PoCRA Water Budget

Presentation to the Technical Advisory Committee

POCRA Team, IIT Bombay

6th Feb 2018

Outline

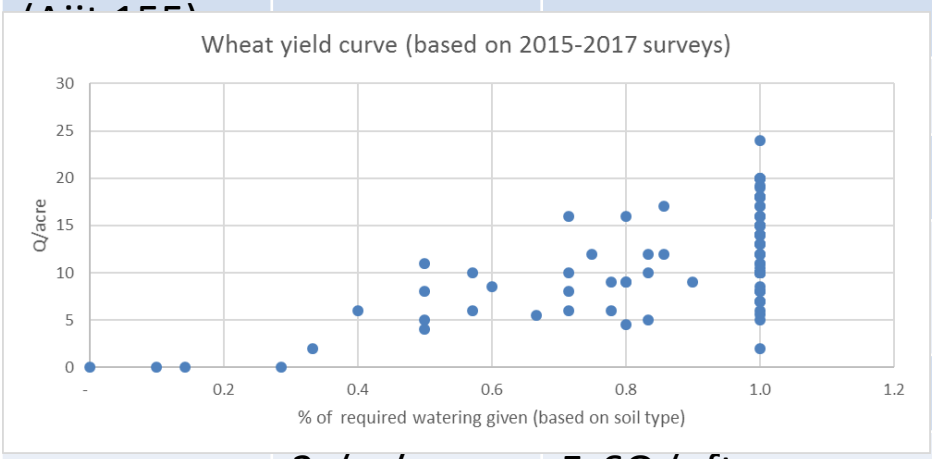
1. Climate resilience and need for water budget
2. Water balance: Technical details
3. Water budget exercise: Methodology adopted
4. Example

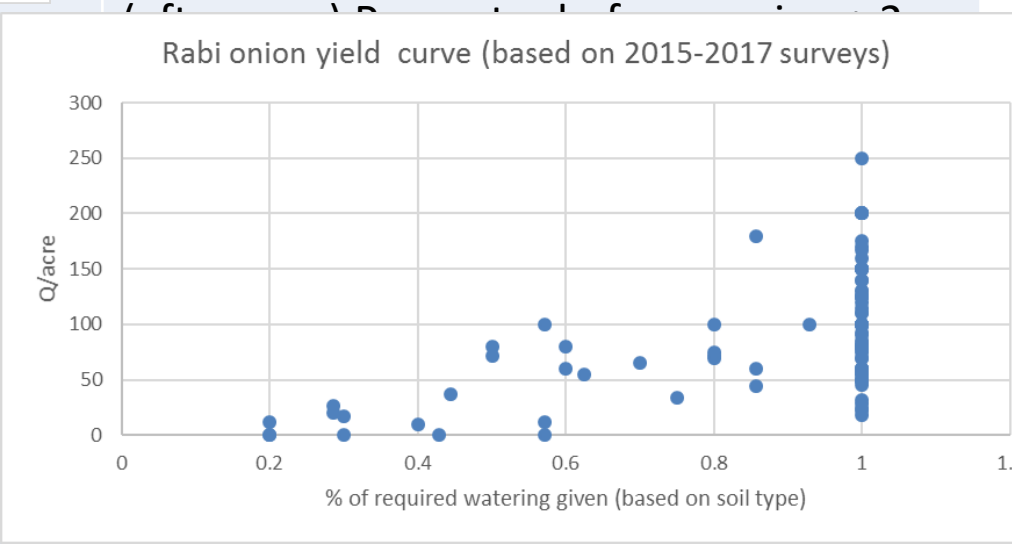
Ghusar cluster: Farmer yields surveys

Crop	Farmer No	Unirrigated	Irrigated
Cotton (Ajit 155)	1. w/FP	7Q/acre (in 2017)	8Q/acre (one irr in 2016)
	2. w/bore	3-5Q	8Q (July 2017 protective irr)
	3.		12Q (1 kharif protective + 1 in Nov 2017)
Harbhara (Vijaya)	1. w/ FP	5Q (2016)	6Q (one irrigation)
	2.	2-3Q	6-7Q (post mung; one irr Oct 2017)
	3. (w/ bore)	5-6Q (after mung, no irrigation)	(after soya) Pre-water before sowing + 2 more in Nov and Dec: 6-7Q/acre
(Jackie)	4.	6-7Q (post mung)	10Q (twice irrigated post mung)
Soyabean	1.	Crop failed (2017)	
	2. (w/bore)		5Q (1 in Oct 2017) full yield ~12Q w/2 more water
	3.	1.5Q (2017)	
Tur	1.	1.5Q/acre	5Q

Ghusar cluster: Farmer yields surveys

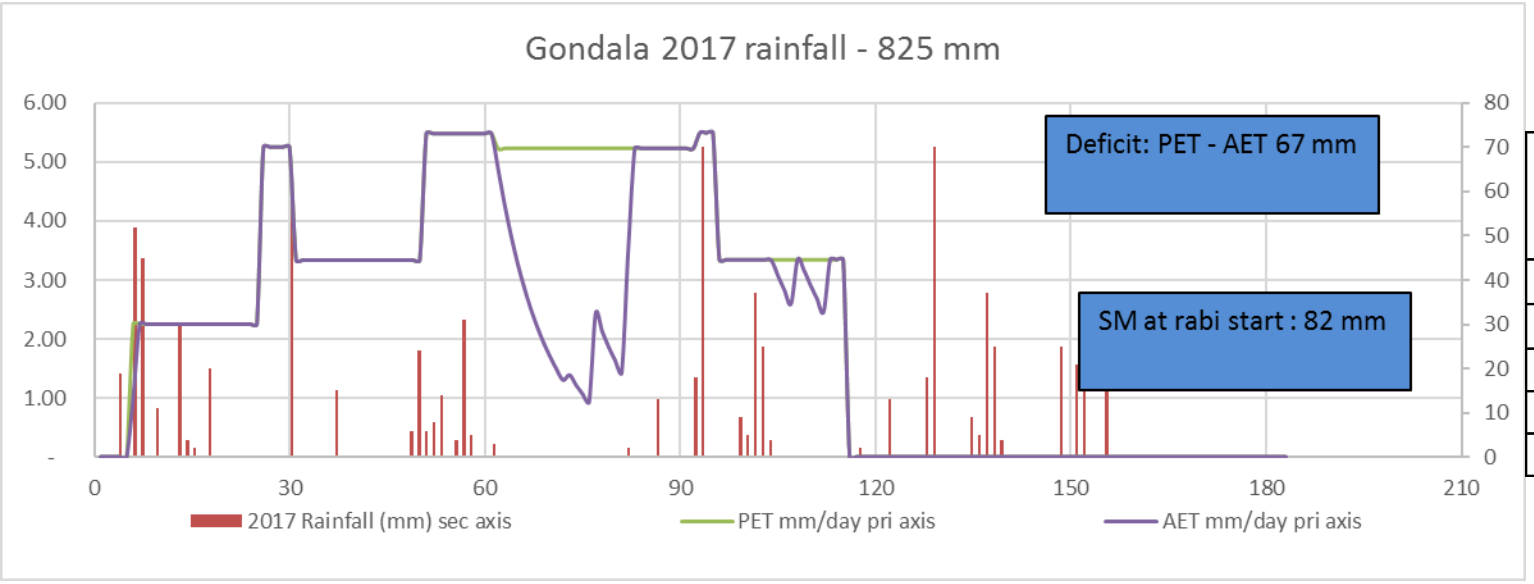
Crop	Farmer No	Unirrigated	Irrigated
Cotton	1. w/FP	7Q/acre (in 2017)	8Q/acre (one irr in 2016)
			8Q (July 2017 protective irr)
			12Q (1 kharif protective + 1 in Nov 2017)
			6Q (one irrigation)
			6-7Q (post mung; one irr Oct 2017)
	3. (w/ bore)	5-6Q (after mung no irrigation)	
(Jackie)	4.	6-7Q (post mung	
Soyabean	1.	Crop failed (201	
	2. (w/bore)		
	3.	1.5Q (2017)	
Tur	1.	1.5Q/acre	





