From People to Pixels and Back: Computing the Landscape with Communities

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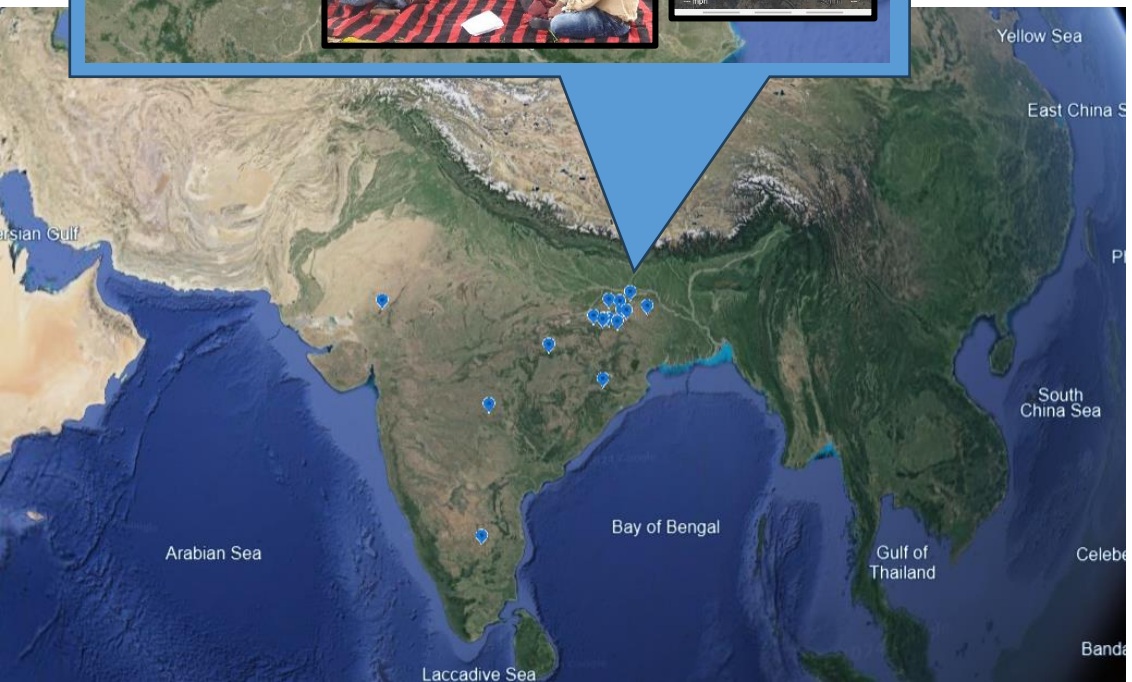
The CoRE stack ecosystem

Community-based problem discovery

States of Bihar, Jharkhand, Odisha, Chattisgarh



Are interventions landscape-appropriate?

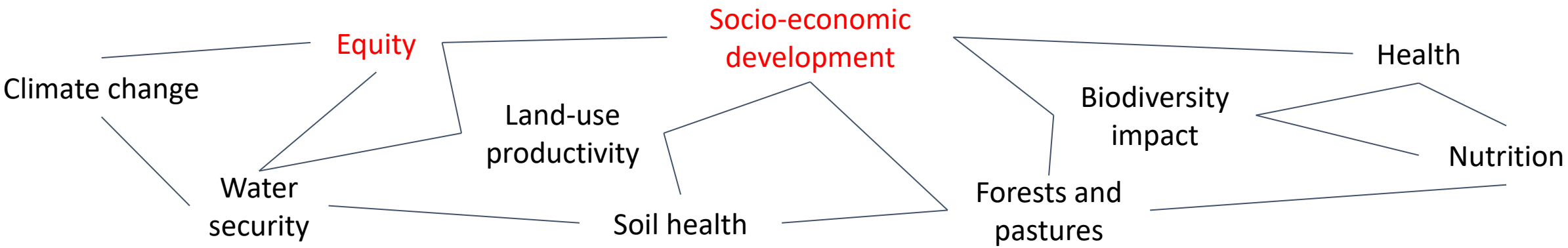
Rejuvenation of traditional systems

Staying within limits even while integrating with the market

Build systems for communities that can empower them to take charge of their own destinies

Taking a systems view to compute the landscape with communities

Social-Ecological systems: A complex web



Disconnect between common and individual good

Disconnect between short-term and long-term sustainability

Climate change: Increasing droughts and floods

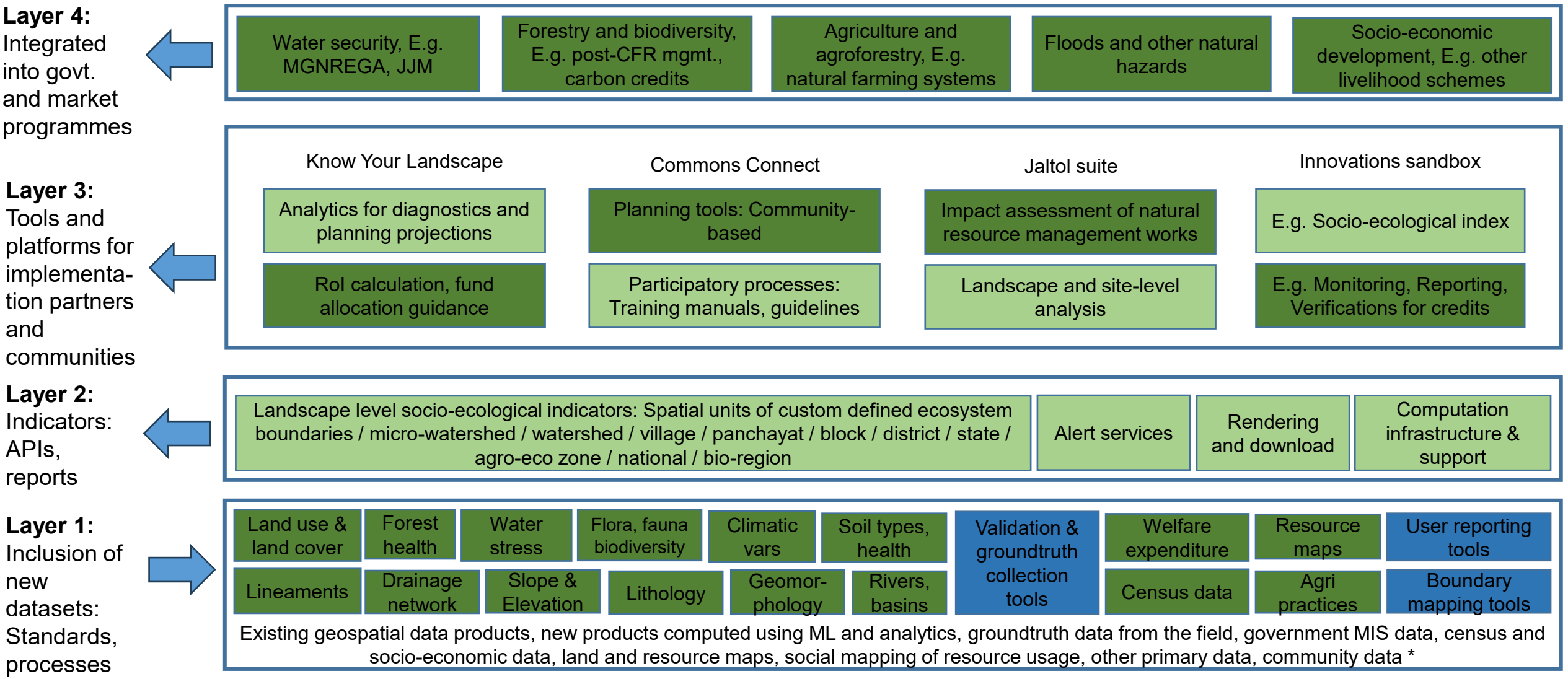
Power-based inequalities: Denial of rights

Collective action: Build a shared data-driven understanding of the stresses in a landscape

Informed strategy: Combine science-based insights and traditional knowledge and wisdom to build context-sensitive action plans

Transparency, accountability, equity: Establish digital trails of claims made especially by marginalized groups, backed with evidence

CoRE stack: A digital public infrastructure approach



** Not an exhaustive list*

Know – Plan – Assess

https://www.explorer.core-stack.org/

Layer 3: Tools and platforms for implementa-tion partners and communities

Know Your Landscape	Commons Connect	Jaltol suite	Innovations sandbox
Analytics for diagnostics and planning projections	Planning tools: Community-based	Impact assessment of natural resource management works	E.g. Socio-ecological index
RoI calculation, fund allocation guidance	Participatory processes: Training manuals, guidelines	Landscape and site-level analysis	E.g. Monitoring, Reporting, Verifications for credits

Compare with known social-ecological patterns and provide advisory on appropriate action strategies.

