IIT Bombay - PoCRA MoU IV
Phase I - Delivery Report

Indian Institute of Technology, Bombay
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Preface

This inception report is the first deliverable in the MoU IV and has an overview of the objectives, locations selected, work done so far, and work planned ahead. While the MoU was signed on August 24th 2021, the Water and Energy groups, who were on MoU III, have been working on some aspects before signing to ensure that timelines based on season are met.

For example, for the validation of the water balance model, sensors, rain gauges needed to be installed and observations begun at the start of the monsoon. For the community action at the Distribution Transformer level, the intervention needed to be implemented in the peak rabi months, and the ground work to select and ensure participation of farmers on 4 DTs needed to be done in time.

The Post Harvest component was a new addition in MoU IV and it formally started after MoU was signed. Hiring of project staff completed in the 2nd week of September.

The table below gives a high-level picture of the three sectors.

	Water	**Energy**	**Post-Harvest**
Start Date	May 20, 2021	July 10,2021	Aug 25, 2021
Team: Project Engineers / Research Assistants	Hemant Belsare Asim R P Chirag M M Vishal Mishra	Devanand Doifode Vinayak Dube Sameer Kulkarni (Left team on Sep. 10) Parashram Akhare (Joined on Oct 1)	Aniket Deo Prathmesh Antarkar Rajesh Ingole
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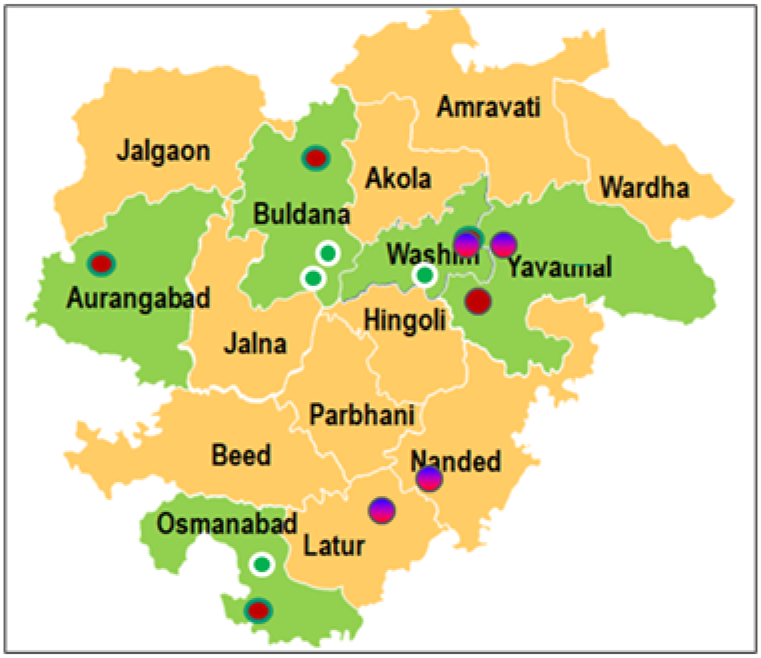
Compnts. begun	A, B, C, E	F, H, J; G (contd. from MoU III)	K, L (a,b)

Locations selected for investigations



The red dots indicate energy group work locations, red and blue shaded are common to water and energy groups and green dots indicate Post harvest

The three sectors have been dealt with in separate documents.

Inception report - Water

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1. Broad objective

As per the fourth MoU signed between IIT Bombay and PoCRA, the proposed engagement will mainly focus on further improvements in the water budget framework along with the validation of the water budget model, the utility of the model in better planning of water resources and in better targeting of the project beneficiaries at the village level, and strengthening the extension mechanisms so as to translate the water budget results to simpler water management concepts which may help in achieving water security at the farmer / village / cluster level.

To this end, the activities and the deliverables to be carried out during MoU IV have been divided into following key components:

A. Model validation and on-field measurements

B. Community Extension

C. Model improvements

D. Rabi Planning framework

E. IT and PMU support

The following Inception Report gives an overview of all the above components one by one. This will include the specific objectives, key activities planned, work done so far and the deliverables along with the next course of action for each component.

2. Component A: Model validation

2.1 Background and objective

The core objective behind the exercise of model validation is to test and enhance the soundness of the model. This has been achieved, to a large extent, over the last two years, through continuous engagements and interactions with PMU, World Bank experts, external agencies and preliminary validation of the model through on-field measurements and farmer narratives.

Model validation exercise was carried out as part of the third MoU between IITB and PoCRA in the monsoon season of the year 2020 in districts of Hingoli and Washim. Considering the limitations due to Covid-19 outbreak and the restrictions on travel, holding meetings in the villages, procurement and installation of equipment etc. The limited results achieved were termed as satisfactory by the World Bank (WB) experts and PMU. Please refer to the interim and final validation reports along with the comments from the WB Expert.

As suggested by the experts from WB and the PMU, the model-validation exercise has been extended to few more locations this year with following key objectives:

- To further strengthen the validation methodology so that it would be replicable and reproducible by other agencies in different geographical regions.
- To validate regional as well as farm-level water balance components (such as surface runoff, soil moisture, crop stress) through a combination of on-field measurements, key observations from field and farmer narratives.
- To carry out field investigations based on observations, measurements and farmer surveys in order to understand and incorporate key phenomena such as regional groundwater flows, baseflows, ponding, stream proximity etc. which will further help in improving the soundness of the model.

2.2 Validation methodology

The PoCRA water budget model computes point-level surface runoff, groundwater recharge, actual evapotranspiration (AET) and soil moisture and then aggregates them to zone / village / cluster. Soil moisture and AET are essentially farm-level attributes and can be measured or observed at farm level. But entities like runoff and groundwater are essentially regional in nature and are typically measured / computed for a region i.e. mostly for a catchment or a watershed.

Thus, we propose the catchment as the unit of validation. Surface runoff would be measured at the outlet of the selected catchment. Groundwater recharge would be measured through monitoring of well-levels in the catchment and empirical Water-Table Fluctuation (WTF) method as proposed by Groundwater Surveys and Development Agency (GSDA). These regional values will be compared with the model results for the whole catchment for specific time period or rainfall events.

Soil moisture would be monitored at few sample points / farms within the catchment so as to cover different soil types and crops. The model results will be obtained for different combinations of soil texture, soil depth, root depth, slope etc. and will be compared with the measured / monitored soil moisture.

Measurement of AET requires fairly sophisticated and costly instruments and is a complicated process. Hence, AET will be verified through simpler on-field proxies such as farmer narratives about crop stress and observations on the field about crop health such as crop height, color etc.

Table 1 shows the planned measurements and their methods –

Table 1: Model component and validation method

Model Component	Scale	Method to be used	On-field activities
Runoff	Point/ Farm	V notch with sensor	Total 7 farms to be monitored
Runoff	Regional	Water Level Sensors on CNB	20 sensors installed at catchment (5) and sub-catchment (14) levels (+1 at Percolation Tank)
Soil Moisture	Point	Soil Moisture Sensor	2 locations per farm, total 5 farms monitored
Groundwater recharge	Regional	Monitoring of well water levels in Kharif and Rabi seasons	About 15 wells per catchment to be monitored during kharif and rabi seasons
AET (Indirect)	Point / Farm	Structured interviews with farmers	About 15 farmers per catchment to be surveyed in kharif and rabi seasons
Post monsoon water availability (GW + SM + Surface water)	Regional (village / cluster)	Farmer interviews, cropping pattern, GW extraction measurements,	10 farmers per village in the cluster to be surveyed during Rabi season

		Baseflow measurements, GW level monitoring	

2.3 Work done so far

2.3.1 Selection of clusters

Clusters were selected based on following criteria

- Rainfall
- Soil types (soil texture and soil depth)
- Land use and Land Cover
- Slope (hilly or flat terrain)
- Logistics (optimal travel to reach clusters considering pandemic and restrictions imposed)

Table 2 shows selected clusters.

Table 2: Selected clusters for fieldwork on model validation

Cluster	**District**	**Taluka**
511_gv-101_03	Nanded	Loha
524_mr-47_05	Latur	Ahmadpur
510_wrb-1a_01	Yavatmal	Ner
502_ptkp-1_03	Washim	Karanja

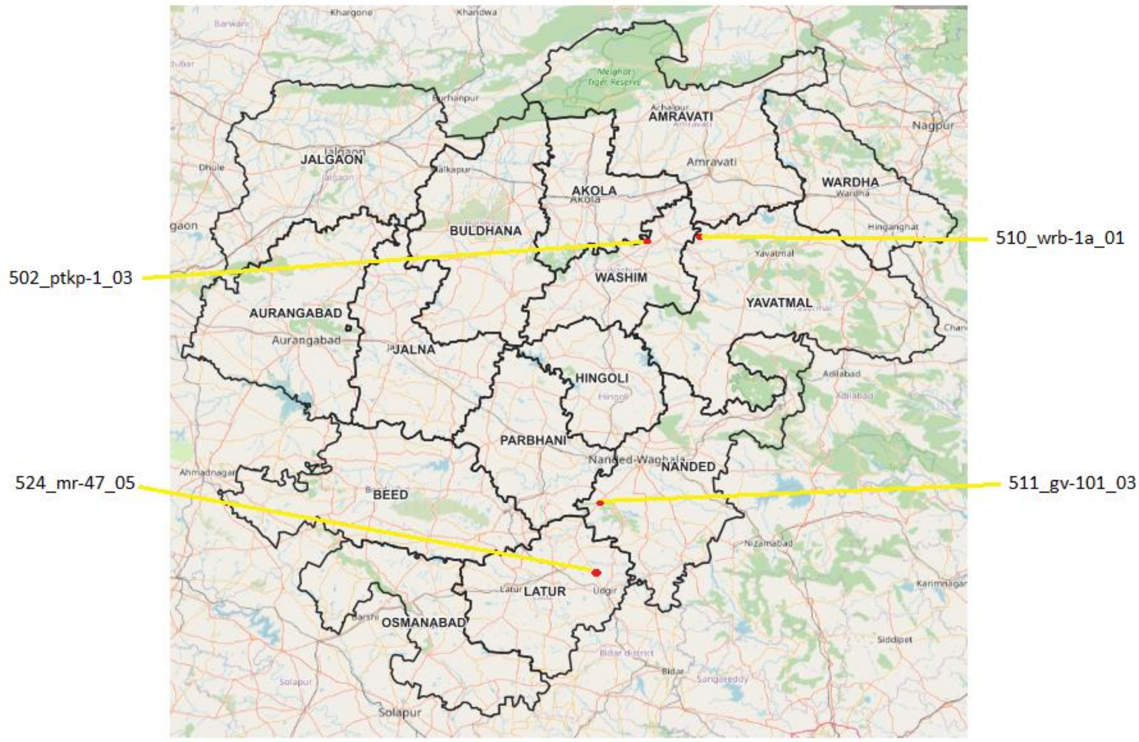

Figure 1: Location of the selected clusters in PoCRA region

2.3.2 Locations of sensors and their installation

<u>Selection of catchments within clusters</u>

After cluster finalization, catchments from the clusters were selected based on the suitability for installation of different sensors and overall feasibility for the execution of model validation methodology. Based on the different attributes of the catchment (soil type and soil depth) and its outlet i.e. CNB (CNB side wall height, storage capacity of CNB), water level sensors of different ranges (1.5m and 2m) were finalized for installation. Prior to sensor installation, preparatory works were carried out which involved site cleaning, channel preparation and stilling well construction wherever required. After successful installation of these sensors, necessary calibration for the same was carried out.