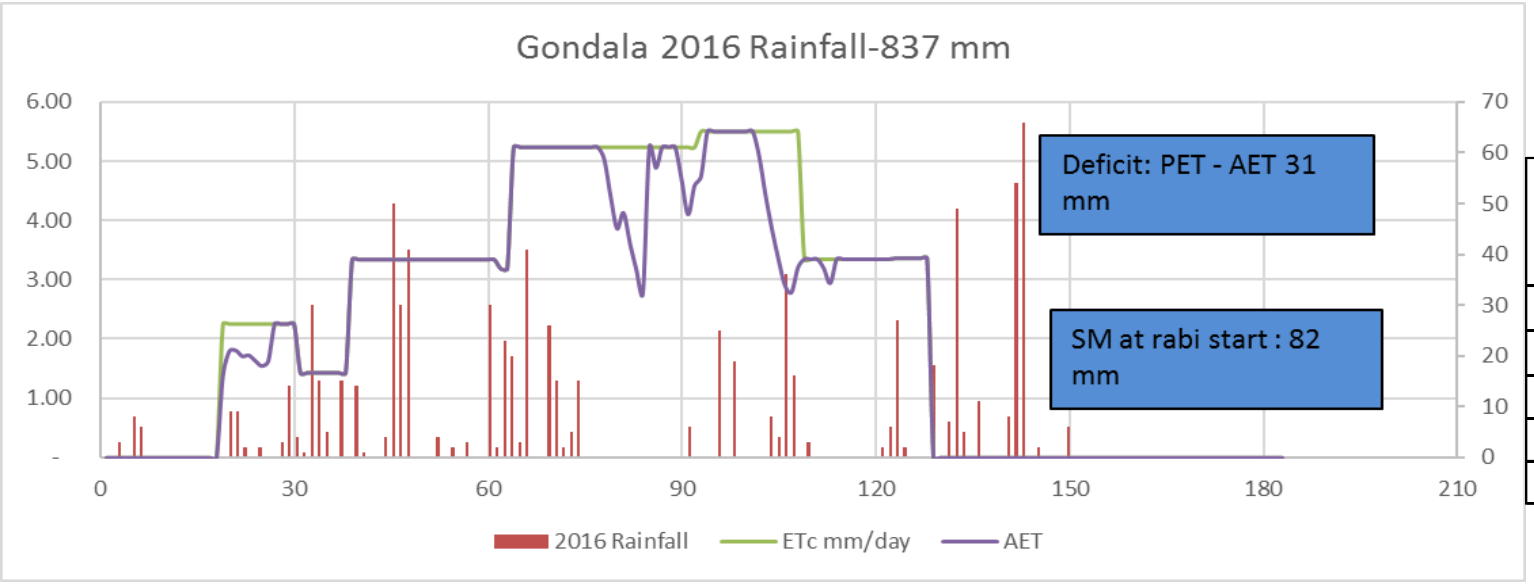
How do we stabilize yields?

Kharif dry spell impact



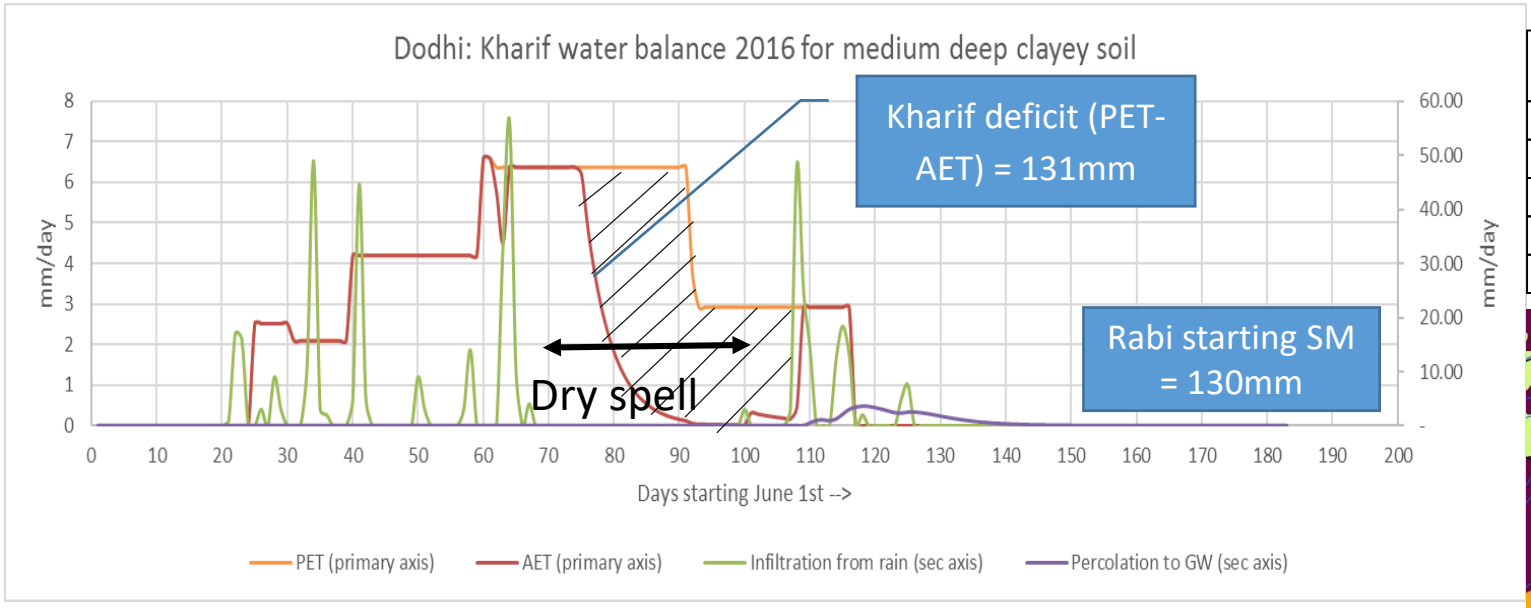
Components (mm)	Year 2017
Rainfall	825.00
Runoff	251.50
Soil Moistur	82.60
GW Rechar	113.83
AET	377.11

Crop: Soyabean

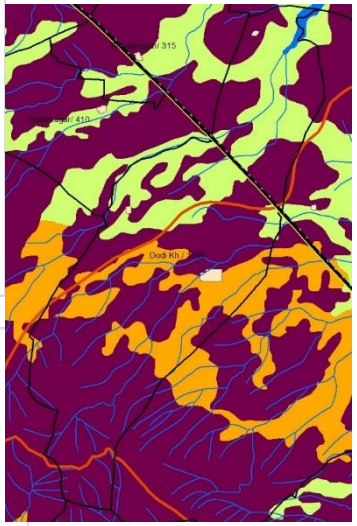


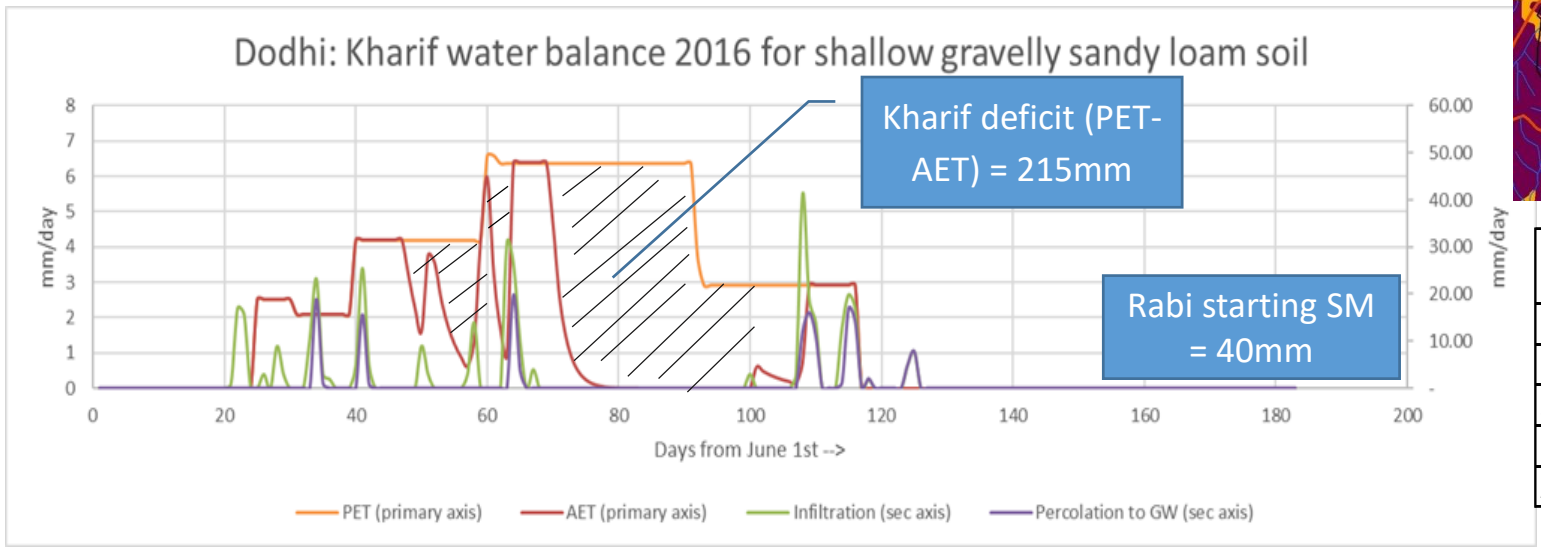
Components (mm)	Year 2016
Rainfall	837.00
Runoff	273.00
Soil Moistur	82.60
GW Rechar	84.40
AET	397.02

Kharif dry spells and soil type



Components (mm)	Medium deep clayey soil
Rainfall	563.00
Runoff	109.98
Soil Moisture	130.00
GW recharge	57.50
AET	265.52





Components (mm)	Shallow sandy
Rainfall	563.00
Runoff	195.43
Soil Moisture	40.00
GW recharge	145.84
AET	181.73

Questions faced by farmers

- How much extra irrigation (mm) should a farmer be prepared to give in Kharif?
- How much of this is available currently and where will the remaining come from?
- What interventions should be made for this?
- Is the Rabi crop secure?

