Climate Change

Mitigation and Vulnerability for the bottom 80%

PoCRA Group IIT Bombay
12th September 2022

India Stats

Average Household Income (monthly, 2019)	Rs. 44,000	PPP (Rs 22/USD) $2000
Average Household income (monthly, Agri.)	Rs. 11,000	$500
Inequality	0.35-0.5 (Gini)	Bottom 50% hold 13% of income
Maharashtra Surface Water Irrigated	20-30%	Fruits, Vegetables, Sugarcane
Groundwater based irrigation	50-60 %	Soybean, Cotton, Wheat, Maize
Completely Rainfed	10-30%	Soybean, Cotton, Millets,
Average Holding	1.34 Ha.	

Energy and GHG

Agriculture, Land Use - relatively stable. Important to put degraded land into forest lands.

Big contributors - Transport and Power.

Power for irrigation - big component.

Connected with groundwater, seasonality and **transfers** in MH.

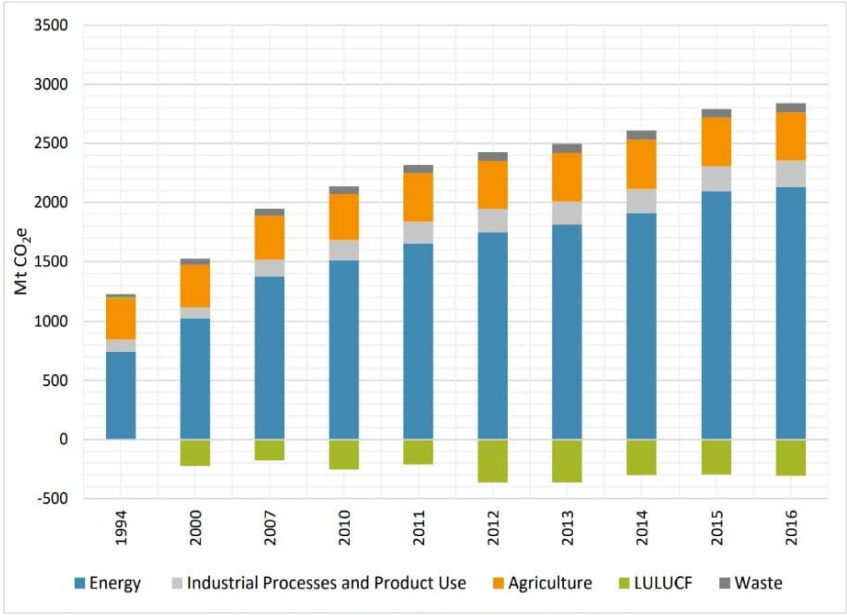
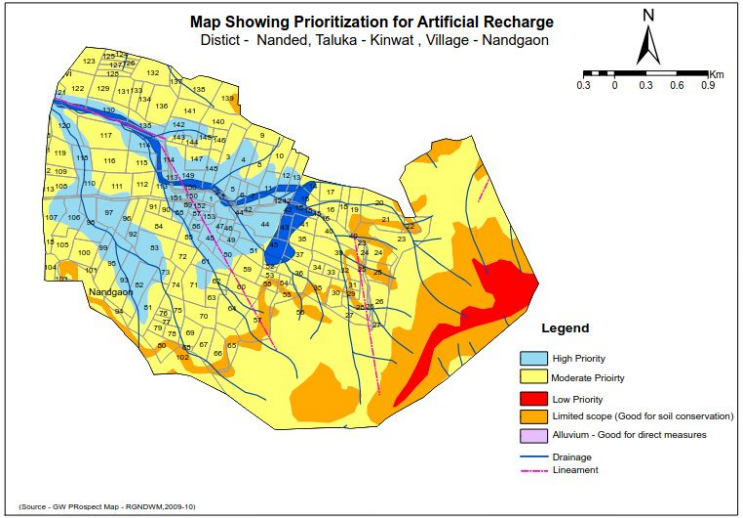


Figure 2.2: Sector-wise National GHG emission in Mt CO_2e for 1994-2016.
Source: (MoEF, 2004); (MoEF, 2012); (MoEF, 2010); (MoEFCC, 2016); (MoEFCC, 2018).

Rice in Maharashtra

Largely in western Maharashtra - monsoon driven, marginal. Hardly any irrigation. Very low energy intensity other than Urea, Largely subsistence and local consumption. **Not long-grain, no GW irrigated, not for global markets!**

