/ W2/ W3 water access in mm	Number	Village Farm	Annual	DPR Fixed frame and variable frame farmer survey for beneficiary	Non beneficiary fixed farmer survey will help evaluate the watershed development works undertaken in the village. Beneficiary will help evaluate the individual benefits

					and non-beneficiary	provided by the scheme.
F8.	Last watering month	Number	Farm	Annual	Fixed frame and variable frame farmer survey for beneficiary and non-beneficiary	Non beneficiary fixed farmer survey will help evaluate the watershed development works undertaken in the village. Beneficiary will help evaluate the individual benefits provided by the scheme.
F10.	Area under P1/ P2/ P3 crops	Number	Village Farm	Annual	DPR Fixed frame farmer survey for beneficiary and non-beneficiary	Non beneficiary fixed farmer survey will help evaluate the watershed development works undertaken in the village. Beneficiary will help evaluate the individual benefits provided by the scheme.

6.4 Measurement formulae and data requirement

This section details out the datasets required and the formulae for computation for the different indicators mentioned in the previous section.

6.4.1 Crop level indices

6.4.1.1 Co-efficient of Variability for yields for rainfed/ irrigated soybean, tur

Spatial and temporal variability of yield can be understood through the CV for yields of different crops. Co-efficient of variability depicts the proportion of variability for different crops spatially and temporally. Co-efficient of variability can be calculated as standard deviation divided by mean and it is an indicator of climate resilience. Improvement in water access achieved through project is linked to reduction in yield variability. i.e. improvement in adaptive capacity to face climate vagaries.

Crop Name	Village name																	
	Chapadgaon, Jalna			Dahigaon, Amravati			Kubhephal, Aurangabad			Tadmugli, Latur			Wabgaon, Wardha			Yewati, Jalgaon		
	Yield (kg/acre)			Yield (kg/acre)			Yield (kg/acre)			Yield (kg/acre)			Yield (kg/acre)			Yield (kg/acre)		
	Std Dev	Mean	CV	Std Dev	Mean	CV	Std. Dev	Mean	CV	Std Dev	Mean	CV	Std Dev	Mean	CV	Std. Dev	Mean	CV
bajra		0.5	0			-	4.9	7	0.7									
cotton	7.73	10.27	0.75	10.1	16.18	0.62	5.58	9.08	0.61				2.88	5.97	0.48	1.23	7.69	0.16
harbhara	4.73	4.67	1.01	18.72	20.95	0.89			-									
maize			-			-	7.93	12.15	0.65							4.54	7.94	0.57
moong			-	0.15	4.00	0.04			-									
onion		1.00	0.00	2.35	40.00	0.06	4.2	20.00	0.21									
orange			-	1.2	6.00	0.20			-									
pomegranate			-		30.00	0.00	34.25	61.40	0.56									

rabi_wheat	4.52	6.00	0.75	3.06	9.33	-	2.3	11.00	0.21				4.27	8.60	0.50	5.61	8.06	0.70
small_vegetables		10.00	0.00		10.00	0.00			-									
sorghum	4.19	3.75	1.12			-	0.52	1.50	0.35				0.35	2.00	0.18			
soybean	7.15	7.95	0.90	27.22	25.75	1.06			-	2.73	4.47	0.61	2.01	4.38	0.46			
sugarcane			-			-			-				89.57	230.00	0.39			
tur	1.96	2.08	0.94	12.27	16.03	0.77	4.82	4.42	1.09	0.72	1.08	0.67	1.10	2.62	0.42	79.99	37.00	2.16
vegetables			-			-			-				33.94	26.00	1.31	0.00	8.00	0

2.1 Table 6-9 Coefficient of spatial variability for study conducted in 6 PoCRA villages

The table above shows the spatial variability for different crops in the village.

