Project on Climate Resilient Agriculture – IIT Bombay MoU II Closure Report

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Table of Contents

List of Figures

List of Tables

Abbreviations

1. Kc – Crop Coefficient
2. ET_0 – Reference crop evapotranspiration
3. ET_c – Crop Evapotranspiration
4. ET_{adj} – Adjusted ET_c
5. GW – Ground Water
6. SM - Soil Moisture
7. DEM – Digital Elevation Model
8. LULC – Land Use Land Cover
9. MLP App – Microplanning App
10. GSDA – Ground Water Survey and Development Agency
11. NBSSLUP – National Bureau of Soil Survey and Land Use Planning
12. MoU – Memorandum of Undertaking

1. Introduction

This report is a component of the overall closure of IITB-PoCRA MoU II. It provides brief description of the set of tools and frameworks delivered by IITB to PoCRA PMU to augment the water budgeting and planning process for climate resilience in agriculture. New frameworks were developed in MoU II built upon the village level water budgeting framework implemented in MoU I. The set of IT tools was also extended in MoU II to serve different functions.

MoU II mainly consisted of following components –

I: Technical refinement of GIS water balance plugin, process automation and extension to various tools such as apps, dashboard.
II: Design of Water Allocation Framework, indicator measurement framework and beneficiary prioritization guidelines.
III: Extension activities involving collaboration with agricultural universities, development of video training material
IV: Support to PMU for smooth implementation of frameworks and processes on ground, overall deployment of apps and tools at PMU.

The chapters in this report are arranged according to these components. The methodology and outcome from each task contributing to the component has been illustrated.

2. Motivation

Field visits were carried out in project villages, analysis was conducted based on field observations, and primary and secondary data. The discussions with the PMU based on this and the outcomes of MoU-I, as recorded in the reports revealed the need for MoU II. MoU II was taken up with following objectives- To technically refine the water balance by incorporating improved, i.e., more timely and accurate, inputs and methods which would take the modelling of water balance closer to field observations. This was to be done through collaboration with different agencies like Skymet, MRSAC to name a few.
Frameworks were to be designed to enable better understanding of water balance so that they could be extended into planning and evaluation tools. Water productivity measurement methodology was to be evolved for the purpose of monitoring and evaluation and extension activities were to be undertaken to improve community comprehension.

3. Overview

This section elaborates the structure of closure report. Chapter 1 provides a background and introduction to MoU II, Chapter 2 describes the need for MoU II, Chapter 3 provides an overview of chapters in this report, Chapter 4 details out the work done to technically refine the plugin through analysis of input datasets, development of improved methodologies and tools. Chapter 5 provides a brief on frameworks developed for water allocation, monitoring and evaluation of water related indicators and beneficiary selection guidelines. Chapter 6 details out the extension activities undertaken for water budget, Chapter 7 elaborates the IT component of MoU II with details of online and offline tools developed and their status. Chapter 8 provides details on support provided to PMU during MoU II, conclusion and future scope.

4. Technical Refinement of Water Balance Plugin

This component consists of procedures related to input data refinement and improved modelling methods for better calibration of water balance model. The tasks undertaken under this component, the methodology followed for them and their outcomes are briefly described here. The naming of these tasks has been done as per MoU II.

A1: MRSAC Soil data analysis:

Soil characteristics are important since they determine runoff, ground water recharge and crop deficit for any location. MRSAC soil data is an important input parameter for our plug-in. Given the experience in several villages there was a felt need to verify secondary data and calibrate water balance computation. This was initiated in following manner –

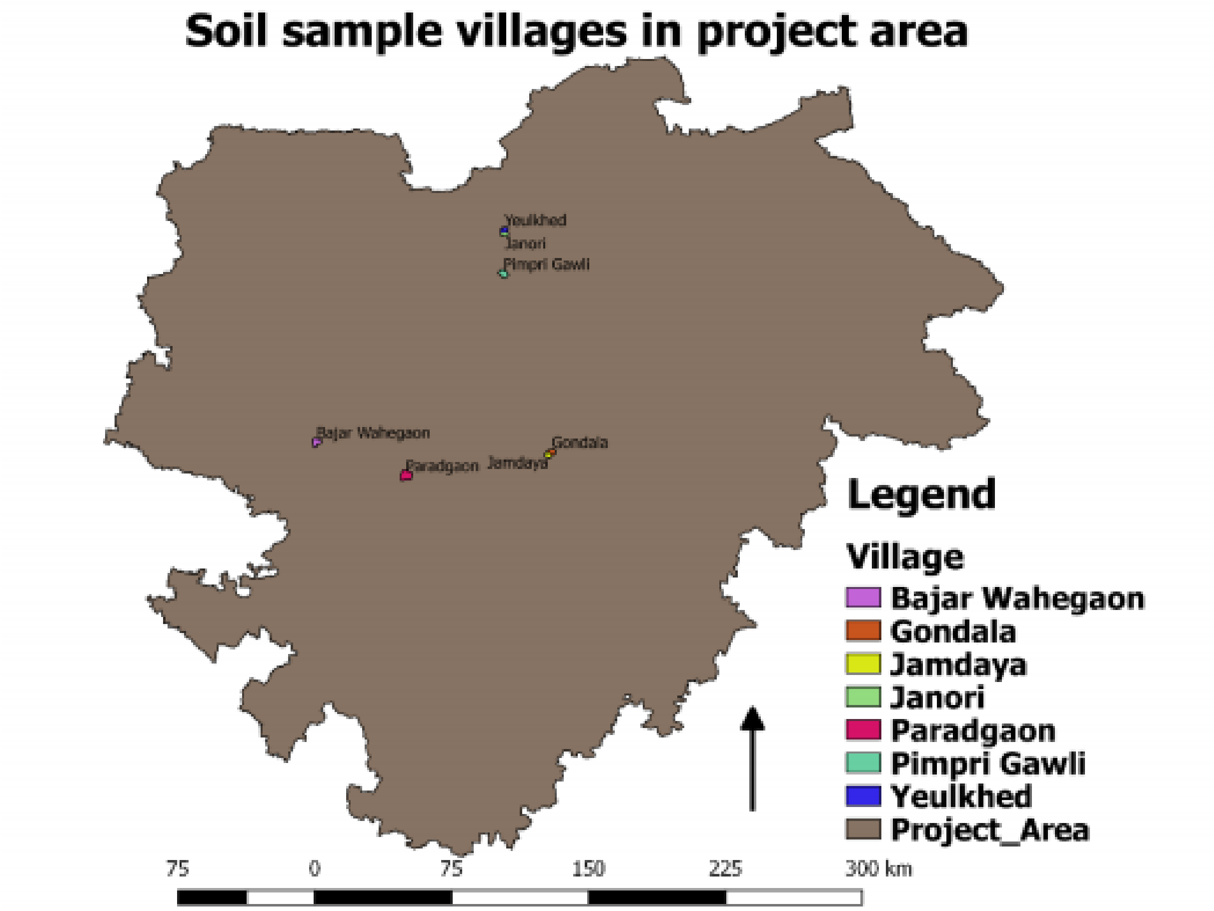


Figure 4-1 Soil sample locations in project area for soil analysis

Method:

a. Validation of MRSAC soil data: To do this, 5 soil samples were collected each, from 7 different villages in project area and tested. Their texture and depth characteristics of field samples were matched with MRSAC soil data characteristics at the same location using MRSAC soil shapefile data. It was found that MRSAC maps generally showed higher clay content and lesser silt content as compared to the tested field soil samples. This resulted in significant variation between the plugin outputs from water balance model and ground reality. A report was prepared which analysed this difference and the corrections that would accrue from correct soil data. [link].
b. Data analysis of NBSSLUP soil data to check feasibility of introducing correction: NBSSLUP soil data at 1:10,000 scale was received for two districts in Maharashtra. it was revealed through discussion that MRSAC data at 1:50,000 scale was built upon NBSSLUP data, by integrating it with various other remote sensing techniques. So, this data was analysed with respect to MRSAC soil data for correlation amongst them, to see if any correction mechanism is feasible. Since the NBSSLUP data had varying name conventions and number of features as compared to MRSAC data, and more details on it were unavailable further, so correlation could not be established.

