# Agenda

5/8/18

- Closure of First MoU
- Marodi Water Balance
- Discussion on phase II MoU
- Budget and schedule

# Closure of First MoU

**Work done and ongoing**

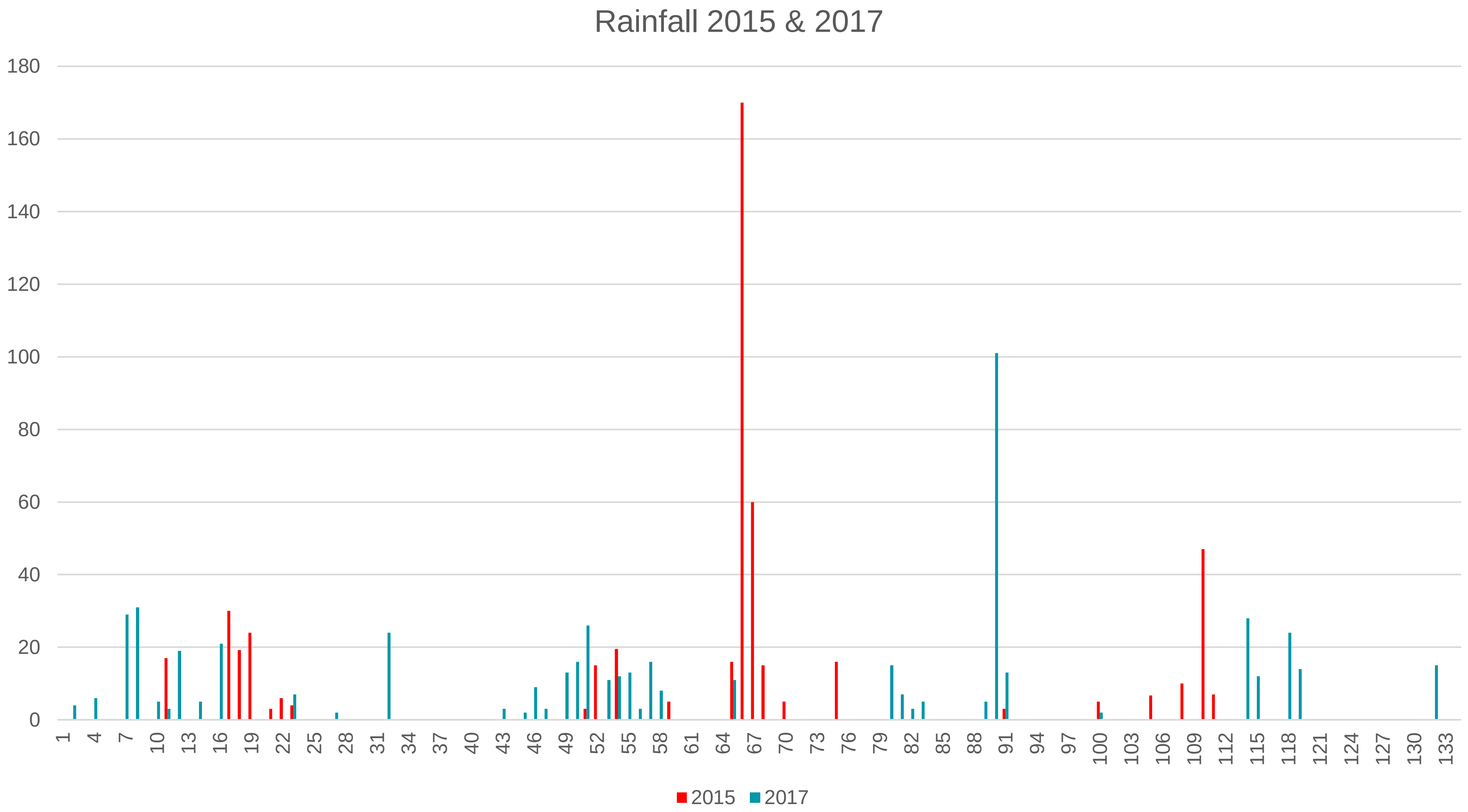
- Prepared zones for 850 villages.
- Generated plugin output for 600 phase I villages and uploaded them to PoCRA app server to enable data collection and water budgeting in App.
- App Training Manual for Water Budgeting part of app further refined and finalized through discussion with PoCRA PMU.
- Help in DPR checking prepared by micro-planning agencies.
- Providing support to PMU in resolving the issues or problems faced by microplanning agencies, clusters assistants, Agri assistants in computation of water budget.
- Item A1 - Analysis of NBSS & LUP data.
- Item A4 – Working on Automation of zoning process.
- Item A6 – Analsis of Mahabhulekh Data.

# Marodi Water Balance Zone 1

| Rainfall | 845.6 | 558.1 | 506.4 | 921.8 | 546.0 | 675.58 |
|---|---|---|---|---|---|---|
| **All Values are in TCM** | Zone 1_2013 | Zone 1_2014 | Zone 1_2015 | Zone 1_2016 | Zone 1_2017 | Average_Zone_1 |
| Monsoon protective irrigation req. (deficit) | 116.8 | 60.1 | 356.0 | 73.9 | 270.7 | 175.5 |
| Storage Available for Crops In Monsoon | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 |
| GW Available for Crops in Monsoon | 18.7 | 0.3 | 0.0 | 10.7 | 0.3 | 6.0 |
| Monsoon Balance: Current Supply - Demand | -93.7 | -55.4 | -351.6 | -58.7 | -266.0 | -165.1 |
| Monsoon Protective Irrigation Index | 0.20 | 0.08 | 0.01 | 0.20 | 0.02 | 0.06 |
| Rabi Total Water Requirement | 566.4 | 1044.5 | 651.5 | 686.9 | 530.6 | 696.0 |
| Drinking Water Requirement | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Water Available from Soil Moisture | 202.2 | 157.6 | 30.7 | 212.2 | 67.9 | 134.1 |
| Water Available from GW | 37.5 | 0.6 | 0.0 | 21.5 | 0.7 | 12.0 |
| Storage Available for Crops in Rabi Season | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 |
| Rabi Balance: GW supply+SM+structures-Rabi Demand-Drinking Water | -322.4 | -881.9 | -616.5 | -448.9 | -457.6 | -545.4 |
| Post Monsson Protective Irrigation Index | 0.43 | 0.16 | 0.05 | 0.35 | 0.14 | 0.22 |
| Water Available from Runoff | 374.0 | 305.2 | 216.7 | 540.2 | 106.8 | 308.6 |
| Additional Water Available for Impounding | 365.2 | 296.4 | 207.9 | 531.4 | 98.1 | 299.8 |

# Marodi Village Water Balance

| Rainfall | 845.6 | 558.1 | 506.4 | 921.8 | 546.0 | 675.58 |
|---|---|---|---|---|---|---|
| **All Values are in TCM** | Village_2013 | Village_2014 | Village_2015 | Village_2016 | Village_2017 | Average_Village |
| Monsoon protective irrigation req. (deficit) | 293.6 | 150.3 | 814.3 | 186.7 | 644.3 | 417.8 |
| Storage Available for Crops In Monsoon | 7.7 | 7.7 | 7.7 | 7.7 | 7.7 | 7.7 |
| GW Available for Crops in Monsoon | 32.9 | 0.3 | 0.0 | 14.9 | 2.3 | 10.1 |
| Monsoon Balance: Current Supply - Demand | -253.0 | -142.2 | -806.7 | -164.1 | -634.3 | -400.1 |
| Monsoon Protective Irrigation Index | 0.14 | 0.05 | 0.01 | 0.12 | 0.02 | 0.04 |
| Rabi Total Water Requirement | 1163.8 | 2117.9 | 1333.6 | 1404.3 | 1092.3 | 1422.4 |
| Drinking Water Requirement | 20.2 | 20.2 | 20.2 | 20.2 | 20.2 | 20.2 |
| Water Available from Soil Moisture | 373.6 | 273.5 | 72.4 | 387.2 | 146.8 | 250.7 |
| Water Available from GW | 65.9 | 0.6 | 0.0 | 29.8 | 4.5 | 20.2 |
| Storage Available for Crops in Rabi Season | 7.7 | 7.7 | 7.7 | 7.7 | 7.7 | 7.7 |
| Rabi Balance: GW supply+SM+structures-Rabi Demand-Drinking Water | -716.6 | -1836.1 | -1253.5 | -979.5 | -933.2 | -1143.8 |
| Post Monsson Protective Irrigation Index | 0.38 | 0.13 | 0.06 | 0.30 | 0.14 | 0.20 |
| Water Available from Runoff | 759.9 | 628.8 | 453.3 | 1096.7 | 237.1 | 635.1 |
| Additional Water Available for Impounding | 744.5 | 613.4 | 437.9 | 1081.3 | 221.7 | 619.8 |



Rainfall 2015 & 2017
180
160
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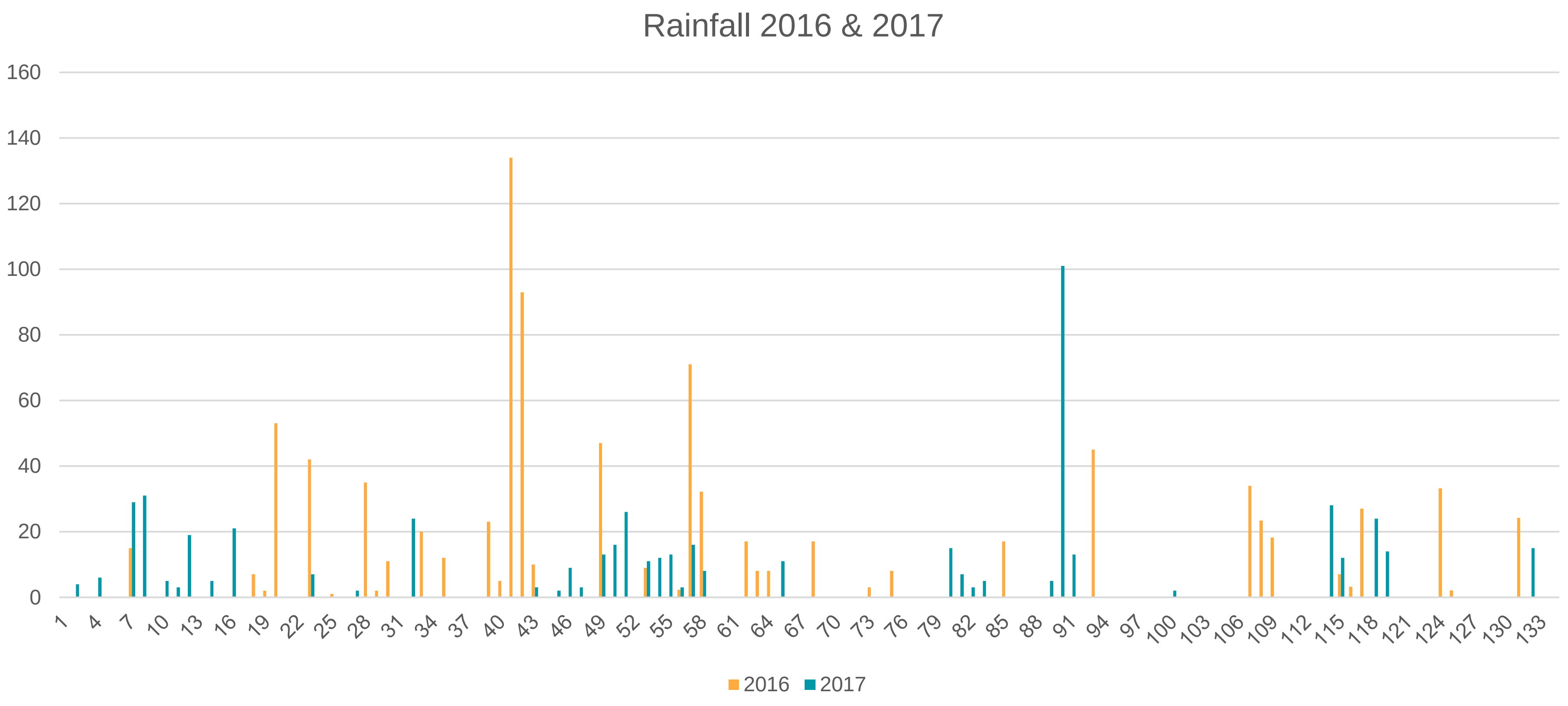
133
2015
2017


Rainfall 2016 & 2017
160
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130
133
2016
2017

# Discussion on phase II MoU

- A1-Soil Analysis on Yavatmal Data
- A2 and A3 – Better estimation of ET and PET for Non agricultural lands, Micro irrigated lands.
- A4 Incorporation of Groundwater Flows
- A5 Groundwater Flows
- A6 Zoning Automation
- A7 Analysis of Mahabhulekh Data for PoCRA app
- E1 and E2 dashboard design, extension.
- E3 and E4 Point level app

# Item A1-Soil Analysis on Yavatmal Data

| | MRSAC Data | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Soil texture | LS | C | HM | SL | SiL | GSCL | M | GCL | GC | CL | GL | SCL | WM | GSL |
| **NBSSLUP Data** | i | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| | m | 38 | 5461 | 118 | 113 | 96 | 823 | 6 | 2101 | 194 | 1099 | 15 | 54 | 274 | 634 |
| | k | 0 | 440 | 3 | 27 | 14 | 28 | 11 | 146 | 3 | 62 | 2 | 2 | 7 | 52 |
| | h | 0 | 16 | 0 | 13 | 0 | 7 | 0 | 41 | 2 | 56 | 5 | 1 | 0 | 23 |
| | f | 1 | 253 | 5 | 9 | 0 | 152 | 0 | 381 | 39 | 163 | 10 | 25 | 26 | 558 |

**Maximum Value in Row**

**Maximum Value in Column**

**Maximum Value in both Row & Column**

**Notations used:-**

1. CL-Clay loam
2. C-Clayey
3. GC-Gravelly clay
4. GCL-Gravelly clay loam
5. GL-Gravelly loam
6. GSCL-Gravelly sandy clay loam
7. GSL-Gravelly sandy loam
8. LS-Loamy sand
9. SCL-Sandy clay loam
10. SL-Sandy loam
11. SiL-Silty loam
12. HM-Habitation Mask
13. WM-Waterbody Mask
14. M-Mining

# Item A1-Soil Analysis on Yavatmal Data

| | MRSAC Data | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **NBSSLUP Data** | Soil Depth | D | VS | DTVD | HM | S | M | WM | MD | VD | STVS |
| | 0 | 12 | 4 | 0 | 91 | 130 | 14 | 220 | 34 | 231 | 23 |
| | 1 | 101 | 55 | 0 | 8 | 2080 | 0 | 8 | 698 | 489 | 297 |
| | 2 | 67 | 178 | 0 | 5 | 1002 | 0 | 8 | 405 | 690 | 147 |
| | 3 | 87 | 3 | 1 | 5 | 354 | 0 | 21 | 255 | 823 | 79 |
| | 4 | 22 | 0 | 1 | 1 | 216 | 0 | 0 | 143 | 453 | 44 |
| | 5 | 0 | 0 | 0 | 0 | 72 | 0 | 0 | 29 | 78 | 6 |
| | 6 | 138 | 15 | 3 | 16 | 627 | 3 | 50 | 395 | 2579 | 95 |

**Notations used:-**

1. M-Mining
2. WM-Waterbody Mask
3. HM-Habitation Mask
4. VS-Very shallow (< 10 cm)
5. S-Shallow (10 to 25 cm)
6. STVS-Shallow to very shallow (< 25 cm)
7. MD-Moderately deep (25 to 50 cm)
8. D-Deep (50 to 100 cm)
9. DTVD-Deep to very deep (> 50 cm)
10. VD-Very deep (> 100 cm)

| |
|---|
| **Maximum Value in Row** |
| **Maximum Value in Column** |
| **Maximum Value in both Row & Column** |

# Cont.

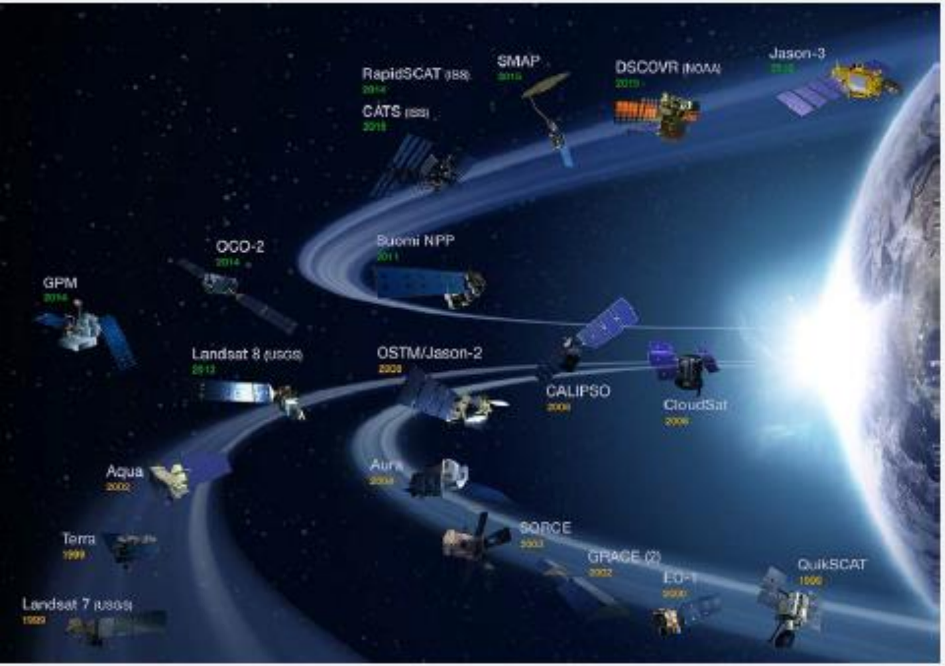
- Better Inputs will increase the water balance computation.
- Soil Texture and Soil Depth Analysis of 10 villages to give us actual values od soil composition to br used in model.
- MRSAC or NBSS&LUP have not given these values.
- Texture/depth validation of NBSSLUP data with MRSAC.
- Possible Collaboration with NBSS & LUP.

- 2 Man Month + 2 month

# A2 and A3 – Better estimation of ET and PET for Non agricultural lands, Micro irrigated lands

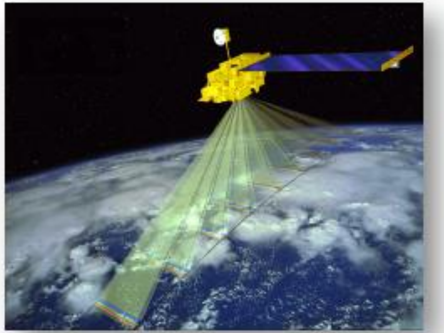
- Primary Approach – Prepare a framework and set of field experiments to compute Kc values for the Important crops like soyabean, cotton, tur, moong etc. and work with SAU's.
- Secondary Approach – Use of Satellite products available and weather parameters for better computation of PET, ET and water productivity.
- Water productivity measures the annual increase in water productivity at sub district level (taluka); it is expressed as a ratio of agricultural production (in kg) over evapotranspiration (in m3). It is measured from Year 3 onwards and for kharif season only. It is expressed as percentage change relative to a baseline value of **0.23 kg per cubic meter**.

