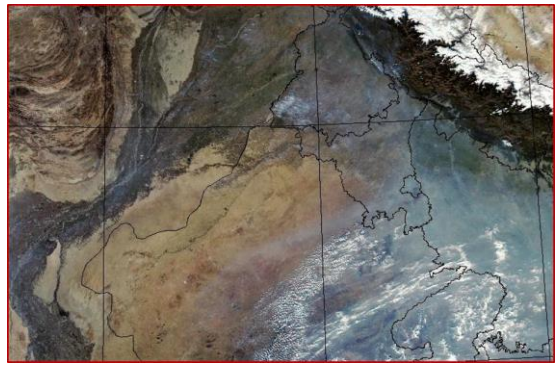
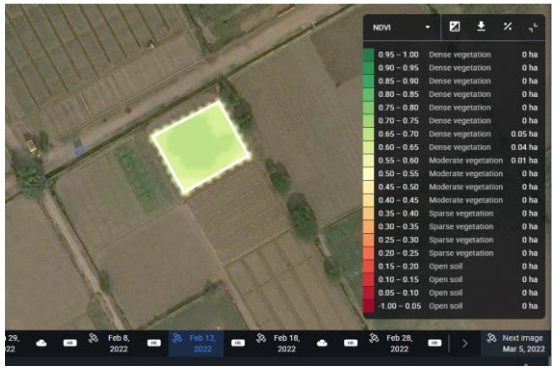
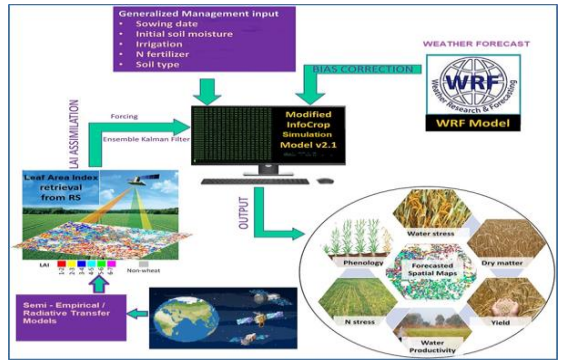
Indian Agricultural Research Institute
भारतीय कृषि अनुसंधान संस्थान
(An ISO 9001:2008 Certified Institute)







Scaling Geospatial Research for Operational Agricultural Applications in India: Space Tech in Agri-action

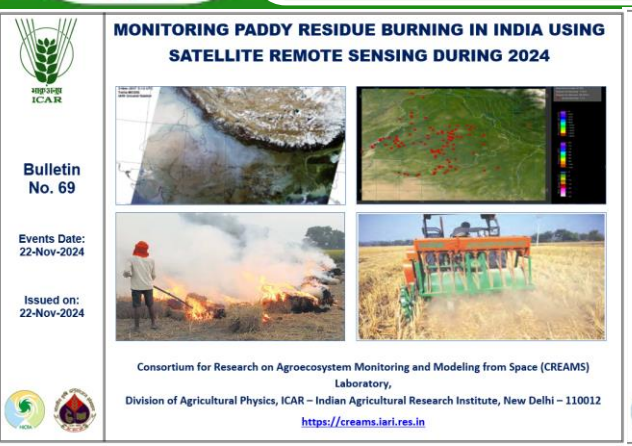
VINAY KUMAR SEHGAL, RAJKUMAR DHAKAR

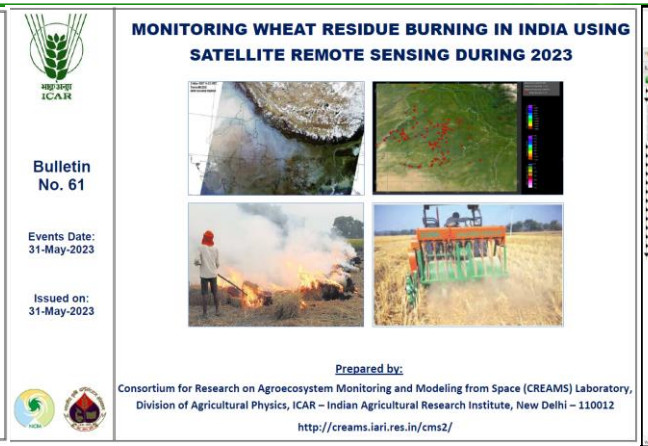
CREAMS Lab, Division of Agricultural Physics
ICAR - Indian Agricultural Research Institute, New Delhi – 110012
https://creams.iari.res.in