Conclusion:

1. NBSSLUP soil data at this finer scale was not available for all districts in Maharashtra, so that it could be utilised for water balance.
2. The MRSAC data currently available appears to be outdated.
3. Considering point 1, point 2 and based on the results of this analysis, it was suggested that a new soil database be created for all districts in project area at 1:10,000 scale in collaboration with NBSSLUP. This database with more accurate soil characteristics would result in improved water balance for agricultural planning. [link]

Outputs:

1. MoU has been signed with NBSSLUP for creation of soil data base at 1:10000 scale for PoCRA districts
2. Android App for soil survey has been developed and deployed in public domain [app apk][app manual]. This app has been demonstrated to NBSSLUP and GSDA, who found it usable for their purpose.

A2. PET for micro-irrigated crops

To incorporate the impact of micro-irrigation into water balance. Literature review of existing research was conducted.

Method: The crop water requirement currently published by WALMI is computed for flood irrigation regime. While the modern efficient irrigation practices like drip and sprinkler lower the crop water requirement by certain extent due to differences in factors such as wetted surface area which influence the evaporation. This effect can be taken into account by applying a factor to crop coefficients K_c.

Conclusion: Based on available literature suitable multiplication factors for computing crop water requirement ET_c of micro-irrigated crops have been suggested [link]. The exact values for these need to be verified from agricultural universities.

Outputs:

1. Discussions conducted with PMU and agriculture universities for taking this further. Formal engagement will be required with the universities for this.

A3. Improvement in water balance reporting formats:

Water balance reporting formats in MLP app were updated based on inputs from PMU. This task was a combination of IT and research.

The old version of app lacked the backend database required for conducting analysis. So, database design was undertaken for water balance part of MLP app to provide a prototype for professional development of new app. The queries for water balance charts and water balance at zone and village level were built upon this.

Water budget previously available for single nearest to average rainfall year was now automated to provide results for all available rainfall years. Facilities such as offline computation of water balance were included.

Outputs:

1. Set of prototype database and queries in PostgreSQL was delivered to developer runtime.
2. Water Balance part of new MLP app was finalized by providing guidance to developer throughout the process, persistent testing and feedback.

A4. Better regional Flows

The existing water accounting framework computes the water budget components at the point level and then those components are aggregated over micro watershed (200-500 ha) which is part of the village (1000 ha). An improvement is incorporated into this framework that takes into account the amount of water flowing into the village boundary from micro watersheds outside the village boundary. It also takes into account the water leaving the village boundary from micro watershed inside the village boundary. Improving upon the existing framework helps in considerable amount of runoff made available to the downstream villages from the upstream villages which can be used to tackle the crop water deficit more effectively.

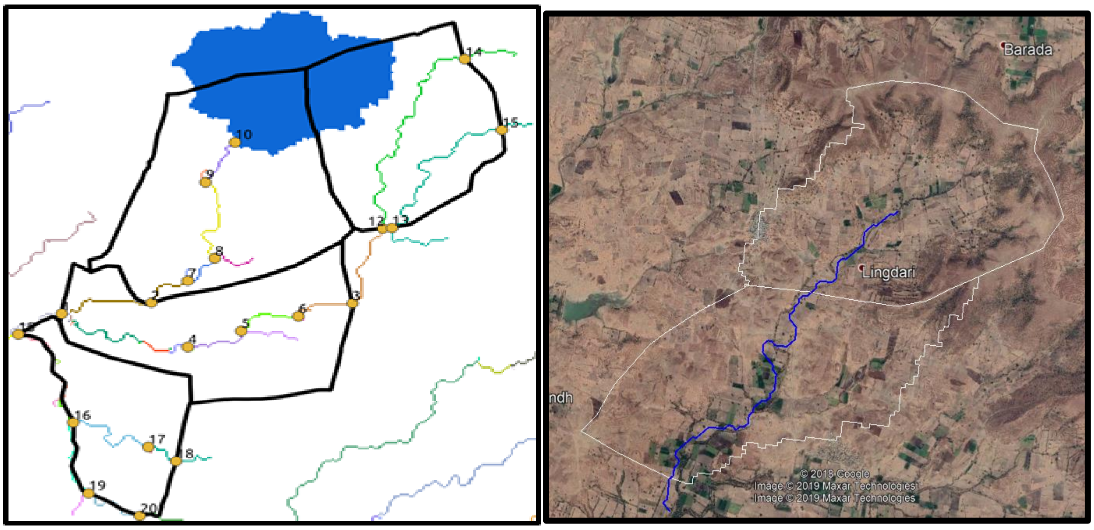


Figure 4-2 Computation of stream-flow in micro-watersheds of Lingdari and Gondala

It also helps in improving the accounting of groundwater by incorporation of stream simulation process. There are three components of groundwater recharge namely farm recharge, stream proximity (bank storage) and channel recharge. the framework now integrates farm runoff with these three components. A separate routine is ready which gives the idea about storage to be created through drain line treatment. Work is being done on integrating the groundwater flows from non-stream areas to stream areas.