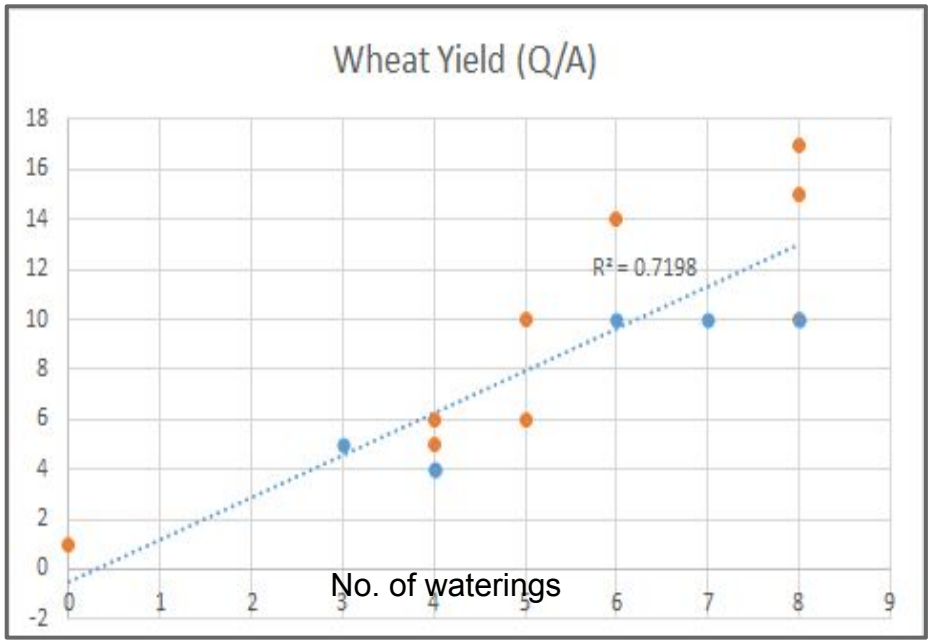
Nandgaon Tanda, Mangrul Cluster

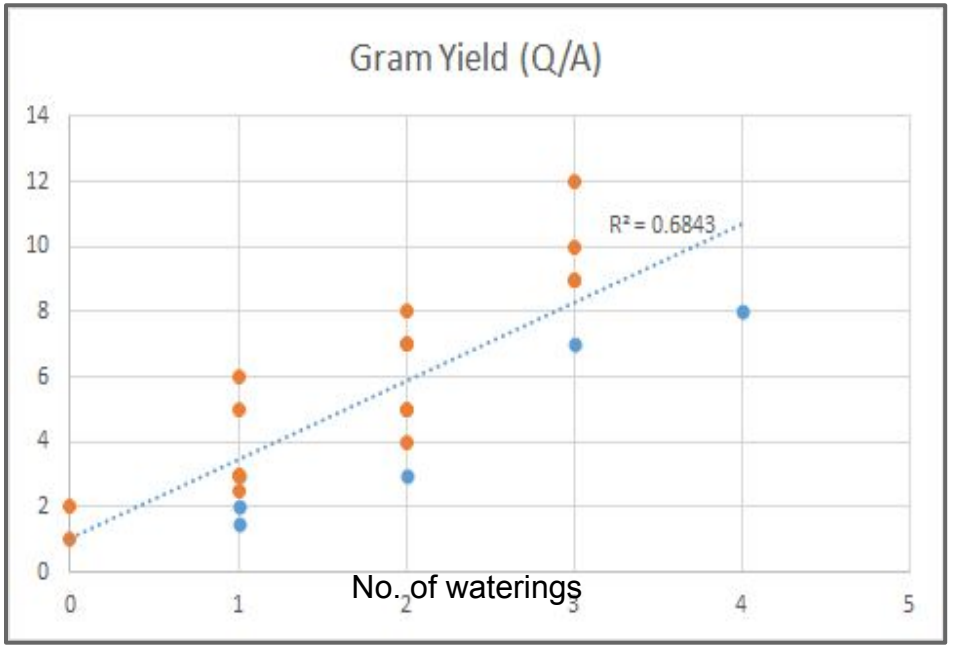


Average rainfall: 900mm. Average crop 400mm. Poor storage - less than 30mm. Recharge 100mm. 10-30% Degraded and non Agri.Lands.
About 80% monsoon (Kharif), 30% post-monsoon (winter, Rabi), 10% summer.

Tehsil	Normal Rainfall (in mm)
Phulambri (Aurangabad)	413.3
Mahur (Nanded)	837.3
Murtijapur (Akola)	584.3
Umarkhed (Yavatmal)	674.9
Jalgaon Jamod (Buldhana)	484.5
Karnja (Washim)	610.4

Overcropping, Rationing of water, yield curves



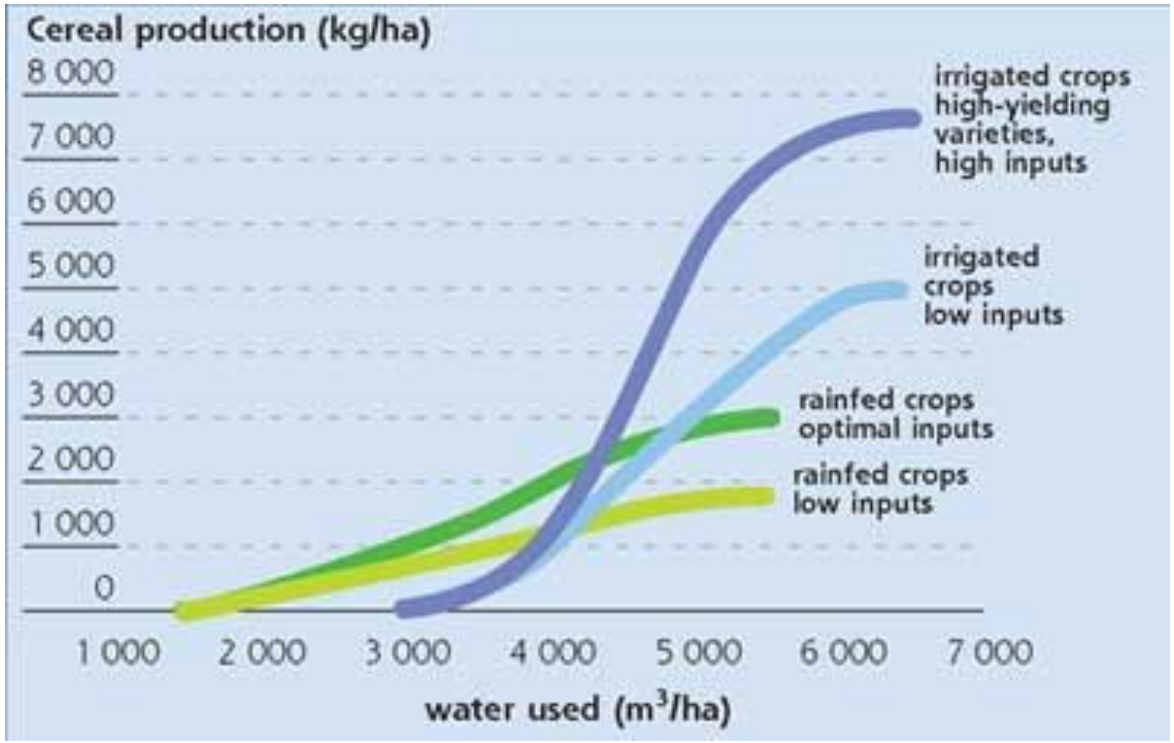


Poor Soil Good Soil

Variation in rabi crop yields due to groundwater availability and soil types (Bavi, Osmanabad 2019)

Ensuring the extra irrigation - for stabilizing rabi yields

The Traditional FAO S-Curve (similar for other crops)



How much,and How sure…

Huge Risk in high value crops - Quality and Timing

Crop	Cultivation season	Average modal Nashik wholesale market rate in 2015-16 (Rs/Quintal)	Standard deviation of modal price distribution in 2015-16	Mean price spread as share of mean price
Pearl Millet	Kharif	1526.00	6%	17%
Soybean	Kharif	3662.00	4%	7%
Maize	Kharif	1442.00	4%	4%
Green leafy vegetables	Kharif	1560.00	48%	56%
Onion	Kharif	1193.80	31%	134%
Tomato	Kharif	1385.75	44%	76%
Green gram	Rabi	4289.00	9%	16%
Sorghum	Rabi	1822.0	8%	3%
Wheat	Rabi	1666.00	12%	14%
Onion	Rabi	622.5	19%	131%
Tomato	Rabi	868.21	40%	70%
Pomegranate	Multi-year	2889.00	64%	114%
Grapes	Multi-year	3644.00	50%	52%

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High yearly variance - thin food processing markets, storage tech.