# NASA Satellites for Water Resources Monitoring




- Landsat: 07/1972 – present
- Tropical Rainfall Measuring Mission (TRMM): 11/1997 – 04/2015
- Global Precipitation Measurements (GPM): 02/2014 – present
- Terra: 12/1999 – present
- Aqua: 05/2002 – present
- Soil Moisture Active Passive (SMAP): 01/2015 – present
- Gravity Recovery and Climate Experiment (GRACE): 03/2002 – present
- Jason 1, 2, 3: 12/2001 - present

# MODIS (Moderate Resolution Imaging Spectroradiometer)



- Spatial Resolution
  - 250m, 500m, 1km
- Temporal Resolution
  - Daily, 8-day, 16-day, monthly, quarterly, yearly
  - 2000-present
- Data Format
  - Hierarchal data format – Earth Observing System Format (HDF-EOS)

- Spectral Coverage
  - 36 bands (major bands include Red, Blue, IR, NIR, MIR)
    - Bands 1-2: 250m
    - Bands 3-7: 500m
    - Bands 8-36: 1000m
- Orbital gaps

Normalized Difference Vegetation Index (NDVI)

• Leaf Area Index (LAI)

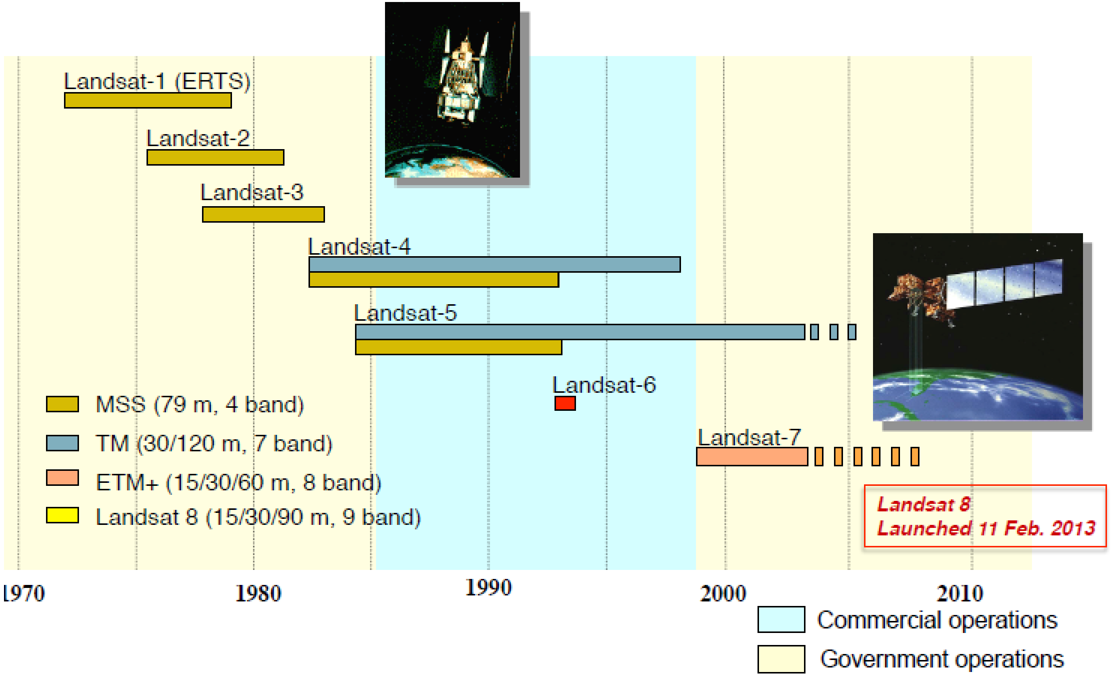
• Albedo (fraction of surface solar radiation reflected back)

# VIIRS
## Visible Infrared Imaging Radiometer Suite

- Spatial Resolution
  - 375 m, 750 m
- Temporal Resolution
  - Daily, 8-day, 16-day, monthly, quarterly, yearly (2012-present)
- Spectral Coverage
  - 22 bands
    - Major bands include R,B, IR, NIR, MIR
    - "I" bands: 375 m
    - "M" bands: 750 m
    - Day-night band: 800 m
- No orbital gaps

*VIIRS was launched on 28 October, 2011*

# Landsat: 30 Years of Observations




- Allows field-level ET (30 m resolution) – much higher resolution than MODIS based ET (1 km)
- Has a thermal band that is important for some ET approaches

# Importance of ET

- The sum of evaporation from the land surface plus transpiration from plants.
- ET transfers water from land surface to the atmosphere in vapor form.
- Energy is required for ET to take place (for changing liquid water into vapor)
- ET depends on many variables:

– solar radiation at the surface

– land and air temperatures

– humidity

– surface winds

– soil conditions

– vegetation cover and types

- Highly variable in space and time

# ET can be derived primarily from:

– Surface Water Balance

ET = Precipitation + Irrigation – Runoff – Ground Water + Vertical Water Transport ± Subsurface Flow ± Soil Water Content

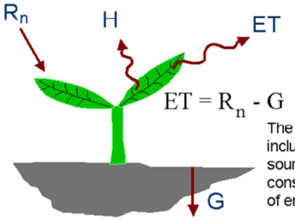
– Surface Energy Balance

- ET (Latent Heat Flux) = Net Surface Radiation – Ground Heat Flux –Sensible Heating Flux

– Meteorological and Vegetation/Crop Data (Penman-Monteith Equation)

# Surface energy balance

ET is calculated as a "residual" of the energy balance




$$ET = R_n - G - H$$

The energy balance includes all major sources ($R_n$) and consumers (ET, G, H) of energy

# Sensible Heat Flux (H)

$$H = (\rho \times c_p \times dT) / r_{ah}$$

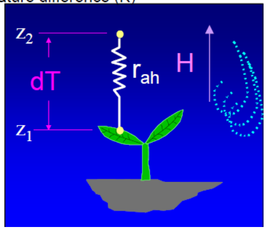
dT = "floating" near surface temperature difference (K)

$r_{ah}$ = the aerodynamic resistance from $z_1$ to $z_2$

$$r_{ah} = \frac{\ln\left(\frac{z_2}{z_1}\right) - \Psi_{h(z_2)} + \Psi_{h(z_1)}}{u_* \times k}$$

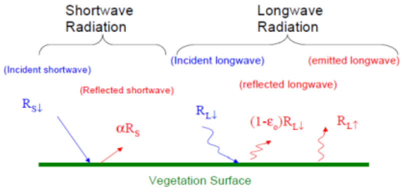
$u_*$ = friction velocity

k = von karmon constant (0.41)




# Surface Radiation Balance

## Surface Radiation Balance




**Net Surface Radiation = Gains – Losses**

$$R_n = (1-\alpha)R_{S\downarrow} + R_{L\downarrow} - R_{L\uparrow} - (1-\varepsilon_o)R_{L\downarrow}$$

$R_L = \varepsilon\sigma T^4$

ε=emissivity

$\sigma = 5.67\ 10^{-8}$ Stefan Boltzm

# Soil heat flux

$$G = f\ R_n$$

- Fraction depends on direct exposure
- Fraction depends on pace of warming up

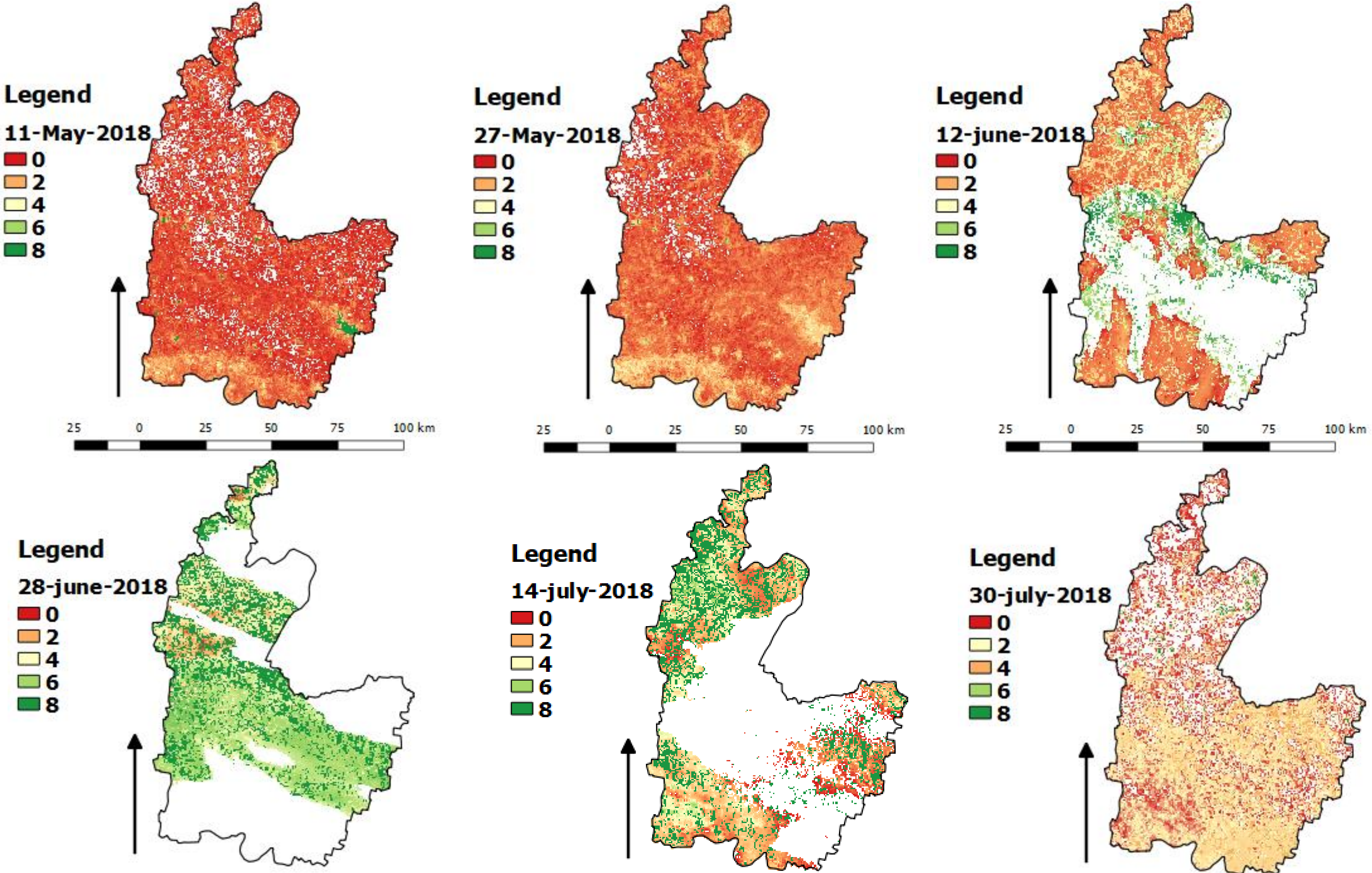
f = 0.4 for deserts
= 0.1 for crops
= 0.5 for water bodies
= 0.05 for forests

# Penman-Monteith Equation for ET

$$\lambda ET = \frac{\Delta(R_n - G) + \rho_a c_p \frac{(e_s - e_a)}{r_a}}{\Delta + \gamma\left(1 + \frac{r_s}{r_a}\right)}$$

- $R_n$: net surface radiation
- G: ground heat flux
- $(e_s-e_a)$: vapor pressure deficit
- $r_a$ & $r_s$: aerodynamic & surface resistance
- $\gamma$: psychrometric constant
- $\lambda$: latent heat constant
- $c_p$: specific heat constant

- Requires climate and crop information
- $r_a$ & $r_s$ depend on Vegetation Height, Leaf Area Index (LAI)
- $R_n$ depends on the fractional solar radiation reflected back from the surface (albedo)
- LAI and albedo are both available from MODIS


Legend
11-May-2018
0
2
4
6
8
25 0 25 50 75 100 km
Legend
27-May-2018
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8
25 0 25 50 75 100 km
Legend
12-june-2018
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4
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28-june-2018
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30-july-2018
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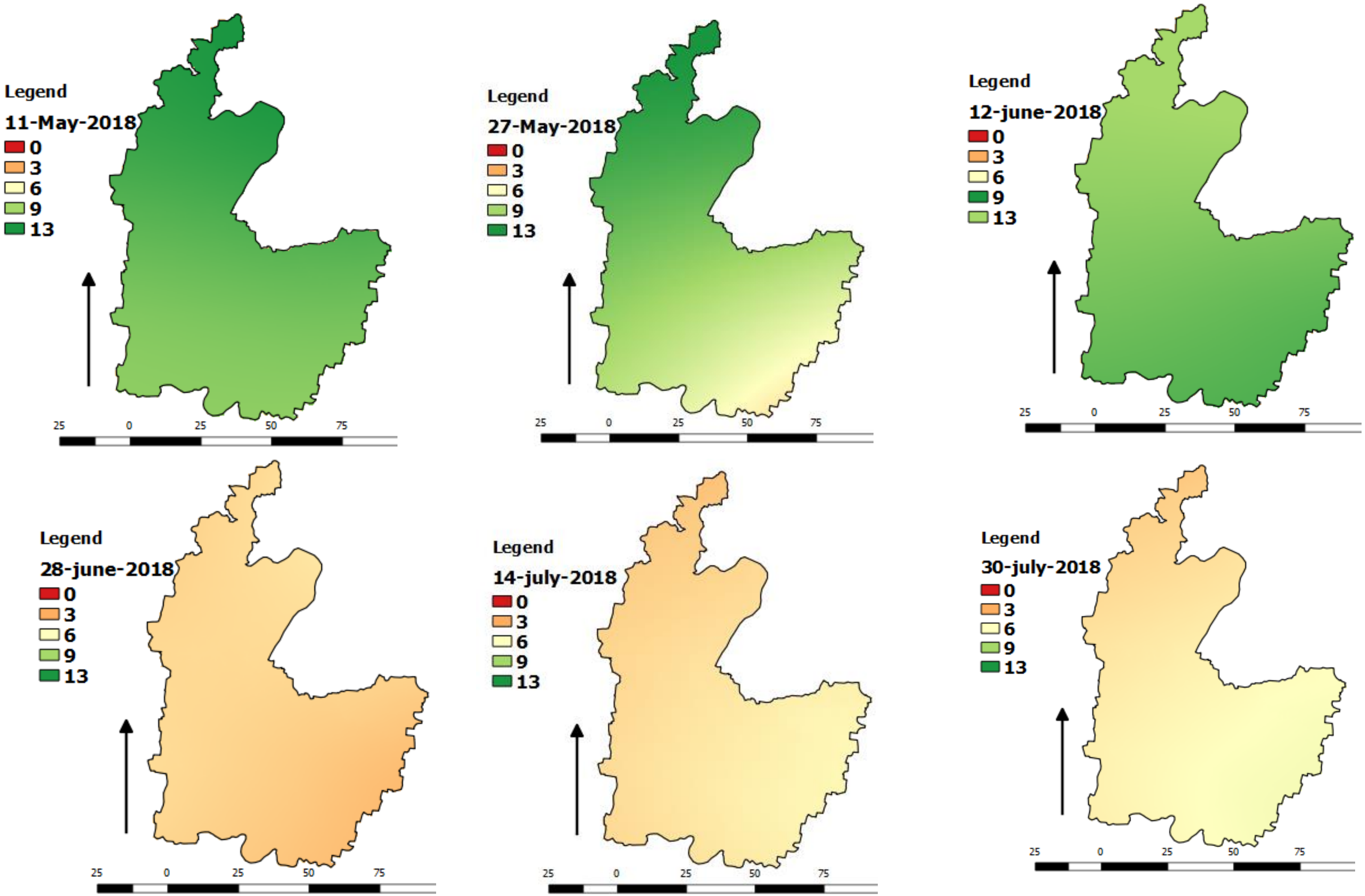
8


Legend
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27-May-2018
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Legend
12-june-2018
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Legend
28-june-2018
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25 0 25 50 75
Legend
14-july-2018
0
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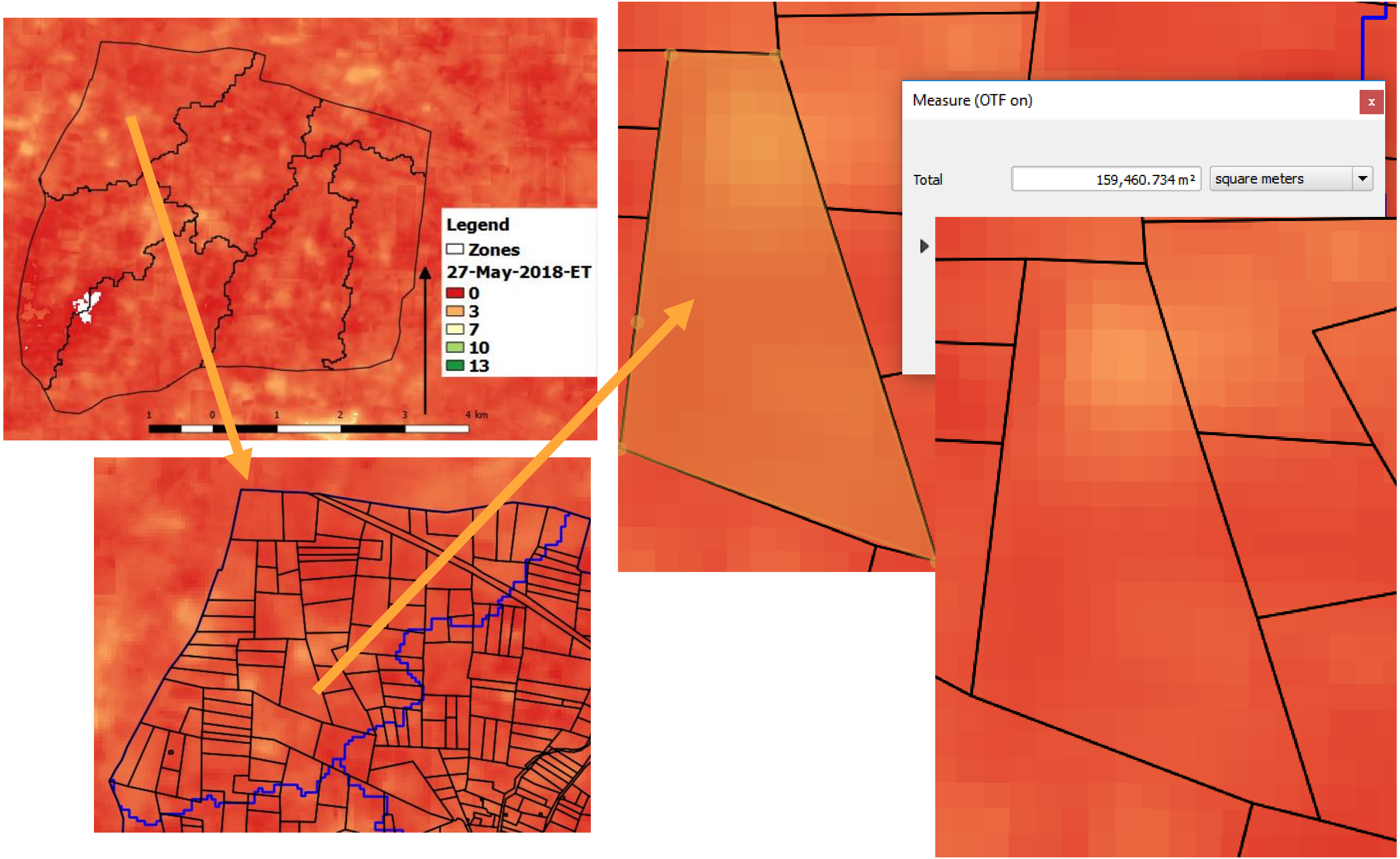
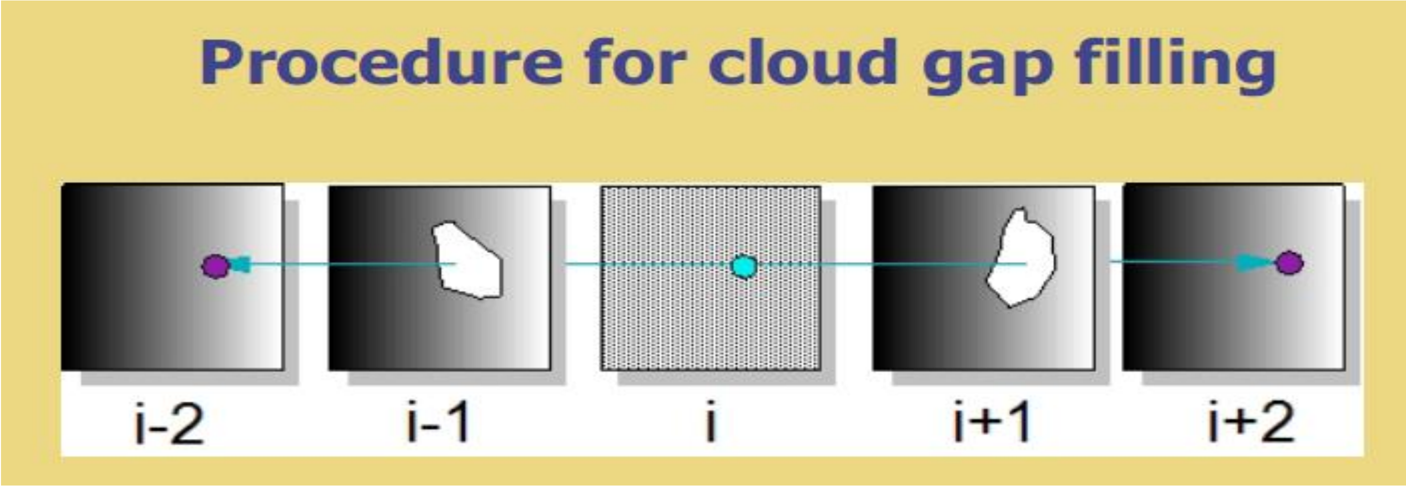
6
9
13
25 0 25 50 75
Legend
30-july-2018
0
3
6
9
13
25 0 25 50 75


Legend
Zones
27-May-2018-ET
0
3
7
10
13
1 0 1 2 3 4 km
Measure (OTF on)
Total
159,460.734 m²
square meters

# Challenges

- Landsat passes over each 16 days
- Parts of the image area are often cloudy
- Landsat ‘snapshot’ may miss the evaporation from rain events in between satellite dates



- Computation of water productivity using landsat or Modis.