Locations of installed sensors:

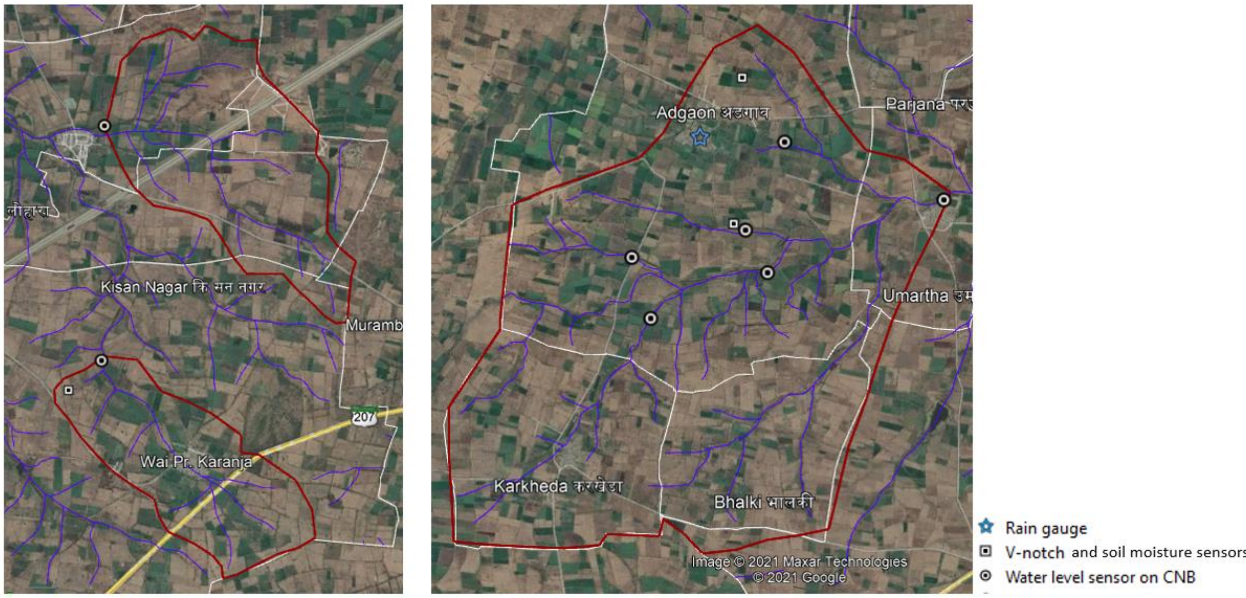

Figure 2: Catchments and sensor locations for clusters from Vidarbha region

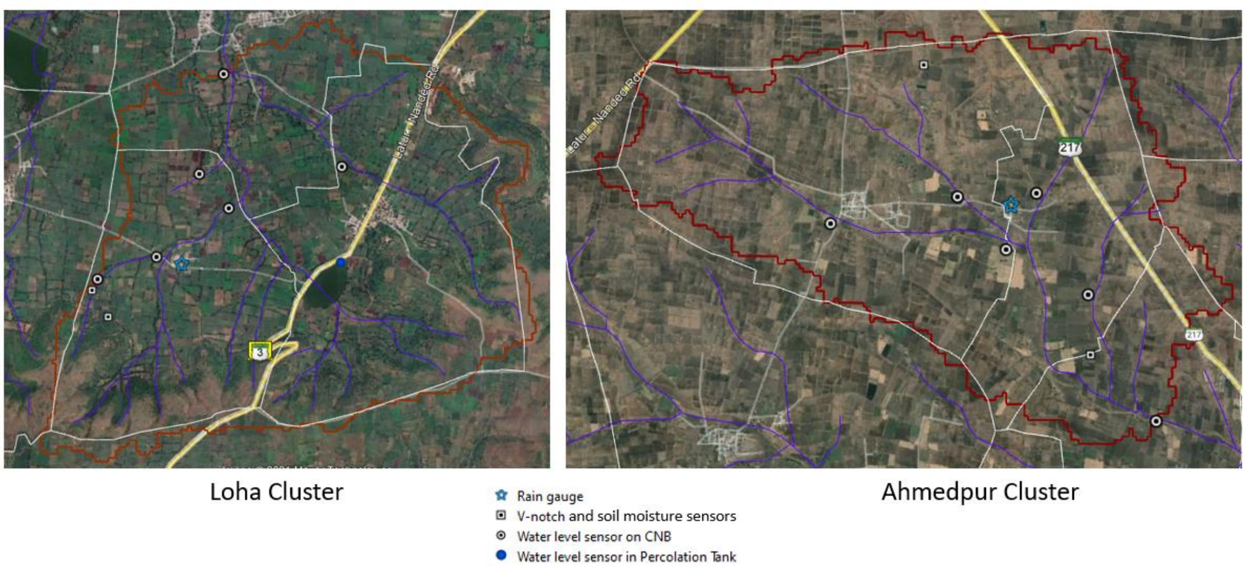

Figure 3: Catchments and sensor locations for clusters from Marathwada region

Table 3 lists the sensors installed in all of the clusters.

Table 3: Clusterwise sensor summary

Cluster	Taluka	District	Villages	No. of water level sensors	No. of soil moisture sensors	No. of V-notches	No. of rain gauges
511_gv-101_03	Loha	Nanded	Mangrul, Polewadi, Berali Kh.	7	4	2	1
524_mr-47_05	Ahmadpur	Latur	Morewadi, Chobali, Gadewadi	6	2	2	1
510_wrb-1a_01	Ner	Yavatmal	Adgaon, Karkheda, Bhalki, Umartha	6	4	2	1
502_ptkp-1_03	Karanja	Washim	Wai Pr. Karanja, Lohara, Kisan Nagar	2	2	1	0

2.3.4 Sensor data

The data from all the sensors and rain gauge will be systematically collated, cleaned, compiled and processed so as to get a meaningful comparison of the same with model results. Water level sensor data will be used to compute discharge which will be further used to compute the volume of the water that has drained from the outlet. This outlet will be CNB for computation of regional runoff and V-notch for computation of the farm runoff. Similarly, soil moisture sensor data obtained in percentage saturation will be compiled and compared with its volumetric counterpart. These results will be then compared with the model output for soil moisture. All this data will be used for event based validation.

2.3.5 Farmer surveys and key observations

The IITB-PoCRA water balance model is planned to be validated not just using the actual measurements but also based on the farmers' narratives for the different events and phenomena. This includes both narratives for the events during kharif as well as rabi seasons.

Farmers' narrative based model validation is planned using two sets of questions. One set of questions are used for validation of the AET and soil moisture results by the model. These questions mainly focus on the irrigation provided by the farmers which is a proxy for the declined soil moisture and the corresponding crop deficit. This set of questions also includes the impact of the dry spell on the crop yield and its comparison with the maximum and frequently observed yield to get an idea about the crop AET.

Similarly, another set of questions deals with the narratives on the water levels in the selected wells. These questions are aimed to understand pre-monsoon water levels, when did the water level start rising which can be considered as a proxy for groundwater recharge and when did wells get filled completely. These observations will be compared with the model results to see if the model indicated occurrence of groundwater recharge around the same time period. After the harvesting of the kharif crop, farmers' narratives on the actual yield will be collected. This would be used for validation of AET shown by the model based on the yield curves obtained from earlier interviews.

During rabi season, farmers' narratives on the number of waterings provided to the crops would be used to estimate the actual groundwater extraction post monsoon. These estimated figures will be compared with the groundwater recharge shown by the model.

2.4 Work planned ahead

- Carry out remaining on-field tasks
    - Soil testing for texture of soils from V-notch plots
    - Farmer interviews to get detailed narratives on actual yields, and yield loss due crop deficit and dry spell, etc.
    - Continued well level monitoring and collection of data on waterings provided and extraction during rabi

- Compile, clean, consolidate and process the sensor data, select key rainfall events for which comparison is to be made with water budget results
- Run water budget model for all the catchments
- Compare the results and justify the gaps if any
- Summarize, and compile the report

2.5 Key deliverables and schedule

Component	Pre-Phase II (May - Sept)	Phase II	Phase III	Phase IV	Phase V
Review of validation methodology, field work, initial report	Methodology , Field work	Initial report			
Data processing, analysis, documentation of observations, insights for model improvements, kharif report	consolidation and cleaning of sensor data	data analysis, comparison with water budget model results	Kharif validation report		
Data processing and analysis in rabi season			Field work, data collection, farmer interviews	data analysis, comparison with water budget model results	Rabi validation and Closure report
Analytical comparison of water budget results for earlier years to understand year-to-year dependence.			Collecting all required data	Data analysis	Report writing and delivery

3. Component B – Community Extension

3.1 Background and objective

While component A focuses on the model-validation and on-field observations / measurements for incorporating new phenomena and improving the soundness of the model, component B focuses on the utility of the model through the community extension activities. This would require linking of the model results and the water budget concepts such as crop water demand, crop deficit, vulnerability, post-monsoon index etc. to concrete problems faced by the community and their translation to simpler water management rules which may help in possibly suggesting remediation measures.

Thus, the key objective of the community extension component is to demonstrate easy-to-understand village level exercises and develop protocols which will feed into the information, comprehension and collective-action based extension framework. The deliverables will be in the form of field-visits and actionable reports which will feed into PMU extension programs. Following are the key activities planned for this component :

Kharif season activities

- Documentation of kharif yields, dry spells, coping mechanisms.
- Use of vulnerability maps for targeting of project interventions and documentation of access to protective irrigation in the village.
- Documentation of solutions-space analysis, cost-benefit analysis of farmer investments and impact of existing interventions.

Rabi season activities

- Demonstration of concepts of entitlements and endowments, zonal water availability, and post monsoon indices to the villagers
- Documentation of rabi yields and rationing of water and presenting the same to the villagers.
- Demonstration of groundwater overexploitation, uncertainty associated with access to water.

- Design of a template for cost benefit analysis of investments by farmers and its demonstration.

- Testing, validation and demonstration in the pilot village for crop planning and crop diversification considering P1, P2, P3 crops and crop hierarchies.

These activities will be carried out through design and conduct of primary farmer-level surveys in the selected villages from the clusters selected for model validation in component A. The outcome of the surveys will be documented in the form of actionable and reproducible reports which may be used by the Extension agents such as Krushi Sahayak, Cluster Assistant etc. to carry out similar surveys in other villages.
The farmer surveys and the collected data on vulnerability, spread of yields, access to water etc. along with the water budget results will feed into the main agenda of the village-level meetings to be conducted by the Village Climate Resilience Management Committee (VCRMC).
Such community meetings will be conducted in the selected cluster as test exercises.

3.2 Work done so far

As the MoU IV was signed in late August, not much work has been done with regards to Extension activities.

As part of model validation few surveys were done in the selected clusters (mentioned in 2.2), the data is still in raw formats and needs to be further processed and analyzed.

