# PoCRA Water Budget

PoCRA Team, IIT Bombay

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# Outline

- JSA and PoCRA water budgets
- PoCRA Architecture
- User-friendliness of PoCRA budget and resources required for same
- Roll Out and  future scope

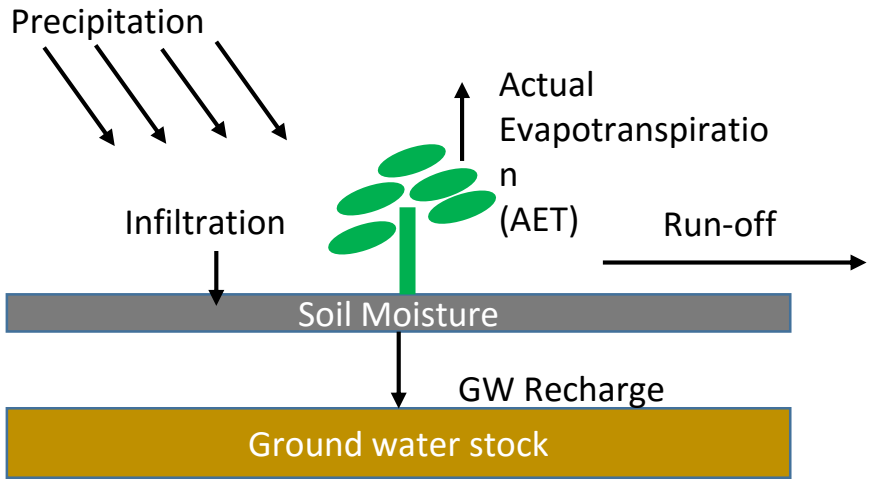
# JSA and PoCRA water budgets

# Daily vs Aggregate water balance model

| | JSA water balance computation | PoCRA Water Balance computation |
|---|---|---|
| 1 | The Strange's table provides the run-off in terms of percentage of the monsoon rainfall for Good, Average and Bad catchments. These are gross estimates. | Runoff is computed based upon SCS curve number methodology which is calibrated with SWAT, an international standard. |
| 2 | Aggregate rainfall model. | Daily time-step. Sensitive to dry spells and peak rainfall events. |
| 3 | It does not take soil conditions or land-use into account | It takes location specific soil and LU properties. Makes the computation of field capacity, wilting point, run-off, recharge more accurate. This helps, e.g., in selection of farm-ponds, interventions. |
| 4 | It does not give kharif water stress. Protective irrigation is assumed to be 10 percent of crop water requirement. | It gives crop-specific kharif water stress based upon the rainfall pattern and need for protective irrigation. |
| 5 | It does not split infiltration into soil moisture (SM) and groundwater (GW) recharge values. | It gives the soil moisture and groundwater available . Knowing SM helps in knowing protective irrigation requirements. Knowing GW helps in deciding if wells will be useful. |
| 6 | It does not give any vulnerability maps. | It gives the vulnerability maps for the identification of vulnerable farmers. |
| 7 | It works at village level. | It allows for zone-wise analysis for better targeting. |

Limitations of both PoCRA and JSA: do not account for sub surface ground water flows. Model output quality limited by quality of input data being used (eg - rainfall, soil texture etc)

# PoCRA Point level Water balance and Validation




Model Validation against SWAT and ongoing field observations

| Component | Method (Reference) | Data source/ Ref |
|---|---|---|
| Rainfall | Input | Maharain.gov.in |
| run-off, infiltration | SWAT method based on SCS-Curve number adjusted for slope | SWAT theory |
| Potential crop ET (PET) | Modified Penman method | ET0: WALMI, Kc: FAO |
| Actual crop ET (AET) | FAO methodology | Soil properties: FC, WP, Crop root depth |
| GW recharge | SWAT methodology | Soil conductivity function of soil texture input |
| Soil moisture | Mass balance | |

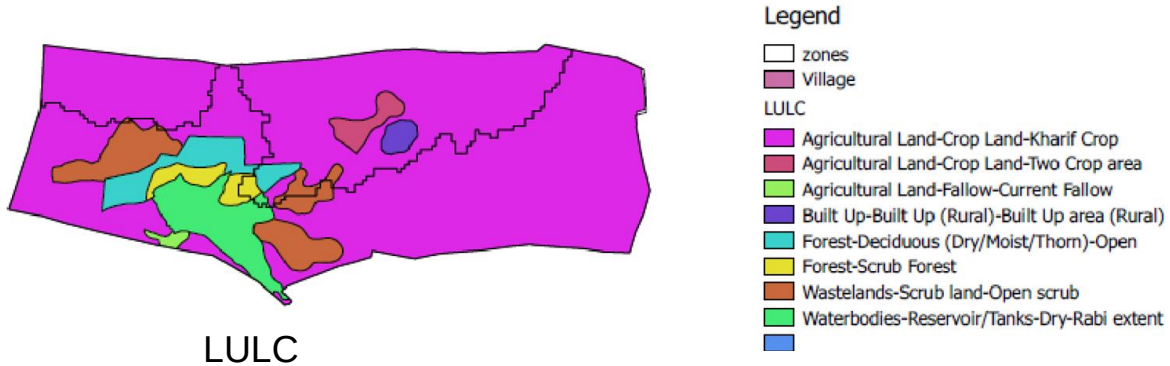
# Validation and Adaptation

- Model validation has been done against SWAT (Soil and Water Assessment Tool), the current industry standard
  - Current model is light-weight  version of SWAT for ease of use
  - Output is consistent with SWAT output
- Input parameters published for Indian conditions by institutes  such as WALMI and SAUs have been used
- Engagement with SAUs and WALMI
  - Further refinement of input parameters such as crop ETs, soil parameters
  - Farm level and village level balance validation

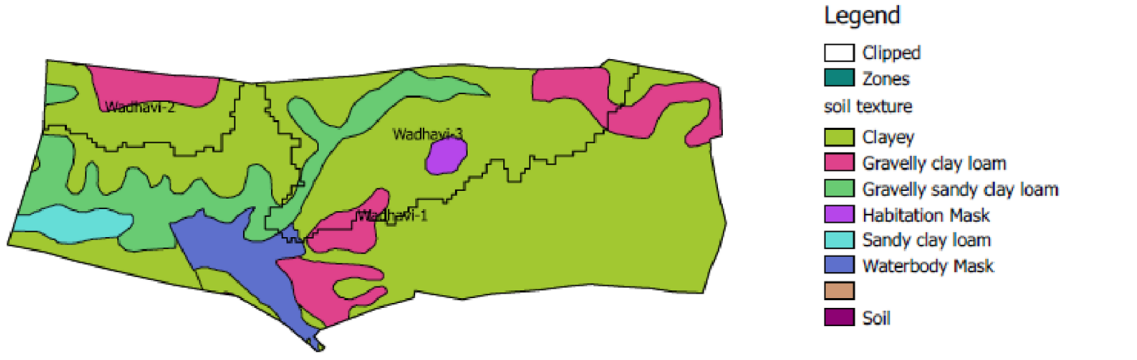
# Comparison of JSA and PoCRA budget with Examples

# Example: Wadhvi Village Karanja Cluster WB

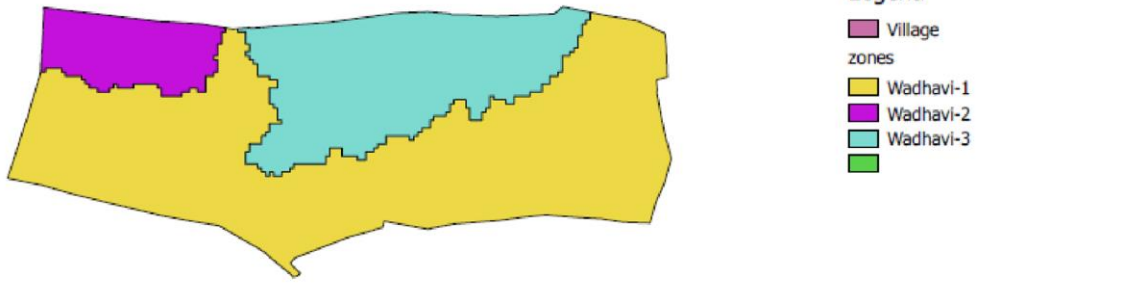
| Wadhavi village, Washim | |
|---|---|
| **Total area** | **562 ha** |
| **Total rainfall (2017)** | **473 mm** |
| **Single kharif crop area** | |
| Soybean | 290 ha |
| Moog | 15 ha |
| Udid | 26 ha |
| **Long kharif crop area** | |
| Cotton | 52 ha |
| Tur | 93 ha |
| **Rabi crop area** | |
| Wheat + Harbara + vegetables | 20 ha |
| **Non agricultural area** | |
| Fallow | 30 ha |
| Grass | 26 ha |
| Forest | 30 ha |