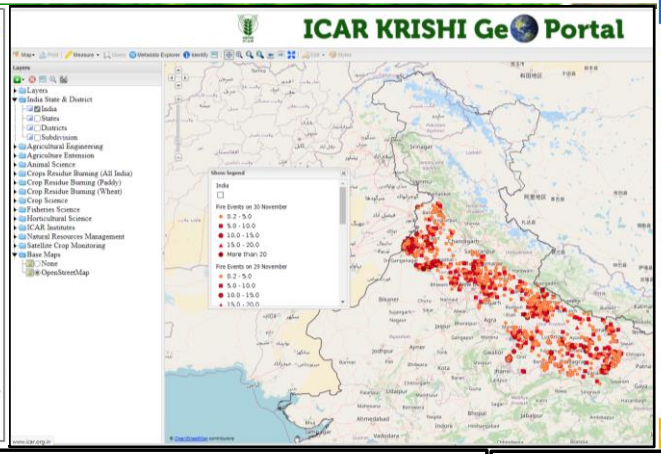
04 December 2025

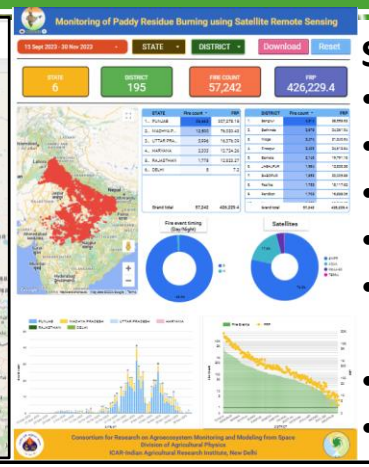
GEO SMART INDIA

Monitoring of Active Fire Events: Paddy



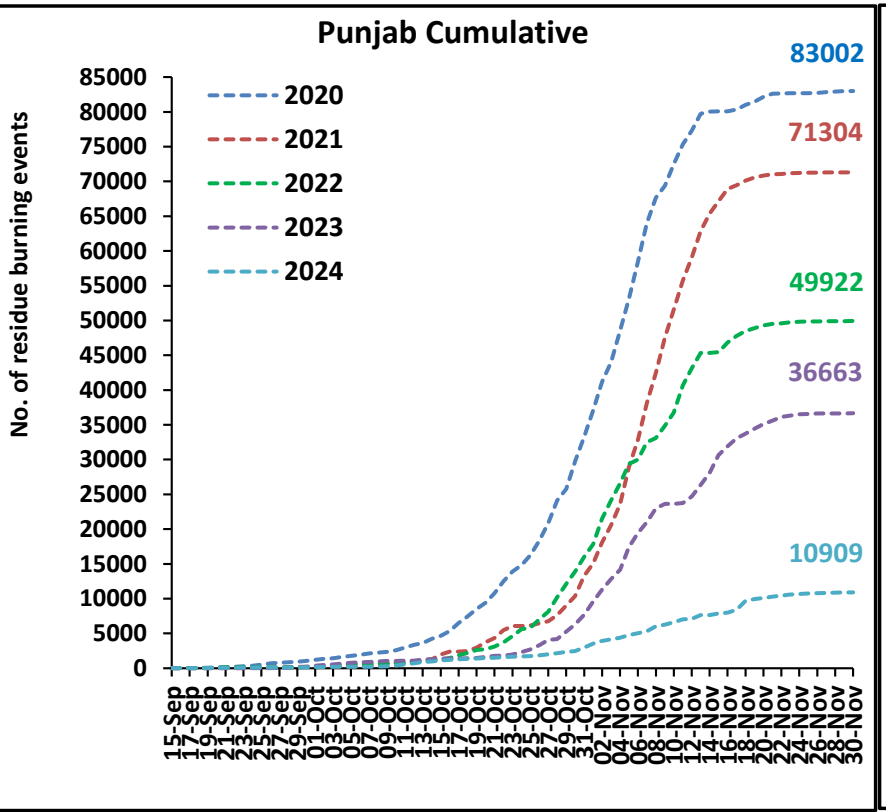


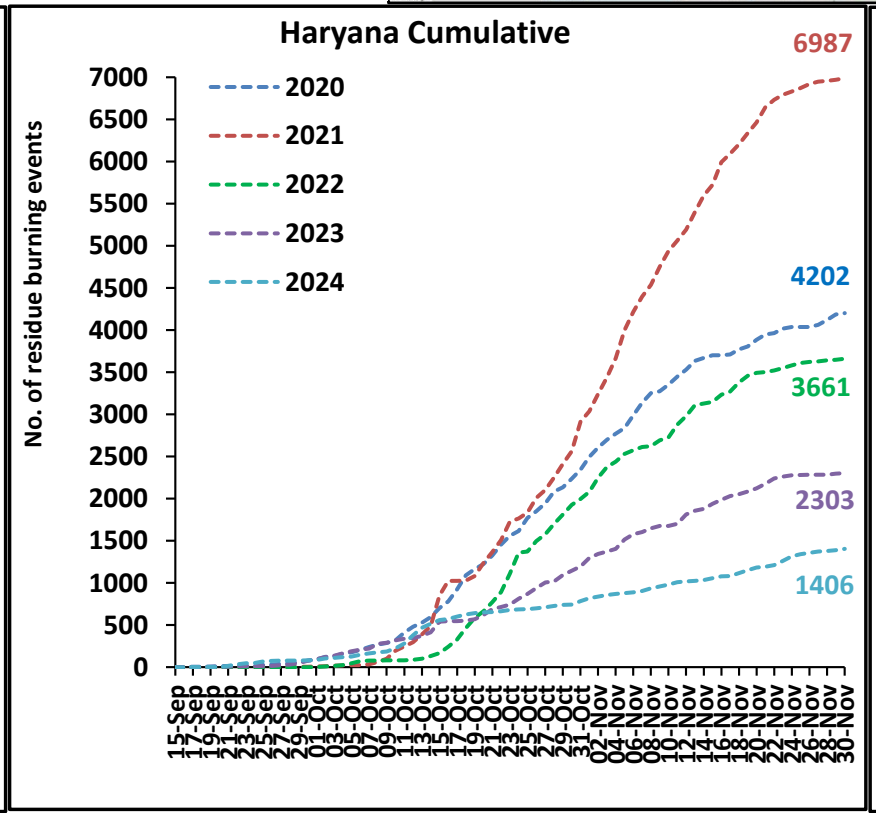


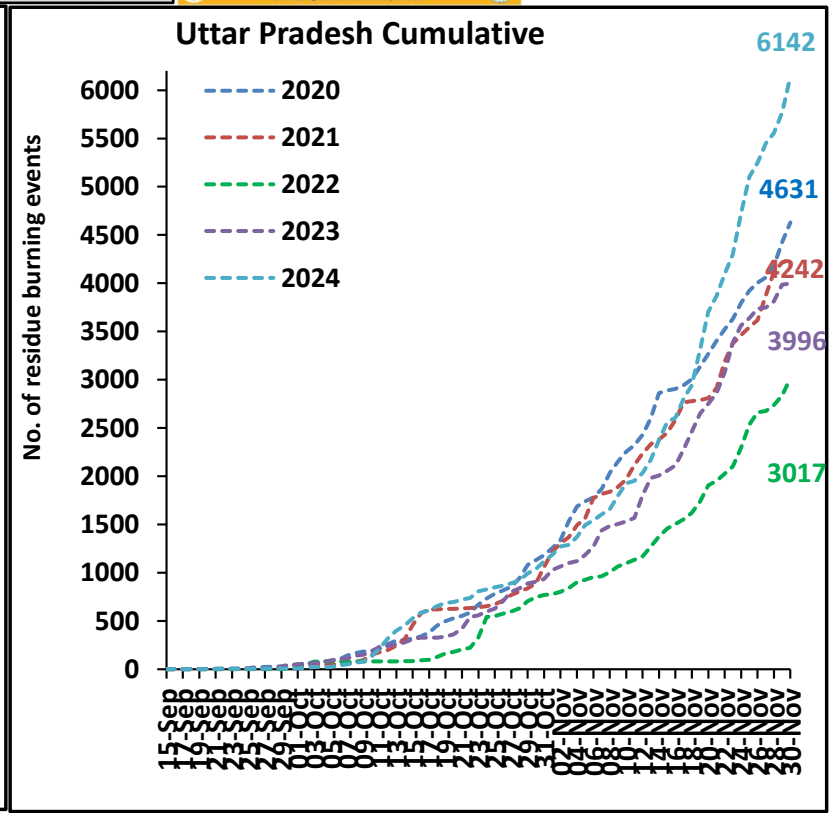


Stakeholders:

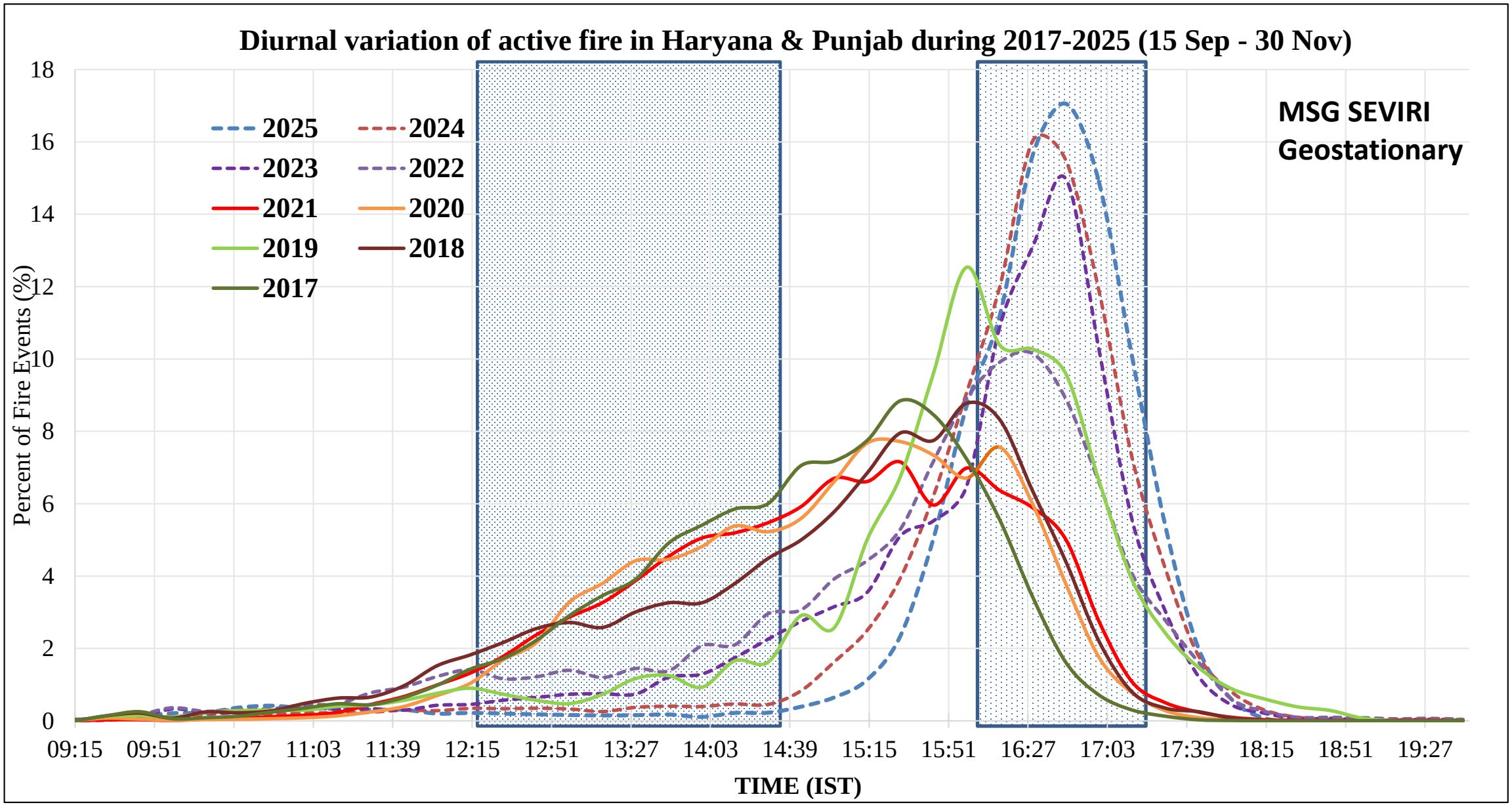
- ICAR (AE, NRM)
- M&T, MoA
- CAQM, CPCB
- VCs, SAU
- State AE / AG Depts
- ATRI & KVK's
- Media



