INCEPTION REPORT
FOR
INTEGRATING ELEMENTS OF CLIMATE RESILIENCE IN MICROWATERSHED PLANS UNDER POCRA

SUBMITTED TO

IITB

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Objectives

The objective of this document is to provide a detailed listing of various tasks which are to be attempted in Part A of MoU-III, and to describe in brief the methodology which is planned.

Village level water balance framework for PoCRA was developed and deployed through MoU I, which was initiated in August, 2017, to help answer core questions of availability and access to water for agriculture. It was based on local and regional analysis of bio-physical attributes, engineering interventions and agricultural practice presented in a supply-demand-allocation framework. This framework guided the village level project plans for PoCRA by providing specific targets for intervention. It was technically refined by incorporating real time inputs from skymet weather data in MoU II. The water balance model estimates were calibrated through field visits and the need for collaborations with NBSSLUP for refined soil data, as well as GSDA for closer estimation of groundwater recharge (deep percolation) was identified. Work was also undertaken to extend the applications of water balance model for monitoring and evaluation, and beneficiary selection purposes. Basic versions of various tools such as farm-level app, dashboard etc were built for this.

These threads are being carried forward in MoU III. The primary objectives in MoU III, Part A are

1. Calibration and mainstreaming of water balance model with the help of NBSSLUP and GSDA.
2. Extension of current framework to community and department and improved linkage of water balance framework to planning, monitoring and evaluation, contingency planning and beneficiary prioritization.
3. Mainstreaming of IT tools for integration of these methodologies and frameworks into project processes.

The activities planned to be undertaken, methodology to be followed and outcomes are detailed out here.

Components

A. Refinement and further development of the Water Balance Framework

Tasks

1. Development of GIS Framework for regional flows.

2. Development of Stream simulation framework and incorporation of near-stream budgets.
3. Coordination with external agencies on run-off measurements and improvements in water balance.

A3 component may require construction/modification of measurement sites. Installation of instruments on measurement site for measurement of various components. PMU will procure the required instruments and liaison with field functionaries for installation and regular monitoring of site and instruments.

B. IT Innovations and extensions

Tasks

1. Mainstreaming and maintenance of existing dashboard. (throughout one year - based on ongoing variations)
2. Design of new project-based indicators and its display on dashboard.
3. Web-access and publishing to district level functionaries (IT part) - Role-based login access to data such as level-wise status details for visualization using the dashboard.
   This will require APIs from PMU that provide authentication support and the relevant data meant for visualization.
4. Integrating architecture with other project activities. - Design and Integration with other project activities like FFS, MLP, Contingency plans.
5. Designing different functionalities on the dashboard based on the role of the user and the purpose of the functionality within PMU, in-house, technical agencies, etc.
   a. These will be based on different types of datasets such as weather data, soil-water balance model data, field data such as from FFS, beneficiary data, project activity status data, other linked data sets as per availability such as census data, command area etc.
   b. Advisory/triggers - provision to generate different advisories/triggers such as irrigation application, pest management will be made based upon contingency planning designed as per inputs from SAU's, CRIDA and data made available from PMU.
6. Tools for access to dashboard backend: There are special tasks like adding /modifying /deleting geo-referenced data sets that are done occasionally. Correspondingly tailored tools will be developed that enable accomplishing these tasks.
7. Improved Farm-level and village-level applet.
   a. Farm-level App - features for computation of water productivity, economic productivity, crop contingencies, etc. and collection of corresponding data.
   b. Village-level - Integration of Spatio-temporal data with village-level maps.

C. Contingency Planning Framework Design and Support

Tasks

1. Development of contingency planning as Scale-Analysis-Trigger-Action (listing of risks stagewise, the threshold to generate a trigger, contingency include market risks, climate risks and other social risks) and Scale-Analysis-Trigger-Action framework.
    a. Identify risks with different stages of crops.
    b. Identifying farm level crop-wise and region-wise contingencies
    c. Downscaling the contingency planning to cluster and village level
2. Integrated implementation plan for SREP, DIP and Contingency planning for climate resilience.
3. Interface with CRIDA and SAUs to provide contingency planning support.
    a. Enhancement of Dashboard
    b. Extension and evaluation of contingency activities as research component of SREP, based on inputs from CRIDA, DIP for incorporation to the dashboard.
    c. Data gathering - mechanism will be finalized by PMU for collection of data for contingencies finalized to be implemented
4. Rabi contingency (crop stress): Rabi contingency framework will be developed using GSDA well observation data and inputs from field.

D. Case studies

Task

1. Review of remote sensing-based water balance and crop identification, sown area, etc.
2. Survey of existing material on teaching of climate resilience in primary and secondary schools by educational activities like village map reading, school painting, collection of existing data
3. Studies on the utilization of water resources in extremely vulnerable clusters in the project area
4. Study on water balance in command areas

E. Main-streaming of inputs of technical agencies

Tasks

1. NBSSLUP - Engagement and integration of new data with existing data and computational frameworks.
2. Analysis of GSDA plans (Recharge plans) and integration with PoCRA water balance
    a. Integration of GSDA GW extraction data at cluster level with current model and method to compute physical AET.
    b. Usage of GSDA recharge priority maps and methodology in integration with current model for planning of GW open wells and farm-ponds in the village.

F. Support for Mainstreaming

Tasks

1. Research on Development of thumb rules for simplified understanding and discussion of water budget at village level to be usable for decision making -
2. Design of community comprehension of WB and collective decision-making framework for village.

3. Training of RAWE students, agricultural officer and PoCRA field staff
    a. Literature survey about current ongoing training to Agricultural officers
    b. Selection of training topics such as water budget, maintaining krushi diary, PoCRA app, etc
    c. Preparation of training material for selected training topics
    d. Training to agricultural officers
4. Other extension activities like study of Jal Saksharta booklets being used in schools and preparation of manuals, toy tools for inclusion in syllabus.
5. Preparation of research papers and reports.
6. Development of Research and Training potential of Key PMU Staff.