Chapter 7 Beneficiary Prioritization Guidelines

This chapter describes the beneficiary prioritization criteria which has been proposed as part of the work to be used for selecting beneficiaries in PoCRA Micro planning exercise. The original beneficiary selection process in PoCRA consists of gathering of individual demands from project village and then approving the demands at three levels starting from VCRMC Committee, followed by Technical Approval by Agricultural Assistant and Pre-sanction by Sub Division Agricultural Officer. The PoCRA Guidelines Manual delineates preliminary criteria for selection of beneficiaries with the primary criteria being prioritized selection of small and marginal farmers with no access to protective irrigation. This is to move towards the objective of climate resilience for such small holding farming systems.

Further, this chapter also provides an analysis of 2 sample villages based on primary survey conducted in these villages. The farmer background is analysed based on proxies for various bio-physical and socio-economic parameters to determine the prioritization criteria for different individual benefits provided under PoCRA such as wells, farm pond, horticulture, drip/sprinkler, polyhouse, polytunnel, sericulture etc.

7.1 Beneficiary selection methodology

The proposed beneficiary selection is to be done on the basis of elimination based on certain requirements and prioritization based on certain parameters. For different kinds of individual benefits the requirements and the parameters to be considered are different. The parameters studied for deciding the criteria are shown in the table below.

1.1 Table 7-1 Data requirement for beneficiary prioritization

Id	Criteria	Current Data source	Problems with current data source	Proposed data sources
1	Land Area	DBT based on form 8A	Total land column in many villages missing in DBT. Land area currently filled only for 1 gat no. according to 7/12	Total land as per form 8A to be used- Farmer beneficiary form / 8A list for each village

Id	Criteria	Current Data source	Problems with current data source	Proposed data sources
2	Stream proximity	Not collected		Farmer beneficiary form
3	Household size	Not collected		Farmer beneficiary form
4	Salaried members in the immediate family	Not collected		Farmer beneficiary form
5	Biophysical vulnerability	Available but not used	Gat number issues in cadastral shapefile - repeated/null/mismatch with updated ones	Computed for every cadastral number from QGIS water balance plugin
6	Water assets	Farmer beneficiary form	Inadequate data collected and not present on DBT portal	Farmer beneficiary form
7	Cropping pattern	Farmer beneficiary form	Inadequate data collected and not present on DBT portal	Farmer beneficiary form
8	Migration	Not collected		Farmer beneficiary form
9	Labour work	Not collected		Farmer beneficiary form
10	Allied business	Not collected		Farmer beneficiary form

In these basic parameters different yes / no questions and their responses can be used to categorize beneficiaries for different kind of benefits which can be availed from the scheme.

The different benefits that can be availed through the scheme can be categorised into 3 types:

1. **Demand side:** These benefits look to change the farmer demand for water by changing the cropping patterns. The benefits which fall in this category are: Horticulture, Sericulture, Tree Plantation, Shade-net, Polyhouse, Polytunnel.
2. **Supply side:** These benefits look at providing water to the farmers. The benefits which fall in this category include well, well rehabilitation, farm pond, lining of farm pond, drip irrigation, sprinkler irrigation, electric/ diesel pumps, pipes, compartment bunding.

The different questions to be asked based on the above categories and the rankings and priorities to be given are mentioned in the table below.

1.1 Table 7-2 List of questions for beneficiary prioritization

Id	**Category**	**Questions**	**Demand side benefits priority**		**Supply side benefits priority**	
1	Land Area	**1A)** Is the land area available more than the reference value of the land area in the village?	Yes- 0	No- 1	Yes- eliminated	No- considered
			Demand side benefits like horticulture, polyhouse, sericulture requires high investments and also carry considerable risk. Thus while priority can be given to small and marginal farmers, other farmers can also be included as beneficiaries as they are the ones who can carry this risk.		This can be considered as an elimination criteria for supply side benefits.	