- Impact of dry spells and excess rainfall depends crucially on local parameters
- A model to account for rainfall into its components: soil moisture, GW recharge, run-off and crop ET

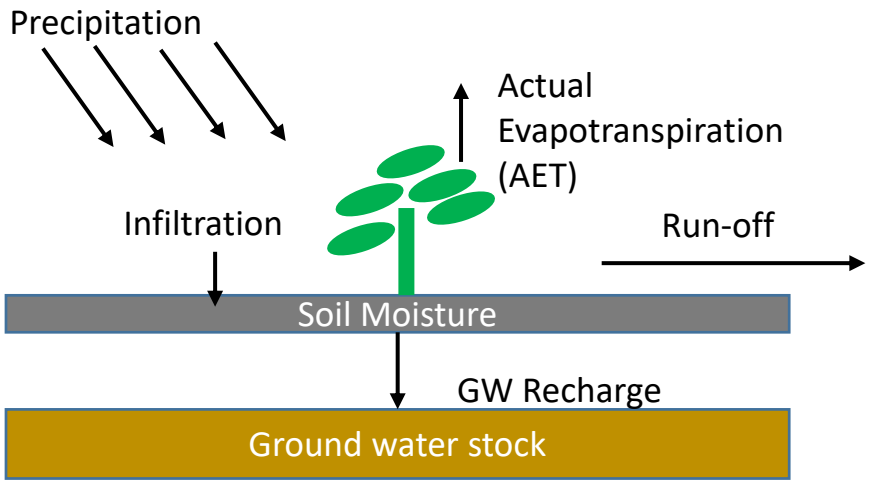
Water Balance Focus Areas

- Kharif dry spell planning:
  - Identification of farmers most vulnerable in dry spells *where*
  - Quantification of monsoon protective irrigation required
  - Computation of run-off and **monsoon deficit** *how much*
- Post monsoon planning:
  - Quantification of soil moisture and ground water available for post-monsoon crops (long Kharif, Rabi, annual crops) *supply*
  - Current post-monsoon crop water requirement *demand*
  - **Post monsoon deficit**
- Guidance on structures based on above
  - Planning at zone (100-250ha) level, using principles of watershed
- Advisory on cropping pattern and land use

Outline

1. Climate resilience and need for water budget
2. Water balance: Technical details
3. Water budget exercise: Methodology adopted
4. Example

Point level Water balance



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	

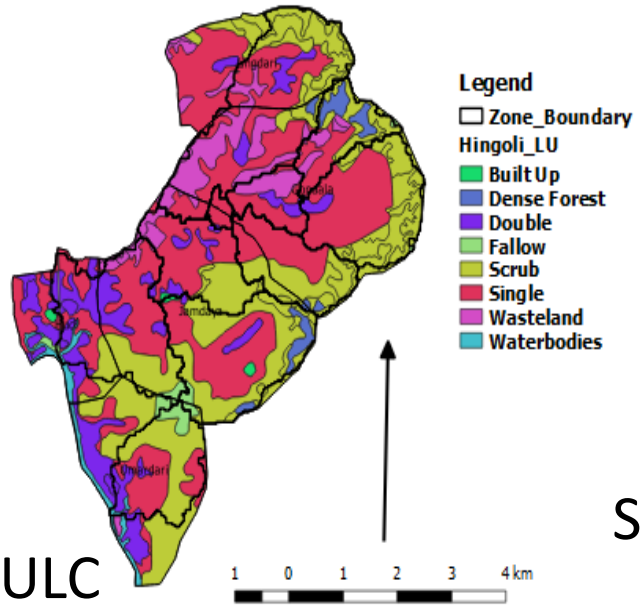
Output: Gondala Monsoon end balance

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

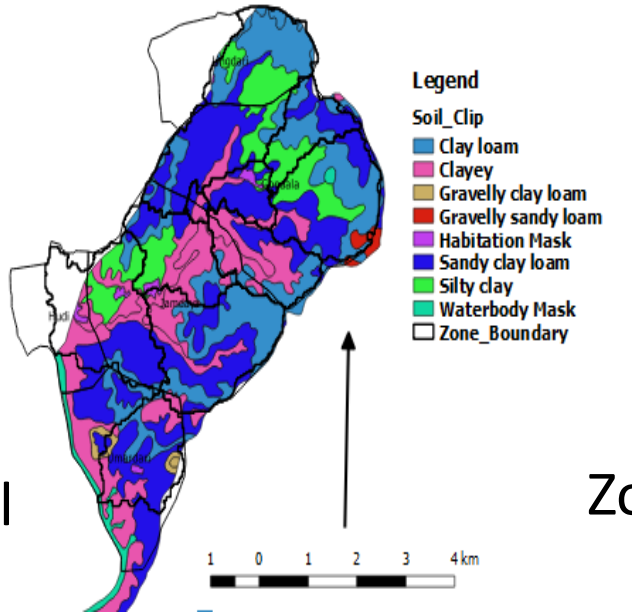
Area for individual crops to come from field assessment