LULC



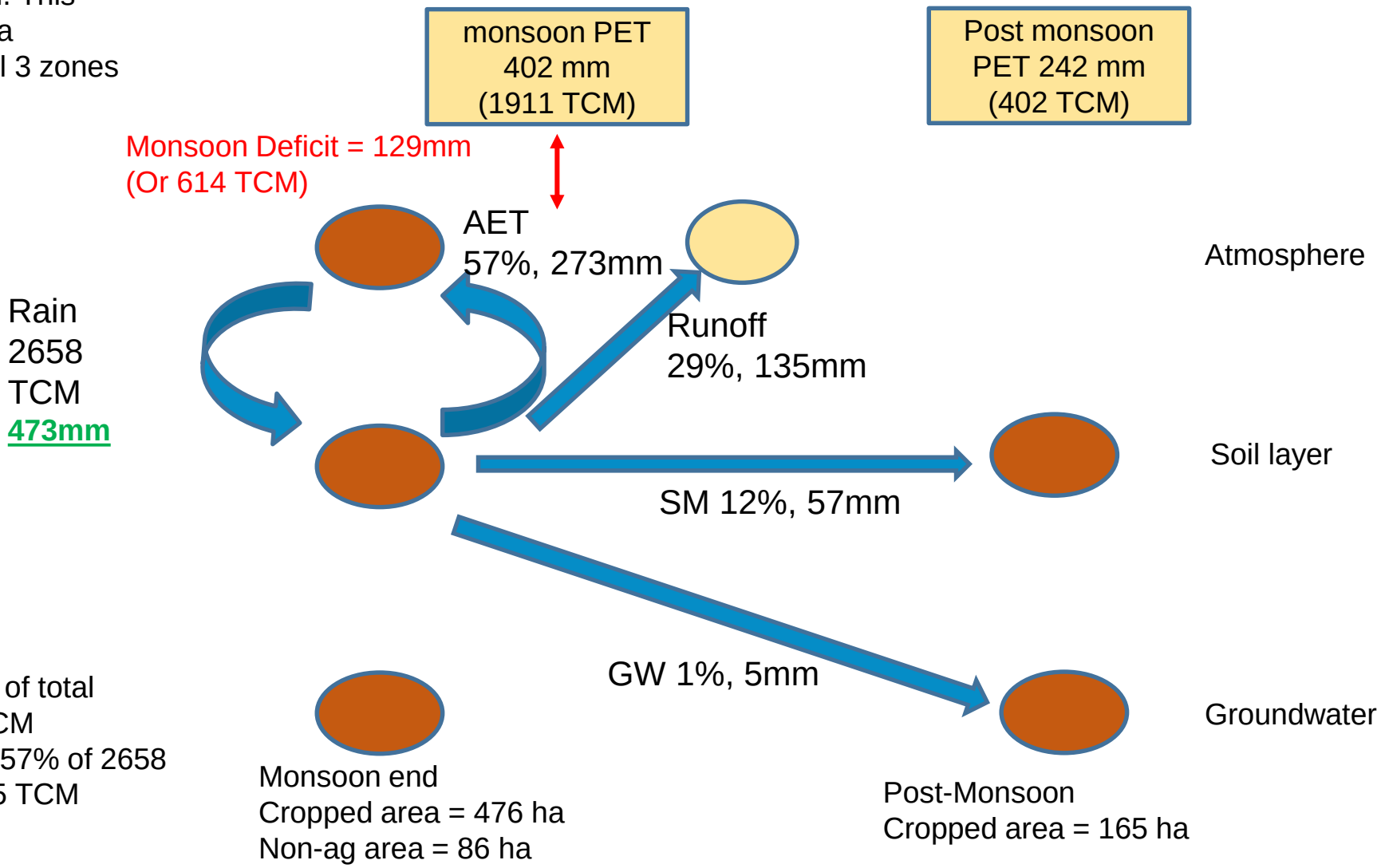

soil



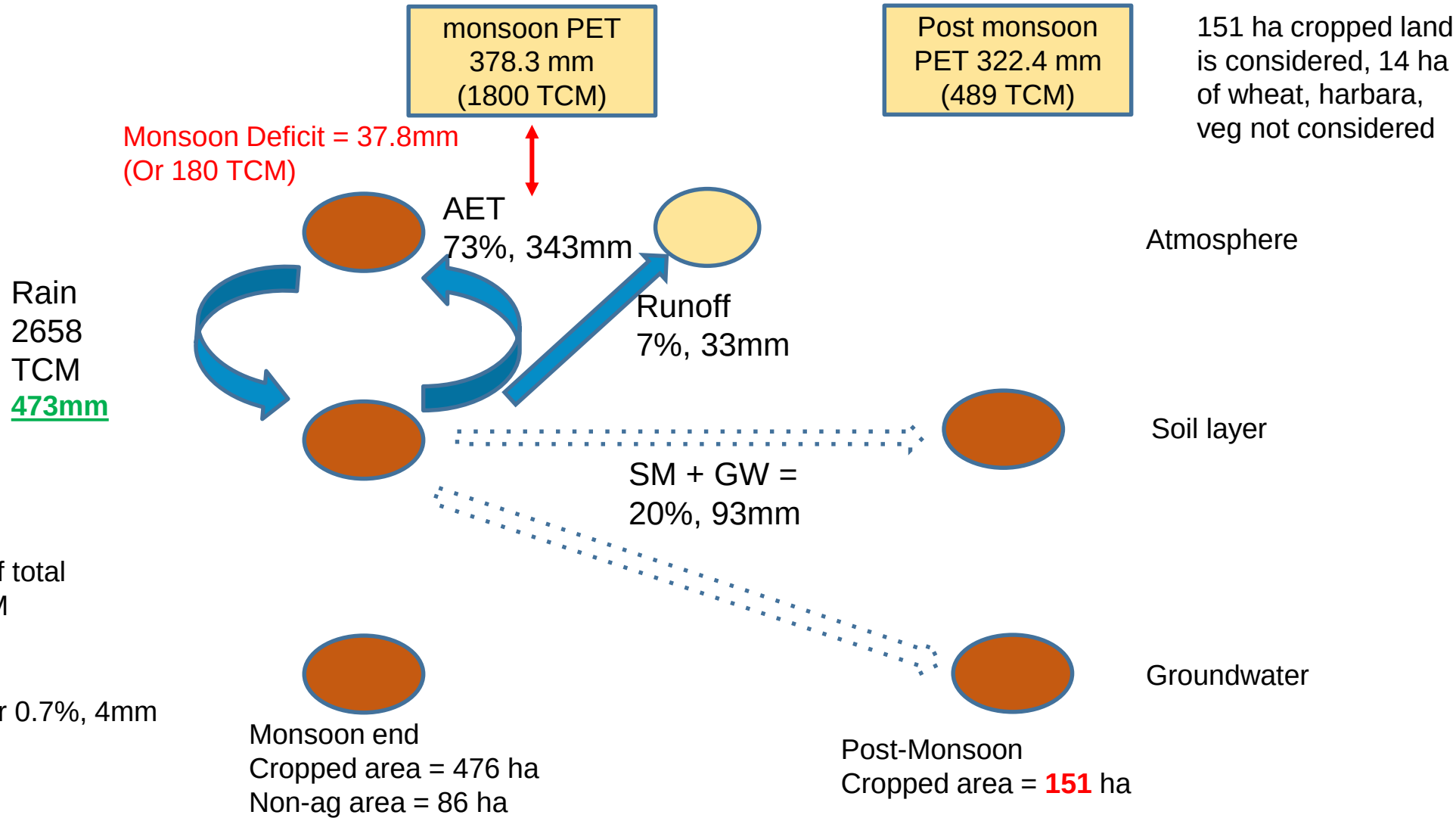

POCRA zone map

# Wadhvi 2017 POCRA village level water balance

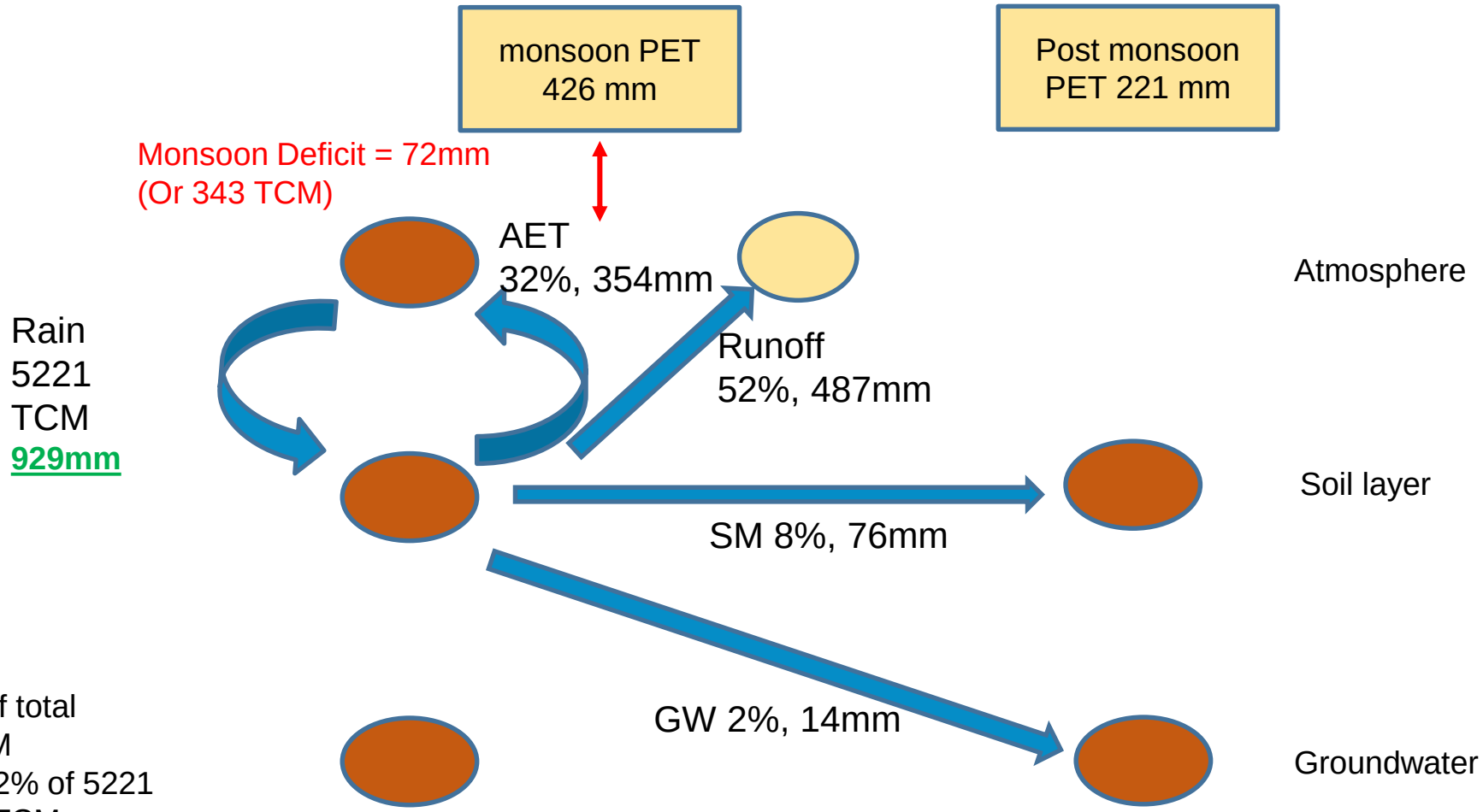
Note: POCRA balance is done at zone level. This village balance is a consolidation of all 3 zones