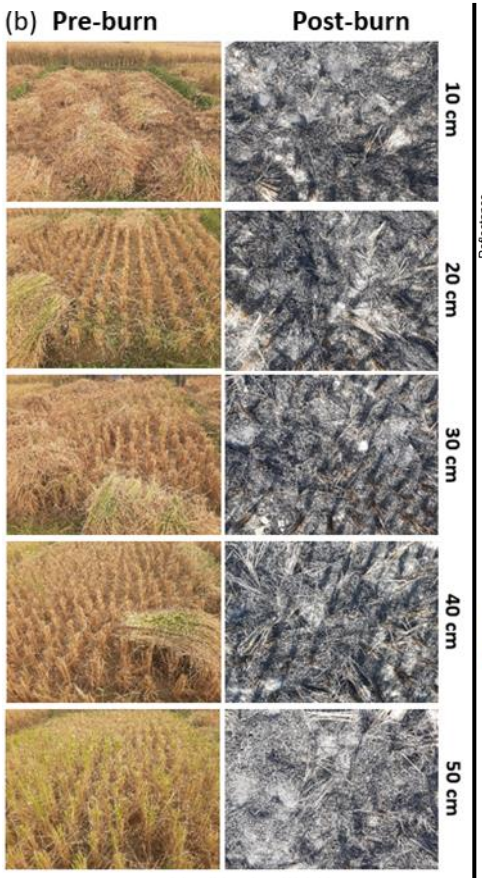


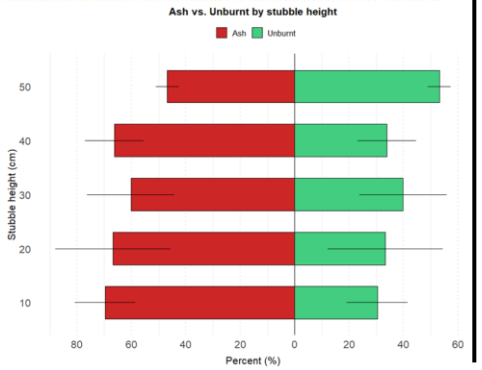


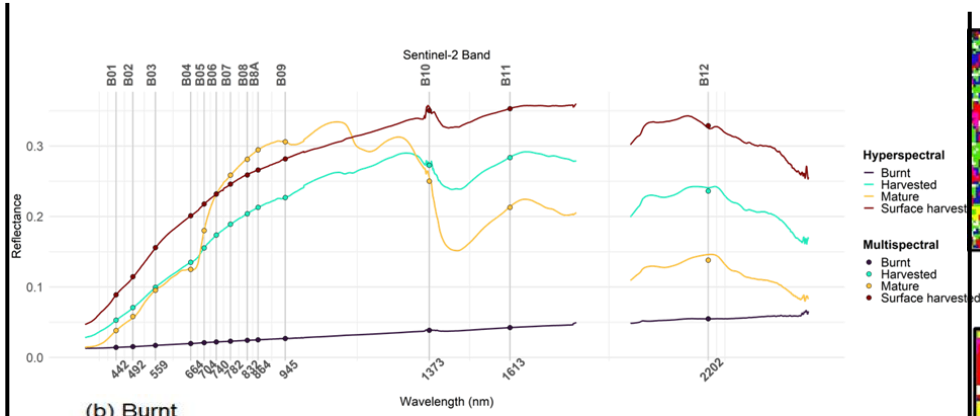
Monitoring of Active Fire Events: Paddy

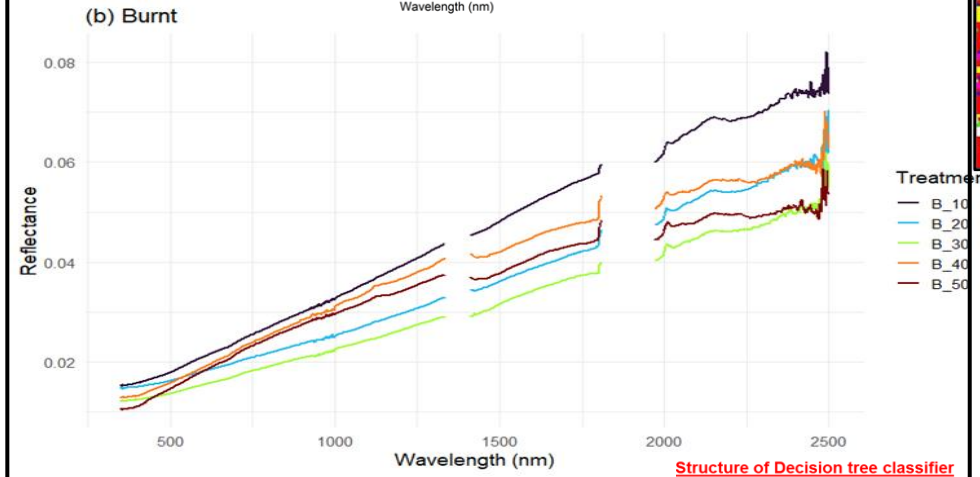


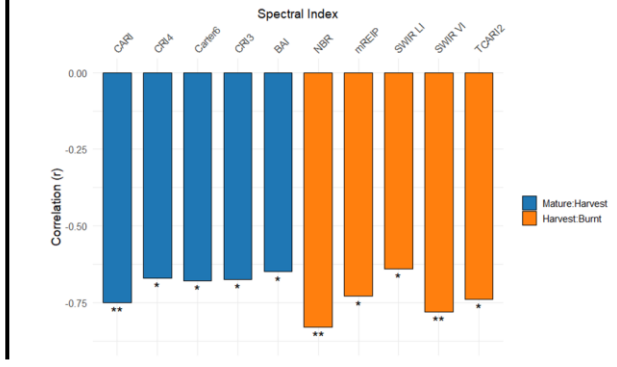
MONITORING AND MAPPING CROP RESIDUE BURNING