A5. Study and design of stream flow and GW based criteria to aid DPR validation

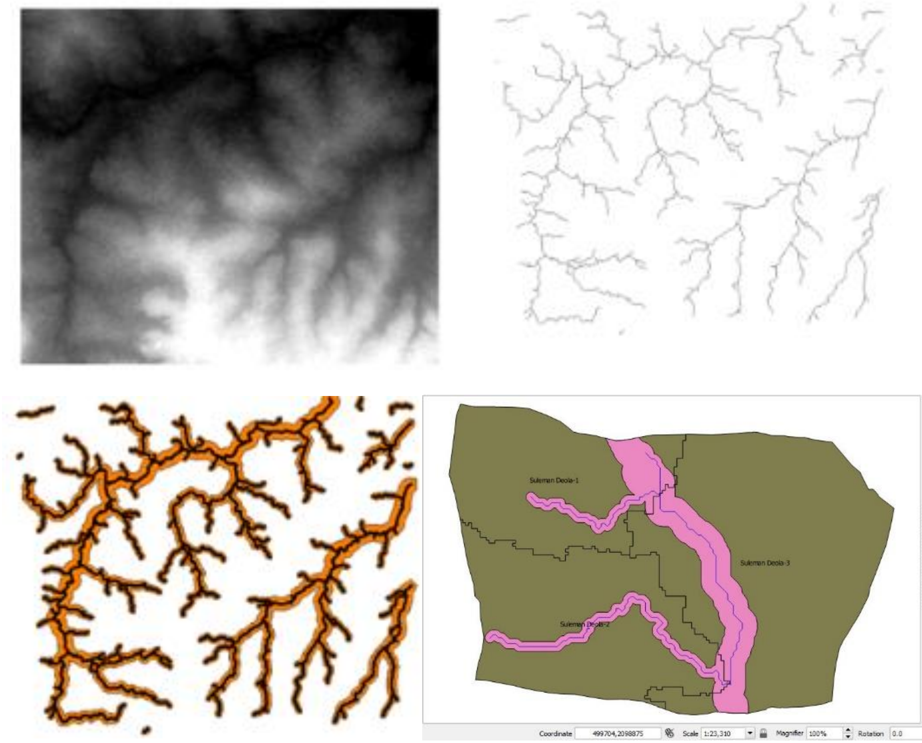


Figure 4-3 Stream proximity routine

A separate routine is available to delineate stream proximity areas from non-stream proximity areas. This was used in M&E framework proposed and beneficiary prioritization criteria proposed in phase II.

A6. Analysis of Mahabhulekh data for default village cropping pattern

Mahabhulekh data for few villages was analysed to check its validity for usage, to get zone or village level default cropping pattern in MLP app. However, many discrepancies and inherent issues were found in data while trying to match it as per MRSAC cadastral map These issues were presented and discussed with PMU and resulted in relying on primary data for getting zone and village level cropping pattern.

Outputs: Report on Mahabhulekh data analysis highlighting additional requirements for usage in PoCRA [link]

A7. Finalization of Methodology for real time ET_0 computation

In version 1 of GIS water balance plugin, The ET_0 used, was that published by WALMI for 7 stations in project area. The project districts were mapped to their nearest ET_0 station and constant ET_0 monthly values were used for computation of crop PET.

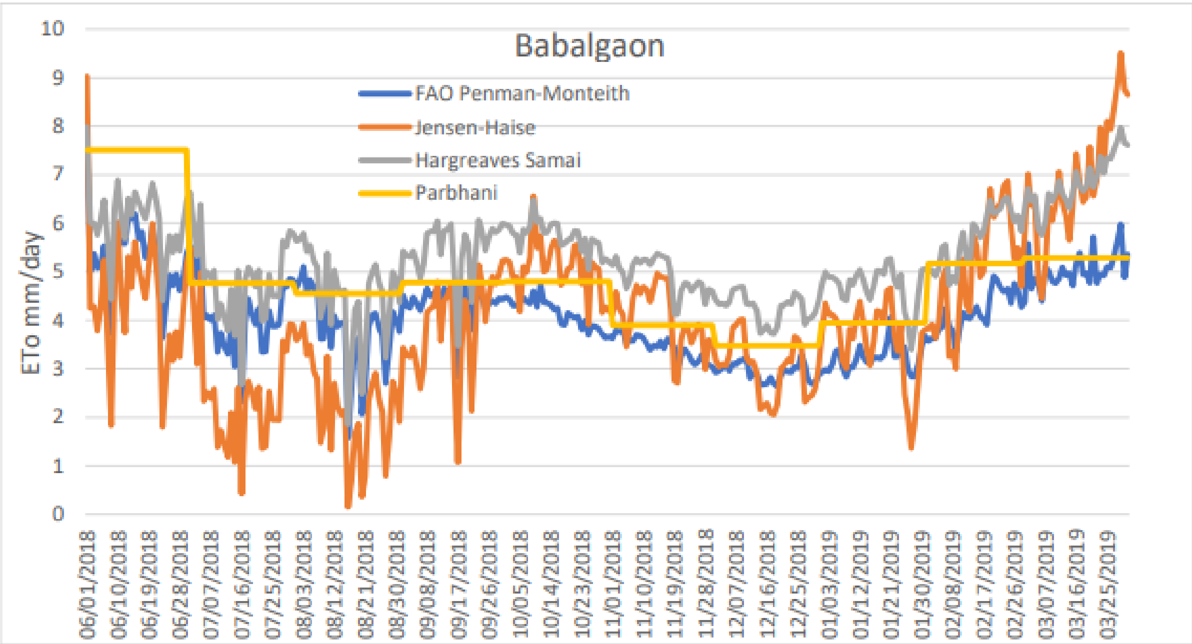


Figure 4-4 ETO comparison for different methods for sample skymet circle Babalgaon

New Method: Real time Skymet data for weather parameters was now made available to IITB from PMU, and based on this study was conducted to select one of the existing PET computation methods for water balance model. Hargreaves method was selected for implementation based on sensitivity analysis and root mean square error analysis with respect to WALMI ET_0 outputs, and presentation and discussions with PMU.

Outputs: Real time ET_0 computation using Hargreaves ET_0 model was implemented in GIS dashboard and plugin from year 2018 for which real time Skymet data was made available.

5. Design of Indicator measurement Frameworks and Beneficiary prioritization Guidelines

The section mainly consists of components B, C and D from MoU II related to design of water allocation and indicator measurement frameworks, their integration with IT part and field visits for Detailed Project Report and framework analysis. The work done in these components is elaborated here.

An M.Tech. thesis [link] by Manasi Bhopale was also devoted to this topic and several frameworks from the thesis were incorporated.

B1. Development of Water Accounting Framework and beneficiary prioritization guidelines

Crop hierarchy and water allocation methodology was developed to better understand the water demand and allocation in the village. This was done to enable planning at the community level. This framework involved development of a method to classify crops into different hierarchies based on their economic returns, watering preferences and water requirements or risks. Allocate available surface and ground water to these crops based on the risk-return-watering preference framework. This computed allocation was to provide an approximation of the new allocation that was likely to emerge under the new regime. This would provide the necessary background for making decisions on cropping pattern changes and selection of appropriate interventions for the village. Example – if more focus should be given on individual interventions or on drainline interventions based on whether to promote annual crops or pulses or rabi crops at community and individual level thus enabling tying up of project objectives to interventions.

Method:

1. This analytical framework was developed by visiting few selected villages and studying their water budgets for good, bad and average rainfall years. For these years, through farmer interviews, the cropping pattern and the actual allocation of water to crops was established.
2. Basic Rabi crop advisory framework was also designed based on this water allocation framework and case study of 3 villages was presented. Further development and automation of rabi advisory framework will require additional data on crop hierarchy, irrigation and economic parameters to be gathered. The link to rabi advisory presentation is [link]. This will be taken up through discussion with the PMU. This framework will be usable as an advisory for rabi planning based on current year water budget.

Outputs: A suitable framework was developed which may form the basis for designing beneficiary prioritization guidelines, rabi advisory and the design of database for analytical evaluation of project villages. Intervention wise beneficiary prioritization guidelines were developed considering the project development objectives and respective data additions required in PMU's IT systems/apps/database mainly through DBT and DPR to gather beneficiary information were suggested in it [link].

B2. Indicator Measurement Framework for Water Productivity

Water productivity is a key performance indicator for PoCRA project which is to be measured at project scale for evaluation of project outcomes. A sampling and measurement methodology was developed for this indicator and presented to PMU [link]. The IITB measurement methodology for water productivity was decided to be incorporated for monitoring and evaluation, after internal discussion with selected Monitoring & Evaluation (M&E) agency and PMU, while M&E agency's sampling methodology was decided to be used for this indicator.