3.3 Work planned ahead

A comprehensive farmer-level survey has been planned in the month of October in four villages in the selected clusters. The main objectives of the survey are:

- to document different types of vulnerability faced at the farm-level
- to document farmer coping mechanisms, investment choices and the village-level interventions through PoCRA (DBT, NRM works etc.)
- to identify key farm-level and village-level problems
- to link the water budget results to the above concrete problems

Table 4: Components of extension activities and key information required

Component	Key information required
Vulnerability	- Soil types, farm location (stream proximity or non-proximity), - Cropping pattern in kharif and rabi season during good and bad years - Maximum, minimum and average yields achieved in the last 10 years for major kharif and rabi crops - crop stress during dry spell in this monsoon, waterings required, and provided
Access to water and energy	- Existing assets and sources of water - wells, borewells, farm pond, drip/sprinkler, pipeline etc. - Ability to provide protective irrigation at crucial times during kharif and rabi seasons - Seasonal water availability - When do wells go dry in the post-monsoon season? - Access to electricity during crucial times, number of DT failures per year, major concerns
Farmer investments and aspirations	- What are the major investments in the last 5 years on assuring access to water? Cost-benefit analysis of the investments - What are the major investments, or crop choices planned in the next one or two years?
PoCRA benefits	- Application history and status - impacts and outcomes of the benefits as per farmer's narrative and whether the benefit was able to reduce vulnerability to some extent

The methodology for doing above farmer-level surveys is as follows:

- Pre-survey desk work
  - Prepare questionnaire
  - Transporting questionnaires to ODK (i.e. Open Data Kit) or platforms such as KoBotoolbox. These are basically suites of tools used for collecting field data in a structured manner using Android mobile devices).
  - Selection of farmers based on
    - Stream proximity
    - Vulnerability map
    - Land use land cover map

        - DBT application data
        - Well density
    - Prepare docket to be carried by the surveyor which would consist of
        - Different maps (Cadastral, Vulnerability, Soil, LULC, Drainage)
        - Rainfall data (past 5-6 years)
        - Summary of water budget results for the current year (key events such as dry spells, soil moisture trends, deficits)
- On-field work
    - First day - Preparatory meeting with Sarpanch, Agriculture Assistant (Krushi Sahayak), Cluster assistant, key VCRMC members
    - First day, Second day – Farmer surveys in different zones
    - Third day – Focused group discussions
- Post-survey analysis
    - Analysis of yields, finding median yields, plotting kharif yield-curves (i.e. number of waterings versus yields for different soil types for major crops)
    - Identifying major problems in the village with regards to biophysical and socio-economic vulnerability, access to farmers, farmer investments, reach of PoCRA benefits etc. and identifying vulnerable zones based on these parameters
    - Preparing maps and charts which may be presented in the village meeting.
- Conduct of village meeting
    - Present findings and results of analysis in the context of water budget based planning framework and take a step towards establishing core-agreement about the major problems faced by the village as a whole.

Such a primary survey would help to better understand the problems at the village-level and would enhance the knowledge-based and measurable extension mechanism. Thus, at the village-level it would help compiling following data -

- Median yields and problematic cases and their analysis
- Yield curves (relationship between yields, soil-type, waterings, incomes for different crops)
- Regions of low yields and poor access to water (vulnerable zones)

- Village resource envelope, cropping patterns and various scenarios, aggregate crop water demand, available water, post-monsoon indices in good and bad years
- Suite of farmer-level and village-level solutions and their consequences, mapping of vulnerability with the benefits as well as beneficiaries, exemplary good and bad cases

The main outcome of such village-level analysis based on farmer surveys would form the basis of the village meeting to be conducted at the start of the rabi season. Eventually, it is hoped that the Krushi Sahayak or the Cluster assistant will conduct such surveys and meetings at the village-level. This is a step towards the maahiti-gaavki (maahiti means information, while gaavki means collective decision making at village level) based extension framework suggested in the MoU III-report mentioned above.

The pilot surveys in the selected clusters will help in producing protocols and formats for farmer surveys which may help in designing training modules for the extension agents in the future.

3.4 Key deliverables and schedule

Component	Phase II	Phase III	Phase IV	Phase V	Phase VI
B1 - Kharif Extension activities	Conceptualization, Field work, conduct of meetings	Documentation, training material, reporting	solutions space analysis, PMU support		
B2 - Rabi Extension activities		Conceptualization, Field work	Data analysis, documentation of key observations, conduct of village meetings	Documentation, training material, reporting	

4. Component C – Model improvements

4.1 Background and objective

This component mainly focuses on the changes and improvements in the existing IITB water budget model. The changes mainly fall under following categories:

- Changes from the user perspective
    - Dynamic computation of the water budget: The current plugin is used by the PMU to compute zone-wise water budgets for PoCRA villages for the past years. The current plugin does not allow to compute the zone-wise water budget for the ongoing year at any point during the monsoon season dynamically. This would require changes to the existing plugin and further support to the PoCRA IT team to incorporate the same into the MLP application.
    - Vulnerability module: This module will help PMU officials to get cadastral-level vulnerability maps based on crop water deficits for any PoCRA village for any year (including the current one) for specific major crops on demand. Such vulnerability maps may be handed over to the field extension agents and to the VCRMC to aid in better targeting of PoCRA benefits as well as in better planning of NRM works.
- Changes to improve soundness of the model and ability to simulate key phenomena at the village and farmer level which could be linked to concrete problems faced
    - Improvements in the core point-level soil water balance engine to incorporate geological attributes such as specific yield and aquifer depths so as to improve the computation of total groundwater stock at the point-level
    - Improvements in the core point-level soil water balance engine to incorporate the phenomenon of ponding so as to improve simulation of runoff generation.
    - Improvements in the method of aggregating the point model results spatially as well as temporally. This will help in better simulation of surface water and groundwater flows.

4.2 Work done so far

- Changes for dynamic water budget computation –

- Space-time interchange: The current plugin takes weather data for the entire year and runs the water budget model for each point in the zone separately for the entire year. In order to run the plugin for the entire zone/village/cluster for a single time-step (or for a single day) would require an interchange of space and time loops in the existing architecture while keeping the integrity of the model intact. This space-time interchange and the required test-cases to check the integrity have been completed and the updated plugin is uploaded on the GitLab (https://gitlab.com/pocra-iitb).
- The space-time interchange was accompanied by multiple minor changes to the existing plugin to make the plugin more time-efficient. The updated plugin takes less time to compute the water budget. For a sample cluster of around 7000 ha, the updated plugin takes 25 minutes as compared to 40 minutes taken by the old plugin. A more detailed report on this will be presented in Phase 2.

- Changes for the vulnerability module – This will be an independent tool which will be hosted on the PoCRA server which will produce vulnerability maps for any PoCRA village for any year (for specific crops) on demand.
    - Changes to existing plugin for decoupling zone-wise water budget computation and vulnerability module - The vulnerability module will take in the cadastral map and will compute the water budget model for the centroid of each Gat no. / survey plot polygon. This logic has now been implemented separately and does not require zone shape files as inputs. Thus, the module is ready to be run independently and has been tested for sample villages. Multiple interactions with the PoCRA IT team have already been carried out in order to design the architecture for hosting the module on the PoCRA server.

- Changes for incorporating groundwater flows
    - Understanding of the MODFLOW solver for simulating groundwater flows through academic and technical literature
    - Coding of a simple prototype groundwater flow model on a small 5x5 grid.

    The prototype GW model demonstrates the temporal and spatial changes in groundwater availability in stream proximity and non-proximity regions in terms of changes in the heads as well as stocks. This gives us the region-to-region transfer of groundwater during rabi season, with given crop water demand and groundwater extraction.

    The model allows the user to set groundwater extraction (i.e. crop water demand) for specific regions for specific time periods. It also allows the user to set different hydrogeological attributes such as hydraulic conductivity, aquifer depths, aquifer storativity etc. and well level conditions as observed on the field as boundary conditions. The user may run the model for different values of extraction in different regions and study various scenarios or outcomes.

    Such a model will help in computing groundwater flows as well as identifying sustainable extraction patterns (and hence sustainable cropping patterns) for different regions in the village.

4.3 Work planned ahead

- Changes to the point model
- Regional geography: The simulation of transfer of surface water flows requires an elaborate stream network, watershed boundaries, differential watersheds to be in place. This work was begun in the third MoU. A python-coded GIS framework for incorporating the stream-flow model was developed and presented in Phase V of MoU III. In the present MoU, this framework will be scaled up for the whole PoCRA region. This would require changes to the IT stack, creation and addition of differential watersheds, stream segments etc. to the existing PoCRA databases, and changes to the multi-crop plugin to integrate the regional geography with the existing water budget model.
- Changes to incorporate groundwater flows -

- Validation of prototype model results with MODFLOW, understand gaps and limitations
- Transporting of the prototype to a GIS platform in order to simulate flows on more realistic terrains
- Field-visits to villages in the selected clusters in order to study actual terrain, slopes, well water levels, extraction practices etc.
- Incorporating on-field observations into the model and carrying out preliminary testing.
- Incorporating the GW flow model into the existing water budget model.

4.4 Key deliverables and schedule

Component	Phase II	Phase III	Phase IV	Phase V	Phase VI
C1 - Point model changes	Dynamic WB computation, updated plugin	Incorporation of field insights, code changes	Point model changes for GW recharge	Note on MLP improvements	
C2 - Implementation of Regional geography framework	code changes, documentation	zone ordering, delineation of stream proximity	PMU support		
C3 - Computation of regional flows	Conceptualization	Code changes, documentation	zonal module for reallocation of water within and across zones		Note on Chart improvements

5. Component D – Rabi planning framework

5.1 Background and objective

Once the water availability at the end of the kharif season is computed through the water budget model along with zonal water reallocation module to compute the flows across zones, then the proposed rabi and summer crop water demand may be compared with the total supply / availability (which includes soil moisture, surface water through impounding of runoff and most importantly groundwater stock).

As seen in most of the villages visited, the majority of the farmers face rabi water stress, especially at the end of the rabi season. One of the main reasons for this shortage is the gap between the demand and the supply aggravated by fierce competition for the scarce groundwater resource. The broad objective of this component is to design a planning framework which provides a platform which facilitates the village community to collectively decide a sustainable village-level cropping pattern so as to minimize the gap between demand and supply during the post-monsoon season, and at the same time maintain the incomes. The inspiration for this module comes from the success story of Hiware Bazar.

Thus the key objectives of this component are:

- To develop a scientific platform based on the water budget model which will produce different sustainable cropping pattern scenarios according to the available water stock at the start of the rabi season
- To facilitate village-level crop planning and diversification based on the water, energy and other constraints
- To provide a regime for GW entitlements and endowments for better GW management.

The outcome of this will be a stand-alone module. The planning tool may be used during village-level Rabi meetings by the community to aid in the crop planning exercise. This will be demonstrated through community meetings at the end of the coming rabi season in the selected clusters as test exercises.

5.3 Work planned ahead

The key tasks would include:

- Preparation of the conceptual outline for the rabi planning framework. This will include the design of the core computation Linear Programming based model which takes in the the water budget results for the kharif season, the crop hierarchy in terms of water requirement as well as profits and incomes per acre, other market constraints, energy constraints, farmer aspirations etc. and produces different cropping pattern scenarios
- Field work for understanding and incorporating key insights into the model such as rationing of water, maximization of available soil moisture by oversowing during rabi season, groundwater extraction practices, impact of increased groundwater extraction in stream proximity regions on the well levels and water availability in the non-proximity regions and so on.
- Incorporating secondary data such as input costs, market rates, water demand, yield-watering curves in different soil types for different crops.
- Design and development of the prototype Linear-Programming based model and running it for pilot villages in the selected clusters.
- Convert the model into a stand-alone application with easy-to-understand and attractive user interface.
- Present the application to different types of farmers, test the results, make changes as per the feedback. Eventually run the model in the village meeting and study the response.
- Identify key datasets to be added in the PoCRA IT stack.

