IIT Bombay - PoCRA MoU V
Phase I - Delivery Report

Indian Institute of Technology, Bombay
Mumbai
May 2023

List of Documents:

Sr. No.	Document	Report Page Number (Bottom Center)
1	Inception report – Water	1
2	Inception report – Energy	24

Inception report - Water

Table of Contents

1. Broad objective

As per the fifth MoU signed between IIT Bombay and PoCRA, the proposed engagement will mainly focus on extension of the water budget framework to the district and village level, and upto the farmer level. The main task would be to demonstrate 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. Kharif advisory and reporting framework

B. District Climate resilience vulnerability and response framework

C. District Climate resilience extension framework

D. Rabi Planning framework

E. Improvements and refinements to the water budget model

I. Special component for image-classification-based and AIML-based advisories

J. Analysis of water budget indices and trends

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

2. Component A - Kharif water budget results reporting and advisory framework

2.1 Key objectives

There are two sub-components under A. A1 deals with the reports and advisories based on the daily water budget model results during the monsoon season. These reports and advisories mainly deal with the water budget entities such as rainfall distribution, rainfall forecasted, soil moisture availability, crop water deficits, runoff generated and so on. A2 deals with the advisories based on crop pests, and probability of occurrence of different pests on different crops during different periods in the monsoon season. The design of the triggers for these advisories will be based on the knowledge inputs from the agricultural experts (such as State Agriculture Universities, Krushi Vidnyan Kendras etc.) and also on the analysis of the historical data on pests collected through the Farm Field School coordinators over the past 4 years in all the PoCRA villages. The sub-component A2 is dealt separately in component I below.

2.2 Main tasks

The main tasks under component A1 can be divided into two categories:

(a) Water-budget reporting

This module will generate on-demand reports or reports at fixed-intervals (such as daily or weekly or monthly) for different regions of interest i.e. for a village or for a taluka or for the whole district.

The key reports identified are:

(i) fortnightly report for the district (to be received by each DSAO in the PoCRA region)

(ii) weekly report for the taluka (to be received by each TAO in the PoCRA region)

(iii) on-demand village report (to be demanded by the Agriculture Assistant or the Cluster Assistant for a particular village)

The reports, their design and content is subject to change as per further discussions with the PMU.

The reports will give the summary of water budget entities such as rainfall, rainfall pattern over the last week, crop water deficit accumulated since the beginning of monsoon season, the trend of

soil moisture availability in the last week, the dry or wet spells, runoff generated till date etc. which will be useful to understand the trends of various important entities during the course of the monsoon season at the village / taluka / district level.

(b) Water-budget based advisories

This category includes reports which are generated based on the preset triggers, such as occurrence of dry / wet spell, the soil moisture availability, runoff generated etc. These reports will also provide advisories for the respective officials regarding the proactive decisions to be made on the ground. The advisories will be generated based on the knowledge inputs as provided / coded by the agriculture experts and will also take into account the rainfall forecast data available from the Indian Meteorological Department (IMD). These advisories will be generated only for the villages / regions where a particular trigger gets activated.

2.3 Ongoing activities

The main activities for the component A1 are:

(i) design of the preset triggers and queries

(ii) design and develop the water budget reporting and advisory module (which takes the point-wise water budget results computed till now and generates data required for the reports / advisories as per the triggers

(iii) design the PDF report templates (design, content and the templates for the PDF reports i.e. how will the data be displayed i.e. maps / tables / graphs / text etc.)

(iv) design and develop the dissemination module (this will take the data from the reporting / advisory module and will generate PDF reports as per the templates, and will disseminate the reports / advisories to the respective user / official through the decided mechanism (whatsapp / email etc.)

The overall schematic for the water budget based reporting / advisory framework is shown in the following diagram.

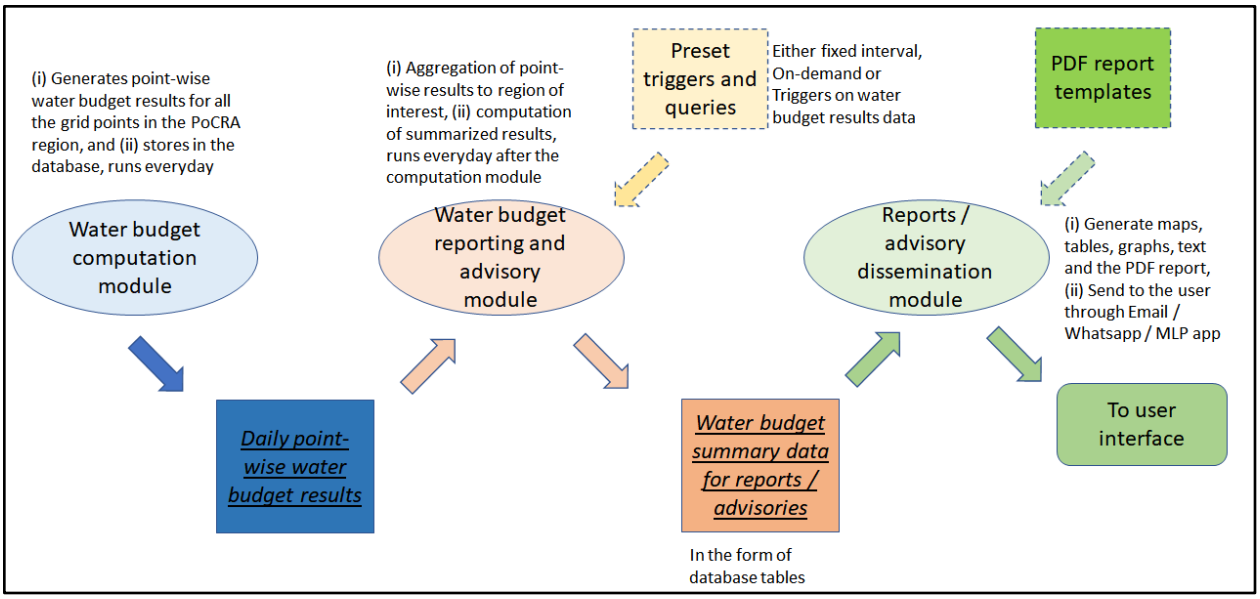


Figure 1: Water-budget advisory and reporting module

Tasks (i) and (ii) are to be done by the IITB team in consultation with the PMU experts. For (iii) IITB team will help in generating the maps / tables / graphs / text to be inserted into the reports. Task (iv) is to be done by the PoCRA IT team with assistance from the IITB team.

Currently, the IITB team is working on tasks (i) and (ii)

2.4 Deliverables and tentative schedule in the coming months

The deliverables for the component A1 are due in Phase 2 i.e. after 3 months from the commencement of work. This will be in the month of August (3 months from 11th May). However, IITB team will plan to deploy the advisory and reporting module as early as possible in the coming monsoon season. Following is the tentative schedule for the component A1.

Table 1: Deliverables and tentative schedule for component A

Task / deliverable *(the items in bold are the deliverables as per MoU document)*	Tentative date
Design of the preset triggers and queries	June 1st week
Design of the PDF report templates and the content of the reports (i.e. graphs / maps / text / tables etc.)	June 1st week
Deployment of the water-budget reporting / advisory module	June 3rd week

Assistance to the PMU team to design the dissemination module - actual dispatch of the advisories / reports	June last week
Note on Kharif advisories to be implemented during monsoon 2023	**August 11th**
Handover of the advisory module	**August 11th**

3. Component B - District climate resilience vulnerability and response framework

3.1 Key objectives

The key objectives of this component are (i) to establish the climate-resilience vulnerability and response framework at the district agriculture office, (ii) to enable vulnerability and response reporting and (iii) to ensure effective dissemination of water budget results, climate, soil, energy advisories from the PMU / Department of Agriculture to the district level and further down to the village level.

This translates to activities at two levels: at the District Superintendent Agriculture Office (DSAO) which is covered in the component B and the other at the village and the farmer level along with the district extension machinery (i.e. the cluster assistants (CAs), the agriculture assistants (AAs), taluka agriculture offices (TAOs) etc. which is covered in the component C.

3.2 Main tasks

The important tasks for the component B are as follows:

(i) Formulate climate resilience planning and response mechanism at the DSAO office. This will require understanding of current mechanisms at DSAO, requirements and demands of the DSA officers from the PoCRA water budget results, limitations in using the PoCRA water budgets etc.

(ii) Conduct a workshop of all the DSA officers in the PoCRA region at IITB in order to demonstrate the important use-cases of the PoCRA water budgets, its connection with the climate-

induced vulnerability and key problems at village-level and farmer-level and possible steps towards an effective action plan for improving resilience.

(iii) Design of an interface at the DSAO for receiving daily / weekly water budget results, timely advisories and updates from the PMU and a mechanism to visualize primary data

3.3 Ongoing activities

(i) Preparation for the preliminary meeting with the DSAO, Beed and DSAO, Wardha

The main discussion items for these meetings would be as follows:

(a) To give a brief about the PoCRA – IITB engagement over last four years
(b) To show the water budget charts and dashboards and explain the importance of these for planning better interventions
(c) To explain the need for strong and robust water budget extension framework at the district and village levels
(d) To explain the agenda for the coming monsoon and post-monsoon seasons (i.e. village level and district level exercises as planned in the MoU)
(e) To get access to required secondary datasets
(f) To understand the current infrastructure at the DSAO with regards to data visualization, data processing, dissemination of advisories to taluka and sub-divisional offices etc.
(g) To understand the demands of the DSAO with regards to extreme climate events, dry spells, wet spells, compensation, planning of NRM interventions, targeting of beneficiaries etc.