Method: The water productivity sampling and measurement methodology was developed by conducting 15-20 farmer interviews from 5-6 villages each to gather crop yield, watering, soil and economic information for major crops. Based on this, a computation method was developed and carried out to obtain water productivity values for these pilot villages.

Output:

1. M&E Methodology for water productivity document [link]
2. Drip and Sprinkler irrigation modelling document [link]
3. M.Tech thesis report [link]

C1 Extension of Farm Level App

In this component the farm level app was to be extended with improved features to guide farmers on crop choices and appropriate interventions based on component B. Work was undertaken for this and the app was updated with following features –

1. Updated features in Farm level app Dynamic ET0 computation
2. Real time rainfall fetching
3. Irrigation selection and modelling

This app is available on IITB PoCRA webpage at link [link]. The app manual is available here [link].

C2 Extension of PoCRA MLP app for plan analysis and broad level guidance

This extension was designed in the form of Visual representation of Water Balance Charts which shows the overall surplus deficit in village for current cropping pattern and last six years rainfall 2013-2018. The chart shows monsoon and post-monsoon balance with current storage capacity, available runoff for six different rainfall years and newly planned storage versus runoff available for impounding. This serves as a simple guidance to villagers to see whether they have planned to arrest all the runoff available for impounding. The variation in water balance situation after implementation of new structures can also be seen through this. It shows the water demand and allocation for different crop seasons such as annual, long kharif, rabi which helps improve the community comprehension of water balance to enable decision making of cropping preferences and interventions.

Method: Different versions of visual representations were prepared and discussed with PMU to incorporate suggested features and finalize a version. Documentation was prepared on procedure to prepare these charts

Outputs:

1. Prototype database and SQL queries to automate chart generation from MLP data and QGIS water balance plugin data.
2. Procedure to prepare charts [link]
3. Live charts portal in public domain [link]. Water balance chart generation was fully automated by guiding the developer throughout the process.
4. English version of charts [link]

An M.Tech. thesis [link] by Swapnil Patil was devoted to this topic and several IT tools consisting of soil survey app, farm level app, water balance charts scripts, stream proximity automation, stream flow algorithms from the thesis were incorporated.

C3 Development of Planning guidelines

Planning guidelines on capping interventions such as wells, farm ponds were to be taken up in this part. This component is linked with component A4 and component A5 which deal with research on incorporation of better regional flows and design of stream flow and groundwater based criteria to aid DPR validation.

Method:

1. Well planning based on simple thumb rules like 2 TCM per well for away from stream zone and 4 TCM per well for near stream zone were suggested to PMU through guidelines document. Stream proximity maps suggested by IITB were to be used for this and the requisite code was supplied. This document also included procedure to finalize location for farm ponds by gauging the runoff through rainfall events. These were discussed with the PMU, and PMU suggested that inputs from GSDA must be obtained and used for deciding number of wells instead of this method [link].
2. CNB profile simulation for two CNB's on same stream for given rainfall was conducted in component A4 to model regional flows were modelled in component A4 to improvise the zoning based on seasonal availability of ground water. Work on ground water and stream proximity based criteria in component A5 was in progress as it is also based on runoff and ground water calibration which in turn is dependent on soil type.

It was decided that planning guidelines will now be developed based on outcomes of runoff and ground water calibration through collaboration with different agencies such as NBSSLUP, GSDA and agricultural research universities. The field validations and improvisations in model based on observations, better simulation of stream and ground water flows will be carried out. These technical outcomes will be an input to charting out better planning guidelines.

Outputs:

1. MoU with GSDA for Ground water recharge plans
2. Document on review of GSDA recharge plans [link]
3. Stream proximity delienation procedure document [link]

C4 Incorporation of frameworks in survey formats and IT tools

Extension of zone and village level survey formats was proposed to gather data needed to implement the water budget based planning and allocation frameworks. This included well readings, soil readings, irrigation practices, yields, farmer surveys etc. Their incorporation was done into existing IT tools based on discussion with PMU. The IT support and main work required to implement these frameworks from IITB has been detailed in chapter 7.

1. Water allocation framework: water allocation framework was designed which divides the crops into three categories P1-which have high risks and high returns, they require maximum water throughout the year and incur huge losses if not provided, due to higher initial investment costs. Annual crops come under this category. P2-medium risk medium return crops like pulses, cotton, rabi crops like wheat, onion come under this category. These happen to be second watering preference for farmers after P1. Rainfed low risk low return crops come under P3 category. Available water has also been divided as W1- surface storage reservoirs, W2-ground water and W3 – soil moisture. The supply demand allocation is done based on this to help decision making. Implementation of this framework will require data on crop hierarchy, market rates for crops, crop yields and watering practices in project villages. The format to gather and use the data has been demonstrated through rabi planning and simple analytical queries.
2. Water balance Charts: The database for input data from MLP app, input data from plugin and output in form of zone and village level water balance, visual water balance charts were designed and documented [link]. The set of queries were also coded. This prototype was demonstrated to PMU and submitted to runtime to enable development of professional version.
3. Beneficiary Prioritization Guidelines: IITB philosophy of nudging the village towards a climate resilient cropping plan which is water neutral, at the same time, increasing the access to protective irrigation in both kharif and rabi by farmers, was the second core objective. For this second objective, the selection of beneficiary for various interventions needs to be done carefully.
   For this water sector interventions were classified as being on the demand side (e.g., new seeds) or the supply side (e.g., drip irrigation system). On the supply side, they were further classified as source (e.g., well or farm-pond), energy (pumps), transmission (pipelines) and application (drip etc.).
   Scoring formats and guidelines were prepared so that beneficiaries could be suitably located [link].
4. Water productivity: survey formats and prototype analysis excel tools were designed to demonstrate methodology for water productivity computation. Analysis and

studies were conducted by collecting survey data. The finalized method and survey formats were shared with M&E agency and are being used for data gathering. The computation process may further be coded based on shared methodology to automate the computation.

5. Soil survey format: soil survey format was developed to gather soil data of texture and depth. This will help in soil calibration for MRSAC maps. Classification of soil categories into light, medium and heavy was done, which are understandable to general public. This soil survey format was then used to build a soil survey app.

D1 - D2: Support for DPR assessment building DPR evaluation guidelines

Support was provided to the PMU to assess water budgets and DPR's for villages. Field visits were conducted to project villages and observations regarding issues in microplanning, DPR preparation, approval and implementation process along with probable solutions were shared through document.

Outputs:

1. DPR evaluation checklist for microplanners, VCRMC and SDAO [link]
2. DRP planning issues observed through field visits [link]

6. Extension Activities and field visits

Extension activities for PoCRA water budget were taken up under this component. These activities involved development of video training material for ease of repetitive training of PoCRA staff and better community comprehension on water budget. Collaboration with agricultural universities for capacity building of agriculture graduates, extension of PoCRA water budget based methodologies and promoting research needful for refinement of PoCRA models was done under this component.

F Preparation of video training material for project

A water budget concept video has been developed and is available online at following link [link]. One more video on using PoCRA MLP app to compute water budget will be developed after updated MLP app is approved from PMU and goes live.