5.4 Key deliverables and schedule

Component	Phase II	Phase III	Phase IV	Phase V	Phase VI
Design of rabi planning framework for crop planning and diversification.		conceptualization	note on conceptual framework		
Designing energy and irrigation practices as a joint constraint.		incorporating insights from field, documentation			

Designing cropping scenarios through Linear Programming (LP) model.		preparation and coding of prototype LP model	Field work, interactions with farmers, documenting various cropping pattern scenarios	testing and strengthening of LP model through coding and field work	stand-alone rabi planning module for pilot villages
Addition of required datasets to IT stack (market rates, P1, P2, P3 definitions, crop hierarchies).			Identifying key datasets such as market rates, crop hierarchy, yield curves through field work	Documentation and design of database schema through interactions with PMU	PMU support for integration into MLP

6. Component E – PMU and IT support

6.1 Well beneficiary prioritization module

Key Objective: To aid the existing beneficiary prioritization process to grant wells to farmers through use of village-level vulnerability maps

Key tasks:

1. Understand existing DBT process for beneficiary selection
2. To design the conceptual framework for incorporation of vulnerability maps and to outline concrete steps for well-beneficiary prioritization
3. To demonstrate the process through prototype for sample villages and get approval from the PMU
4. To identify key datasets (such as Cadastral maps, DBT data, LULC maps etc.) required and document gaps and limitations in existing data
5. To incorporate DBT data and LULC into the existing vulnerability module and run for a pilot district and to test the results.
6. To design village-level PDF format for publishing the prioritization results and to make code changes to produce these PDFs.
7. To design the architecture for the GIS-based prioritization module to be hosted on the PoCRA server for the whole PoCRA region.

8. To port the local prioritization module to the PoCRA server and handover the code.

Currently, the tasks 1 to 4 have been completed, task 5 is ongoing. Tasks 6 to 8 require further interaction with the PoCRA IT team to go ahead. These tasks are planned to be done in the coming two weeks.

6.2 Other support activities

Other activities include:

- Support to PMU regarding issues and bugs in the MLP app and village water budget chart generation process. Involvement of IITB is limited to identification of bugs/issues, recommendations on resolution of the issues and testing and comparison of the water budget results between MLP app and Village water budget charts.
- Support to PMU in the process of scaling up the water budget module of PoCRA dashboard for the whole state of Maharashtra and to aid in the process of handover of the functionality to the Agriculture department, GoM. This would involve attending meetings, preparation and sharing of key technical documents, support in knowledge and technology transfer etc.

Inception Report- Energy Component

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1. Introduction

Water and energy are both key resources and their availability are key constraints which need to be managed together. The work in MoU III had indicated that energy infrastructure is constrained to a great degree. This will only be exacerbated with changing cropping patterns, and increases in: the need for protective irrigation, water transfers and micro-irrigation. In addition, unreliable electricity supply leads to poor control over management and usage of water. Villages must then be guided to undertake more sustainable irrigation practices, adopt appropriate pumps, use capacitors etc., and practice load management and scheduling. Estimation of energy consumption in PoCRA villages and extension of the above techniques is proposed in MoU IV. Moreover, at the farmer-level, indices for investments for irrigation infrastructure and matching estimates for public energy infrastructure will be developed. This will help in guiding farmers and villages in choosing appropriate crop-plans which are economically sustainable. MoU IV objectives build on the work done in MoU III to address these issues.

The inception report presents the work planned in some detail. The first chapter is a description of the objectives of MoU IV. Chapter two lists the locations which are selected, or planned, for each objective. Chapter three describes at a high level, the work done so far.

Objectives

F: Strengthening community action for demand-side interventions

Under MoU IV we are exploring demand-side interventions through community action for the first time. A significant improvement in the quality of electricity supply can be brought about through demand-side management at the Distribution Transformer (DT) level, or through community action by the farmers on one DT.

The two major objectives of the study are:

1. To demonstrate easy-to-understand DT-level load scheduling exercises, for a selection of 4 distribution transformers in 1 to 2 clusters.
2. To develop protocols that will feed into the ‘Information comprehension and Collective action’ based extension framework.

DT selection will be done such that DT are overloaded and farmers are interested in conducting the proposed Demanside activities of load scheduling and capacitor installation.

After DT selection, detailed surveys are to be conducted for collecting data on individual farmer load, cropping pattern, irrigation method, irrigation behavior, and to come up with a feasible sample load management schedule to avoid DT overloading and to prevent low voltage issues.

LT distribution network data of the DTs will be collected and mapped. The selected DTs are to be metered to monitor the usage pattern and loading on the DT. Farmers will be encouraged and supported to install capacitors.

Hand Holding of farmers will be done regularly during peak Rabi season to create load management schedules suited to the farmer requirements, to monitor whether the load schedules are being followed, to identify and rectify problems occurring while following the load management schedule.The exercise will be used to develop a set of guidelines for functioning of, and assistance to, such DT User Groups (DTUGs).

G: Monitoring energy and water usage on selected farmers

The objective of monitoring energy and water usage for farmers is continued from MoU III for the same set of farmers. The tasks under this objective are the following:

- To continue monitoring of water and energy meters with cropping and irrigation surveys in 8 villages in 5 districts selected during MoU III.

Water and energy usage was metered to get representative data from individual farmers to feed into all other objectives. A decision was made to continue the monitoring for another year since 2020-21 was a heavy rainfall year, and a more typical rainfall year should be monitored for more representative usage patterns.

H: MLP based energy estimation tool prototype at the village level

In MoU a framework was developed to estimate the energy and water consumption by crops in a group of village(s) under one feeder based on MLP data, and secondary datasets, and some primary surveys in the villages. This framework is developed into a tool to estimate energy infrastructure sufficiency in a village.

MLP data and some primary information about the village which will be supplied by the VCRMC will be the inputs to the tool. The tool output will be an indication of energy infrastructure status to indicate overloading or insufficiency, the effect of various crops, irrigation methods, and water transfers. This may be used for policy decisions such as targeting villages for interventions for load management and demand-side management, or other planning to be done in conjunction with, or communicated to, MSEDCL.

In MoU IV, we select 3 feeders in three clusters for the implementation of the energy estimation tool. The tool output will be validated using the feeder energy consumption data which is collected at the substation. In addition, energy meters will be installed at selected Distribution Transformers (DT) to correlate cropping, agro-climatic and other data which are inputs to the tool, and energy consumption pattern at the DT. 6-8 DT meters will be installed on the three selected feeders. The developed tool will be integrated with the IT Stack and submitted for implementation in all PoCRA villages.

I: Cropping pattern based Irrigation and Investment indices, village level, for irrigated and non-irrigated farmers

Indices for investments for irrigation infrastructure and matching estimates for public energy infrastructure at the farmer level will be developed. This will help in guiding farmers and villages in choosing appropriate crop-plans which are economically sustainable. The indices will themselves be village-wise indices, and will be developed for 4 villages in MoU IV.
The tasks under this objective are the following:

1. Review and restructuring of existing indices (from literature or in current practice) and proposal of new indices
2. Selection of villages (4), development of farmer sampling methodology (30 farmers per village), design of questionnaires and surveys
3. Survey of farmers in selected villages.

Surveys will be conducted to develop a comprehensive picture of expenditure over the years by farmers on infrastructure, as well as schemes benefitted from at an individual or community level, and related changes in operational expenses.

J: Load Management Application Development and MLP tool IT Stack Integration.

This is a new objective to automate and support the work done under objectives F and H of MOU IV. The tasks under this objective are the following:

1. Development of Load Management Application to be used in upcoming rabi by IITB to support 4 pilot DTUGs in component F. The application will allow representation and evaluation of schedules for infrastructure performance. This application will be a tool that allows farmers to coordinate their DT network usage to reduce overloading.

2. Porting of MLP based energy estimation tool into IT Stack. Incorporation of new data sets such as dugwell depths, high-level parameters of irrigation tanks / dams in village, groundwater levels, energy infrastructure and other village parameters, to support component H for a select set of clusters.

2. Selection of Locations

In MoU III, 5 districts were selected for various objectives: Aurangabad, Buldhana, Osmanabad, Yavatmal, and Washim. In MoU IV, additionally, we are selecting locations in Latur and Nanded. The clusters, villages names and components are indicated in Figure 2.1.

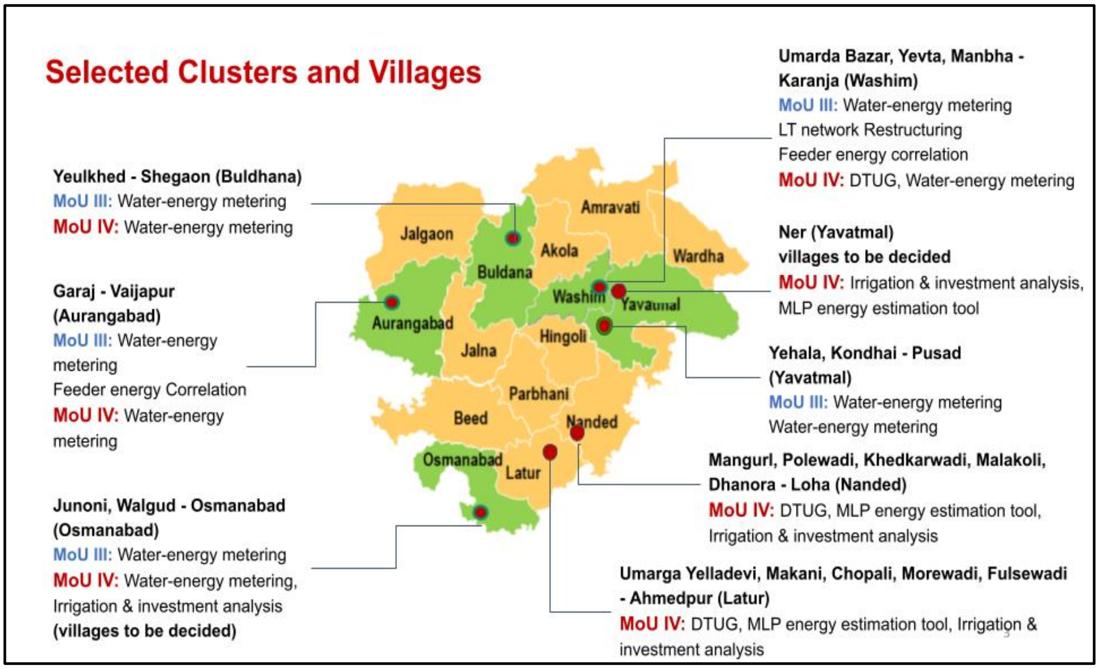

Figure 2.1: Locations of energy component objective implementation.

F: Strengthening community action for demand-side interventions.

Figure 2.2 illustrates the villages selected for DT User Group interventions. A few more villages are still being explored to ensure that we have 4 locations where the farmers are committed to trying out the proposed community actions.

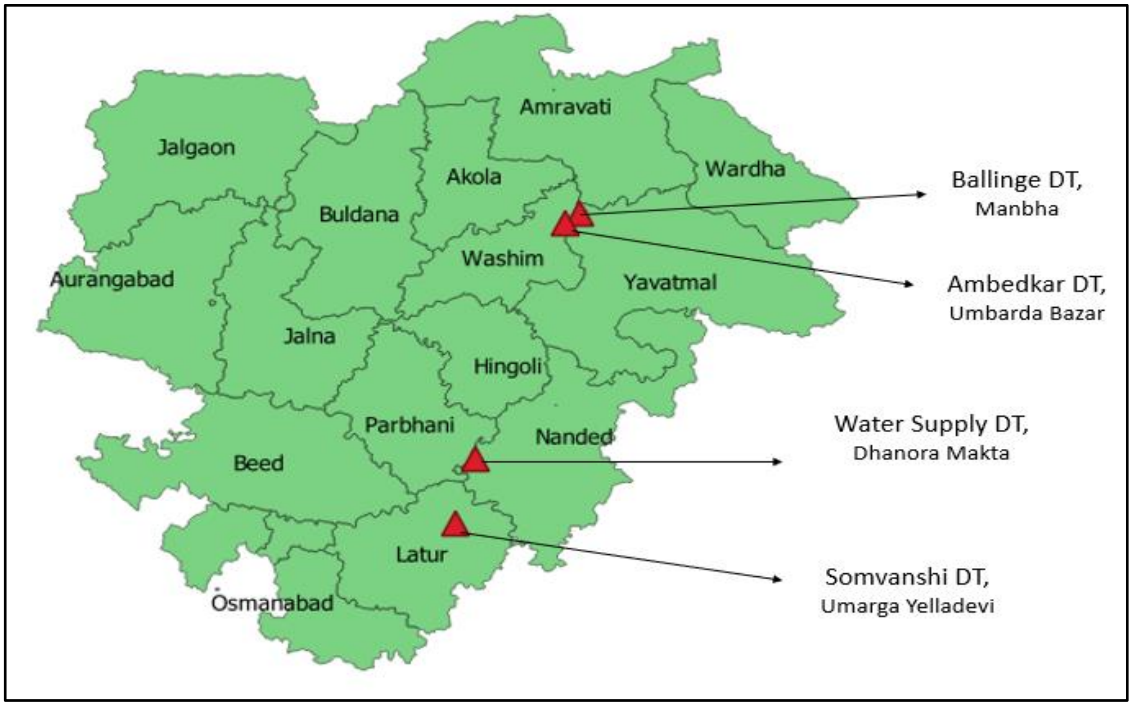

Figure 2.2: Locations of DTs selected for strengthening community action for demand-side interventions.