# Wadhvi 2017 JYS village level water balance

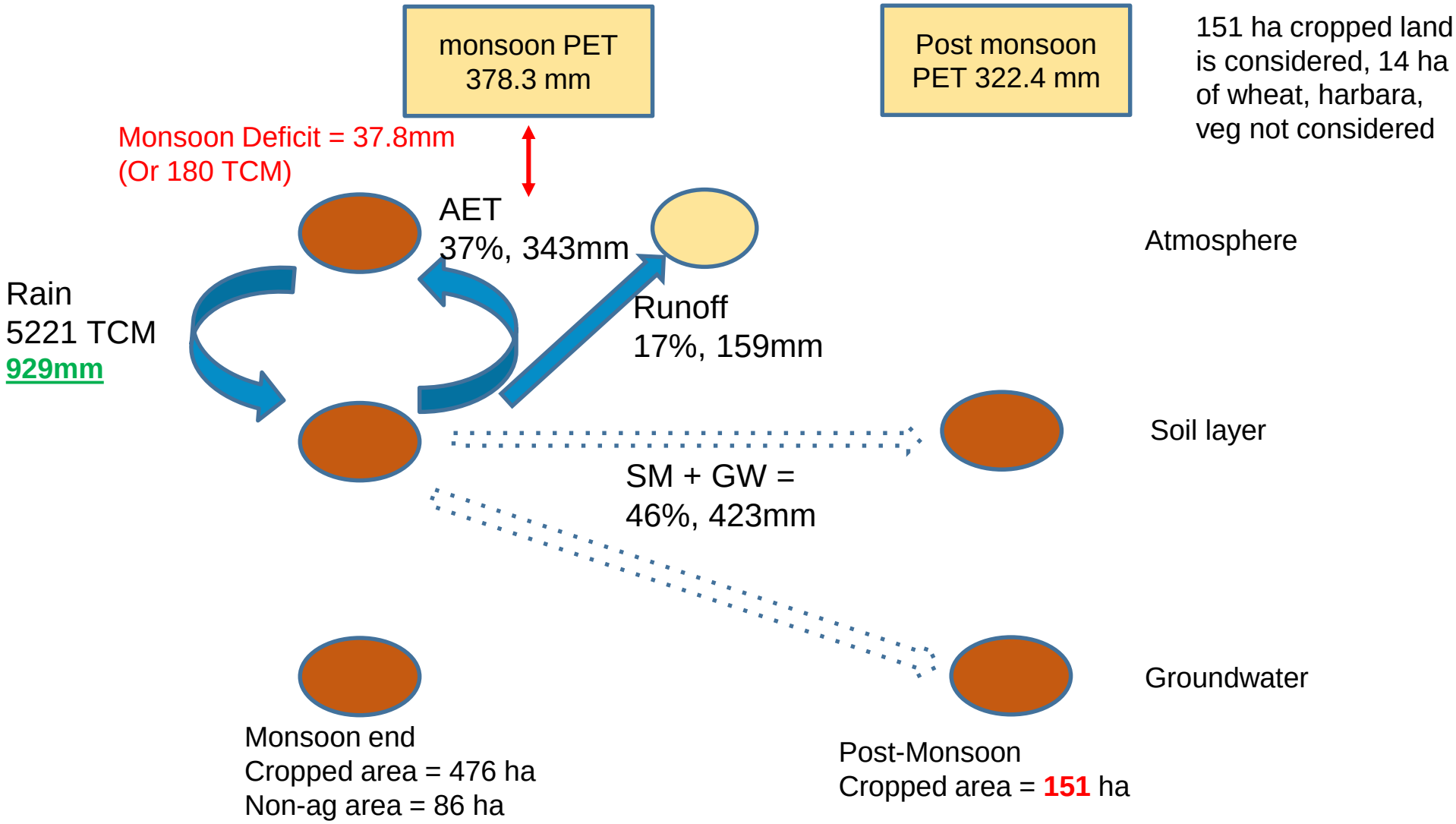


# Wadhvi 2016 POCRA village level water balance



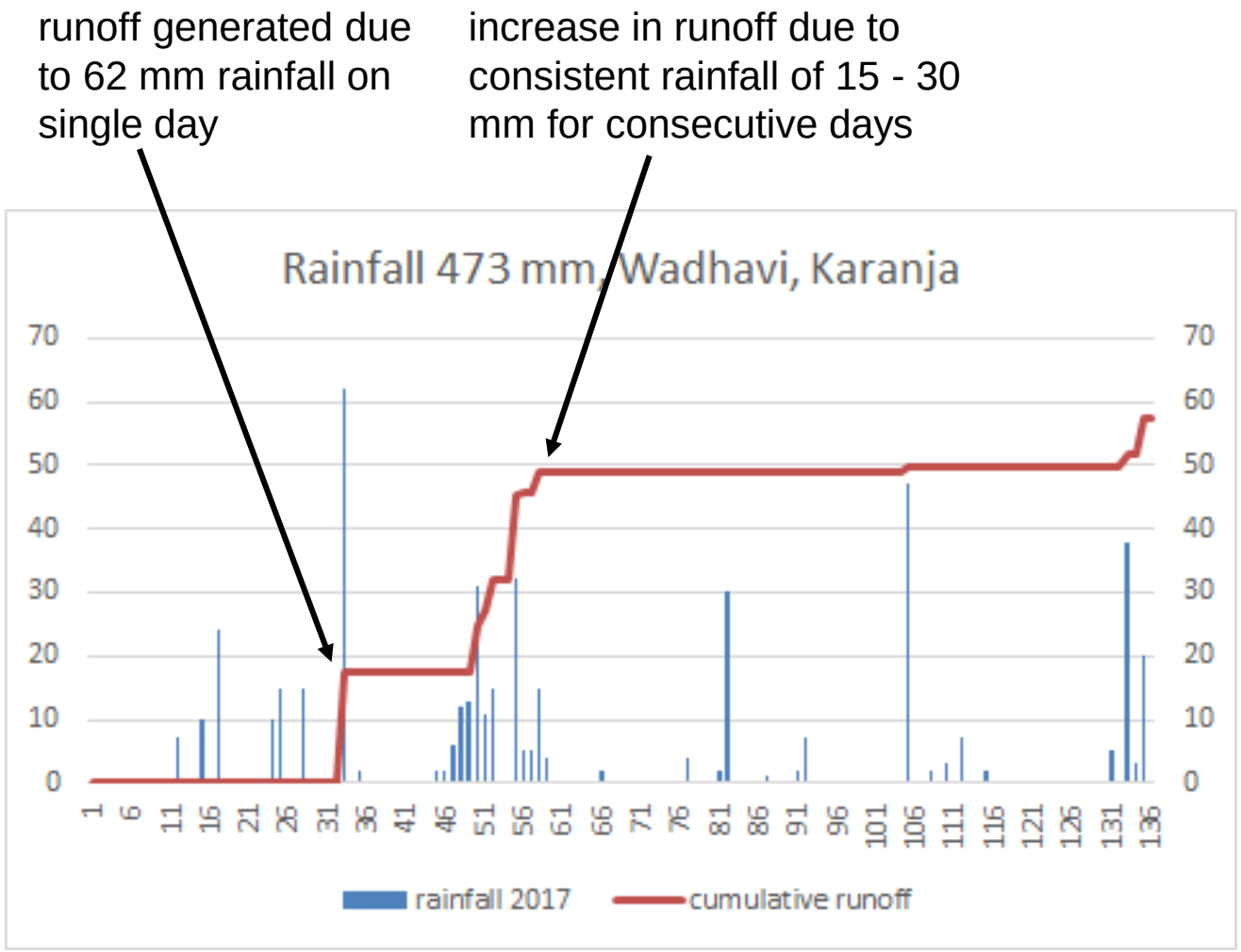

All % are % of total rainfall in TCM
E.g. AET is 32% of 5221 TCM = 1671 TCM

# Wadhvi 2016 JYS village level water balance



| Rainfall – 473 mm | JYS | PoCRA |
|---|---|---|
| **Runoff generated** | **7% or 186 TCM**<br>(as per aggregate rainfall using Strange's table) | **29% or 771 TCM**<br>(as per daily rainfall events using SCS CN methodology and soil properties) |
| Current storage available for use | 203 TCM | 203 TCM |
| Kharif water demand | 1800 TCM<br>(full K + 1/2LK) | 1911 TCM<br>(full K )+ (LK  PET upto monsoon end) |
| Kharif deficit | **180 TCM**<br>(10% of demand) | **614 TCM**<br>(as per soil and crop type calculation) |
| GW Recharge<br>Soil Moisture | 532 TCM or 93mm total | GW Recharge: 5mm or 27 TCM<br>Soil Moisture: 57mm |
