Phase III Review and Work Ahead

IITB PoCRA Water Group

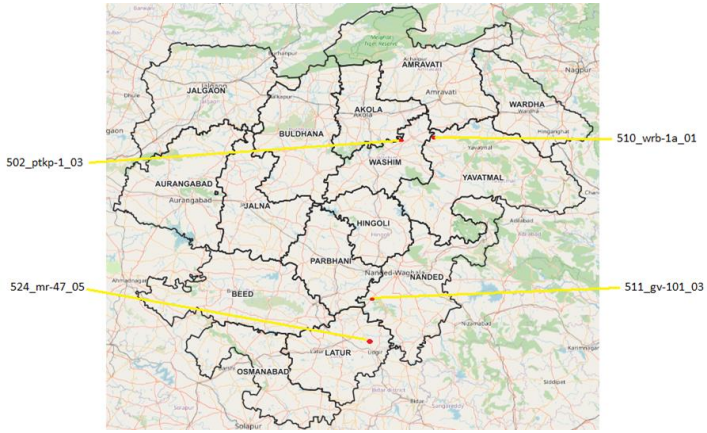
26-05-2022

Outline

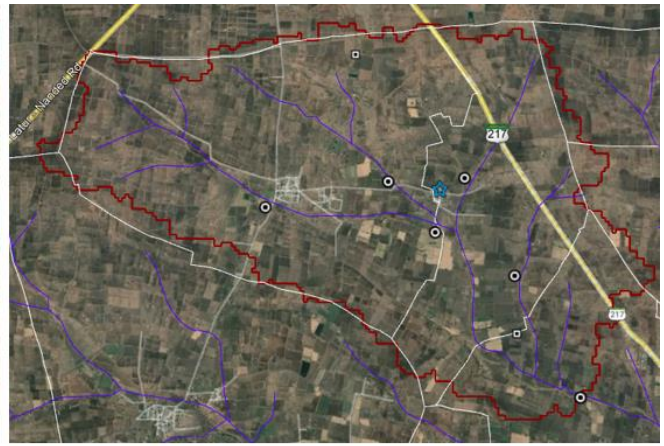
- Phase III Deliverables
  - Report on Model Validation: Kharif
  - Report on Kharif Extension Activities
  - Note on WB Model Enhancements
- Phase IV and Ahead
  - Pending tasks
  - New priorities
- Post MoU IV work (Proposed)
  - Model improvements (GW flows)
  - Expansion to new geographies
  - Extension and mainstreaming

Report on Model Validation: Kharif

Selected catchments and Site locations

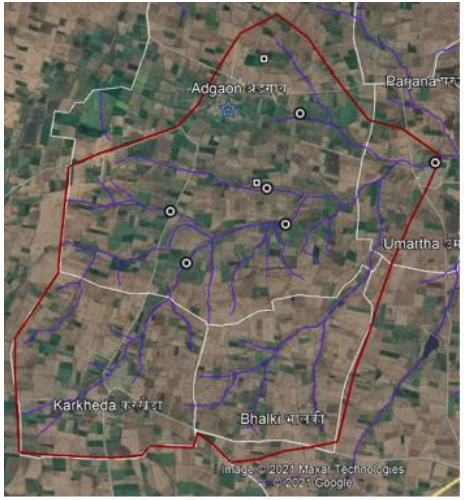


Loha Cluster

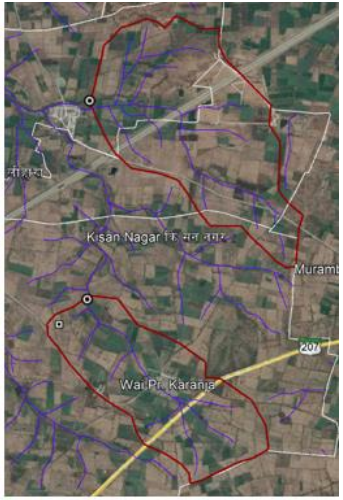


Ahmedpur Cluster

- Rain gauge
- V-notch and soil moisture sensors
- Water level sensor on CNB
- Water level sensor in Percolation Tank



Ner Cluster



Karanja Cluster

- Rain gauge
- V-notch and soil moisture sensors
- Water level sensor on CNB

Cluster Taluka	No. of rain gauges	No. of water level monitoring systems	No. of soil moisture monitoring systems	No. of V-notches
Loha	1	7	4	2
Ahmedpur	1	6	2	2
Ner	1	6	4	2
Karanja	0	2	2	1

Stilling Well Installation

Direct Installation

(a) Stilling well (regular)

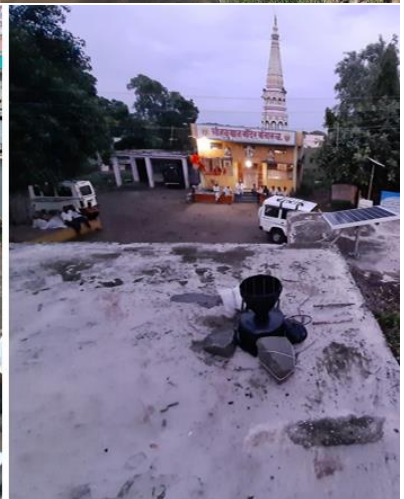
(b) Stilling well (regular + ultrasonic)

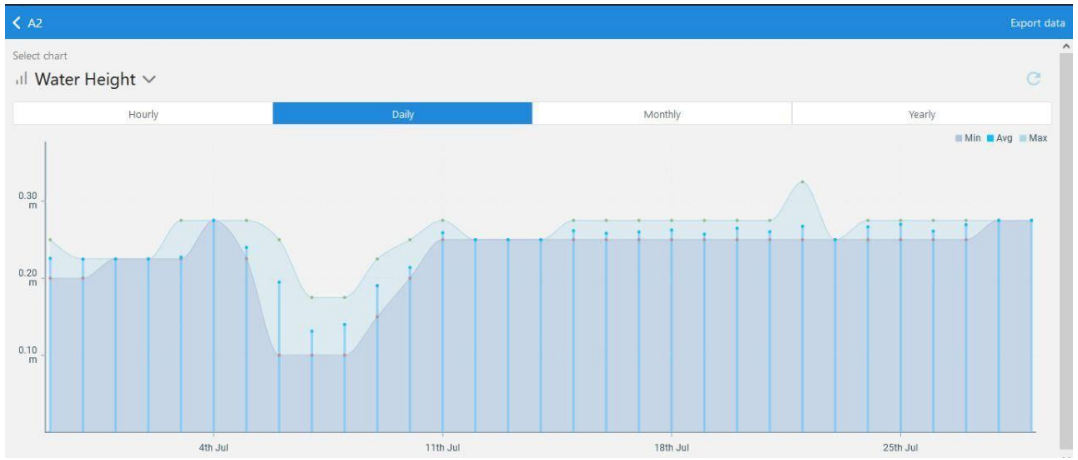
(c) Direct mounting (regular)