G Collaboration with agricultural universities

Meetings were conducted with different agricultural universities to enable integration of research experiments for PoCRA into RAWE framework. Research experiments were framed for RAWE and workshops were conducted for RAWE students of 12-15 colleges who were allotted PoCRA villages. They were trained to conduct water budget, compute water productivity, mark well profiles, mark interventions on village map and analyse the village budget and microplanning. The details of workshop conducted are given in Table 6-1.

Table 6-1 RAWE workshop schedule

Workshop Date	Place	Number of colleges	Number of students
9th Oct 2019	Aurangabad	4	38
11th Oct 2019	Jalna	1	33

This was done to enable improved planning guidelines and measurement of project impact. Meetings were also conducted with universities to promote collaboration to take up technical research such as development of yield watering curves for important field crops in project area, runoff validation and calibration etc.

Field Visits

Field visits were conducted for the purpose of developing water productivity framework, DPR evaluation, model validation, soil sample collection. Table 6-2 gives the details of field visits conducted.

Table 6-2 Field Visits conducted during MoU II

Sr. no.	District	Field Visit	Date
1	Wardha	Wabgaon	2^{nd} and 3^{rd} Feb 2019 (different team)
2	Jalgaon	Yevati	2^{nd} and 3^{rd} Feb 2019 (different team)
3	Latur	Tadmugli	4^{th} and 5^{th} Feb 2019
4	Jalna	Chapadgaon	14^{th} and 15^{th} March 2019
5	Aurangabad	Tongaon, Kumbhephal	15^{th} and 16^{th} March 2019
6	Amravati	Dahigaon	1^{st} April and 2^{nd} April
7	Beed	Suleman Deola, Wangi	11^{th} June 2019 and 9 weeek field stay
8	Nanded	Rohi, Pimpalgaon, Chikala, Ijali	3^{rd}-4^{th} June 2019
9	Wardha	Bhidi, Akoli	19^{th} and 20^{th} August 2019

Figure 6-1 Field Visit photos

7. Dashboard, IT and other Support

This section details out the work done in IT part of project which involves building of GIS project dashboard, database, apps and plugins. Various small online and offline tools / codes were developed to test, analyse and implement new improvements and frameworks. Table 7-1 provides details of all online and offline tools developed during MoU II which mainly include GIS dashboard in component E and Farm level app.

We contributed to the following four IT processes at the PMU. Besides this, other tools developed are mentioned in Table 7-1.

1. Web GIS dashboard: One of the deliverable items under this MoU is a web-GIS based dashboard application that will enable geo-referenced monitoring of the current status (and of the recent past) of field-level soil-moisture and related water-budget components. Since currently, data is being collected at the field-level only for the weather parameters (from Skymet's weather stations), the soil-moisture and related water-budget parameters have to be estimated. A simulation model proposed for such use-cases in the previous MoU, is being used for this estimation. While that model used fixed district-wise monthly values to estimate evapotranspiration, it has

been refined, as part of this MoU, to incorporate location-based daily dynamic estimation of evapotranspiration based on weather parameters.

The dashboard primarily provides geo-referenced visualization in the form of basic interactive maps. Each map pertains to a component of the soil-water-budget; like rainfall, runoff, evapotranspiration, etc. and provides a pseudo-colour display of the estimated/measured amount of that water-component over the entire region of the 15 PoCRA districts. This pseudo-coloring is user-customizable, which turns the dashboard into a basic, yet potent, visual spatial analysis tool. Currently, the dashboard also provides access to a tabular dataset related to the FFS component of PoCRA along with the ability to query and map that data. This tabular data functionality has been implemented in a way that can be easily extended to other such datasets that the PMU wants to publicize.

The dashboard web-GIS application is being served from a backend whose GIS components are the PostGIS database and GeoServer. The data on estimated parameter values that is required to generate the maps on the dashboard is produced on the server by a python application that simulates the aforementioned model. The model requires static data about the characteristics of soil, land-use, and terrain and dynamic data on the weather conditions. These datasets have been procured and provided by the PMU, except for the terrain data which is openly available on the internet. Also, all the software components used to develop the dashboard are free-of-cost and open-sourced. The link to current version of Dashboard is [link].

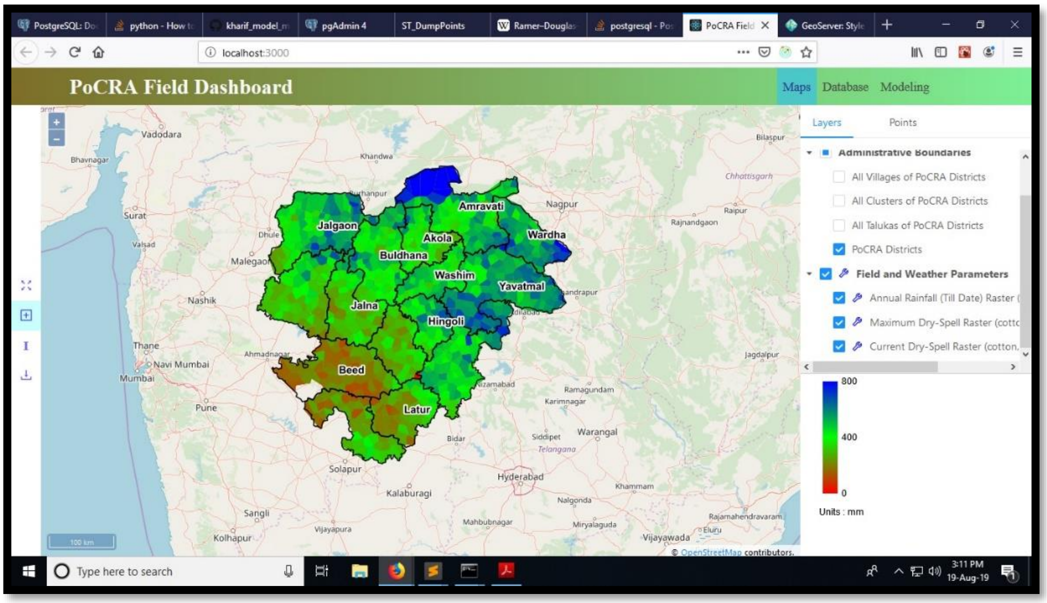


Figure 7-1 GIS Dashboard

2. Farm Level water balance android app: new features as mentioned in component C2 are added to this app. This app is usable by pocra project officials, agricultural assistants, farmers to get farm level water balance. Its functionalities are extended to

run for different irrigation types such as drip, sprinkler, flood. The functionalities may further be extended to provide water productivity and other advisories in MoU III [app_manual][apk_link].

Figure 7-2 Farm Level App with Irrigation type selection facilities

3. Soil survey app: This is a simple android app developed to collect geotagged soil characteristics. This can further be developed by adding various sections to provide farmer profiles, water allocation, beneficiary prioritization etc as asked by PMU. It is usable by NBSSLUP for their work on soil.