Example: Gondala cluster inputs

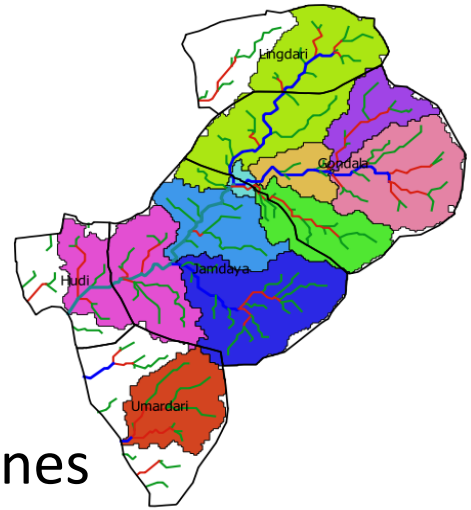
LULC



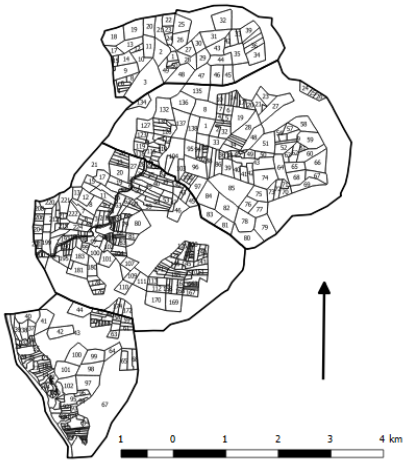
Soil



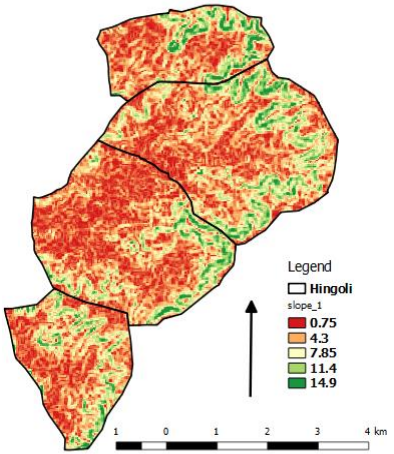
Zones



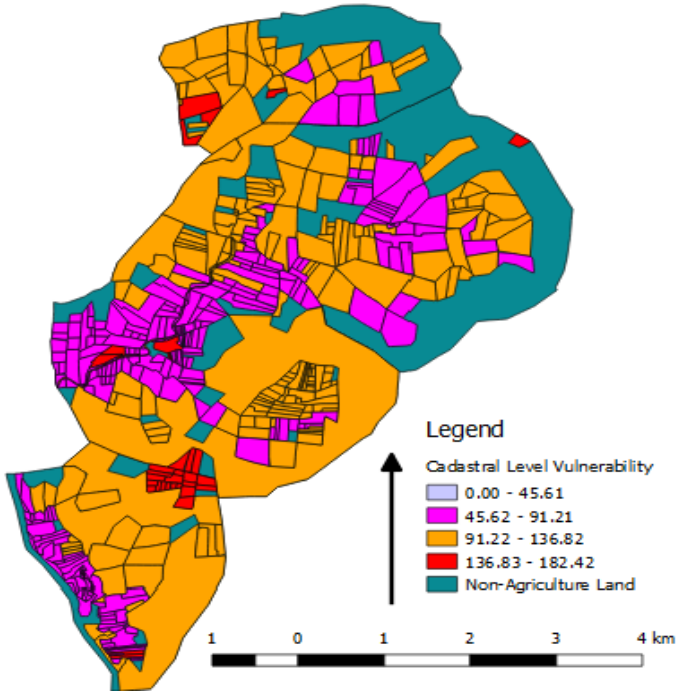
Cadestral

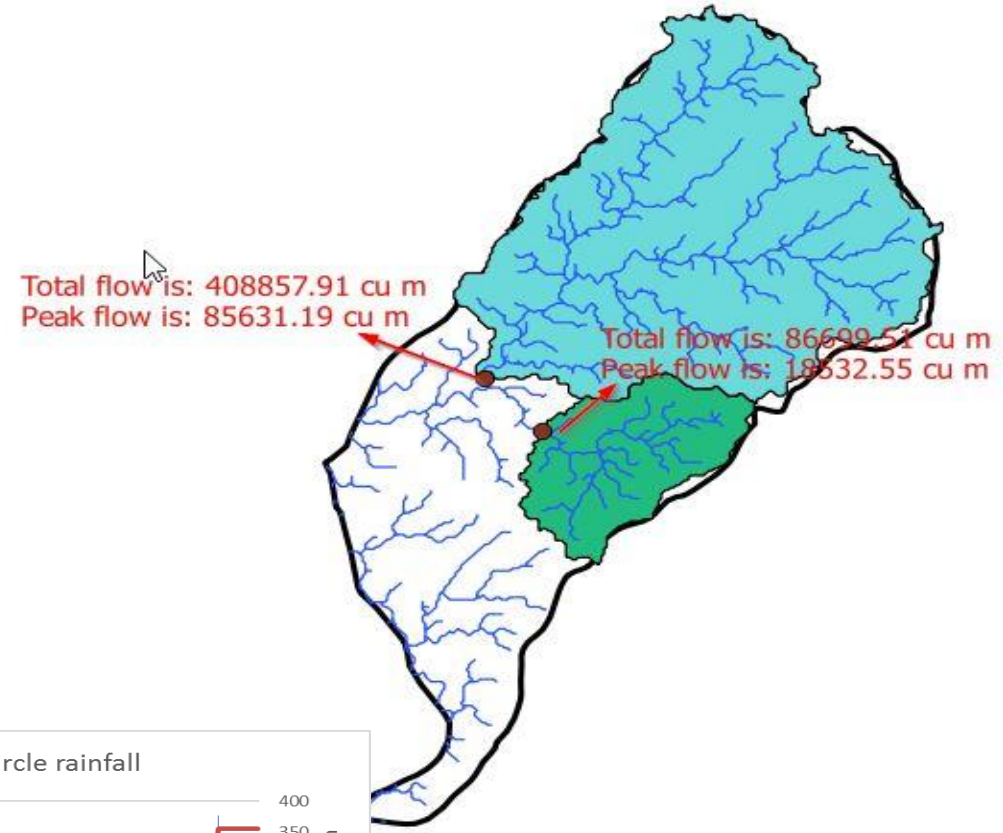


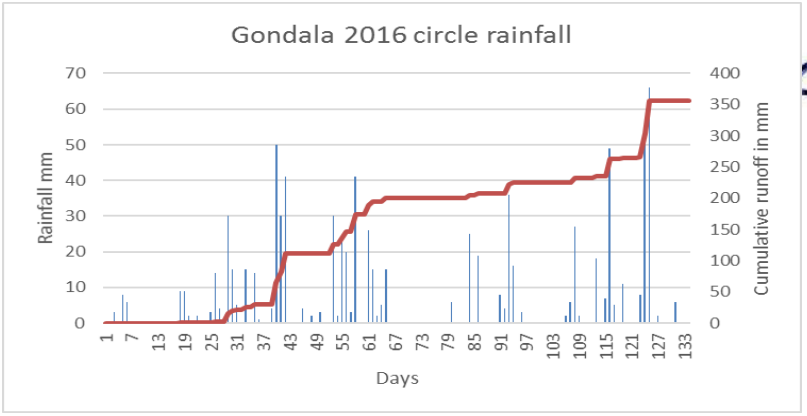
Slope



Output 1: Monsoon vulnerability maps







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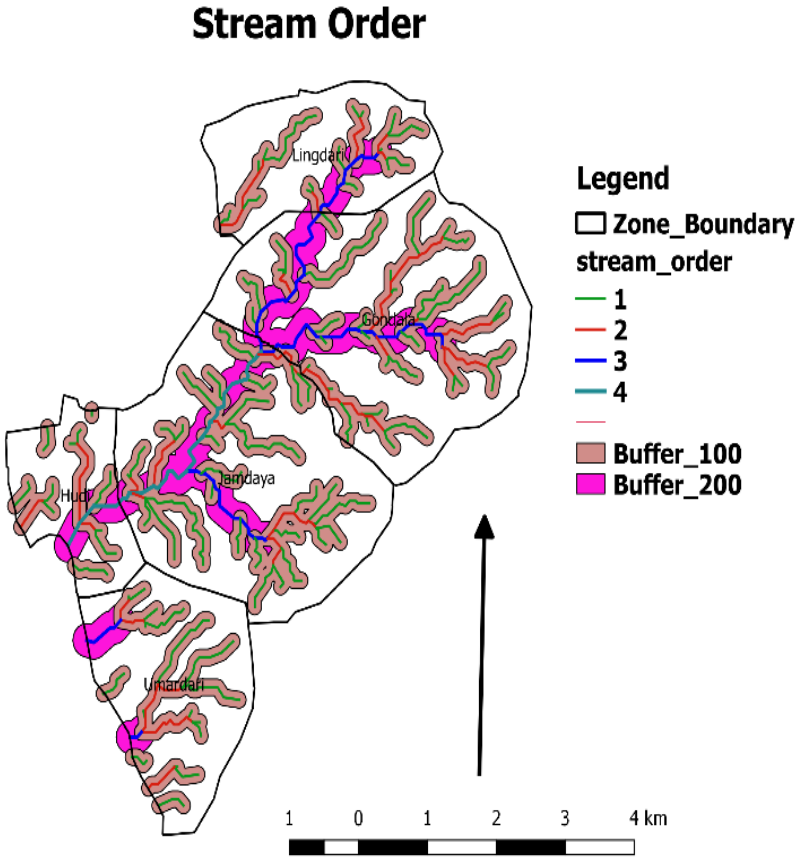
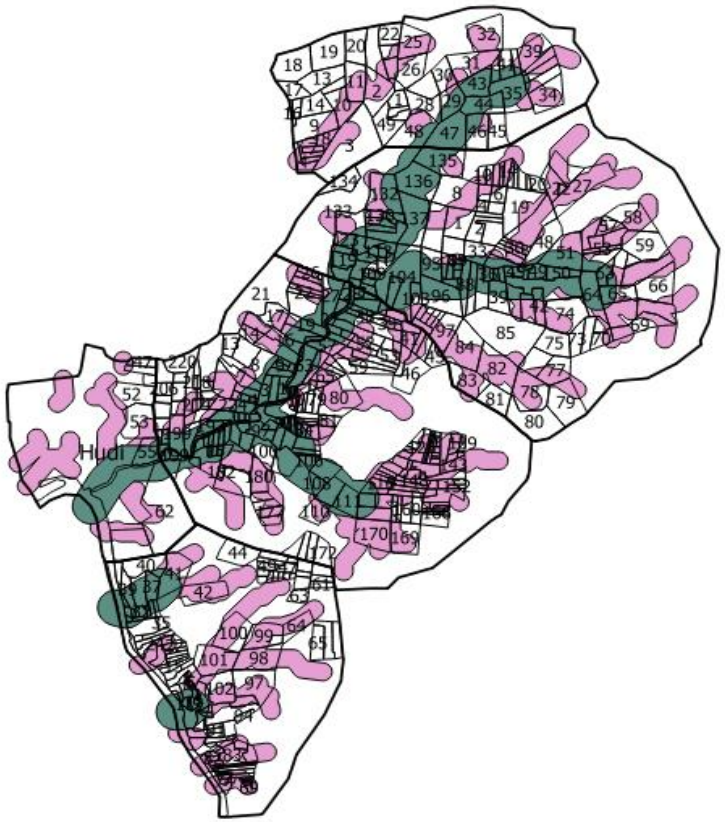
Output 2: Stream proximity map