Id	Category	Questions	Demand side benefits priority		Supply side benefits priority	
2	Stream proximity	**2A)** Is there a stream within 100 m from your farm?	Yes-0	No- 1	Yes- 0	No- 1
			Stream near the farm provides a great advantage through better soils, better water access etc.		Stream near the farm provides a great advantage through better soils, better water access etc.	
3	Household size	**3A)** Is your household size more than 4?	Yes- 1	No- 0	Yes- 0	No -1
			For horticulture crops, polyhouse etc. larger household sizes are beneficial. These cropping pattern changes come with greater amount of work. Because the risk associated with the crops is high it is important to consider households with higher household size to reduce risks associated with animal attacks, pest and also added work.		The vulnerability for smaller households is greater and thus smaller households should be given a priority in beneficiary selection.	
4	No. of salaried members	**4A)** Is there a salaried member in your immediate family?	Yes- 1	No- 0	Yes- 0	No- 1
			Having a secondary stable income makes it easier to manage the risk		The absence of a salaried member in the immediate family increases the vulnerability and	

<table>
<tr><th>Id</th><th>Category</th><th>Questions</th><th colspan="2">Demand side benefits priority</th><th colspan="2">Supply side benefits priority</th></tr>
<tr><td></td><td></td><td></td><td colspan="2">associated with horticulture crops.</td><td colspan="2">dependence on agriculture. Thus families without a salaried member should be given the priority.</td></tr>
<tr><td rowspan="2">5</td><td rowspan="2">Biophysical vulnerability</td><td rowspan="2">5A) This parameter will be precomputed for all the cadastral numbers in the village for a reference crop soybean.

This will be made available from the plugin</td><td>Deficit< 100 mm- 1</td><td>Deficit> 100 mm -0</td><td>Deficit< 100 mm- 0</td><td>Deficit> 100 mm -1</td></tr>
<tr><td colspan="2">Farmers with cadastral numbers having a deficit less than 100 mm for Soybean crop should be given priority. For farmers with land in more than 1 cadastral numbers, the cadastral number with the larger area should be considered.</td><td colspan="2">Farmers with cadastral numbers having a deficit more than 100 mm for Soybean crop should be given priority. For farmers with land in more than 1 cadastral numbers, the cadastral number with the larger area should be considered.</td></tr>
<tr><td>6</td><td>Water Assets</td><td>6A) Do you have a well / borewell / farm pond or any other irrigation</td><td colspan="2">Yes- 1 No- 0
(elimination criteria)

Yes- 1 No- 0

Yes- 1 No- 0</td><td colspan="2">Yes- 0 No- 1
(elimination criteria for well)

Yes- 0 No- 1

Yes- 0 No- 1</td></tr>
</table>

Id	Category	Questions	Demand side benefits priority	Supply side benefits priority
		source on your land? **6B)** Is the well/ borewell/ farm pond functioning? **6C)** Does any one of your water source have water available for irrigation after the month of January?	It is necessary to have a water source which lasts throughout the year for horticulture crops.	Priority for farmers without any water source needs to be provided.
7	Cropping pattern	**7A)** Do you cultivate an annual crop? **7B)** Do you cultivate a rabbi crop? **7C)** Do you provide irrigation to your kharif crop?	Yes- 0 No-1 Yes- 1 No-0 Yes-1 No-0 It is necessary to understand whether the farmer can provide irrigation to his/ her existing cropping pattern. Farmers with rabbi crop should be preferred as they can provide water upto the months of Jan.	Yes- 0 No-1 Yes-0 No-1 Yes- 0 No-1 Priority needs to be given to rainfed kharif farmers for asset creation.