G. Improvements in the management, planning of the project.

Suggestions will be provided in this component.

Tasks

1. Study of Existing Literature on FFS, technology, methodology, FFS inputs
2. IT and Other Support
3. Analytical Support

Methodology and Approach

A. Water Balance Research Expansion

The core water balance used in MoU-I and MoU-II is at the farm level. During MoU I and MoU II, it was observed, at few locations, that model estimates of runoff probably exceeded actual run-off and underestimated groundwater recharge. Possible reasons are the simple aggregation of farm-level runoff which does not add up to regional run-off. Other possible reasons are coarse Soil texture - depth data, variation of rainfall in the village and at circle level. These factors are addressed separately.

To address the first factor, the farm-level runoff will now be integrated with streamflow simulation to obtain regional run-offs. Inflows from the villages located in the upstream side will be added to villages located downstream side using streamflow simulation. As a consequence, we also obtain near-stream groundwater recharge estimates. This will lead to better estimates of both runoff and groundwater components. As a result, it will help us in better understanding and quantification of the impact of drain line treatment, identify linkages between intensification of cropping and wells near streams. As with the farm-level water balance, we plan to adapt SWAT models to simulate stream flows. We must first create the GIS infrastructure that generates the required inputs or parameters for streamflow simulation. In the next step, the actual simulation and integration with the farm level model is achieved. In section A1, the creation of GIS infrastructure is planned. In section A2 preparation of the technical framework and the actual estimation will be done. In section A3 model validation will be done.

A1. GIS Framework for regional Flows

(Man Months - 4)

Creation and integration of GIS framework for generating differential watersheds, estimation of different geographical characteristics of streams like channel length, slope, width, identification of stream hierarchy, key inputs for estimation of surface water inflows at any point (such as key watershed structures, village outlet, village inlet) will be done. These inputs will help in running the physical simulations described in section A2. This will involve the development of separate API's for each component and integrating them using GIS.

The key steps in this process are:

- Preparation of module for generation of key locations from the intersection of the village boundary and streams, importing of data for watershed structures, e.g CNB, MNB, percolation tanks.
- Module for the generation of stream network hierarchy with flow direction using key locations.
- Differential area generation for individual stream segment of the stream hierarchy.

A2. Development of Stream simulation framework and incorporation of near-stream budgets

(Man Months - 4)

For the purpose of stream simulation, our Daily Water Balance model will be converted to Hourly Water Balance and results will be aggregated at the daily and seasonal level. This will help in better estimation of farm-level runoff, infiltration, groundwater. The hourly model will be validated in the field. Based upon the result if found suitable the model will be extended to the project area and replace the DWB.

A lumped model for regional (i.e. inter- as well as intra-watershed) surface flows, was tested in MoU-II and the initial report was shared with PMU on water accounting framework. A water routing methodology from SWAT theory documentation has been used for this purpose. This framework helps in linking the farm-level runoff as predicted currently, with the flows in the stream network.

It is proposed to extend this framework for general stream flow simulation and obtain regional water budgets. The output of A.1 will be combined with the above model to obtain the regional water budgets.

The combined result of hourly and streamflow simulation will be validated in the field. After validation, this framework will be extended to all the PoCRA villages in MOU III.

A3. Coordination with external agencies on run-off measurements and improvements in water balance

(Man Months - 8)

Results generated using GIS-based surface and groundwater accounting framework needs to be validated using actual field measurements. To do this over a period of the next two months, 5 each suitable first-order streams, third-order streams, on-farm sites, wells will be selected in different parts of the project area. On the selected sites, streamflow, farm runoff, stage level, area of cross-section, water level, etc will be estimated at regular intervals and if possible continuous monitoring of these using appropriate sensors will be done. Staff gauging (discrete data), pressure transducers (continuous data) will be used for monitoring the runoff in the streams. A report will be prepared which lists the methodology for site selection, instruments to be used and its specifications, maintenance and its use. The procurement of various instruments, erection and installation of different instruments like staff flumes/Weirs on first order streams will be done by PMU. Work of modification in case of existing CNB's or construction of weir or Notch on third-order streams for stage recording will be done by the concerned departments in liaison with PMU.

B. IT innovations and extensions

There have been two threads of work in the IT component of previous MoUs. One relates to developing tools that enable simulating the PoCRA model for water-budgeting. The other relates to developing a GIS-based dashboard web-application that enables monitoring various aspects of the project with a focus on geo-referenced visualization of the project and field status. The tools that were developed for simulation as part of the former thread, could be used mainly by suitably skilled personnel. The dashboard developed as part of the latter was effectively a prototype for a more comprehensive successive version to be taken up by PMU.

In this MoU, the broad vision in the IT component is to develop an extension framework around the dashboard and other tools that can incorporate further features which enable decision and action support. In its specifics, this framework will be demonstrated, as it is developed, by using it to provide new features on the dashboard (and other tools) that are meant to expand the user-base and the value and scope of abilities/facilities. The framework is aimed at inculcating an IT development approach that weaves the two aforementioned threads of work in a synergistic manner towards developing a decision- and action-support system that is based on GIS and modeling.

The tasks in the IT component as agreed in the MoU have been enumerated such that it enables clear assessment by PMU. However, from an implementation perspective which is in line with the above vision, the tasks in the IT component of this MoU can be grouped (not necessarily exclusively) into three sets.

- Framework design, implementation and evolution: Part of Task B1 and of Task B5
- Embedding the dashboard within this framework and demonstrating its further development therein: Part of Task B1 and Tasks B2, B3 and B4

- Embedding the modeling and other tools within this framework and demonstrating their further development therein: Part of Task B5 and Task B6

Each of these tasks is detailed below while noting how it caters directly to PoCRA's use-cases and when applicable, how it contributes to the design and evolution of the framework envisaged above.

B1. Stabilization and mainstreaming of the current dashboard

(Man Months - 2)

The dashboard web-application, as submitted at the end of previous MoU, is a prototype that has been developed through what is referred to as a rapid application development (RAD) process. To tap into its extensive potential through its further development for valuable decision support, the following two objectives will be addressed.