Know – Plan – Assess

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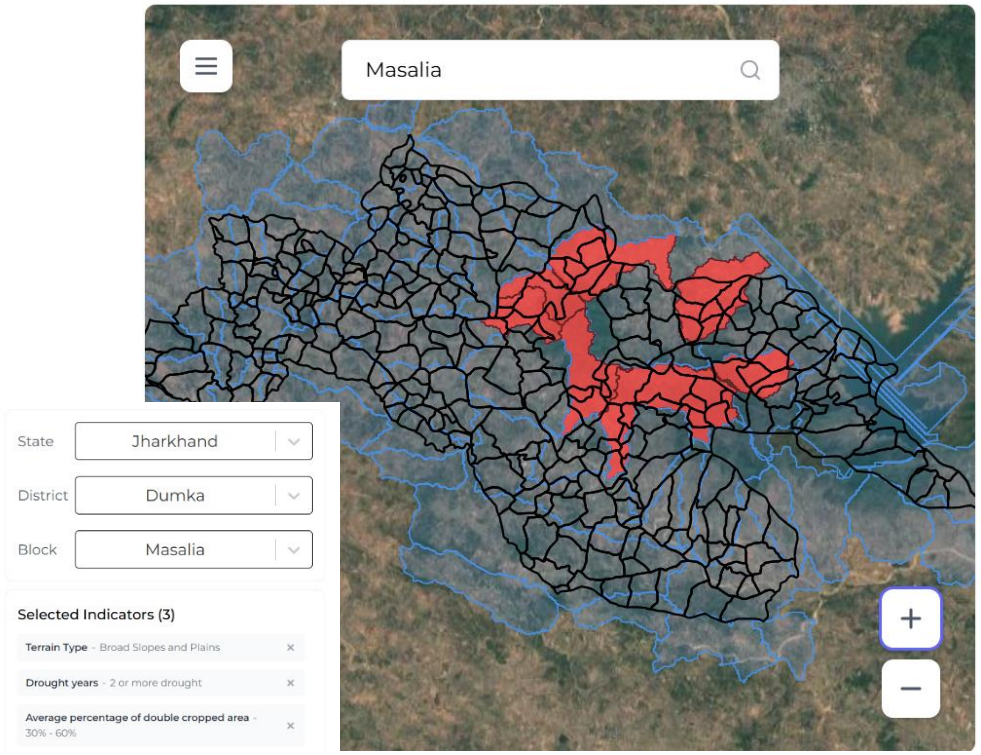


For **government departments, CSR, CSOs**, to plan largescale interventions in terms of which programmes might be more relevant in which areas, undertake participatory modeling

For **community stewards**, to understand the key stresses in their landscape, and starting points for community discussions

पहचाने गए सूखे के वर्षों का विश्लेषण - 2017 से वर्षा के पैटर्न जैसे कि सूखे के अंतराल और सामान्य वर्षा से विचलन के बारे में महत्वपूर्ण जानकारियाँ सामने आई हैं। पहचाने गए सूखे के वर्षों के दौरान, 2017 में...

Landscape description and recommended actions

Example – Dumka: aquifer_type == "hardrock" and terrain == "slopesplains" and trend_g == steady and (double_cropping <= 30% or fallow_area >= 10ha and fallow_area_terrain == "plains")

Groundwater usage is okay and increased double cropping can improve farmer incomes. Please investigate why farmers are not double cropping or using fallow land more productively. Possible reasons could include soil degradation and therefore helping shift towards agro-ecological practices, not using synthetic fertilizers, etc. may help. A reason could also be lack of capital amongst smaller farmers to utilize borewells. Groundwater sharing and collectives may help in this.

Example – Gaya: aquifer_type == "alluvial" and terrain == "plains" and soge == "safe" and trend_g == negative

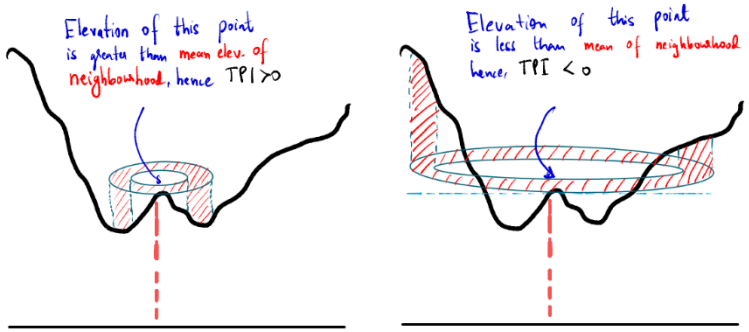
Groundwater is available in surplus but annual usage is in the deficit. Requires close monitoring to check that the situation is not worsened. Downstream areas in groundwater flow may be at a disadvantage though and steps should be undertaken to reduce groundwater usage by doing better rainwater harvesting and use of drip irrigation techniques. Traditional rainwater harvesting should be revived.

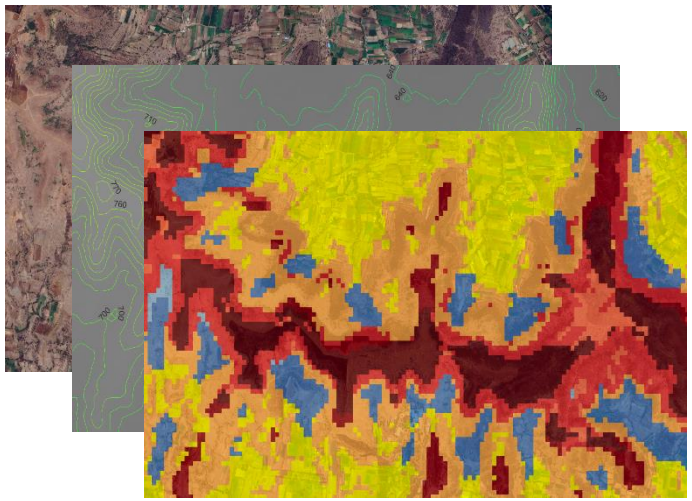
Evolve into a methodology to codify local ecological knowledge of what action strategy might be best suited in a particular landscape?

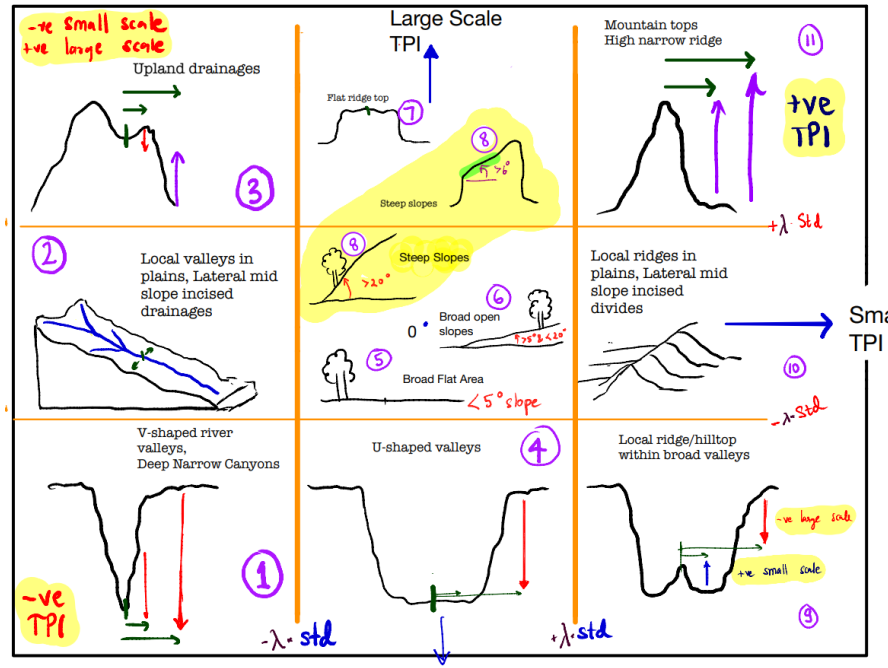
Landscape description and recommended actions