Identify suitable pixels and suitable farmers for the following components. This will Improve the existing water balance model.

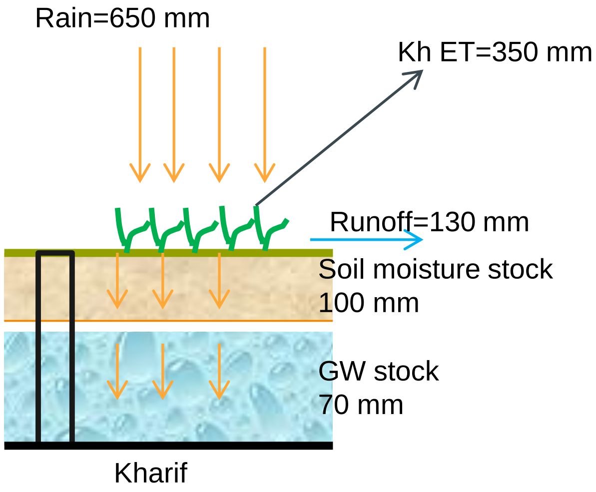
- Evaporation from Non ag landuse area and treated area
- Kc management for various crops important for project area.
- Study, Incorporating and validating Drip/sprinkler PET’s for various crops.

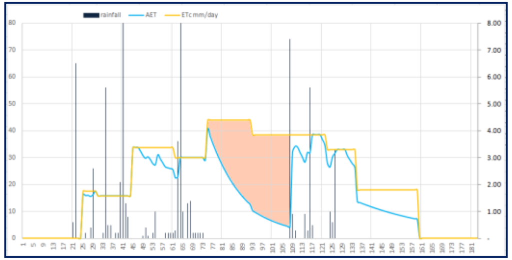
I. 2 Man months for Primary Experimentation.
II. 3 man months - for studying existing approaches or models for ET computation, various satellite products available from different countries.
III. 3 man months for various components like kc for different crops, non ag land and impact of drip and sprinkler.
IV. 1 man month for developing PET model for daily computation using various weather parameters. Item E3
V. 3 man months for integration into the dashboard. Item E3

- 2 Man Months + 3 man months+ 3 man months

# A4 Incorporation of Groundwater Flows

# PoCRA soil moisture balance model




The current PoCRA model is based on the point level daily soil moisture balance model

Which takes daily rainfall as input and gives
1. point/farm level soil moisture
2. Crop AET
3. Surface runoff generated at farm level and
4. Vertical groundwater recharge at farm level

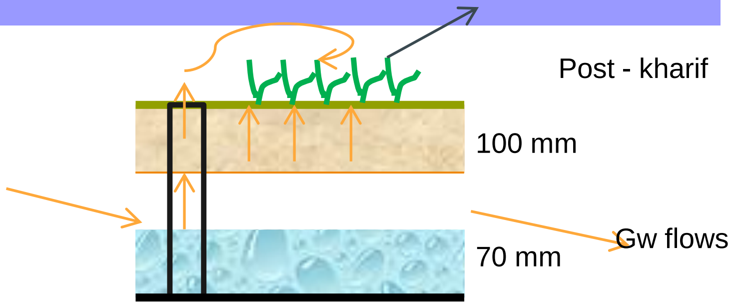
From this daily balance, all these quantities are Aggregated for the whole season

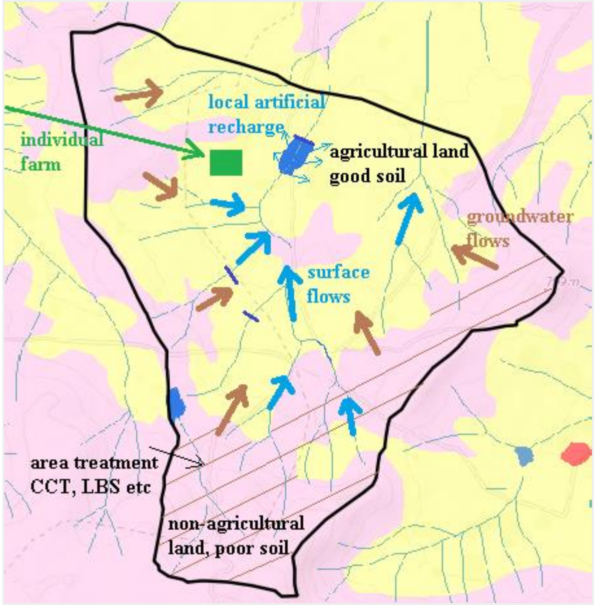
At the same time, all the quantities are Aggregated spatially for the zones

**This is very important to determine crop water stress/deficit during kharif season and identify the vulnerable regions in the village**

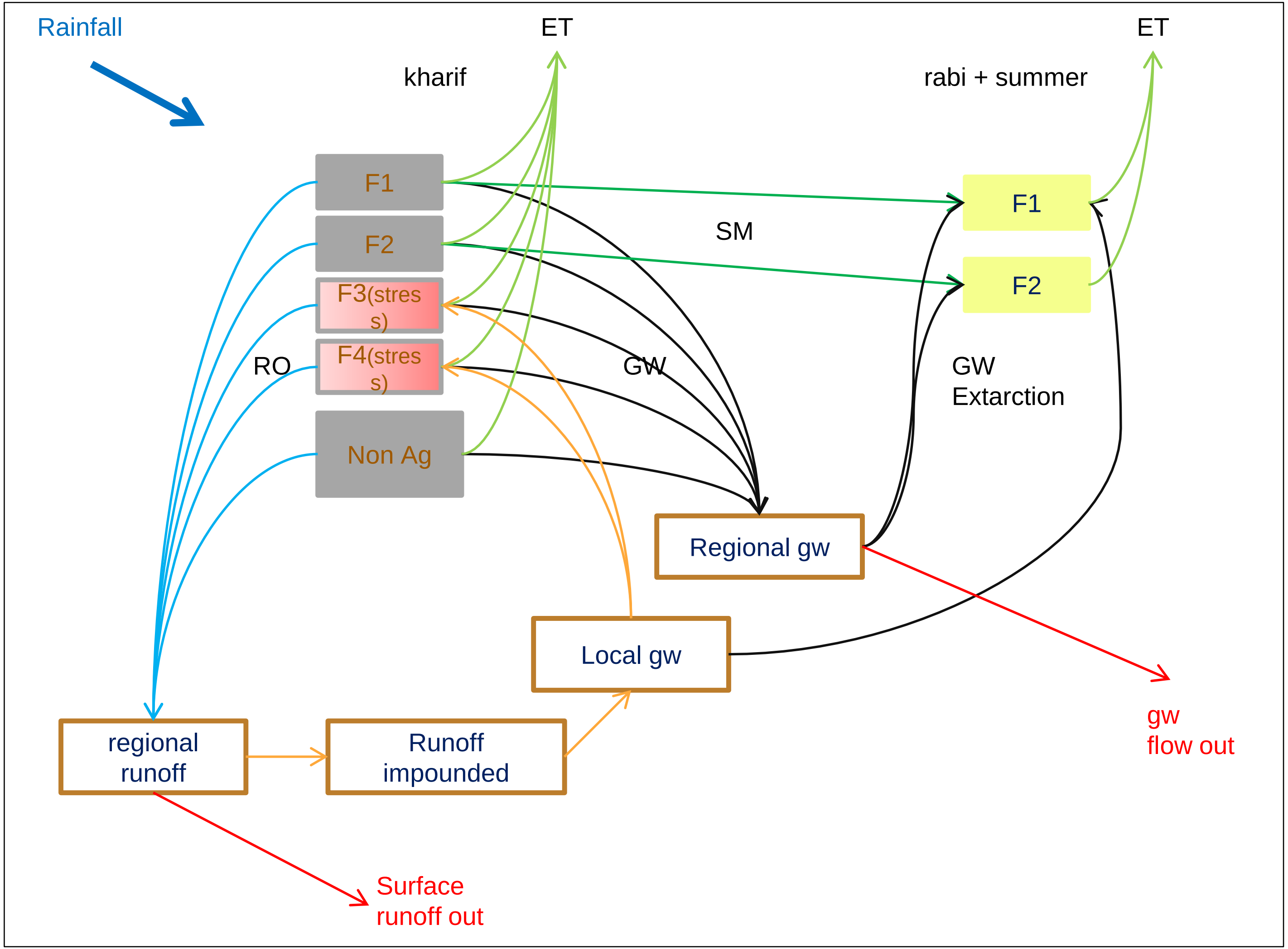
# Need for estimating regional flows

- During kharif, soil moisture is the key determinant of the farm level crop security
- But post – kharif crop water security depends on –
    - Surface runoff impounded which increases gw locally
    - Groundwater / sub-surface flows
    - Baseflows
- Which are all regional flows. All flow from the recharge area to discharge area (high gradient to low gradient)
- These flows together with impounding structures determine access to water in rabi and summer seasons



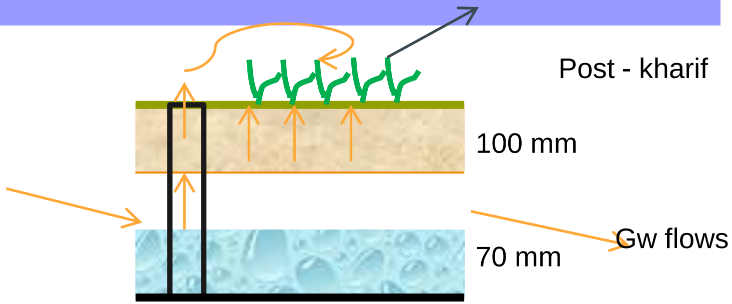




Hiware bajar map

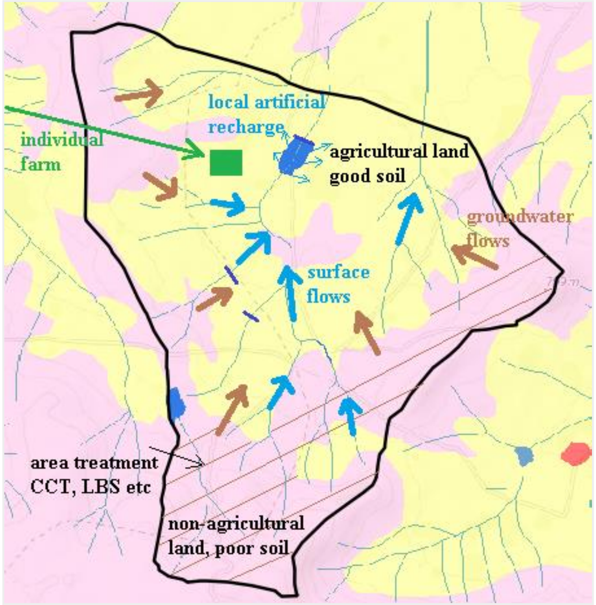

Rainfall
ET
kharif
ET
rabi + summer
F1
F2
F3(stress)
F4(stress)
Non Ag
SM
F1
F2
RO
GW
GW
Extarction
Regional gw
Local gw
regional
runoff
Runoff
impounded
gw
flow out
Surface
runoff out

# Need for estimating regional flows

- Thus, soil moisture is in-situ
- can be transferred from kharif to rabi on the same farm
- is not transferred from one farm to other

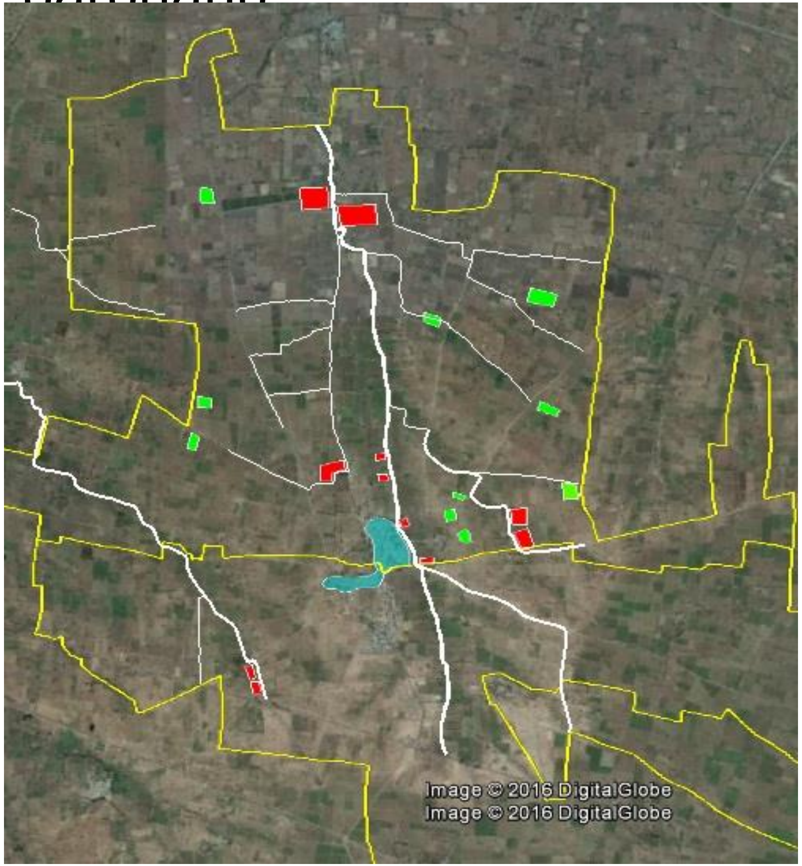



- Surface runoff and Groundwater flows are regional
- Recharge and runoff generated on one farm or on non-ag land during kharif are transferred to different farms in rabi (due to gradients and geological setup)
- **Thus, cannot be transferred from kharif to rabi on the same farm**




Hiware bajar map

# Gw and surface flows towards stream proximity (pedgaon, parbhani)



# Way ahead

- Thus, there are significant transfers of w1 + w2 water from p3 farmers to p1 or p2 farmers
- Identifying recharge and discharge areas to estimate the intra-zone flow transfers is important. PoCRA zones if realigned with this logic, can help in estimating these regional natural transfers of water
- These are important factors which need to be considered while planning for the interventions.

- New models required
    - Water balance for impounding structures to determine actual gw rechagred (currently only volume of impounding structure considered which might underestimate the gw recharge)
    - Simple thumbnail conceptual GW flow model for intra-zone flows which can be verified / validated by MODFLOW

3 month

# Item A6 Zoning Automation

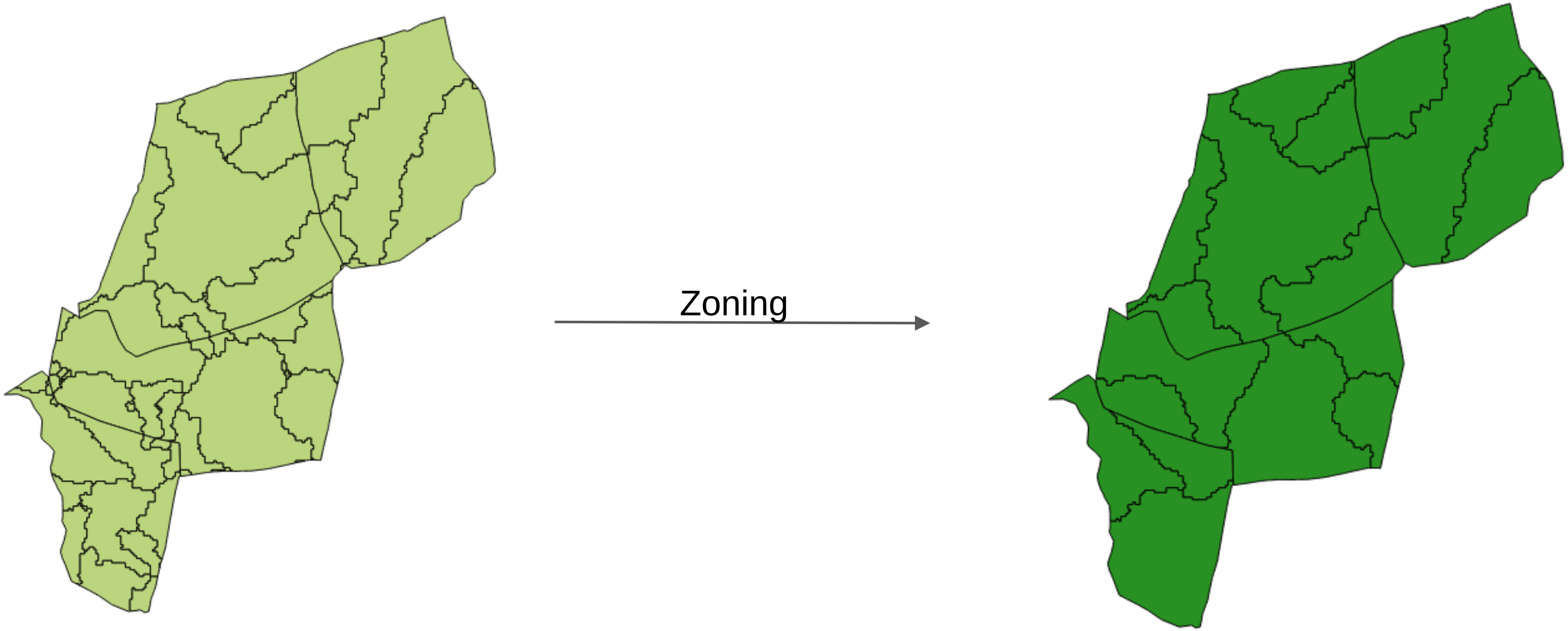
- Partial automation of zones is achieved.
- Testing is on going.
- Inclusion of stream proximity.
- Achieving its automation.