3.4 Deliverables and tentative schedule in the coming months

Table 2: Deliverables and tentative schedule for component B

Task / deliverable *(the items in bold are the deliverables as per MoU document)*	Tentative date
Meeting with DSAO, Beed and DSAO, Wardha	June 1st week
Introductory meeting with officials of the selected villages (online)	June 2nd week
Introductory meeting with the sarpanch and the village committee in the selected villages (physical)	June 2nd and 3rd weeks

Deployment of the interface at the DSAO for receiving advisories / reports from the PMU	July 1st week
DSAO workshop at IITB	July 2nd week
Preliminary report for setting up climate resilience planning framework at the DSAO	**August 11th**
First version of interface for on-demand report generation in the 2 selected district offices along with Software Requirements Specification, insights and roadmap for next version	**August 11th**

4. Component C - District climate resilience extension framework

4.1 Key objectives

Component C deals with the extension of the water budget framework at the village level. The key objectives are (i) to design and demonstrate community collective-decision platforms at the village-level such as kharif and rabi hangam baithaks where the water budget results and the key information in the village is presented to the community in order to induce scientific and collective decision making, and (ii) training of the village-level state and project officials to facilitate the hangam baithaks and to collate the required information to be presented during the baithaks

4.2 Main tasks

The village extension framework is as follows:

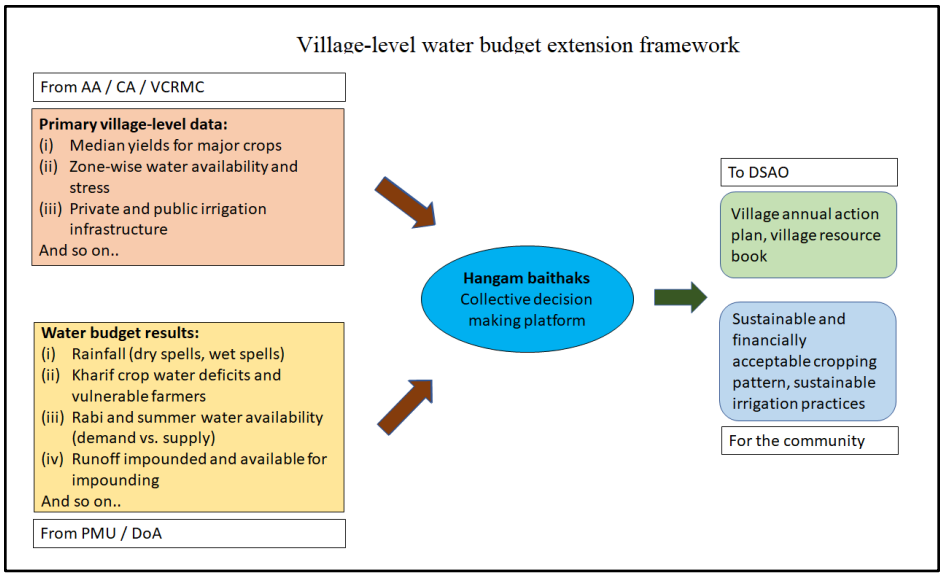


Figure 2: Village water budget extension framework

This translates to following main tasks:

1) Design training material and survey formats and other material to be used during extension activities

2) Hold training workshops for AAs and CAs at IITB for conduct of surveys, collection of primary data (such as cropping pattern, yields, stress etc.), implementation of water budget calendar, conduct of hangam baithaks etc.

3) Collect baseline data in the selected villages through NRM surveys and farmer interviews along with the AAs and CAs to capture key village level indicators such as yields, access to water, irrigation investments, water stress etc.

4) Work with school students and teachers (through VCRMC and Gram Panchayat) to install rain gauges in the selected villages and hold training sessions in the school for recording, documenting, displaying and interpreting daily rainfall data and its consequences.

5) Conduct rabi hangam baithak in the selected villages to explain the kharif 2023 water budget and present key pointers to probable supply-side and demand-side interventions to the community

6) Prepare village resource book and vulnerability reports which document the village level problems, water budgets, yields, stress, spatial imbalance in water availability,

investments, access to water, success stories, failure stories and devise a mechanism to update it every year /season and make it available and accessible to all.

7) Run the annual water budget for the selected villages at the end of the rabi season, prepare new improved charts and display them in the selected villages. Conduct closure meetings and compare the proposed cropping pattern with the actual cropping pattern, discuss probable demand-side interventions with the community

4.3 Ongoing activities

(i) Village selection in Beed and Wardha districts: As per the MoU, it has been decided that the above village-level water-budget based extension framework would be demonstrated in a few selected villages in two PoCRA districts. The two PoCRA districts of Beed and Wardha have been selected for the exercise.

Criteria for selection of villages for demonstration of the village-level water-budget based extension framework in the districts of Beed and Wardha:

A. Logistical
    a. Distance and time required from the base station in the district
    b. Village area and village population
B. Climate and biophysical factors
    a. Rainfall over last 3 years
    b. Area under different soil types
    c. Percent of non-agriculture / Forest area
    d. Rabi area and cropping pattern
C. Demographics and census (socio-economic) data
    a. Percent of SC and ST population
    b. Male and Female literacy
    c. Drinking water situation as per census 2011 data
    d. Other amenities data from census 2011 such as tap connections, cooking fuel, presence of two-wheelers, bank accounts etc.
D. Presence of motivated state / project officials

a. To be suggested by the DSAO office or concerned TAO offices

E. Other PoCRA indicators such as DBT data
   a. Total landholders, total farmers registered for DBT
   b. Total DBT applications disbursed
   c. Total DBT amount disbursed
   d. Unique farmers benefited through DBT
   e. Major DBT components

Based on the above selection criteria, following probable clusters and villages have been selected in the Beed and Wardha districts:

Table 3: Beed village selection

Village no.	Clusters	Taluka	Probable villages in the clusters
1	523_gv-59_01 523_gv-59_03 523_gv-63a_03	Patoda Shirur Kasar	Amalner, Karegaon, Pangri, Hiwarsinga, Limba
2	523_gv-69_01 523_gv-73_01 523_gv-73_03	Beed	Warwati, Jarud, Babhal Khunta, Kutewadi, Maujwadi, Shivni, Loladgaon, Kurla, Mhalaspur, It
3	523_gv-56_03 523_gv-64_02 523_gv-64_02	Georai	Rakshasbhuvan, Bagpimpalgaon, Antarvali Bk.
4	523_gv-68_01	Georai	Rui, Dhanora, Nipani Jawalka

5	523_gv-80_01	Wadwani	Hiwargavhan, Pusra, Tigaon
6	523_mr-6_01	Kaij	Massajog, Ekruka, Kalegaon Ghat

Table 4: Wardha village selection

Village no.	Clusters	Taluka	Probable villages in the clusters
1	504_wr-27_01	Arvi	Bodad, Wai, Gaurkheda
2	504_wrwbd-4_04	Karanja	Ambhora, Sindi Vihiri
3	504_wry-2_04	Wardha	Waifad, Lonsawali
4	504_wr-25_04	Deoli	Akoli, Wabgaon
5	504_wry-4_04, 504_wrw-3_01, 504_wrw-3_02	Wardha, Seloo, Samudrapur	Bhuigaon, Neri, Kinhala, Hamdapur, Pardi
6	504_wry-6_01, 504_wrw-1_02	Hinganghat	Chanki, Rohankheda, Tembha,

The list of selected villages is subject to change based on suggestions and recommendations by the DSAO and TAO offices in Beed and Wardha.

4.4 Deliverables and tentative schedule in the coming months

Table 5: Deliverables and tentative schedule for component C

Task / deliverable *(the items in bold are the deliverables as per MoU document)*	Tentative date
Finalize the list of villages	June 1st week
Installation of rain gauges in the selected villages	June 3rd week
Design of training material and survey formats for extension activities	June 4th week
Workshop of AAs and CAs of the selected villages at IITB	July 1st week
Baseline data collection in the selected villages	July 2nd week to August 4th week
Note on village-level extension activities in kharif 2023 in the selected villages in two pilot districts	**November 11th**
Report on training of extension agents during kharif 2023 including water budget runs at DSAO offices	**November 11th**
Report on baseline data collection and guidelines for using collected data in rabi hangam baithaks	**November 11th**
Delivery of the Training material, survey formats, presentations during workshops etc. to PMU	**November 11th**

5. Component D - Rabi planning framework

5.1 Key objectives

The key objective of this component is to design a planning module and an interface which would take in the water budget results for the kharif season, especially the total water available for the rabi and summer seasons, and would produce different scenarios of cropping patterns for the village which are sustainable as well as economically viable.

The main objective here is to facilitate village-level crop planning and diversification based on the water availability and other financial as well as equity constraints. The rabi planning module

developed will be used by the AAs and the CAs during the rabi hangam baithaks i.e. just before the sowing of the rabi crops.

The prototype rabi planning module developed in MoU IV will be refined and revised based on tests and validations conducted on field and will be used during the rabi hangam baithaks in the selected villages.