(d) Direct mounting (regular + ultrasonic)

Effect of Dry Spell on Crop Yield

Sr. No.		
Date		
Farmer Name		
Village		
Gat No.		
Lat		
Long		
Area of the land parcel		Acre
Type of soil		(Good/चांगली, Medium/मध्यम, Poor/हलकी)
Depth of soil		feet
Crop		
Sowing date		
Duration of the crop		days
Crop variety		
Source of seeds		(Mahabeej/ Private/ From previous year)
Expected yield this year		Q/A
Maximum yield fetched from the parcel of land		Q/A
Minimum assured yield for the parcel of land		Q/A
Frequently observed yield for the parcel of land (सर्वसाधारण उत्पादन)		Q/A
Number of dry spells this year		(1/2/3/4)
Occurrence of dry spell at crop stage		Immediately after sowing/ Flowering/ Pod formation/ Seed formation
Duration of each of the dry spell		(About 10 days/About 2 weeks/ About 3 weeks/More than 3 weeks
Irrigation facility		(Yes /No)
Source of irrigation		(Well/ Bore/ CNB/ Nallah/ Percolation tank/ Other)
Location of irrigation source		(Near or in the land parcel/ Away from the land parcel)
If away from the farm, distance of water source from the farm		meters
Type of irrigation used		(Furrow/Sprinkler/Drip)
Number of waterings provided		(1/2)
Date of waterings provided		
Yield loss due to dry spells considering no watering		Q/A
Yield loss due to dry spells considering actual waterings (0/1/2) provided		Q/A

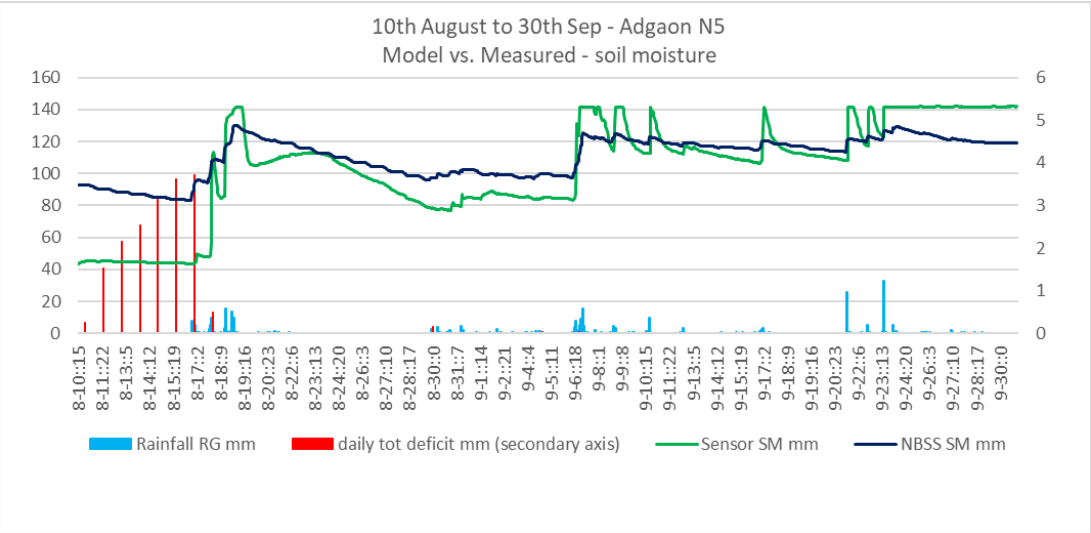




Farm-level results

Farm-level soil moisture and runoff measurements using soil moisture sensor and V-notch installed at the farm outlet (Adgaon)

V-notch measurement period - 4th July to 30th September
Soil moisture measurement period - 10th August to 30th September

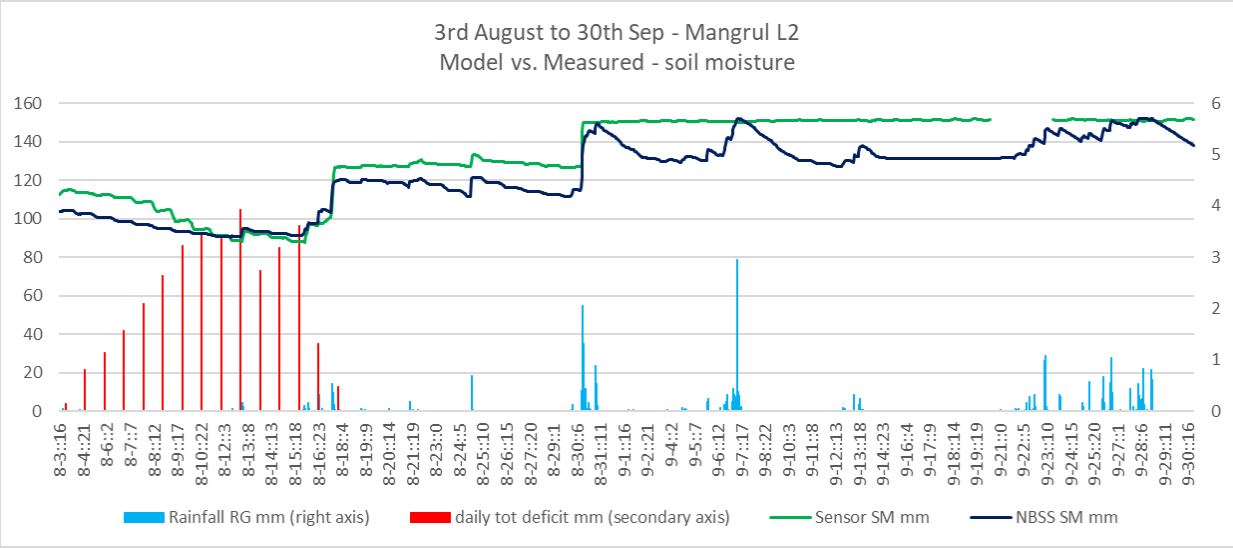


Total rainfall mm	550
Model runoff mm	119
Measured runoff mm (V-notch)	116
Model deficit mm	18

- Measured runoff value matches the model runoff during the measurement period
- The modeled soil moisture trends and changes match closely with the ground reality