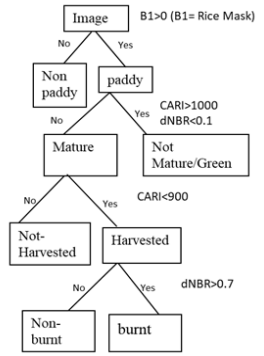


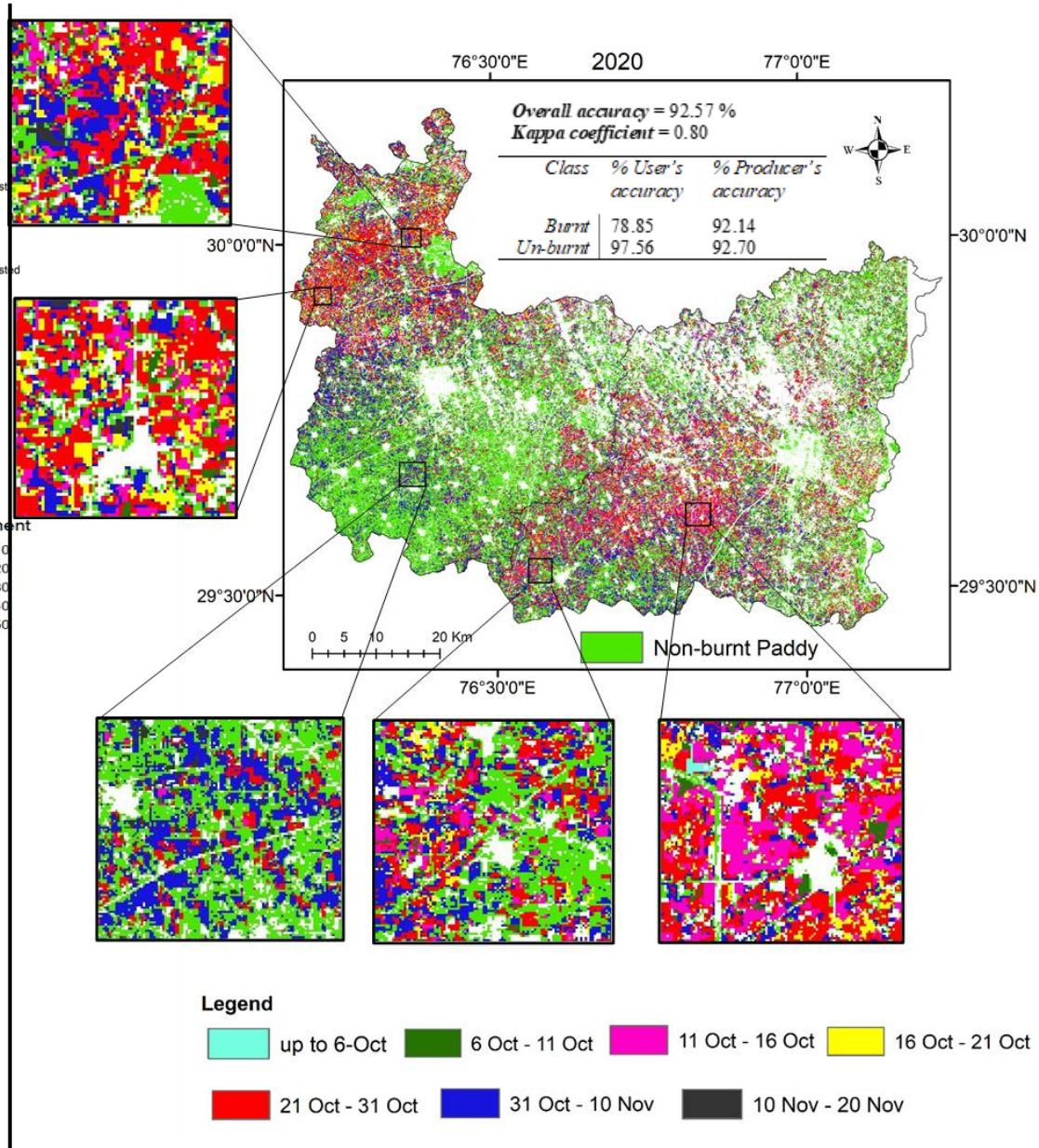




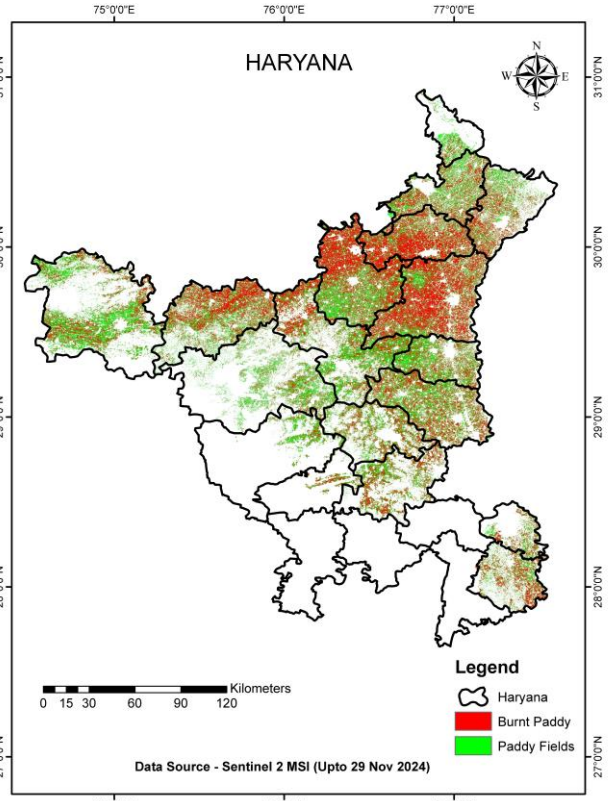


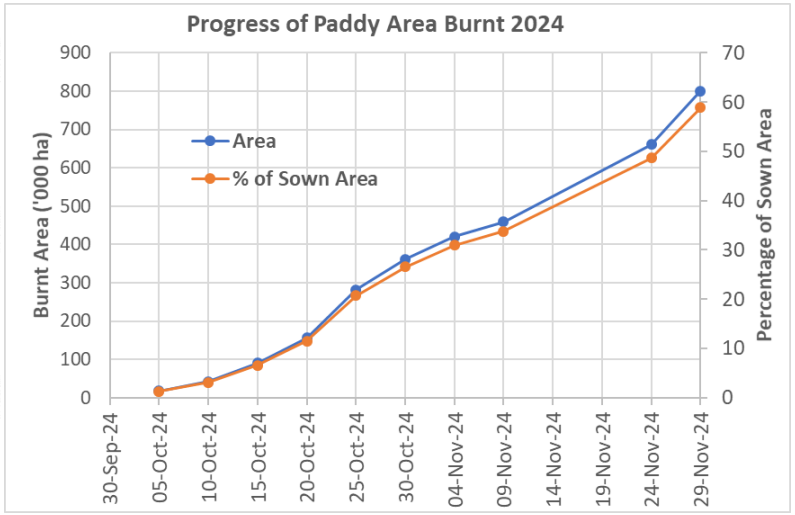
Structure of Decision tree classifier



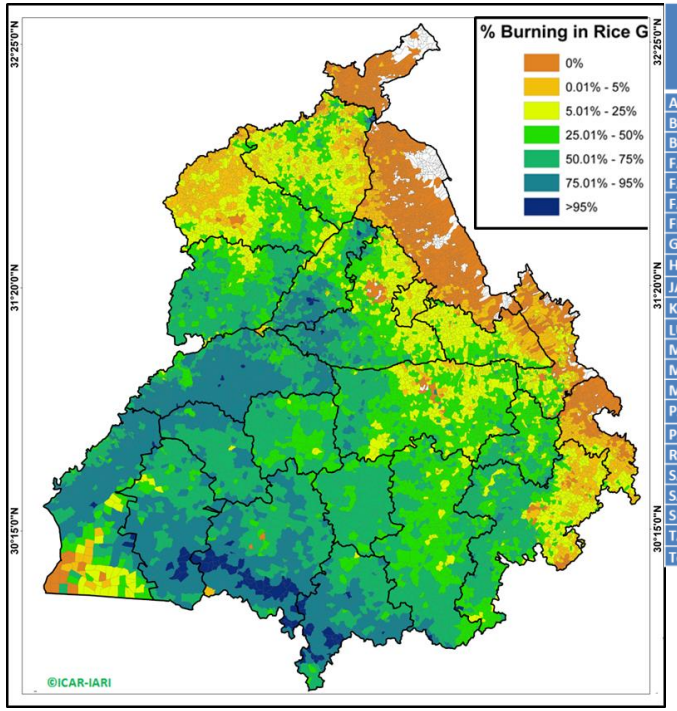


MONITORING AND MAPPING RICE RESIDUE BURNING 2025

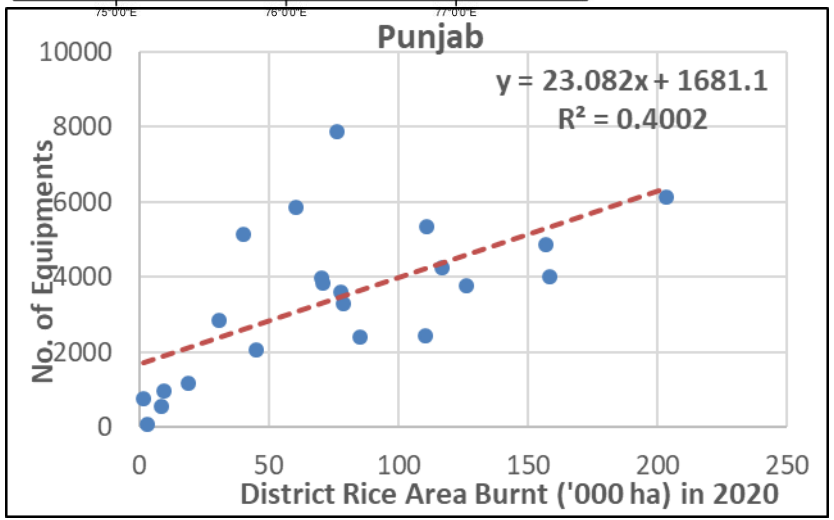


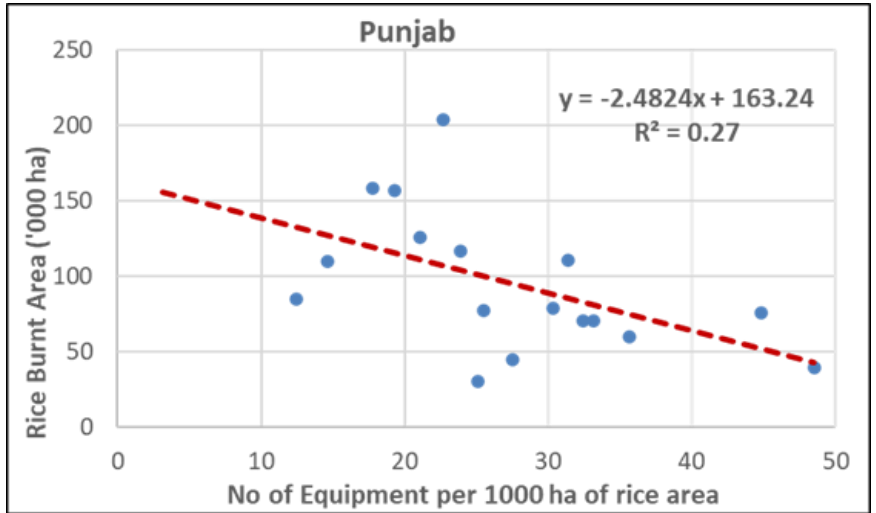


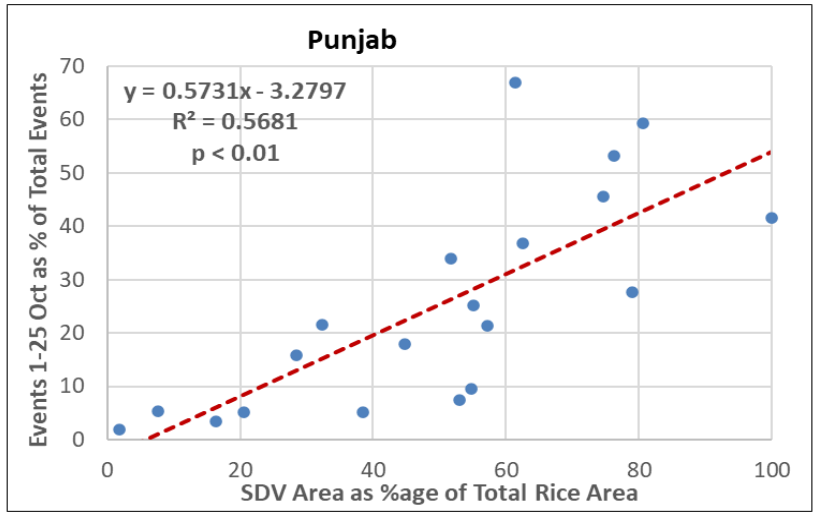
Paddy Sown Area: 1.36 M ha
Paddy Burnt Area: 0.80 M ha
% Area Burnt: 58.94 %



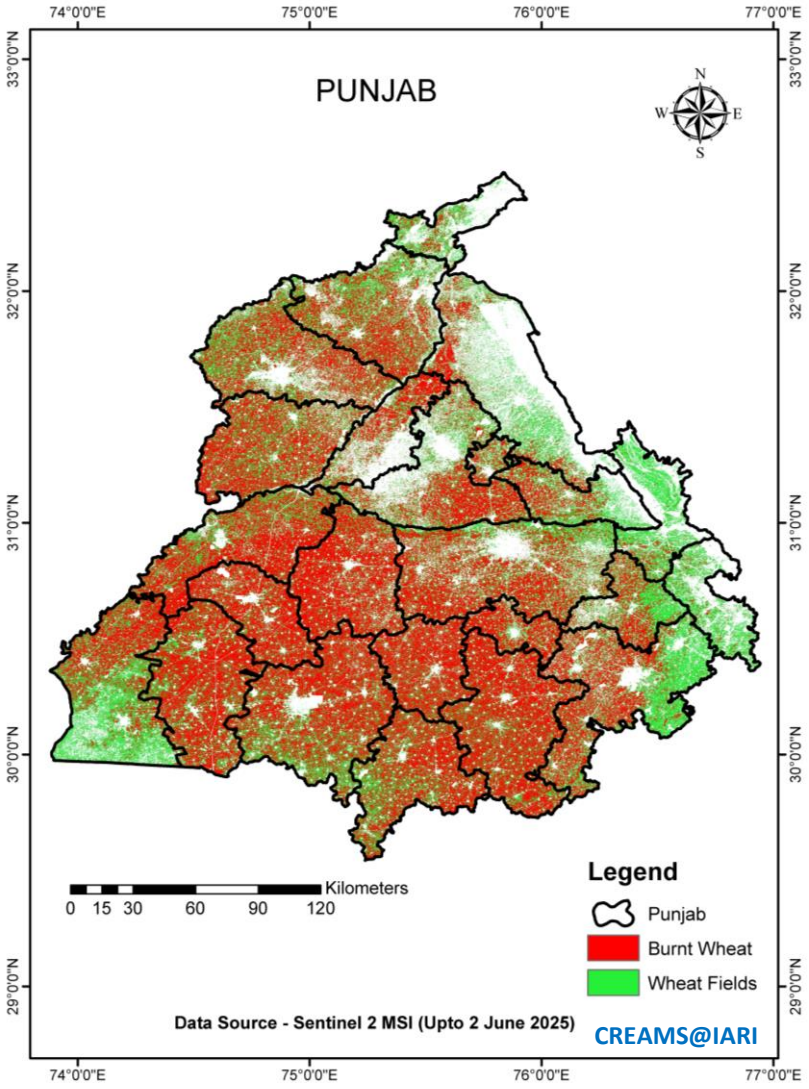
DISTRICT NAME	No of Villages				
	Rice cultivating	Rice burning	Zero rice burning	>0 to 5% rice area)	> 95% rice area burnt
AMRITSAR	776	762	14	269	0
BARNALA	133	133	0	0	0
BATHINDA	294	292	2	1	40
FARIDKOT	171	171	0	0	1
FATEHGARH S	416	415	1	1	0
FAZILKA	439	425	14	10	4
FIROZPUR	734	734	0	1	5
GURDASPUR	1216	1167	49	230	3
HOSHIARPUR	1234	165	1069	165	0
JALANDHAR	996	974	22	37	3
KAPURTHALA	684	681	3	23	6
LUDHIANA	965	941	24	34	0
MANSA	244	244	0	0	27
MOGA	171	171	0	0	0
MUKTSAR	236	236	0	0	7
PATHANKOT	359	15	344	15	0
PATIALA	984	952	32	174	1
RUPNAGAR	575	373	202	121	0
SANGRUR	593	593	0	1	1
SAS NAGAR	441	244	197	174	0
SBS NAGAR	473	442	31	57	0
TARN TARAN	493	493	0	1	0
Total	12627	10623	2004	1314	98