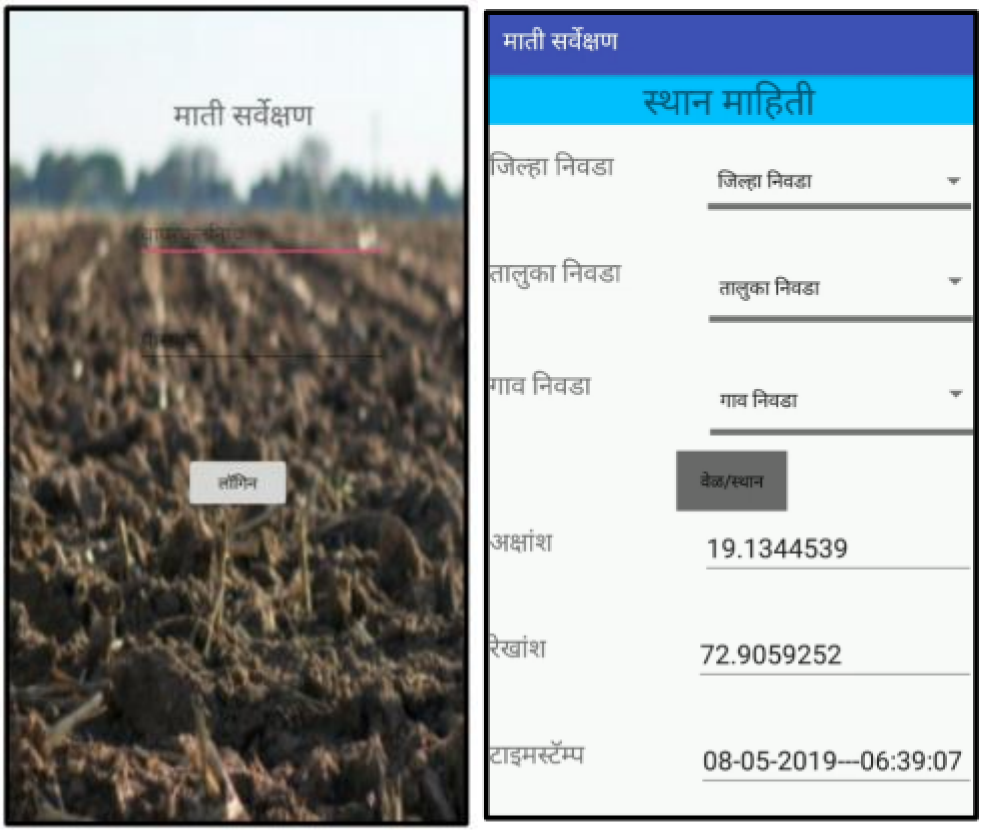


Figure 7-3 Soil survey App

4. QGIS water balance plugin: This plugin was updated to run for multiple crops – multiple years and multiple clusters.

Support:

I Realtime ET_0 computation

1. Real time weather data was made available from Skymet since 2019. Uptil 2018 Maharain rainfall data, fixed ET_0 values as per WALMI were used in QGIS plugin, apps and models. Now since real time data was made available and real time ET_0 computation method was finalized. This has been implemented in Dashboard for real time daily computation of ET_0.
2. Work was done to extend the real time ET_0 to QGIS plugin, and farm level android app.

II Real time Rainfall

1. Earlier the daily rainfall data to run the model was obtained from Maharain website for period 2013-2018. Now when realtime Skymet data is available. The rainfall circle selection algorithm (nearest neighbour algorithm) was updated. There were issues in rainfall circle matching between Maharain and skymet and this was resolved by developing geographical nearest neighbour rainfall selection algorithm. The selection and aggregation mechanism to extend it to zone and village level was decided and implemented [link].

2. Changes in the plugin code were made for this. Similarly, the farm level app was also modified to fetch real time rainfall data from skymet from 2019 onwards.

III QGIS – python command line plugin

Apart from the dashboard, a server-hosted python-based software application is being delivered as part of the support component under this MoU. This application provides a command-line interface to serve a couple of use-cases encountered by the PMU which relate to accessing weather data and generating water-budget estimates. Data storage required by the application is provided by the Postgres database. Currently, the application is deployed only on the server, but can be converted into a client application with only little to moderate software development effort.

IV Other IT work

1. Code was written to automate Stream proximity generation
2. Code was written to randomly select cadastral numbers for farmer sampling in M&E
3. Code has been written to separate point level plugin from QGIS to enable better research and analysis.
4. PostgreSQL database and queries were written for new framework implementation for water balance

V support in water budget part of MLP app

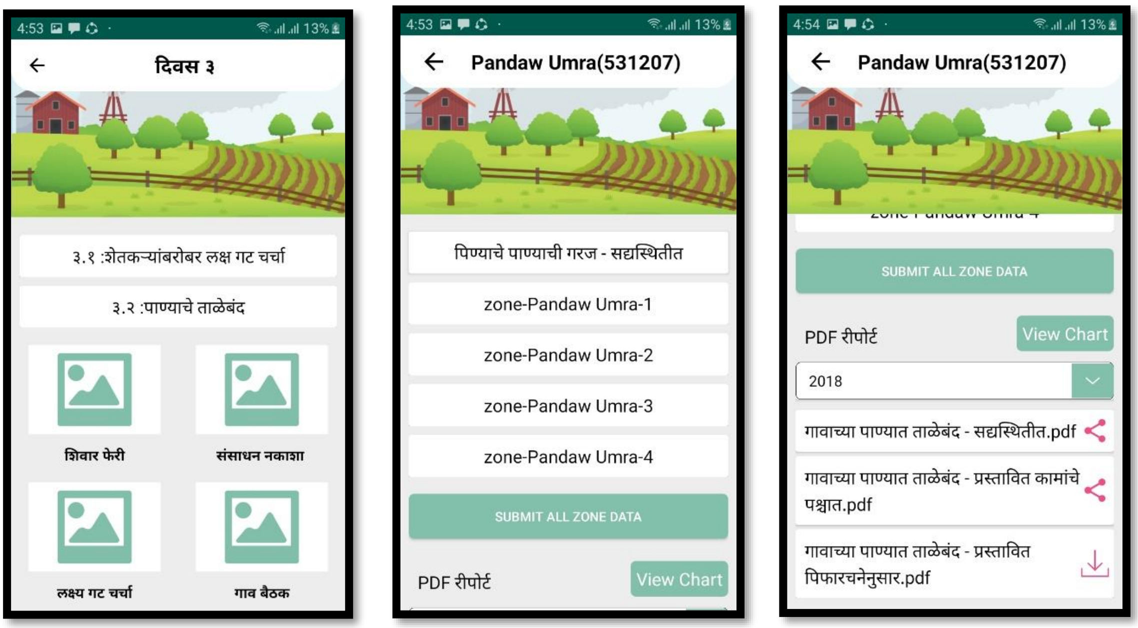


Figure 7-4 New MLP app with added functionalities

1. Support and guidance was provided to PMU IT team to build water budget part of App in lines with the prototype PostgreSQL database and queries.
2. Guidance was provided in database design, modification and building queries for three reports of water balance being generated in earlier nanostuff MLP app.
3. Thorough testing of new app was done to ensure satisfactory results.

4. Final round of correction in query formulas and app front end for water budget part has now been suggested and will be checked on implementation.

VI Visual representation chart

1. Guidance was provided for implementation of online chart platform and automation of chart generation. The sample charts can be found in Annexure II.