The following distribution transformers were selected for a pilot study on DT level demand-side interventions.

Table 2.1: Details of the location of selected DTs for community action.

DT Name	Village	Village Code	Cluster Code	Feeder	Substation	Taluka	District
Ambedkar	Umbarda Bazar	530952	502_wrb-3_04	Umbarda	Umbarda	Karanja	Washim
Ballinge	Manbha	530948	502_wrb-1a_01	Umbarda	Umbarda	Karanja	Washim
Somvanshi	Umarga Yelladevi	560401	524_mr-47_05	Ajansonda	Chapoli	Ahmedpur	Latur
Water Supply	Dhanora Makta	545275	511_gv-101_03	Sunegaon	Loha	Loha	Nanded

The DT selection was done primarily based on (i) Some variation in locations - hence two from Washim, and one each from Latur and Nanded (ii) The collective interest shown by farmers on a

DT to take part in the load management exercise. (iii) The load management incentivizes overloaded DT farmers as it will considerably improve their electricity supply with reduced DT tripping and improved voltage. All DTs selected are overloaded and face tripping issues and reduced hours of supply. (iv) The presence of a local leader or a person/s or authorities of influence in some locations helped in the initial ice-breaking with the farmers and readiness to listen/try out a load management schedule.

1. **Ambedkar DT, Umbarda Bazar**

The first interaction with farmers of Ambedkar DT occurred as part of the village level energy infrastructure study (MoU III) in Umbarda Bazar. **The DT was selected mainly because of the history of load management once tried out by the farmers.**

The DT being overloaded resulted in frequent trippings during peak season and low voltage issues at the pumps located far from the DT. Farmers had themselves tried and failed operating partial loads at a time taking turns among themselves. This was done without any formal arrangements or schedules being made. The practice stopped as all farmers were not involved and some started irrigating in slots not allocated to them. Farmers collect money for transformer maintenance before peak season and don't allow illegal ‘hooking’ on their DT during peak seasons. Hence it seems like there is some history of community action here which may allow us to leverage it.

Farmer meetings are to be organized for Ambedkar DT farmers to get all of them on board for load management to work and to assist in creating a load management schedule as per their irrigation requirements. Umbarda Sarpanch promised his full support in organizing meetings and agreed to circulate the awareness video made by PoCRA among farmers.

2. **Ballinge DT, Manbha**

Ballinge DT is located towards the farther end of the feeder and receives low voltage at the DT itself. A further voltage drop occurs due to 2km long LT lines and overloading. Frequent tripping occurs at the DT. Even though farmers use local pumps operational at low voltages, effective supply hours available are less. As the DT has poor supply conditions, the willingness of farmers for trying out load management was enquired during individual farmer interactions, to which only some gave a positive response. A couple of farmers offered to help persuade other farmers to take part in the initiative if some formal arrangements can be made to legitimize the load management schedules once it is made. With the push from the village sarpanch and a local person of influence on the DT, the farmers have expressed their readiness to get capacitors installed at their pumps. **The DT was selected mainly because of the local support available.**

Farmer meetings need to be organized at the DT level, to ensure the participation of all farmers and to get them involved in the preparation of the load management schedule.

3. **Somvanshi DT, Umarga Yelladevi**

The village was identified from village level discussions with several villages as elaborated below.

During the village level meetings at villages on Makni feeder & Malakoli Feeder in Latur & Nanded districts respectively, discussions were put forth regarding capacitor installation by all farmers. The importance of capacitors as a low-cost alternative to significantly improve supply by reducing the load on the DT and increasing voltage at the pumps as well as to avoid loss of irrigation due to DT and pump burnouts were discussed. The awareness video was shown during the meeting and circulated among farmers. Emphasis was given on getting all farmers on the DT to install capacitors to achieve the desired results.

In 6 villages among the 10 villages visited which showed interest in the capacitor initiative, trying out load management to overcome the supply issues associated due to overloading was suggested. Among these villages, Umarga Yelladevi farmers agreed to try out load management strategies to improve their supply hours and quality. Others were reluctant as they were doubtful and in some cases sure that farmers won't follow a set schedule and everyone would want to get their irrigations done first as the supply hours are not reliable. Supply hours get further reduced in these villages as the electric lines are poorly maintained leading to feeder tripping and DT tripping due to faults at the LT lines.

Among the overloaded DTs in the village, the Sarpanch suggested Somvanshi DT (Sarpanch's DT) for initial study as it's easier to get farmers together to create and adhere to a schedule. **The DT was selected considering the local support available and the interest shown by farmers on the DT.** The farmers on this DT are mostly a homogenous population (same community or family) and leadership and influence of the Sarpanch would help in continuing the demand-side interventions in the future.

4. **Water Supply DT, Dhanora Makta**

The village and DT was identified with the help of MSEDCL officials. Meetings were held at MSEDCL Sub division office Loha (Nanded) and Shirur(Latur) with Executive Engineer (EE) and Deputy Executive Engineers where a brief overview of the research work done so far by the PoCRA-IIT Bombay team was given. Plans to do demand side interventions to improve electricity supply for irrigation were discussed, and help in identifying an overloaded DT in a village with cooperative farmers was requested. MSEDCL officials at Loha Sub Division suggested Dhanora Makta village for the load management exercise based on requirements given to them. A meeting was organised by the Assistant Engineer (Loha Section MSEDCL) at the village and after discussions with the farmers, **Water Supply DT was selected based on the response from the farmers and as suggested by the AE, MSEDCL.**

During follow up meetings with Water Supply DT farmers, it was identified that farmers showed readiness to try out load management initiatives as they were forced to operate at around 4 hours supply per day during peak times as opposed to 8 hours that should be available to them as a result of frequent trippings at their DT due to overloading, voltage issues also exist due to long LT lines.

G: Monitoring energy and water usage on selected farmers.

The list of villages to continue monitoring energy and water usage are the following:

Table 2.2: List of villages with farmers for monitoring energy and water usage.

Sr. No.	District	Taluka	PoCRA cluster code	Village	No. of farmers
1	Aurangabad	Vaijapur	515_gv-34_05	Garaj	7
2	Buldhana	Shegaon	500_ptgi-1_01	Yeulkhed	7
3	Osmanabad	Osmanabad	525_sa-33_04	Junoni	5
4	Yavatmal	Pusad	510_pgp-3_04	Kondai	3
5	Yavatmal	Pusad	510_pgp-3_04	Yehala	4
6	Washim	Karanja	502_wrb-3_04	Umarda	2

7	Washim	Karanja	502_wrb-3_04	Yevta	2
8	Washim	Karanja	502_wrb-1a_01	Manbha	4

As per Table 2, eight villages and 34 farmers in five districts are selected to continue monitoring their energy and water usage for various crops.

H: MLP based energy estimation tool prototype at the village level.

The selection of villages for further developing and testing the energy estimation tool prototype was done in conjunction with the objectives of the water component. Since, water and energy are codependent resources in the context of agriculture and allied activities, the interventions addressing the two should not be developed in an isolated manner. Thus, we selected the villages in the PoCRA clusters that were identified for water-based interventions to have better coordination between the water and energy-based interventions. The clusters for the water component interventions were selected based such that the selected villages/clusters should be representative of the PoCRA villages in the region in terms of:

a. Soil type - combination of different soil textures and depths
b. Rainfall
c. Terrain
d. Land use and cropping pattern

The clusters selected for the water component investigations are:

Table 2.3: List of clusters selected for water component interventions.

District	Taluka	PoCRA cluster code
Nanded	Loha	511_gv-101_03
Latur	Ahmadpur	524_mr-47_05

The energy estimation tool requires all the selected villages to be on the same feeder, since the energy estimation can only be validated from energy measurements taken at the substation at the feeder level. Thus, three feeders have been (will be) selected, one from each cluster. Feeders were selected such that the maximum number of villages on the feeder are PoCRA villages. Some basic investigations as required for the energy estimation will also be done in the non-PoCRA villages.

The villages and their respective feeders that were selected for the intervention are the following:

Table 2.4: List of villages selected for MLP based energy estimation tool prototype.

Sr. No.	District	Taluka	PoCRA cluster code	Feeder	Village	Under water component
1	Nanded	Loha	511_gv-101_03	Malakoli	Mangrul	Yes
2	Nanded	Loha	511_gv-101_03	Malakoli	Polewadi	Yes
3	Nanded	Loha	Non-PoCRA	Malakoli	Khedkarwadi, Ramachiwadi	No
4	Nanded	Loha	Non-PoCRA	Malakoli	Malakoli, Ghughewadi	No
5	Latur	Ahmadpur	524_mr-47_05	Makani	Chopali	Yes
6	Latur	Ahmadpur	524_mr-47_05	Makani	Morewadi	Yes
7	Latur	Ahmadpur	524_mr-47_05	Makani	Makani	No
8	Latur	Ahmadpur	Non-PoCRA	Makani	Fulsewadi	No

Three feeders were planned for selection under this objective. Thus, one more feeder would be selected from Ner taluka in Yavatmal district using the same methodology. The list of probable villages from Ner taluka are the following:

1. Adgaon, Ner, Yavatmal
2. Umartha, Ner, Yavatmal

These villages are PoCRA villages under the cluster code 510_wrb-1a_01 and are also selected for the water based interventions.

I: Cropping pattern based Irrigation and Investment indices, village level, for irrigated and non-irrigated farmers.

The village selection under this component will be done at a later stage. 4 villages will be selected, one from each of the following locations:

a. Osmanabad (Taluka and cluster to be decided).
b. Ahmadpur taluka, Latur (PoCRA cluster - 524_mr-47_05).
c. Loha taluka, Nanded (PoCRA cluster - 511_gv-101_03).
d. Ner taluka, Yavatmal (PoCRA cluster - 510_wrb-1a_01).

3. Work executed till date

F: Strengthening community action for demand-side interventions.

As part of strengthening community action for demand-side interventions, the following activities were done in study locations in Nanded and Latur districts

- Apart from the two DTs that were already identified from Umbarda & Manbha villages in Karanja, Washim, activities were carried out as explained in the earlier section for identification of two remaining DTs in Nanded & Latur.
- To monitor the loading pattern on the selected DTs during the Rabi season, 12 DT meters are being ordered.
- A planning meeting was arranged on 20th August with PoCRA Project Management Unit, Mumbai, Agriculture Department officials, Nanded and Latur, and MSEDCL officials, Nanded and Latur, for communicating the objectives of the Energy Component under PoCRA and to seek feedback on the capacitor drive intervention in the selected villages.
- Capacitor drives were conducted in the 6 villages namely; Morewadi, Chopli, and Makni village in Ahmedpur Taluka, Latur and Mangrul, Polewadi, and Khedkarwadi village in Loha Taluka, Nanded.