Terrain based classification

Topological position index:
Weiss, 2001

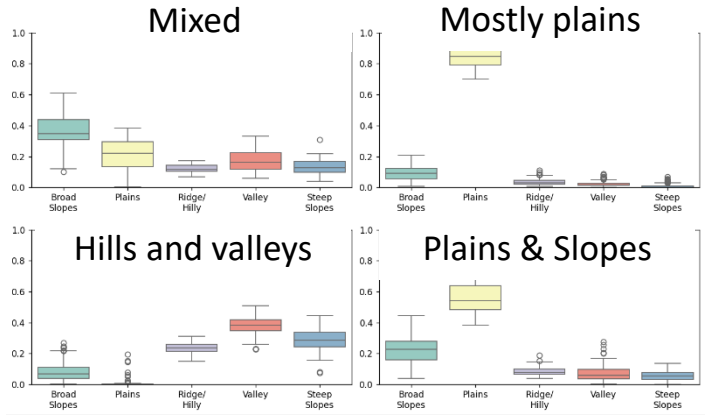


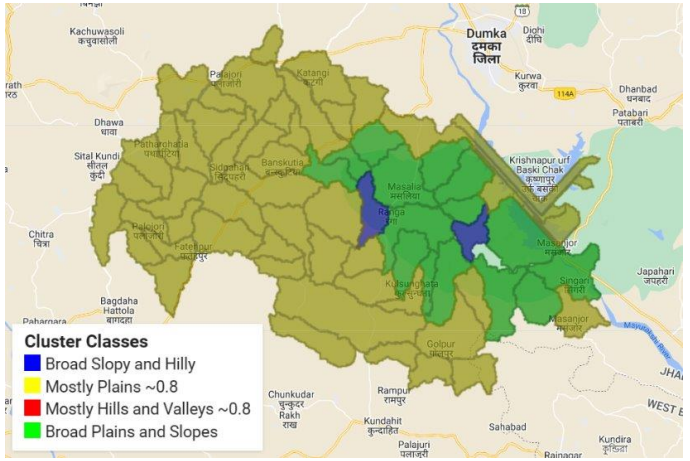




$$\lambda = \max(3 - \log_{10}(1 + \sigma_{elev}), 0.3)$$

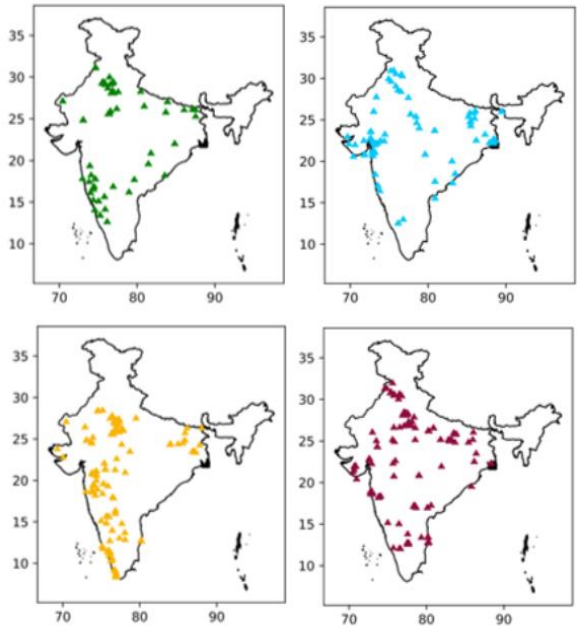
σ_{elev} is std-dev of elevation in the study area

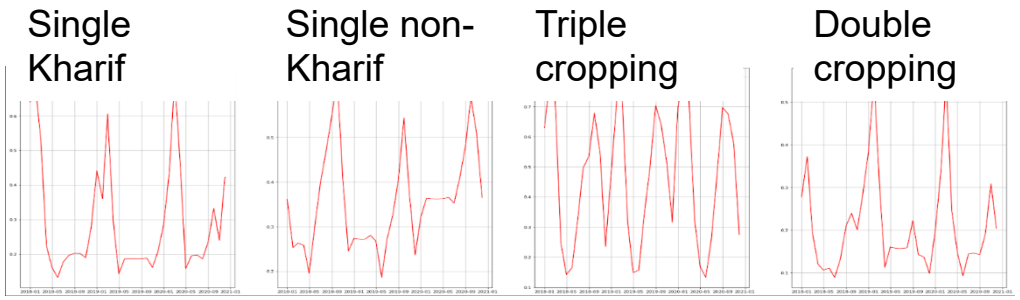


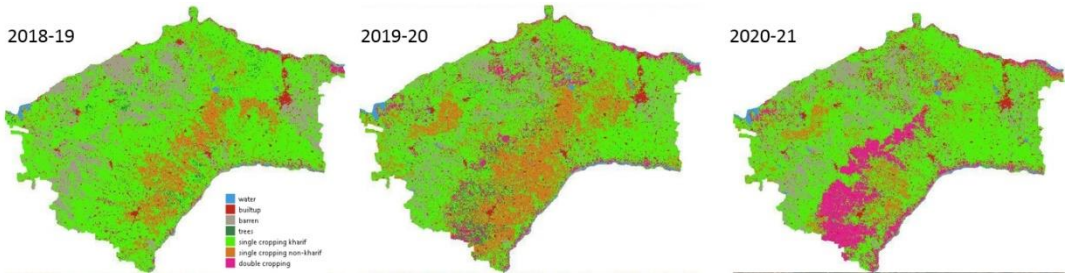


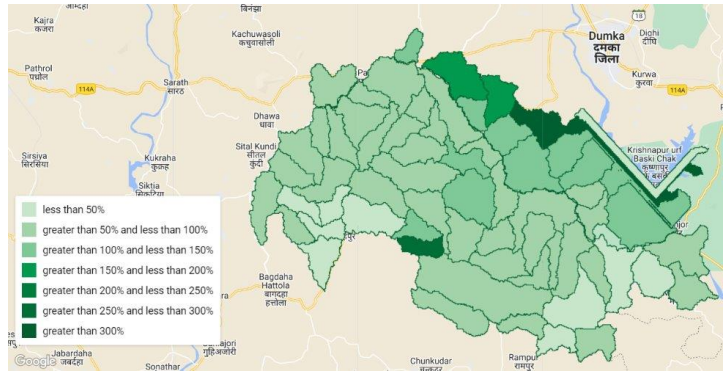
Landscape description and recommended actions

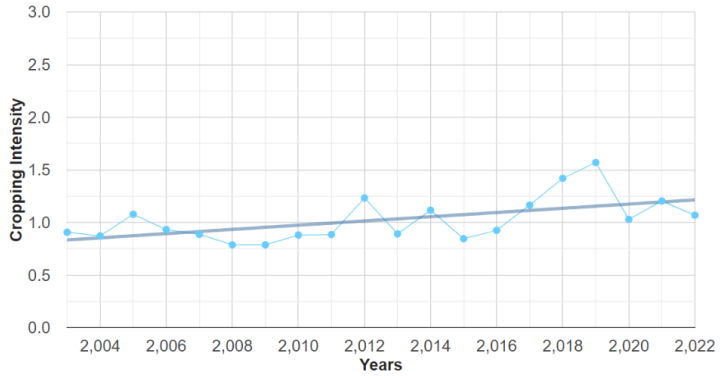
Cropping intensity







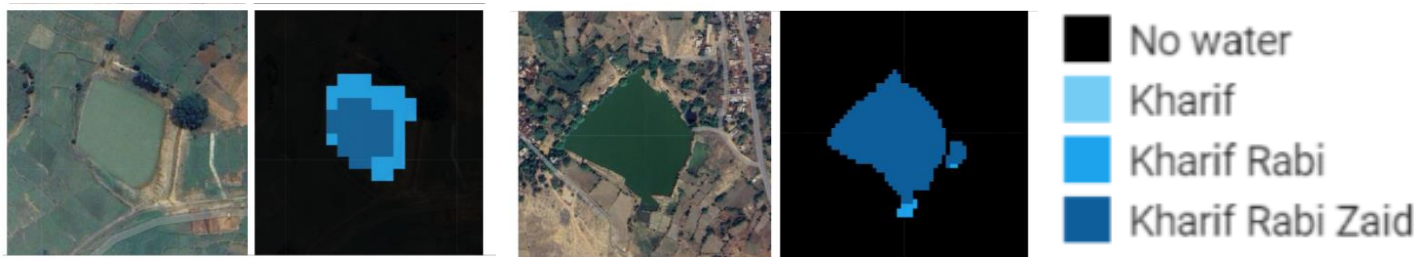


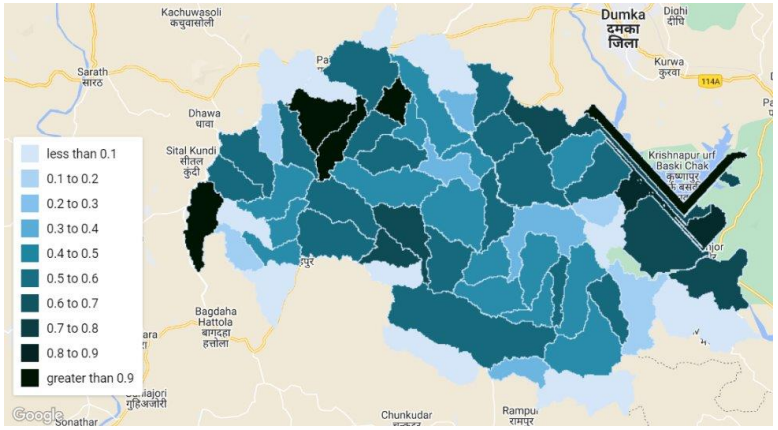


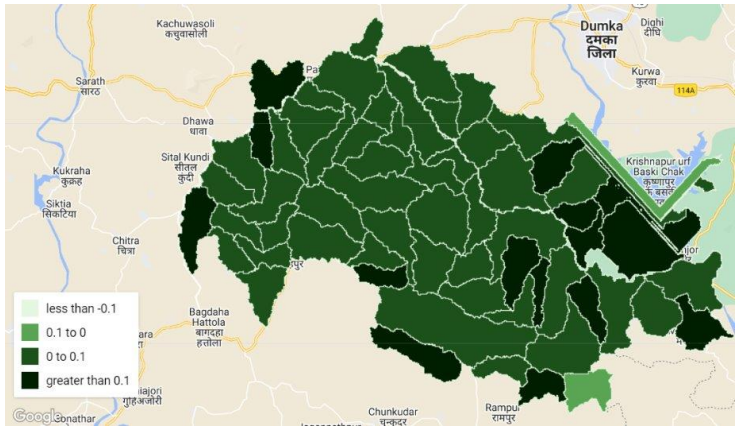
Unsupervised clustering. Labelling of clusters. Validation against groundtruth collected by us [challenges with using other datasets – GPS accuracy, missing timestamp, obvious errors]