Farm-level soil moisture on a farm in Mangrul - moderately deep Clayey soil

Measurement period - 3rd August to 30th September

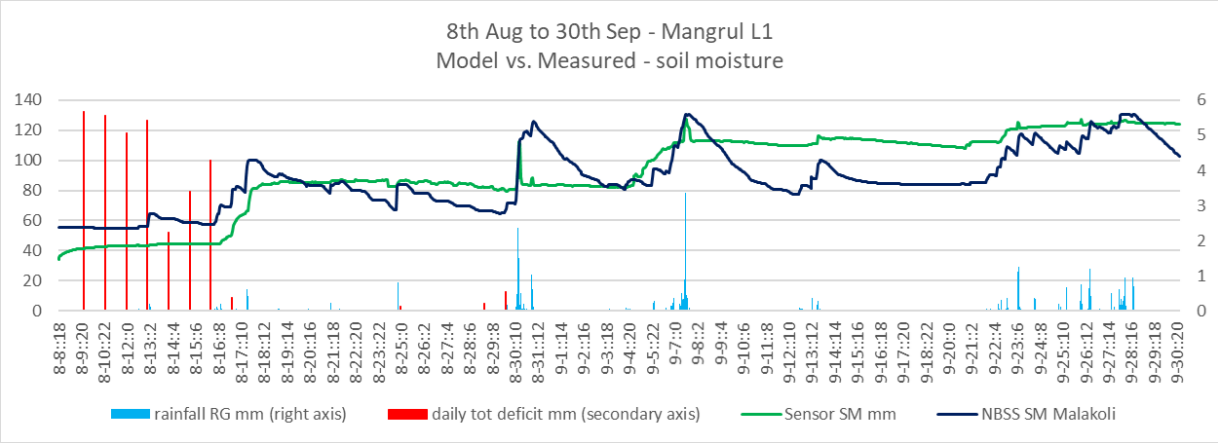


Total rainfall mm	859
Model delta SM mm	34
Measured delta SM mm	39
Model deficit mm	33

- The modeled soil moisture trends and changes match closely with the ground reality

Farm-level soil moisture on a farm in Mangrul - shallow silty loam soil

Measurement period - 8th August to 30th September



Total rainfall mm	859
Model delta SM mm	72
Measured delta SM mm	90
Model deficit mm	56

- Model successfully highlights the differences in water availability, trends, crop stress etc. for different soils
- The crop deficits during the dry spell were correctly simulated by the model for different soils. This was verified through farmer interviews.

Regional (catchment-wise) results

IITB Water Balance Results at Catchment Level

Sr No.	Catchment	Area (ha)	Rainfall (mm)	Measured Runoff (mm)	Model Runoff (mm)	Model GWR (mm)	Rejected GWR (mm)	Corrected Model Runoff (mm)	% Gap
1	A2	201	550.5	108.7	95	126	5	100	8.00%
2	A4	487	499	100.0	82	122	0	82	18.00%
3	A5	168	550.5	121.4	114	165	2	116	4.45%
4	A6	78	550.5	99.0	92	146	16	108	9.09%
5	L1	114	1090	745.4	545	325	263	808	8.40%
6	L2	26	1090	713.9	536	335	278	814	14.02%
7	L3	245	1031.2	773.6	531	319	222	753	2.66%
8	L5	219	1090	779.6	498	299	213	711	8.80%
9	L6	714	1090	714.4	511	276	145	656	8.17%
10	N1	323	566	164.3	125.9	97.8	0	125.9	23.37%
11	N2	113	583	191.0	105	276	116	221	15.71%
12	N3	98	583	194.0	98	195	71	169	12.89%
13	N4	807	566	158.6	118.4	143.7	17.7	136.1	14.19%
14	N5	246	323.6	78.6	69.6	73.5	0	69.6	11.45%
15	N6	2042	566	150.0	118.6	119.2	0	118.6	20.93%

Conclusions

- **A robust validation framework** has been designed, which can be used by different external agencies as well as state departments to perform validation and monitoring of key hydrological components in various geographies

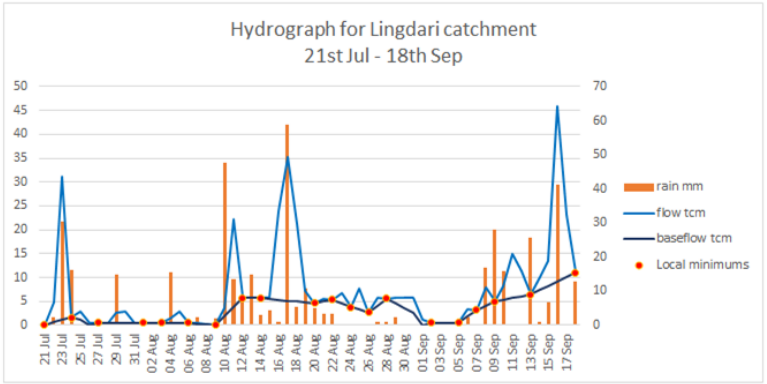
- IITB-PoCRA water balance model **results reasonably matched** with the measured / observed quantities in the selected catchments during the monsoon season of 2021

- The IITB-PoCRA model shows the ability to **demonstrate and simulate key phenomena at farm and village level** such as soil moisture stress, crop stress, runoff generation in different soils etc. and thus enables more effective planning

- The soil sample data tested from **NBSS lab proved to be more accurate** than the MRSAC soil data

Resolution of Prof. M. Sekhar's comments - improved GW recharge

- For Shallow soils
  - High amount of rejected groundwater recharge flowing out as baseflows into surface runoff during monsoon
  - Changes to model for incorporating aquifer depth and specific yield
  - Data from GSDA awaited



- For deep clayey soils
  - The Ksat value used as per existing FAO properties is too less 0.51 mm/hour
  - The improved Ksat values as per soil testing at NBSS shows higher values of the order of 5 mm/hour
  - This has improved groundwater recharge in clayey soils and is now closer to GSDA values.
  - Improved soil data from NBSS awaited

Recommendations

- Regarding data: Improved soil maps and hydrogeological data shall be made available for better results at the aggregated level (catchments / village / clusters)
- For selected CNB’s proposed in MLP, a provision (in terms of civil works) should be made right at the time of construction to install water level sensors
- Department of Agriculture (DoA) should install water level sensors on CNBs and soil moisture sensors in farms at selected locations in each tehsils and monitor data of the same
- Validation is a continuous exercise and needs to be carried out in future for different geographies and weather patterns by the DoA
- Local engineering colleges should take up studies based on the validation methodology formulated

Report on Kharif Extension Activities

Basis of extension - Comparing two role models

Kadwanchi

Horticulture-based, farm-pond driven business model (grapes). High investments, returns, risk.

Focus on supply-side interventions. Very high investments. Little demand-side planning

Steadily increasing crop-water demand i.e. increasing area under Grapes

Demand may exceed supply frequently - reduction in downstream flows, scarcity in downstream villages

No community meetings;
but collective action for disseminating knowledge about grape cultivation to all farmers

Progressive-farmer-based extension

Hiware Bazar

Diversified business model (vegetables, dairy, fodder crops etc.)

Demand-based planning along with supply-side interventions

Area under vegetables and rabi, summer crops based on water-budget based planning

Planned demand always less than availability leading to sustainable water use and resilience.

Two community meetings per year for deciding crops, planning interventions, resolve issues etc. Collective ban on sugarcane, grazing, tree-cutting, digging of borewells etc.