Objectives:

- To improve the structure of the dashboard software-code and stabilize it, so as to allow its easy extension, both from a semantic viewpoint for its users and from a software development viewpoint for the developers.
- To mainstream the process of extension through the incorporation of new features to as much an extent as possible so that little or no *ad hoc* methods of software development be required when a new dashboard use-case turns up.

Approach:

- Design and set-up a coherent codebase that incorporates all the deliverable items, which primarily includes the dashboard web-application and the model simulation tools.
- Design and arrange a dev-ops environment for the deliverable items; primarily the dashboard web-application. This serves the purpose of enabling continued future development of the deliverable.
- Given that a variety of software components are involved, assess the scope for an automated testing environment. Design and arrange one to the extent that it seems meaningful.
- Prepare detailed documentation that would be useful as definitive reference for the delivered software and that also provides guidelines to incorporate new features into the dashboard and other delivered items.

To set-up a dev-ops and any automated testing environment, a separate dedicated virtual machine(VM) will have to be allocated on the cloud for this purpose, in addition to the existing VM that can then be dedicated for live web-service. Similarly, to store the gradually accumulating daily water-budget estimates, the existing VM's storage will have to be expanded. Further, if the live web-server faces high web-request loads, its computing resources may have to be increased.

Given that a dashboard already exists as a product form the previous MoU, and that it is planned for expansion throughout this MoU, the stabilization and mainstreaming of the dashboard will be an ongoing process throughout the period of this MoU.

B2. Project based Indicators and expansion to dashboard attributes

(Man Months - 3)

There are a variety of indicators which are usable for different purposes in project like gauging the agricultural status of village, real-time assessment of project performance to enable PMU take appropriate actions, comparison of project villages and evaluation of project impact. For example the Indicators such as current storage capacity in village not only serves as a baseline for evaluation of project impact but also helps identify vulnerable villages which do not have the capacity to provide one protective irrigation for kharif rainfed area. The planned storage in village will also serve as an indicator to PMU for corrective actions in DPR finalization/approval.

These indicators will be designed or identified from existing datasets, as a part of this component. They may be computed from water balance studies, centralised PMU database such as MLP app data, DBT benefits data etc.

Objectives:

1. Enable visualisation and assessment of project villages from agricultural, water balance and project perspective.
2. Enable feedback loop for corrective actions for PMU by display of these indicators.

Approach:

1. Design bio-physical, agricultural and project based indicators depicting basic water balance, agricultural and project profile of village.
2. Develop IT infrastructure to compute indices
3. Enable visualization of these indicators through dashboard

These indicators will be implemented into the dashboard based on approval and feedback from PMU.

B3&B5. Web-access and publishing to district level functionaries. Design of user-based facilities

(Man Months - 3)

The two primary uses of a web-dashboard would be:

- (near-/pseudo-)real-time monitoring and tracking of events or processes/activities
- quick, reliable and uniform dissemination of information

These tasks (B3 and part of B5) cater to the information dissemination part.

Objectives:

- Publish geo-referenced technical information useful for field-level assessment and actions
- Enable/disable access to and visualization of information that pertains to each administrative level of functionaries, especially with respect to the trigger-action framework of contingency plans.

Approach:

1. Conduct a requirement analysis in association with relevant PMU staff, regarding the scope and type of information that is to be published
2. Develop prototypes that accommodate such information on the dashboard, while incorporating and aligning it with the provisions required by the trigger-action framework.
3. Incorporating the Single-Sign-On facility to enable user-based access to various parts of the information
4. Detailed design, implementation, testing and release

As per suggestions from the concerned PMU subject expert, it is intended to include the various packages of evolving information in a gradual manner, one-by-one. Specifically, for each set from a list of various sets of information, the steps in the above approach would be used to actually incorporate it on the dashboard, one at a time. This also naturally fits into the intended dev-ops environment described above.

B4&B5. Design and Integration with other project activities like FFS, MLP, Contingency plans

(Man Months - 3)

These tasks (B4 and part of B5) cater to the former of the two uses of a dashboard mentioned under sub-section (Task) B3. Essentially, the motivation is to enable geo-referenced monitoring of the progress of the activities in various components of PoCRA like Farm-Field Schools(FFS), Micro-Level Planning(MLP), etc.

Objectives:

1. Make provisions to include geo-referenced data-sets from other PoCRA components onto the Dashboard, including the project-based indicators from Task B2 and action/recommendation information from any contingency plans (Task C) that get triggered.
2. Provide web-APIs to enable developers working on software for other PoCRA components to use the Dashboard for map-based visualization of geo-referenced data-sets that they generate.

Approach:

1. Collect the meta-data about the various types of geographic data-sets in other domains like FFS, MLP, contingency plans, etc.
2. Initiate an evolving design of a generalized framework in which suitably tailored PoCRA-specific geo-referenced data-sets can be embedded on a plug-in-plug-out basis. (Note: This is a plug-in-

plug-out framework for information dissemination on the dashboard; not to be confused with the aforementioned framework that embeds all the deliverable software programs and weaves their development process together.)

3. Prototype and implement the above design. This will also provide the necessary APIs mentioned in the objectives above.
4. Gradually include the data-sets from 1 in the consequently evolving framework design

Prototyping of the initial framework design in steps 2 and 3 can start with and will be informed by step 1 and will take about a man-month. Step 4 will help shape the framework and web-APIs.

B6. Tools for access to Dashboard backend

(Man Months - 3)

The dashboard is, for the most part, meant to be used for monitoring and information dissemination. The complementary tasks of procuring or generating suitable information and populating the dashboard backend with it for publication, are to be handled only by authenticated PMU expert or in rare cases authenticated lower level functionaries. More importantly, these tasks will require validation and pre-processing of the information before being uploaded to the backend. This motivates the need for a separate more powerful tool (or a set of them) than what a web-application would usually be.