VII Support was provided to run python plugin for phase II villages. scripts were written to enable dumping of results into central PostgreSQL database where it can be used by MLP app. The scripts are currently installed in PMU workstation and has been delivered to the PMU for regular operational usage.

Table 7: IT Tools delivered by IITB to PMU

Sr. No	Type	Title	Version	Inputs	Outputs/ Expected Outputs	Features
1.	Android App	Water Balance	V1	Cadastral ,Soil ,LULC, Village Layer, Slope Rainfall,K_c Crop, Structures	Point level crop deficit AET ,SM ,Runoff ,GW recharge	Point level implementation of Water Balance Model
2.	Android App	M&E		Farmers Questionnaire, Farmer Sampling data	Farmer report, Village indices and crop indices Can be used for farmer surveying	
3.	Android App	Soil Sample Survey	V0	Soil Type, Location	Soil texture and Soil depth mapping	Farm level data collection of soil.
4.	Android App	Beneficiary App		Questionnaire	It will compute farmer priority rank which will be useful in farmer prioritization for different demand and supply benefits	
5.	Dashboard	PoCRA GIS Dashboard	Vo	All water balance Data from Database	Monitoring of Parameters AET ,SM ,Runoff ,Deficit	Monitoring of Parameters AET ,SM ,Runoff ,Deficit
6.	QGIS Plugin	Point Level Plugin	V1	Cadastral ,Soil ,LULC, Slope Village Layer Rainfall,K_c Crops, Location, Sowing Threshold ,Watering	Crop deficit, AET ,SM ,Runoff ,GW recharge	Point level implementation of Water Balance Model
7.	QGIS Plugin	Cluster level Plugin	V1	Cadastral ,Soil ,LULC, Village Layer, Slope Rainfall,K_c Crop, Sowing Threshold ,Watering	Crop deficit, AET ,SM ,Runoff ,GW recharge	Integration of Point level implementation of Water Balance Model Can be used for all Villages in Cluster

8.		District Level Plugin	V1	Cadastral ,Soil ,LULC, Village Layer, Slope Rainfall,K_c Crop, Sowing Threshold ,Watering	Crop deficit AET, SM, Runoff ,GW recharge	Integration of Point level implementation of Water Balance Model Can be used for all Cluster in District Multiyear and multicrop Plugin
9.	Scripts (postgresql ,Python)	Chart Preparation of Water Budget	V0	Postgre Database ,MLP, Plugin output	Chart table	Charts can be prepared from Database data and plugin data.
10.		Farmers geographical sampling	V0	Cadastral, LULC layer	List of randomly selected Survey numbers	Random selection of Survey number's
11.		Land Holding criteria	V0	Cadastral, LULC layer	Land Holding criteria for Village	Survey numbers holding 50% of village area can be enlisted based on land holding criteria.
12.		Zoning	V1	DEM, Villages	Zones in cluster	Watershed delineation at cluster level

8. Conclusion and Future Scope

Overall this MoU resulted in formalization and extension of version I frameworks implemented in MoU I. The new set of tools has enabled extension of functionalities from simple water budgeting to monitoring of bio-physical indicators in project area, providing advisory based on these indicators, enabling better community comprehension through visual charts and water balance concept video, evaluation of project villages based on water budget based indicators.

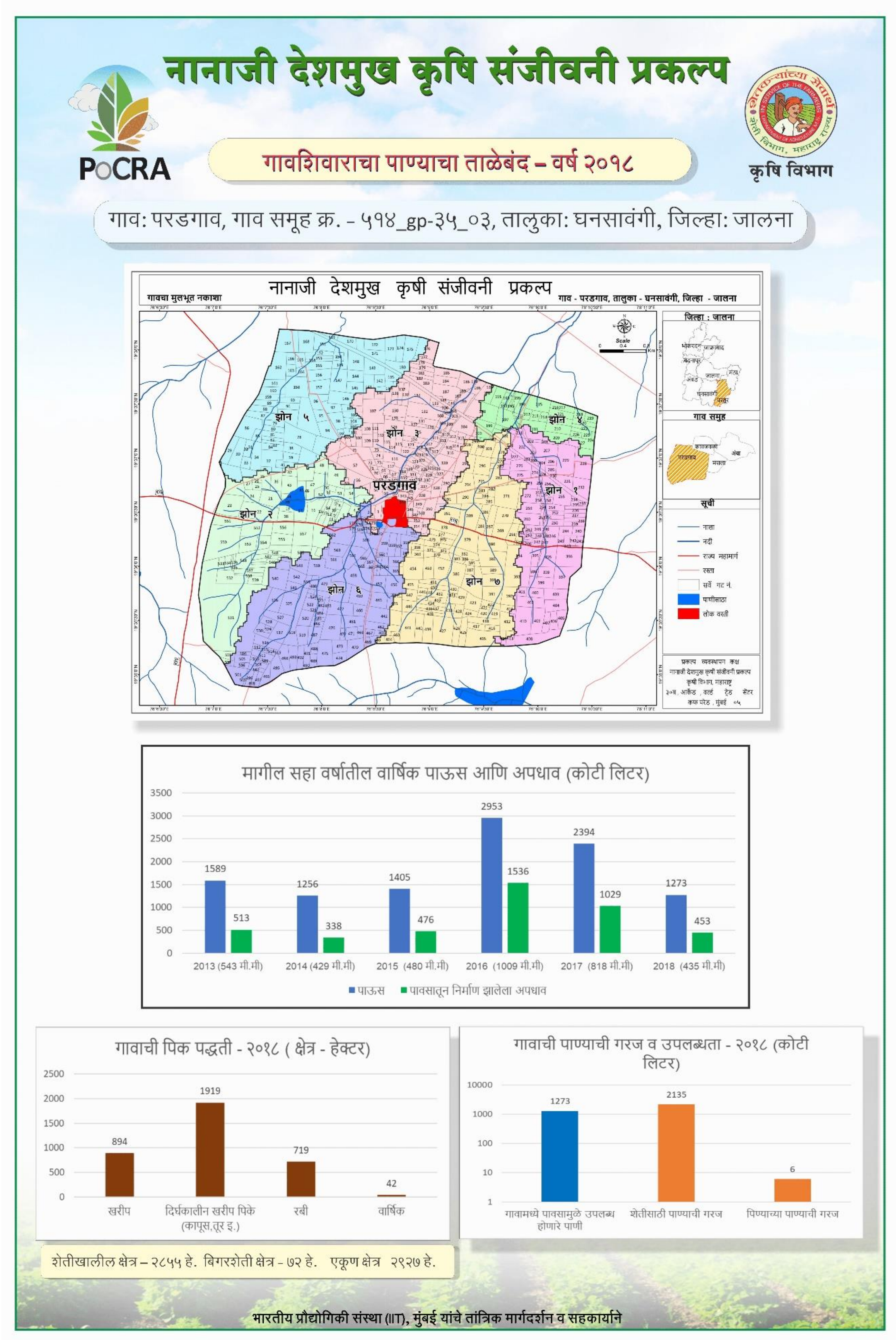
This new set of tools and frameworks has provided a basis for development of contingency planning to design a set of triggered advisories based on bio-physical indicators. Various impact evaluation indicators, DPR process evaluation mechanisms, beneficiary prioritization and selection procedures, improved water budget based planning mechanisms in collaboration with GSDA, thumb rules for post monsoon cropping decisions at village level can be implemented through these tools and frameworks. Utilities can be defined and they can be extended to various stakeholders as per the utility objectives. All these are to be taken up in MoU III in collaboration with PMU and other technical agencies.