  Village level meetings were organised from 1st to 8th September, where officials from the Agricultural department, MSEDCL and PoCRA attended for the capacitor drive. Discussions were initiated regarding the supply problems faced by them and what can be done to overcome those. Usage of capacitors and load management was suggested as alternatives that can be explored from the farmer's side. The significance of installing capacitors at the pump by all farmers on the DT was discussed.

Awareness video created by the PoCRA team was displayed using projector. Farmers had confusion regarding the placement of capacitors in the circuit, which the team explained with the help of video as well as showcased a demonstration of capacitor installation at one of the farmer pumps in each village, clearly indicating a drop in current in improvement in voltage using power analysers.

Farmers in this region (Nanded & Latur Study region) are supplied by mixed feeders (agricultural and residential loads), two-phase supply is available during the non-Ag supply period. Farmers use two-phase to three-phase conversion capacitors to run their pumps during these periods. This practice damages their pumps and farmers are forced to opt for it as against the loss of irrigation. Confusions arose regarding the working of three-phase capacitors along with these phase conversion 'condensers'. This might create an issue with how farmers perceive capacitor usage.

- Individual Farmer Survey Questionnaires were developed for the collection of data required for creating load management schedules.
- A detailed farmer survey was done for Umarga Yelladevi - Somvanshi DT and Dhanora Makta - Water Supply DT farmers.

Profile of Villages selected for Load Management Initiative

Umarga Yelladevi:

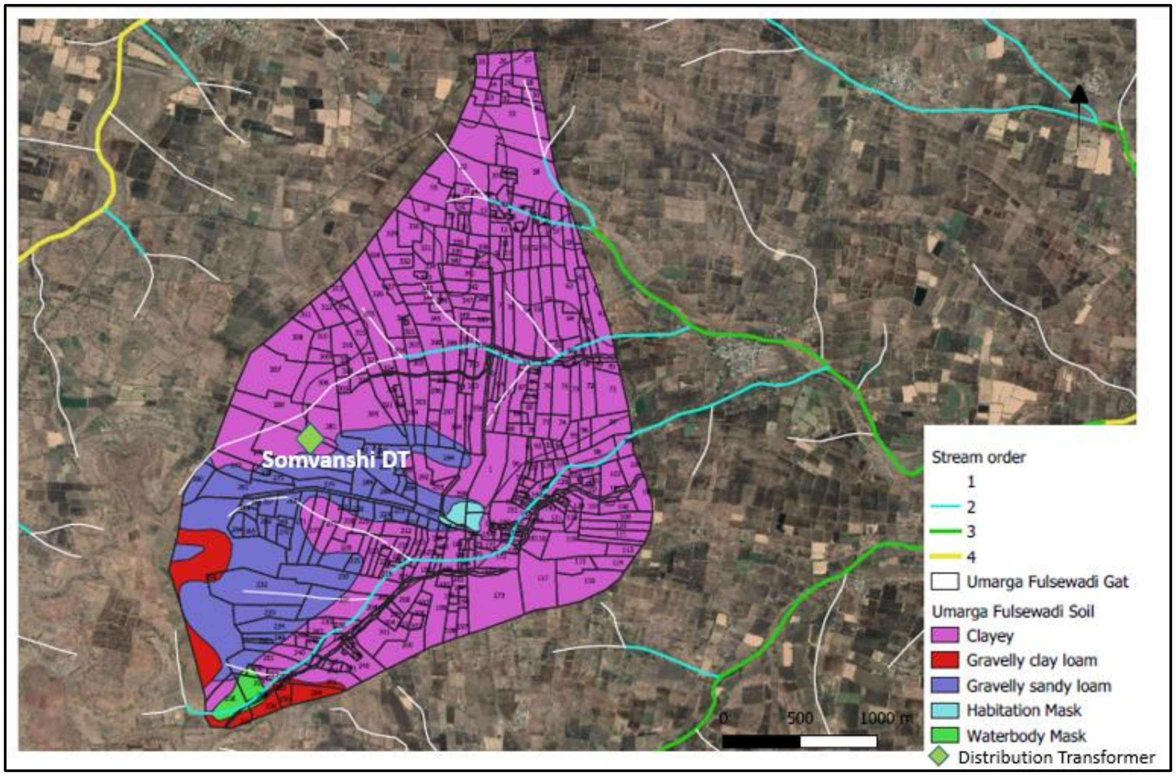

Figure 3.1: Umarga-Fulsewadi map with location of selected DT.

Table 3.1. Umarga Yelladevi Village Details.

Village	**Umarga Yelladevi**				
Cluster Code	524_mr-47_05	**Geographical Area**	819 ha	**DT Selected**	Somvanshi DT
Taluka	Ahmedpur	**Rainfall (2020)**	688 mm	**Feeder**	Ajansonda Feeder
District	Latur			**Substation**	Chapoli 33/11 kV

Soil type: Black Soil and medium soil.

Major crops Grown

Kharif : Soybean, Tur

Rabi: Jowar , Wheat, Gram ; Annual: Sugarcane

Water sources: Open wells and Borewells

Energy Infrastructure for Irrigation

- There are 10 DTs in the village, 8 * 63 kVA DTs and 2 HVDS transformers.

- Some DTs are overloaded mostly because of additional illegal pumps run by sanctioned farmers and a few seasonal connections. Upto 20 pumps operate on an overloaded DT, where individual pump capacities vary from 3HP to 7.5 HP.

Somvanshi DT (63kVA) selected has 18 pumps (93 HP) operating on it. Farmers on the DT mostly irrigate sugarcane.

Dhanora Makta

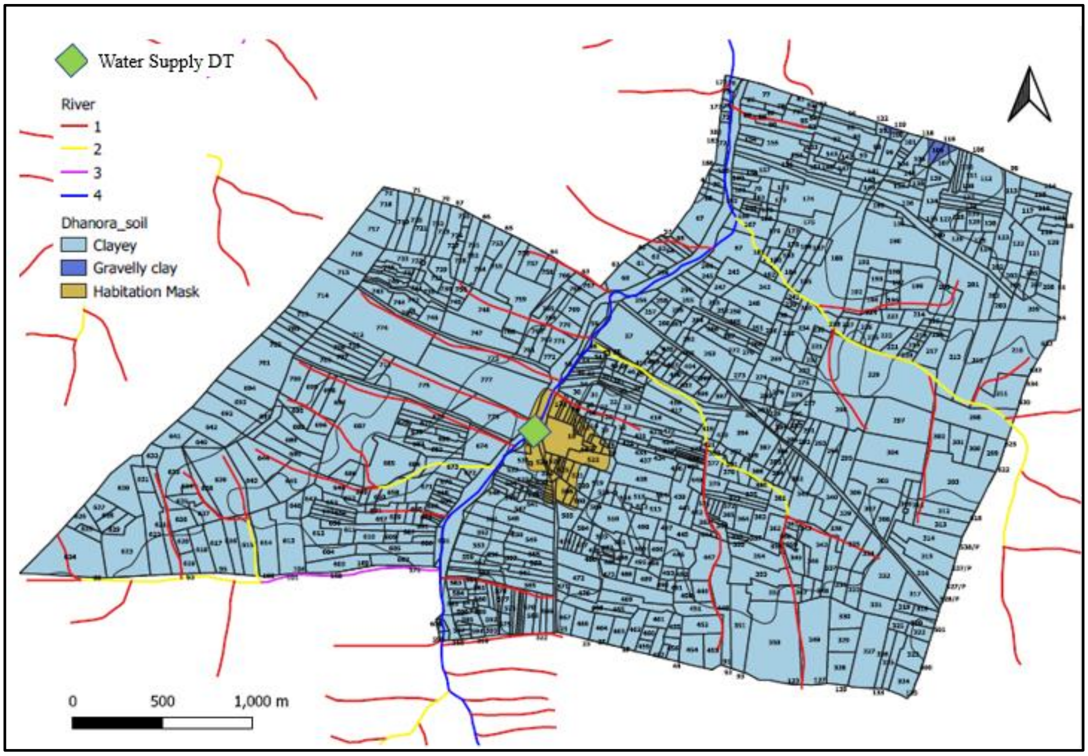

Figure 3.2: Dhanora Makta map with location of selected DT.

Table 3.2 Dhanora Makta Village Details.

Village	**Dhanora Makta**				
Cluster Code	511_gv-101_03	**Geographical Area**	1199 ha	**DT Selected**	Water Supply DT
Taluka	Loha	**Rainfall (2020)**	690 mm	**Feeder**	Sunegaon Feeder
District	Nanded			**Substation**	Loha 33/11 kV

Soil type: Black (Changli), Medium (Halaki), Murum

Major crops:

Kharif: Soybean, Cotton, Tur,

Rabi: Wheat, Jowar, Gram

& Turmeric

Water sources: Open wells, borewells, CNBs, river (perennial and/or seasonal)

Energy Infrastructure for Irrigation

- There are 14 DTs in the village, both 63 and 100 kVA (including 2 HVDS).
- Pump capacities are in the range 3HP to 5 HP.
- Overloaded DTs have around 30-40 pumps operating on them, of which around 10 pumps are additional illegal pumps operated by sanctioned farmers and around 5 seasonal pumps.

The Water Supply DT(100kVA) selected is heavily overloaded (38 pumps), and the farmers irrigate for the crops, wheat, gram , jowar and turmeric.

G: Monitoring energy and water usage on selected farmers

The 34 selected farmers from five districts, namely Aurangabad, Buldhana, Yavatmal, Osmanabad, and Washim, are currently being monitored for their energy and water usage for various crops for the year 2021-22. The process that was being followed last year is being continued - for each village:

- A local project assistant hired by IITB is in-charge of collecting data from the meters installed on the farmers' pumps
- Energy meters log data. The data is stored locally and with the help of project assistants this data is downloaded using a cellphone app monthly, and get uploaded to the server, which is then accessed by IIT.
- The water meter records the cumulative volume of water passed through the pipe and a photo of the water meter is shared by the same project assistant monthly.
- A fortnightly phone survey of each farmers is carried out by the IIT team to note the irrigations done in the period so as to correlate the energy and water consumption to crops

The project assistant selected earlier at Yeulkhed, Buldhana has not responded well during MoU III hence a visit is made by one project research engineer to check on it.

H: MLP based energy estimation tool prototype at the village level.

To further develop the energy estimation tool, we conducted the activities detailed below in the selected districts as part of the village selection process. Summary high level data has been collected in two out of the three clusters identified for objective H.

Data has been collected for the following villages:

Table 3.3 List of villages where primary surveys have been completed under objective H.

Feeder	**Village**
Malakoli	Mangrul
Malakoli	Polewadi
Malakoli	Khedkarwadi
Malakoli	Malakoli, Ghughewadi, Ramachiwadi
Makani	Chopali
Makani	Morewadi
Makani	Makani
Makani	Fulsewadi

Detailed set of work done:

1. Selected the PoCRA clusters which were selected for water based interventions in the selected districts of Latur and Nanded.
2. Visited the villages selected for water based interventions in these clusters.
3. Identified the villages connected to the same feeder using the data obtained from respective MSEDCL sub-division offices and corroborated by the MSEDCL substation operators.
4. In the PoCRA villages, conducted VCRMC meetings in the aforementioned villages along with GP representatives, PoCRA officials, and Agriculture Dept. officials to understand

the village profile in terms of soil, land use, cropping pattern, water sources, irrigation practices, electricity scenario and issues, etc.