5.2 Main tasks

1. Conduct focused group discussions in selected villages for documenting key inputs (such as input and operating costs, yield curves, market prices, irrigation practices etc.) required by the rabi planning module and design templates for carrying such surveys by AAs and CAs
2. Conduct on-field tests of the LP (Linear Programming) model and rabi planning module for testing various input scenarios
3. Refine and improve the LP model based on feedback from the field
4. Design interface for the rabi planning module and/or integrate rabi planning module in the MLP for effective community decision-making during rabi hangam baithaks
5. Demonstrate the use of rabi planning module in the selected villages to arrive at an proposed optimal cropping pattern for rabi 2023-24
6. Conduct zone-level meetings in the selected villages to verify the results of the rabi planning module and demonstrate use of water budget results and explain the linkage between biophysical, climatic factors with farmer decisions, irrigation practices, crop choices, competition between farmers etc.

5.3 Ongoing activities

As the tasks and deliverables for this component are planned for the end of the kharif season and the rabi season, the work related to this component will begin post 2nd phase delivery i.e. after August 11th.

5.4 Deliverables and tentative schedule in the coming months

Table 6: Deliverables and tentative schedule for component D

Task / deliverable *(the items in bold are the deliverables as per MoU document)*	Tentative date
Focused group discussions for documenting key inputs required by the rabi planning module	August 2nd week
Conduct on-field tests of the LP model and refine the model as per the feedback	August last week, Sept 1st week
Design and develop an interface for the rabi planning module and test on the field	Sept 3rd and 4th weeks
Conduct rabi hangam baithaks in selected villages and demonstrate the use of rabi planning module	October, November
Report on field testing and refinements to rabi planning module	**November 11th**
Input datasets for rabi planning module in the form of csv / tables, along with technical documentation and SoP	**November 11th**
Note on conduct of rabi hangam baithaks and use of rabi planning module in the selected villages	**Feb 11th**
Note on changes to rabi planning module and design of interface for integration of rabi planning module into MLP with technical documentation and workflow	**Feb 11th**
Rabi hangam baithak and data collection guidelines	**Feb 11th**
Rabi planning module scripts / code in the format of integration into PoCRA system	**Feb 11th**

6. Component E - Improvements and refinements to the water budget model

6.1 Key objectives

The key objectives in the component E are (i) to incorporate the improved datasets available i.e. NBSS soil data, the improved Kc values etc. into the existing water budget model, (ii) to scale up the water budget computation to all the villages in the PoCRA region, and (iii) to improve the efficiency of the model, so that it can finish computation of daily water budget for all the grid points in the PoCRA region (i.e. around 3650000 points and 32 crops = ~11 crore computations) in reasonable time.

6.2 Main tasks

1. Incorporate NBSS and other available improved input datasets in the water budget model, test results and get approved by PMU
2. Minor improvements in code-efficiency, setup of automated scripts and dry run of the real-time water budgets for kharif 2023
3. Prepare zones and prepare water budget scripts for all the non-PoCRA villages in the selected districts.
4. Run Regional Geography (RG) for the selected 10 clusters during kharif 2023
5. Refine Regional Geography (RG) Surface flow module through feedback from the field observations done during kharif 2023
6. Assist PMU in changes to MLP and village water budget charts as proposed during MoU IV

6.2 Ongoing activities and tasks

Some of the main tasks for this component are:

(i) Incorporation of improved datasets

(a) NBSS soil data: The improved soil maps are made available by the NBSSLUP, Nagpur. The new datasets are the results of several soil soil samples and detailed laboratory tests conducted at the NBSS labs. Some of the important parameters which are useful for the water budget computation are, Soil texture, sand-silt-clay percent, soil depth in cm, Field Capacity, Wilting point, Saturation point etc. These layers will be made available by the NBSS as pixel-based raster maps where there will be a unique value for each pixel.

Depending on the range of the values for each layer, IITB team will build classes for each dataset. These classes will be used to prepare Hydrologic Response Units (HRUs) which will be used in the water budget model.

As of now, the NBSS data is available for all the PoCRA villages. However, the data may not be available with the same accuracy for the non-PoCRA villages in the PoCRA region. In that case, the existing MRSAC soil maps may be used for the non-PoCRA villages till the improved NBSS maps are not available.

(b) Crop Kc values: As a part of PoCRA, the three state agriculture universities (Dr. Punjabrao Deshmukh Krushi Vidyapeeth, Akola, Vasantrao Naik Marathwada Krushi Vidyapeeth and Mahatma Phule Krushi Vidyapeeth, Rahuri) have conducted Lysimeter studies on various crops to estimate the crop coefficients for the local conditions in the PoCRA region. These improved crop coefficients will help in estimating the crop water demand more accurately. The new Kc values for all the crops which have been covered by the above three universities will be incorporated in the water budget model.

(ii) Scaling up to non-pocra villages

For the coming monsoon season, the water budget will be computed for all the villages (including non-PoCRA) in the PoCRA region. The water budget model will not make any distinction between poCRA and non-PoCRA villages while computing the water budgets. The results will be computed daily for each district in the PoCRA region. The results for all the grid-points will be stored in the database daily. The results can be aggregated to any region of interest, say a village, taluka or a district or even a cluster or zone of user's choice.

With regards to zones for the non-PoCRA villages, it has been decided currently to consider each non-PoCRA village as a single-zone i.e. village boundary equal to zone boundary. The zones for

the non-PoCRA villages can be delineated in the future, without any changes to the water budget model.

The computation of water budget for non-PoCRA villages will provide a demonstration for scaling up the water budget framework to the whole state in the future.

(iii) Improvements in the efficiency of the model with regards to time taken to compute water budget for the whole PoCRA region.

With all the villages in the PoCRA region (i.e. around 23000 villages), the computation load increases significantly. The total number of grid points in the whole PoCRA region will be close to 36 lakhs. As the water budget is run repeatedly for 32 crops for each grid point, the total number of water budget computations will be around 11 crores.

Currently, for a single village (which is around 150 grid points on average), it takes around 19 seconds to finish a single day's water budget computation. This will take more than one day to finish the whole PoCRA region.

IITB team has designed significant changes to the water budget model in order to reduce the time.

Some steps taken for improvements in time:

a. Separation of computation and reporting (and importantly, aggregation) into two separate modules
b. Smart design of HRUs
c. Getting rid of costly QGIS operations and switching completely to PostGIS
d. Smart storage of results

6.4 Deliverables and tentative schedule in the coming months

Table 7: Deliverables and tentative schedule for component E

Task / deliverable *(the items in bold are the deliverables as per MoU document)*	Tentative date
Dry run and demonstration of water budget results to the PMU	June 1st week

Deployment of the water budget model at the PMU (with improved datasets, and improved efficiency)	June 10th
Test results, resolve errors if any, and deploy final code	June 3rd week
Assist PMU for changes in the MLP app and the MLP workflow	July 2nd week
Note on changes to the water budget model to incorporate improved input datasets	**August 11th**
Newer version of water budget model with improved datasets and code	**August 11th**

7. Component I - Special component for image-classification and AIML-based advisories

7.1 Key objectives

This component deals with specific tasks with regards to two different categories of advisories:

a. On-demand, curative advisories based on crop digital libraries and image classification: The main objective here is to develop image-classification algorithms for the processing, classification and mapping of the crop-pest or crop-disease images uploaded by the farmer to the ones in the prepared / procured crop digital library for identification of the pest / disease to generate annotation and using it for existing triggers for advisories.

b. Use of AIML to analyze performance of rule-based advisories: The main objectives here are (i) to create a mechanism to collect and record current rule-based advisories and farmer responses, and (ii) to prepare a training dataset from the positive and negative farmer responses received, and develop machine-learning tools to generate required annotations for improving existing triggers for these advisories

7.2 Main tasks and ongoing activities

(i) Image Classification:

The task is to train a machine-learning model that takes as input an image of a plant, or a part of the plant, and classify the image as being that of a healthy plant or a plant affected by a pest or a disease. The IITB team had discussions with the Pocra team about the approach to be taken in this regard. The IITB team has made the following plan for the future work:

Available Datasets: Image data of plant crops in Maharashtra isn't available and accessible right now, but it will be collected in the coming year using a survey team working with Pocra's team. Nevertheless, the IITB team would start working on openly-available datasets for similar tasks considered worldwide, which are freely available online. There may be two kinds of such datasets: (i) where an image of only the plant leaf is captured (after the leaf is plucked off the plant and placed against a flat-colored background) and (ii) where the image of the leaf is taken while the leaf is attached to the plant and where the image may also show other parts of the plant such as the nearby leaves and branches. We will explore such available datasets until we can access image data through Pocra. We have started efforts in this direction.

Learning: Using available datasets, we will explore, design, and develop methodologies relying on deep neural networks (DNNs) for the purpose of image classification. We have started efforts in this direction.

Learning on Pocra Data: Once we have data available from Pocra, then we will transfer our DNN-based methods, probably using some modifications in design and learning strategies, to the Pocra dataset.

(ii) Providing Crop Advisories For Pests/Disease:

The task here is to be able to predict the risk for pests or disease in a crop based on various factors including environmental factors (daily temperature variation, rainfall, humidity variation, etc.) and crop stage in its life cycle (type/name of crop, number of days from sowing, time of year, etc.). In this application, some past data may be available in raw form across farms spread across several parts of Maharashtra. After in-depth discussions with the Pocra team, the IITB team has planned the following strategy for (i) dataset curation and (ii) machine-learning based prediction. The Pocra team will provide the raw data, from the farm-field school (FFS) project over the last few years, to the IITB team that will mine and curate data in a form suitable for machine-learning based

prediction algorithms. Here, the curated dataset will comprise (irregular) instances of specific farms' (i) environmental factors, (ii) crop parameters, and (iii) crop condition (healthy or diseased). The teams will first curate a dataset by searching for (i) two instances of available data from the same farm, where the instances spread apart around a month's duration, and (ii) where the first instance indicated a healthy crop and the second instance indicated either the presence of some crop pest/disease or a healthy crop. The team will first assess the available data, and depending on the quality and quantity of the data, explore, design, and develop machine-learning based probabilistic prediction schemes that will aim to predict the probability of crop disease/pest based on environmental and crop-stage factors available from the previous month's data for that farm. The IITB team has started efforts in this direction.