Output 3: Gondala Monsoon end balance

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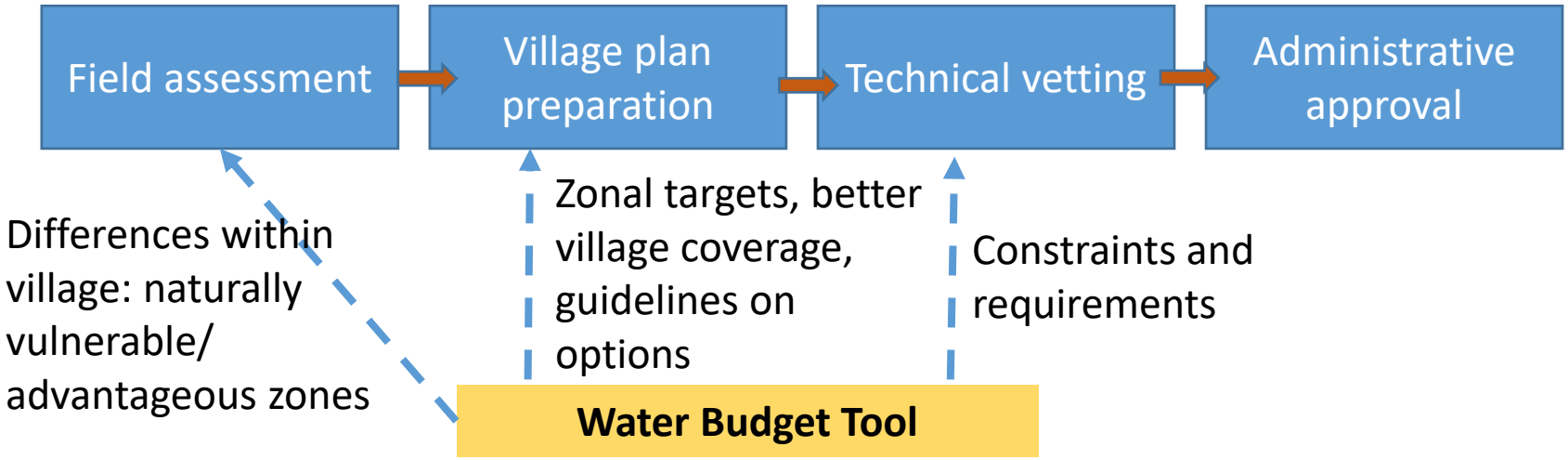
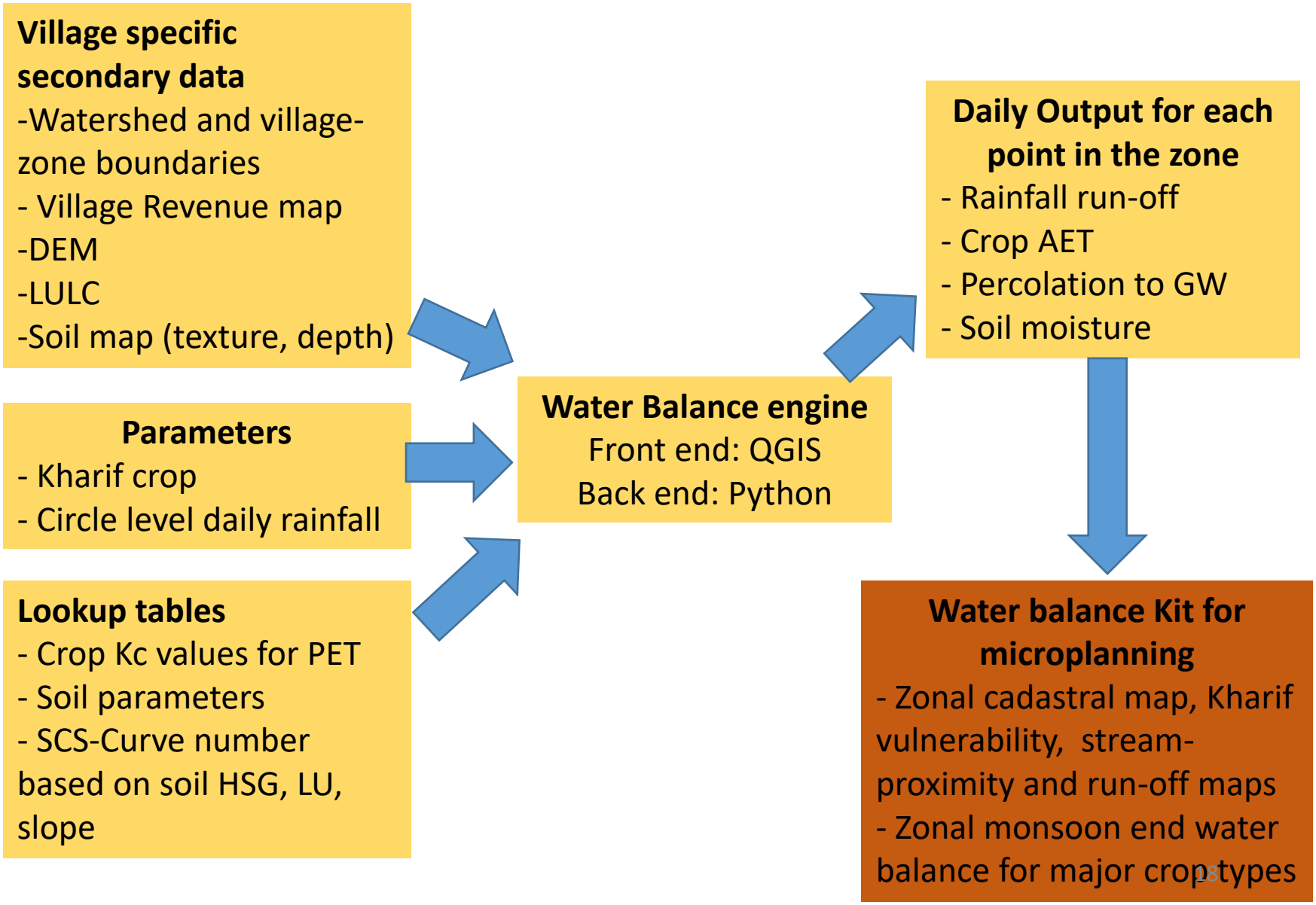
New water balance approach



- How does community benefit?
  - Identification and targeting of naturally vulnerable farmers
  - Better choice, siting and better utility from interventions
  - Better coverage of entire village, uniform benefits
  - Focus on assuring protective irrigation to improve yields
  - More informed rabi cultivation and guidance on sustainability
  - Better land use and overall water availability including DW

Methodology adopted – Pre-planning



Methodology adopted- WB during Microplanning

Field data collection/ validation in transect walk

- Collection of zonal cropping data
- Existing structures and capacity
- Human and animal population
- Validation of vulnerability zones
- Zonal Farmer surveys to capture yields and asset-poverty