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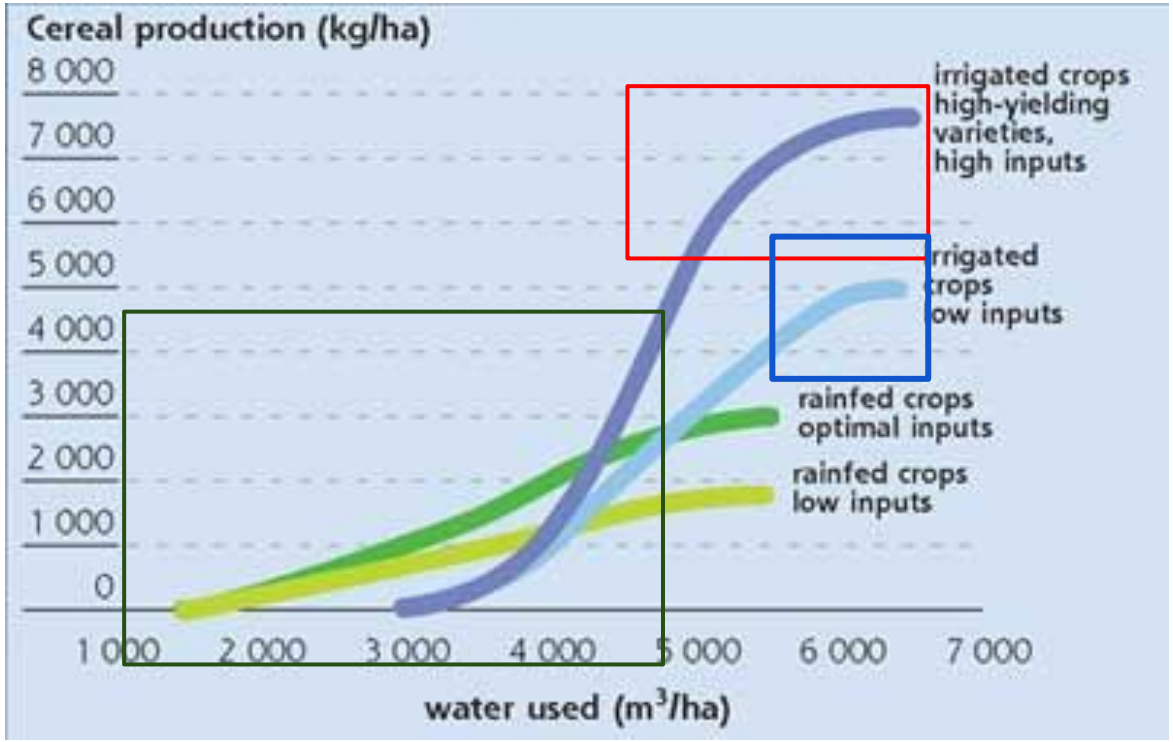
High daily variance - quality perception and high risk for farmers - **the flat part of the S-curve!**

Crop Choices and Risk

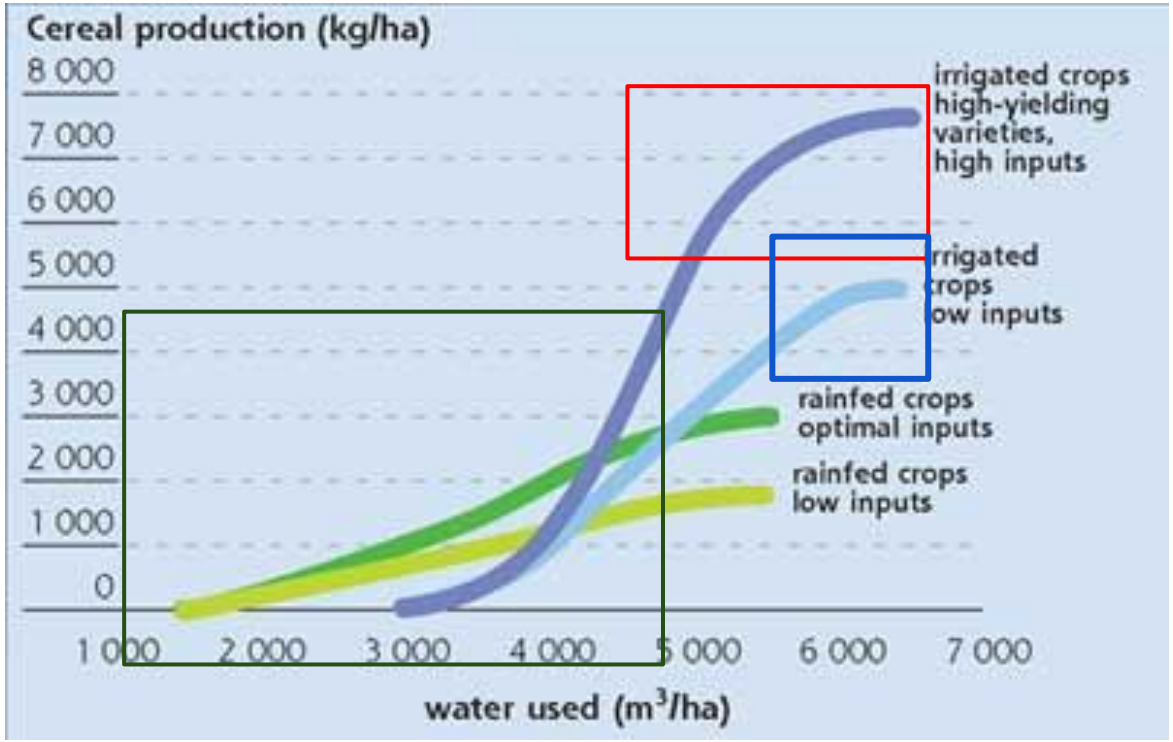


P1: Risky Red - High returns, High Variability and High Energy Intensity

P2: Surface Water - Low Risk, High returns, High Energy Intensity

P3: Groundwater-local surface water. Low risk, Bad returns. Low Energy intensity. Bottom 80%.

Target Group



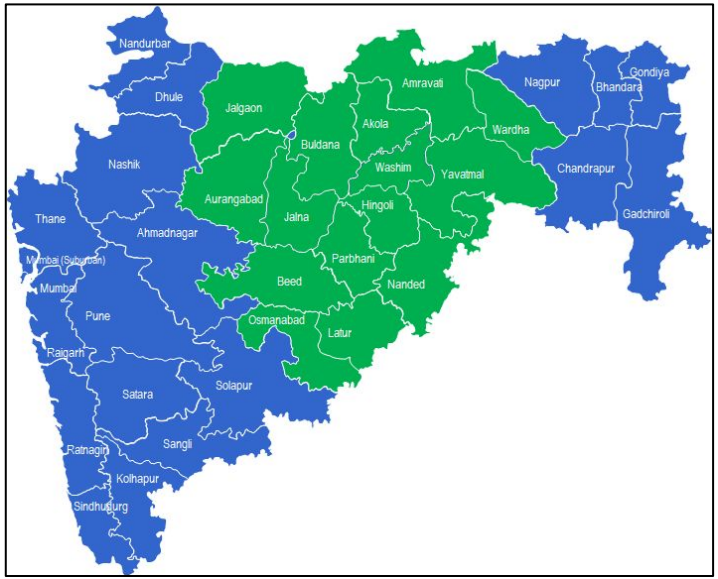
P1: Risky Red - High returns, High Variability and High Energy Intensity

P2: Surface Water - Low Risk, High returns, High Energy Intensity

P3: Groundwater-local surface water. Low risk, **Medium returns.** Low Energy intensity. Bottom 80%.