7.3 Deliverables and tentative schedule in the coming months

Table 8: Deliverables and tentative schedule for component I

Task / deliverable *(the items in bold are the deliverables as per MoU document)*	Tentative date
Brief note on Terms of Reference for this component	**August 11th**
Preliminary report on Image-Classification-based and AIML-based advisories and approach / methodology to be followed	**August 11th**

8. Component J - Analysis of trends and outcomes

8.1 Key objectives

The key objective here is to integrate the village supply-side and demand-side data for the last few years and to compute and analyze trends of kharif and rabi indices. This will measure supply-side interventions done by the PMU and DoA and demand-side changes at the community level.

8.2 Main tasks

1) Collection and curation of required input datasets and creation of panel of villages

2) Preparation of inputs, running water budgets with the above input datasets

3) Computation of indices and analysis of trends

4) Final summary report on overall trends

This will require following datasets:

(i) Supply-side interventions data - NRM structures along with their storage capacities per village for last four years

(ii) Demand-side data - seasonal cropping pattern per village for last four years

(iii) Individual irrigation-related DBT data - Disbursements made for drip/sprinkler, pipelines (for water transfers), farm ponds, wells etc.

(iv) M & E data - Yields for major kharif, rabi and annual crops, irrigation methods and other panel data for baseline and mid-term surveys.

8.3 Deliverables and tentative schedule in the coming months

Table 9: Deliverables and tentative schedule for component J

Task / deliverable *(the items in bold are the deliverables as per MoU document)*	Tentative date
Meeting with PMU regarding collation of all the input datasets required for running the water budgets for the last five years	June 2nd week
Preliminary report on curation of input datasets, creation of panel of villages for analysis and preparation of inputs for running water budgets for last four years	**August 11th**

Inception report - Energy

1. Introduction

Access to electricity is crucial for reliable access to irrigation and is a key constraint along with water in crop-planning. In the first two years of engagement, it was pointed out through field-work that supply of electricity, its quality and schedule, are important aspects in strengthening farmers against unreliable rainfall and increasing crop demands. Consequently, the Energy component was included from MoU III onwards.

Objectives accomplished in MoUs III and IV

Extensive field as well as analytical work in the agricultural-energy sector over the past 3.5 years has resulted in the following main outcomes:

- A prototype framework for proposal of optimization of energy infrastructure at village-level through restructuring of LT networks
- A framework to estimate energy usage and infrastructure requirements based on cropping and irrigation practices. The parameters used in the framework have been obtained through extensive water and energy usage measurements, as well as surveys and field observations of irrigation practices.
- Extension work for building farmers awareness of use of capacitors, appropriate pump selection and load management
- Pilot Load management initiative at the Distribution Transformer level and a preliminary app to illustrate schedules and communicate to farmers.
- Cropping pattern-based Irrigation and Investment indices to indicate the investments in private irrigation infrastructure

The work done in MoU III resulted in developments along three aspects: Understanding the current status, supply side solutions, demand side solutions, development of a framework to connect supply and demand. Some of these aspects were taken forward in MoU IV. The development of these results from MoU III to MoU IV is:

Demonstration of current status:

Stress in the network and its contours; The status and reasons for the constraints in getting new

agricultural connections (*MoU III)*

Supply side solutions - Restructuring of LT networks:

The proposal of optimization of infrastructure through restructuring of LT networks (*MoU III)*

Matching infrastructure to demand:

Development of framework to estimate energy usage and infrastructure requirement based on cropping and irrigation practices. This included measurements of energy and water usage as well as observations of irrigation practices. (*MoU III*)

Determination of Distribution Transformer loading based on cropping (*MoU III*):

MLP-based Energy estimation tool prototype: The framework developed in MoU III was integrated into the IT stack with the village level data collection app to determine Distribution Transformer capacity requirement and shortfall if any. The farmers with metered energy and water usage were monitored in MoU IV also.

Demand side solutions:

Extension work, building farmers awareness of use of capacitors, pump selection and load management (*MoU III*)

Pilot Distribution Transformer User Group on select DTs. Load management and capacitor installation was implemented. An app was developed to illustrate schedules and communicate to farmers.

Cropping pattern-based Irrigation and Investment indices were developed for irrigating and non-irrigating farmers. These indicate the investments in private irrigation infrastructure being made by farmers and through government expenditure (subsidies), and the profits as a function of these investments, to aid in policy design.

Objectives of MoU V

In the current MoU V, we propose to take forward the community engagement and demand-side management components as the following objectives. The lettering is as used in the MoU V document and will be referred to in all reports.

- F. Structured demonstration of value of capacitors in 10 villages
- G. Load Management app upgrade to include scheduling
- H. Implementation of Energy estimation tool in 10 villages towards Information, Comprehension, and Collective action

The next few chapters discuss each component with its objectives, tasks, ongoing work, schedules, and deliverables. The districts Wardha and Bid of Maharashtra are selected for implementation in the current MoU - see Figure 1. Districts covered under past MoUs include Washim, Aurangabad, Osmanabad, Yavatmal, Buldhana (MoU III), and Latur, Nanded, Washim, Buldhana (MoU IV).

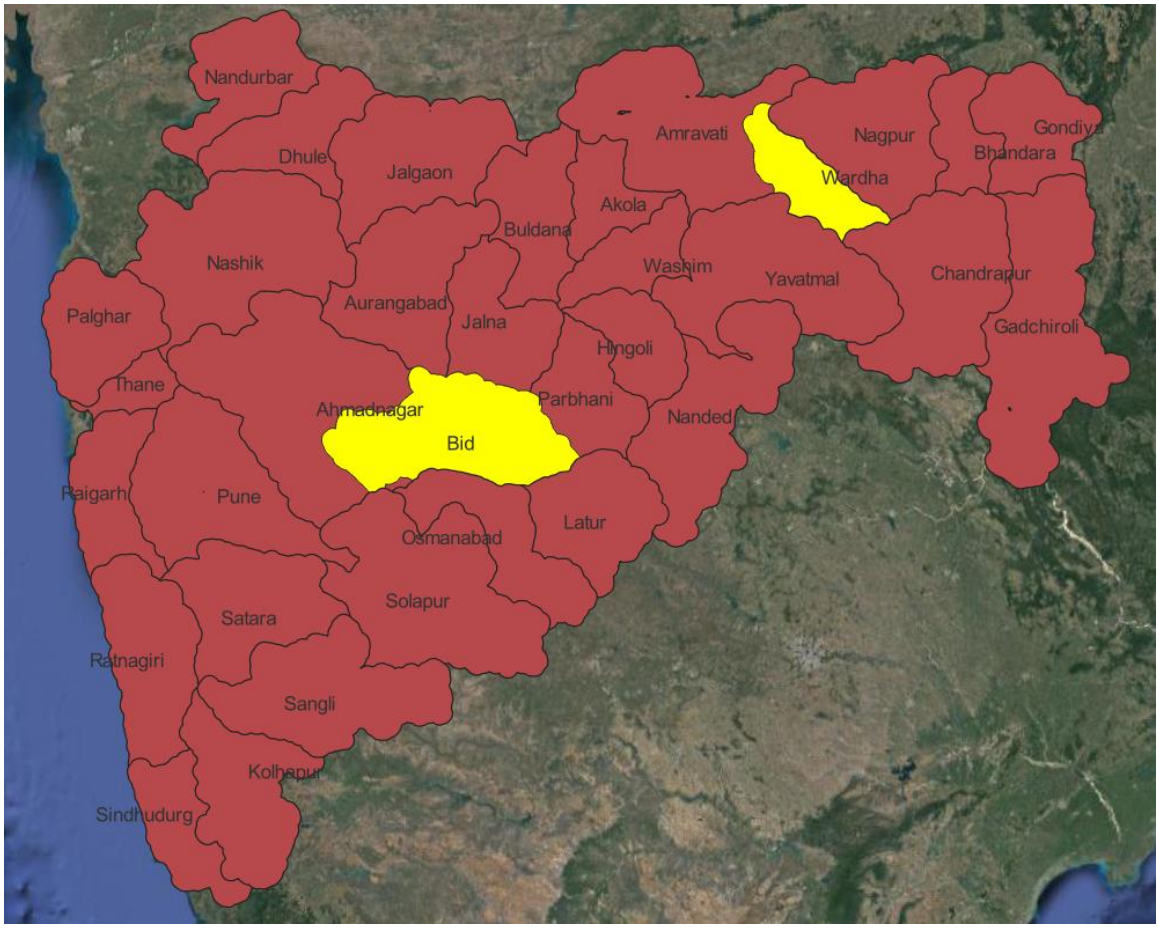


Figure 1: Districts selected for MoU V

2. Component F - Structured demonstration of the value of capacitors in 10 villages

The value of using capacitors with induction motors to reduce the load on the system and improve the quality of supply is universally accepted. While a rule exists wherein farmers are expected to install capacitors, farmers are unaware of the benefits or purpose of capacitors and do not use them. In fact, most farmers do not know about capacitors. In MoU III awareness building material was created and was provided to cluster assistants to present in their villages. In MoU IV a load management pilot project carried out with 3 Distribution Transformer (DT) groups in 3 villages included capacitor installation.