| Water available for rabi | 527 TCM<br>(assumes all SM+GW to be available for Rabi since separate values not known. Current storage-PI  available for Rabi) | 261 TCM<br>(⅔ of GW+ ½ of current storage+SM available in Rabi area)<br>(note this is reduced because most water is in soil moisture which is a local stock) |
| Rabi + summer water demand | 487 TCM<br>(322 mm) | 402 TCM<br>(242 mm over 165 ha) |
| Rabi water use index (supply / | **1.08** | **0.6** |

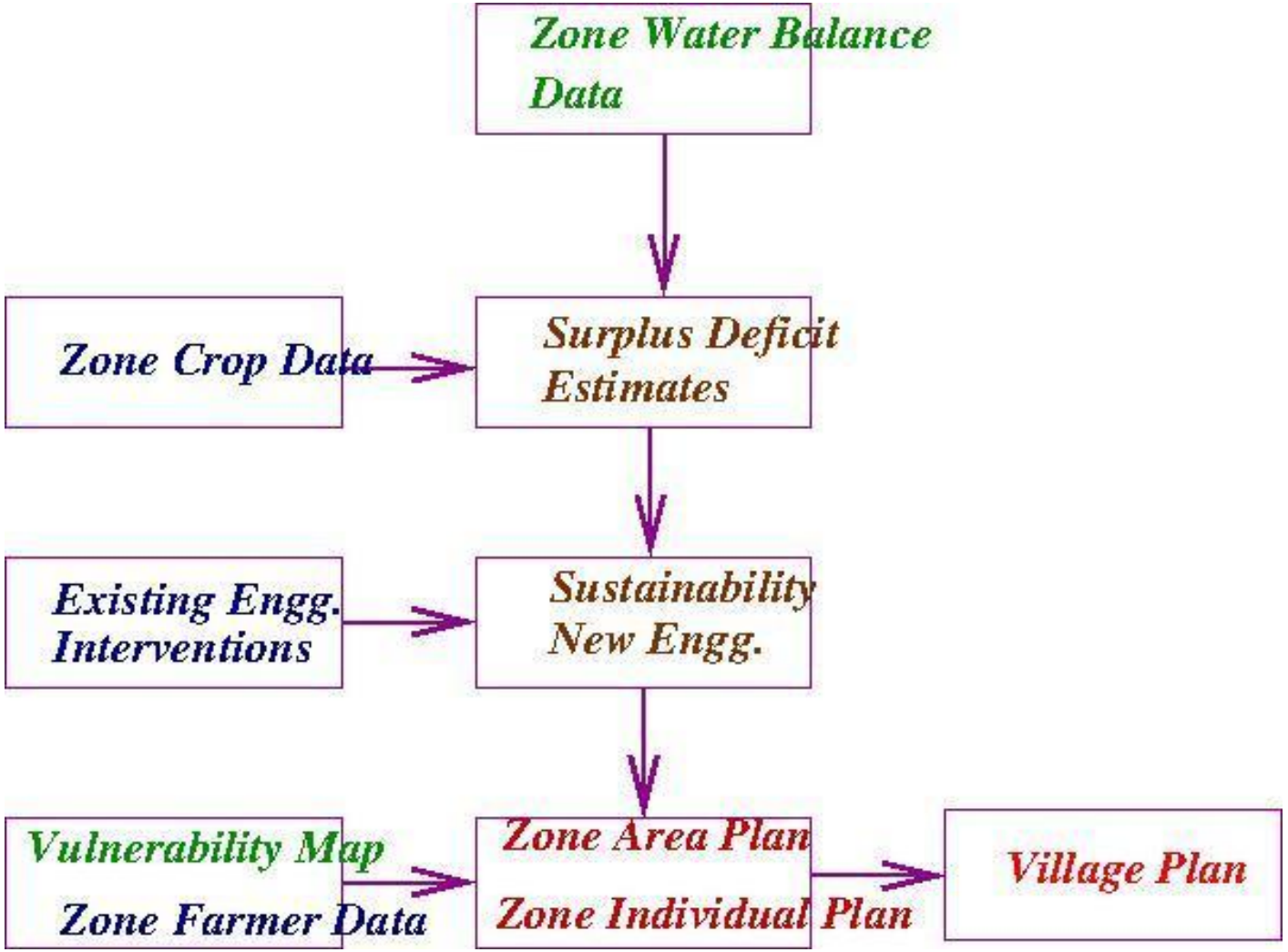
# Rainfall-Runoff relation




- Runoff typically depends on rainfall pattern and distribution
- Sufficient amount of rainfall on consecutive days leads to wetting of soil, after which 30 mm and above daily rainfall is sufficient to generate runoff
- Similarly very high amount of rainfall on any day also results in runoff
- Both these scenarios are seen in adjacent figure and captured in the model