PoCRA – Project on Climate Resilient Agriculture

- A project within the Department of Agriculture, Government of Maharashtra (GoM) - World Bank, worth Rs. ~3000 crores
- Implemented in around 6000 villages over 15 districts in Marathwada and Vidarbha regions of the state.
- **To make smallholder farmers resilient to climate variability through various targeted interventions.**



Based on a Supply-Demand-Allocation framework developed by IIT Bombay.

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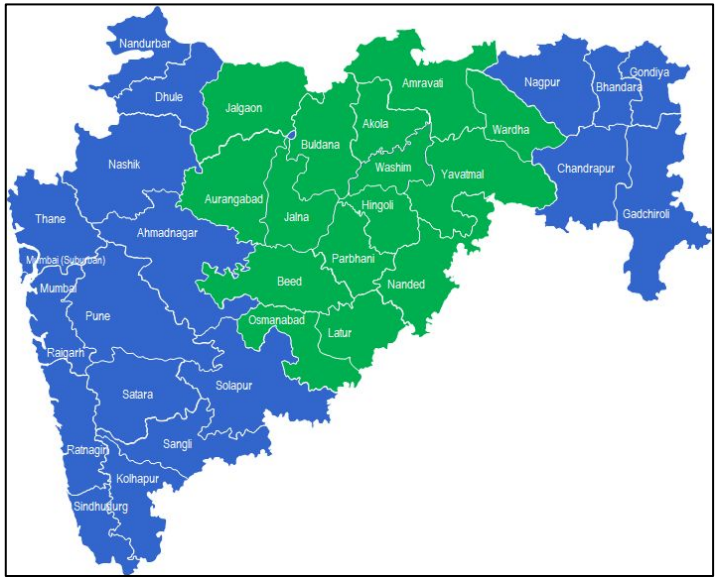
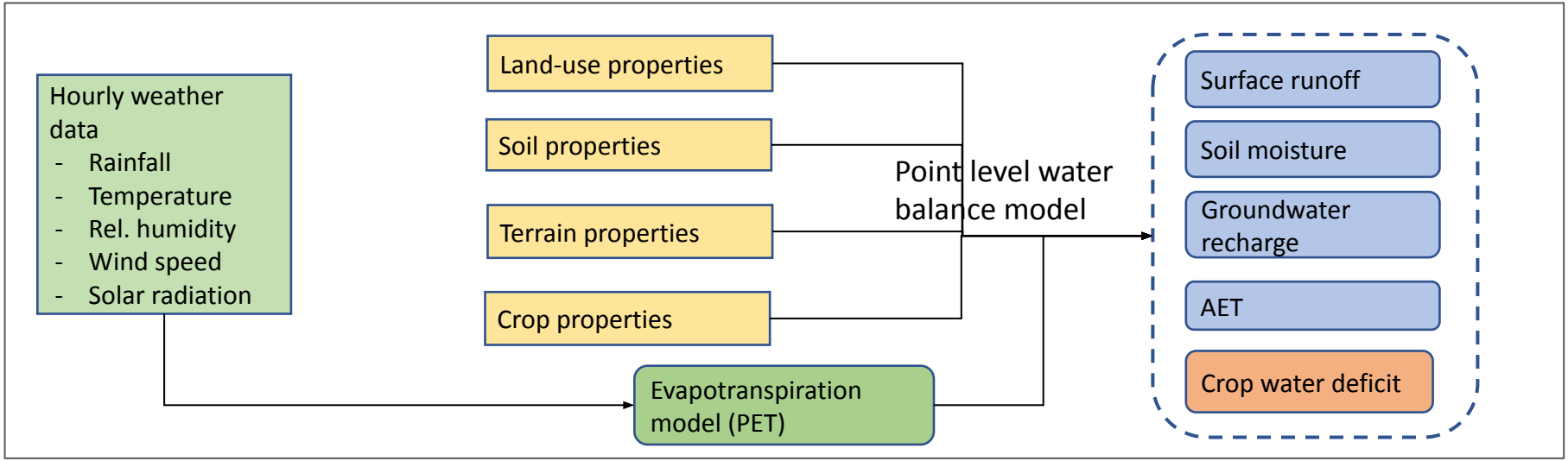
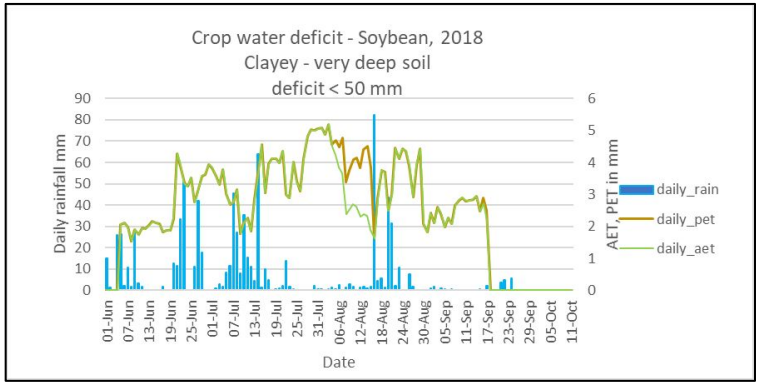


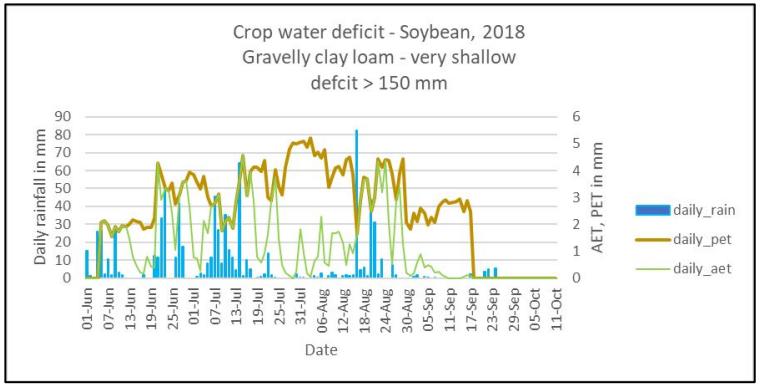
Measurable Yardsticks: *Monsoon and Post-Monsoon Indices measure the Demand-Supply mismatch. Storage in mm measure ability to save run-off.*