WB Kit for microplanning

- Zonal monsoon end water balance for major crop types

Water balance app on tablet

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

Methodology adopted- Water budget and planning

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

- Additional run-off to be impounded

How much

Water balance Kit for microplanning

Zonal Kharif vulnerability maps

Stream proximity map

Run-off maps if required

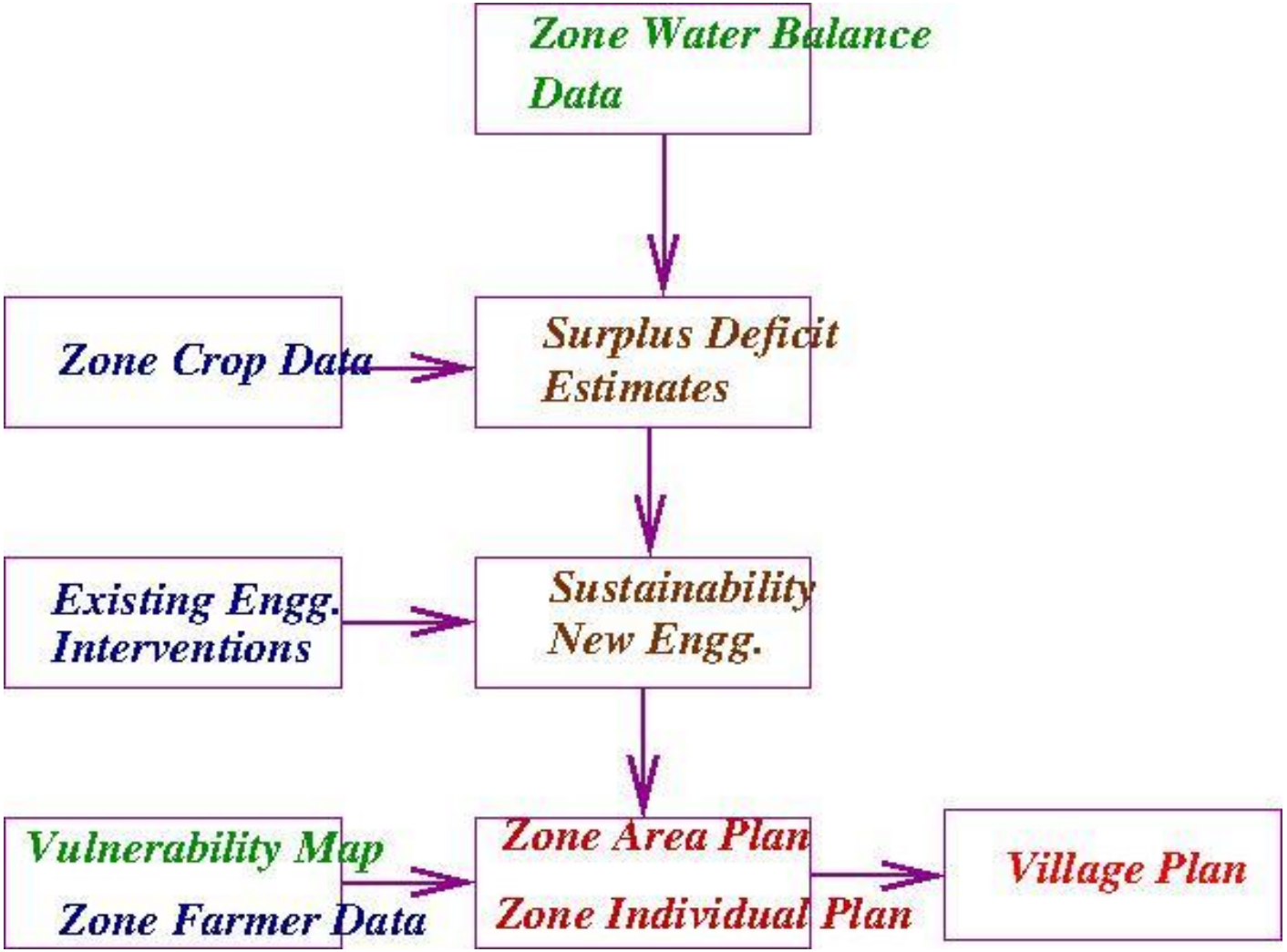
Where

Advisory on how much additional water to impound (TCM) in each zone

Advisory on which farmers to target when planning location of interventions

Testing different options and re-evaluating water budget as "what-if" scenarios

Basic Outline of Water-balance enabled planning



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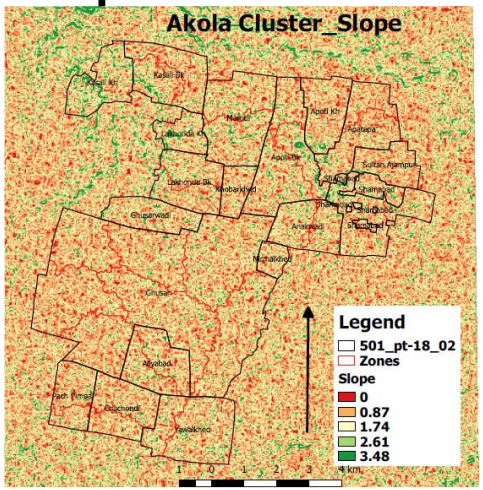
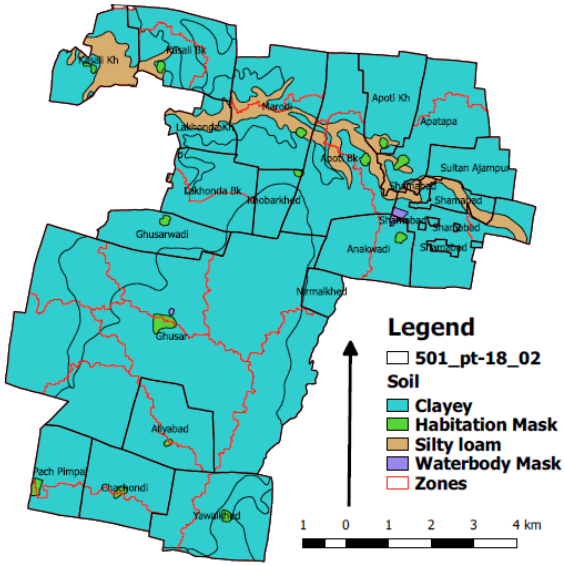
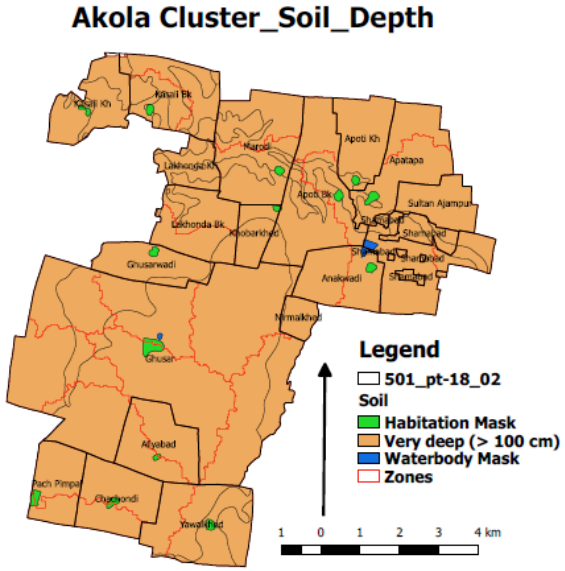
Towards an ideal village plan: example

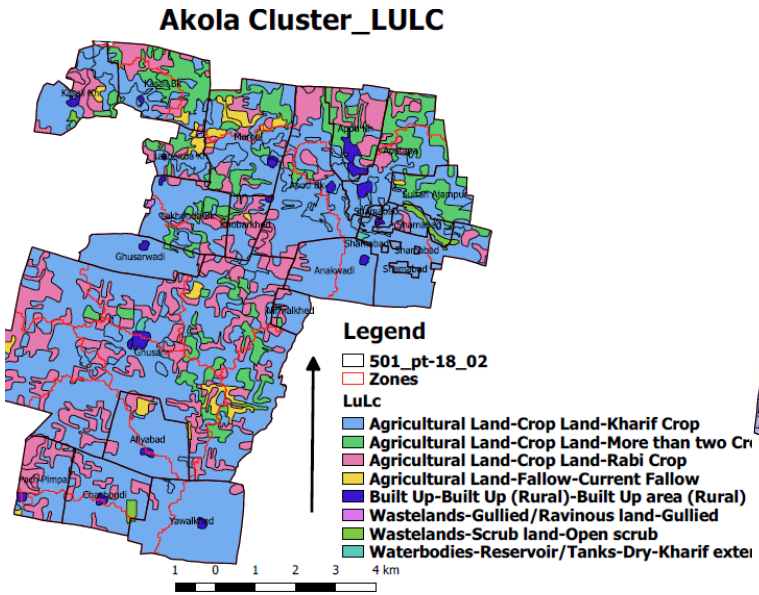
- Broad village description: land use, crops, major sources of water, soil type, socio-economic situation
- Key water budget indicators and vulnerabilities and their general verification, good rainfall vs. bad rainfall scenarios
- Targets: seasonal indicators, cropping plan, storage, land use
- Strategy: Selection of interventions and overall justification
- Locations: maps, gat numbers
- Verification of targets through computation
- Financial outlay, KPI, community, vulnerability and sustainability report

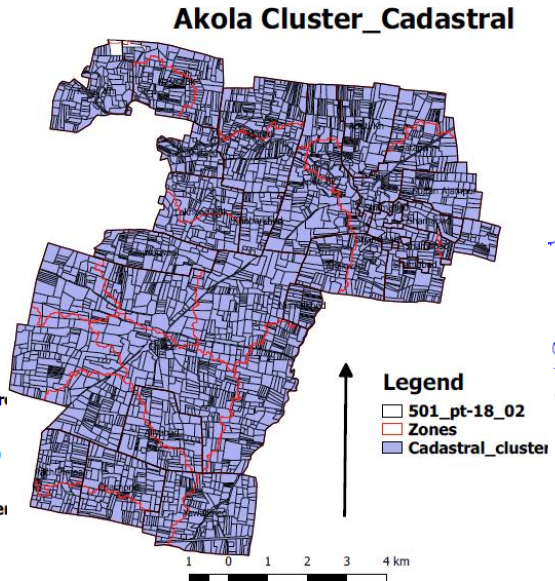
Example – Ghusar (saline belt) village inputs