# The PoCRA Architecture

# Basic Outline of Water-balance enabled planning



# Overall Usage Methodology: Inputs an Outputs

**Front End**

**Input Data required from field**

- Collection of zonal cropping data
- Existing structures and capacity
- Human and animal population

**WB Kit for microplanning**

- Zonal monsoon end water balance for major crop types in village

**Back End**

**Water balance app on tablet**

**Output in PDF format**

**Output for Zone**

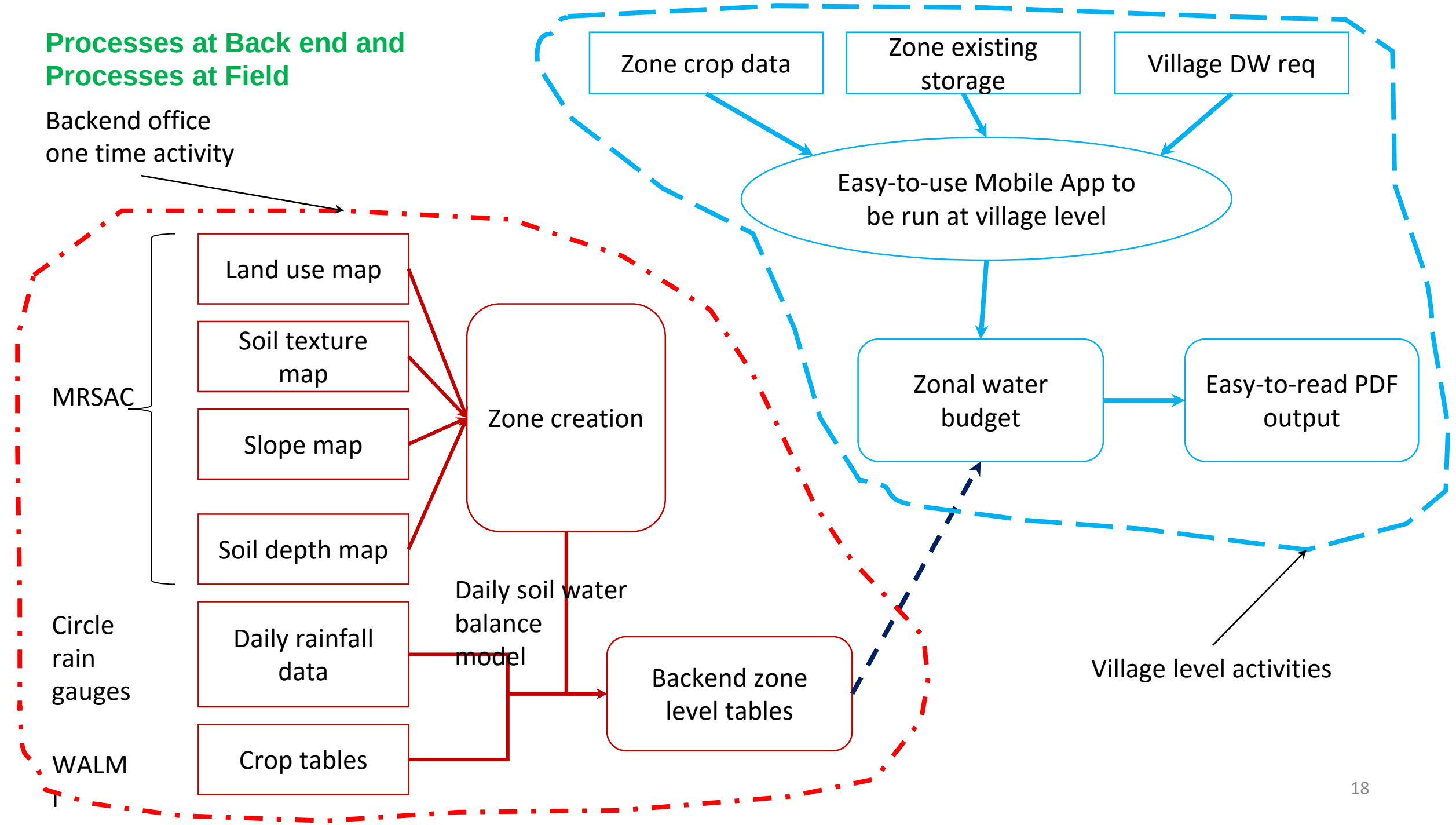
-Monsoon balance: monsoon stress and available supply

**Monsoon security Index**

- Post-monsoon balance: irrigation requirement vs. supply of soil moisture and GW

**Post-monsoon security index**

## Processes at Back end and Processes at Field

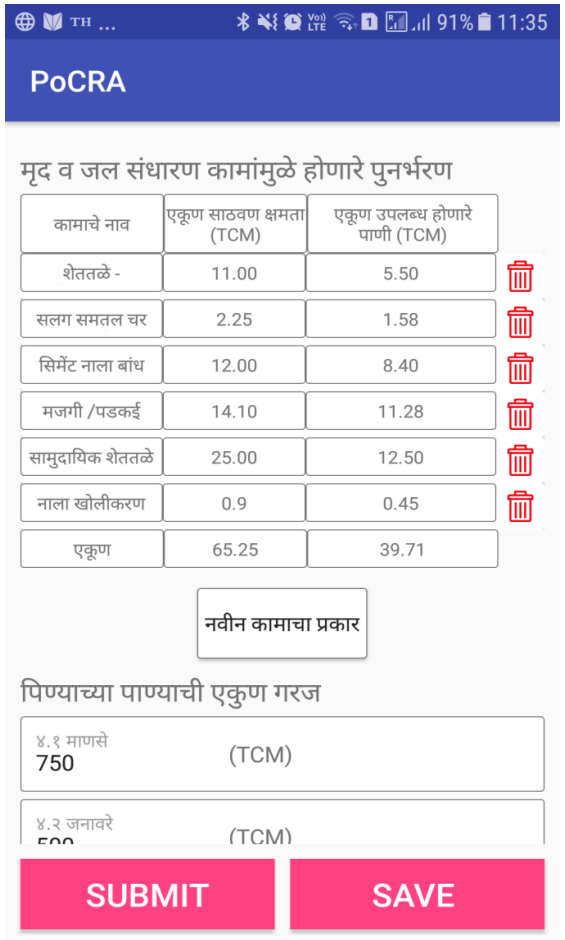


# On Field User Friendliness of PoCRA Water Budget Model

# In the Field: PoCRA App Interface

## Cropping Pattern


## Existing Storage Structures




## Drinking Water Requirement


App available for downloading on google play store.

Can be used on Tablet as well as Smartphones

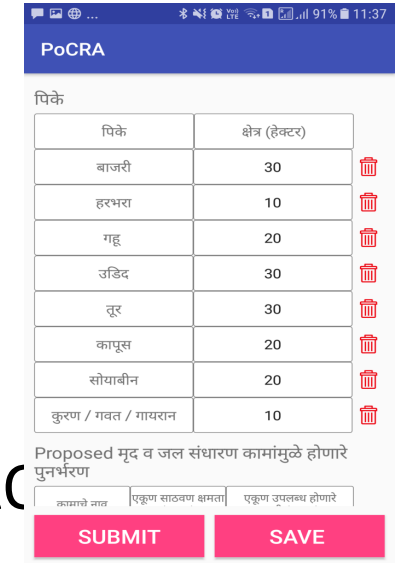
# Water Budget Output Table in PDF format (to be simplified)

| Wadhvi village - 473mm -2017 Rainfall | | Zone 1 | Zone 2 | Zone 3 | Village |
|---|---|---|---|---|---|
| | Zone Area in hectare | 423 | 60 | 179 | 662 |
| Monsoon Balance (TCM) | Monsoon protective irrigation req. (deficit) | 435.2 | 32.9 | 150.1 | 618.2 |
| | Storage Available for Crops In Monsoon | 34.0 | 5.1 | 122.7 | 161.9 |
| | GW Available for Crops in Monsoon | 4.7 | 0.2 | 1.2 | 6.2 |
| | Monsoon Balance: Current Supply - Demand | -396.5 | -27.6 | -26.1 | -446.7 |
| | Monsoon Protective Irrigation Index | 0.09 | 0.16 | 0.83 | 0.27 |
| Post Monsoon Balance (TCM) | Rabi Total Water Requirement | 162.5 | 11.5 | 230.6 | 404.6 |
| | Drinking Water Requirement | 0.0 | 0.0 | 39.4 | 39.4 |
| | Water Available from Soil Moisture | 35.9 | 2.6 | 35.7 | 74.2 |
| | Water Available from GW | 18.9 | 0.9 | 4.9 | 24.7 |
| | Storage Available for Crops in Rabi Season | 34.0 | 5.1 | 122.7 | 161.9 |
| | Rabi Balance: GW supply+SM+structures-Rabi Demand-Drinking Water | -73.7 | -2.9 | -106.7 | -183.3 |
| | Post Monsoon Protective Irrigation Index | 0.55 | 0.75 | 0.60 | 0.59 |
| Design (TCM) | Water Available from Runoff | 276.3 | 16.6 | 90.5 | 383.3 |
| | Additional Water Available for Impounding | 208.2 | 6.4 | 0 | 59.5 |