Id	Category	Questions	Demand side benefits priority	Supply side benefits priority
8	Migration	**8A)** Do you migrate for more than 3 months in the year?	Yes-1 No- 0	Yes-1 No- 0
			Priority needs to be given to families migrating for work.	Priority needs to be given to families migrating for work.
9	Labour work	**9A)** Do you engage in labour work in the village for more than 3 months?	Yes-1 No- 0	Yes-1 No- 0
			Priority needs to be given to farmers dependent on labour work.	Priority needs to be given to farmers dependent on labour work.
10	Allied business	**10A)** Do any of your immediate family members engage in any allied business?	Yes-0 No- 1	Yes-0 No- 1
			Priority needs to be given to farmers not involved in any allied businesses.	Priority needs to be given to farmers not involved in any allied businesses.

A number can be allocated for each farmer based on these two methods. The priority list will then be set on a descending scale. The highest number will receive the first priority. For different assets different combinations of these indicators will be used. The formulae for different assets will be different depending on the dependencies and pre-requisites of different assets. The formulae for different assets are provided in the table below.

1.1 Table 7-3 Beneficiary prioritization logic

Benefit	**Elimination criteria**	**Prioritization formula**	**Relevance**
Horticulture	6A+6B	1A+2A+3A+4A+5A+6C+7A+7B+7C+8A+9A+10A	The elimination criteria considered eliminates farmers without a water source and further prioritizes farmers with water for longer durations. The prioritization formula is in accordance with the demand side benefits.
Sericulture	6A+6B	1A+2A+3A+4A+5A+6C+7A+7B+7C+8A+9A+10A	The elimination criteria considered eliminates farmers without a water source and further prioritizes farmers with water for longer durations. The prioritization formula is in accordance with the demand side benefits.
Tree plantation		1A+2A+8A+9A+10A	Tree plantation benefit under PoCRA mainly consists of trees alongside the farms. These include local tree varieties in the region which do not require any specific watering. Farmers generally provide watering to such trees rarely and if they do, household water supply or irrigation methods used primarily for other crops are generally used. These trees thus do not require the presence of a water source or lesser bio-physical vulnerability.
Shade-net	6A+6B	1A+2A+3A+5A+6C+7A+7B+7C+8A+9A+10A	Shade-net requires the farmer to have a water source. Shade-net helps reduce the risks associated with crops

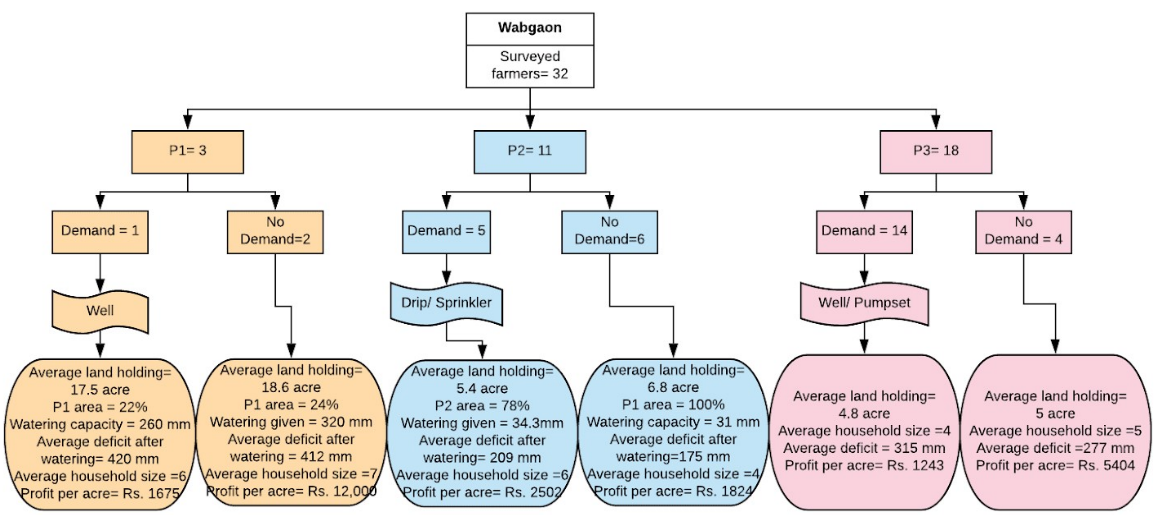
Benefit	Elimination criteria	Prioritization formula	Relevance
			relatively and also provides an income soon after investment.
Polyhouse/ Polytunnel	6A+6B	1A+2A+3A+5A+6C +7A+7B+7C+8A+9 A+10A	Polyhouse/ polytunnel requires the farmer to have a water source. Polyhouse/ polytunnel helps reduce the risks associated with crops relatively and also provides an income soon after investment.
Well	1A+6A	2A+3A+4A+5A+7B +8A+9A+10A	Wells should be provided to farmers without any existing source of irrigation. Source of irrigation should include borewells or well.
Well rehabilitatio n	1A+6A(Yes)+ 6B	2A(yes- 1)+31A+4A+5A+6C +7B+7C+8A+9A+1 0A	Well rehabilitation should be provided to farmers with a well which is currently not functioning with/ without any other source of irrigation with priority given to the farmers without any source of irrigation.
Farm pond (Run-off based)	1A	2A+3A+4A+5A+6A +6B+7A+7B+7C+8 A+9A+10A	Farm ponds based on run-off should be provided preferably to farmers near streams.
Groundwate r based farm pond	1A+ 6A (Yes)+ 6B (Yes)	2A+3A+4A+5A+6C +7A+7B+7C+8A+9 A+10A	Farm ponds based on ground water should be provided to farmers with limited GW resources temporally.
Lining of farm ponds	1A+ 6A(farm pond)	2A+3A+4A+5A+6A +7A+7B+7C+8A+9 A+10A	Lining of farm ponds should be provided to farmers already having farm ponds.