Objectives:

- As a first-cut, provide a suitable UI to the scripts/programs that are already being used to access the dashboard's backend database. One obvious example is the water-budget estimation process that is scheduled to run daily.
- Develop desktop tools that enable authenticated users to modify the data used at the dashboard's backend.
- The tools should provide suitable processing facilities to prepare new data for upload and to change existing data while maintaining the consistency of dashboard's backend database.
- Make the above process reproducible in the sense that future development allows new tools or features to be easily incorporated using the same methods as used here.

Approach:

1. Design and implement UIs for the existing scripts/programs that access the dashboard's database.
2. Conduct a requirement gathering and analysis exercise for the use-cases that PMU (or other authenticated staff) will face with regard to adding newly available geographic data and modifying existing one on the dashboard.
3. Use agile software development to build the complementary tools required for the use-cases like the ones collected in step 2 above while also integrating this development process with the dashboard development process.
4. Evolve and establish a generalized process for the development of such tools which will fit into the overall software development framework.

Steps 1 and 2 can start in parallel and are independent. Step 3 above plays the important complementary (to dashboard development) role in developing the overall software framework envisaged above for the IT component of this MoU.

B7. Improved Farm-level and village-level app.

1. **Improved Farm-level applet** (Man Months - 4)

This app will act as an important decision-making tool for farmers. It will have a simple farm water balance module on its backend. It will be integrated with the skymet data, FFS data, weather forecast services and primary information from the farmer through API's. API's of the different datasets will be provided by the PMU.

Based on PMU requirements, the App will provide a platform for communicating important information like sowing date, irrigation, pest attack, etc from FFS data or through advisories. Through primary data from farmer, it may be used to predict real-time crop water requirement and likely yield. The app can also help in computing economic productivity based upon the market information received from PMU and through farmers.

The farmer will be able to mark important assets on his farm and submit the information to PMU. He will be able to calculate the distance between the important sites like a source of water and his farm. Further app can give support to him in terms of expected expenditure in fetching the water from a distance and optimize his resources. After discussion with the PMU and making any changes based on suggestions this app will be given to farmers. This app will be used to extend farm or village level advisory based on the output from the water balance model and other datasets like FFS, skymet, groundwater etc.

2. **Village-level applet** (Man Months - 4)

The objective is to improve the efficiency and accuracy of field operations by providing improved access to GIS datasets. It will help in both PMU and field functionaries (cluster assistant and agri assistant, circle officer) in the dissemination and gathering of data and to guide beneficiary and intervention selection. Village wise cadastral layer will be provided on the Google map API to help in the location of different structures on the app like CNB's, wells, percolation tanks etc. Field functionaries will be given access to different datasets and maps available at the PMU level.

C. Contingency Planning Framework Design and Support

As per PoCRA - Combined Project Information Document (PID), contingency plans at district level need to be made accessible to various functionaries at different levels. Whence there needs to be a framework for documenting and operationalizing various contingencies. We will use a risk-trigger-action framework to map contingency. Various risks faced in agriculture as a result of unpredictable weather and market scenarios will be mapped. These risks are triggered by different variables and actions are recommended to combat risks as response to each trigger.

This component involves study of contingency plans for developing formats to prepare lookups for risks, triggers and field actions and populating the formats for various weather based and market based contingencies as a part of C1. Integration methodology based on Strategic Research and Extension Plans (SREP) , Comprehensive District Agriculture Plan (C-DAP) is to be proposed to enable implementation as a part of C2. The prototype contingency framework for few selected crops and risks in C1 may then be taken ahead with CRIDA by PMU to enable further extension with consultation support from IIT Bombay as a part of component C3.

C1. Development of SATA (Scale-Analysis-Trigger-Action) framework

(Man Months - 4)

Objective

A Scale - Analysis - Trigger - Action (SATA) framework based on existing district level contingency plans will be designed to automate contingency triggers. This involves studying different contingencies and developing query-based documentation formats for them.

Contingencies occur at different scale such as crop, farm or village, and the SATA framework needs to adapt to these scales. Sample datasets for monitoring occurrence of identified contingencies will be prepared. It is proposed that, after the occurrence of each contingency, the trigger will be generated automatically and field actions from predefined datasets will be fetched and displayed.

Example: For meteorological/weather based contingency like a delayed monsoon, daily rainfall data will be monitored continuously. Wherever a delay in the monsoon has occurred, such circle/villages will be identified. Necessary action for delayed monsoon contingency is to sow short duration varieties. This respective action will be fetched from the predefined action data set and despatched to field officials.

Objectives:-

- To design a documenting framework for contingency plans to enable operationalization using dashboard and IT tools
- Listing crop stage-wise risks, their quantification, generation of triggers, quantifying market risks.

Approach:-

1. Few contingencies for 2-3 crops will be identified by studying the district contingency plans.
2. Data Formats for documentation of identified contingencies (risks - trigger - action) will be prepared.

3. Sample input datasets such as (rainfall and other available weather parameters, short - long variety seed database etc.) for monitoring of identified contingencies will be prepared.

    i. Datasets for queryable contingencies.

    ii. Datasets for non-queryable contingencies, such as availability of farm machinery in the situation of water logging will also be prepared.

4. Methodology for trigger generation and acknowledgement for identified contingency.

    i. Trigger values will be set for monitoring of queryable contingencies.

    ii. Monitoring for non-queryable contingencies. These will be questions based on field inputs.

5. Formats for actions after the occurrence of identified contingencies will be prepared.

This prototype SATA framework for 2-3 crops and chosen contingencies will be presented to PMU for taking it ahead with CRIDA for further extension and scaleup under their guidance and availability of technical input database.

C2. Integrated implementation plan for SREP, C-DAP and Contingency planning for climate resilience.