Note: Zone 3 has a large reservoir currently

# App Features

- Coded into easy to use water budget app
- Requires minimal input from the field
  - Zone Level Cropping pattern
  - Existing Storage Structures in the zone
  - Village population for drinking water demand
- All computations done in app backend to display final output
- Can be used by cluster assistant, agricultural assistant as well as TAC
- One time process of zone creation
- Flexible in use: can be run on village as well as zone level
- Plugin run on each cluster to generate water balance and upload input data into app. This should be updated for every year rainfall.
- Dedicated back office staff and GIS specialists required to handle back end processes



# Back End Processes: Description Of Plugin and Data requirement

Front End Inputs Need to Given by User

1 Cluster Boundary with zones
2 Land Use Land Cover
3 Soil
4 Slope
5 Cadastral
6 Rainfall

Back End Inputs used in the Plugin

1 Reference Evapotranspiration, ETo
2 Crop Coefficients - Kc,
3 Hydrologic soil Group, Curve Number
4 % Sand, % Silt, % Clay
5 Wilting Point, Field Capacity, Saturation
6 Ksat, Bulk Density, Available water content
7 Crop Root zone, Crop Depletion factor p

**Plugin**

**Options**
Colour Code Intervals
Crop Selection
Sowing Threshold

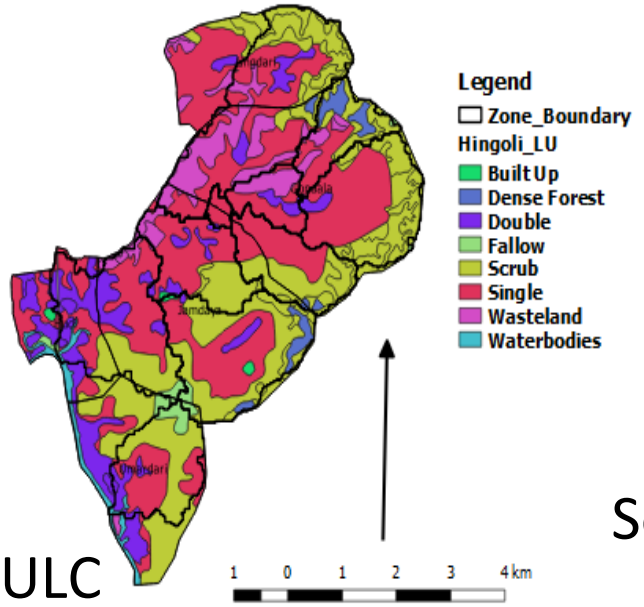
Output Generated by Plugin

1 Cadastral Vulnerability Map
2 Point wise Vulnerability Map
3 Cadastral wise Vulnerability CSV
4 Zone wise Computation CSV

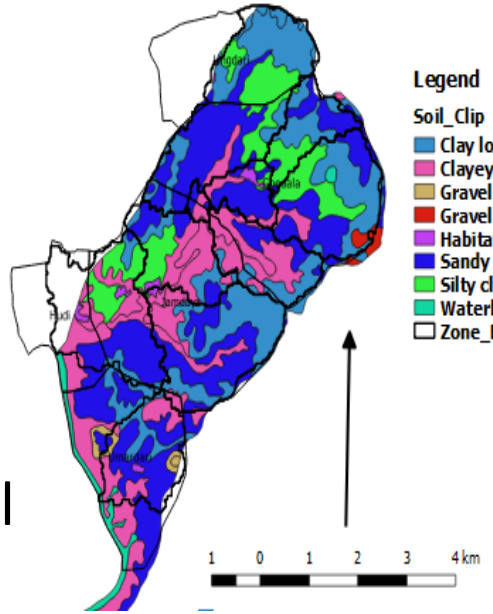
Front end secondary data shape files are available for all PoCRA districts, can also be obtained for remaining districts.

# Example: Gondala cluster inputs

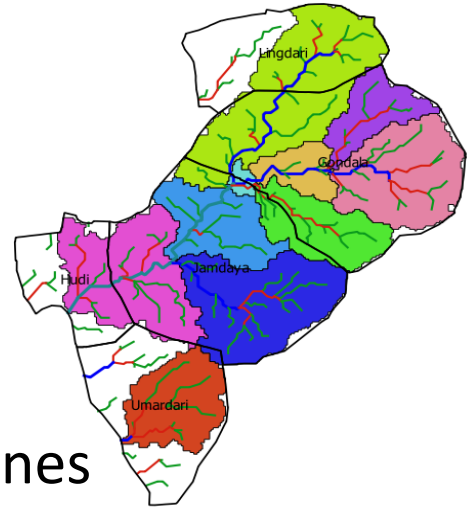
LULC




Soil

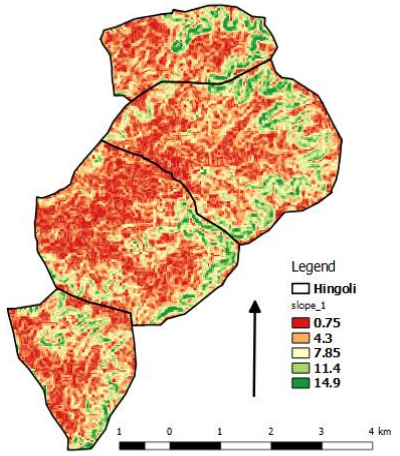



Zones




Cadestral


Slope



# Input layer pre processing : Back Office Support

| Sr.No | Input | Processing | Output |
|---|---|---|---|
| 1 | Cluster Boundary | Project the cluster boundary with number of villages in UTM projection. | Cluster Shapefile with required spatial extent. |
| 2 | LULC | Using the cluster shapefile clip the LULC layer in UTM Projection | LULC layer with require spatial extent. |
| 3 | Soil | Using the cluster shapefile clip the soil layer in UTM Projection | Soil layer with required spatial extent. |
| 4 | Cadastral Map | Using the cluster shapefile clip the Cadastral layer in UTM Projection | Cadastral layer with required spatial extent. |
| 5 | DEM | Extraction of sub watersheds or zones from Dem | Zone layer with required spatial extent. |
| 6 | Cluster Boundary with zones | Intersection of cluster boundary and zone layer and naming of zones | Cluster boundary with number of zones |
| 7 | Slope | Extraction of slope layer from Dem | Slope layer with required spatial extent. |
| 8 | Rainfall | Full year rainfall data in CSV format in two columns days and Rainfall | Rainfall CSV file |

One time operation to prepare zonal data shapefiles for all villages.

Repetitive operation to run the plugin for different rainfall scenarios and cropping pattern.