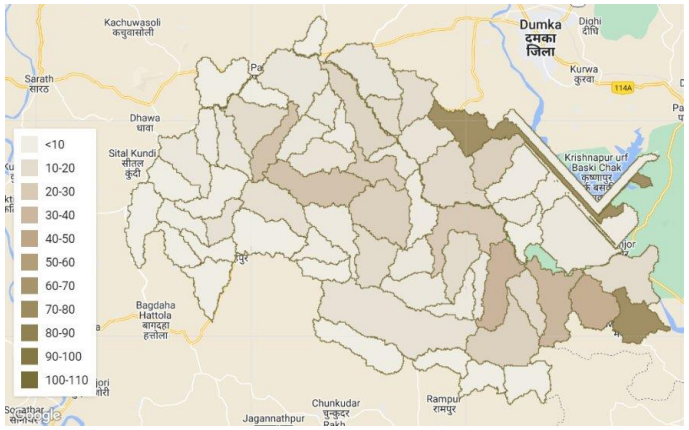
Landscape description and recommended actions

Vulnerability indicators







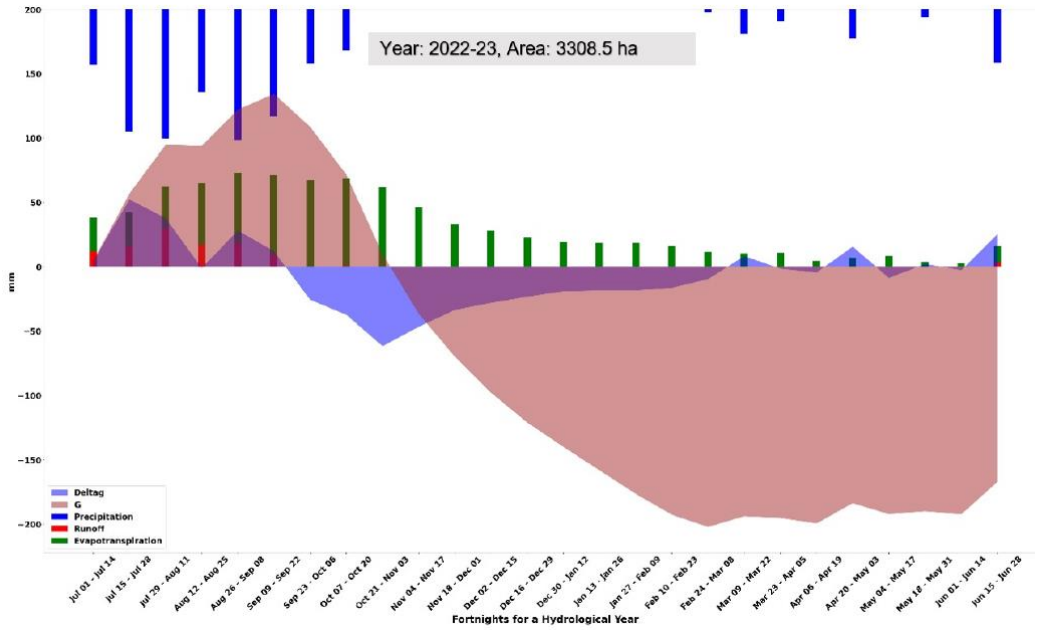


- Sensitivity to drought: Impact of droughts on surface water presence, impact on cropping intensity
- E.g. high impact on CI and SW => rainfed agriculture vulnerability
  low impact on CI, high on SW => groundwater irrigation in use

Number of soil and water conservation structures commissioned under MGNREGA

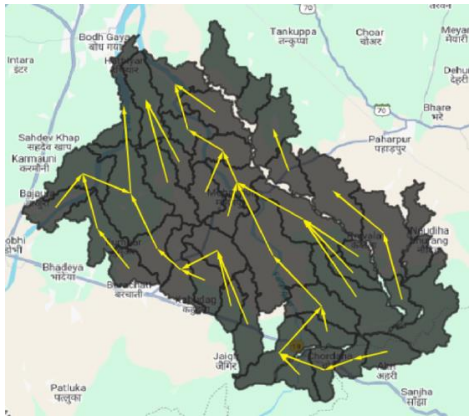
Landscape description and recommended actions

Groundwater stress



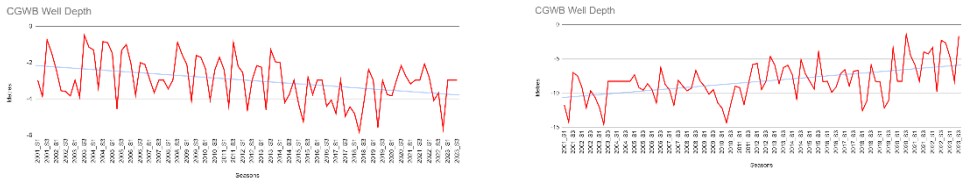
Vertical water balance :

$$\Delta G = \left(P_C - R \right) - CWC - \Delta SM$$



Incorporate incoming runoff for higher accuracy

Finite element simulation or graph ML calibration to hydrological properties to translate to communicable groundwater stress indicators.



Modelling of lateral flow

Know – Plan – Assess

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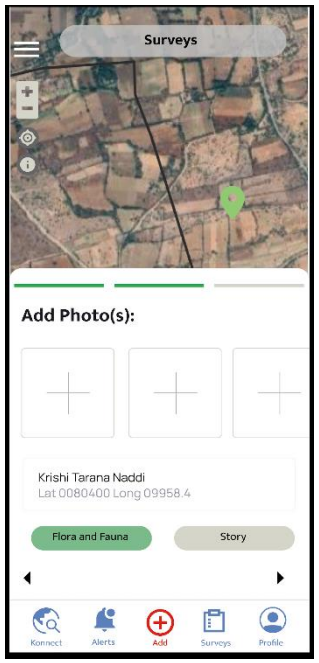
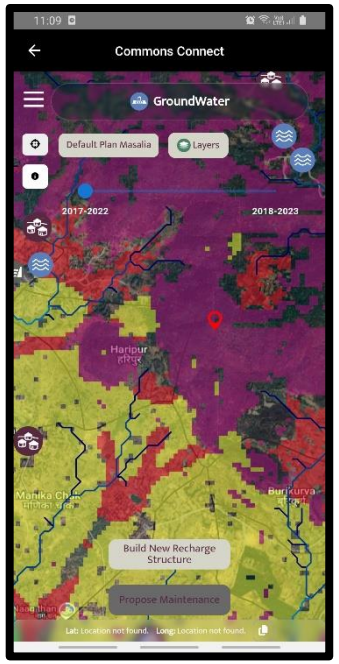
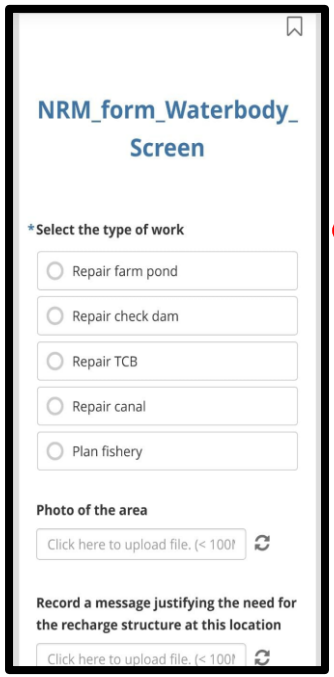
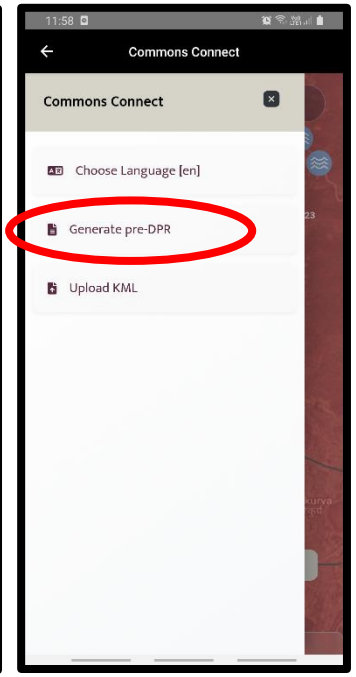