- 1 Man Month + 3 month

# Steps of Zoning

1. Generate Stream and Watershed from DEM
2. Load Village and Watershed Layer
   a. Add zone_area attribute to watershed layer
   b. Apply Eliminate Sliver Polygons algorithm with appropriate threshold to watershed layer
3. Intersect Village and Cleaned Watershed Layer
4. Clip the Intersected layer to generate separate polygons for each village
   a. Update the zone_area attribute of each Clipped layer
5. Clean the separated polygons individually
   a. Use v.clean with appropriate threshold for each layer
6. Merge all the Cleaned Layers
   a. Update the zone_area attribute of the merged layer

# In short..

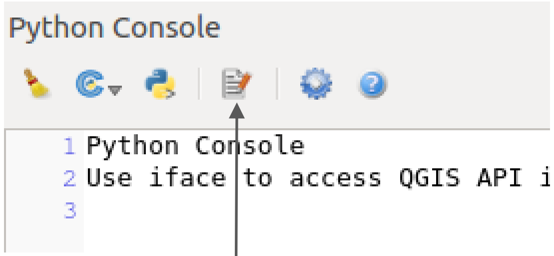



Intersected Layer

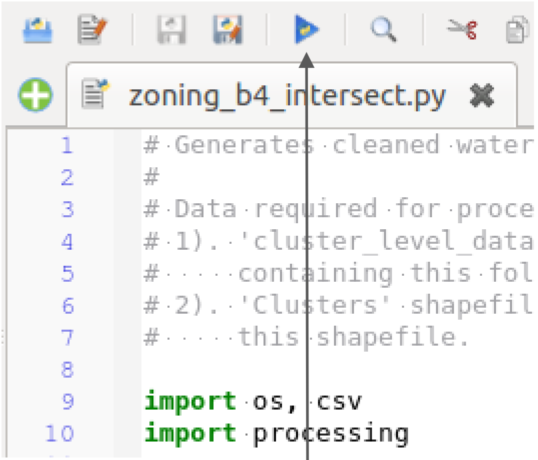
Merged Layer

# Running Zoning Script


Click on “Python Console”
(Top right of QGIS panel)



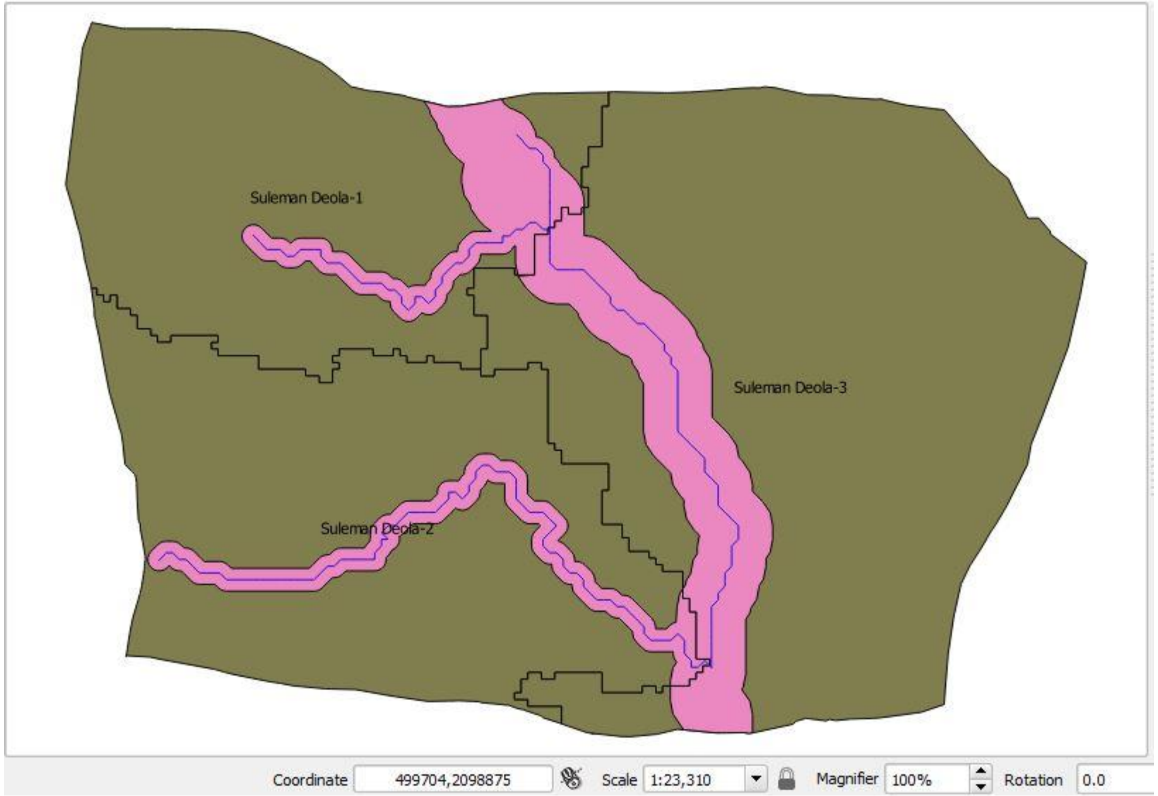

Click on “Show Editor”
option in Python Console




Copy paste the script and click on “Run Script” option

Note:-You need to set the “path” variable to DEM,Village Boundary containing folder before running the script.

# Inclusion of stream proximity




- Variation in Surface and ground water availability in stream proximity and non proximity will be taken into account

# Item- A7 Analysis of Mahabhulekh Data for PoCRA app

# Need of the Mahabhulekh data

- Cropping pattern data is critical for **water budget computation** as it is representative of actual cropping pattern in the zone and same can be used to evaluate the new **zoning*** criteria.
- Currently we are running cropping pattern over entire region and then aggregating over entire agricultural region of the zone.
- If we get the cropping data consistent with the cadastral maps then it can be used to compute the water budget of the region with respect to its cropping pattern.
- Efficient Zone based Water Budgeting
- Reduced Computation Time
- Advisory Support
- Enable Predictions

# Comparative Analysis on Mahabhulekh & Cadastral Data

For a given district and taluka, the ccode(state census code for village), Location/Village name and Gat number count for both Mahabhulekh and Cadastral data can be obtained for all the villages.

Below is one such sample (Yavatmal-Kalamb):-

| | | Mahabhu_Gat_no_count | MRSAC_Gat_no_count |
|---|---|---|---|
| ccode | location | gat_no_count | p_gat |
| 271400030171660000 | चापर्डा | 30 | 121 |
| 271400030171670000 | बेलोना | 44 | 136 |
| 271400030171680000 | घोटी | 37 | 170 |
| 271400030171690000 | कळंब (खंड 1 ) | 61 | Kalamb=993 |
| 271400030171690000 | कळंब खंड2 | 152 | Kalamb=993 |
| 271400030171700000 | मलकापूर | 31 | 54 |
| 271400030171770000 | जोंधळणी | 28 | 29 |
| 271400030171780000 | दत्तापुर | 10 | 73 |
| 271400030171810000 | औरंगपूर | 5 | 15 |
| 271400030171850000 | सातेफळ | 13 | 59 |

# Comparative Analysis on both data

It can be seen that there is significant difference in the cadastral and mahabhulekh data count of gat no.Also,it has been observed that the data sent in postgres db form is less than that of sent in excel format.

**Data Analysis:**

| Parameter | Mahabhulekh | Cadastral (PoCRA) |
|---|---|---|
| District Count | 12 | 15 |

Missing:-Hingoli,Parbhani,Washim

District Name:- Akola

| Parameter | Mahabhulekh | Cadastral (PoCRA) |
|---|---|---|
| Taluka Count | 7 | 7 |
| Village Gat Number Count for Taluka | | |
| Taluka name | Mahabhulekh Village Count | Cadastral (PoCRA) Village Count |
| Akola | 19 | 199 |
| Akot | 6 | 180 |
| Balapur | 2 | 103 |
| Barshitakli | 4 | 159 |
| Murtijapur | 2 | 162 |
| Patur | 3 | 96 |
| Telhara | 4 | 106 |
| | | |

- 2-4 man months

# Item B, C, D

## Planning and Measurement Framework to Target Project Development Objectives

# Target Project Development Objectives by streamlining Planning and Measurement Framework

**Planning Activities**

1. Targeting vulnerable smallholder farmers
2. Incorporating planning based on spatial variability
3. Planning to enable farmer movement into higher income category

2,3

**Targeted PDO**

1. Increased Water productivity
2. Improved yield uniformity and stability (spatial and temporal yield variability)
3. Annual farm income

1,2,3,4

**Measurement activities**

1. Increase in yield for main kharif and rabi crops
2. Inter zonal yield variation, increased water availability, rabi area etc.
3. Farmer movements to higher return crops
4. yield/water given for selected beneficiaries

Participants: Shubhada Sali, Pooja Prasad

Total Man months: 9-12

# Key Tasks

B. Development of suitable indices aligned with PDO’s

- We follow Budyko principles (Also as in S. Muddu)

C. Developing Guidelines for Planning so that plans are aligned with B

D. Evaluation and analysis of DPR to ensure that B and C are followed

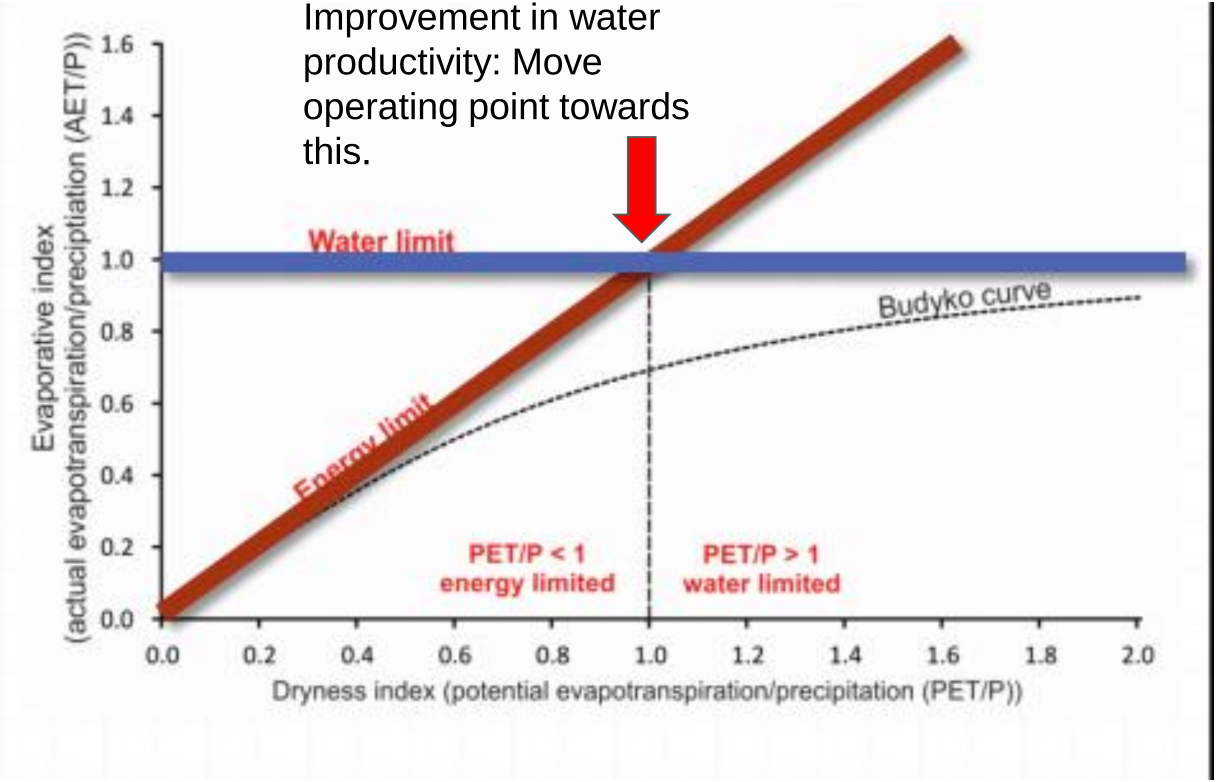
# Measuring watershed yields: Budyko curve

**Indicator: Improved Water utilisation**

1. AET/Effective Rainfall: Indicates the extent of rainfall being useful to crops with optimal value at 1
2. AET/PET - indicates the extent of water requirement fulfilled and an indicator of yield (optimal value at 1)

We plot village operating point based on water allocations to various crops from water budget based planning framework.

Improvement in water productivity: Move operating point towards this.



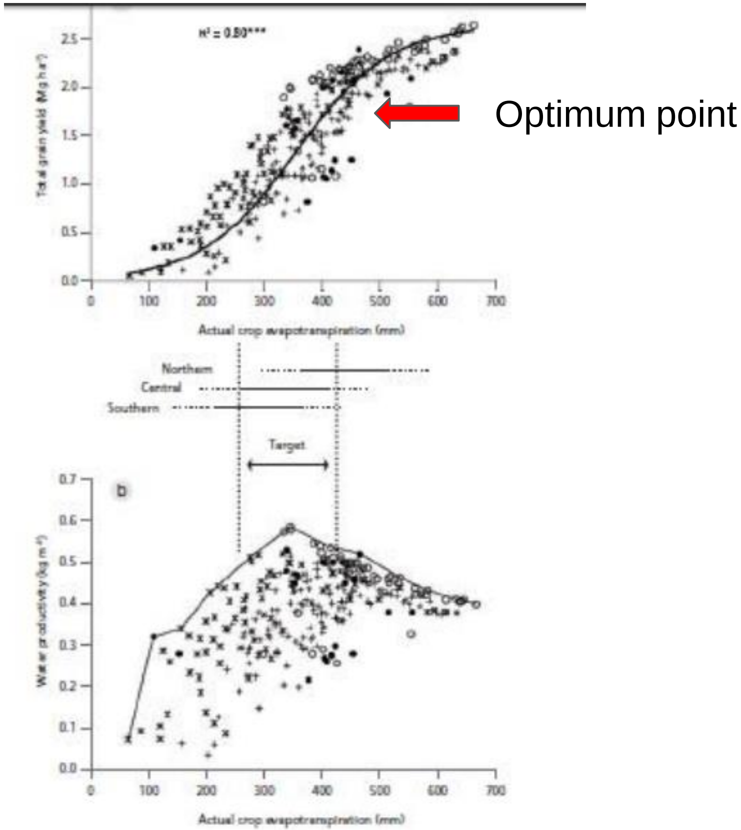
# Tracking water productivity: Yield Watering Curve

1. The operating point on yield watering curve for each of main P1, P2 and P3 crops in village will be measured and its movement towards optimum point will be tracked temporally.
2. The water allocation regime based on planning framework will be utilized for this.

$$\frac{\text{Yield * Area}}{\text{(AET+Water Allocation)}} \quad \text{(kg/cum)}$$

**If Yield watering curves for main crops in PoCRA region are available from Agricultural universities**

1. **enable tracking wrt optimum point**
2. **Enable measurement of water given to crops**




Source: FAO

# Old indices and its problems

1. Monsoon protective irrigation index:

$$\frac{\text{Monsoon supply } ((\frac{1}{2}) \text{ of arrested runoff} + (\frac{1}{3}) \text{ of ground water recharge})}{\text{Monsoon Demand (Monsoon protective Irrigation requirement)}}$$

2. Post Monsoon water use index:

$$\frac{((\frac{1}{2}) \text{ of arrested runoff} + (\frac{2}{3}) \text{ of ground water} + (\text{soil moisture for rabi})}{\text{Post monsoon crop deficit} + \text{drinking water requirement}}$$

# Typical village indices

| Village | Paradgaon ( 2927 ha, 547 mm- 2013 rainfall | Ghusar (2887 ha, 588 mm - 2015 rainfall) | Wadhwi (562 ha, 473 mm 2017 rainfall) |
|---|---|---|---|
| Monsoon supply in TCM | 505 | 232.7 | 618 |
| Monsoon demand in TCM | 3214 | 737 | 167 |
| **Monsoon Index** | **0.16 (-2709 TCM)** | **0.31 (-505 TCM)** | **0.27 (-446 TCM)** |
| Post Monsoon supply in TCM | 1808 | 1968 | 259 |
| Post Monsoon demand in TCM | 8504 | 6841 | 443.4 |
| **Post Monsoon index** | **0.21 (-6697 TCM)** | **0.28 (-4837 TCM)** | **0.59 (-183 TCM)** |
| **Main crops** | **Cotton ( 45% area), others soybean, tur** | **Cotton (54% area) and Moong (28% area)** | **soyabean (61%) and Tur (19%)** |

Connection with PDO's not clear, largely intervention and planning based indices….

# Problems and need for refined indices

- **Dryland farming** involves **less irrigation** translating into **low AET for high PET**
- Crops are **watered** based on their **risk and returns**
- Crops like soybean, moong, bajra are not watered at all in preference of watering to high return crops like cotton, onion in kharif.

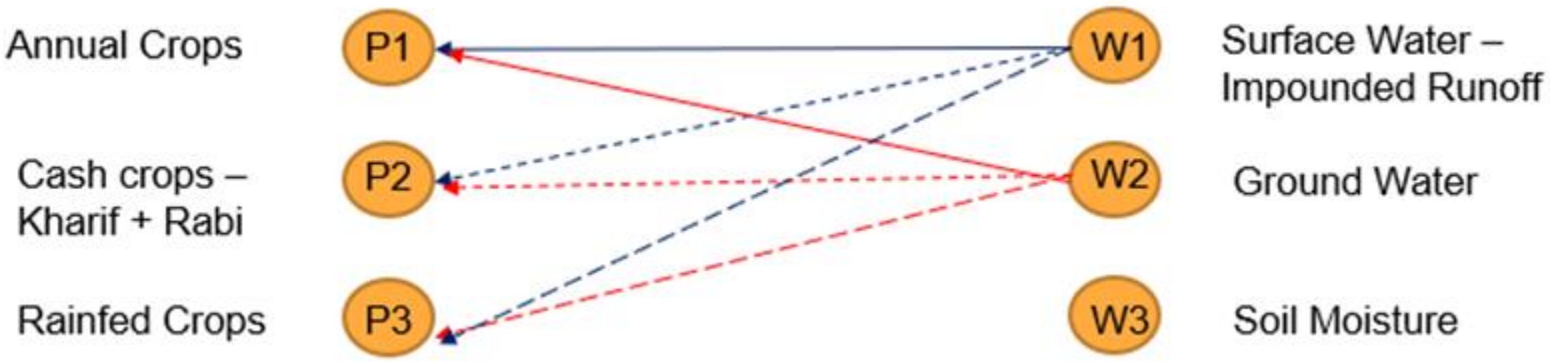
**In order to take field practices, risks and returns of crops into account there is need to develop crop hierarchy and water allocation framework**

- In case of long kharif crops like cotton and Tur with 350 mm of post monsoon requirement, at most 2 irrigations are given by farmers in November to get optimum yield. 250 mm of irrigation requirement in not met.

**To account for dryland irrigation there is a need to consider optimum point on yield watering curve**

# Crop hierarchy and Water Allocation framework

- Measuring compulsory load (P1) and discretionary load (P2,P3) in the village
- Measuring Water availability – W1- surface storage, W2 - GW recharge and W3 - soil moisture
- Strategizing intervention planning to convert P2 load to P1, P3 load to P2 or P1 to more area




- Preparing norms to limit no. of proposed farm ponds, wells
- Measuring how much additional land can be brought under P1 crops without damaging P3 crops
- This can be converted into an handheld planning analysis app

# Crop Hierarchy and water allocation based on irrigation priority

| Priority | Description | Kharif crops | Rabi crops | Current cropped Area (ha) |
|---|---|---|---|---|
| P1 | 100% committed water | Sugarcane, mosambi, limbu, grapes, | | 42 |
| P2 | Plan to irrigate (but may be unable to) | Soybean, irrigated cotton/tur | Wheat | 588* |
| P3 | No plan to irrigate | Rainfed cotton, tur, Mung, Kharif Jowar, Bajri | Harbhara, Rabi Jowar (fodder) | 2866* |

*Note: since we do not have separate cropped area for irrigated and rainfed crops it is assumed that 10% of cotton and tur area is irrigated and 90% is rainfed

**Water Allocation**

1. Allocate W1, W2 and W3 water to reach 0.9 AET/PET for P1 crops
2. If water remains after satisfying P1 demand - allocate remaining water to reach 0.7 AET/PET for P2 kharif crops
3. If water remains after satisfying P2 kharif demand allocate the remaining water to P2 rabi crops, P3 rabi crops in sequence.

- Water allocations will be studied and refined based on farming practices
- To study and develop crop hierarchy based on risks, returns and input costs

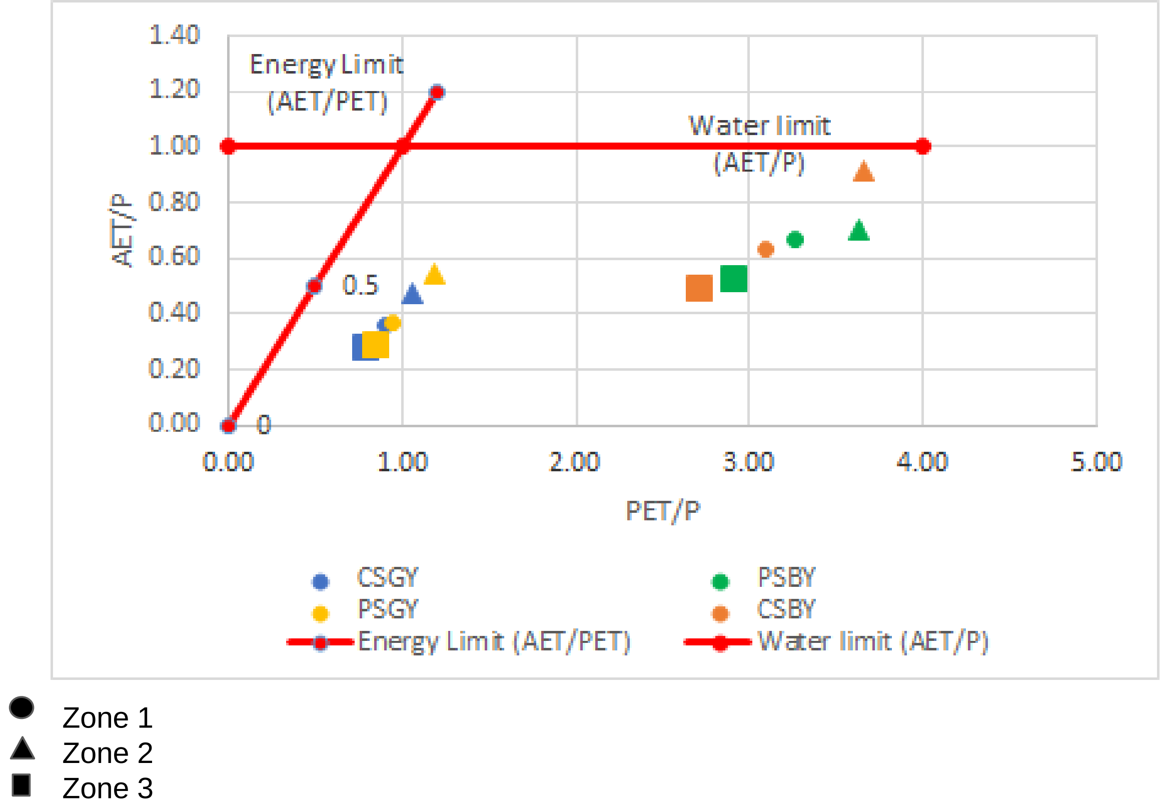
# Key Indices - Water Productivity + Zone-level Temporal variability

1. AET/PET (yield index) and water availability (AET/P) at zone level for each crop type, i.e., P1-P3.

- Pre-plan, post-plan for next 3 years.
- Secondary. Based on year-wise cropping pattern, rainfall, completed interventions and simulation (water budget).