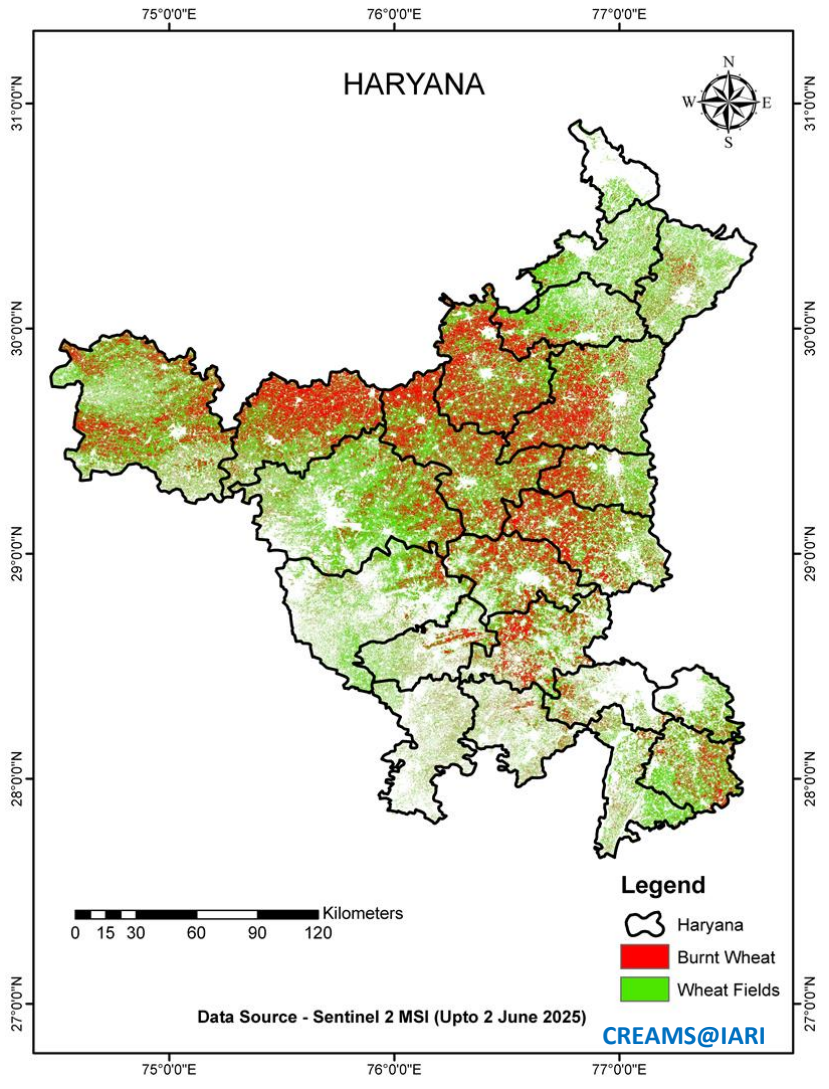




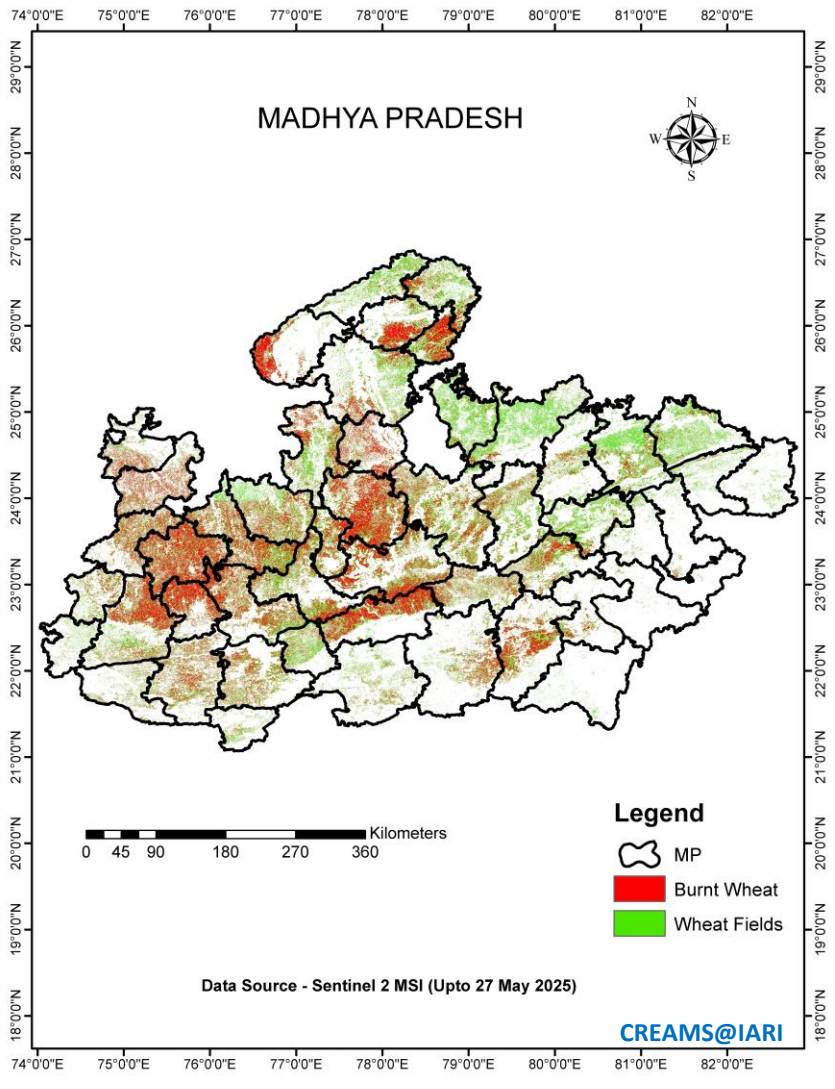
MONITORING AND MAPPING WHEAT RESIDUE BURNING 2025



Wheat Sown Area: 3.52 million ha
Paddy Burnt Area: 2.13 million ha
% Area Burnt: 60.05 %

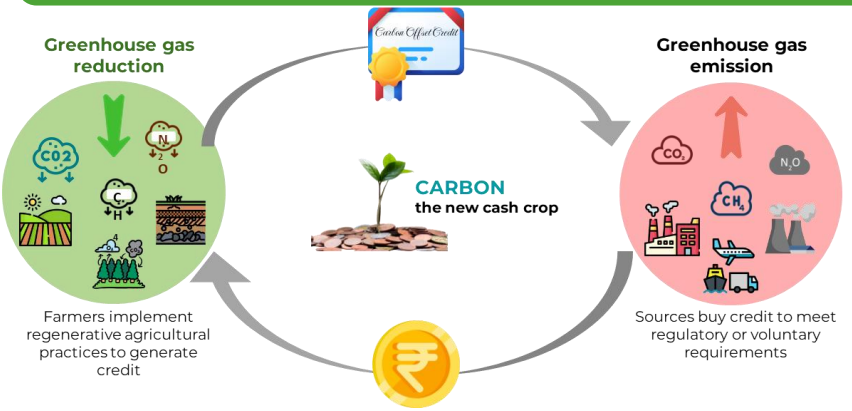


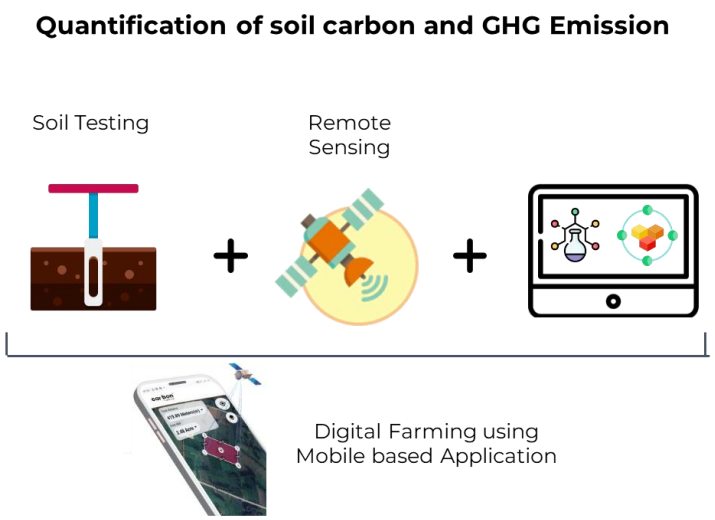
Wheat Sown Area: 2.25 million ha
Paddy Burnt Area: 0.84 million ha
% Area Burnt: 37.33 %



Wheat Sown Area: 7.14 million ha
Paddy Burnt Area: 3.23 million ha
% Area Burnt: 45.23 %