Extension targets: *Access and Median Yield.*

The core engine – soil water balance model







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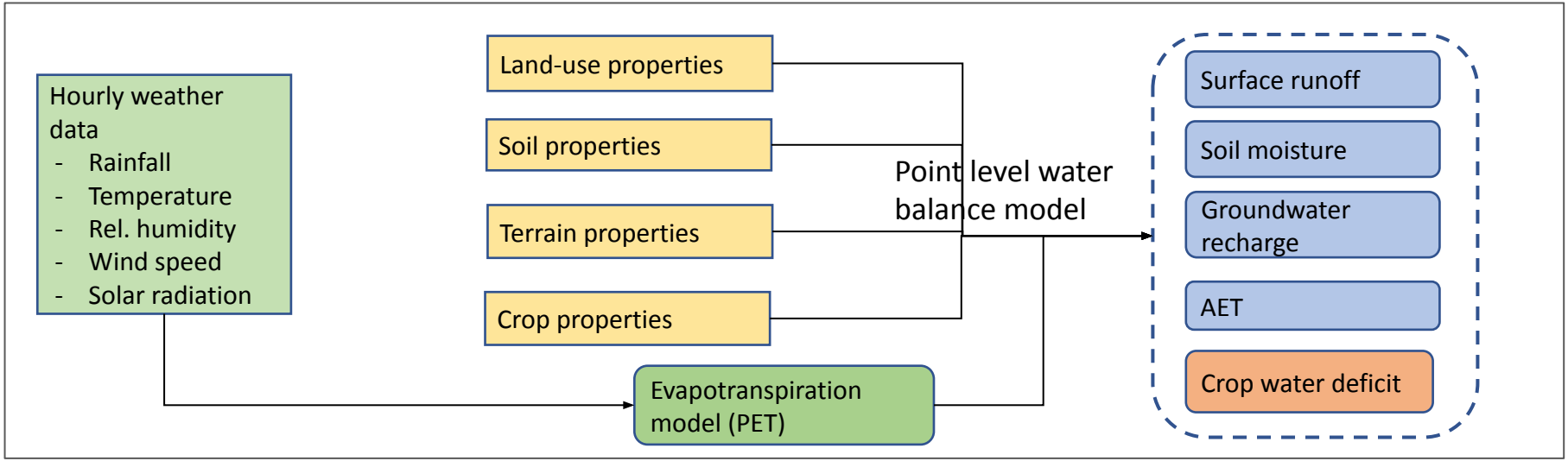
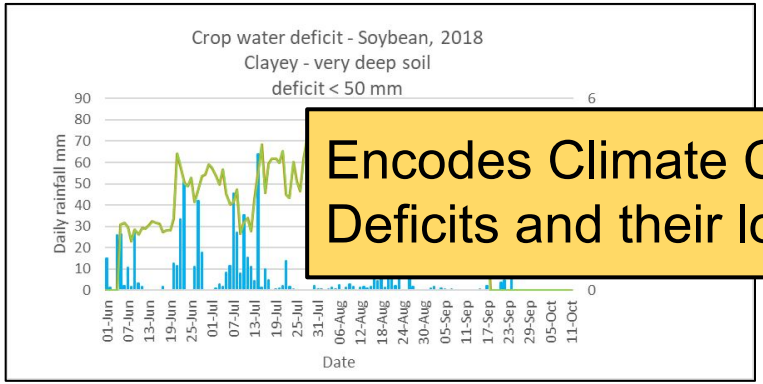
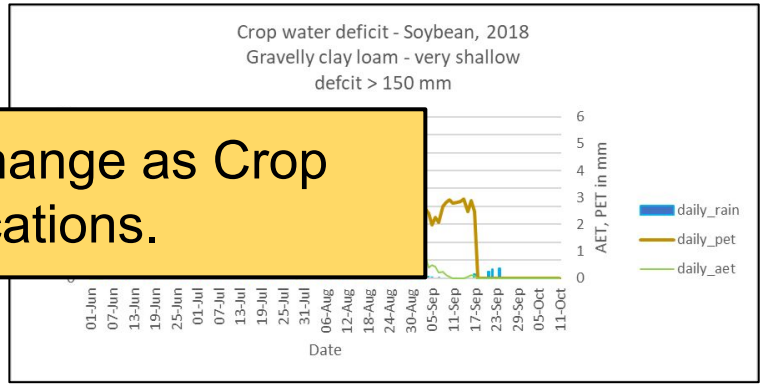


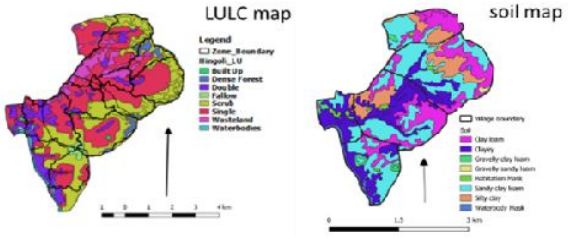


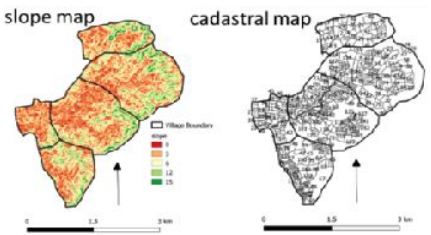


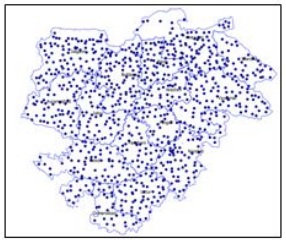
Encodes Climate Change as Crop Deficits and their locations.

Locating Vulnerability and Guiding Resilience

Inputs



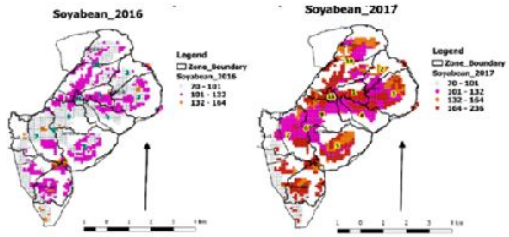




Geo-spatial platform [QGIS + Postgres + Python]

Outputs

Vulnerability maps



Zone-wise water balance results for each crop (in mm)

Crop	Area	PET Monsoon End	AET Monsoon End	Monsoon Deficit(PET-AET)	GW Recharge in Monsoon	Runoff Monsoon	Soil Moisture in 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

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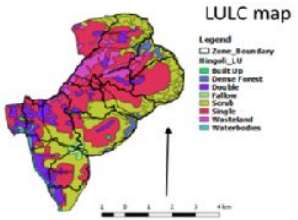