(Man Months - 2)

Objectives:-

- To understand the interlinking of SREP and C-DAP with contingency plans
- To prepare conceptual and integrated planning framework for the interlinking of SREP and C-DAP with contingency planning

Approach:-

1. Literature review of C-DAP and SREP of few PoCRA districts for the understanding relationship between C-DAP and SREP with contingency plan as well as an operational hierarchy for C-DAP and SREP.
2. Understanding different roles of agencies in contingency planning such as contingency identification, monitoring and trigger generation, field actions.
3. Inputs for the design of a common contingency planning platform and inputs to different agencies involved in contingency planning for interlinking SREP and C-DAP .

This needs support from PMU to interface with selected agencies for gathering required inputs.

C3. Interface with CRIDA, Manage and SAUs to provide contingency planning support.

(Man Months - 3)

The prototype framework will be extended to more crops or contingencies/risks based on technical inputs from CRIDA and SAU's. Support from PMU will be required to facilitate the provision of Inputs from agencies like CRIDA, SAU's for this purpose and deliverable will be solely based on provision of these inputs.
The inputs will consist of additional contingencies (risk - quantified trigger - action) and their background database for running trigger, action code for automation.

Objective-

1. Consultation support to PMU/CRIDA on extension formats for contingency plans.

Approach:-

1. Visit to CRIDA for the discussion of operational contingency planning.
2. Understanding different roles of agencies in contingency planning such as contingency identification, monitoring and trigger generation, field actions.
3. Inputs for the design of a common prototype contingency planning platform for different agencies involved in contingency planning.

C4. Rabi contingency planning

(Man Months -2)

This component will enable scenario analysis for various rabi cropping patterns in villages. Two important criteria will be considered - water availability and economic returns. Water availability will be estimated at post monsoon for surface storage and ground-water. For rabi crops ground water availability and extraction are important constraints. Inputs from GSDA regarding extraction and ground water availability in rabi will be incorporated.

Objectives:-

- Design rabi planning support framework based on water balance and economic returns.

Approach:-

1. Prepare methodology for conducting scenario analysis for varying P2 (eg - wheat, onion), P3 (eg - jowar fodder) rabi crops for sample villages based on their kharif cropping pattern.
2. Yield analysis will be provided based on availability of average yield data for required crops from PMU.
3. Economic analysis for varying rabi cropping patterns will also be provided based on availability of market rate data or its source from PMU.
4. Prepare prototype database to demonstrate automation of same, which can be taken up by PMU's IT agency.

D. Pilot Case studies

D1. Review of remote sensing-based water balance and crop identification, area sown, etc.

(Man Months -4)

Review of remote sensing data sources for surface water budget components, and run through estimating a water budget of a watershed using remote sensing components will be done. Different open-source datasets from Instruments/Missions: such as TRMM, Terra, SRTM, SMAP, GPM, Landsat, MODIS and Aqua, etc will be explored for remote sensing-based water balance for two talukas in the project area and its comparison with the existing model-in-use will be given. Based upon the results suitable datasets will be proposed for the future water balance.

A company, *Satsure* is using optical datasets for providing sowing intelligence, crop acreage, health, water productivity, crop yield, etc. Another company, *Earth analytica* is using SAR datasets to provide crop stress maps, crop maps, crop type maps, land cover maps. After due validation in the field, their utilization in the current water balance process will be explored.

D2. Survey of existing material on teaching of climate resilience in primary and secondary schools by educational activities like village map reading, school painting, collection of existing data

(Man Month-1)

Literature review and field visit to understand present initiatives for incorporating climate resilience in school syllabus are to be done. Different activities in line with component F2 and F4 will be enlisted. This literature of activities will be helpful for community comprehension.

D3. Studies on the utilization of water resources in extremely vulnerable clusters in the project area

(Man Months -4)

In MoU I, water allocation methodology has been designed. This has to be further extended to understand the impact of water allocation by farmers on water resources and ultimately cluster vulnerability. This study will help to deepen the understanding of water allocation practices and improve crop area planning as per water availability.

Objective:-

- To understand the relationship between cropping pattern and water resource utilization in most vulnerable clusters.

Approach:-

1. Some (3-4) vulnerable clusters will be selected from PoCRA clusters.

2. Analysis of the cropping pattern of all villages in clusters to estimate area under cultivation of P1,P2 and P3 crops will be performed.
3. Analysis of existing structures for understanding temporal and spatial water availability.
4. Field visit to understand water allocation by farmers for P1,P2 and P3 crops and the resulting water utilization and economic benefits.

D4. Study on water balance in command areas

(Man Months -3)

During the fieldwork of phase-II, we observed that several clusters come in the canal command area (e.g., in Wardha and Nanded District). In a few clusters, there is also water imports from nearby water bodies (e.g., in Kumbhefal cluster, Aurangabad). Due to canal/imported water Kharif-Rabi water availability and stress computation of these regions will not be the same as in rainfed regions. This component involves the study of water balance in command area and development of formats/framework to prepare water balance of those clusters which have canal command area. Two clusters will be selected based on the percentage of command area in the clusters. Analysis of canal water use in these clusters will help build a framework for command area water balance.

Objectives

1. To propose changes in existing water balance computation to incorporated canal/imported water in the clusters/villages having canal command area
2. To develop vulnerability map according to new water balance and farm level water availability

Approach

1. Selection of two clusters from those clusters having canal command area
2. Collection of secondary data like canal command area maps, canal rotations data at least the last five years, water audit report of command area project
3. Collection of primary data through fieldwork to understand and record existing practices like irrigation, WUA management, cropping and water use, etc.
4. Making changes in water balance plugin using above data and maps

E. Main-streaming of inputs of technical agencies

E1. NBSSLUP Soil - engagement - integration with our data

(Man Months -3)

It is expected that NBSSLUP will provide new soil data for selected PoCRA villages. This data needs to be analyzed before its incorporation and main-streaming. This will include the analysis of new shapefiles obtained from the NBSS&LUP. The NBSSLUP data will be validated by soil sampling and testing in 2-3 selected villages. Once validated, the water balance model will be run using the new shapefiles. The result will be analyzed and the report will be shared. After this, all the new shapefiles will be integrated into the existing GIS framework.