For **community stewards**, to map community demands for supply-side interventions, influence appropriate demand-side changes, build upon local ecological knowledge

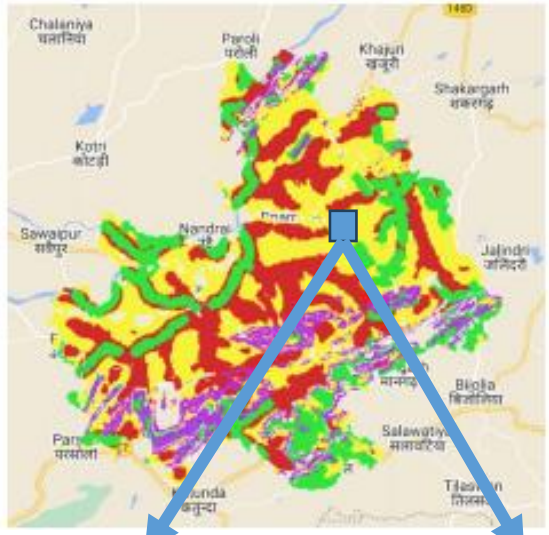
For **communities**, to build digital trails for effective claims making



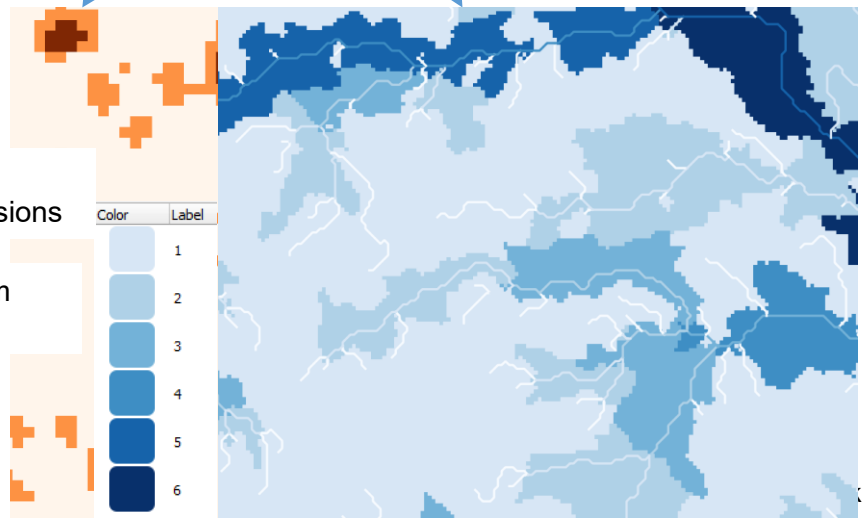


Informed demand generation

Feasibility assessment of water structures



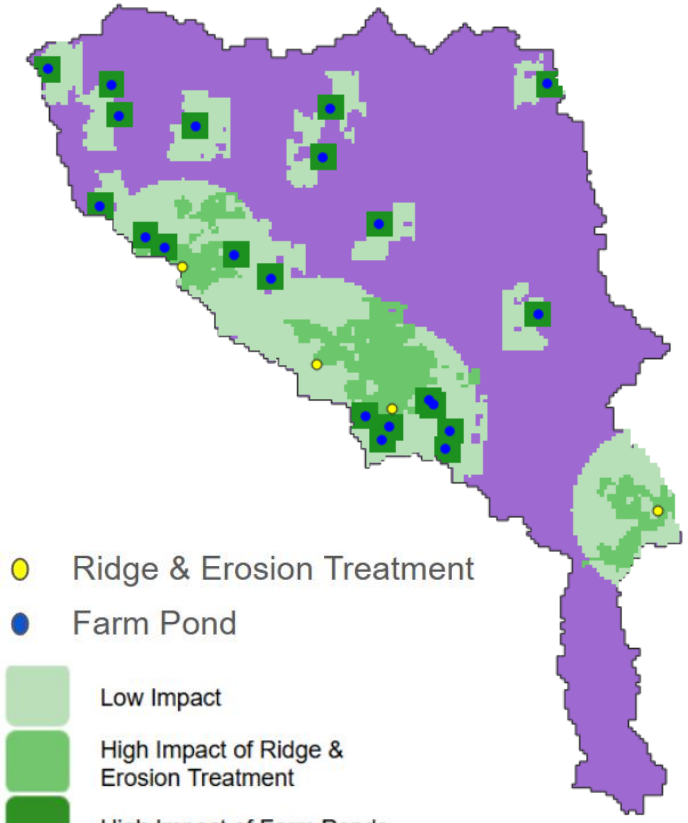
Step 1: Assessment based on groundwater recharge potential as well as surface water availability

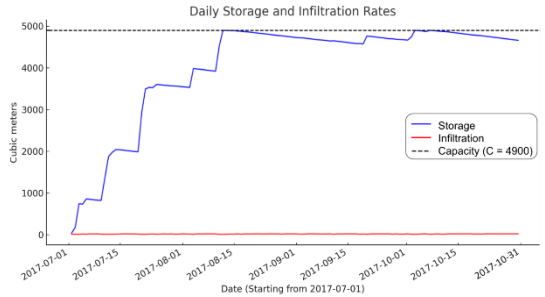


Natural depressions

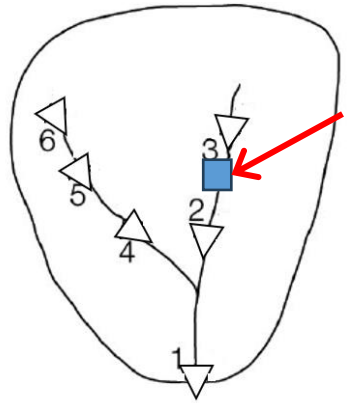
Stream order

Step 2: Hydrological simulations for more precise impact projection





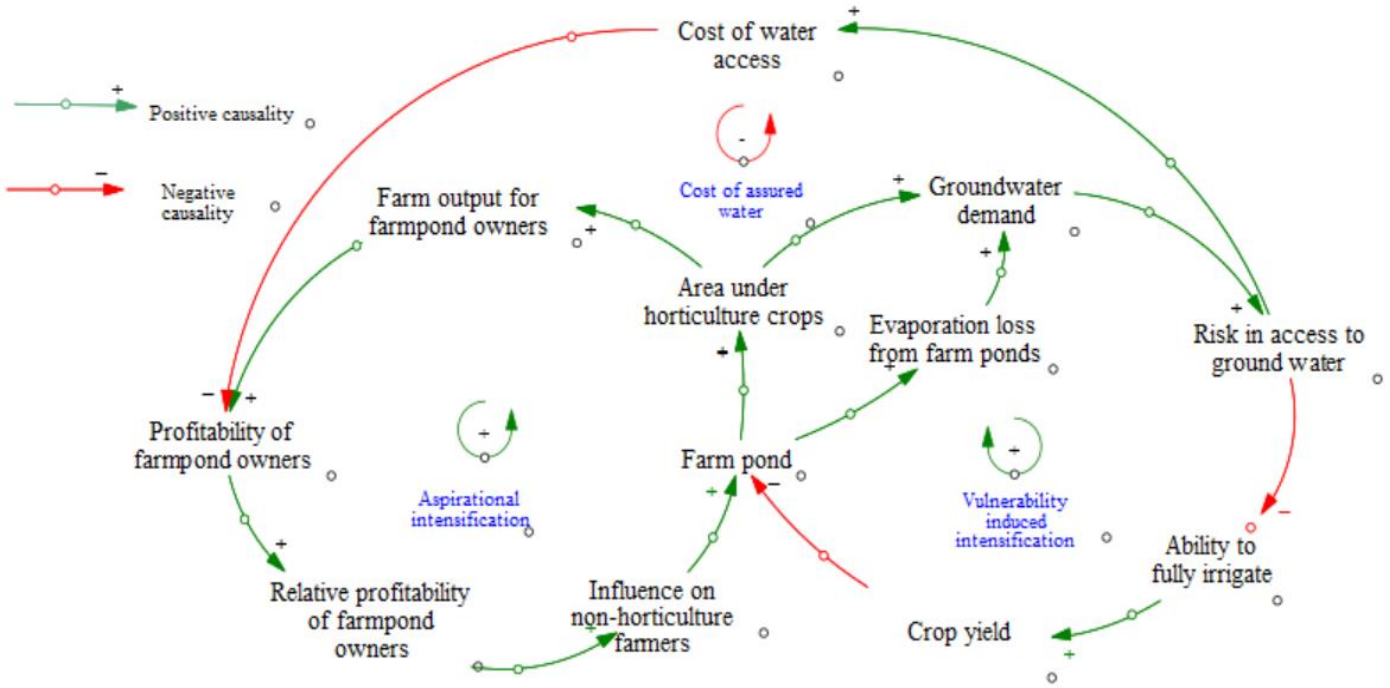
Number of weeks of water availability in farm pond