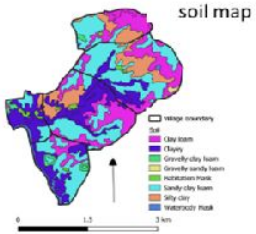

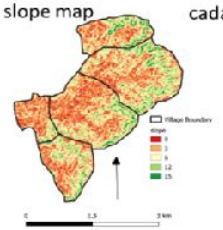

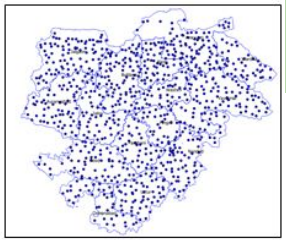

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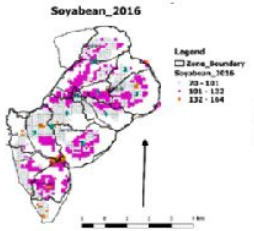

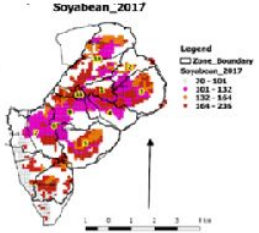

Output: Village-level water budgets

Zone-wise water balance results for each crop (in mm)

			Monsoon Deficit(PET-AET)	GW Recharge in Monsoon	Runoff in Monsoon	Soil Moisture Monsoon end	Post Monsoon PET
		.9	107.9	29.1	251.4	81.8	0.0
		.7	87.8	29.1	273.1	44.6	304.6
		.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
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Harbhara		0.0	0.0	0.0	0.0	0.0	0.0	250.0

Locating Vulnerability and Guiding Resilience

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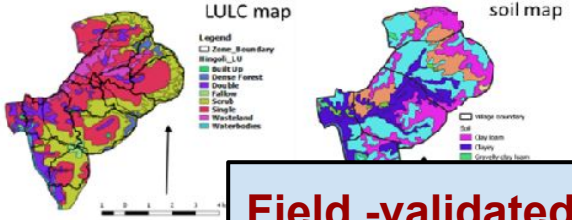
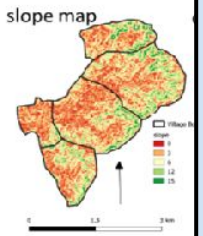
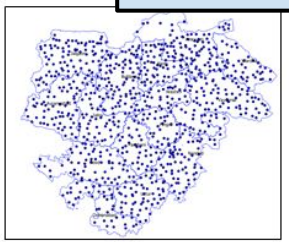
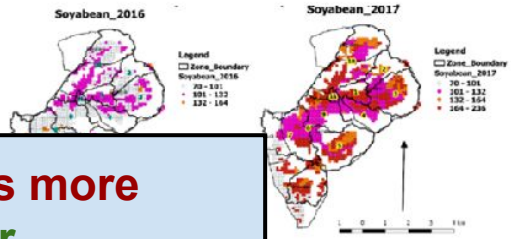






Outputs

Vulnerability maps



Field -validated extensively across more than 20 locations and > 150 farmer trajectories.

Robust - but more farm-level histories important - Access and median yield!

balance results for
n)

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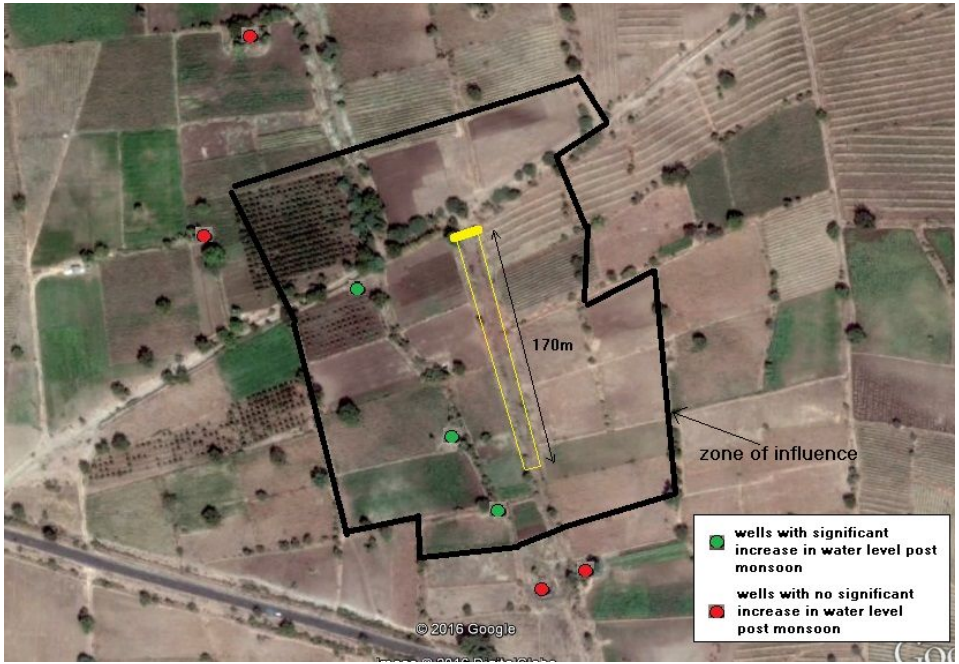
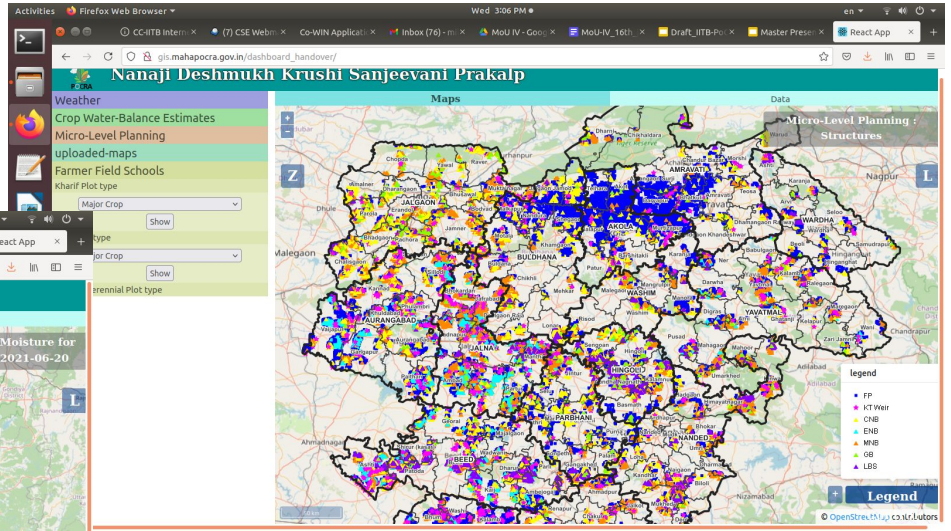
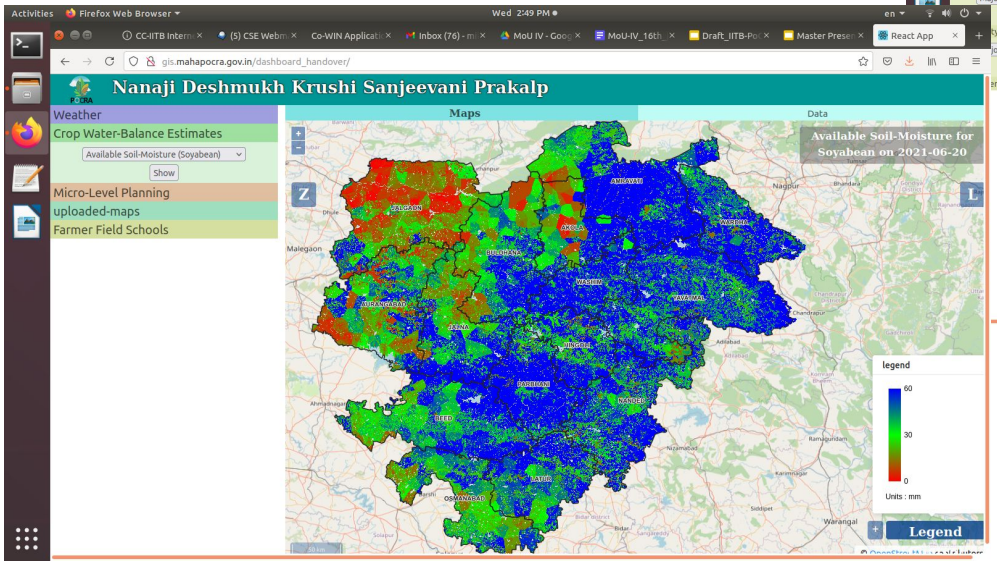
Many local infrastructure design applications.