E2. Analysis of GSDA recharge plans and stream proximity, its incorporation in PoCRA

(Man Months - 4)

This will aim at incorporating GSDA recharge plans into planning and implementation activities. Groundwater extraction data to be provided by GSDA at village and block level will be incorporated to generate physical AET(ET_{cadj}) computation. Based on the data shared by the GSDA and model output, an attempt will be made to predict the number of feasible wells and farm ponds in the village.

F. Support for Main-streaming

F1. Research on the development of thumb rules for water budget

(Man Months - 4)

Simplified thumb rules are to be developed to enable discussion of water budget at village level. These will be used for decision making e.g., on cropping pattern at the beginning of rabi season. The rules are to be developed in line with the Hiware Bazaar model and others which has formulated village level action points depending on the amount of total rainfall till october in given year.

Objectives:

1. To simplify state planning processes for water balance by taking up topological studies.
2. Preparation of simple thumb rules to enable better community comprehension and decision making at village level based on water balance.

Approach:

1. Statistical studies will be conducted on water balance results from varying rainfall amounts, soil, land topology etc. to define thumb rules for decision making insights on cropping pattern and storage. This study will be conducted using PoCRA water balance model to arrive at a middle level decision support tool between PoCAR model and JYS strange table method.
2. Analytical research and study will be undertaken depending on village cropping pattern, storage capacity, amount of protective irrigation required for kharif, drinking water requirements and rabi sown area to formulate metrics for decision making.
3. The metrics will be designed for various scenarios or goals - such as to ensure 12 months drinking water in case of low rainfall, ensure one protective irrigation for rainfed kharif area, ensure fodder availability. These metrics will guide on cropping pattern and will be useful to trigger villagers to modify their cropping pattern from long term as well as short term scenario depending on their goals and available water.

F2. Design of community comprehension of water budget and collective decision-making framework for village

(Man Months - 3)

Objectives:-

- To make aggregated village water budget positive.
- To build community understanding about water budget
- To enable self regulation of ground water extraction by changing cropping pattern

Approach:-

1. Literature review and field visit to understand existing success stories about community decision making and self-regulation such as APFAMGS(Farmer managed groundwater system),ACWADAM (participatory groundwater management), Hiware Bazar(community crop planning)
2. Field visit to 2-3 PoCRA villages for understanding existing scenarios regarding
    a. Participation of community in micro planning exercises
    b. Interpretation of water budget
    c. Community perception about water budget and crop planning
    d. Documentation of various cropping pattern scenarios
3. Design of community decision making framework
    a. Maintaining Gram Panchayat level data sets such as rainfall data, crop data, soil maps, locations of structures etc.
    b. Interactive tools for scenario building
        I. Preparation of Water Budget by the farmers.(Comprehension Part)
        II. Interpreting Water budget and understanding spatial and temporal water availability.(Interpretation Part)
        III. Crop planning (Planning Part)
    c. Use of training material and school competitions such as map-reading etc. for scenario playout.

F3. Training of RAWE students, agricultural officer and PoCRA field staff

(Man Months - 3)

Objective:-

- Capacity building of field staff through identified training activities.

Approach:-

1. Trajectory of Agricultural officers career will be studied, required skill set will be understood. Roles and responsibilities of PoCRA field staff will be studied.
2. Topic for training will be selected from the above step.
3. training sessions of skill sets identified will be proposed and conducted.

F4. Other extension activities like study of Jal Saksharta booklets being used in schools and preparation of manuals, toy tools for inclusion in the syllabus.

(Man Months - 4)

Based on literature conducted in D2 component, different activities will be designed and trial runs will be conducted to understand inclusion of climate resilience in primary and secondary schools. 2 or 3 villages will be selected and visited for this activity. This component is interlinked with F2.

Objective:-

- To prepare sample note for incorporating climate resilience in school syllabus

Approach:-

1. Existing activities identified in component D2 will be conducted and promoted in schools if required.
2. Map reading activity will be conducted in secondary schools so students can understand how to read a map and local village resources.
3. Sample exercise of painting of water budget on school walls will be conducted in one village.

F4. Preparation of research papers and reports

(Man Months - 3)

- Scientific description of Water balance model at its use-cases in 2-3 sites and its results
- Water Balance framework

F5. Development of Research and Training potential of Key PMU Staff

Support will be provided to identified PMU staff (Mr. Vijay Kolekar) to enroll for sponsored PhD at IIT Bombay to enable development of research and training potential at PMU. The PhD will be sponsored through this MoU.

G. Project support

G1. Study of Existing Literature on FFS, technology, methodology, FFS inputs

(Man Months - 4)

Farm field schools are an important channel for technology extension. In MoU II few FFS plots have been visited to understand the importance of FFS. Currently FFS is mainly used only for technology demonstration purposes while the same tool can be helpful to understand many farming practices by farmers such as seed variety, irrigation applications etc. There is need to build data formats and questionnaire in line with ongoing FFS activity.

Objective:-

- To understand FFS hierarchy as a tool for technology extension as well as a tool for acquiring common farming practices by farmers.

Approach:-

1. Field Visit for understanding the operational hierarchy of FFS.
2. Sample data formats or questionnaire to understand farming practices will be prepared.
3. Periodic analysis of data collected using FFS.

G2. IT and Other Support

(Man Months - 6)

This "task" is primarily meant to fill any gaps between what the PMU intends to achieve using the IT and related deliverables from this MoU. In essence, this is the support component for the deliverables seen as a product, extended with an understanding to enable PoCRA to achieve its expected goals from the deliverables.

Such support, which can be classified in the following ways will be provided as per mutual understanding between PMU and IIT vis-a-vis the strain on other tasks in this MoU.