  - To be done for all project villages, and all years with circle rainfall.
  - Detailed methodology to be developed and documented.
  - Extension of PoCRA App will be provided.

# Secondary measurements: AET/PET (Village Suleman Deola)




1. Movement towards water limit from CSGY to PSGY indicates improved water utilization
2. Movement towards right on PET/P axis indicates increase in cropping area or cropping pattern shift.

(note that the PET/P in bad year are higher because of low rainfall)

- **PoCRA aims to minimize this variation in bad and good year (climate resilience) and track improved water availability**

# Zonal details: Suleman Deola

| | CSGY - 753 mm 2017 | | | PSGY - 753 mm 2017 | | | CGBY - 218 mm 2015 | | | PSBY 218 mm 2015 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Indicators** | **Zone1** | **Zone2** | **Zone3** | **Zone1** | **Zone2** | **Zone3** | **Zone1** | **Zone2** | **Zone3** | **Zone1** | **Zone2** | **Zone3** |
| PET/rainfall | 0.9 | 1.1 | 0.8 | 1.0 | 1.2 | 0.8 | 3.1 | 3.7 | 2.7 | 3.3 | 3.6 | 2.9 |
| AET/PET (energy limit) | 0.4 | 0.4 | 0.3 | 0.4 | 0.5 | 0.3 | 0.2 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 |
| AET/P (natural water limit) | 0.4 | 0.5 | 0.3 | 0.4 | 0.5 | 0.3 | 0.6 | 0.9 | 0.5 | 0.7 | 0.7 | 0.5 |
| Ag Area in ha | 211 | 303 | 325 | 211 | 303 | 325 | 211 | 303 | 325 | 211 | 303 | 325 |
| Non Ag Area in ha | 44 | 9 | 186 | 44 | 9 | 186 | 44 | 9 | 186 | 44 | 9 | 186 |
| **Effective Rainfall in mm (P)** | **910** | **775** | **1184** | **910** | **775** | **1184** | **263.5** | **224.5** | **342.8** | **263.5** | **224.5** | **342.8** |
| Effective Rainfall in TCM | 1920.2 | 2349.4 | 3847.8 | 1920.2 | 2349.4 | 3847.8 | 555.9 | 680.2 | 1114.0 | 555.9 | 680.2 | 1114.0 |
| P1 Area | 14 | 15 | 15 | 14 | 15 | 15 | 14 | 15 | 15 | 14 | 15 | 15 |
| P2 kharif Area | **52** | **41** | **120** | **63** | **60** | **135** | **52** | **41** | **120** | **63** | **60** | **135** |
| P2 rabi Area | **24** | **31** | **32** | **36** | **51** | **62** | **24** | **31** | **32** | **36** | **51** | **62** |
| P3 kharif area | 145 | 247 | 190 | 134 | 228 | 175 | 145 | 247 | 190 | 134 | 228 | 175 |
| P3 rabi area | 113 | 175 | 262 | 113 | 175 | 262 | 113 | 175 | 262 | 113 | 175 | 262 |
| P1 PET (mm) | 69 | 60 | 37 | 69 | 60 | 37 | 69 | 60 | 36 | 69 | 60 | 36 |
| P2 kharif PET (mm) | 163 | 163 | 188 | 187 | 234 | 204 | 162 | 163 | 187 | 186 | 138 | 203 |
| P3 kharif PET (mm) | 235 | 325 | 154 | 221 | 305 | 144 | 233 | 321 | 153 | 219 | 302 | 143 |
| P2 rabi PET (mm) | 56 | 58 | 37 | 83 | 95 | 71 | 56 | 58 | 37 | 83 | 95 | 71 |
| P3 rabi PET (mm) | 155 | 196 | 179 | 155 | 196 | 179 | 155 | 196 | 179 | 155 | 196 | 179 |

# Key Indices - Farmer Spatial and Temporal Variability

2. AET/PET (yield index), actual yield and water availability (AET/P) at farmer level for each crop type.

- Pre-plan, post-plan for next 3 years.
- Primary. Based on cropping pattern, CCT and irrigation history
- Two levels - **Interview and CCT based**.

Done for selection of direct beneficiary and indirect beneficiary farmers, across various zones and stream-proximity.

Detailed methodology will be developed.

New farmer survey app will be provided. Extension of DB form will be undertaken.

# Measurements: Farm Level to Village Level

Activities:

1. Interview Based Rapid Assessments
2. Crop Cutting Tests for Yield Measurement

Sampling and Village selection to be decided

- For villages selection at Taluka Level -sample size -  30 - 40 farmers
- For village selection in Cluster - Sample size - 10-12 farmers

# Field Level data Collection for Measurement Activity

1.Crop cutting reports and survey of 10-12* / 30-40* samples farmers in each village based on delineated criteria.

2. Water Budget computed for measurement years

3. Cropping Pattern data for village

4. Market prices of selected crops in village to decide crop hierarchy P1-P2-P3.

5. Input costs per hectare for selected crops in village

# Water productivity

## Computation:

$$\frac{\text{Yield * Area}}{\text{(AET+Water Allocation)}} \quad \text{(kg/cum)}$$

-Conducted at Village level/Zone level for P1, P2 and P3 crops together covering atleast 80% area in village.

- Conducted separately for Main P1 crop, P2 kharif crop and P3 kharif crop at village/zone level

- Conducted for sample farmers in each zone to gauge spatial yield variability

# PDO4: Annual Farm/Village income

| PDO Indicator | Index | Crops | Measurables | Level |
|---|---|---|---|---|
| 1. Shift in cropping pattern at village level<br><br>Track movement of P1, P2 and P3 category farmers to higher income group.<br><br>Measure shift in cropping pattern and shift in minimal profitability | 1.Ratio of P1:P2:P3 kharif crop area<br><br>2. Ratio of profitability range - profitability from P1:P2:P3 | 1.Main P1 crop,<br>2.Main P2 kharif<br>3.Main P3 Kharif (typically rainfed)<br><br>These three crops in total should cover at least 80% of village agricultural area | 1. Selected P1, P2 and P3 crop yields from CCT for village<br>2. P1, P2 and P3 crop area in hectare<br>3. Market price of selected crops for measurement year<br>4. Input cost of selected crops per hectare | Village Level indicator |

# Farmer Selection Guidelines for Measurements

| **Farmer category** | **Main Crops** | **Intervention** | **Farm location** | **Indicator** |
|---|---|---|---|---|
| **Measures vulnerability** | **Measures impact on crop choice** | **Measures impact of intervention** | **Measures spatial variance** | **Measures productivity** |
| P3 farmer with no assets and no watering given | Main P3 kharif crop in village | Public Intervention - streamline (CNB/MNB/PT) | In stream proximity below intervention location | Yield benefit to near stream small holder farmers |
| P2 farmer with no assets | Main P2 kharif crop in village | Public Intervention - streamline (CNB/MNB/PT) | In stream proximity below intervention location | Yield benefit to near stream small holder farmers |
| P2 farmer with new watering asset | Main P2 kharif crop in village | away/not impacted by public intervention | Away from stream proximity | Yield benefit due to project intervention |
| P3 farmer with new watering asset | Main P3 kharif crop in village | away/not impacted by public intervention | Away from stream proximity | Yield benefit due to project Intervention |

*Indirect beneficiaries - pink, direct beneficiaries - purple

# Continued..                                    (for rabi season)

| Farmer category | Crops | Intervention | Farm location | Indicator |
|---|---|---|---|---|
| P3 farmer with no assets and no watering given | Main P3 rabi crop in village | Public Intervention - streamline (CNB/MNB/PT) | In stream proximity below intervention location | Yield benefit to near stream small holder farmers and **movement to high return crop in rabi** |
| P2 farmer with no assets | Main P2 rabi crop in village | Public Intervention - streamline (CNB/MNB/PT) | In stream proximity below intervention location | Yield benefit to near stream small holder farmers |
| P2 farmer with new watering asset | Main P2 rabi crop in village | away/not impacted by public intervention | Away from stream proximity | Yield benefit due to project intervention |
| P3 farmer with new watering asset | Main P3 rabi crop in village | away/not impacted by public intervention | Away from stream proximity | Yield benefit due to project Intervention |

# Other Indices

Net Rabi land and (Rabi PET) pre-plan, post-plan

Area under micro-irrigation.

Net P1,P2 and P3 land and  (PET in mm/hectare) pre-plan, post-plan

# Data Analysis Support.

- Integration of village level data sets. Geographical analysis. Integration with spatial and temporal indices of PDOs.
- Statistical analysis of farmer data and validation of secondary indices.
- Correlation of farmer and village level data to get kg/m^3
- Use of satellite images to cross-validate.

# Target Project Development Objectives by streamlining Planning and measurement Framework

**Planning Activities**

1. Targeting vulnerable smallholder farmers
2. Incorporating planning based on spatial variability
3. Planning to enable farmer movement into higher income category

← 2,3

**Targeted PDO**

1. Increased Water productivity
2. Improved yield uniformity and stability (spatial and temporal yield variability)
3. Annual farm income

1,2,3,4 →

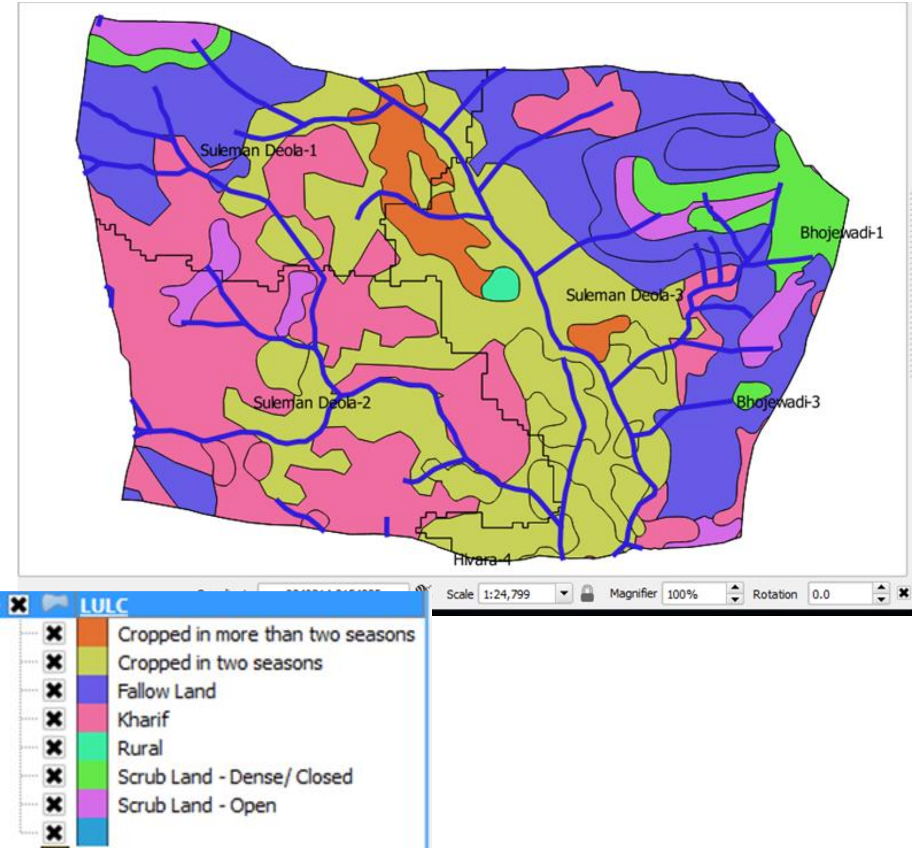
**Measurement Activities**

1. Increase in yield for main P1,P2 and P3 kharif and rabi crops
2. Inter zonal yield variation, increased water availability, rabi area etc.
3. Farmer movements P3->P1, P3->P2, P2->P1
4. yield/water given for selected beneficiaries

Participants: Shubhada Sali, Pooja Prasad

Total Man months: 9-12

# Sample Village Measurements: Suleman Deola, Bid




Village Area: 1079 hectare

| Zone Cropping in hectare | Zone 1 (ha) | Zone 2 (ha) | Zone 3 (ha) | Village (ha) |
|---|---|---|---|---|
| **Agricultural Area** | 211 | 303 | 325 | 839 |
| Annual Area | 14 | 15 | 15 | 44 |
| Kharif Area | 142 | 208 | 240 | 590 |
| Rabi Area | 136 | 206 | 294 | 636 |
| **Non Agricultural Area** | 44 | 9 | 187 | 240 |
| **Zone Area** | 255 | 312 | 512 | 1079 |

Analysis conducted for 4 scenarios -

1. Current state good year (CSGY)
2. Current state bad year (CSBY)
3. Proposed state good year(PSGY)
4. Proposed state bad year (PSBY)

Good year 2017: 753 mm rainfall

Bad year 2015: 218 year rainfall

# Cropping pattern: Current and sample Proposed to see impact on indices

| | Existing Cropping pattern | | | | Proposed cropping pattern | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Zone Cropping in hectare | Zone 1 (ha) | Zone 2 (ha) | Zone 3 (ha) | Village (ha) | Zone 1 (ha) | Zone 2 (ha) | Zone 3 (ha) | Village (ha) | Crop Category |
| Bajra | 55 | 80 | 70 | 205 | 55 | 80 | 65 | 200 | P3 |
| Moong | 18 | 42 | 31 | 91 | 13 | 33 | 26 | 72 | P3 |
| Maize | | 4 | 2 | 6 | | 4 | 2 | 6 | P3 |
| Soyabean | 12 | 37 | 32 | 81 | 12 | 37 | 32 | 81 | P3 |
| Udid | 25 | 34 | 15 | 74 | 19 | 24 | 10 | 53 | P3 |
| onion | 0 | 0 | 0 | 0 | 11 | 19 | 15 | 45 | P2 |
| Tur | 35 | 50 | 40 | 125 | 35 | 50 | 40 | 125 | P3 |
| Cotton | 52 | 41 | 120 | 213 | 52 | 41 | 120 | 213 | P2 |
| Orange | 12 | 12 | 12 | 36 | 12 | 12 | 12 | 36 | P1 |
| Pomegranate | 2 | 3 | 3 | 8 | 2 | 3 | 3 | 8 | P1 |
| Gram | 16 | 16 | 27 | 59 | 16 | 16 | 27 | 59 | P3 |
| Onion | 17 | 19 | 23 | 59 | 23 | 29 | 38 | 90 | P2 |
| Jowar / fodder | 96 | 159 | 235 | 490 | 96 | 159 | 235 | 490 | P3 |
| Wheat | 7 | 12 | 9 | 28 | 13 | 22 | 24 | 59 | P2 |
| **Rabi Area** | **136** | **206** | **294** | **636** | **148** | **226** | **324** | **698** | |
| Current Fallow | 44 | | 20.3 | 64.3 | 44 | | 20.3 | 64.3 | - |
| Non Ag | | | 2.7 | 2.7 | | | 2.7 | 2.7 | - |
| Permanent Fallow | | | 19 | 19 | | | 19 | 19 | - |
| scrub | | 9 | 145 | 154 | | 9 | 145 | 154 | - |
| **Total Agricultura** | **211** | **303** | **325** | **839** | **211** | **303** | **325** | **839** | |
| **Zone Area** | **255** | **312** | **512** | **1079** | **255** | **312** | **512** | **1079** | |

cropping pattern varied to -

1. 10% movement from P3 kharif to P2 kharif (Moong, udid -> Onion)
2. Overall 10% increase in rabi land for onion and wheat P2 crops

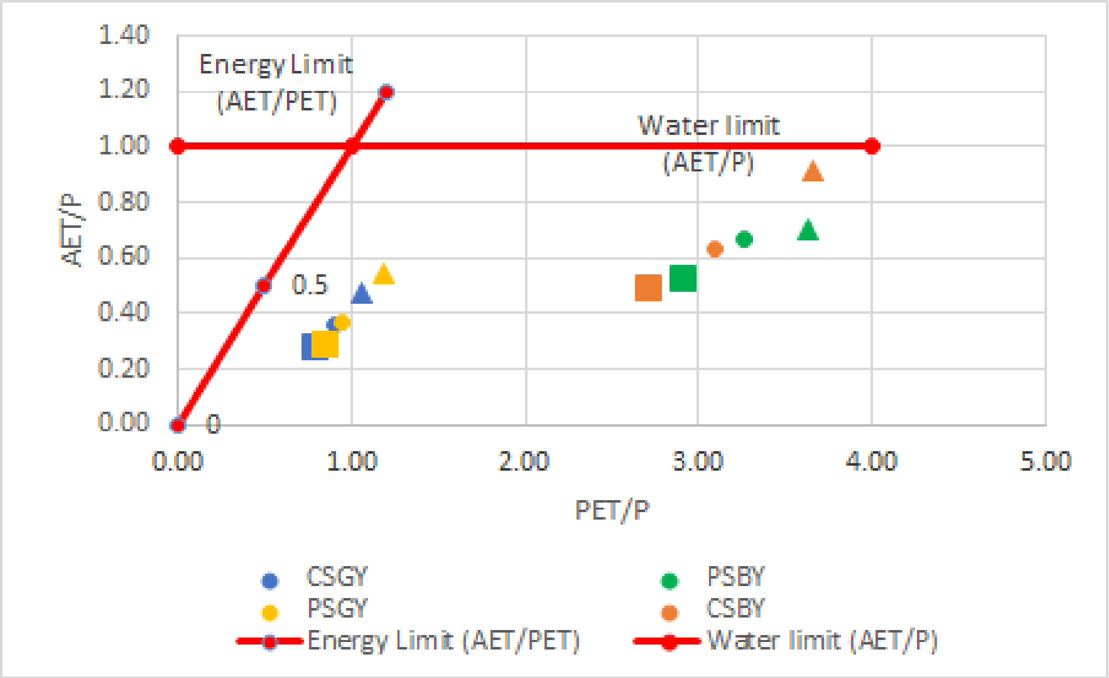
# Interventions: current and proposed water allocation

| Intervention categorization | Water categorization |
|---|---|
| CCT | W2 |
| Deep CCT | W2 |
| Compartment Bunding | W2&W3 |
| Loose Bolder | W2 |
| Gabion Bunds | W2 |
| Community farm pond | W1 |
| Farm pond with plastic | W1 |
| Percolation Tank | W1 |
| Nala Deepening | W1 |
| CNB | W1 |
| MNB | W1 |

- Water from non-ag area treatment is accounted in W2 ground water.
- 90% of water from compartment bunding is accounted in W2 and 10% in W3 soil moisture

| Water Allocation Existing in TCM | Zone 1 | Zone 2 | Zone 3 | total |
|---|---|---|---|---|
| W1 | 16.8 | 42.2 | 19.8 | 78.8 |
| W2 | 9 | 9 | 9 | 27 |
| W3 | | | | 0 |
| Water Allocation Proposed in TCM | Zone 1 | Zone 2 | Zone 3 | Total |
| W1 | 76 | 58 | 91 | 224 |
| W2 | 78 | 68 | 250 | 396 |
| W3 | 0 | 4 | 20 | 25 |
| W2 model GW good year | 70.7 | 121.9 | 191.7 | 384.4 |
| W2 model GW bad year | 15.28 | 25.87 | 67.38 | 108.53 |
| Available runoff good year | 543.96 | 617.02 | 1188.92 | 2349.90 |
| Available runoff bad year | 138.91 | 122.44 | 351.44 | 612.80 |

# Secondary measurements: AET/PET (Village Suleman Deola)




● Zone 1
▲ Zone 2
■ Zone 3

1. Movement towards water limit from CSGY to PSGY indicates improved water utilization
2. Movement towards right on PET/P axis indicates increase in cropping area or cropping pattern shift.