Dashboard - for regional contingency planning

Enables village-level and taluka-level advisories and contingency planning

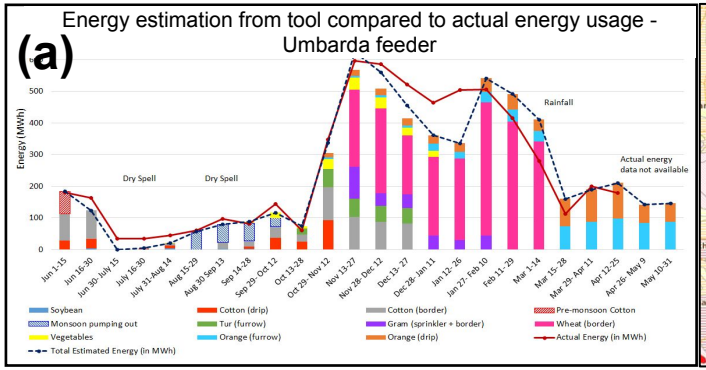




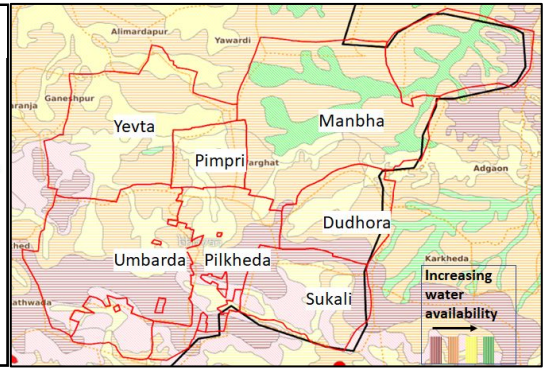
Dashboard link
http://gis.mahapocra.gov.in/dashboard_handover/

This year: Water Availability during a Dry Spell, Total storage

Energy infrastructure: (a) Requirement (b) Usage optimization



Estimate -dashed line, data- solid line. Cropwise energy usage in bars. Feeder energy used to determine goodness of tool result

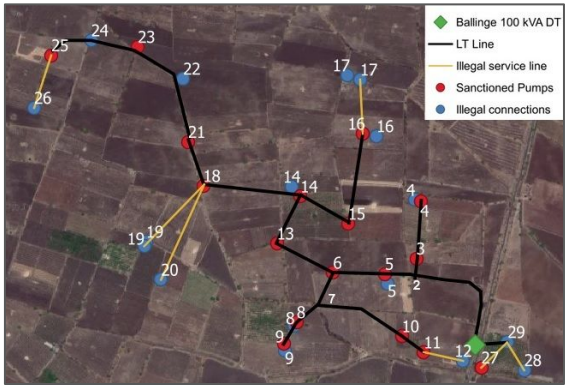


Umbarda feeder villages groundwater availability

IT stack
-> Seasonal irrigation requirement
-> Energy infrastructure requirement
-> Planning tools at various levels: Distribution Transformer, feeder, distribution substation, and higher

(b)

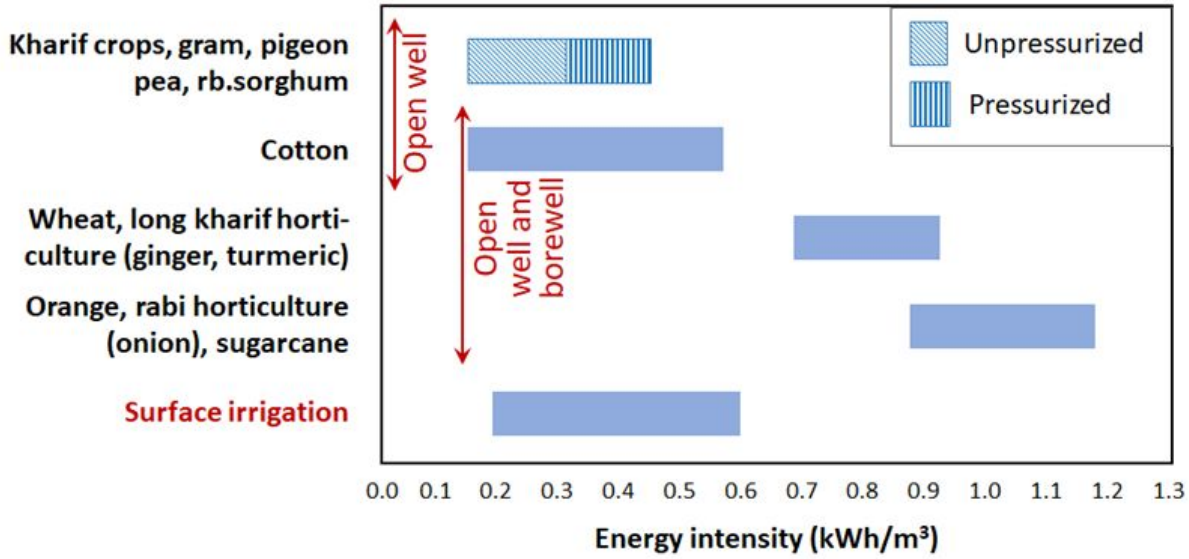
Demand side optimization of DT network
->Schedule for pump usage to reduce loading
-> Based on cropping, irrigation requirement and simple network balancing rules
-> Optimization based on power flow model, for voltage quality and transformer loading