Median-farmer-based extension

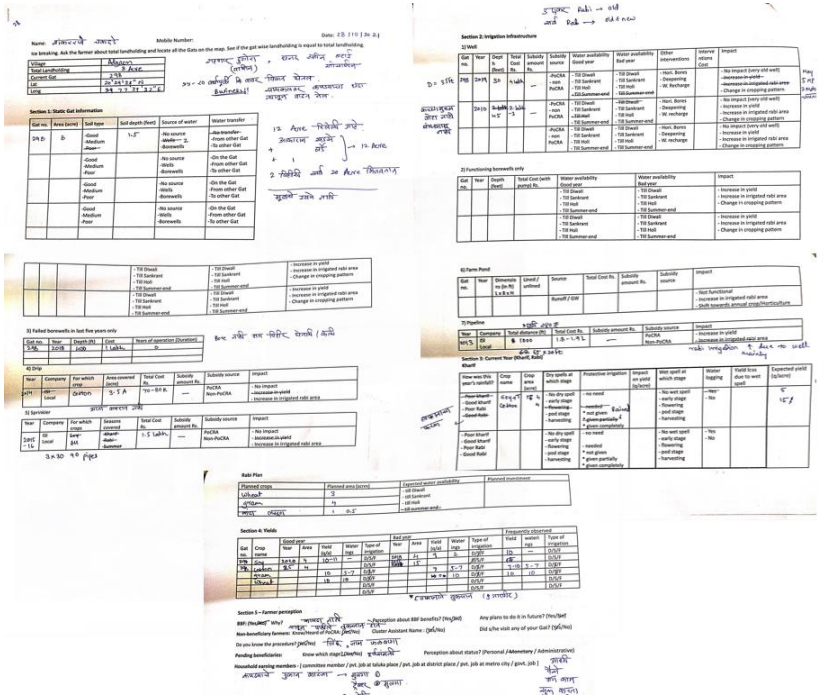
Within Village - Extension Strategy

Median Yield as the Pivot of Extension

- Linking farmer/village experience to Water Balance, NRM and Energy quantities.
- Developing Bad and Good farmer narratives.
- Linking NRM, vulnerability maps into DBT and NRM planning
- Improved linkages and common formats and interfaces with other departments
- *Hangam baithaks* (seasonal community meetings) and platforms on strengthening the above

The Village Handbook and Agenda for Hangam Baithak

Phase 3 work - conduct of farmer surveys in two villages



The Village Handbook - A tool for extension

Key Contents in the Handbook

- Secondary data such as cropping patterns, budgets and deficits
- Maps such as drainage, soil types, vulnerability maps
- Recording and documentation of key parameters
  - Kharif and Rabi yield and its spread in the village for major crops
  - % of farmers below breakeven point for major crops
  - Seasonality of the groundwater availability in different zones of village
- Documentation of narratives - bad and good cases
- Documentation of minutes of village level community of meetings
- NRM register to maintain
  - Current status of storage structures at zone-level
  - Storage capacity at zone and village level
  - Need for repair of structures or new structures according to zone deficits
- Energy Infrastructure and issues
  - Number of DTs, sanctioned load, current load, season wise failure, cost for repair

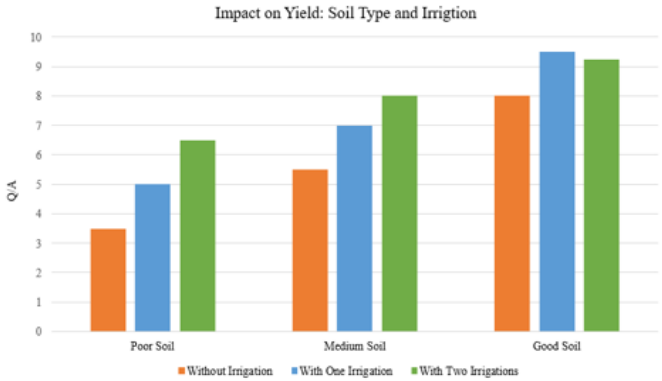
Standard Village Output

Median Yield

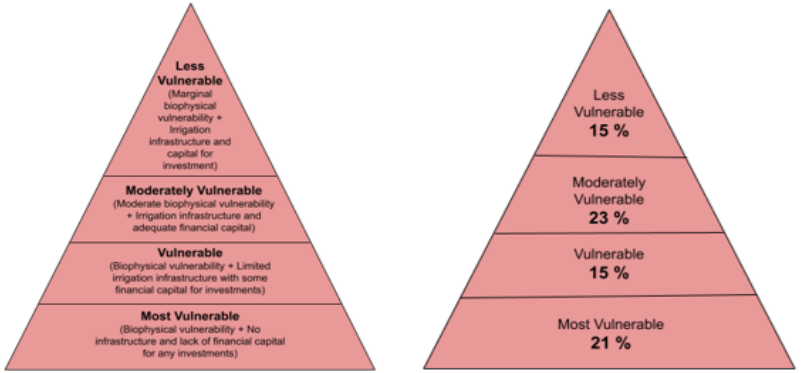
Median yield for the village	5 Q/A
Target median yield for the village	8 Q/A
% Farmers operating below break-even yield	24 %
Average Yield for the village	5.5 Q/A

Zonal Picture

Zone Name	Average Zone Yield (Q/A)	Storage Capacity (in mm)	Average Yield Loss due to Dry Spell (Q/A)	Average Yield Loss due to Wet Spell (Q/A)
Adgaon 1	7.5	18	1	2
Adgaon 2	6	12	1	1.5
Adgaon 3	4	5	2.5	1



Yields, Soil Type and Irrigation



Vulnerability Pyramid

Note on WB Model Enhancements

Water budget model - dynamic execution

Space-Time Interchange : What is the objective?

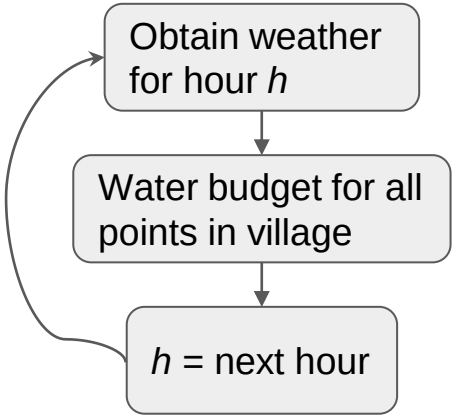
- Water budget model should advance spatial state, one time step at a time [done]
- Real time cropping pattern updates per season [proposed]
- Krishi Sahayak to show kharif water budget in the village at the start of rabi season for better rabi planning [proposed]

What does this allow: Automated daily/weekly updates to zone-wise water balance in kharif season

- Villages going through a dry spell and suffering highest crop water deficit as of today
- Surface water stock in the village as of today.
- Villages under wet spell. How much more rain per hour can a village accept without flooding?
- Kharif water budget ready by the end of kharif season to be published in the village