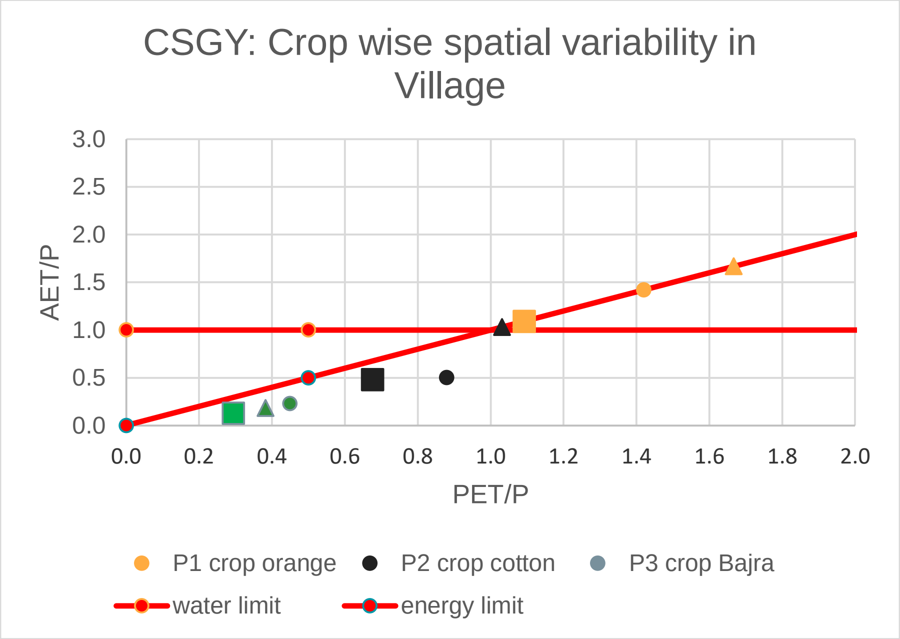
(note that the PET/P in bad year are higher because of low rainfall)

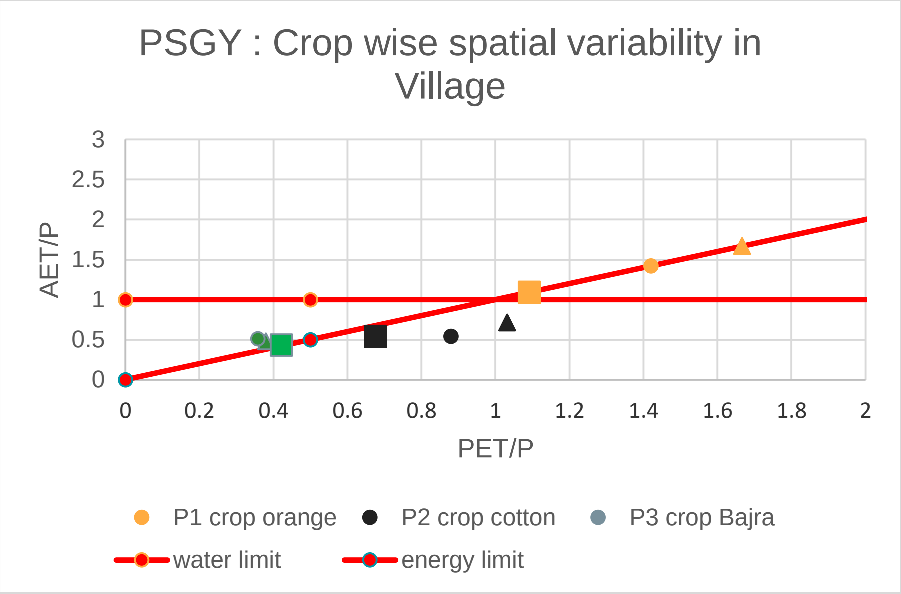
- **PoCRA aims to minimize this variation in bad and good year (climate resilience) and track improved water availability**

# Zonal details: Suleman Deola

| | CSGY - 753 mm 2017 | | | PSGY - 753 mm 2017 | | | CGBY - 218 mm 2015 | | | PSBY 218 mm 2015 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Indicators** | **Zone1** | **Zone2** | **Zone3** | **Zone1** | **Zone2** | **Zone3** | **Zone1** | **Zone2** | **Zone3** | **Zone1** | **Zone2** | **Zone3** |
| PET/rainfall | 0.9 | 1.1 | 0.8 | 1.0 | 1.2 | 0.8 | 3.1 | 3.7 | 2.7 | 3.3 | 3.6 | 2.9 |
| AET/PET (energy limit) | 0.4 | 0.4 | 0.3 | 0.4 | 0.5 | 0.3 | 0.2 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 |
| AET/P (natural water limit) | 0.4 | 0.5 | 0.3 | 0.4 | 0.5 | 0.3 | 0.6 | 0.9 | 0.5 | 0.7 | 0.7 | 0.5 |
| Ag Area in ha | 211 | 303 | 325 | 211 | 303 | 325 | 211 | 303 | 325 | 211 | 303 | 325 |
| Non Ag Area in ha | 44 | 9 | 186 | 44 | 9 | 186 | 44 | 9 | 186 | 44 | 9 | 186 |
| **Effective Rainfall in mm (P)** | **910** | **775** | **1184** | **910** | **775** | **1184** | **263.5** | **224.5** | **342.8** | **263.5** | **224.5** | **342.8** |
| Effective Rainfall in TCM | 1920.2 | 2349.4 | 3847.8 | 1920.2 | 2349.4 | 3847.8 | 555.9 | 680.2 | 1114.0 | 555.9 | 680.2 | 1114.0 |
| P1 Area | 14 | 15 | 15 | 14 | 15 | 15 | 14 | 15 | 15 | 14 | 15 | 15 |
| P2 kharif Area | **52** | **41** | **120** | **63** | **60** | **135** | **52** | **41** | **120** | **63** | **60** | **135** |
| P2 rabi Area | **24** | **31** | **32** | **36** | **51** | **62** | **24** | **31** | **32** | **36** | **51** | **62** |
| P3 kharif area | 145 | 247 | 190 | 134 | 228 | 175 | 145 | 247 | 190 | 134 | 228 | 175 |
| P3 rabi area | 113 | 175 | 262 | 113 | 175 | 262 | 113 | 175 | 262 | 113 | 175 | 262 |
| P1 PET (mm) | 69 | 60 | 37 | 69 | 60 | 37 | 69 | 60 | 36 | 69 | 60 | 36 |
| P2 kharif PET (mm) | 163 | 163 | 188 | 187 | 234 | 204 | 162 | 163 | 187 | 186 | 138 | 203 |
| P3 kharif PET (mm) | 235 | 325 | 154 | 221 | 305 | 144 | 233 | 321 | 153 | 219 | 302 | 143 |
| P2 rabi PET (mm) | 56 | 58 | 37 | 83 | 95 | 71 | 56 | 58 | 37 | 83 | 95 | 71 |
| P3 rabi PET (mm) | 155 | 196 | 179 | 155 | 196 | 179 | 155 | 196 | 179 | 155 | 196 | 179 |

# Spatial variability: Zonal AET/PET and Yield



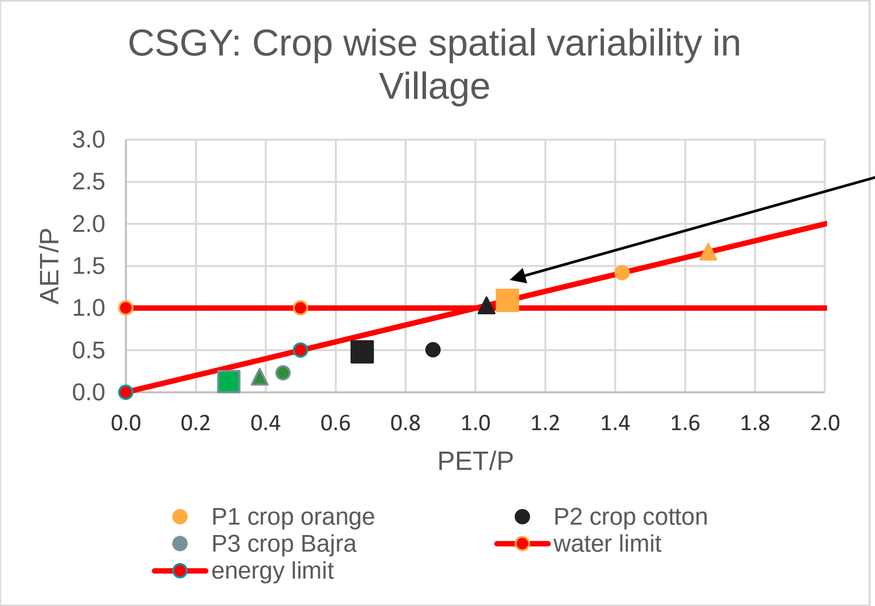



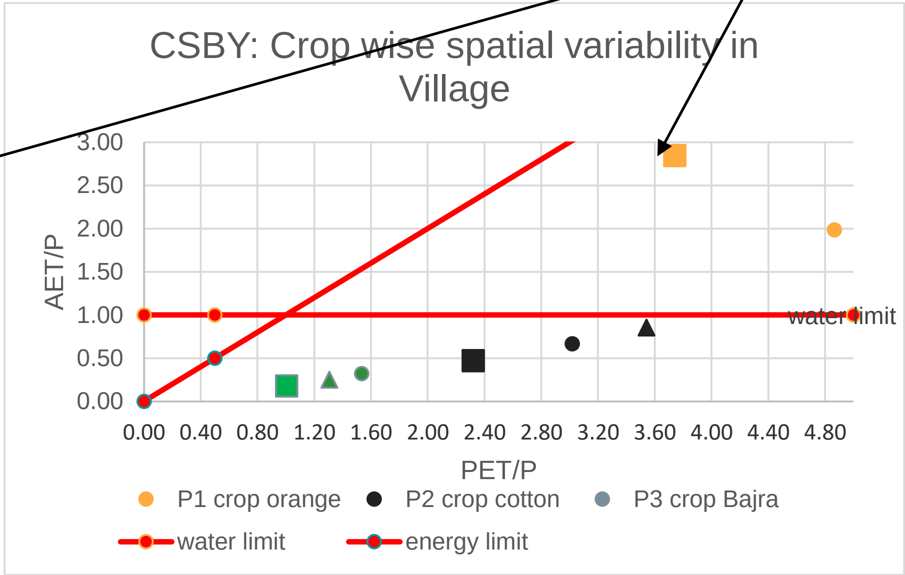

● Zone 1
▲ Zone 2
■ Zone 3

This indicator will track spatial and temporal improvement in water availability. (movement of zones towards water limit)

# Measuring or planning for climate resilience

P1 orange demand for zone 3 unmet in bad year




Measure temporal variability due to varying rainfall and target for reducing it

(plan to meet Prioritized crop demand even in bad year)

- ● Zone 1
- ▲ Zone 2
- ■ Zone 3

# Planning

1.To develop farmer prioritization guidelines based on

-> data collected in DBT form (gat no., current assets, cropping pattern, irrigation)

-> vulnerability and stream proximity maps

Broad Guidelines

a. Target small holder P3 farmers without watering sources in offstream areas first to enable availability of water for protective irrigation
b. Target small holder P3 farmers without watering assets in stream proximity region for movement to high return crops in P2 or P1 category
c. Target P2 farmers for movement to higher category

# Intervention prioritization guidelines

- Guidelines for intervention selection will be developed
    - Guidelines for well allocation in stream areas (4TCM), well allocation in non stream areas (1.5 TCM)
    - Guidelines for Farm Pond allocation to check if Farm pond will get filled
    - Guidelines for capping no. of wells and farm ponds based on water budget

# Targeted Project Development Objectives and ToR Items contributing to it

**Targeted PDO**

1. Increased Water productivity
2. Improved yield uniformity and stability (spatial and temporal)

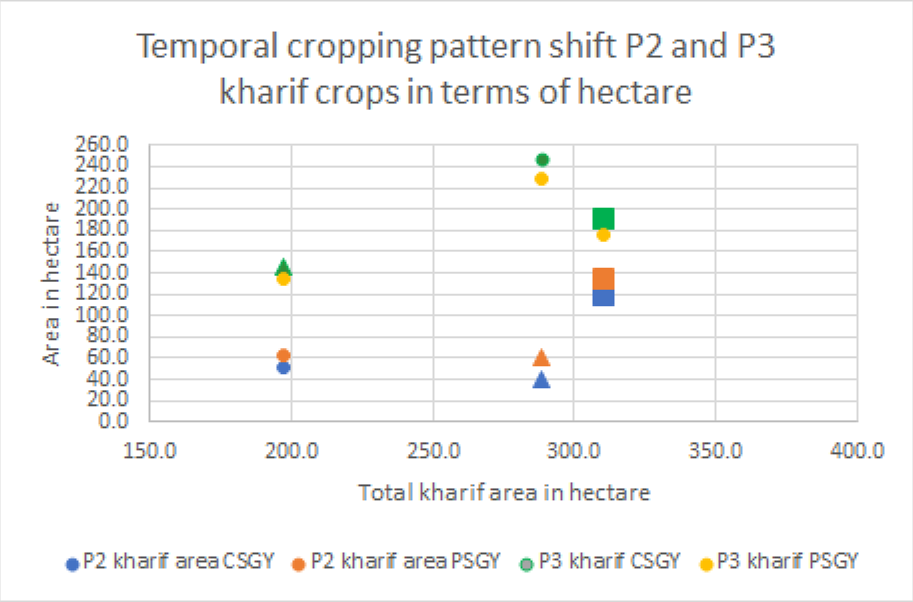
**TOR Items contributing to PDO measurement**

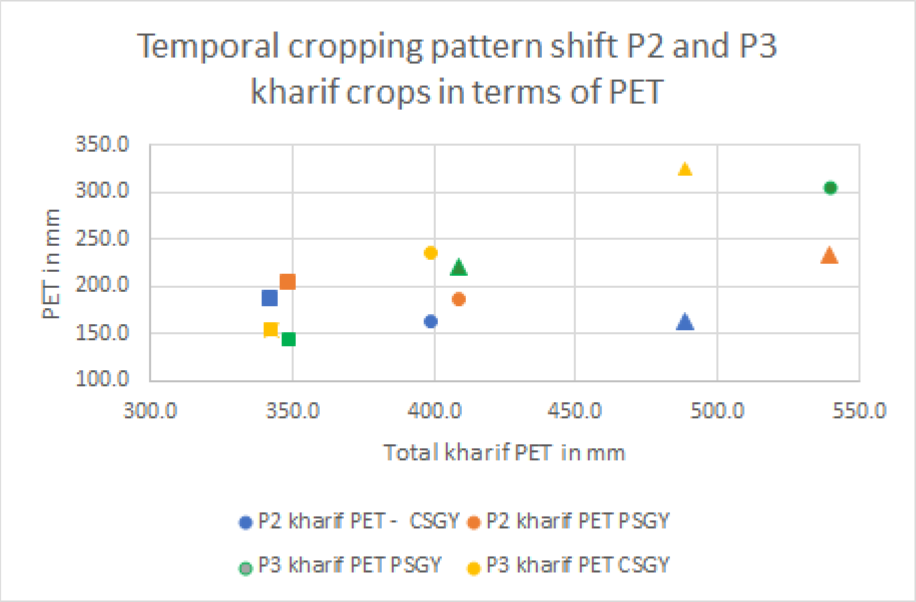
1. B1 - Design of village level water accounting framework.
2. B2 - Design of vulnerability, risk indices and key performance indices
3. C1 - Design of planning and index measurement survey format for integration with microplanning and M&E process
4. C2 - Development of farmer level app
5. C3 - Addition of plan analysis section to PoCRA water budget applet
6. D1 Updation of DPR assessment guidelines
7. D2 Field Assessment of DPR (5-8 villages)
8. D3 Desk assessment of DPR

| Item no. | Objectives | Overall Strategy | Man months |
|---|---|---|---|
| B1 | Design of Village level water accounting framework | Measurement of W1, W2, W3 water, P1, P2 and P3 loads and their allocation to strategize village/zone level planning | 4-5 |
| B2 | Design of risk, vulnerability indices to enable analysis of various allocations. Design of key performance indices | Design of indices based on current QGIS model output, existing maps and water accounting framework | 4-5 |
| C1 | developing village level planning guidelines based on framework and indices and Design of Survey formats for integration of planning framework with microplanning | analysing various allocations and designing indices to develop planning guidelines.<br>Integrate with DBT form for minimal data collection required for planning and monitoring of indices based on B. | 2 |
| C2 | Farmer app for individual intervention selection guidelines | Prioritization guidelines based on farmer category, assets, survey and geographical location | 2 |
| C3 | Addition of Plan Analysis section to PoCRA water budget applet | Integration of B1, B2 into app to generate village water accounting from village water budget. | 3-4 |
| D1 | Updation of DPR assessment guidelines | Design based on field visit and interaction with project employees consisting of TAO, Project specialists, Microplanning agencies staff and cluster assistants. | |
| D2 | Field Assessment of DPR (5-8 villages) | Maximum 2-3 villages per month | 3-4 |
| D3 | Desk assessment of DPR | 3-4 DPR per month based on data to be assessed | 3-4 |

# Indices Backup

# Measuring shift in cropping pattern

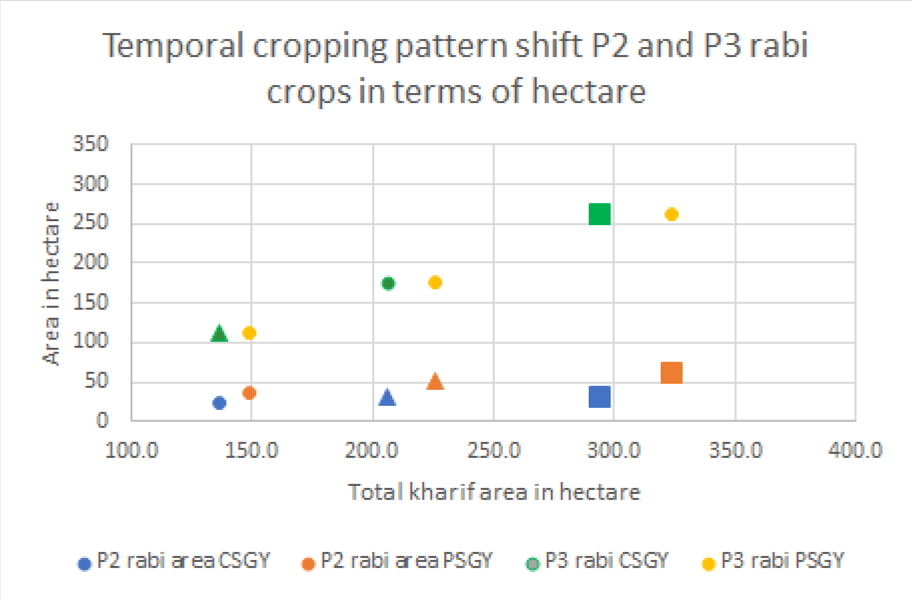


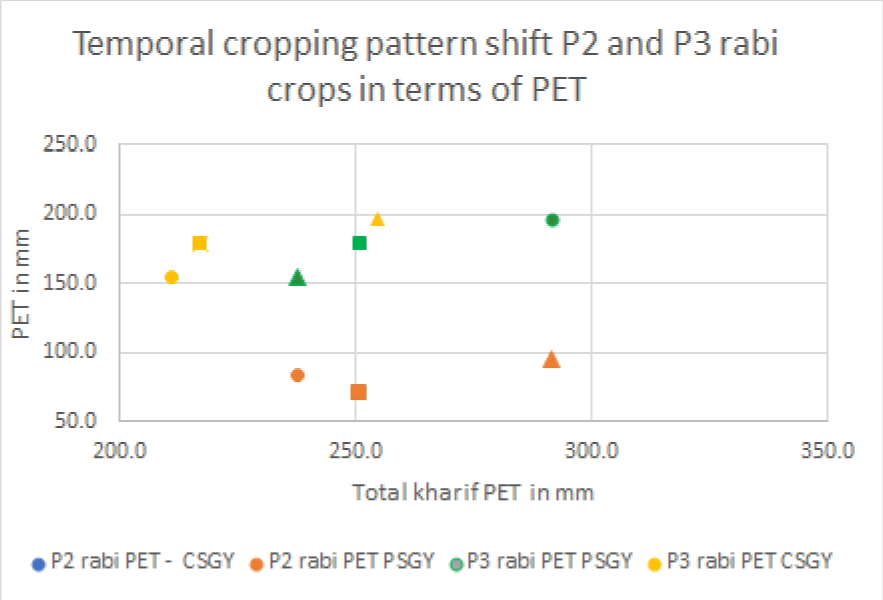




- ● Zone 1
- ▲ Zone 2
- ■ Zone 3

Shift in categories can be a measure of marginal increase income

# Measuring shift in cropping pattern: Rabi




● Zone 1
▲ Zone 2
■ Zone 3

Shift in categories can be a measure of marginal increase income

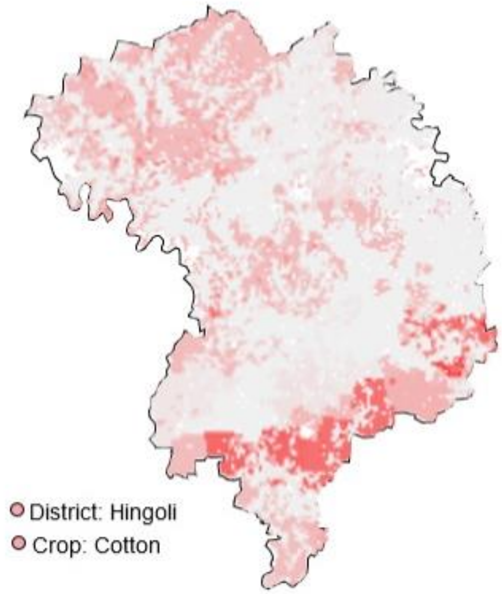
# Part E: GIS based Dashboard

# Dashboard (Items E1+E2)

**Purpose:**

- Immediate:
  - Real-time (daily) geo-referenced tracking of the status of field-level technical parameters; in particular, soil-moisture deficit/crop stress
  - Platform for georeferenced technical/research inputs-outputs
- Extended:
  - Enable the incorporation of technical planning and advisory support
  - Enable the creation of a platform that eases any drudgery in the technical processing components and streamlines the end-to-end technical process.