Distribution Transformer and Low Tension network - Balinge DT in Washim

App for scheduling and commun-ication

Irrigation Practices and Energy Consumption

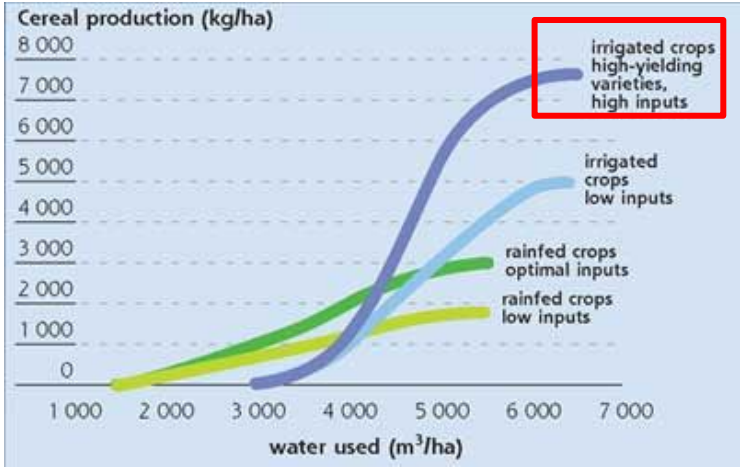


Correlation with practice, sources and seasons.

Besides GW depths - sprinkler/drip use and **transfers over long distances contribute much more to energy intensity.**

Energy and infrastructure costs become a substantial portion of the profits.

Irrigation Practices and Energy Consumption



This happens because (i) farmers must reach the top of the S curve to get the right price, (ii) GW is limited.

This leads to competitive extraction, transfers and extreme risks.

Need for community level management and measurements at the local level.

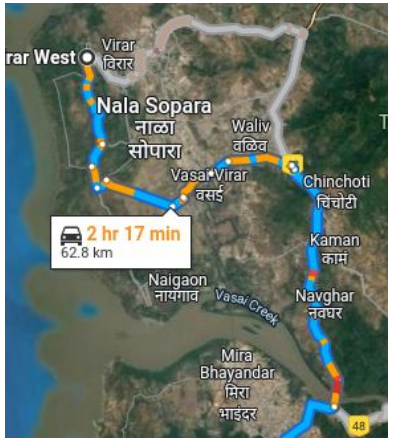
Vulnerability and Mitigation for the bottom 80%

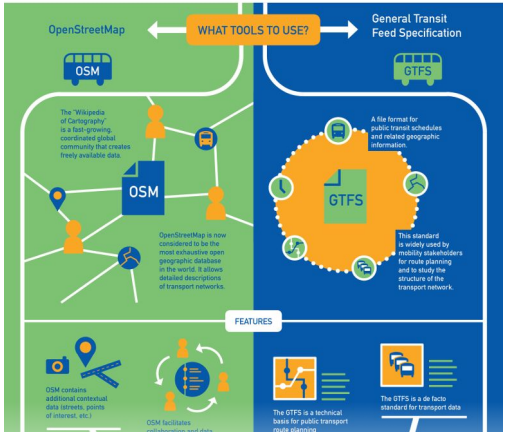
- Reduce information asymmetry - weather, stocks and flows and community
- Move vulnerable farmers to optimum zone
- Direct state agencies to address individual and community level vulnerability
- Stabilize cropping patterns away from risky crops
- Encourage load balancing in power sector to optimize infrastructure use.
- Reduce competitive investments and race-to-the-bottom

Develop a suitable IT stack at the local level for agencies, farmers and community. Develop suitable vendor models.

Encourage better food habits! Demand-side Management.

The Transport IT Stack



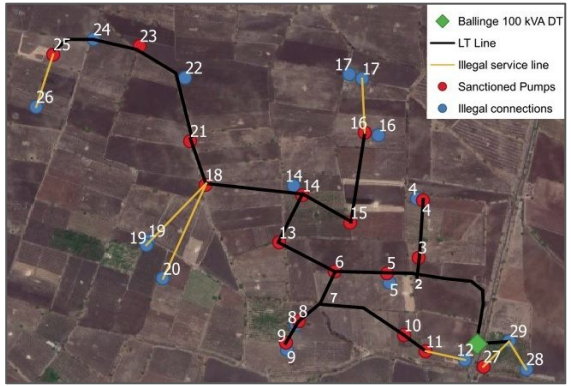


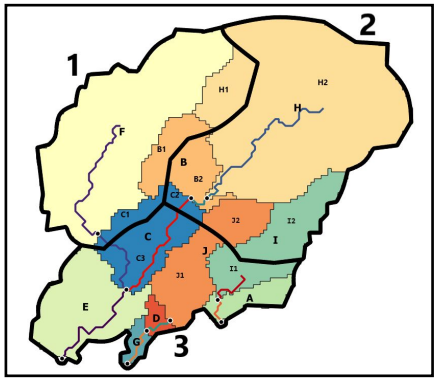
Spatial to Temporal to Enterprise-level support.

Multiple layers of APIs and data feeds and thriving vendor market.

But much to be done in India - weak regional transport institutions, weak background data infrastructure

The Agriculture IT Stack





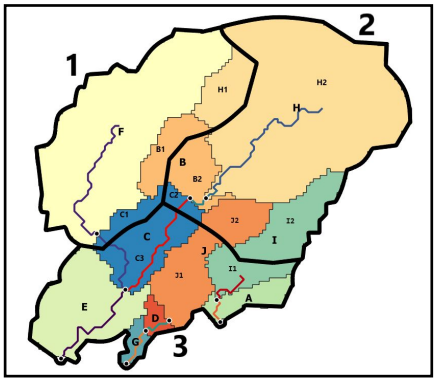
The Spatial and the Temporal - The Farm - The Village - The Model

Integration of agronomic, biophysical, infrastructural and administrative.

Farm-level and community advisories.

Important in Climate Resilience - and drought. Even more important in rapidly moving wet-spells!

The Agriculture IT Stack



Key Problem: Build Spatial and Temporal Vector models

The discretization of the image into entities is a key first step.

Anthro-Krishi is an excellent beginning!