Functional enhancements

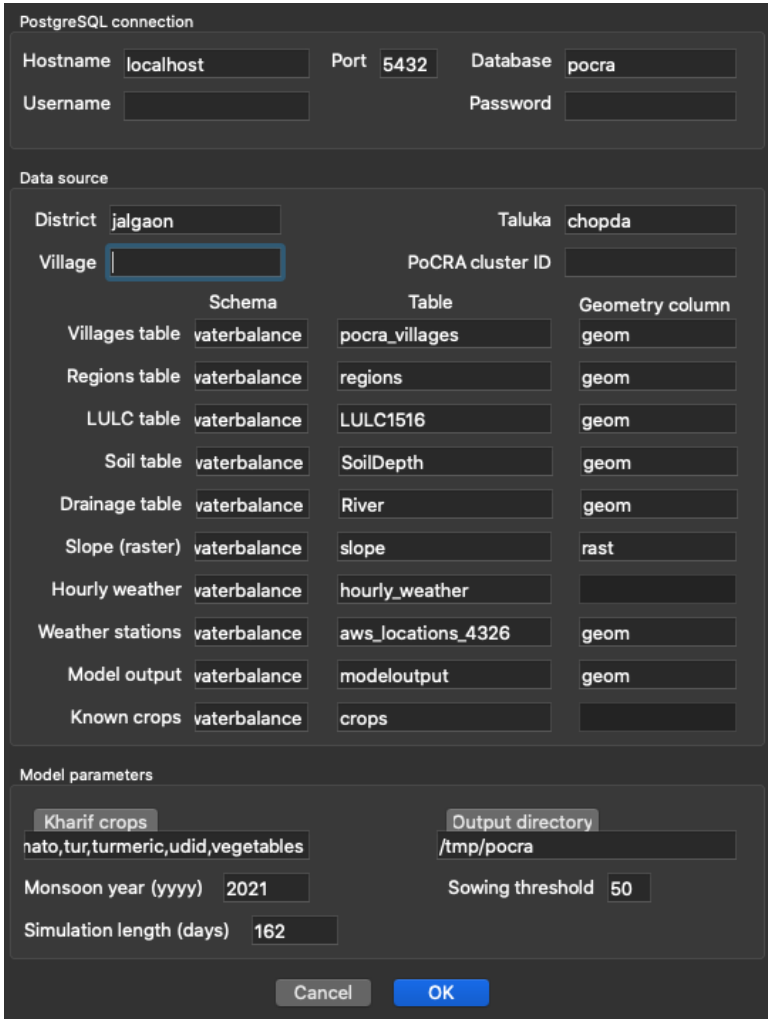
- Space-time interchange
  - Ability to continue from previous water budget results as and when new weather data becomes available
  - Foundation for real time generation of water budget charts at village level
- Error logging
- Output identification
  - Water budget records for a village are assigned the same timestamp



Technical enhancements

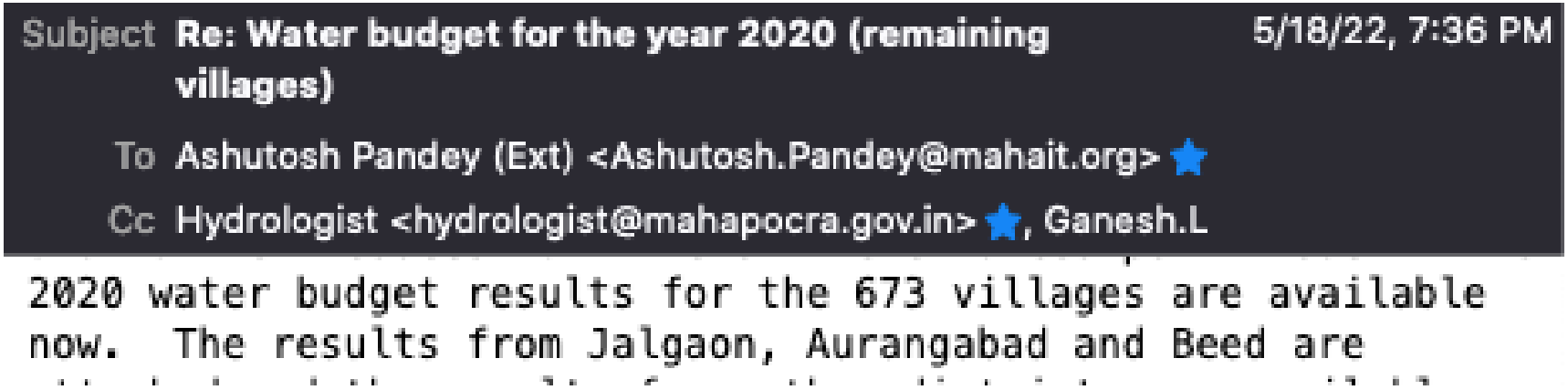
- Simpler weather format
  - Easy to validate data obtained from skymet
- Pointwise water budget records are written to a PostGIS table with point geometry
  - SQL based validation of results (mass balance)
  - Join with villages table to obtain remaining villages
  - Aggregate results over desired region, e.g. zones, villages, etc.
- Decoupled from the dashboard server
  - Tested on Linux, MacOS and MS Windows

V2 screenshot



V2 deployed at PMU

- Deployed on the linux workstation setup for well DBT
- Used to generate 2020 water budget for 673 villages
  - Time taken: about 45 seconds per village
- Results shared, data issues found and reported, feedback awaited:



V2 deployed at PMU (summary of 673 villages)

district	villages	villages_with_error	error
Yavatmal	196	0	
Wardha	94	2	no agricultural land in LULC
Washim	85	0	
Amravati	80	2	invalid zone geometry
Hingoli	42	3	invalid zone geometry
Osmanabad	37	2	invalid zone geometry
Nanded	29	1	invalid zone geometry
Jalna	24	0	
Jalgaon	19	1	no agricultural land in LULC
Buldhana	18	1	invalid zone geometry
Aurangabad	14	1	invalid zone geometry
Parbhani	14	3	no agricultural land in LULC
Akola	13	0	
Beed	5	0	
Latur	1	0	

MoU IV and Ahead

Pending tasks as per MoU

Task	MoU component	Req. man months	Delivery phase
Final Validation report	A	3	Phase V
Rabi extension activities	B	4	Phase V
Regional geography	C	5	Phase IV
Rabi planning framework	D	6	Phase IV
IMD forecast incorporation	E	2	Phase IV
Chart improvements	E	2	Phase V

New priorities

Task	Status	Req. man months	Compensated task
Well DBT	Done	7	None
Incorporate NBBS data for 70 clusters	Ongoing	2	A4
Compute PMI for GSDA clusters	Ongoing	1	A4
MLP issues	Done	1	None
Water productivity computation	Done	1	None
Other PMU support	Done/Ongoing	1/1	None