2.1 Key objective

In this component, a structured demonstration is to be carried out in 10 villages, 5 each in Wardha and Beed. One DT is to be selected in each village for capacitor installation and demonstration. The village will be included in the demonstration process over one rabi season. Farmers' feedback, outcomes, and awareness-building material developed in the objective will be used to further technology diffusion with the help of krishi sahayaks and MSEDCL personnel.

2.2 Main Tasks

A. Select One Distribution Transformer (DT) in each of 5 villages of 2 talukas / 2 districts. Convince farmers on the DTs to participate in the demo.
B. Collection of data about DT through farmers surveys, field survey, and measurements, and preparation of report on status of DT.
C. Prepare communication and awareness building material and protocol. Village meetings to share results and show awareness building material. Installation of capacitors.
D. Conduct power factor measurements at DT during rabi. Survey farmers. Get feedback about any issues.
E. At the end of rabi, conduct surveys. Estimate number of pump breakdowns, tripping etc. Prepare material for presentation to the village.
F. Conduct village meetings to present results.

2.3 Village selection

To install capacitors it's more important to consider the loading pattern on DT and more heavily loaded DTs will be selected. But as we don't have reliable DT overloading status data we have to look at other indicators which direct us towards the same effect and those indicators are as follows. Details about indicators are given in Chapter 5 - detailed village selection methodology.

A. Village Cultivable Area
B. Cropping pattern
C. Command area
D. Waterbody area along village contour
E. Total number of irrigation-related disbursements done through PoCRA DBT per Hectare
F. Percentage of soil textures/ types
G. Elevation standard deviation within the village contour
H. Vicinity to water group selected villages

Based on these indicators the tentative villages from Beed district are selected as shown in Figure 2. The final selection will be done after field visits and collection of secondary data from concern stakeholders such as Krishi Sahayaks and MSEDCL ground staff.

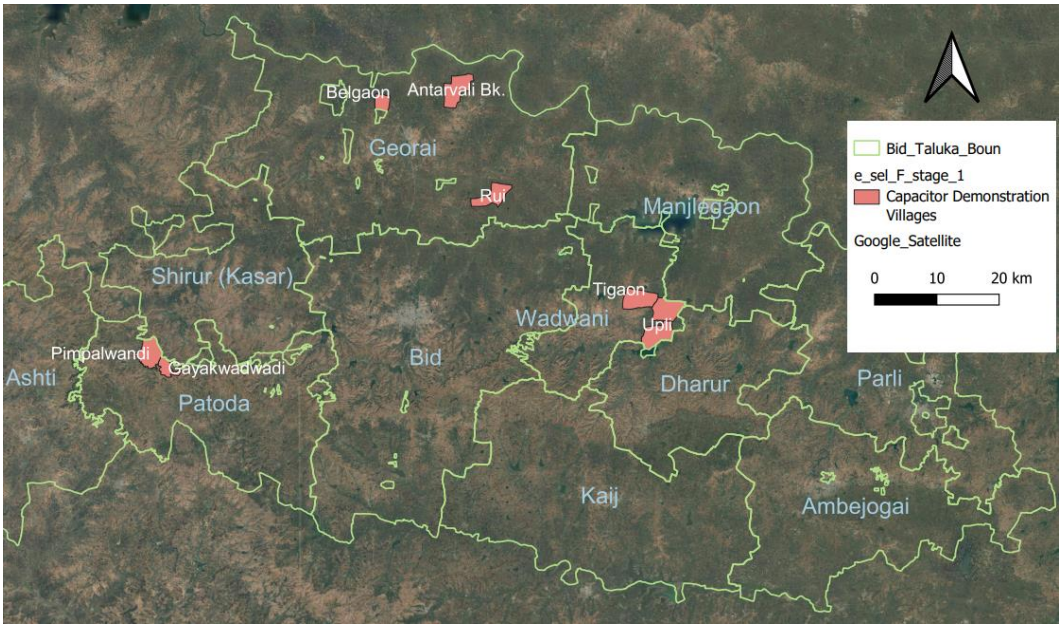


Figure 2. Villages selected from Bid district for structured demonstration of the value of capacitors

2.4 Schedule and deliverables

The following table lists the tasks to be done in each quarter and the deliverables due in that quarter in bold.

May - July
Brief report on selection of DT for capacitors scale-up
Selection of 10 DTs from 10 villages of 2 talukas/ 2 districts
August - October
Detailed report on status of 10 DTs selected for capacitor scale-up
Collection of data about each DT through farmers surveys, field surveys, network analysis, and preparation of report on status of DT
Prepare communication and awareness building material and protocol
Conduct village meetings to present results.
November - January
Material shared in village meetings for capacitors demonstration
Conduct power factor measurements at DT during rabi. Survey farmers. Get feedback about any issues.
February - April
Report on results of capacitor demonstration and village response
At the end of rabi, conduct surveys. Estimate number of pump breakdowns, tripping etc. Prepare material for presentation to village.
Village meetings to share results and show awareness building material. Getting capacitors installed.

3. Component G - Load Management app upgrade to include scheduling

Load management pilot projects were successfully implemented in MoU IV with schedules made by the IIT team.

3.1 Key objective

In MoU V, the app will be upgraded to include partially automated schedule creation so as to aid the farmers to work independently. Selected DT user groups will be engaged to develop the app functionality, and they will be encouraged to use the app in the rabi season and provide feedback.

3.2 Main Tasks

A. Select 6 DTs to get inputs for development of app
B. Design and develop the schedule automation with inputs from these DTs
C. Develop stand-alone app with the following functionality:
    - Partially automate scheduling
    - Allow farmer addition and modifications
    - Assist PMU to integrate app into MLP
D. Test and feedback in rabi from those Distribution Transformers

3.3 Village selection

Similar to capacitor installation village selection, priority is given to loading patterns on DT and more heavily loaded DTs will be selected. But apart from this farmers consensus and their willingness to do load management activity is given more priority. Hence the villages selected for this component are selected based on indicators given in section 2.3 from A to H along with farmers' consensus.

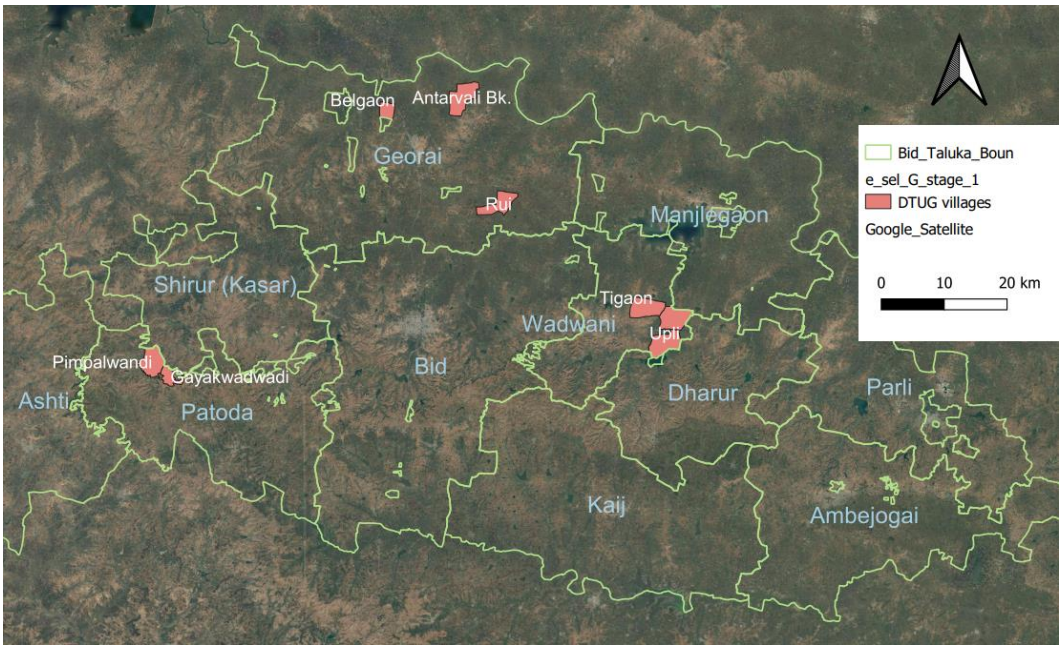


Figure 3. Villages selected from Bid district for Load Management app upgrade to include scheduling

3.4 Schedule and deliverables

The following table lists the tasks to be done in each quarter and the deliverables due in that quarter in bold.

May - July
Brief report on selection of DTs for load management app development
Select 6 DTs to get inputs for development of app
August - October
First version of design specifications and functionality of load management app
Design and develop the schedule automation
Develop app
November - January
Feedback from DT on the app usage and load management experience
Test and feedback in rabi from those DTs
February - April

Load management app with scheduling in the format of integration with PoCRA system

4. Component H - Implementation of Energy estimation tool in 10 villages towards Information, Comprehension, and Collective action

The energy estimation was developed to estimate village level requirements, create awareness of current status and demand side activities, and promote community action.

4.1 Key objective

This objective develops the training material, formats and protocols to be followed in the hangam baithaks to incorporate the energy status discussion, feedback, and action. It also includes the process of data collection for the tool by krishi sahayaks to enter into the energy estimation tool, as well as the feedback from the rabi hangam baithak.