Impact on downstream waterbodies

Informed demand generation

Factoring social response to natural resource management



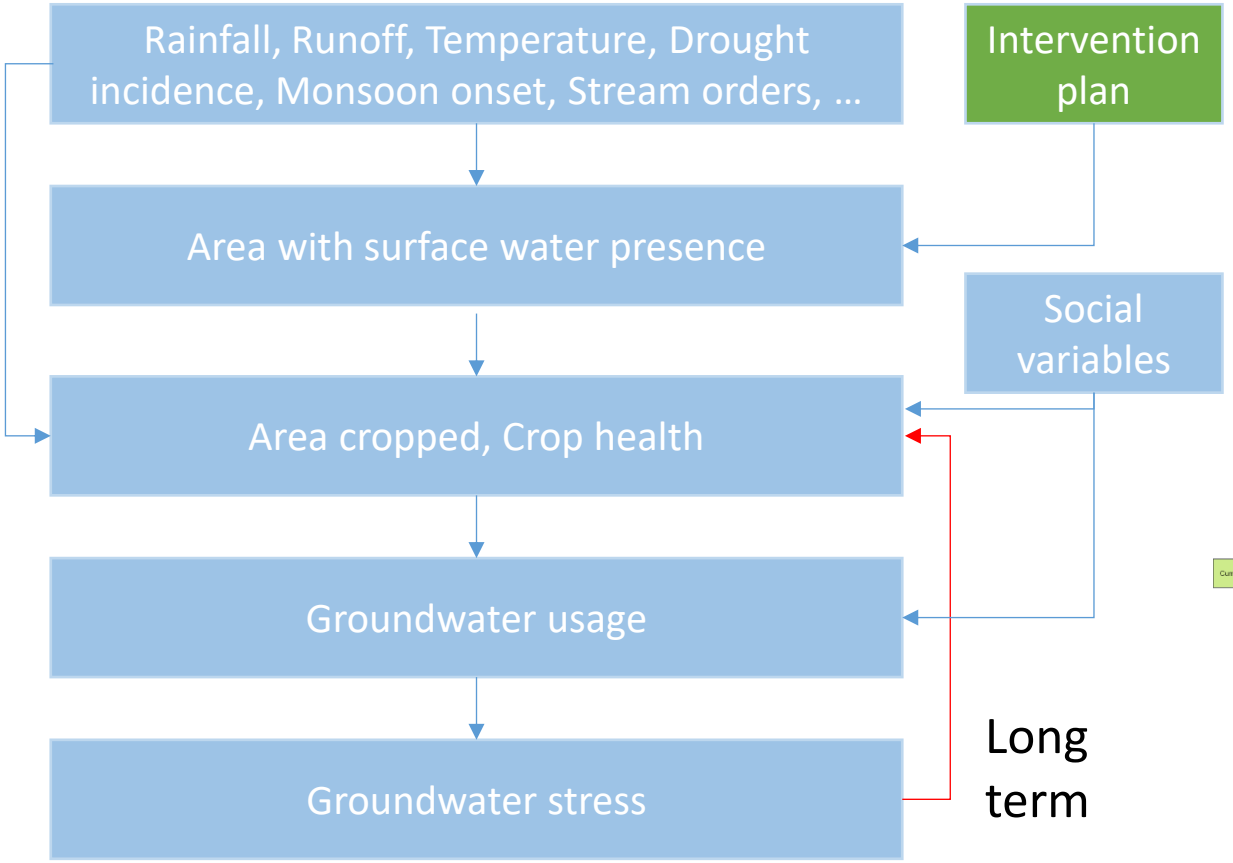
Prasad, et. al. 2020

In general, more availability of water leads to more water consumption rather than to alleviate water stress in the long term. Depends on social response: Collectivization in the community, household ability to utilize assets effectively, overall administrative efficiency of welfare scheme management.

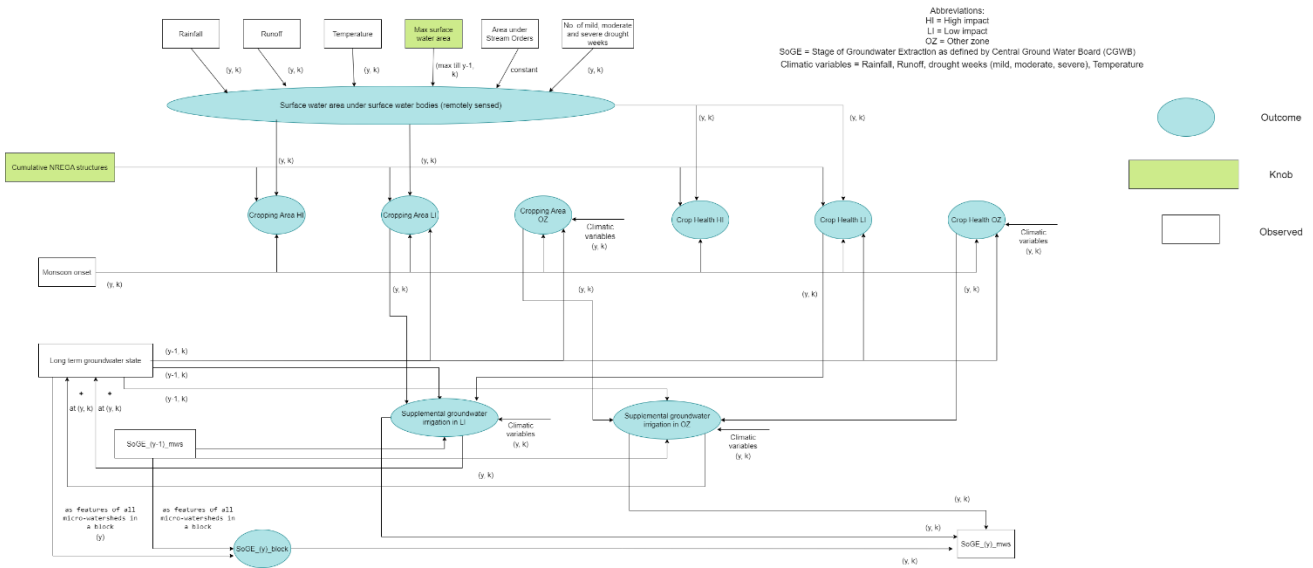
Informed demand generation

Factoring social response to natural resource management

Agent-based modeling trained on observed data



High level research question: Is all this adequate to model the complexity? Are there limits to datafication of social-ecological phenomena?



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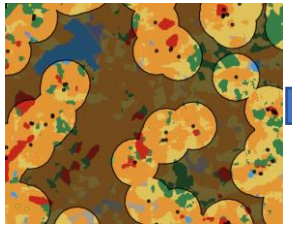
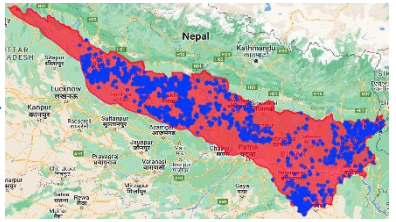
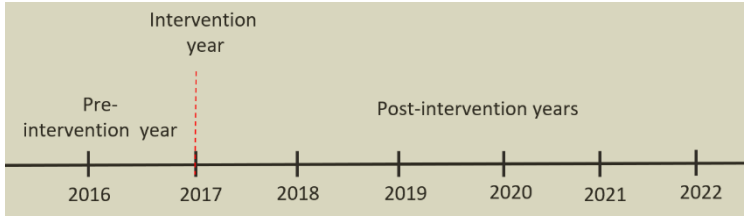
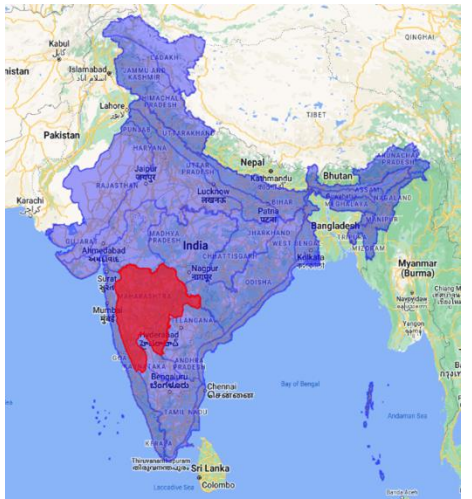