- Extra man months (around 10) during monsoon 2021 (MoU IV began in August 2021)
- Extra man months (around 12) for the non-MoU PMU IT requirements (well DBT, changes to WB model, MLP issues)
- Reduced some man months in components C and D to compensate above
- But still 14 extra man months till the end of MoU – deadline to shoot by 1 or 1.5 months

Mou Component	Allotted man months	Actual work till now	Pending till MoU end	Total Extra man months	Remarks
A – Model validation	32	32	4	4	MoU signed in August 2021, but field work for extension and validation begun in May 2021
B – Extension	8	9	4	5	
C – Model improvements	14	6	5	-3	Compensated urgent PMU IT requirements by reducing some planned IT man months
D – Rabi planning	10	0	6	-4	
E – Support	6	13	5	12	Well DBT, water productivity, MLP errors, 670 villages
Total	70	60	24	14	

Post MoU IV Work (Proposed)

- Extension and mainstreaming of water budget based planning
- Model changes for expansion to other geographies
- Model improvements - incorporating GW flows

Extension Activities (at four levels)

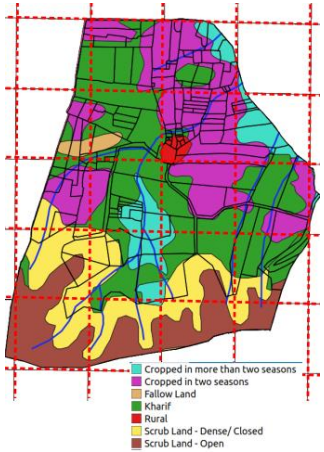
Farmer level	Village level	Regional level	Department level
Identification of vulnerable farmers, Advisories, Farm level interventions	Median yield, vulnerable zones NRM register Village handbook	Planning framework at SDAO/TAO for village level advisories (dry spell / wet spell contingencies)	Climate Innovation Centre as the HQ for GIS cell with regional cells at JDA
Strengthen Krushi Sahayaks and Cluster Assistants Design of Survey formats Conduct of surveys	Design of community planning tools Conduct of meetings for Kharif and Rabi planning Integration of Water, Energy, Post-harvest, Irrigation	Design of dashboards and advisories	Design of IT calendar for the DoA Decentralization of WB computation and map generation Bringing MSEDCL, WRD, Water Conservation together

Expanding WB to the state

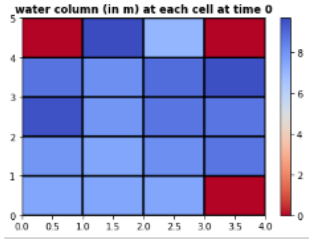
- Taking GIS based Water Budget computation to the state of Maharashtra
- Changes and improvements required while expanding to the state
    - Incorporation of command areas (important especially for Western Maharashtra and Northern Maharashtra)
    - Appropriate change to accommodate regions of distinct geography such as regions of very high slopes and thin soils such as Konkan, dense forest and deep soils such as Eastern Vidarbha
    - Appropriate changes to accommodate different major crops such as paddy

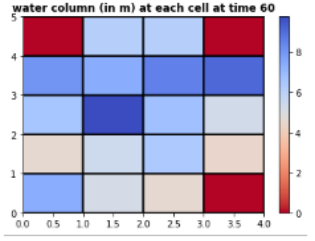
Grid Model for Groundwater Flows

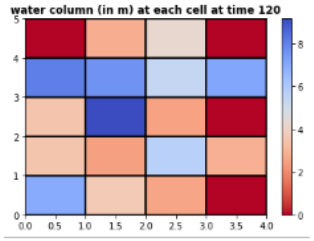
- About Discrete Grid Model for simulation
  - Village divided in 500m by 500m size cells
  - Regions according to LULC of village
- Case Study of Mangrul
  - Preliminary results
  - How head values will change for a given cropping pattern - match reasonably with the farmer narratives
  - Water shared between regions - how much water will be available according to regions
  - Can suggest optimal cropping pattern

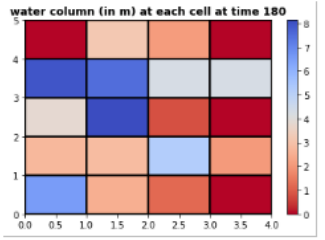


x 0	c 420	e 415	x 0
b 430	b 425	d 420	e 425
c 440	e 430	d 440	d 450
b 470	c 460	b 470	b 480
a 480	a 490	a 500	x 0