Dedicated personnel required for pre-processing of input layers and running the water budgets and uploading the output into app from backend

# Backend Zone creation process: Activities

- Pre Processing of shapefiles.
  - Village shapefile
  - clipping LULC for village
  - clipping Soil for village
- DEM Processing
  - DEM download
  - Extraction of slope and streams
  - Extraction of micro watersheds around 200 ha
- Processing of zones - one time activity
  - Intersection of micro watersheds with village boundary, cleaning of shapefile and merging of small watersheds to form zones, adding zone names and area in attribute table.
  - Extra efforts - If groundwater shapefiles are to be used.
- Selection and downloading rainfall data
- Preparing ET0 file
- Running of plugin

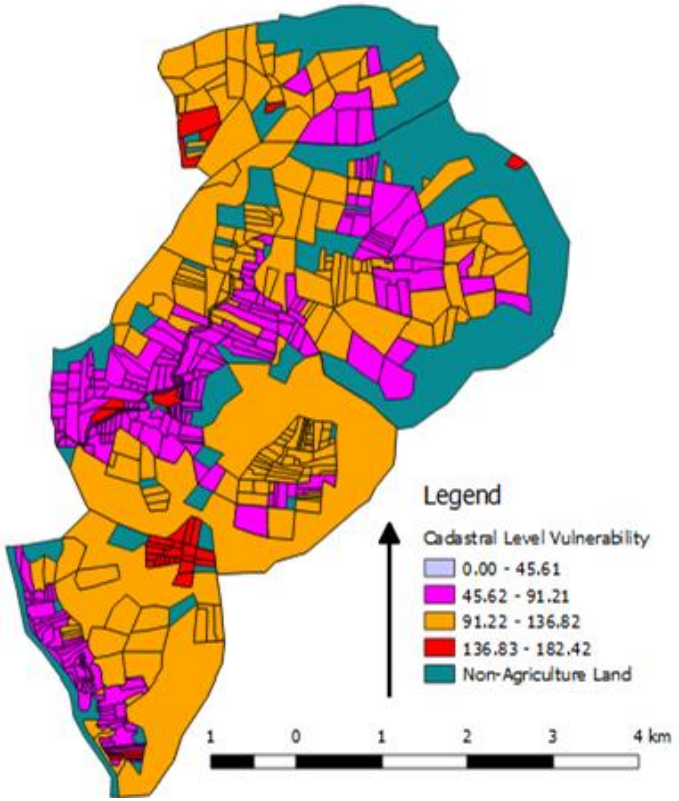
# Water Balance Generation and uploading to App: Activities

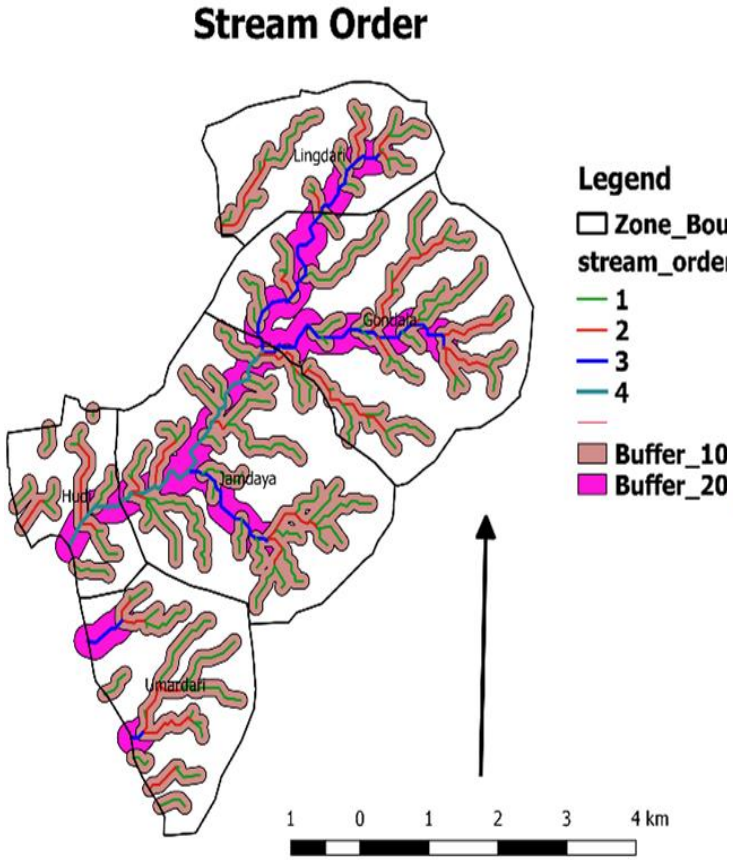
- Zone wise input of data
  - Crop Data
  - Structures Data
  - Population Data

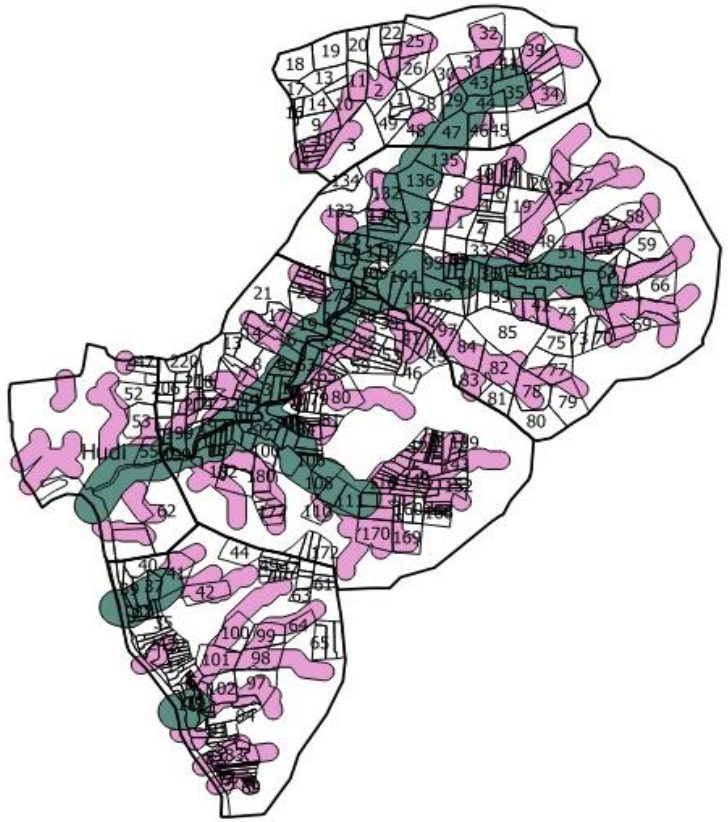
  Water Balance Generated
  - Proposed structures data
  - Revised Cropping pattern

  New water balance table

# Outputs: Monsoon Farm Level Vulnerability map and Stream proximity map



# Water Balance kit: Gondala Monsoon end balance

| Crop | Area | PET Monsoon End | AET Monsoon End | Monsoon Deficit(PET-AET) | GW Recharge in Monsoon | Runoff in Monsoon | Soil Moisture Monsoon end | Post Monsoon PET |
|---|---|---|---|---|---|---|---|---|
| Soyabean | | 453.8 | 345.9 | 107.9 | 29.1 | 251.4 | 81.8 | 0.0 |
| Cotton | | 449.5 | 361.7 | 87.8 | 29.1 | 273.1 | 44.6 | 304.6 |
| Udid | | 276.0 | 194.9 | 81.0 | 81.7 | 339.2 | 92.1 | 0.0 |
| Tur | | 415.5 | 338.2 | 77.2 | 32.3 | 286.9 | 51.0 | 185.1 |
| Wasteland | | 517.9 | 258.8 | 68.9 | 53.7 | 328.6 | 67.6 | 0.0 |
| Scrub | | 634.0 | 298.5 | 43.6 | 51.5 | 304.6 | 54.4 | 0.0 |
| Forest | | 778.9 | 368.6 | 102.1 | 54.3 | 250.6 | 35.5 | 0.0 |
| Harbhara | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 250.0 |