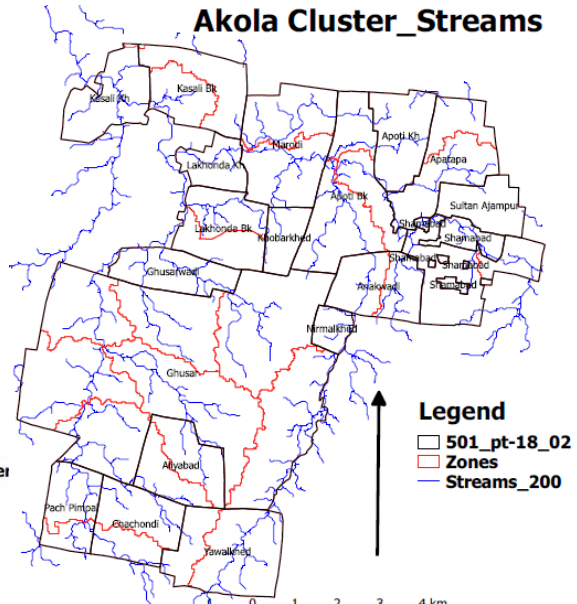




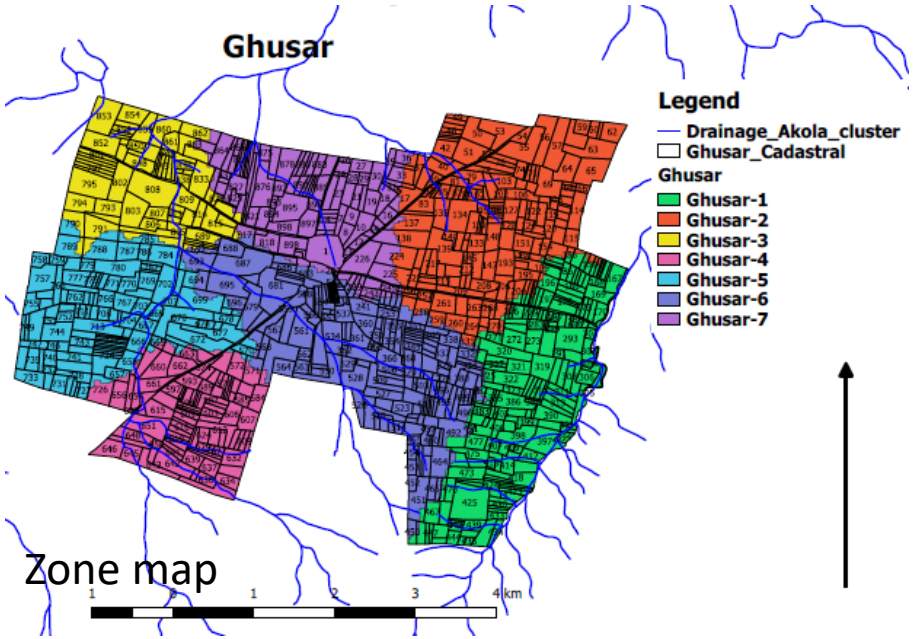




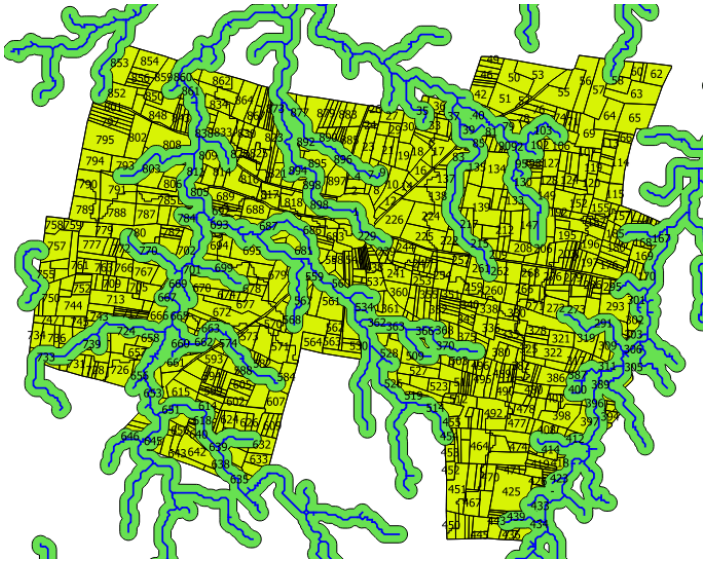




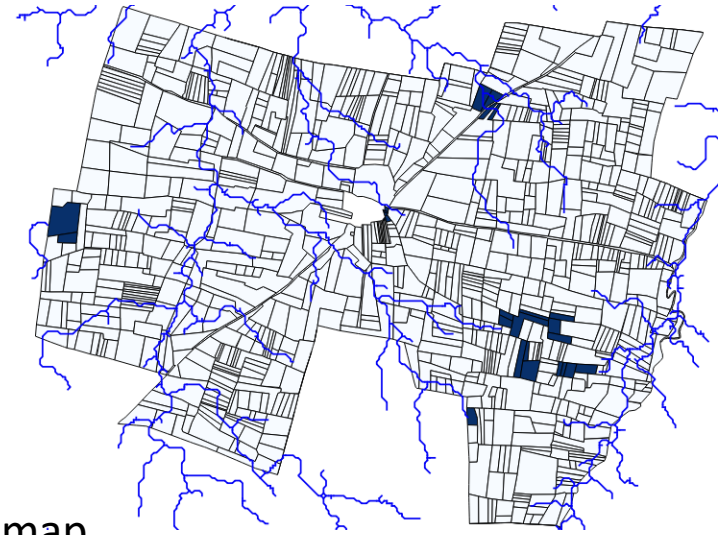
Ghusar: Microplanning kit



Zone map



Stream proximity map



2016 Vulnerability map

Ghusar Post monsoon computation (good year and bad year)

2017: Rainfall 550mm	PET Monsoon End	AET Monsoon End	Monsoon Deficit(PET-AET)	GW Recharge in Monsoon	Runoff in Monsoon	Soil Moisture Monsoon end	Post Monsoon PET
Cotton	401.09	381.15	19.95	-	76.93	76.92	389.13
Moong	261.37	228.09	33.28	-	116.66	190.25	-
Tur	376.04	359.13	16.91	-	90.45	85.42	242.37
Soyabean	434.56	377.16	57.39	-	69.08	88.76	-
Harbhara	-	-	-	-	-	-	250.00
2016: Rainfall 920mm	**PET Monsoon End**	**AET Monsoon End**	**Monsoon Deficit(PET-AET)**	**GW Recharge in Monsoon**	**Runoff in Monsoon**	**Soil Moisture Monsoon end**	**Post Monsoon PET**
Cotton	342.51	337.27	5.24	-	410.14	113.60	424.43
Udid	232.12	228.80	3.32	4.68	426.45	201.06	-
Tur	314.97	295.34	19.63	-	437.19	126.45	288.90
Soyabean	403.78	346.98	56.80	-	402.37	111.65	18.62

Ghusar field inputs: cropping pattern and current structures

Crop	Ghusar 1	Ghusar 2	Ghusar 3	Ghusar 4	Ghusar 5	Ghusar 6	Ghusar 7	Total village
Soybean	20	21.29	0	0	0	15.6	10.11	67
Jowar	14	6	8	7	4	20	13	72
Cotton	314.92	375	70	67.89	149	348.95	257	1582.76
Moong	52	90	182	177	220	70	26	817
Udid	5	4	5	5	7	12	6	44
Tur	55	65	35	30	27	60	20	292
Total	460.92	561.29	300	286.89	407	526.55	332.11	2874.76
Ag Area	461.92	561.29	300	297.41	407.73	526.55	332.11	2887.01
Non Ag	0.27	0	0	0	0	0	0	
Farm ponds	33	30	34	19	21	36	39	212

Ghusar Seasonal zonal water balance –good year (2016)