4.2 Main Tasks

A. Identify 10 villages for detailed follow-up
B. Develop training material, formats, and protocols for the krishi sahayaks to understand and conduct the Information, Comprehension, and Collective action with regard to energy infrastructure in the village; Design interface for village survey for energy estimation tool, and rabi baithak feedback.
C. Training for krishi sahayaks in 10 villages
D. Validate the internal integrity of data collected by krishi sahayaks in the 10 villages and the output of the energy estimation tool for the same.
E. Energy estimation tool model improvement based on output of 10 villages
F. Integrate learnings into design of input interface for energy estimation tool
G. Support PMU for changes in MLP app for energy estimation tool input and feedback at rabi baithak
H. Observe and get feedback at the rabi hangam baithak in 10 villages
I. Develop checks for quality of data collected in rabi hangam baithak

4.3 Village selection

For this component the village selection methodology is somewhat different than the earlier components. We require a representative cropping pattern of the region to capture the maximum number of approximations or correlations to build a robust energy estimation tool/framework, which is then scaled up for the region.

Therefore, the villages selected will be the mixture of various cropping patterns in the region, command and non-command areas, the irrigation infrastructure related DBT's through PoCRA provided or not, the all soil types and elevation. And based on this the villages selected from Bid district are as shown in Figure 4.

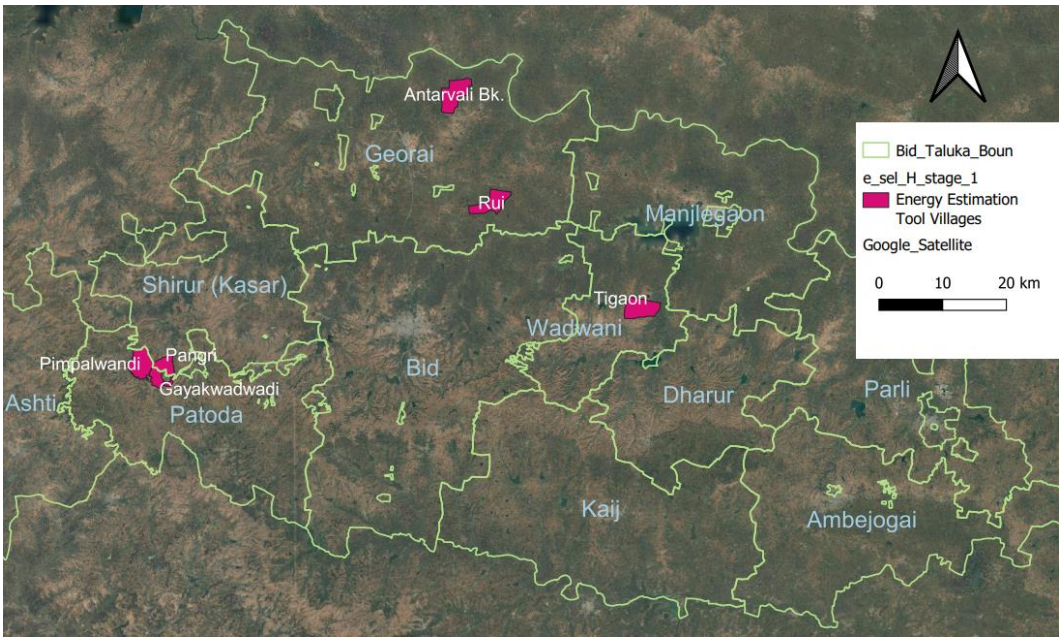


Figure 4. Villages selected from Bid district for implementation of Energy estimation tool towards Information, Comprehension, and Collective action

4.4 Schedule and deliverables

The following table lists the tasks to be done in each quarter and the deliverables due in that quarter in bold.

May - July
Brief report on villages selected for energy ICC

Identify 10 villages from 2 talukas/ 2 districts
Preliminary training material developed for ICC
Develop training material for the krishi sahayaks to understand the Information, Comprehension, and Collective action with regard to energy infrastructure in the village
August - October
Output of energy estimation tool from 10 villages
Conduct training in 10 villages
Validate internal integrity of data from krishi sahayaks in 10 villages and output of the MLP tool
Final set of training material developed for ICC
Support to PMU for integration of energy estimation tool into MLP app, and interface for feedback in rabi baithak
Incorporate improvements in Energy estimation tool model and in interface for data collection. Support to PMU to integrate input interface into MLP app.
Observe and get feedback at the rabi hangam baithak in 10 villages
November - January
Report on energy ICC discussion in rabi hangam baithak in 10 villages
Develop checks for quality of data collected in rabi hangam baithak
Summary on results of rabi baithak from 2 districts
February - April
No deliverable

5. Detailed Village Selection Methodology - Work Done so far

5.1 Detailed village selection methodology

Village selection plays an important role in the appropriate and representative achievement of objectives to enable successful scale-up. It is also important for the effective and efficient execution of operations. Therefore, a detailed and clear understanding of relevant physical parameters and indicators in regards to our project is important. This chapter describes the main physical parameters with their relevance.

A. Village Cultivable Area

Village cultivable area plays an essential role in calculating irrigated cultivable area per DT which in turn gives us loading status on a DT. And which is further calculated as village irrigated cultivable area divided by the number times the capacity of DTs catering to the cultivable village contour. As of now we don't have DT data hence we cannot use this parameter to select our village directly. The villages in Bid district are categorised according to village cultivable area in Figure A1 in Appendix A.

B. Cropping pattern

Each crop has its own water demand and if it is not met through rainfall then it has to be met through irrigation. Therefore the villages are categorised based on cropping pattern as high water intensive crop growing villages, less water intensive crop growing villages, and rainfed crop growing villages.

C. Command area

Villages with a canal flowing through it are called villages under command area. This canal facilitates the farmer to cultivate high water intensive crops with high consumption of electricity for irrigation. Further high energy consumption means high chances of possible electrical related issues. Hence a few villages from the group of villages in the command area of Jayakwadi dam's (built in Godavari river basin) right canal flowing through Bid district are selected - Figure A2 in Appendix A.

D. Waterbody area along village contour

E. Total number of irrigation-related disbursements done through PoCRA DBT per hectare

F. Percentage of soil textures/ types

G. Elevation standard deviation within the village contour

H. Vicinity to water group selected villages

5.2 Work Done so far

Villages Selection in Bid for various components

F. Structured demonstration of the value of capacitors in 10 villages
8 villages are selected whose details are as follows:

G. Load Management app upgrade to include scheduling
8 villages are selected whose details are as follows:

H. Implementation of Energy estimation tool in 10 villages towards Information, Comprehension, and Collective action
6 villages are selected whose details are as follows:

Appendix A:

Figures for village selection:

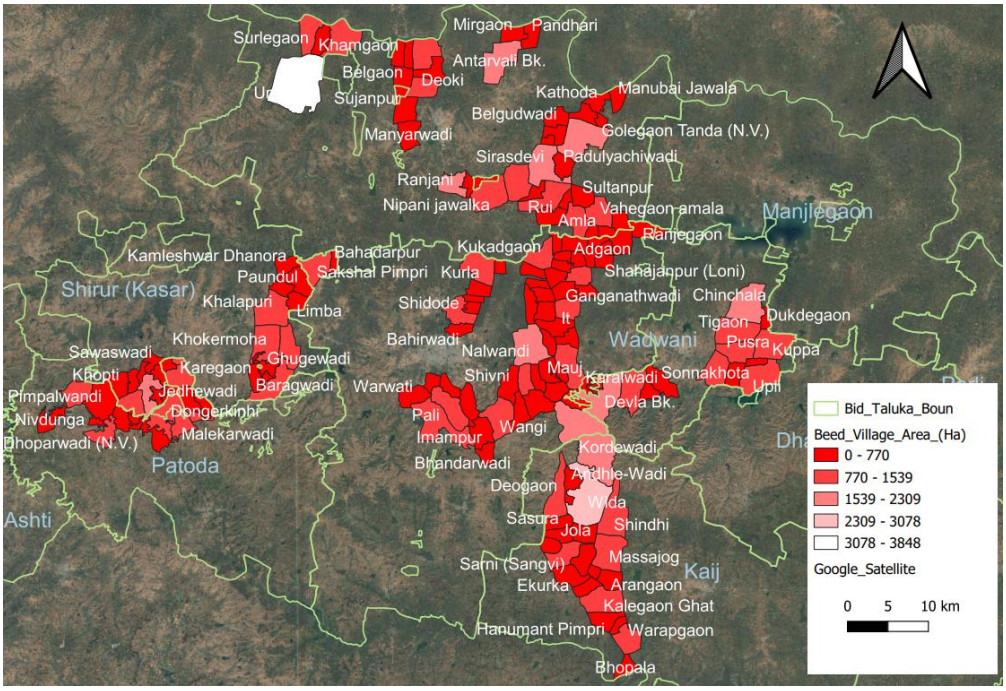


Figure A1. Villages in Bid district are catogorised according to cultivable area

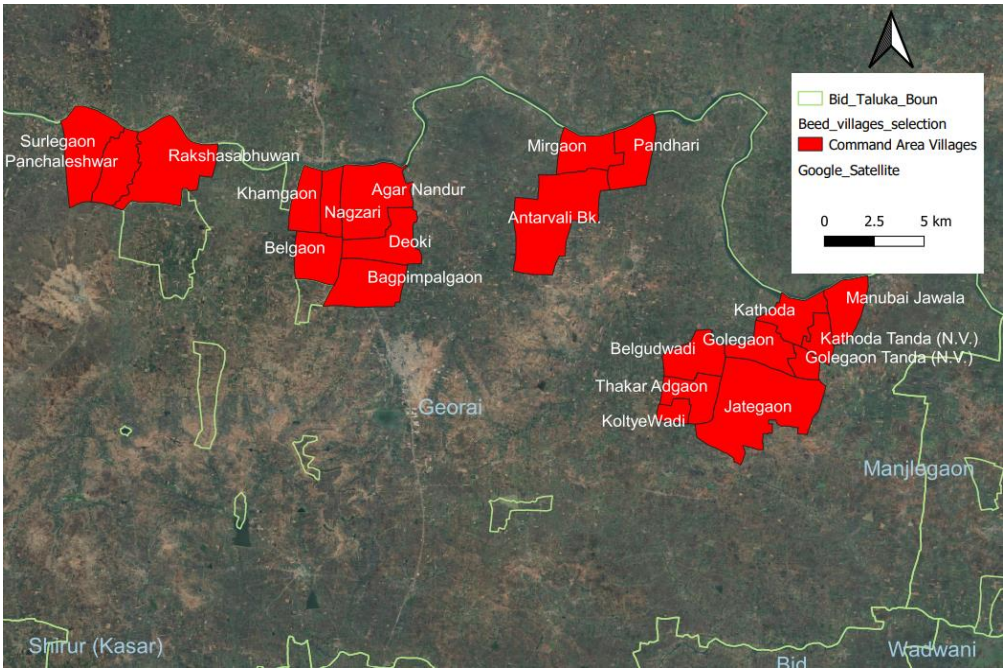


Figure A2. Villages in Bid district under command area of right canal of Jayakwadi dam

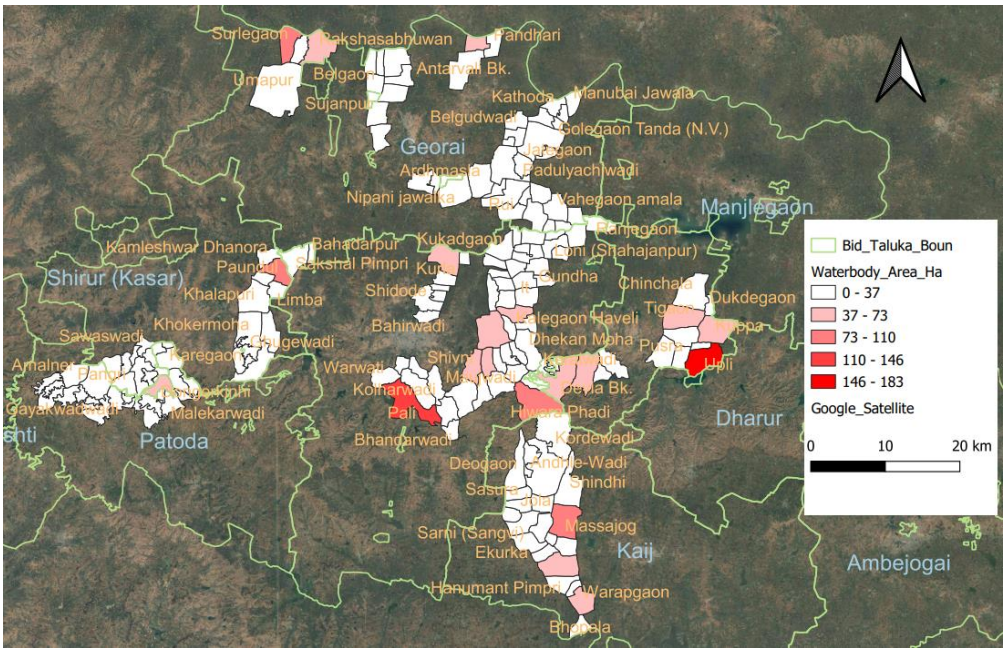


Figure A3. Villages in Bid district categorised according to waterbody areas in Hectares

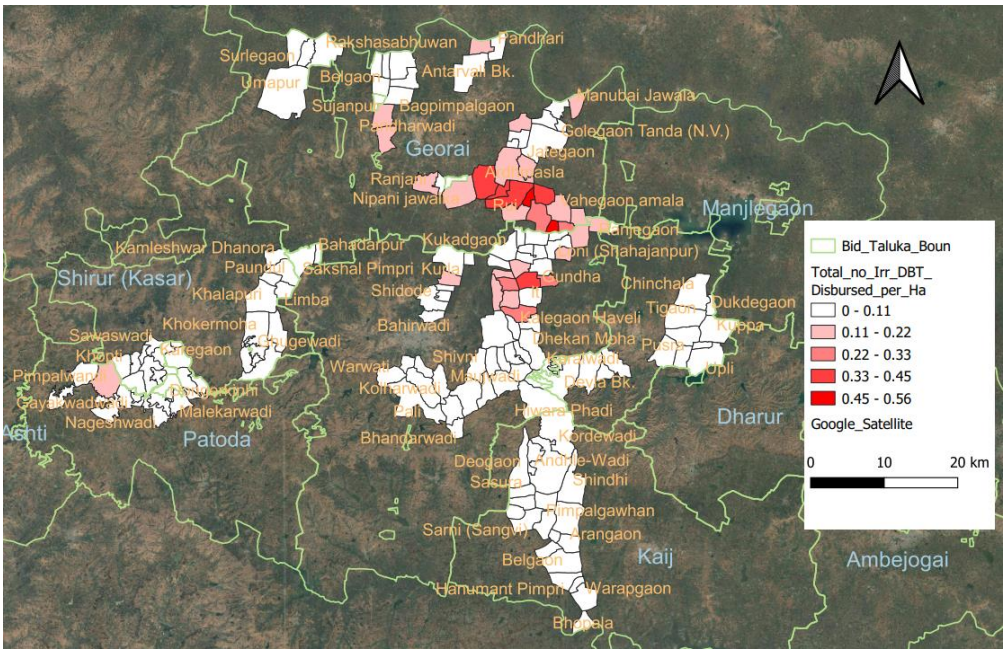
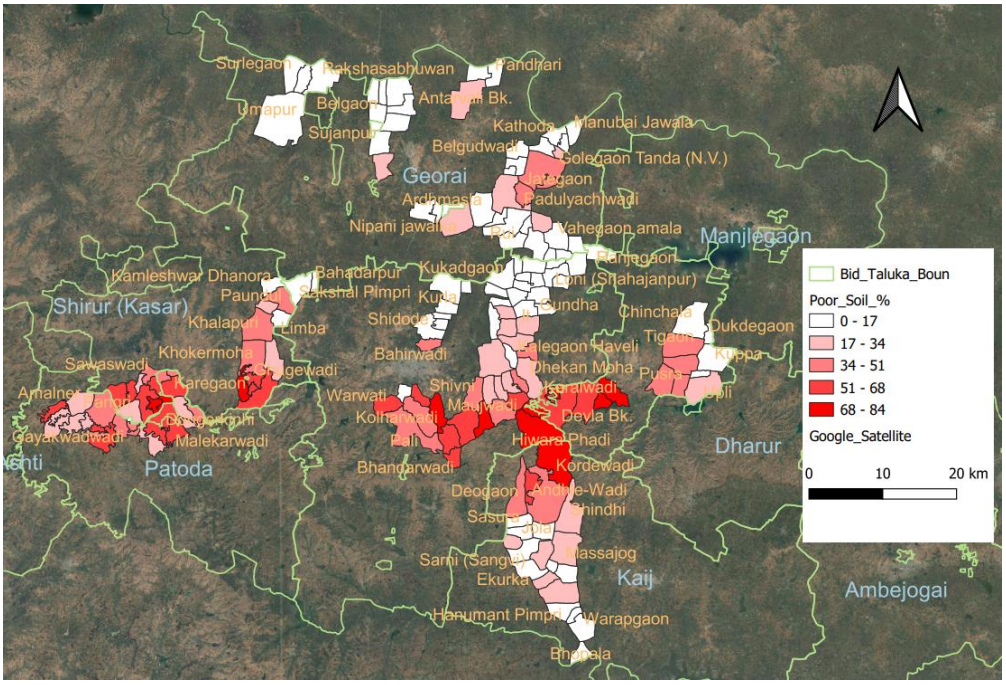
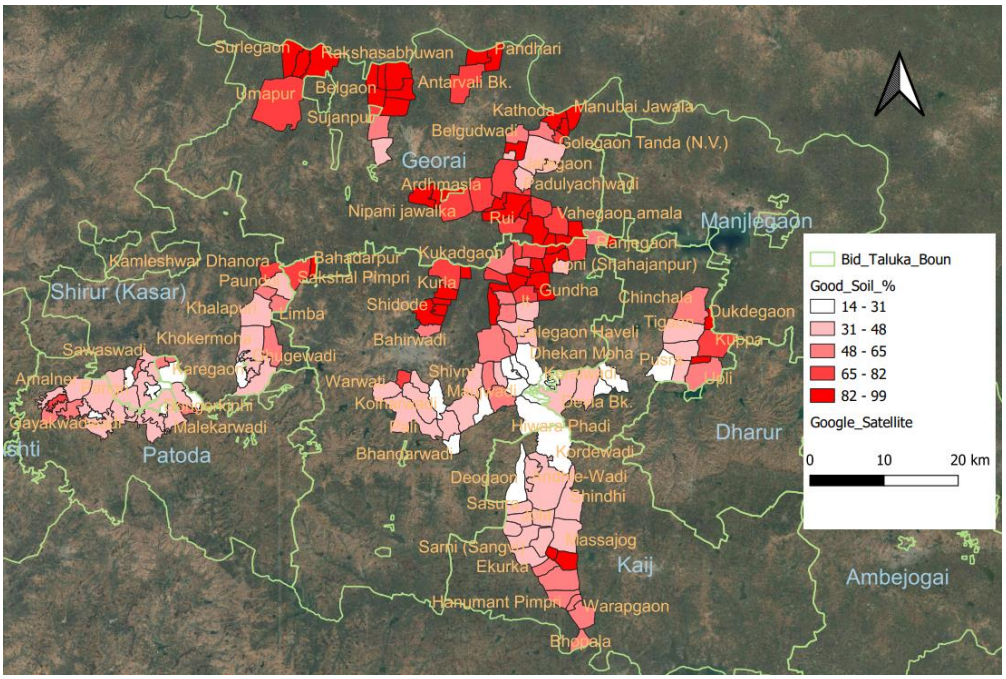
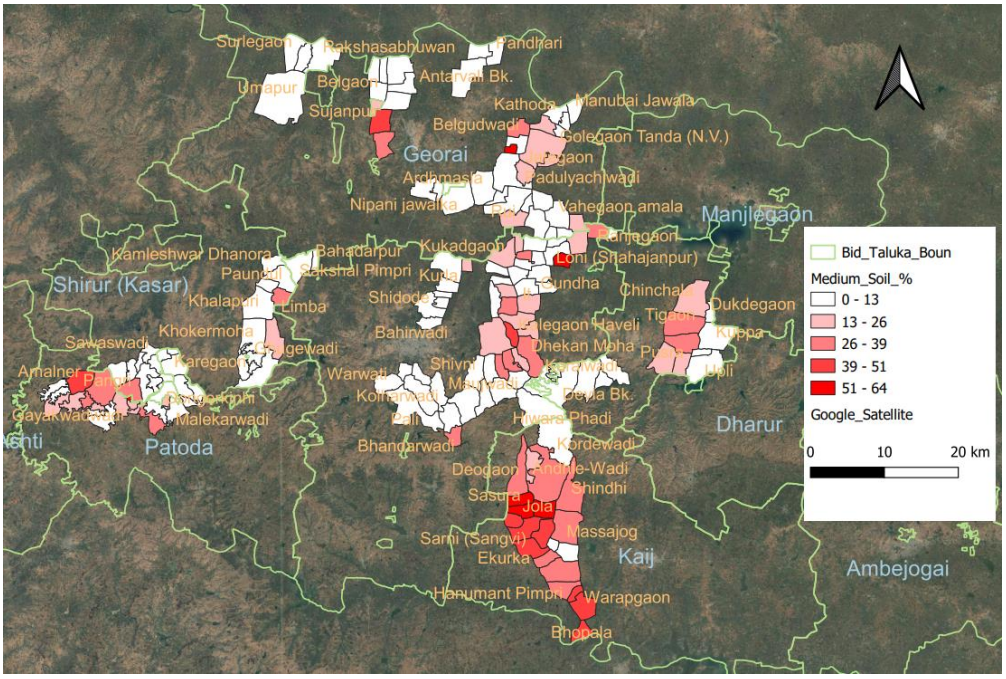
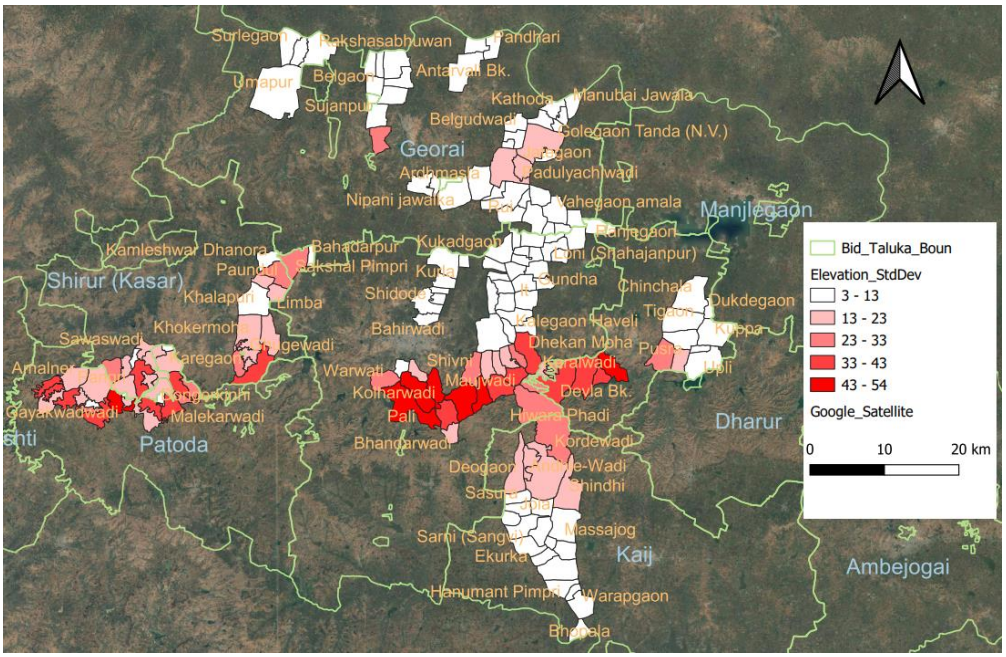