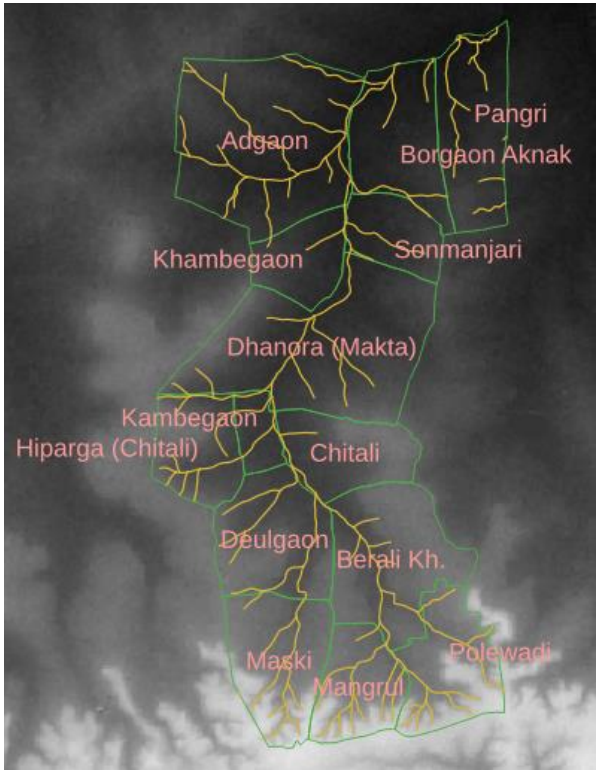








Village wise groundwater flows in pristine condition

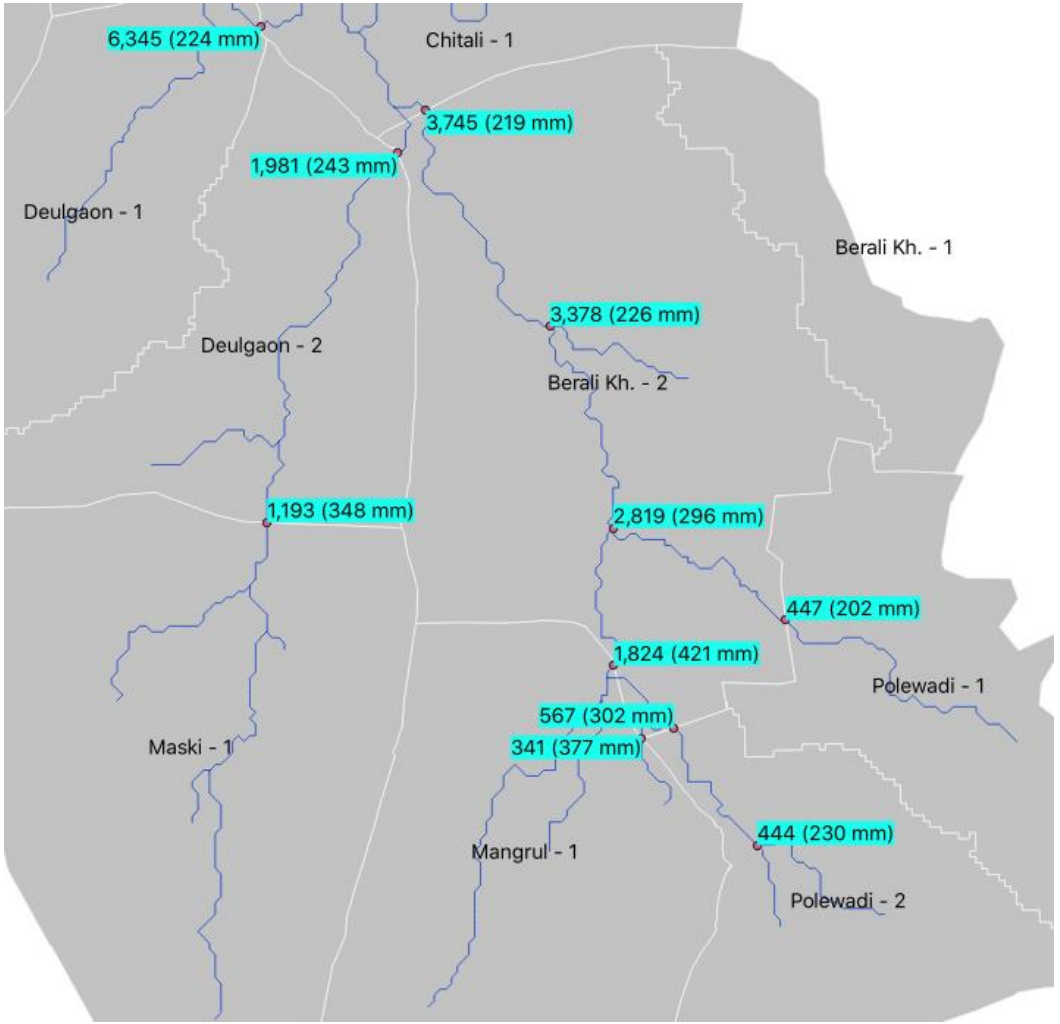


Village ID	Village Name	GW stock initial (TCM)	GW stock final (TCM)	Baseflow out (TCM)	GW in (TCM)	GW out (TCM)
1	Maski	675	478.4	-153.51	424.65	-467.75
2	Mangrul	375	275.75	-132.44	280.17	-246.98
3	Polewadi	625	365.62	-214.02	415.23	-460.59
4	Deoulgaon	625	511.49	-123.3	268.05	-258.26
5	Berali	825	658.15	-192.18	382.98	-357.65
6	Hipperga	450	321.31	-66.65	197.48	-259.52
7	Kambegaon	125	124.15	-29.84	51.74	-22.75
8	Chitali	450	358.86	-101.32	188.7	-178.53
9	Dhanora	1425	1213.99	-240.32	617.55	-588.24
10	Khambegaon	275	243.77	-22.15	86.64	-95.72
11	Sonmanjari	350	327.82	-35.26	92.03	-78.95
12	Adgaon	1350	1247.11	-106.78	319.85	-315.97
13	Borgaon	600	564.04	-42.75	118.89	-112.1
14	Pangri	650	602.67	-46.38	130.25	-131.2
	Total	8800	7293.13	-1506.9	3574.21	-3574.21

THANK YOU !!!

Regional Geography

- Cumulative surface water flows among adjacent zones in a Loha cluster. All values in TCM.
- Can be done at daily, peak event, season etc.
- Allows for wet-spell and dry-spell analysis
- Allows for cluster-level NRM planning

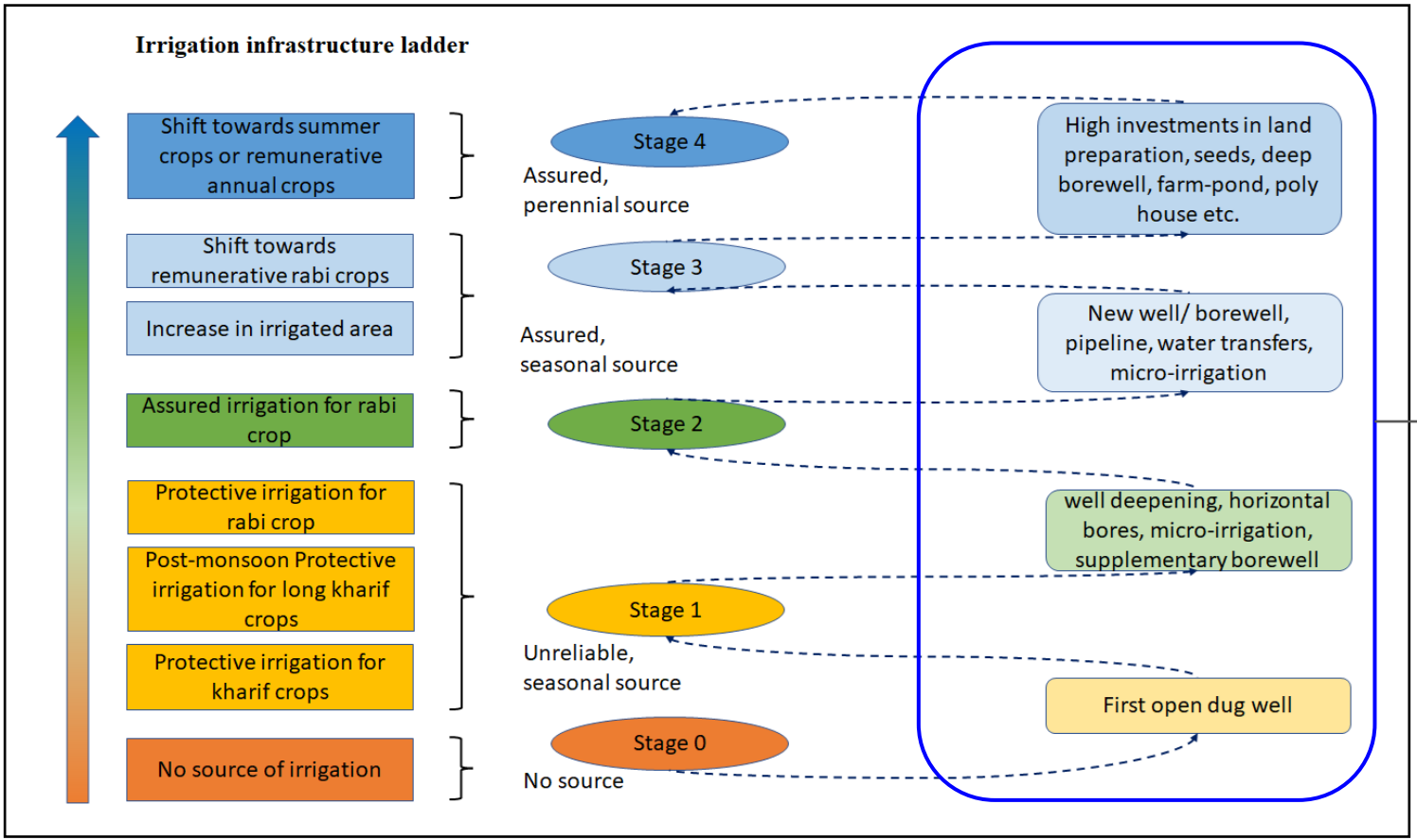


Runoff in mm computed using kharif water budget model with soybean crop, 2020 weather data