2016 Seasonal Water Budget		Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7
Monsoon balance (TCM)	Monsoon Protective Irrigation Demand	40.4	45.5	23.6	28.0	26.2	26.2	30.4
	Existing Runoff Storage	36.2	32.9	37.3	20.9	23.1	39.5	42.8
	Monsoon balance: current supply-demand	-4.1	-12.5	13.7	-7.1	-3.1	13.4	12.4
	Monsoon Protective Irrigation Index	0.9	0.7	1.6	0.7	0.9	1.5	1.4
Post-monsoon balance (TCM)	Rabi Total Water Requirement	1608.4	1891.9	510.7	436.3	822.9	822.9	1261.1
	Drinking Water Requirement	0.0	0.0	0.0	0.0	0.0	110.0	0.0
	Water Available from Soil Moisture	502.0	582.8	198.4	194.7	278.1	278.1	391.9
	Water Available from GW	4.8	4.8	4.8	4.8	4.8	4.8	4.8
	GW recharge available from current storage	36.2	32.9	37.3	20.9	23.1	39.5	42.8
	Rabi balance : GW supply+ SM + structures-Rabi demand - DW	-1065.3	-1271.3	-270.1	-215.9	-517.0	-610.5	-821.5
	Post-monsoon Protective Irrigation Index	0.3	0.3	0.5	0.5	0.4	0.3	0.3
Design (TCM)	Water Available from Runoff (80%)	1675.2	1907.0	801.3	785.5	1032.6	1032.6	1362.4
	Additional water available for impounding	1602.7	1841.1	726.7	743.8	986.4	953.5	1276.8

Ghusar Seasonal zonal water balance –bad year (2017)

2017 Seasonal Water Budget		Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7
Monsoon balance (TCM)	Monsoon Protective Irrigation Demand	116.4	130.0	64.1	62.9	187.6	78.5	98.9
	Existing Runoff Storage	36.2	32.9	37.3	20.9	23.1	39.5	42.8
	Monsoon balance: current supply-demand	-80.1	-97.1	-26.8	-42.0	-164.5	-39.0	-56.0
	Monsoon Protective Irrigation Index	0.31	0.25	0.58	0.33	0.12	0.50	0.43
Post-monsoon balance (TCM)	Rabi Total Water Requirement	1471.6	1729.3	469.7	449.8	695.9	757.7	1161.0
	Drinking Water Requirement	0.0	0.0	0.0	0.0	0.0	110.0	0.0
	Water Available from Soil Moisture	356.8	411.5	151.2	145.4	187.9	205.2	282.3
	Water Available from GW	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	GW recharge available from current storage	36.2	32.9	37.3	20.9	23.1	39.5	42.8
	Rabi balance : GW supply+ SM + structures-Rabi demand - DW	-1078.6	-1284.9	-281.2	-283.5	-485.0	-623.1	-836.0
	Post-monsoon Protective Irrigation Index	0.27	0.26	0.40	0.37	0.30	0.28	0.28
Design (TCM)	Water Available from Runoff (80%)	349.2	393.4	184.0	179.1	232.5	226.8	288.2
	Additional water available for impounding	276.7	327.5	109.3	137.4	186.4	147.7	202.5

- Rabi sowing for bad rainfall year should be reduced
- Current demand will not impound all available run-off even in a bad rainfall year (1400 TCM available)

Ghusar –Planning guidance from WB

- No scope for area-treatment
  - Saline GW, clayey soil
- Large scope for inlet-outlet type farmponds
  - Factors: Clayey soil, saline GW, large run-off, need to drain fields from run-off during monsoon, large landholding farmers
  - Large demand from farmers for farm ponds but siltation is an issue
  - Where? A 30x30x3 (or 2TCM) farm pond can be filled from run-off on 2 ha land (run-off is close to 100mm even in bad rainfall year)
  - How many: more than 500; constrained only by demand and budget
- Drain line
  - Good scope for widening/ deepening streams with gabion structures for soil conservation
  - Desilting of village pond and farm ponds
  - CNBs, MNBs

Village Demand	No.
Orchards (lime, mango, peru)	11 ha
Farm ponds w/o plastic w/ plastic	212 253
MNBs	10
CNBs	10
Gabion structures	10
Wells	50
Stream deepening/ widening	3 km

Additional ~ 1150 TCM

Ghusar cluster: Farmer yields surveys

Crop	Farmer No	Unirrigated	Irrigated
Cotton (Ajit 155)	1. w/FP	7Q/acre (in 2017)	8Q/acre (one irr in 2016)
	2. w/bore	3-5Q	8Q (July 2017 protective irr)
	3.		12Q (1 kharif protective + 1 in Nov 2017)
Harbhara (Vijaya)	1. w/ FP	5Q (2016)	6Q (one irrigation)
	2.	2-3Q	6-7Q (post mung; one irr Oct 2017)
	3. (w/ bore)	5-6Q (after mung, no irrigation)	(after soya) Pre-water before sowing + 2 more in Nov and Dec: 6-7Q/acre
(Jackie)	4.	6-7Q (post mung)	10Q (twice irrigated post mung)
Soyabean	1.	Crop failed (2017)	
	2. (w/bore)		5Q (1 in Oct 2017) full yield ~12Q w/2 more water
	3.	1.5Q (2017)	
Tur	1.	1.5Q/acre	5Q

2.1 TCM FP allows 2 water to 2 ha harbhara => ~Rs 20k/ yr

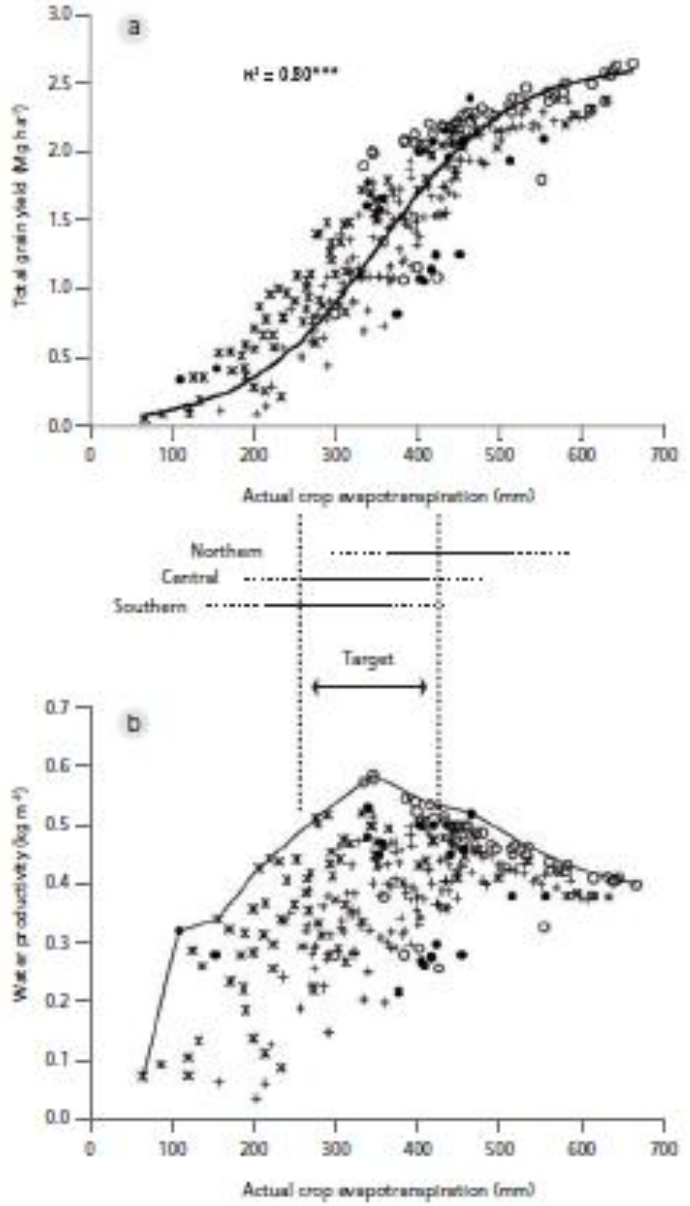
Improvement over existing models

- Seasonal model with special attention to Kharif protective irrigation planning
- Addresses differences within a village spatially and ensures good coverage
  - Creation of vulnerability maps
  - Zone as a unit of planning
- Takes soil moisture and soil type into consideration
- Easy-to-use format requiring some key field data as input
- Coupling with advisory on intervention planning and cropping pattern
  - “what-if” scenarios
- Areas for further improvement (part B of this presentation)

Thanks

More crop per drop: rationing water

- When available water is limited, most crop per drop can be attained at lower AETs even though this leads to lower yields
- Seen in farmer decisions (e.g. harbhara vs cotton, kharif vs. long kharif crop)



Ref: FAO Paper 66 on crop yield response to water

Daregaon potential treatment plan

Legend

- Linaments/Dyke
- Contour 5 Meter
- Watershed Boundary
- Survey/Gat No. Boundary
- Village Boundary

Drainage Line Treatment

- Gully Plug or LBS
- Earthen Nalla Bund/ Gabian Bandhara
- Nala Desilting/C.N.B./K.T.

Area Treatment

- Dry land Agriculture/Contour Bunding/ Farmpond
- Afforestation/ Dry Land Horticulture/Plantation
- CCT/Deep CCT/WAT/Forest Pond
- Compartment Bunding/Graded Bunding/Fram Pond/Well Recharge
- River/ Waterbody
- Village Area