Benefit	Elimination criteria	Prioritization formula	Relevance
Drip/ Sprinkler irrigation	1A+ 6A	2A+3A+4A+5A+6B +6C+7A+7B+7C+8 A+9A+10A	
Electric/ Diesel Pumps/ Pipes	1A+ 6A	2A+3A+4A+5A+6B +6C+7A+7B+7C+8 A+9A+10A	
Compartme nt bunding	1A	2A+3A+4A+5A+6A +6B+6C+7A+7B+7 C+8A+9A+10A	

Based on these formulae, a number computed for different demand side and supply side benefits can be computed. Farmers with a higher number will be given a higher priority while choosing beneficiaries.

7.2 Beneficiary selection case study: Wabgaon, Wardha

Considering the case for Wabgaon village, the current status of village based on primary survey of 32 farmers is given in the figure below.



2.1 Figure no. 18 Wabgaon Applicant Profile

It can be seen that maximum applications are from P3 farmers for well / pump set. The farmers with no applications amongst P3 are seen to have a lower deficit amongst the P3 farmers. The P2 farmers have applied for drip/ sprinkler. The average landholding is seen to be above 5 acres amongst the farmers applying for the benefit however, the farmers not submitting any demands have a higher average landholding size than the ones applying for the demand. The mismatch between the land details present in the DBT and the land details as per primary survey is because in most places the total land area has not been filled. Land detail information as per 7/12 is present in the DBT.

These collected samples were further analysed on the basis of the criteria selected. The table below shows a sample data collected for the farmers in Wabgaon.

1.1 Table 7-4 Sample Beneficiary Prioritization Data

	Demand side interventions														**Supply side interventions**													
Farmer name	**1 A**	**2 A**	**3 A**	**4 A**	**5 A**	**6 A**	**6 B**	**6 C**	**7 A**	**7 B**	**7 C**	**8 A**	**9 A**	**10 A**	**1 A**	**2 A**	**3 A**	**4 A**	**5 A**	**6 A**	**6 B**	**6 C**	**7 A**	**7 B**	**7 C**	**8 A**	**9 A**	**10 A**
Lotkar	0	0	1	0	0	0	0	0	1	1	0	1	1	0	0	0	0	1	1	1	1	1	1	0	1	1	1	0
Purshottam Paradpure	0	0	1	0	0	0	0	0	1	1	0	1	0	0	1	0	0	1	1	1	1	1	1	0	1	1	0	0

Based on the above data and the formulae for different interventions the computed index for different interventions is as shown in the table below.