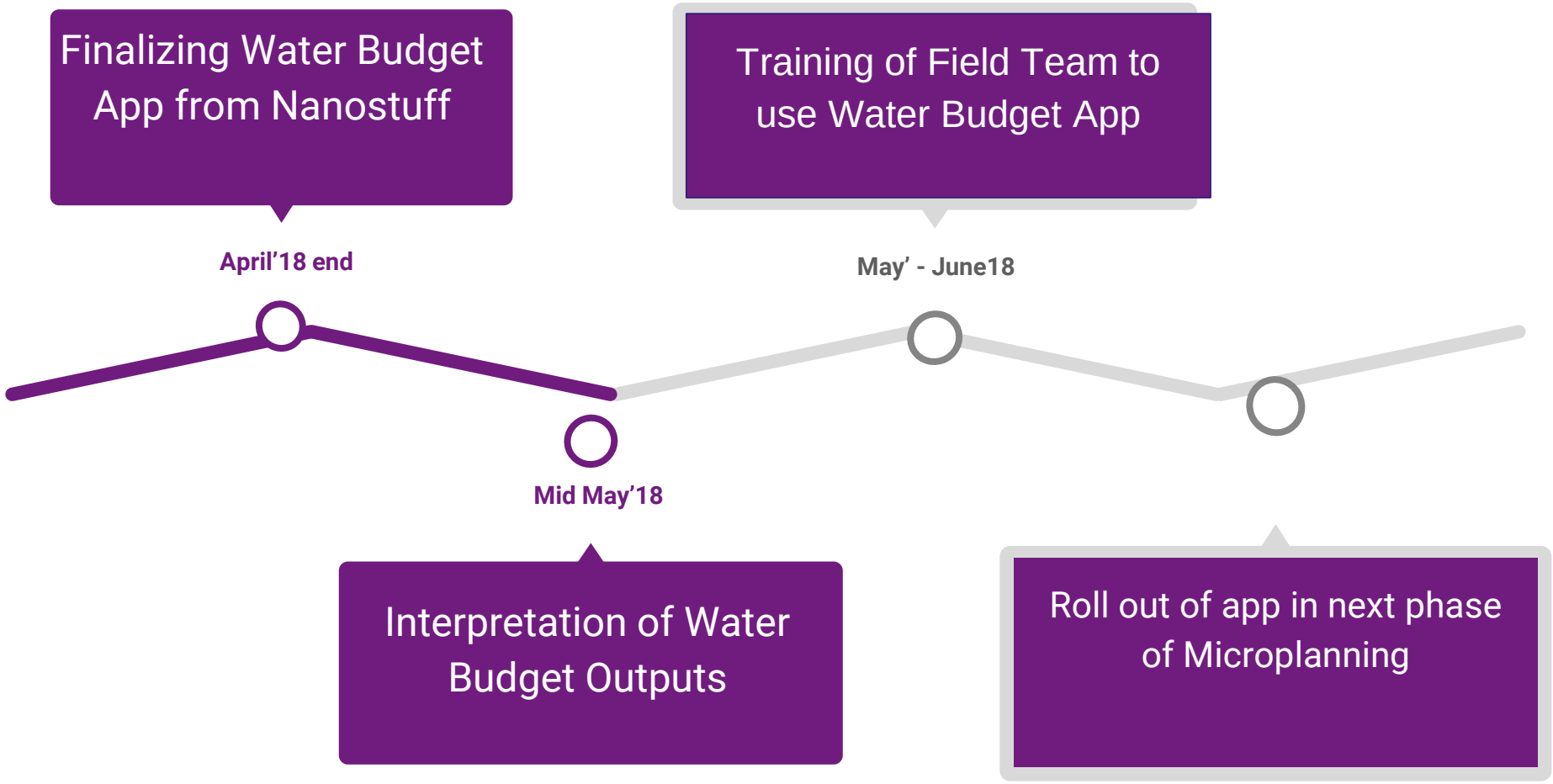
Area for individual crops to come from field assessment

# Roll Out in PoCRA

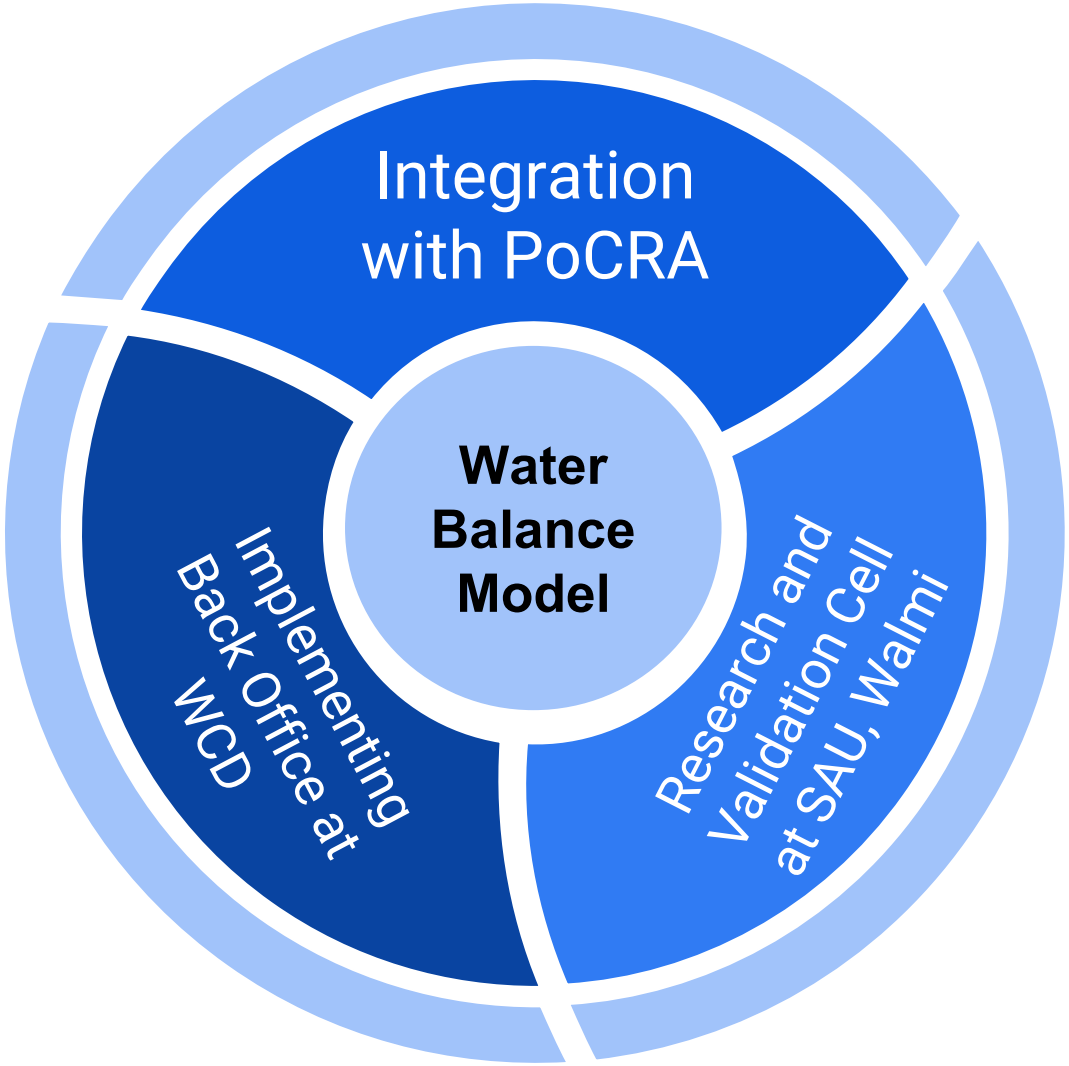
Field Level requirement

- Gathering or estimating zone wise cropping pattern data for village on field
- Currently agriculture assistant coordinates with the cluster assistant in estimating zonewise cropping pattern
- This can also be done by conducting FGD's with group of farmers in each zone
- Finalization of Water Budget App and its deployment to field (Finalization to happen in next 15-20 days, deployment from next Microplanning)
- Training field users to use Water Budget App (Training to be conducted before next microplanning when new field team is ready)
- Guidelines on Interpretation of outputs from water budget for intervention planning purpose
- Improvisation in Water Budget output table from app to make it easier for public comprehension

# Roll Out at PoCRA Level: Timeline



# Requirements for Roll Out at Maharashtra Level



# Watershed Planning Cells in SAU's

**Initial Handholding from IIT**

- Technology Transfer
- Support and Training

**Watershed Planning cell at SAU**

- 20-30 villages
- 2-3 Faculty Members
- 8-10 student projects
- GIS team

**Validation of Data Inputs (GIS maps) and Adaptation of budget to field conditions**

- Validate Soil, Landuse and other Maps
- Conduct Research on Yields, watering, economics
- Incorporate the research into Water Budget

# Role of WALMI

- Interpretation of Water Budgets for Villages and development of village planning protocols
- Coordinate with SAU Watershed Planning Cells
- Prepare guidelines for area/drain-line treatment and specific interventions such wells or farm-ponds.

# Back Office: Technology and Manpower


- Dedicated Back Office of GIS specialists required at WCD
- QGIS, GRASS softwares required

# In Future

- Village or zone level rain-gauges will increase model accuracy significantly
- Model can be integrated with yield and economic parameters to allow for cropping pattern advisory. This is to be done in partnership with SAUs and WALMI
- Integration of ground water flows and improved zoning based on aquifer properties