Promoting Regenerative Agriculture through Carbon Credits

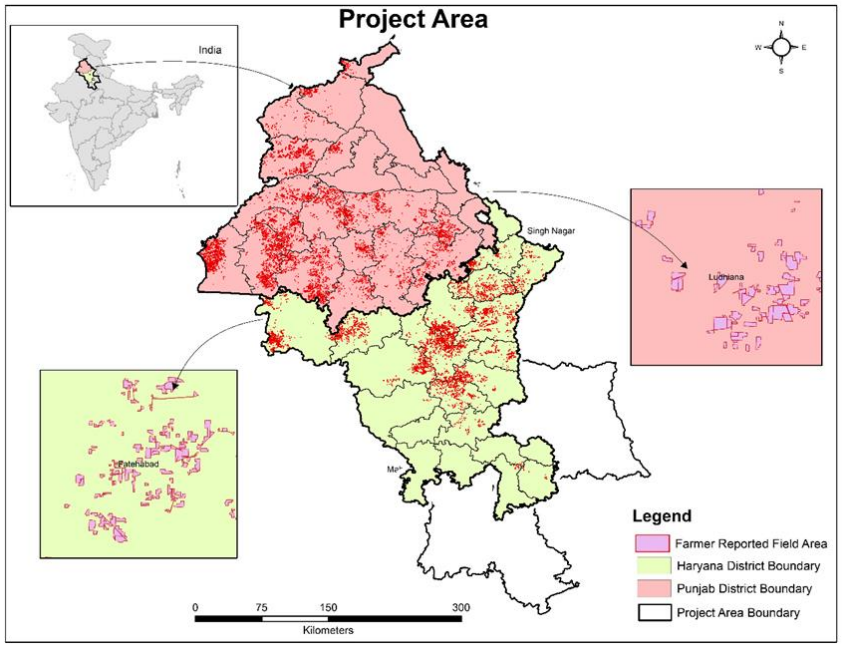




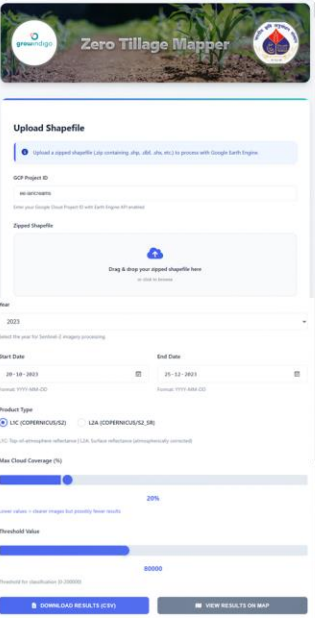
VERRA

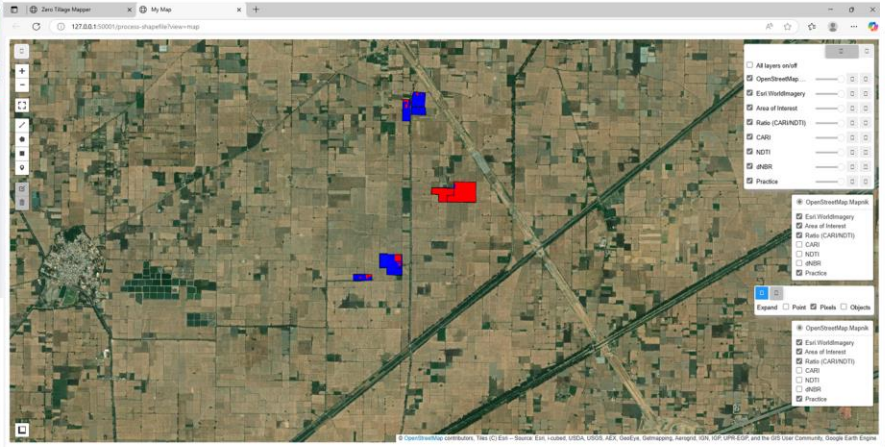
Verified Carbon Standard

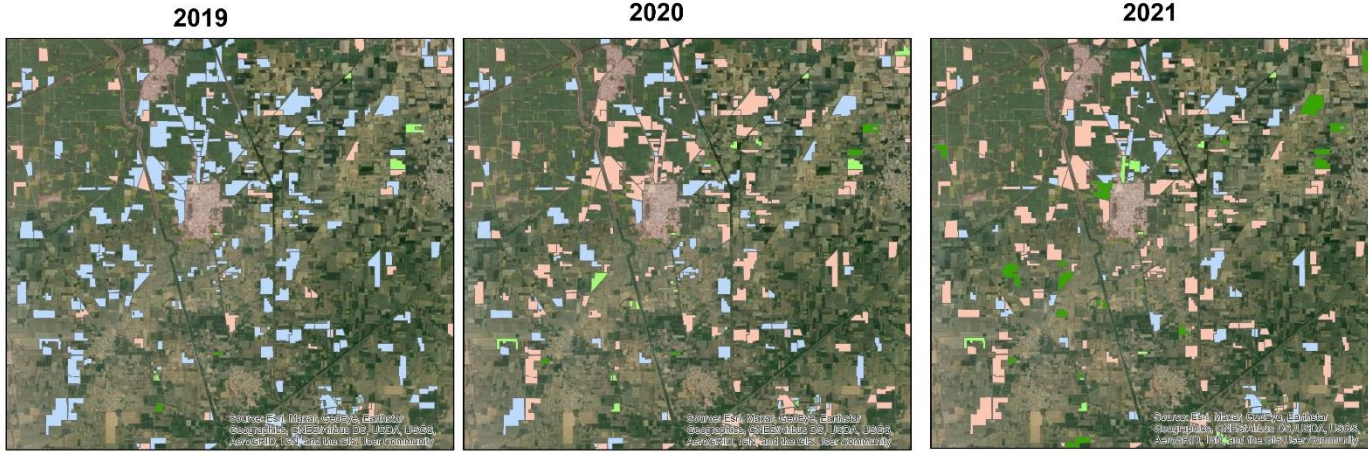
Monitoring Reporting & Verification



Zero Tillage Mapper Software



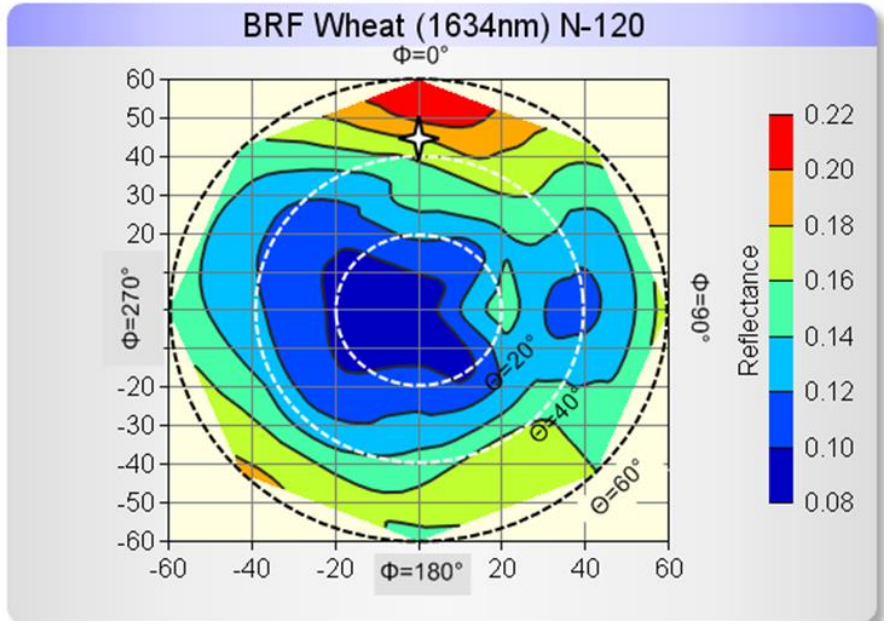


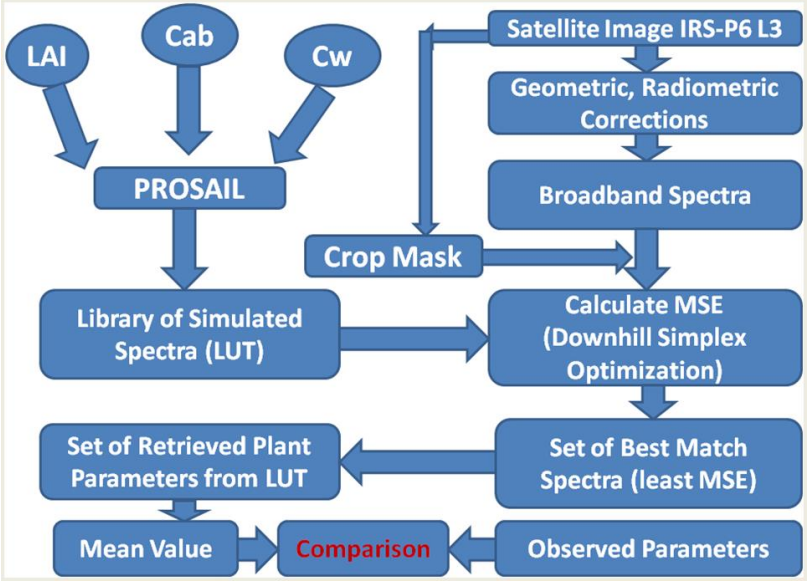


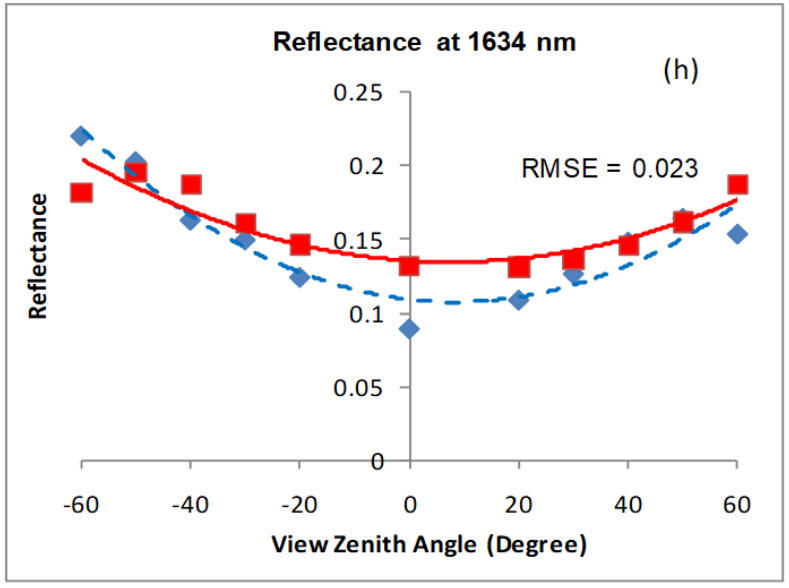
Time-series adoption of zero-tillage in wheat for 63000 farmers fields were monitored over years 2018 - 2023.

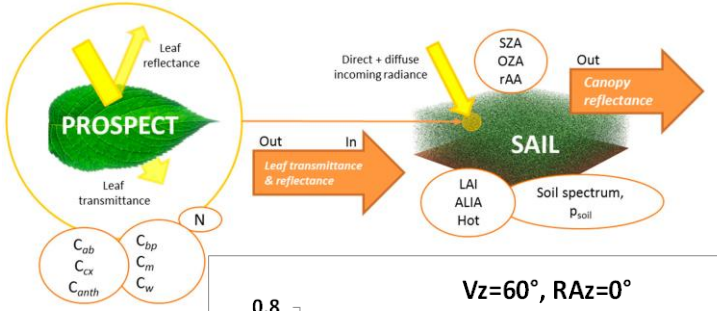
Fazilka Fields

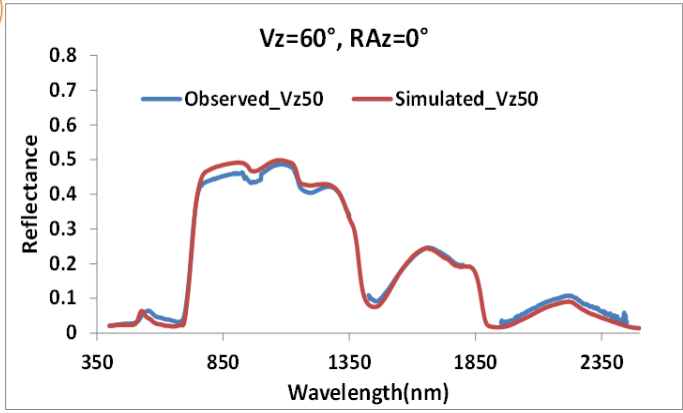
Retrieval of Crop Biophysical Parameters from Remote Sensing