2.1 Table 7-5 Sample Beneficiary Prioritization Calculation

	Demand side		**Supply side**				
Farmer name	**Horticulture/ Sericulture/ shade-net/ Polyhouse**	**Tree plantation**	**Well**	**Well rehabilitation**	**FP Run-off based**	**GW based FP**	**Drip/ Sprinkler irrigation/ pumps/ pipes/ CB**
Lotkar	0	2	4	4	7	0	0

	Demand side		**Supply side**				
Farmer name	**Horticulture/ Sericulture/ shade-net/ Polyhouse**	**Tree plantation**	**Well**	**Well rehabilitation**	**FP Run-off based**	**GW based FP**	**Drip/ Sprinkler irrigation/ pumps/ pipes/ CB**
Purshottam Paradpure	0	1	3	3	6	6	6

7.2.1 Demand side beneficiary priority ranking

The priority ranking for horticulture, sericulture, polyhouse, polytunnel is shown in the table below. We can see there are fewer farmers eligible for this benefit and are distinctly different from farmers eligible for supply side benefit.

1.1 Table 7-6 Demand side beneficiary prioritization

Farmer Name	Index	Priority rank
Suman Lokhande	8	1
Haribhau Umbre	8	1
Pramod Bale	7	2
Kalpana Lokhande	7	2
Bharat Shidulkar	7	2
Lilabai Rajurkar	6	3
Haridas Hande	6	3
Dhananjay Didphay	6	3
Vandu Khusate	5	4
Dilip Lotkar	5	4
Ramesh Debade	5	4
Mangesh thote	4	5
Ujjwala Narayane	3	6
Savjyoti Dabhire	3	6
Prashant Bhade	3	6

For farmers with same priority rank, benefits can be given as per to those applying for which benefit and beyond that alphabetically or the previous methodology of priority to small landholding and SC/ ST community applicants.

7.2.2 Supply side beneficiary priority ranking

The priority ranking for supply side benefits is much different than that for demand side benefits. The priority ranking for wells is shown in the table below. For choosing beneficiaries for wells, this can be used alongside GSDA permissions.

2.1 Table 7-7 Well priority ranking

Farmer name	**Well**	**Priority rank**
Ishwar Vishwanath	6	1
Madhukar Shelke	5	2
Kisan Paratpure	5	2
Madhukar Bobade	5	2
Prabhawati Wavre	5	2
Sahebrao Hore	5	2
Sudhakarrao Khurmule	5	2
Chandrakant Nehare	4	3
Haridas Raut	4	3
Lotkar	4	3
Narayan Paratpure	4	3
Shalikam Shelke	4	3
Vanabai Tolase	4	3
Vasanta Bhade	3	4
Purshottam Paradpure	3	4
Shevantabai Paratpure	3	4
Rupesh Shelke	1	5

The priority ranking for well rehabilitation makes it necessary for the farmer to possess a well which is not functioning. The survey sample collected in Wabgaon did not have any farmer with these specifications and thus a priority ranking list was not made.

The priority ranking for farm ponds based on run-off according to this formula is shown in the table below.

3.1 Table 7-8 Farm Pond Priority ranking

Farmer name	FP RO based	Priority rank
Ishwar Vishwanath	9	1
Madhukar Shelke	8	2

Kisan Paratpure	8	2
Madhukar Bobade	8	2
Prabhawati Wavre	8	2
Sahebrao Hore	8	2
Sudhakarrao Khurmule	8	2
Chandrakant Nehare	7	3
Haridas Raut	7	3
Lotkar	7	3
Narayan Paratpure	7	3
Shalikam Shelke	7	3
Vanabai Tolase	7	3
Vasanta Bhade	6	4
Purshottam Paradpure	6	4
Shevantabai Paratpure	6	4
Rupesh Shelke	4	5

Based on the formula mentioned above and the calculations the priority ranking for drip/ sprinkler irrigation / pumps/ pipes / compartment bunding, ground water based farm pond are depicted in the table below.