Figure A4. Villages in Bid district categorised according total number of irrigation related disbursements made through PoCRA DBT per Hectare


Surlegaon
Rakshasabhuwan
Pandhari
Umapur
Belgaon
Antarvali Bk.
Sujanpur
Kathoda
Manubai Jawala
Belgudwadi
Golegaon Tanda (N.V.)
Georai
Ardhmasla
Nipani jawalka
Manjlegaon
Kamleshwar Dhanora
Bahadarpur
Kukadgaon
Shirur (Kasar)
Khalapuri
Limba
Shidode
Chinchala
Dukdegaon
Khokermoha
Bahirwadi
Sawaswadi
Amalner
Warwati
Shivni
Devla Bk.
Hiwara Phadi
Dharur
Malekarwadi
Patoda
Bhangarwadi
Kordewadi
Deogaon
Sasti
Sarni (Sangvi)
Ekurka
Kaij
Ambejogai
Hanumant Pimpri
Warapgaon
Bhopela
Bid_Taluka_Boun
Poor_Soil_%
0 - 17
17 - 34
34 - 51
51 - 68
68 - 84
Google_Satellite
0
10
20 km


Surlegaon
Rakshasabhuwan
Pandhari
Umapur
Belgaon
Antarvali Bk.
Sujanpur
Kathoda
Manubai Jawala
Belgudwadi
Golegaon Tanda (N.V.)
Georai
Ardhmasla
Nipani jawalka
Manjlegaon
Kamleshwar Dhanora
Bahadarpur
Kukadgaon
Shirur (Kasar)
Khalapuri
Limba
Shidode
Chinchala
Dukdegaon
Khokermoha
Bahirwadi
Sawaswadi
Amalner
Warwati
Shivni
Devla Bk.
Hiwara Phadi
Dharur
Malekarwadi
Patoda
Bhangarwadi
Kordewadi
Deogaon
Sasti
Sarni (Sangvi)
Ekurka
Kaij
Ambejogai
Hanumant Pimpri
Warapgaon
Bhopela
Bid_Taluka_Boun
Good_Soil_%
14 - 31
31 - 48
48 - 65
65 - 82
82 - 99
Google_Satellite
0
10
20 km


Surlegaon
Rakshasabhuwan
Pandhari
Umapur
Belgaon
Antarvali Bk.
Sujanpur
Kathoda
Manubai Jawala
Belgudwadi
Georai
Ardhamasla
Nipani jawalka
Manjlegaon
Kukadgaon
Shirur (Kasar)
Khalapuri
Limba
Shidod
Chinchala
Dukdegaon
Khokermoha
Bahirwadi
Dhekan Moha
Sawaswadi
Warwati
Shivni
Amalner
Kolharwadi
Devla Bk.
Gayakwadwadi
Malekarwadi
Patoda
Dharur
Bhandarwadi
Kordewadi
Deogaon
Shindhi
Sasura
Jola
Massajog
Sami (Sangvi)
Ekurka
Kaij
Ambejogai
Hanumant Pimpri
Warapgaon
Bhopala
Bid_Taluka_Boun
Medium_Soil_%
0 - 13
13 - 26
26 - 39
39 - 51
51 - 64
Google_Satellite
0
10
20 km


Surlegaon
Rakshasabhuwan
Pandhari
Umapur
Belgaon
Antarvali Bk.
Sujanpur
Kathoda
Manubai Jawala
Belgudwadi
Georai
Ardhamasla
Nipani jawalka
Manjlegaon
Kukadgaon
Shirur (Kasar)
Khalapuri
Limba
Shidod
Chinchala
Dukdegaon
Khokermoha
Bahirwadi
Dhekan Moha
Sawaswadi
Warwati
Shivni
Amalner
Kolharwadi
Devla Bk.
Gayakwadwadi
Malekarwadi
Patoda
Dharur
Bhandarwadi
Kordewadi
Deogaon
Shindhi
Sasura
Jola
Massajog
Sami (Sangvi)
Ekurka
Kaij
Ambejogai
Hanumant Pimpri
Warapgaon
Bhopala
Bid_Taluka_Boun
Elevation_StdDev
3 - 13
13 - 23
23 - 33
33 - 43
43 - 54
Google_Satellite
0
10
20 km

This is total Disbursement in Rs per Ha