# Geo-referenced monitoring illustrated for Hingoli district

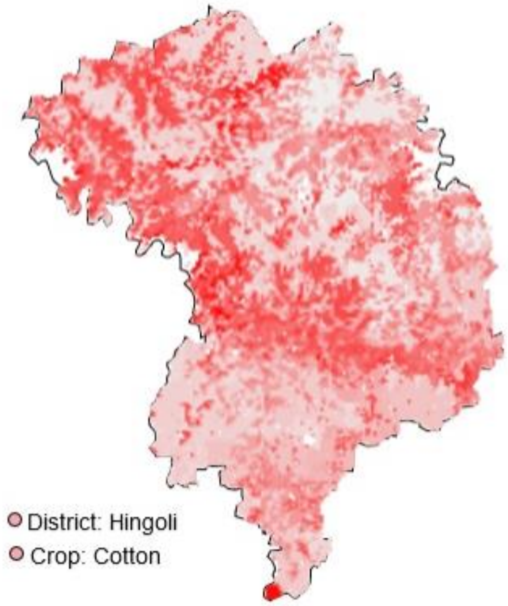


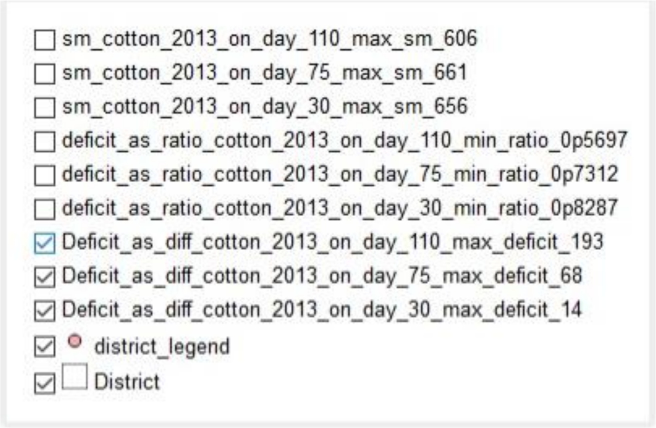

- [ ] sm_cotton_2013_on_day_110_max_sm_606
- [ ] sm_cotton_2013_on_day_75_max_sm_661
- [ ] sm_cotton_2013_on_day_30_max_sm_656
- [ ] deficit_as_ratio_cotton_2013_on_day_110_min_ratio_0p5697
- [ ] deficit_as_ratio_cotton_2013_on_day_75_min_ratio_0p7312
- [ ] deficit_as_ratio_cotton_2013_on_day_30_min_ratio_0p8287
- [ ] Deficit_as_diff_cotton_2013_on_day_110_max_deficit_193
- [ ] Deficit_as_diff_cotton_2013_on_day_75_max_deficit_68
- [x] Deficit_as_diff_cotton_2013_on_day_30_max_deficit_14
- [x] district_legend
- [x] District

(More details, options and features to be added in the actual implementation)

PET - AET on day 30

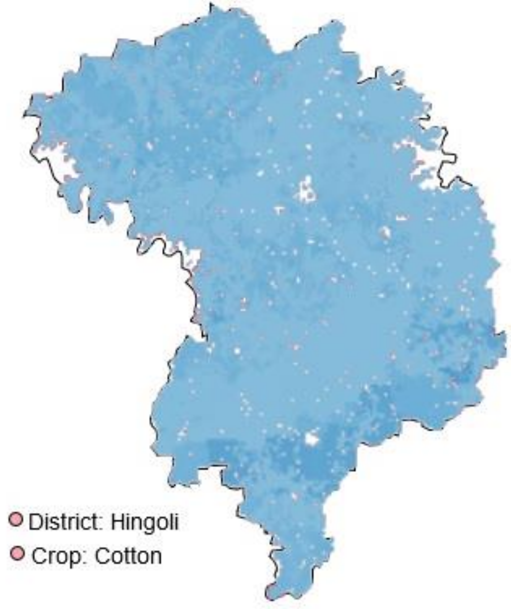
# Geo-referenced monitoring illustrated for Hingoli district




PET - AET on day 110

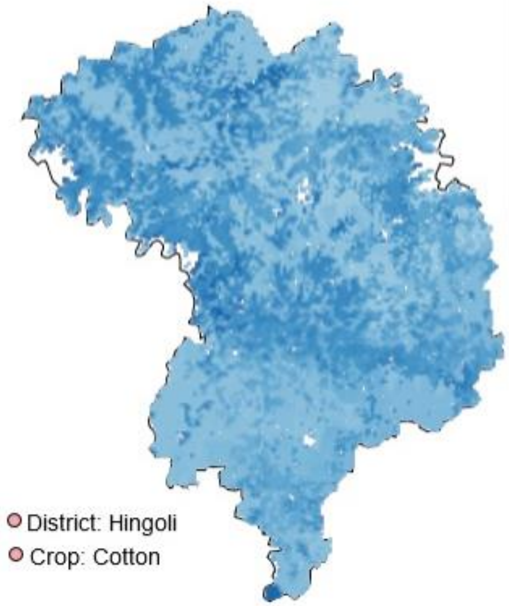
# Geo-referenced monitoring illustrated for Hingoli district





AET / PET on day 30

# Geo-referenced monitoring illustrated for Hingoli district




- [ ] sm_cotton_2013_on_day_110_max_sm_606
- [ ] sm_cotton_2013_on_day_75_max_sm_661
- [ ] sm_cotton_2013_on_day_30_max_sm_656
- [x] deficit_as_ratio_cotton_2013_on_day_110_min_ratio_0p5697
- [x] deficit_as_ratio_cotton_2013_on_day_75_min_ratio_0p7312
- [x] deficit_as_ratio_cotton_2013_on_day_30_min_ratio_0p8287
- [x] Deficit_as_diff_cotton_2013_on_day_110_max_deficit_193
- [x] Deficit_as_diff_cotton_2013_on_day_75_max_deficit_68
- [x] Deficit_as_diff_cotton_2013_on_day_30_max_deficit_14
- [x] district_legend
- [x] District

AET / PET on day 110

# Dashboard: User-level design

- Geo-referenced tracking of physical parameters:
  - Display status as state-wide raster layers
  - One raster layer each for each desired status-variable (like moisture content, crop stress, AET/PET, etc.)
  - Basic GIS map features: Zoom-in/zoom-out, Pan, Pixel Selection, etc.
  - Crop-wise rasters: Until cropping-pattern is available, user will have option to select crop
  - Support for historical status, e.g. status during earlier years, as estimated by the model using available historical data.
- Geo-referenced tracking and access to technical information:
  - Region-wise information: District-wise, Cluster-wise, Village-wise, etc.
  - Technical statistics for user-selected regions
  - Track the status of technical inputs(data) and outputs(results/reports) for user-selected region

# Dashboard: Implementation design

- The Dashboard will be a web-application hosted on PoCRA's server
- Based on
  - Django python framework for server-side development
  - Postgres+Postgis as the database
  - Client-side GIS libraries like OpenLayers or Leaflet as deemed suitable
- Estimation of status is to be based on a particular soil-moisture(SM) model already available from phase-1
- API-access for externally available weather data required by the model

Version 2: The current SM-model uses fixed ET0 values per district per month. An ET0-estimation model based on weather parameters will be decided and implemented to incorporate current field level ET0 values in the SM-model.

# Dashboard: Issues in implementation

- Missing data:
  - slope values, rainfall circle
  - workaround by using neighbouring pixel/circle values
- Performance:
  - Background process runs the model for each of the desired points using previous day’s status
  - With finest resolution at 50m-grid, ~ 120 million points for Maharashtra
  - What finest resolution is possible depends on the performance of the server machine
- Cloud-based server scenario:
  - Decision to use only thriving open-source software systems/tools and frameworks
  - Timely support expected to resolve issues, if any, with such softwares on the cloud-machine
  - Difficult to closely mimic the cloud environment in development environment; so will have to monitor live performance carefully and adjust computational load that updates the daily status

# Dashboard: Schedule

1. For Immediate features (georeferenced tracking):
   a. Server-side scripting and building database: 2 man-months
   b. Client-side scripting: 3 man-months
   c. Background status-updation process: 1 man-month
   d. UAT, deployment, tuning: 2 or more man-months (depends on cloud environment and support)

   Current status: Database creation underway, server-side models being designed.

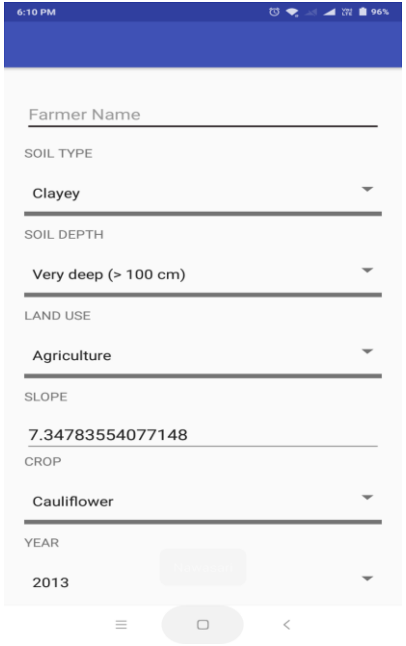
1. For extended features (support for technical planning, advisory and end-to-end technical data and process flow) :

   Depends on exact requirements

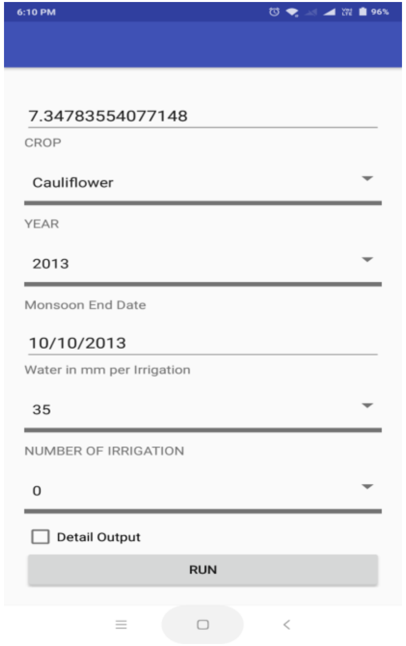
# Item – E4 Farm based Water Budgeting Android App

# App Working & Features


Location Displayed




Values Fetched from Server



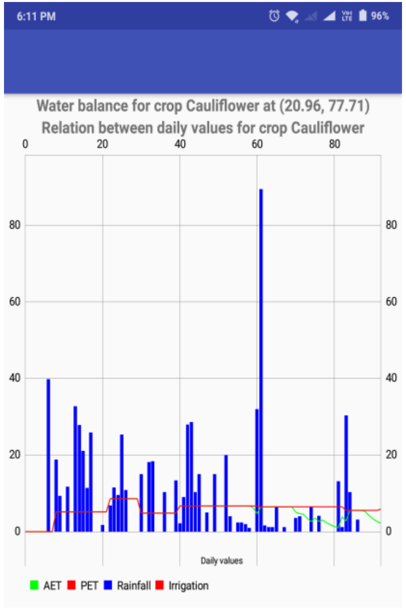

Click Run for Output

-Farmer Name-Required

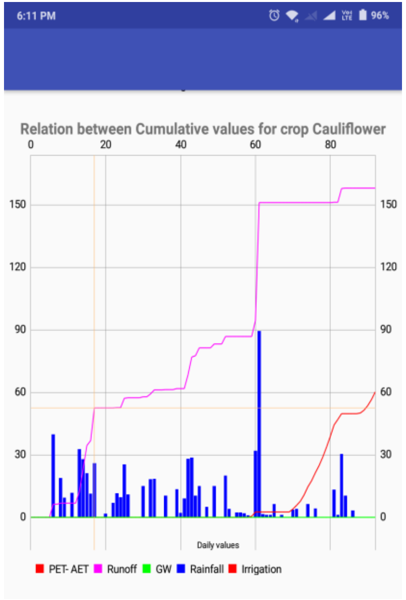
-Check “Detail Output” for daily computation values

-All fields can be adjusted manually

# Output Graphs




Daily values for Crop



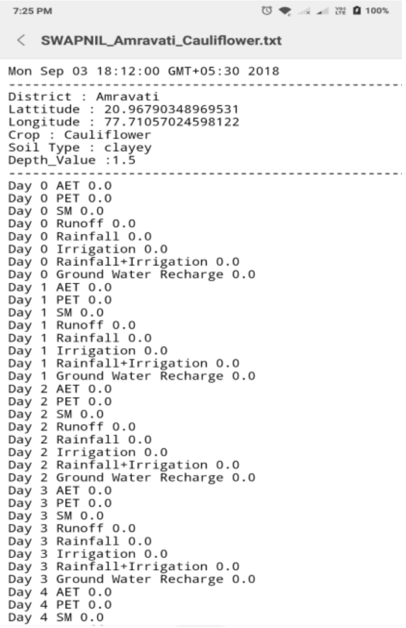

Cumulative values for Crop


Summary values for Crop

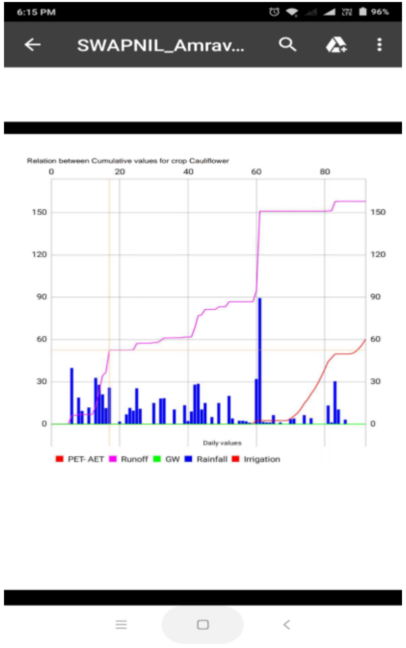
-Computation values include:

- PET
- AET
- PET-AET
- Runoff
- GW
- Rainfall
- Irrigation

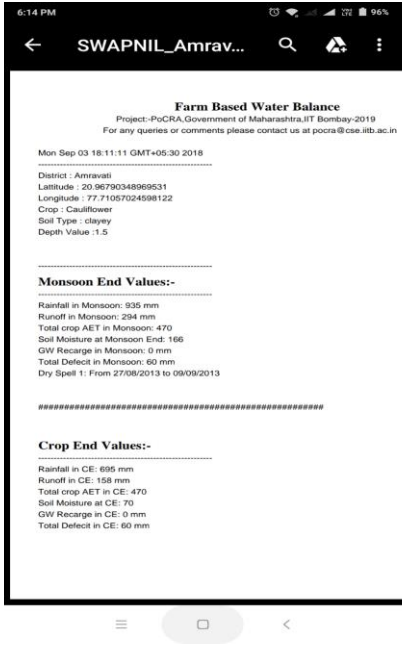
-"Save Output" option will generate a report will graphs,summary values and all the input values




Daily Values Log




Output Saved in Report




Summary Values Saved in Report

-The report will be generated with name as: FarmerName_DistrictName_CropName.pdf at location “storage/emulated/0”.

-The daily log value file (if checked) will be generated at location “storage/emulated/0/Android/data/com.example.sudhanshu.gis/files” with name as: FarmerName_DistrictName_CropName.txt

# App Download Information

PoCRA site link- https://www.cse.iitb.ac.in/~pocra/Android_app/app-debug.apk

Additional Permissions to app:

- Access Device Location
- Storage Access

The permissions to the App are required to be given by going manually at Setting->Permissions->FarmBudget or permission pop-up during startup of app depending upon the android version.

Note:-It is recommended to turn on GPS before starting the application .

# Issues In the App

1. If the app crashes when it starts make sure that the GPS is turned on.
2. Even after turning on the GPS if the app still crashes it is due to instant unavailability of GPS location ,so it is recommended to wait for a minute to get the app working.This may not be the case with all android versions.
3. The “Detail Output” option if checked will take time(2-3 sec) to generate the outputs as it will be logging the daily computation values to the file in the back-end which is heavy operation with respect to time.
4. After clicking “Next” button on the map activity if the app takes time to fetch values from the server then it is most likely the Server issue, so in any such cases feel free to write us at pocra@cse.iitb.ac.in

# Item G and Item H

- Workshop, collaboration with agricultural university.
- Curriculum design for field work
- Extension of Dashboard for other project activities

# F: Training Videos

Need: Enable repetitive and quality training of PoCRA team at various levels for water budgeting and planning.

Methodology: IITB to do research, direction and provide scripting support to video making agency by handling this assignment.