4.1 Table 7-9 Irrigation equipment priority ranking

Farmer name	Drip / Sprinkler irrigation / pumps / pipes / cb	Priority rank
Ishwar Vishwanath	9	1
Madhukar Shelke	8	2
Kisan Paratpure	8	2
Madhukar Bobade	8	2
Prabhawati Wavre	8	2
Sahebrao Hore	8	2
Sudhakarrao Khurmule	8	2
Chandrakant Nehare	7	3
Haridas Raut	7	3
Narayan Paratpure	7	3
Shalikam Shelke	7	3
Vanabai Tolase	7	3
Lotkar	7	3

Farmer name	Drip / Sprinkler irrigation / pumps / pipes / cb	Priority rank
Purshottam Paradpure	6	4
Shevantabai Paratpure	6	4
Vasanta Bhade	6	4
Rupesh Shelke	4	5

Beneficiary prioritization is important to ensure that the scheme reaches the intended beneficiaries. In this analysis the demands submitted are based on primary survey. These demands do not match the list available on the DBT portal. This is due to mismatch between *gat* numbers or the status of the remaining farmers has not been uploaded on the DBT portal.

Chapter 8 Concluding remarks

8.1 Conclusion

In the drought-prone villages of Maharashtra, climate change manifests through erratic monsoon. The reduction in number of rainy days and increase in heavy rainfall occurrences lead to crop loss and make irrigation all the more important. Access to protective irrigation to safeguard the kharif crop has become important in villages of Maharashtra. The decision of rabbi crop based on rainfall patterns and availability of data in the village to make an informed decision has also become important. These two parameters translate to economic returns through dependable yields.

PoCRA aims to improve climate resilience by improving access to protective irrigation, providing information regarding water availability before rabbi season while simultaneously working on improving water availability through watershed works and changing cropping patterns. Vulnerability due to climate change can be meaningfully studied through a mixed approach of bio-physical and socio-economic vulnerability. These should be studied with a direct outcome based context for meaningful results. Climate resilient agriculture in the context of this study is understood as maintaining villages and farmers at an aggregate positive in the water balance and ensuring economic returns, through changing cropping patterns, ensuring access to water, strengthening yields and in turn economic returns. Further, framework for beneficiary selection through a more detailed understanding of different benefits provided by the project and the requirements for each benefit individually, monitoring and evaluation for PoCRA is prepared. The monitoring and evaluation framework goes beyond the key performance indicators identified by World Bank and tries to extract maximum meaning from the Project Development Objectives.

Beneficiary prioritisation provides a robust method of beneficiary identification focussing on outcomes and dependencies of different benefits provided in the scheme. It aims to identify farmers which are most suitable and appropriate according to the different benefits provided in the scheme.

Monitoring and evaluation framework looks at the Project Development Objectives and divides them into quantifiable indicators at the crop, farm and village level to properly monitor the outcomes of the project and evaluate the project.

8.2 Limitations of the study

The research carried out in this study is majorly based on data collected through field visits. Thus this data is just a sample representation of the actual conditions and although adequate coverage has been ensured, does not represent the entire range of possibilities. Thus the interventions need to be designed accordingly.

Also, the Beneficiary Prioritisation Guidelines and M&E Framework created as part of this study have been submitted to PoCRA and their team has been trained on the usage of these modules. But there is a high level of dependancy on PoCRA to actually use these modules in the field effectively.