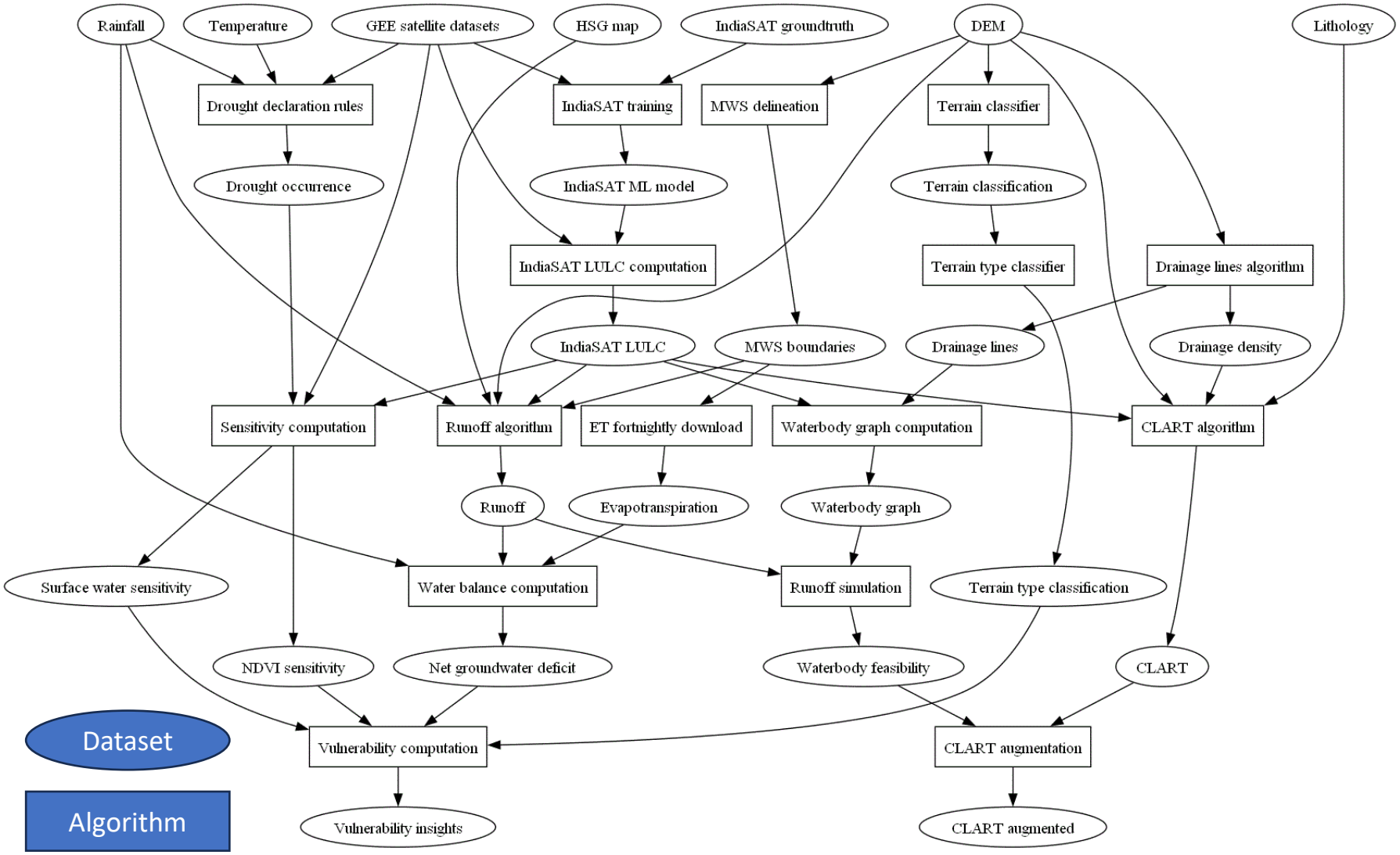
ATE of 20-40% increase in crop yields, reduced drought sensitivity

For **government departments, CSR, CSOs**, to assess the impact of their interventions, learn about local socio-ecological processes that are in play, enhance modeling for insights

ATE of 20-40% increase in crop yields, increased drought sensitivity



Some systems building challenges



1. Manage algorithm and dataset versions
   - Represent as a DAG in Airflow
   - Primitives
     - full_exec
     - alg_update
     - dataset_update
     - dag_augment
     - get_lineage
     - propagate_until
   - Extensions to the STAC standard to specify DAG and dataset lineage

2. GPU versions of some hydrology algorithms

Deploying CoRE stack for landscape stewardship

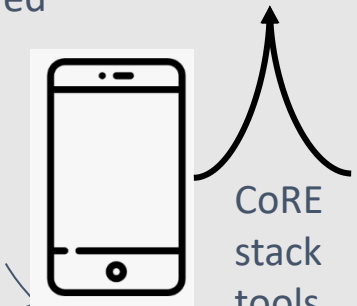
Community-driven landscape stewardship

Market financed, E.g. carbon credits

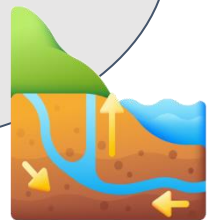
Govt. driven

Locus of action
- Demand of new works, maintenance of assets
- Changes in local practices – agroecology, collectives
- Restoration of degraded ecosystems

Principles
- Social: Equity
- Ecological: Stay within landscape limits
- Monitoring and modeling tools
- Informed decision making – data + local ecological knowledge



CoRE stack tools



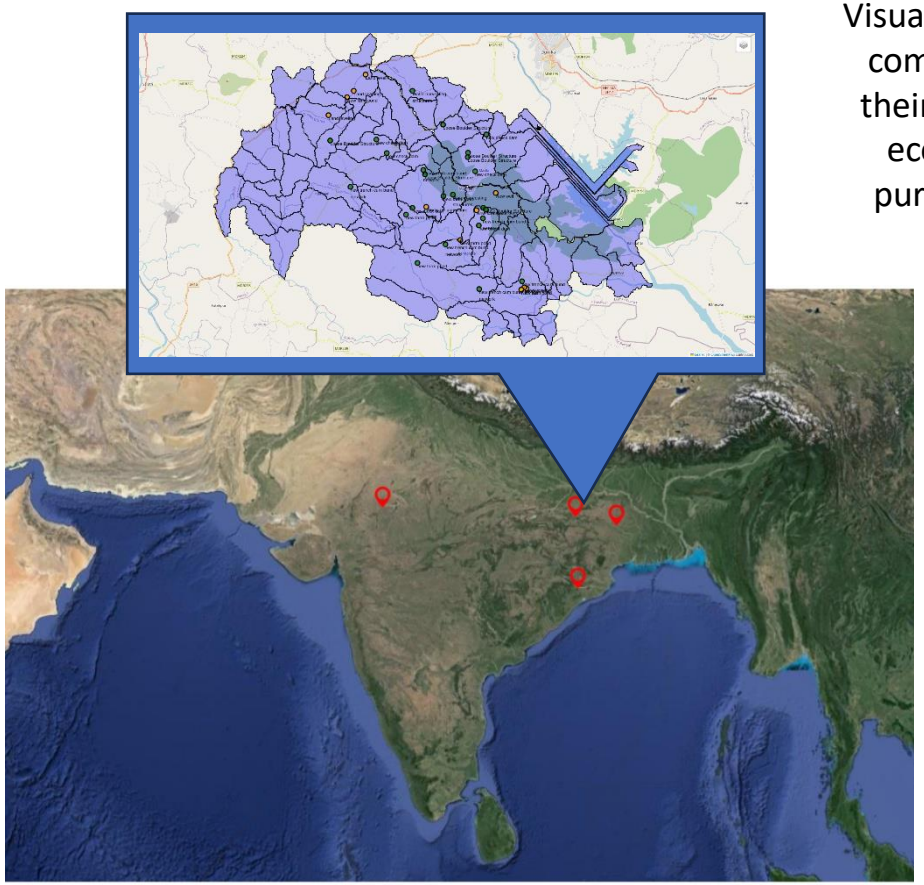
Common model that can be layered with many programmes

Green jobs
- NREGA mates
- SRLM VRPs
- Krishi Sakhis
- CSO CRPs
- Para-hydrologists
- …

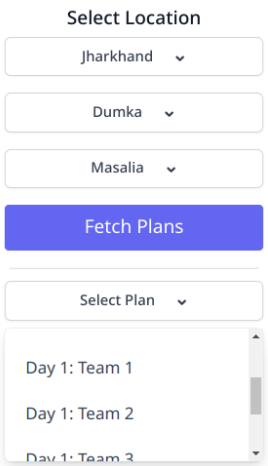
Gig economy model but done right

Making landscape stewardship financially sustainable

- Number of partners using the CoRE stack: 15
- Number of blocks active: 88
- Number of plans under development: 79
- Number of stewards trained: 28



Visualize plans made by communities, assess their projected socio-ecological impact, purchase landscape credits.