5. In the non-PoCRA villages, conducted meetings with GP representatives, Agriculture Dept. officials and a few farmers to understand the village profile.
6. Developed a questionnaire to capture the detailed village profiles of the selected villages in terms of soil, land use, cropping pattern, water sources, irrigation practices, electricity scenario and issues, etc.
7. Conducted primary surveys in the villages and mapped the surveyed farmers on various village level maps (with streams, soil type, and gat no.) to test the questionnaire and sampling methodology.
8. Obtained the daily energy consumption data for the two feeders - Makani feeder in Ahmadpur, Latur, and Malakoli feeder in Loha, Nanded, from June 2020 till date from respective MSEDCL substations.

J: Load Management Application Development and MLP tool IT Stack Integration.

The load management schedule is being developed using thumb rules based on farmer input. The process will continue as we proceed to interact with DT user farmer groups as described in objective **F**. The application will be developed as the parameters for scheduling become clearer with farmer inputs and interactions.

रबी चे सिंचन दिवस ->	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	दिवसाचा वीज पुरवठा - ३ फेज़							रात्रीची वीज पुरवठा - ३ फेज़						
माधव घोरे	5	5	5	5	5	5	5	5			5	5	5	5
विष्णू सोमवंशी	5	5	5	5	5	5	5	5	5	5	5	5	5	5
निवृत्ती सोमवंशी	5	5	5	5	5	5				5	5	5	5	5
नारायण सोमवंशी						5	5	5	5	5				
क्षेतकारी - १									5					
रामप्रसाद सोमवंशी							5	5	5	5				
नारोबा दवाणे	3	3	3	3	3					3	3	3	3	3
गणेश श्रीमंगठे	5	5	5	5	5	5	5	5	5	5	5	5	5	5
अंतराम सोमवंशी	5	5	5	5	5	5					5			
क्षेतकरी - २												5		
एकूण पंप एच. पी.	**28**	**28**	**28**	**28**	**28**	**30**	**25**	**25**	**25**	**28**	**28**	**28**	**23**	**23**

Figure 3.3 Load Management schedule developed for potential DTUG in Dhanora, Loha, Nanded.

The MLP tool IT stack integration will be done towards the end of component H submission timeline. The work in the 3 locations will fine-tune the water-energy correlation model developed in Mou III and integrate the model with MPL data.

4. Current activities and schedule

The rabi season begins in October in some villages, hence the activities relating to the DTUG need focus at this point. The DT gets overloaded in November , December, and we need to ensure that capacitor installation gets done, and farmers are engaged with regard to the Load Management.

Other tasks to be done before the Phase II Deliverable are:

- Selection of feeder in Ner, Yavatmal for MLP based energy estimation tool
- Installation of DT meters when they are delivered by the vendor on DTUG locations as well as energy estimation tool villages

Inception report: Post-Harvest processing

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Background

The project has a stated vision that Farmer Producer Companies (FPCs) will be strengthened and also benefit from the project, through climate-resilient investments in value chain development with the promotion of backward and forward linkages, and access to business development and incubation services. In line with this vision, it is proposed to assess and provide post-harvest and value-added technological solutions to the screened and selected FPCs. To take advantage of value-added agricultural potential, FPCs should be aware of value-added opportunities, as well as informed about the feasibility, planning and market development associated with a value-added business. There could be a possibility of additional revenue by adding a new enterprise around the commodities (which are being traded in a conventional manner), adopting new practices in cooperation with existing enterprises or by adding value to a commodity that is currently being produced.

Objective

The objective is to reduce postharvest losses of selected agriculture produce through appropriate technological interventions such as appropriate storage structures and increase farmers' financial returns through value addition route which includes primary and secondary processing.

The proposed work of developing a detailed project report (DPR) will be useful for FPC in taking decisions prior to entering a new business and understanding the nature of the markets, the expected financial returns and the risks that surround the expected outcomes associated with new ventures.

This includes cost estimates of plants set up with different capacities, value chain proposition, opportunity, the operating plan, the marketing plan into anticipated financial results. It contains the status and the future projection of financial performance of the business with the selection, evaluation, and interpretation of financial data along with other relevant information in financial decision making. Perform risk analysis by building models of possible results considering variations in all important variables. This would help us understand all the possible outcomes of decisions and assess the impact of risk, allowing for better decision making under uncertainty.

The Feasibility analysis that is a part of this MOU will also eventually lead to a long-term handholding of the FPCs for the actual implementation of the DPRs developed by them in the course of time.

Methodology

Part 1: Technology Intervention to reduce post-harvest losses of onions

Task A: Development of a detailed project report (DPR) for one existing Farmers Producer Company (FPC) in regard to technological intervention in large scale (500-1000 tons) onion storage structure.

Activities

a. Detailed mapping of onion production, processing and storage in selected PoCRA areas and current storage practices.

b. Screening of FPCs for technology intervention. This will be based on different parameters (Technology readiness, Capability, Scale of Operation etc.) which will be used for screening based on primary and secondary analysis.

Task B: Landscape and stakeholders' analysis which includes FPC portfolio, quantum and productivity of onion crop, detailed activities including production, trading, current storage practices, interest and willingness to adopt technology for enhanced shelf life of rabi onions.

Activities

a. To conduct a detailed study for potential technological interventions. This would include questionnaires, interviews, group discussion etc. and involve collection of relevant primary and secondary data.

b. Financial model: Projected income and expenditure, financial structure and sustainability, Cost-benefit and break-even analysis for the proposed intervention.

c. Implementation planning: Determination of human resources requirements, regulatory and legal approval, SWOT analysis, risk mitigation strategies, implementation schedule

Part 1 Deliverables

Detailed Project Report (DPR) and an implementation plan to commission the project. Commissioning of the project will be taken up by the FPC with the technical assistance of IITB. (details are mentioned in the MOU)

Part 2: Technology Intervention for value addition of agriculture produce via processing

Tasks:

Prepare a detailed project report for one FPCs in regard to value addition of agriculture produce via new processes & products developed at IIT Bombay and elsewhere. Commodities for value addition and proposed processes are as follows:

- Turmeric: Multiple products including Curcumin, essential oils, starch
- Ginger: Dry ginger powder, Essential Oil
- Soybean: Soybean flour, Soybean-millets flour, Soybean Oil, Protein Isolate, Nuggets and chunks
- Maize/Corn: Starch, glucose, oil, animal feed

a. Development of a matrix to screen crops in selected POCRA areas be used as a feedstock for value addition. This would also help assess the availability and accessibility of selected raw material throughout the year.

- Estimating economics of cultivation of selected crops as per local agroecology
- Estimating production potential of selected crops in different geographies

b. Screening of FPCs for technology intervention (as mentioned in 1).

- Selecting criteria for screening based on FPC data received from PMU
- Data analysis based on field surveys after first level of screening
- Final screening of FPC for preparing detailed project report

c. Conduct a detailed feasibility study for one or more potential technological interventions for the selected commodity/commodities.

- Field level investigation with selected FPC including questionnaires, interviews, group discussion etc. to collect relevant primary and secondary data

- Explore possible products profile and the factors influencing the supply chain by analyzing primary and secondary data

d. Financial viability: Cost-benefit and break-even analysis for the proposed intervention.

- Analysis of cost of production, scale of production/processing, value chain, processing infrastructure, variable costs, logistics, revenue potential

e. Market viability: Identifying potential buyers (B2B) based on current demand of product and prepare a list of potential forward linkages.

f. Details of food safety measures and regulatory aspects

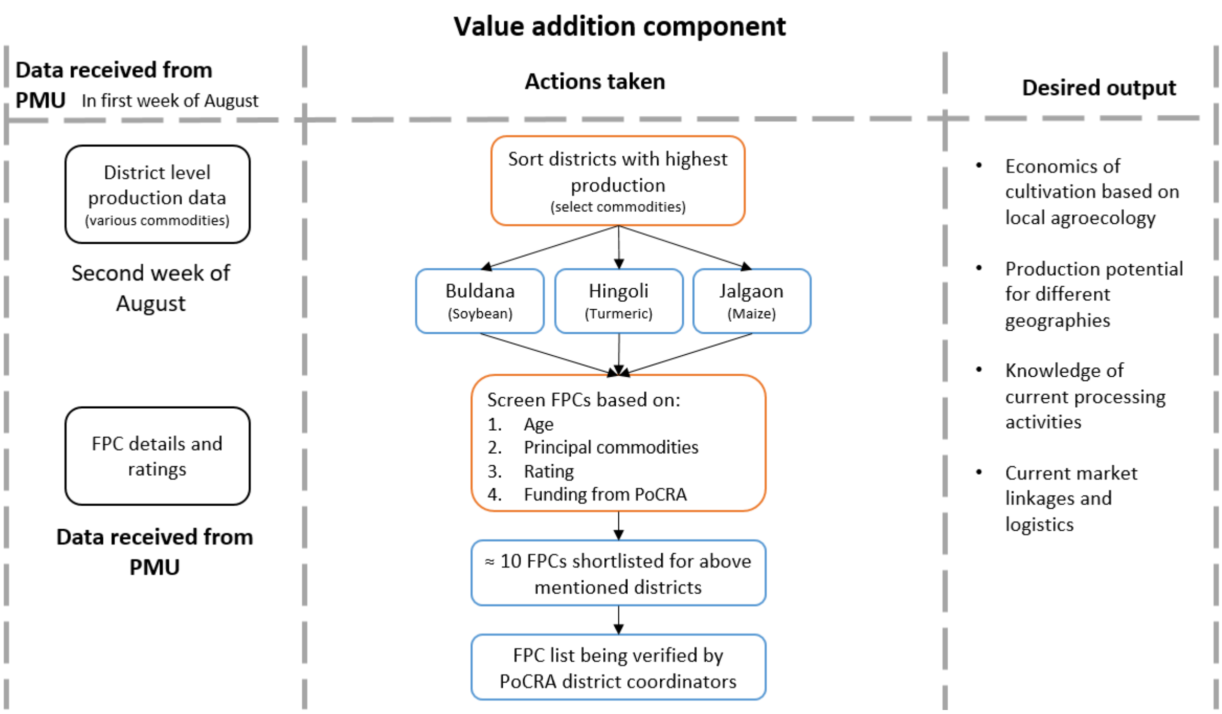
- Reporting food licensing, regulation and standard operating procedures

Deliverable (2)

Development of Detailed Project Report (DPR) with interested FPC. This shall be done with the interested FPC who would like to implement the project further through the financial support of an external funding agency including the agribusiness component of the PoCRA project.

Work done so far

a. Value addition component



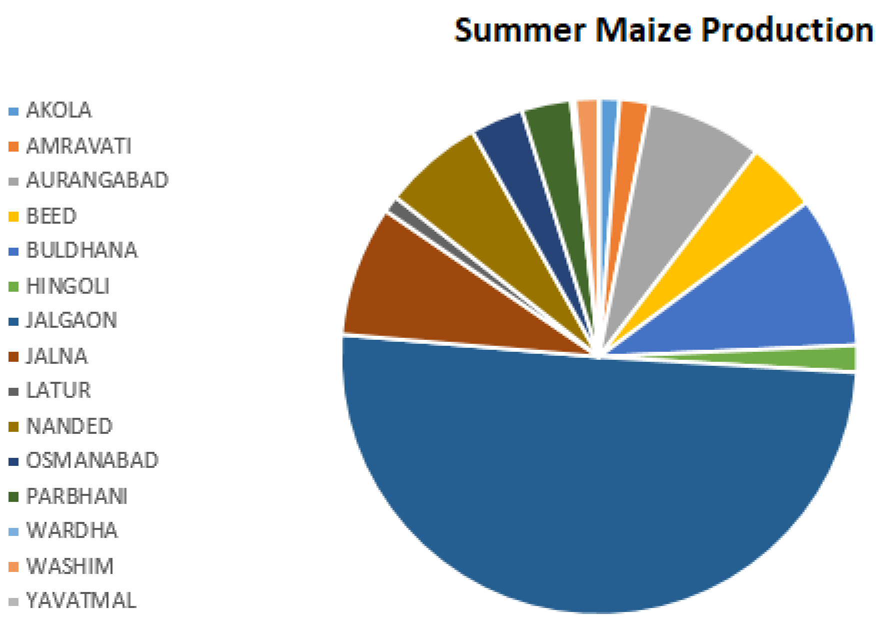
Screening of FPCs

- The purpose of screening was to select certain FPCs with whom preliminary field surveys and interactions could be initiated.