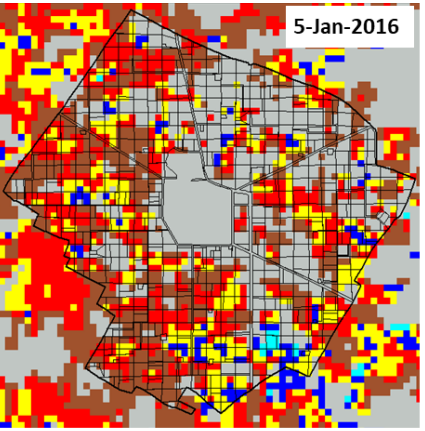


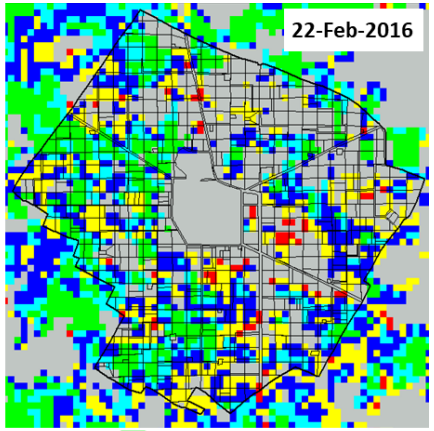






Retrieval of Crop Biophysical Parameters from Remote Sensing



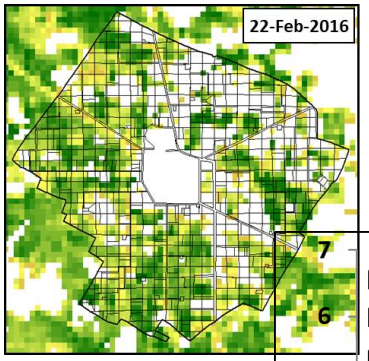


LAI

Non Wheat | 1 - 2 | 3 - 4 | 5 - 6

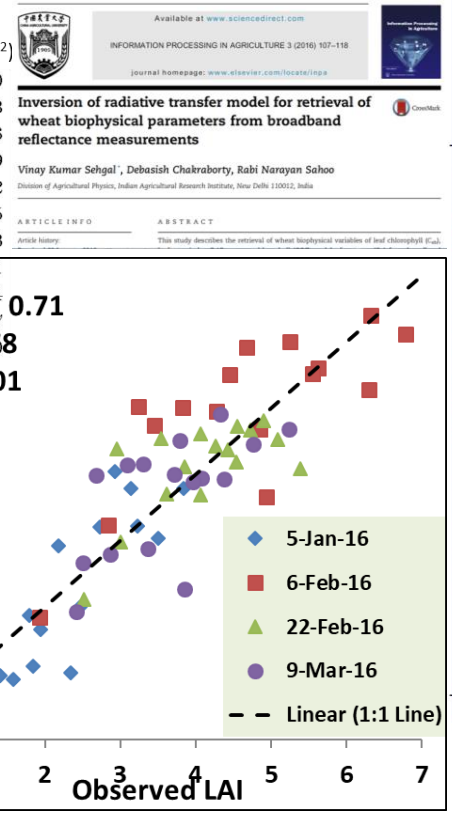
0 - 1 | 2 - 3 | 4 - 5 | 6 - 7

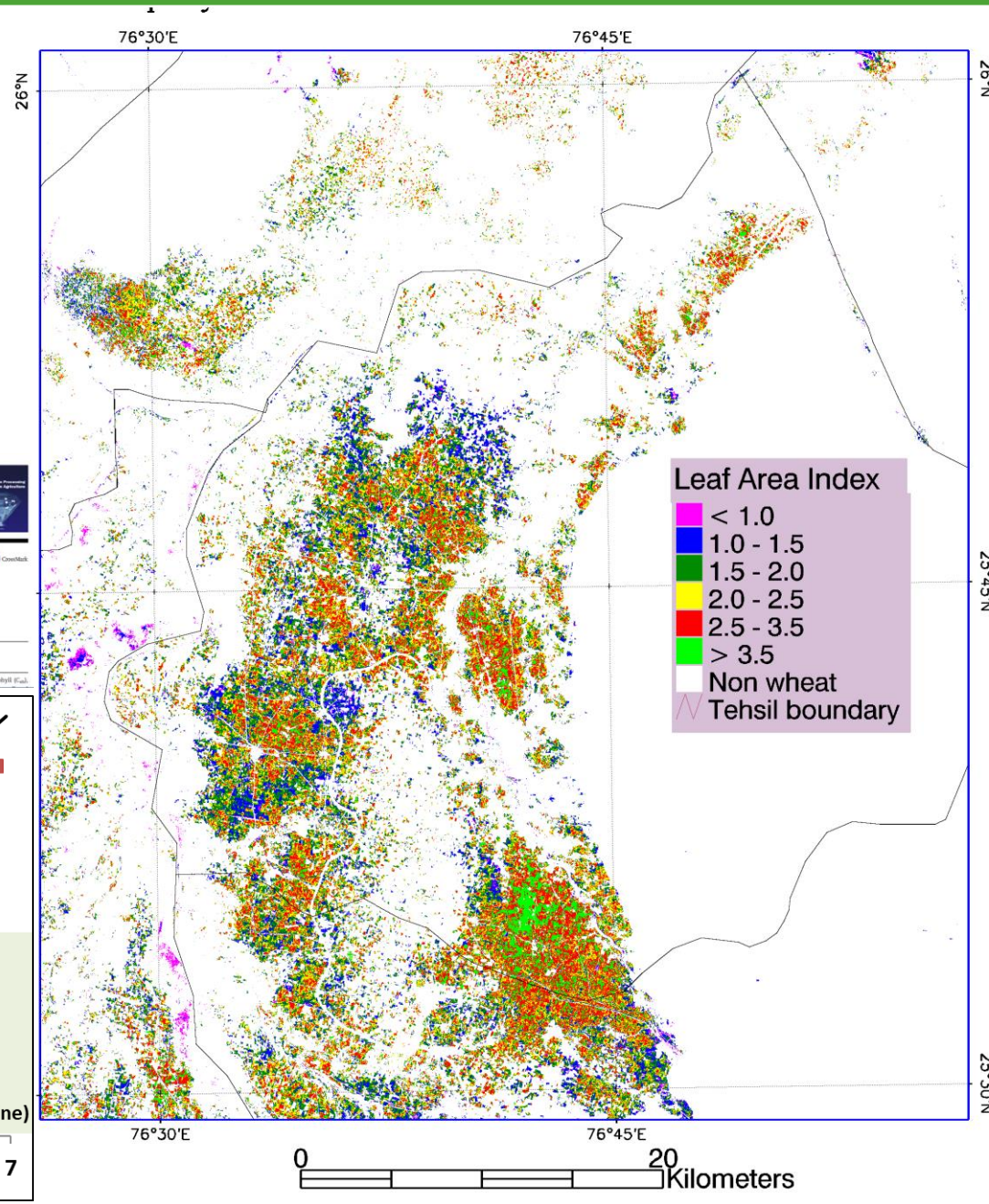
Chlorophyll (a+b) Content

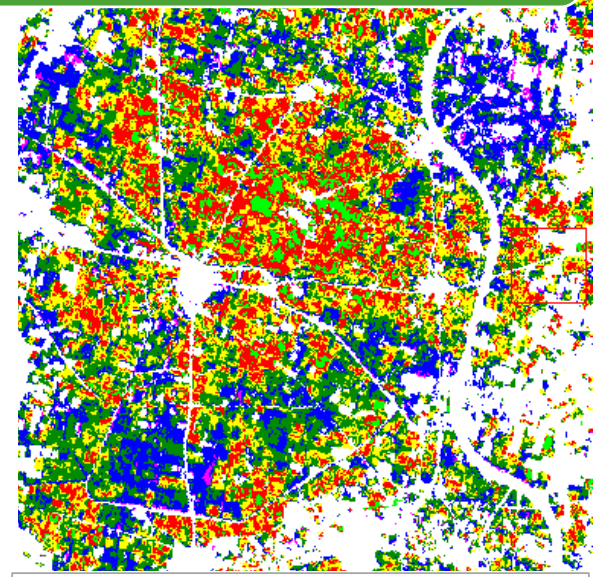


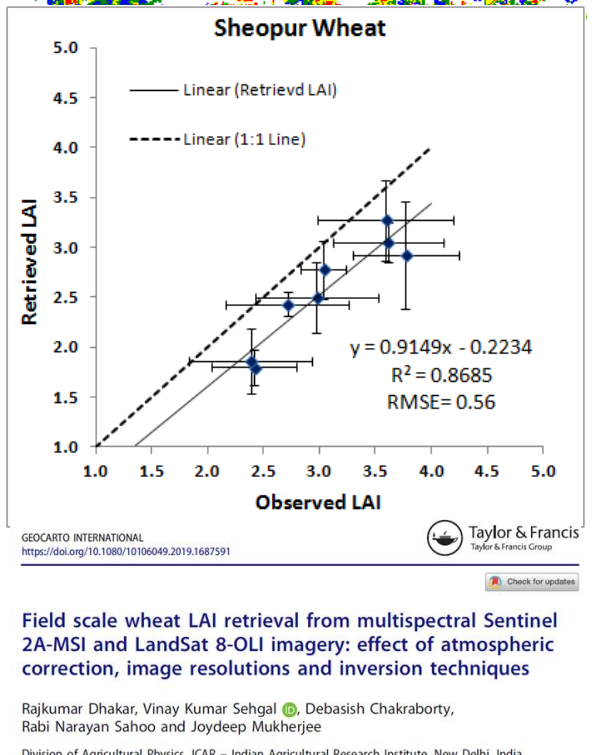
(µg.cm^{-2})

20 23 26 29 32 35 38 41 44 47 50









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Inversion of radiative transfer model for retrieval of wheat biophysical parameters from broadband reflectance measurements

Vinay Kumar Sehgal*, Debasish Chakraborty, Rabi Narayan Sahoo

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GEOCARTO INTERNATIONAL

https://doi.org/10.1080/10106049.2019.1687591

Taylor & Francis

Field scale wheat LAI retrieval from multispectral Sentinel 2A-MSI and LandSat 8-OLI imagery: effect of atmospheric correction, image resolutions and inversion techniques

Rajkumar Dhakar, Vinay Kumar Sehgal, Debasish Chakraborty, Rabi Narayan Sahoo and Joydeep Mukherjee

Assimilation of Crop Biophysical Parameters in Crop Simulation Model

The Discrete Kalman Filter

$$\mathbf{x}_k = \mathbf{A}_{k-1}\mathbf{x}_{k-1} + \mathbf{B}_{k-1}\mathbf{f}_{k-1} + \mathbf{w}_{k-1}$$