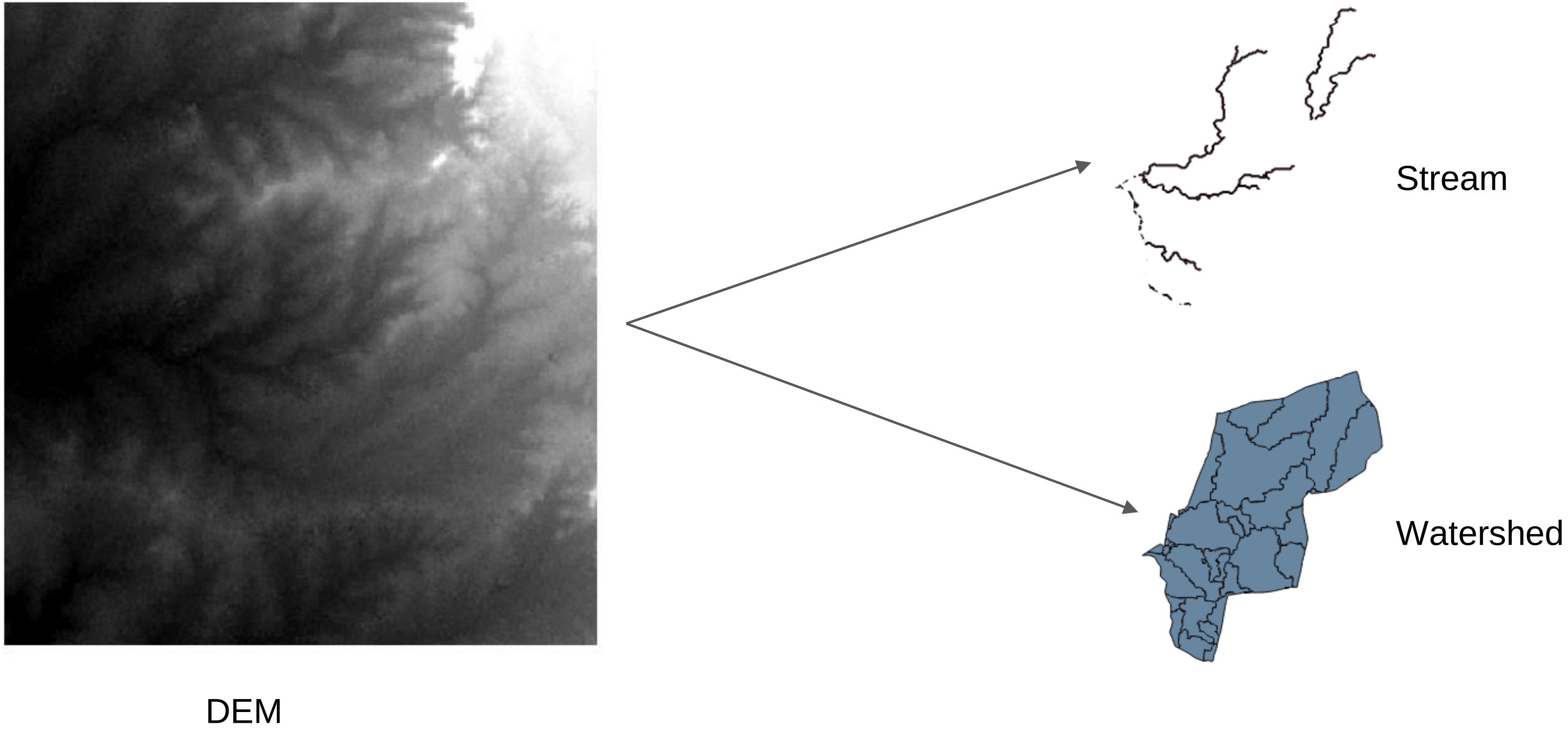
Benefits: Easily accessible video training material for PoCRA project.

Participants: Shubhada Sali

Manmonths: 8-9

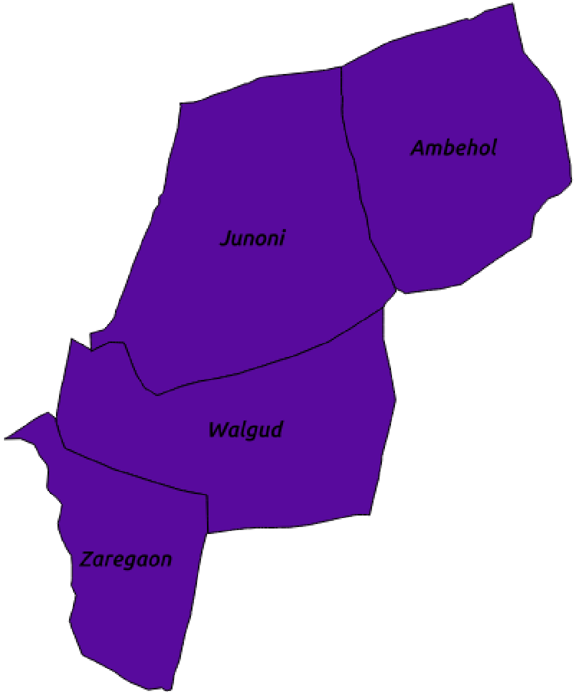
# Zoning and Mahabhulekh Backup

# Step 1:- Generate Stream & Watershed from DEM



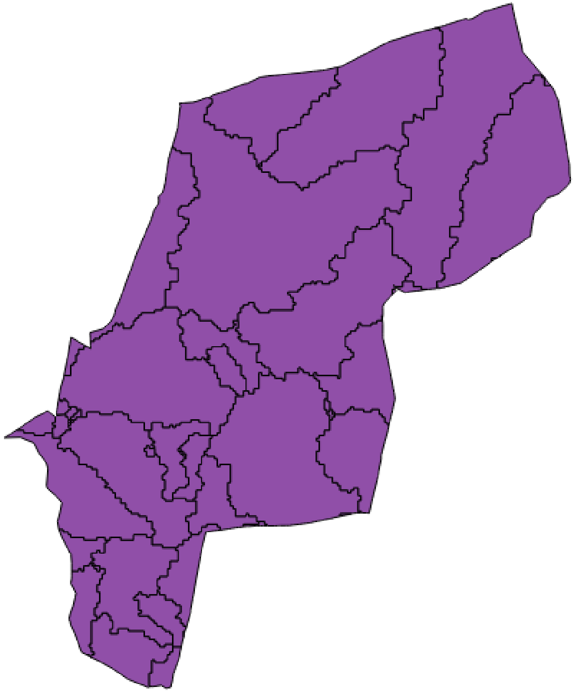
# Step 2:-Load Village and Watershed Layer

E.g. Osmanabad




Village Layer

Drainage Layer



Watershed Layer

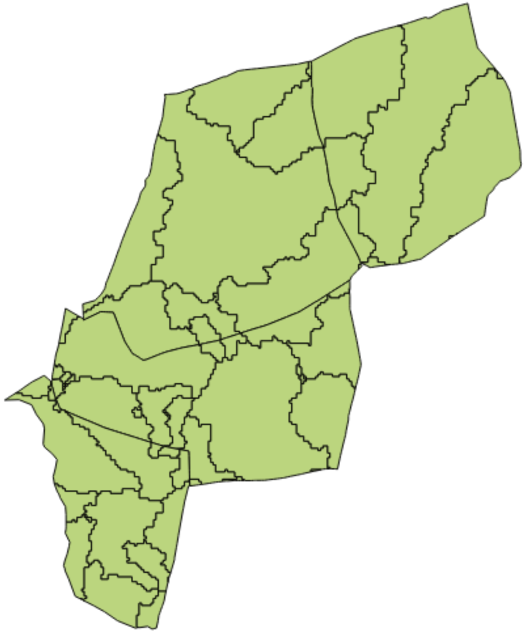
# Step 3:-Intersect Village & Cleaned Watershed Layer

i)Zone_area attribute updated

ii)ESP applied

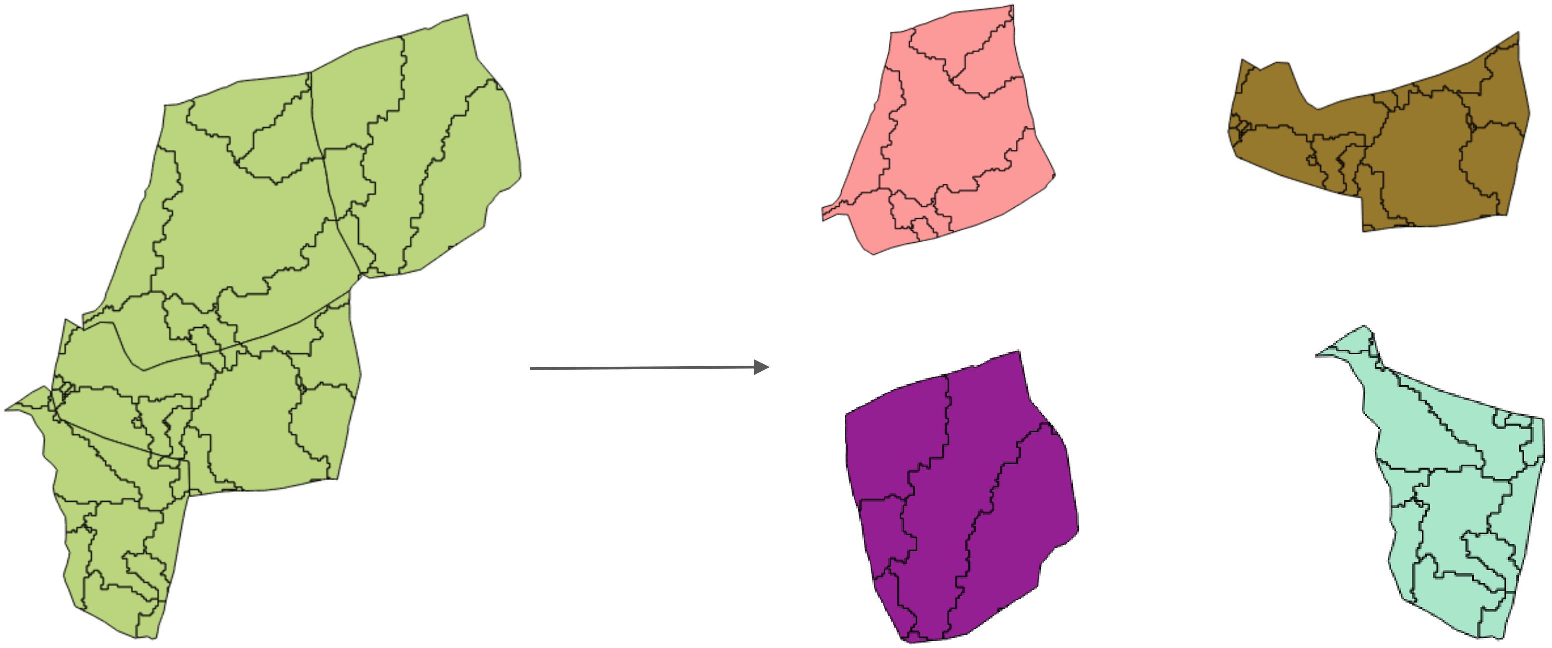
iii)Intersection algorithm applied

| | value | label | zone_area | OBJECTID_1 | STNCODE | DVNCODE | DTNCODE | THNCODE | VINCODE | VIL_NAME |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 158 | | 2547190.1... | 9733 | 27 | 2704 | 525 | 04240 | 561463 | Ambehol |
| 2 | 126 | | 847750.55... | 2523 | 27 | 2704 | 525 | 04240 | 561462 | Junoni |
| 3 | 128 | | 1878206.1... | 2523 | 27 | 2704 | 525 | 04240 | 561462 | Junoni |
| 4 | 128 | | 1878206.1... | 9733 | 27 | 2704 | 525 | 04240 | 561463 | Ambehol |
| 5 | 124 | | 3826745.0... | 2523 | 27 | 2704 | 525 | 04240 | 561462 | Junoni |
| 6 | 124 | | 3826745.0... | 9733 | 27 | 2704 | 525 | 04240 | 561463 | Ambehol |
| 7 | 162 | | 1818309.1... | 9733 | 27 | 2704 | 525 | 04240 | 561463 | Ambehol |
| 8 | 124 | | 900.00000... | 2523 | 27 | 2704 | 525 | 04240 | 561462 | Junoni |
| 9 | 114 | | 866949.28... | 2523 | 27 | 2704 | 525 | 04240 | 561462 | Junoni |
| 10 | 114 | | 866949.28... | 2526 | 27 | 2704 | 525 | 04240 | 561464 | Walgud |
| 11 | 164 | | 1080.0250... | 9733 | 27 | 2704 | 525 | 04240 | 561463 | Ambehol |
| 12 | 130 | | 1667224.8... | 2523 | 27 | 2704 | 525 | 04240 | 561462 | Junoni |



Intersected Layer

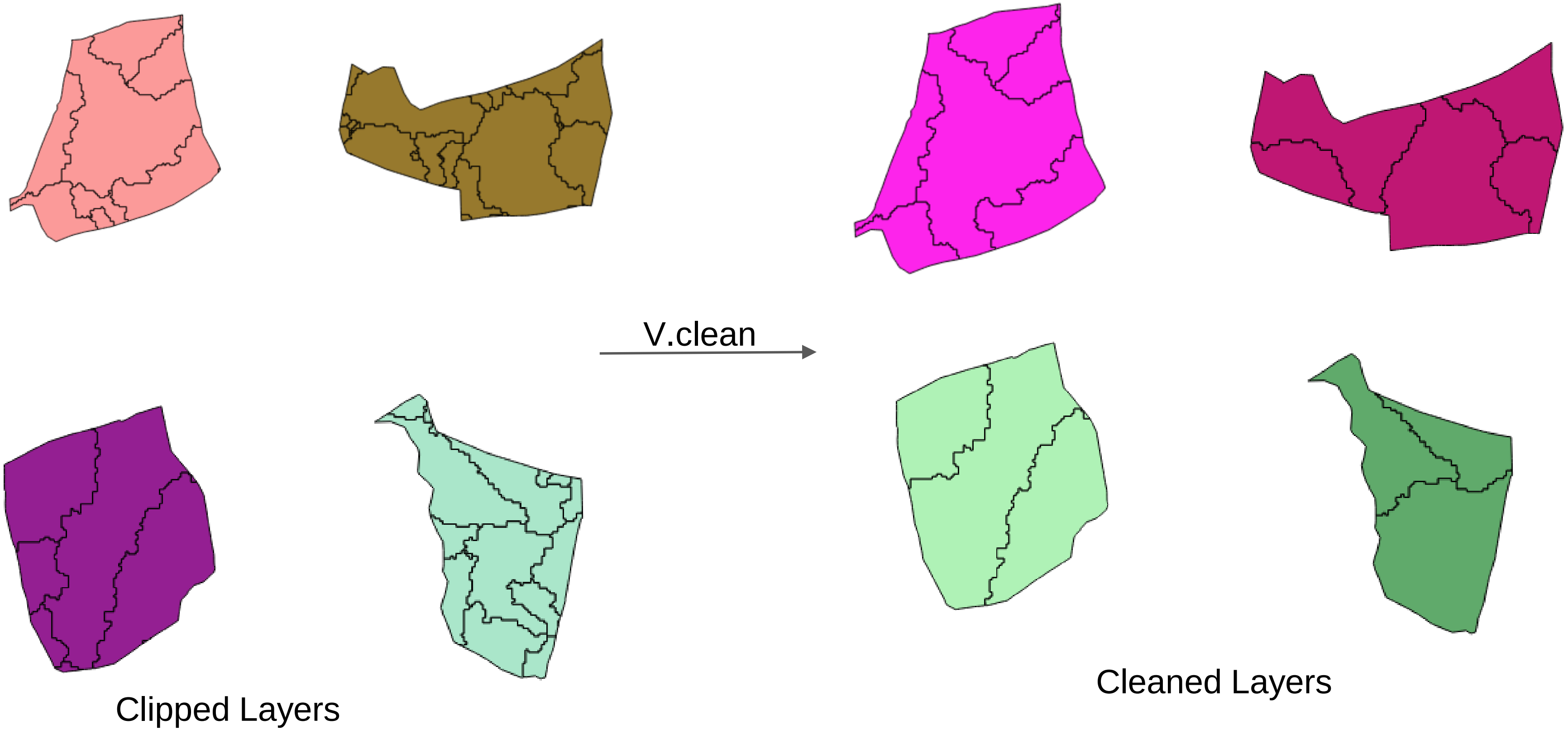
# Step 4:-Clip the Intersected layer to generate separate polygons



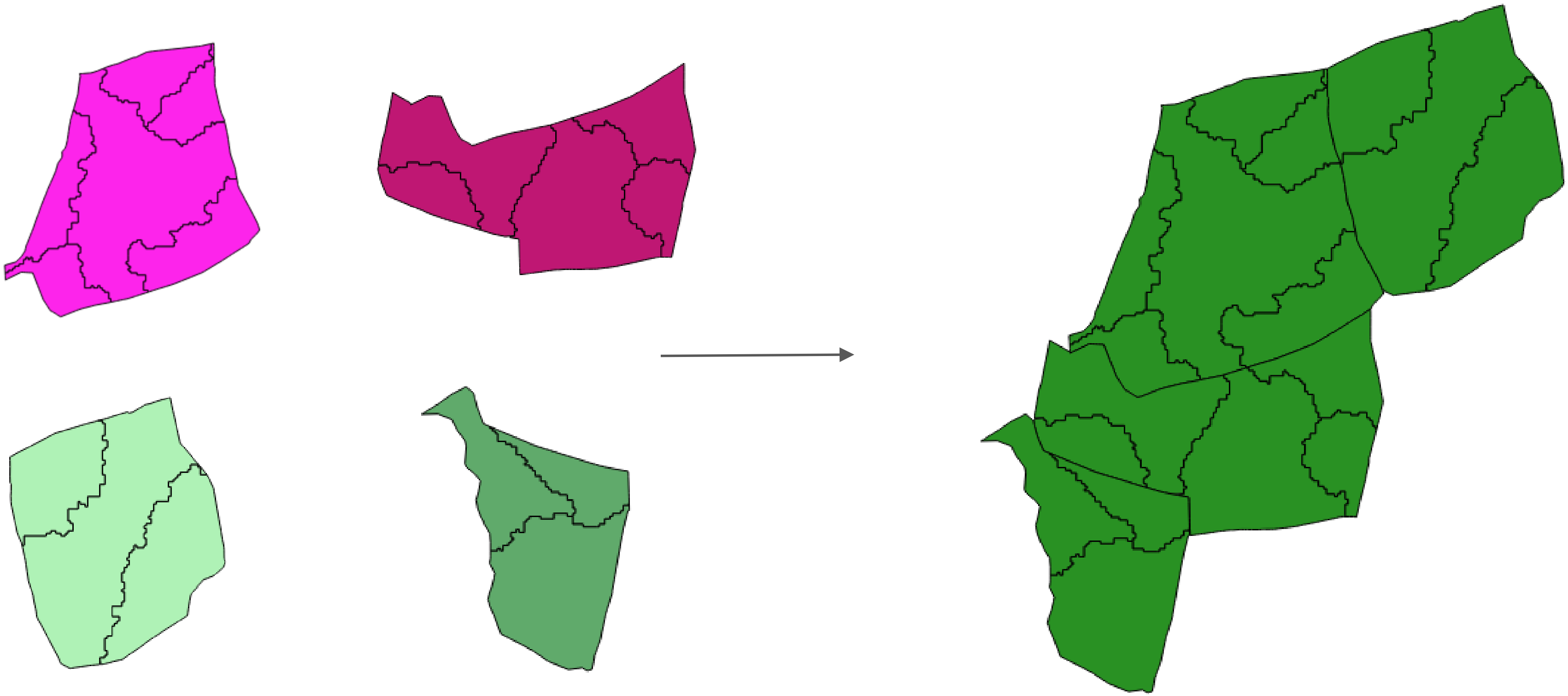
Intersected Layer

Clipped Layers

# Step 5:-Clean the separated polygons individually



# Step 6:-Merge all the Cleaned Layers



Cleaned Layers

Merged Layer

# Village Count for Mahabhulekh & Cadastral data

Taluka-wise count of villages and total count for district:-e.g Akola

```
mhrorako_akt_gat_count.csv----6
mhrorako_tel_gat_count.csv----4
mhrorako_pat_gat_count.csv----3
mhrorako_bar_gat_count.csv----4
mhrorako_mur_gat_count.csv----2
mhrorako_bal_gat_count.csv----2
mhrorako_ako_gat_count.csv----19
Total Villages= 40
```

Mahabhulekh Village Count

```
akola_akot_gat_count.csv----180
akola_akola_gat_count.csv----199
akola_telhara_gat_count.csv----106
akola_murtijapur_gat_count.csv----162
akola_barshitakli_gat_count.csv----159
akola_balapur_gat_count.csv----103
akola_patur_gat_count.csv----96
Total Villages= 1005
```

Cadastral Village Count

# Discrepancies in the Mahabhulekh data

1. Missing Survey numbers in villages
2. Non-Standard formats for survey number representation
3. Number of villages covered is significantly less than known number of villages present in taluka (Village count given in folder of each district taluka-wise)
4. Some districts are missing (Hingoli,Parbhani,Washim)

Similar, taluka wise analysis for cadastral data is provided to cross-check the count of talukas, districts, gat_nos, etc. including missing data for mahabhulekh.

P.S. Wardha does not have location info in cadastral so its comparative data is missing in both sources.