Annexure I: List of submitted documents and tools

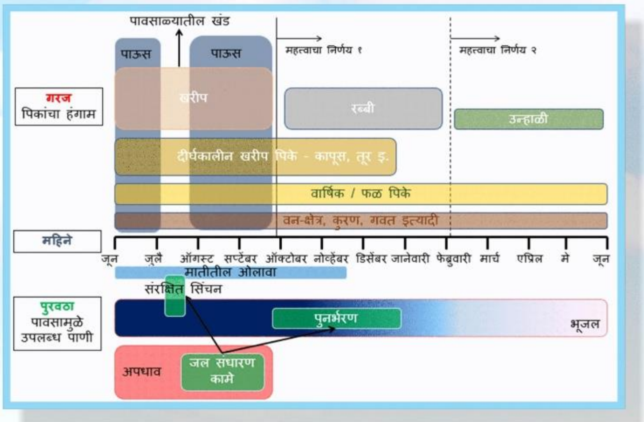
Sr. no.	Documents and presentations	links
1	Procedure for preparation of village water balance	link
2	Sample chart – English version	link
3	Database formulation for water balance in postgress	link
4	DPR Assessment checklist	link
5	Water allocation framework - version I	link
6	Report on Soil Texture Data Analysis and Validation	link
7	Report on Mahabhulekh Cropping Data Analysis and its Integartion with Cadastral shapfile	link
8	Presentation two month update MoU II (Water Allocation part)	link
9	Presentation Phase II Delivery - Monitoring and Evaluation Framework	link
10	Resilience through improving access to water for Agriculture,SDAO Training - Yashada, Pune	link
11	Beneficiary Prioritization Methodology for PoCRA	link
12	Documentation on Dashboard (GIS Dashboard for monitoring of bio-physical parameters in project area)	link
13	Report on Regional Decomposition of Water Budget	link
14	Soil Sampling App Manual	link
15	Water Balance App Manual	link
16	Review of Crop Cutting Experiments and Yield Assessment	link
17	Report on Proposed M&E Framework	link
18	Method for computation of Reference Evapotraspiration (ET_c)	link
19	Incorporation of Impact of Micro-irrigation on Crop Evapotraspiration	link
20	Irrigation modelling for Drip, sprinkler and flood irrigation scenarios (useful for computation of water productivity)	link
21	Phase III Delivery presentation	link
22	Presentation to World Bank on MoU II	link
23	Presentation to World Bank on terms for MoU III	link
24	Ground Water Recharge Plan - GSDA review and requirement in PoCRA	link
25	Stream proximity running procedure	link
26	Observations and suggestions on Planning issues (Wardha Field visit)	link
27	Dashboard definition document	link
28	RAWE field work and training worksheet	link
29	Soil and Water Conservation RAWE training manual	link
30	PoCRA Water balance concept video	link

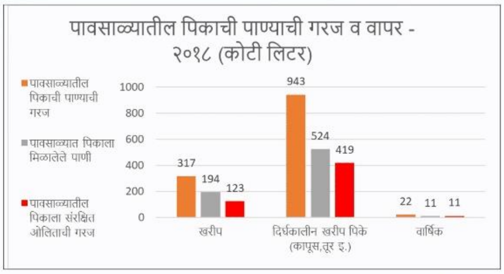
31	Farm Level App version I	link
32	Soil Survey App	link
33	Live Water Balance Charts	link
34	Farm Level App version II	link
35	Rabi Advisory framework ppt	link
36	M.Tech Thesis – Swapnil Patil	link
37	M.Tech Thesis – Manasi Bhopale	link

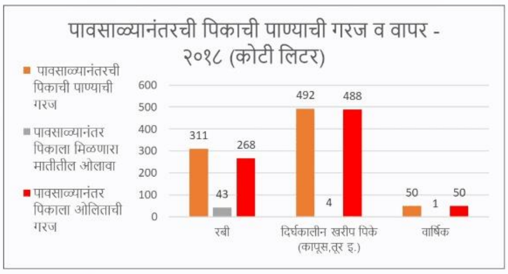
Annexure II: Village Water Balance Chart - Example



गावाच्या शेतीच्या पाण्याचे गणित







पाण्याचा ताळेबंद: सारांश (वर्ष - २०१८)

	पावसाच्या पाण्याचे गणित		
१	गावाचे एकूण क्षेत्र (हेक्टर)	२९२७	
२	पावसाचे पाणी (कोटी लिटर)	१२७३	
३	पावसाळ्यात पिकाने घेतलेले पाणी (कोटी लिटर)	७४०	
४	भूजल पुनर्भरण (कोटी लिटर)	१२	
५	मातीतील ओलावा (कोटी लिटर)	६७	
६	गाव शिवारातून निर्माण झालेला अपधाव (कोटी लिटर)	४५६	
७	गाव शिवारात अडविण्यासाठी उपलब्ध अपधाव (कोटी लिटर)	२२८	
८	गाव शिवारात आतापर्यंत अडवलेला अपधाव (कोटी लिटर)	८५	
९	अडविण्यासाठी शिल्लक अपधाव (कोटी लिटर)	१४३	
१०	प्रस्तावित कामांनंतर अडणारा एकूण अपधाव (कोटी लिटर)	१२४	
	पिकाची पाण्याची गरज आणि उपलब्धता	पावसाळ्यातील	पावसाळ्यानंतर
	पिकाची पाण्याची गरज (कोटी लिटर)	१२८३	८५३
१२	पिकाला मिळालेले पाणी (कोटी लिटर)	७२९	४७
११ १३	पिकाला ओलिताची गरज (कोटी लिटर)	५५३	८०६
१४	अडवलेला अपधाव (कोटी लिटर)	४३	४३
१५	उपलब्ध भूजल (कोटी लिटर)	४.०	८.०
१६	सध्यस्थितीत पाण्याचा ताळेबंद	-५०६	-७५५
१७	एकूण तुट (कोटी लिटर)	१२६२	
	प्रस्तावित कामांनंतर पाण्याचा ताळेबंद		
१८	सध्याच्या पिकपद्धतीनुसार प्रस्तावित कामे केल्यानंतरची तुट (कोटी लिटर)	१२२३	

१.शिल्लक अपधाव १४३ कोटी लिटर अडवण्यासाठी नवीन मृद व जल संधारण कामे घेण्यास वाव आहे.

२.शिल्लक अपधाव अडवल्यावर देखील पाण्याची तुट असल्याने पिक पद्धतीत बदल करणे आवश्यक आहे. २०१८ मध्ये पर्जन्यमान कमी झाल्याने खरीप पिकांच्या उत्पादकतेवर व रबी पिकांच्या पेरणीवर परिणाम झाला आहे.

३.सूक्ष्म सिंचनाचा वापर वाढवणे, कमी पाणी लागणारी आणि कमी कालावधीची पिके घेणे आवश्यक आहे.

भारतीय प्रौद्योगिकी संस्था (IIT), मुंबई यांचे तांत्रिक मार्गदर्शन व सहकार्याने