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Annexures

Annexure-1

Farmer Survey questionnaire_______________ Date of survey______________ Interview#_____________ lat/long________/_______

Village name: _______________ Name of interviewer__________________________

1. **General information**

1	Name of person			
2	Contact number			
3	Number of family members	Age 0-15_______ Age15-60_______ Age >60_________		
4	Number of earning members	Farm	Other	
6	Main occupation	☐ Agriculture & Allied ☐ Artisans ☐ Business	☐ Service (Salaried) ☐ Ag. Labor	☐ Non-ag. Labor ☐ Any Others (Specify)
7	Secondary occupation	☐ Agriculture & Allied ☐ Artisans ☐ Business	☐ Service (Salaried) ☐ Ag. Labor	☐ Non-ag. Labor ☐ Any Others (Specify)
9	Gat No.s and their Area in acre			
10	Total Area in acre			

2. **Livestock: Bulls/ cattle/ goats**
   No. of bulls
   No. of cows
   No. of goats
   Approximate annual income from livestock:
3. **Resources: water**

<u>Migration information:</u>

Do you migrate?		Do you migrate along with your family?	
How many		Daily wages recieved	

Source of Fodder ____ Availability in months

Source of Drinking Water: ____ availability in months____________________________

Well/ Borewell information

No.	Source type: well/bore	Gat no.	Depth	Max level	Max level month	Dried in month	Pump capacity (HP)	Pumping Distance (ft/m)

4. **Cropping Pattern**

Multi-year crop (orchard)

Crop Name	Crop variety	Area planted	No. of plants	Year of crop	**Source of water in each season**	Irrigation how many times in different months (e.g. July – Aug: 0, Sept – Dec: weekly etc)	Pump HP and hours run in each season	Drip irrigation Y/N?	Drip spacing / No. of drippers	No. of hours of watering in each watering	Avg input cost /yr (maintenance)	Average yield per acre per year (ekari utpann)	Avg market rate of produce	which APMC/private trader/ village market

Kharif

Crop	Crop Variety	Area under the crop	Sowing date	Crop duration	No. of waterings	**Irrigation source**	Pump HP and hours run per irrigation	Drip irrigation Y/N?	Drip spacing / No. of drippers	No. of hours of watering in each watering	Avg input cost (including labour, seeds, chemicals, transportation etc)	Market rate	Market

Rabi and summer crops

Crop	Crop Variety	Area under the crop	Sowing date	Crop duration	No. of waterings	**Irrigation source**	Pump HP and hours run per irrigation	Drip irrigation Y/N?	Drip spacing / No. of drippers	No. of hours of watering in each watering	Avg input cost (including labour, seeds, chemicals, transportation etc)	Market rate	Market

Kharif-Rabi 2017-18 plan

Crop	Area under the crop	Sowing date	Crop duration	No. of waterings	**Source of Irrigation**	Pump HP and hours run per irrigation	Drip irrigation Y/N?	Avg input cost (including labour, seeds, chemicals, transportation etc)	Avg return that they expected	% self-use or marketed	market

5. <u>Crop Loan</u>

Area for which crop loan was taken?		Unpaid loan amount (thakbaaki)	
Bank Name		Why could you not repay the loan? Why?	

Crop for which it was taken		Did you ever receive loan waiver? Year?	
Amount of the crop loan taken this year			

PoCRA Individual assets

Form	Gat No.	Form	Gat No.	Form	Gat No.	Form	Gat No.
Falbaug		Well		Pipes		Poultry	
Sericulture		Well Rehabilitation		Compartment Bunding		Apiary	
Tree plantation		Farm Pond		Pumpset		Fishery	
Shed-net		Lining of farm pond		Drip /Sprinkler		Vermicompost	
Polyhouse							

Changes after receiving interventions

Falbaug/ Sericulture/ Polyhouse

Area under Falbaug/ Tutti		Additional water (source)		Source of finance	

Sufficient Water		Cost of additional water			

Well/ Well rehabilitation

New cropping pattern		How do you expect yields to increase?	