- Supplementation of skills and/or time at PMU's disposal: This arises when key deliveries are held up for shortage of skilled staff. For example, in a previous MoU, a tool was delivered that could estimate zone-wise water budgets for an entire list of villages/clusters. If not for this tool, some PMU staff would have to run the zone-budget estimation program individually for each village/cluster in the list.
- Reasonable, but unforeseen, changes: At times, there is a change in the expected deliverable or the interface for access to the deliverable. This may require a re-work or extension to the deliverable.
- Minor extensions to MoU terms with mutual understanding: A deliverable may produce sub-deliverables that may be of interest to PMU/PoCRA, but were not explicitly agreed in the MoU as part of the formal deliverable. Such products/produce may be shared by IIT with PMU/PoCRA with suitable interface/documentation to use it.

It should be reiterated that this task offers support on the basis of mutual understanding as part of good-will and professional ethos. It expects that the other party appreciates the strain it may put on or modifications it may cause to the schedule and man-months already agreed formally in the MoU.

G3. Analytical Support

(Man-Months- 4)

Various data-sets coming from project implementation, planning and bio-physical processes will be analysed for improvements in project implementation.

Energy for Irrigation

This component addresses issues related to energy usage in irrigation. This connects directly with project requirements (of enhancing energy and water productivity , and also as a determinant of increased access to water.

An important objective of PoCRA is to increase on-farm availability of surface water and groundwater for protective irrigation to deal with the effects of erratic rainfall and uncertainty in availability of rabi water. There is already an unmet dependence on energy for irrigation which will continue to increase with the dependence on protective irrigation leading to further shortfalls in the energy infrastructure capacity thus exacerbating uncertainty. Important steps towards resilience are: understanding the cost of power contingencies to farmers, reducing these contingencies and hindrances related to energized irrigation, understanding the cost of water and energy in crops, and the role of water in crop choices.

The main sections/objectives of the project are:

- Calculations of water productivity and cost of water/energy in crop production based on protective irrigation measurements and water balance calculations.
- A framework to identify and evaluate risks in access and quality of power to farmers as a constraint to farming.
- Design of an extension program to improve pump selection and water infrastructure, thus improving system performance and making energy use more efficient.
- Report on village level irrigation energy infrastructure and its determinants and impacts on access.
- Delivery of framework, tools, reports and dashboard facility.

The outcomes address different levels of intervention:

Water and energy productivity of crops
Identification of current and potential risks relating to energy infrastructure
Tools to track the risks
Pilots and templates of interventions to be conducted with beneficiary engagement for demand-side management
Inform PoCRA / higher level policy for supply-side improvements

H. Calculation of water productivity

Water productivity for key crops will be calculated using protective irrigation data collected and water balance method developed in previous phases. The data collected will indicate water usage patterns of farmers, quantification of constraints in irrigation, rationing of water among crops, and crop productivity as a function of irrigation.

Tasks

1. Village selection (6 villages in 6 clusters) for water productivity measurement and installation of 48 water/energy data loggers:
   1.1 Select 6 clusters based on phase I cropping and disbursement data and high level village cropping / water usage, electricity quality and issues (from cluster assistants)
   1.2 Get permission from MSEDCL for (*i*) Relevant feeder level data (*ii*) To set up energy meters on select Distribution Transformers for feeder level correlations
   1.3 Finalize 6 villages and 48 farmers for energy/water data logger installation in selected 6 clusters (Preferably group 2-3 farmers on a DT ; These villages will be referred to as '*WP villages*' in the rest of the document); Install energy/water meters on pumps.
   1.4 Select 1 feeder each for 2 *WP villages* (2 feeders) to develop feeder level energy consumption and crop-wise energy and water productivity correlations
   [These 2 feeders will be referred to as '*WP feeders'* in the rest of the document

2. Crop water and energy usage data and productivity analysis for Kharif and rabi crops
   3.1 Productivity calculated using metered energy/water data of farmers, crop productivity and irrigation survey data
   3.2 Compare yields with other farmers in the villages with no protective irrigation
   3.3 Collect cropping and yield data from talathi / krishi office or use PoCRA data for comparisons

3. Water and energy usage estimate in offseason and summer based on feeder level energy consumption and partial metered farmers' data

4. Develop framework for feeder level energy consumption and crop-wise energy and water productivity correlations, based on analysis of the 2 *WP feeders*
   5.1 Cropping data from the talathi office (or get PoCRA data)
   5.2 Feeder level data energy consumption / interruption / DT failure data / changes in feeder configuration
   5.3 High level data from villages on sprinklers/drip, status of water sources (depth, availability), and any anomalies such as DT failures, unseasonal rain, etc.

<u>Method for selection of villages:</u>

Villages to be selected based on rainfall regions of the state, cropping data, and irrigation equipment disbursement in PoCRA. Villages will be selected as follows:

Assured rainfall region – 3 villages, Moderate rainfall – 2 villages, and Scarcity regions – 1 villages. Cropping data will be a guide to select villages with representative cropping patterns of that district, and will attempt to cover all the major crops in PoCRA districts. (See Appendix for a summary of this data.) Since plantation/horticultural crops are a very small percentage we will try to bring them in where possible among the 48 planned farmers but keeping the focus on major crops.

Farmers will be selected to cover:

- Crops: Soybean, cotton, tur, maize, gram, moong, perennial (?)
- Irrigation methods: Drip, sprinkler, furrow
- Water sources: Dugwells, Borewells, dams, nallas, farm ponds
- Other characteristics such as water transfers, location on LT network, DT location on feeder to factor in the effect of the power supply on irrigation, for only a few farmers

I. Identify and evaluate risks in access and quality of power to farmers

A framework will be developed for a Low Tension network (one Distribution Transformer) based on data such as number of farmers, pendency of agricultural connection applications, gat locations, water availability and variation over the year and cropping pattern. This will connect to the PoCRA dashboard facility to flag potential and current problem zones within the area (~25 farmers). The solution will be implemented for one village with a plan for its replication to other villages will be prepared. This facility will flag vulnerability due to energy infrastructure issues.