Rabi Planning

- Rabi Planning Framework
- Design scenarios and link them to zone wise water budget results
- Pilot design for formulating linear programming problem (LPP)

A Typical Farmer's Journey: Moving up the irrigation infrastructure ladder

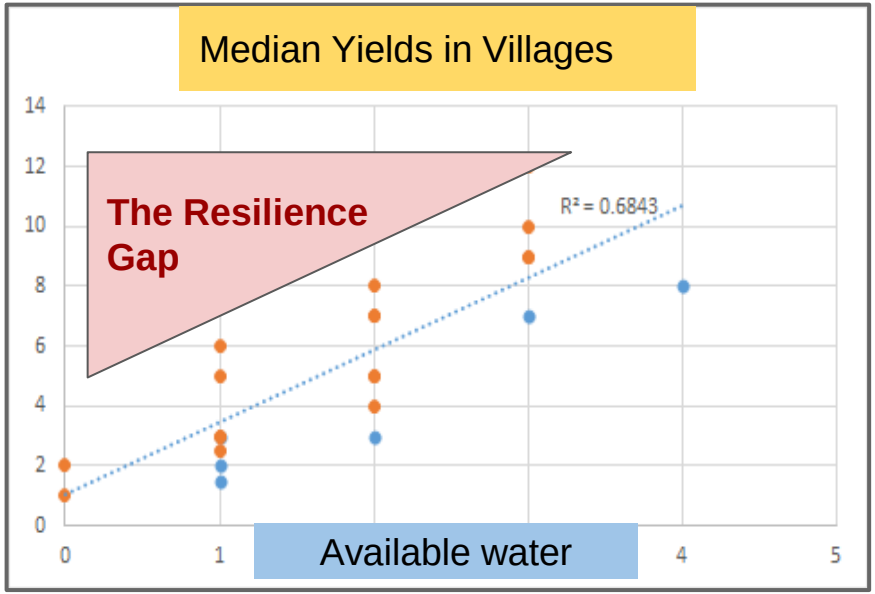


How can the subsidies be better targeted?

Making Villages Resilient

Stabilizing Kharif and Rabi yields village-level analysis

- Rabi- Demand-side planning
- Kharif- Improving Access
- **Aggregate indices** - median yields, mean deficits, storage in village, energy infrastructure
- Better allocation of resources - better analysis - **One taluka at a time!**
- Better Knowledge support. New workflows.
- Progressive Krishi Sahayaks, Progressive Junior Engineers!

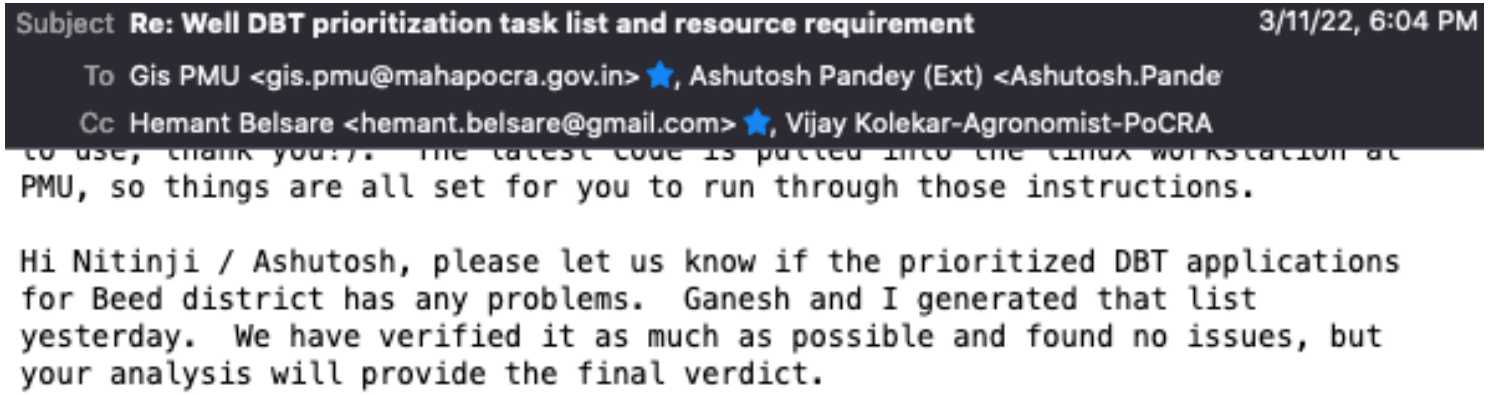


Already available: Post-Monsoon Index, Kharif Index

Additional work and Readjustment of deliverables

Well DBT

- Python application to assign priority to well DBT applications at village level
- Cadastral vulnerability computed with point model is leveraged
- Can be used for DBT applications other than open dug well
- Deployment at PMU with reports for a few districts including Hingoli, Beed, etc.
- Feedback awaited



Subject **Re: Well DBT prioritization task list and resource requirement** 3/11/22, 6:04 PM

To Gis PMU <gis.pmu@mahapocra.gov.in>, Ashutosh Pandey (Ext) <Ashutosh.Pande

Cc Hemant Belsare <hemant.belsare@gmail.com>, Vijay Kolekar-Agronomist-PoCRA

to use, thank you!). The latest code is pulled into the Linux workstation at PMU, so things are all set for you to run through those instructions.

Hi Nitinji / Ashutosh, please let us know if the prioritized DBT applications for Beed district has any problems. Ganesh and I generated that list yesterday. We have verified it as much as possible and found no issues, but your analysis will provide the final verdict.

PMU IT Support (accounting extra man months)

- Quoted man months as per MoU: 3
- Deployment of well DBT includes
  - resolving setup issues found on PMU IT workstation
  - preparing dataset
  - running the DBT application for several districts
  - video recording to illustrate the process
  - script to automate data preparation
- Deployment of the point model V2 includes
  - preparing dataset
  - running the application for 673 remaining villages from 2020