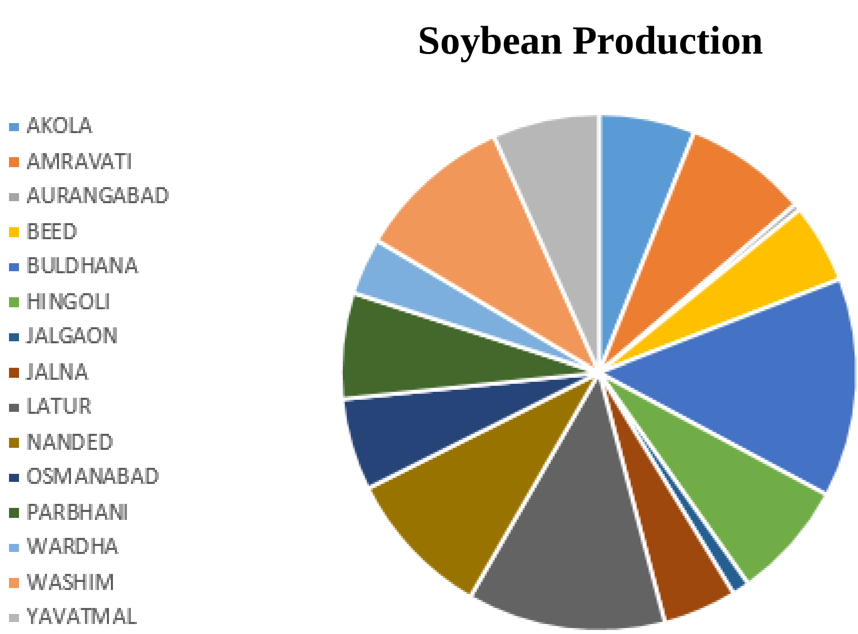
- A list of 1451 FPCs was received from the PMU
- Certain criteria for FPC screening were derived from the FPCs data received from the PMU
- The criteria were as follows:
    - Age of FPC -
        - FPCs operating for more than three years from date of registration were considered.
    - Principal crops-
        - FPCs solely dealing with commodities which were out of scope of this project such as cotton, milk, poultry etc. were screened out.
    - Number of stakeholders-
        - FPCs having number of stakeholders below 10 were screened out
    - Rating:-
        - Assessment of FPCs was done by PMU based on criteria such as organizational, administrative, financial, infrastructural and managerial performances. FPCs with score of 50 and above were screened
    - Incomplete data-
        - FPCs which have incomplete data pertaining to contact details, stakeholders, principal crops, area coverage or current activities were screened out.

Analysis of Production data

- District wise production data for different commodities was received from PMU
- The data enabled identification of production clusters and distribution of production in the PoCRA districts (Figure 1)
- Maps are being prepared to highlight production cluster and density of FPCs dealing in the selected commodities



(a)



(b)

Figure 1: Production distribution in PoCRA districts for (a) Summer maize and (b) Soyabean

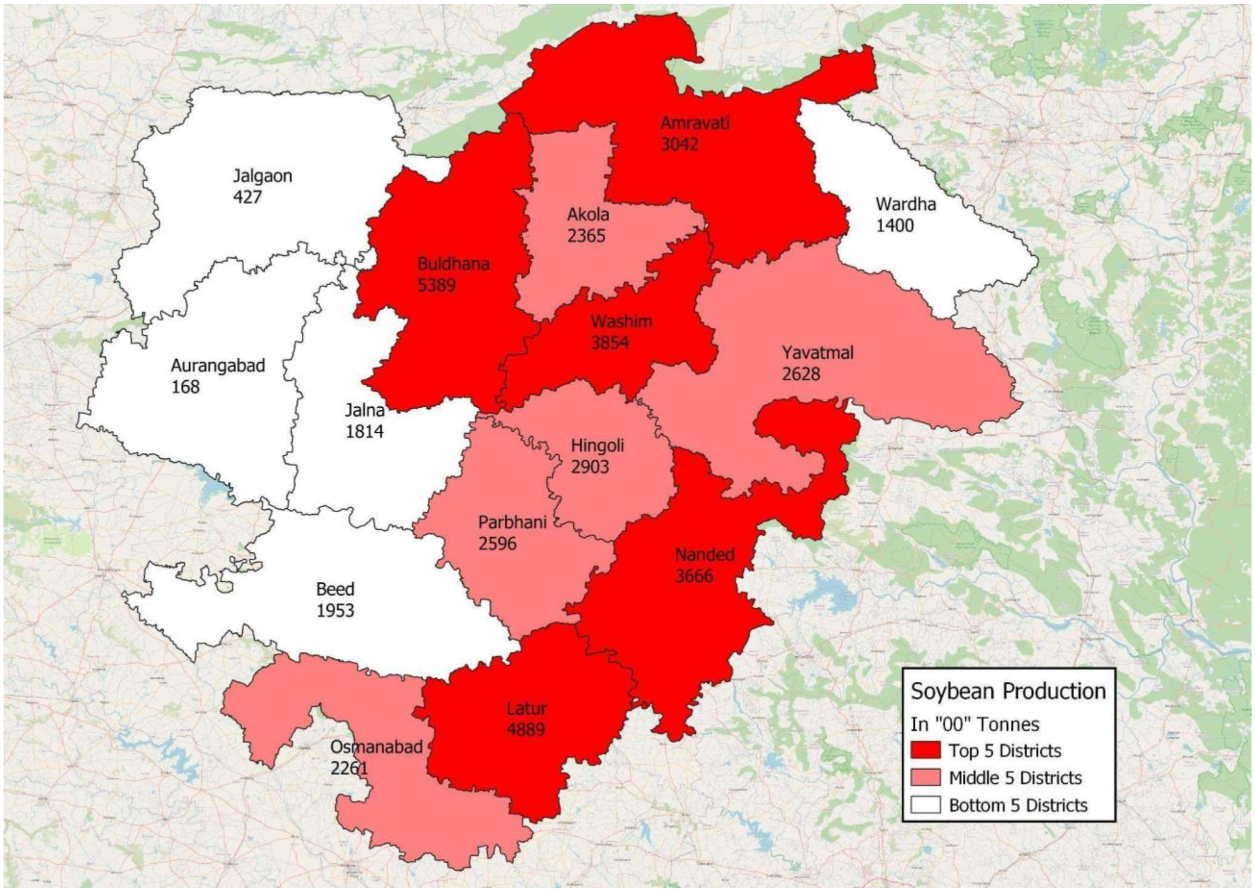


Figure 2: Mapping of soybean production in PoCRA districts

- The production data revealed that Buldhana, Hingoli and Jalgaon districts have the highest production of Soybean, turmeric and maize, respectively.
- As per the screening criteria mentioned above, top 10 performing FPCs from these districts are identified.
- In coordination with the concerned district coordinators, field visits for the selected FPCs will be planned to understand the economics of cultivation of various commodities, potential for value addition and corresponding market analysis for the processed products.

b. Meetings with MAHAFPC and other Onion FPCs

I. With the help of PMU-PoCRA, virtual meet was organized with Mr. Yogesh Thorat (Chairman, MahaFPC) and IIT Bombay Post harvest team. Agenda of the meet was to discuss the current scenario of storage technologies employed in the field by MahaOnion and their opinion on appropriate storage technology developed by IIT Bombay. Dr.Meghna Kelkar from PMU and Prof. Amit Arora along with their respective teams participated in the discussion. It was decided to visit the storage structures employed by Mahaonion and to present a comparative analysis of both the technologies on technical as well as economic grounds.

II. Second virtual meet was organized with the Onion FPCs from Jalna district, where agenda was to listen to farmers who are working with Onion commodity storages. Technology from IIT Bombay was presented and all the queries from the farmers were answered by Prof. Amit Arora. It was then decided to visit these FPCs and discuss with them the appropriateness of Onion storages developed by IIT Bombay. Meeting was organized by PMU-PoCRA. Dr. Meghana Kelkar (PMU-PoCRA) and Prof. Amit Arora (IIT Bombay) along with their respective teams attended the meet.

Work Plan for the year 2021-2022

Part1: Technology Intervention to reduce post-harvest losses of onions

Tasks	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Preliminary Report (Overall: Field & Desk)												
1. Matrix Development												
1.1 Mapping of Onion FPC within PoCRA-												
1.2 Total Production/Productivity/Area Sowing & Harvesting Schedule, Variety of onion.												
1.3 Current Practices (Selling in Market/Processing), Mode of Selling, Any Current Value Addition & Storage, Seasonality												
1.4 FPC Portfolio (No of Farmers associates, variety of onion, Revenue, Profit												
1.4.1 Identifying potential buyers based on the current demand of products (Onion). Prepare a list of potential forward linkages.												
1.5 Identification turn- key providers for onion storage intervention (Pre fab structure, cooling system, sensors & controls)												
1.6 Screening of FPCs from PoCRA project list for Technological Intervention based 1.												

1.7 Detail Market Analysis of Onion/Onion based products resulting from technological intervention (seasonality-based Market Demand, Export, Price trends, Profit margins												
2. Match Making with FPCs with Technological Intervention												
3. Financial Viability Model												
4. Installation & Commissioning												
4.1 Selection of vendors from 1.5												
4.2 Installation and post Installation support (As per MoU)												
4.3 Final Impact report preparation												

Part 2: Technology Intervention for value addition of agriculture produce via processing

Tasks	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Preliminary Report (Overall: Field & Desk)												
1. Matrix Development												
1.1 Mapping of Crops FPC within PoCRA												
1.2 Total Production/Productivity/Area Sowing & Harvesting Schedule, Variety												
1.3 Current Practices (Selling in Market/Processing), Mode of Selling, Any Current Value Addition												
1.4 FPC Portfolio (No of Farmers associates, variety of crops, Revenue, Profit												
1.5 Ranking/Screening of Crops based on (1.1-1.4) Economic Value, Market Integration/Demand												
1.5.1 Identification of a list of technological interventions which are feasible (based on Shelf life, scale & economics) eg: Soybean to protein, soya oil etc.: Turmeric to curcumin etc.												
1.5.2 Identifying potential buyers based on current demand of products. Prepare list of potential forward linkages.												
1.6 Identification turnkey providers for screened technological interventions												

1.7 Screening of FPCs for Technological Intervention based 1.4												
1.8 Detail Market analysis of product resulting from technological intervention (Market Demand, Export, Domestic Demand, Price trends, Profit margins)												
1.9 Logistics of processed products (Storage + Transport)												
2. Match Making with FPCs with Technological Intervention												
3. Financial Viability Model												
4. Details food safety measures & regulatory aspects.												
5. Preparation DPR and necessary revisions												

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Team

Following are the details of the team working on the project:

Sr.No	Name	Qualification/Designation	Position
1	Amit Arora	Associate Professor, PhD	Principal Investigator
2	Aniket Deo	PhD	Project Research Engineer
3	Prathamesh Antarkar	MTech	Project Research Assistant
4	Rajesh Ingole	Msc	Project Research Assistant
5	Ravi Sethi	BA + NIIT (IT)	Project intern
6	Mayur Nilawar	PhD Student	Student intern
7	Nilesh Vadgave	PhD Student	Student intern