Tasks

1. Design of suitable methodology for the project. Set up liaisons, permissions, data from MSEDCL
   1.1 Finalize one of the WP villages for power quality and risk evaluation. [This village will be referred to as the 'PQ village' in the rest of the document]
   1.2 Procure network diagrams from MSEDCL, install meters on select DTs

2. Energy infrastructure analysis for 25% Distribution Transformers (DT) in *PQ village*, geo-tagging of water sources
   2.1 Geo-tagging of grid-connected water sources on 1-2 DTs, power flow analysis of the selected DTs and validation with field data
   2.2 Develop load management framework at DT level, with feedback from connected farmers
   2.3 Develop framework to identify constraints

3. Energy infrastructure analysis for rest of the 75% DTs (3-4) in *PQ village*, geo-tagging of water sources
   (*Sub-points same as 2*)

4. Finalize the energy infrastructure framework to identify constraints and suggestions for resolution by PoCRA and higher policy changes
   4.1 Include data on pending connections, and other analysis of village infrastructure developed in [K].

5. Integration of indicator for flagging issues on DTs on the dashboard
   5.1 Based on analysis of 4, develop a flagging algorithm that takes input from the DT data loggers of the PQ village

J. Design of extension program for users to improve energy infrastructure performance

Appropriate pump and pipe selection guidelines will be developed to ensure efficient operation at field conditions. Thus leading to a reduction in load thereby lowering constraints to getting new electrical connections. An awareness program for use of capacitors and load management will provide immediate relief to villages suffering from DT overload and voltage issues. In addition, since there is a thrust on solar PV pumps by the government, 6 solar PV pumps will be surveyed to check efficacy for feedback on pump selection to MSEDCL/government. An extension program will be developed and tested.

Tasks

1. Survey of pump selection practices through PoCRA and otherwise
   1.1 Survey of pump selection and maintenance practices from farmers, pump vendors, pump mechanics in select *WP* and *PQ villages;*
   1.2 Identify pumps available in the market with robustness in voltage variations with regard to performance and efficiency
   1.3 Report on practices for water infrastructure including pumps and pipeline selection, pump efficiencies in field, and propose guidelines for pump / pipes selection

2. Measuring operational efficiency of pumps in the farms
   2.1 Calculate efficiency of electrical pumps from data collected on 10 pumps installed with water & energy data loggers
   2.2 Conduct efficiency measurements on additional 20 pumps (from *WP farmers' pumps*)
   2.3 Survey usage of 6 solar PV pumps in the field to find efficacy and suitability in usage various irrigation methods such as with drip/sprinkler/furrow

3. Design of extension programs

3.1 Develop guidelines for pump and pipe selection based on pump characteristics, irrigation practices (drip/sprinkler), and characteristics of water sources

3.2 Design extension program on training and awareness for farmers, (non-MSEDCL) wiremen, pump mechanics, for community-wide improvement in energy services including education on load management strategy, capacitor usage, selection of appropriate pumps and pipes.

3.3 Testing and fine tuning of extension program on training and awareness with groups of farmers/pump mechanics/wiremen in a PoCRA village not visited previously with regard to energy investigations in this project.

K. Measure village level irrigation energy infrastructure, its determinants and impacts on access

Agricultural energy usage is very inefficient in many ways leading to system overloading which in turn creates problems for farmers in their irrigation and possibly crop productivity. Reasons for usage of diesel pumps, lack of capacitor usage, usage of pumps with an unsuitable head range, usage of de-rated and non-standard pumps), usage of inappropriately sized pipes, grid connection pendency, and hindrances in applying for grid connections will be investigated with suggestions for PoCRA and higher policy decisions.

Tasks

1. Energy infrastructure – impact on water usage due to power anomalies

   1.1 Energy quality observed from energy meters on 48 farmers pumps, as well as from data collected in PQ village, and other DT failure data collected in WP villages.

2. Energy infrastructure

   2.1 Collation of relevant data on irrigation infrastructure collected in H.6.1

   2.2 Analysis of reasons for water transfers over sources (borewell to dugwell), across long distances and reasons. Estimate of additional energy consumed.

   2.3 Analysis of additional load due to pump oversizing and longer hours of pumping

3. Analysis of reasons for diesel usage, pending grid connections, and latent demand for grid connections

   3.1 Conduct survey of diesel pump usage to understand seasonality and extent of usage, reasons for not getting a grid connection

   3.2 Conduct survey to identify pending grid connections, reasons for illegal connections, and latent demand for grid connections

   3.3 Report on diesel usage, pending grid connections, and latent demand for grid connections

   3.4 Suggestions for betterment - PoCRA and high level policy suggestions

Appendix

Sr. No	District	Agro-climatic - R	Main Crops (Each crop > ~1 Soyabean/Cotton/Tur	Other crops	PoCRA disbursement			
					Drip	Electric	Farm pond	Spri-nkle
1	Akola	Assured	Soybean, Cotton, Tur	Moong, Gram, Tu	13	58	4	124
2	Amravati	Assured	Soybean, Cotton, Tur		150	190	3	656
3	Buldana	Assured	Soybean, Cotton, Tur		97	277	19	235
4	Jalgaon	Assured	Cotton		491	569	29	94
5	Jalna	Assured	Soybean, Cotton, Tur		39	123	317	57
6	Parbhani	Assured	Soybean, Cotton		41	365	35	87
7	Latur	Assured	Soybean, Tur	Gram (14%)	22	131	9	201
8	Osmanabad	Assured	Soybean, Tur		28	252	38	274
9	Beed	Assured and Scarcity	Soybean, Cotton	Bajra (17%)	5	80	11	29
10	Washim	Moderate	Soybean, Cotton, Tur		1	166	2	120
11	Wardha	Moderate	Soybean, Cotton, Tur		12	59		82
12	Yavatmal	Moderate	Soybean, Cotton, Tur		29	144	3	227
13	Hingoli	Moderate	Soybean	Gram (13%)	116	275	1	262
14	Aurangabad	Scarcity and Assured	Cotton	Maize (21%)	751	1245	695	307
15	Nanded	Assured and Moderate	Soybean, Cotton, Tur		16	113	1	68