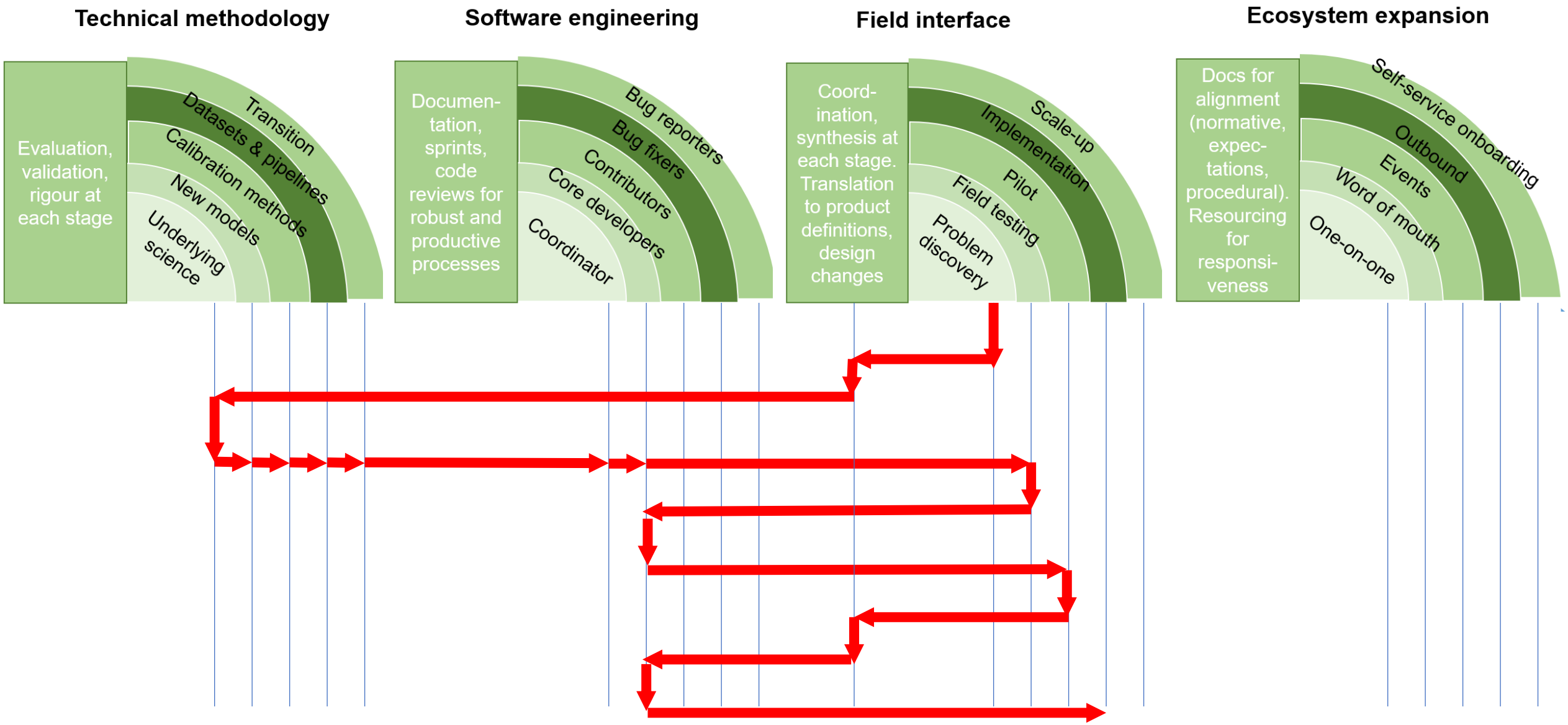
Projected impact

- Considering only NREGA, average INR 25L spend per panchayat, 60% on NRM. Not all works are planned well
- With more informed decision facilitated by community stewards, we project an additional:
  - 6000 m^3 of water conservation per steward
  - 4 tCO_2 sequestered per steward
  - 11 hectares of forest degradation avoided

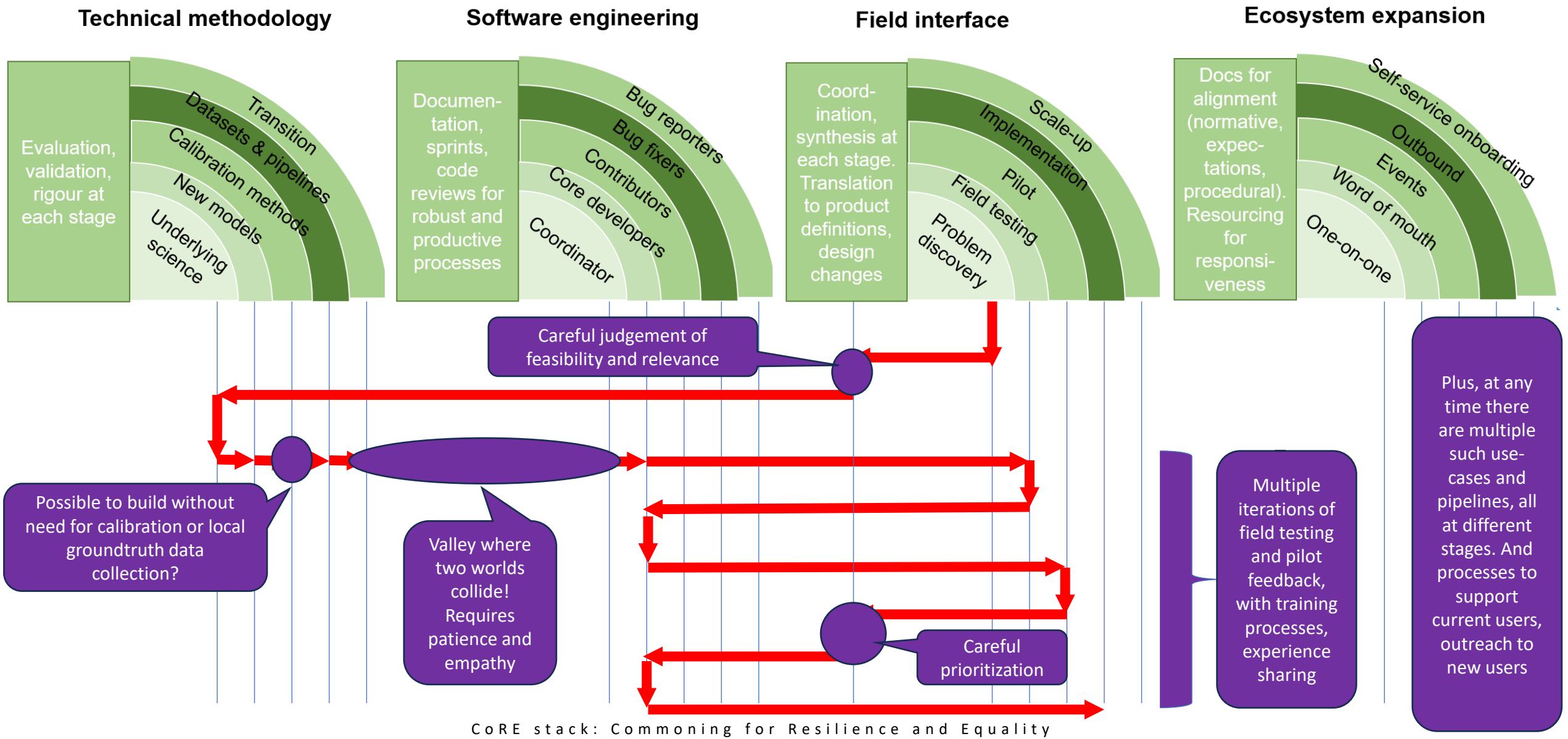
Operationalization at scale

- Goal: Reach 25,000 community stewards in 5 years
- Communities build plans in a bottom-up manner, assisted by community stewards
- Plans are visible to government departments, CSR donors, micro-funding platforms, etc.
- Impact tracking: Outcome-based using change detection methods – Status of water bodies, Health of tree plantations, Impact on water security

Nuts and bolts of building the CoRE stack



What makes it complex



Join the CoRE stack community

Open positions too: Research Associates @ IIT Delhi, Geospatial data specialists @ CommonsTech Foundation

https://github.com/orgs/core-stack-org/

- Technical manual.
- Long list of new datasets and pipelines to build. Detailed guide is now available.
- Implement cutting edge research papers, solve open research tasks.
- Use APIs to ingest the analytics in apps and bots for new use-cases.
- Enrich with primary data collected through standardized modules.
- Knowledge representation and engineering to integrate traditional and local ecological knowledge with positivist scientific knowledge

https://core-stack.org

A collaborative network – computer scientists, hydrologists, ecologists, implementation organizations, policy researchers…

Thanks for listening! Get in touch: contact@core-stack.org