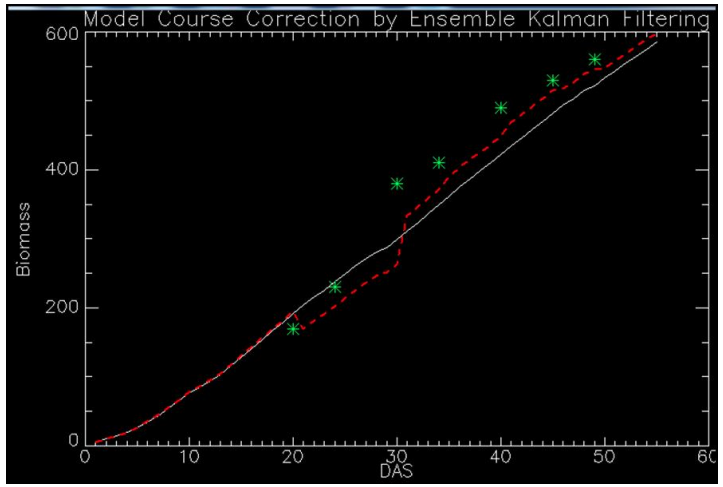
$$\mathbf{y}_k = \mathbf{H}_k\mathbf{x}_k + \mathbf{v}_k$$

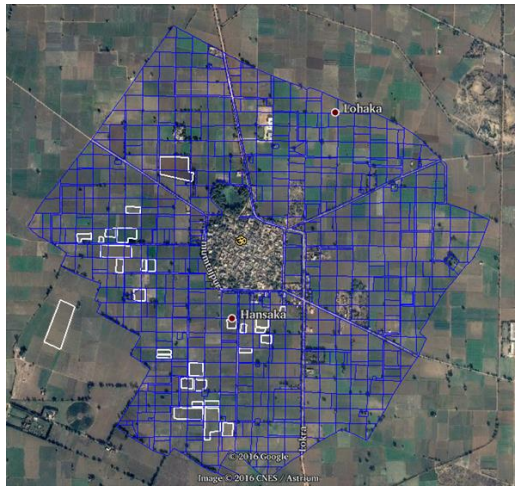
$$\hat{\mathbf{x}}_k^+ = \hat{\mathbf{x}}_k^- + \mathbf{K}_k\left(\mathbf{y}_k - \mathbf{H}_k\hat{\mathbf{x}}_k^-\right)$$

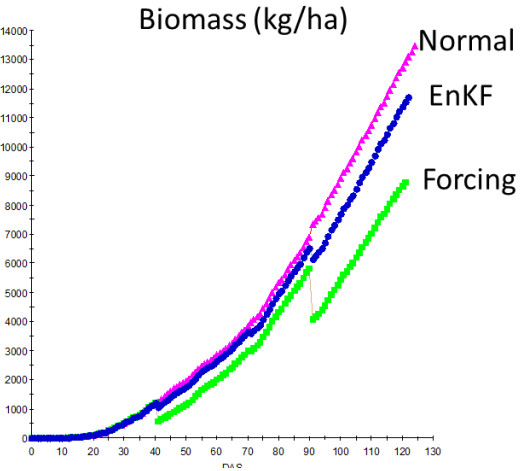
$$\mathbf{K}_k = \mathbf{P}_k^-\mathbf{H}_k^{\mathrm{T}}\left[\mathbf{H}_k\mathbf{P}_k^-\mathbf{H}_k^{\mathrm{T}} + \mathbf{R}_k\right]^{-1}$$

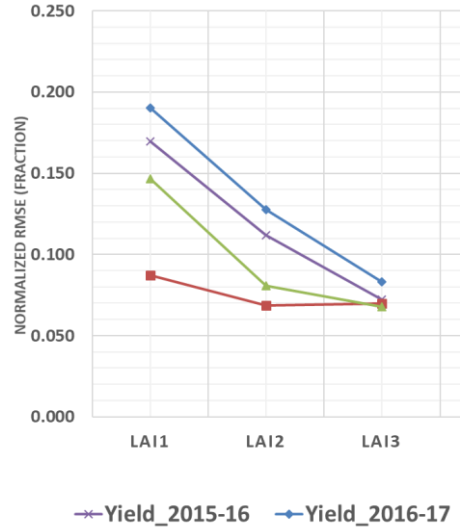
$\mathbf{R}_k$ is the observation error covariance, and $\mathbf{P}_k^-$ the background error covariance.

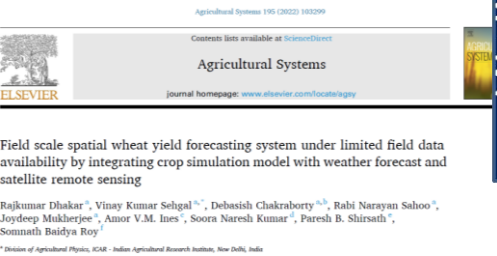
The Kalman Gain is thus a weighting factor between the observation error and the model error *mapped onto observation space*.





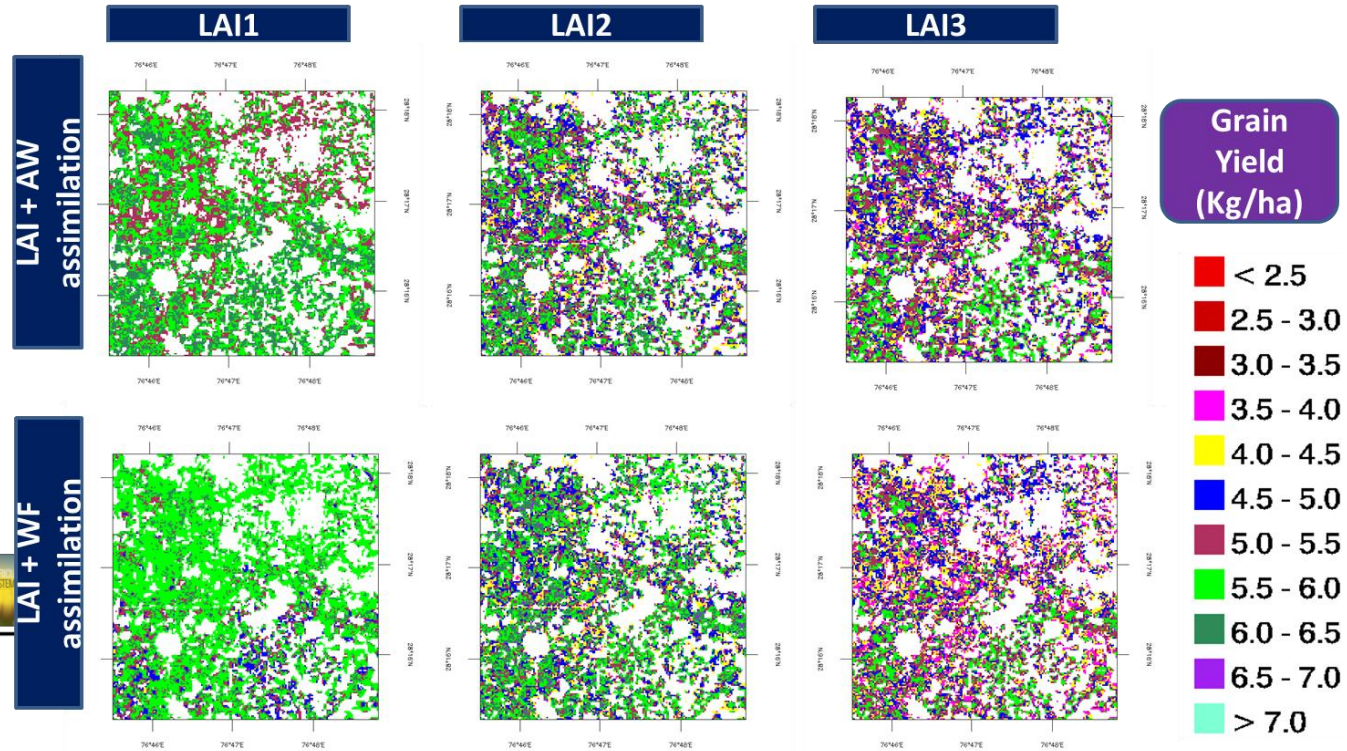


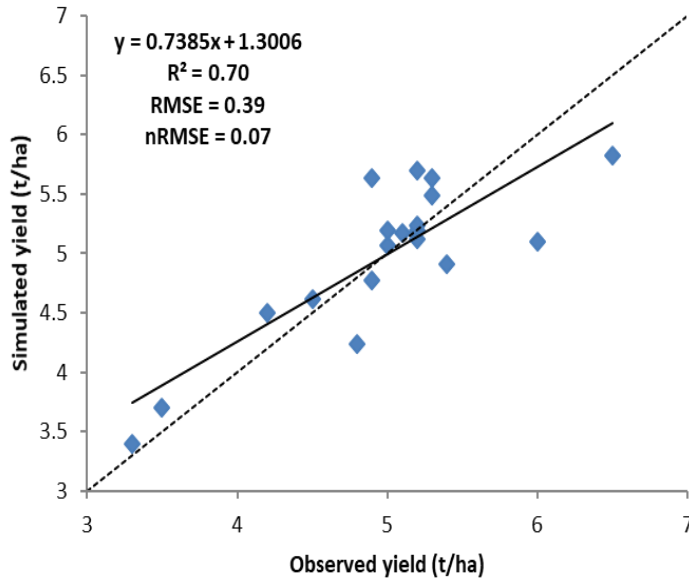




Field scale spatial wheat yield forecasting system under limited field data availability by integrating crop simulation model with weather forecast and satellite remote sensing

Rajkumar Dhakar, Vinay Kumar Sehgal, Debasish Chakraborty, Rabi Narayan Sahoo, Joydeep Mukherjee, Amor V.M. Ines, Soora Naresh Kumar, Paresh B. Shirsath, Somnath Baidya Roy



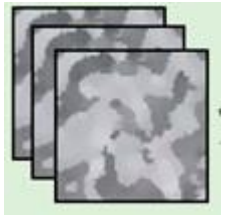


FASAL 2.0: Approach

Forecasting **A**gricultural Output using **S**pace, **A**grometeorology & **L**and Observations

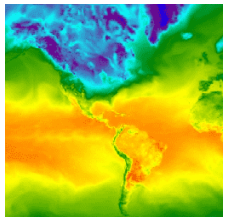
Input data

Satellite data



Sentinel-1/2 time series

Gridded weather data



CFSV2

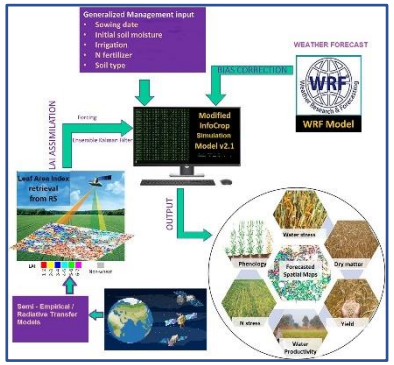
Initial condition

Planting date

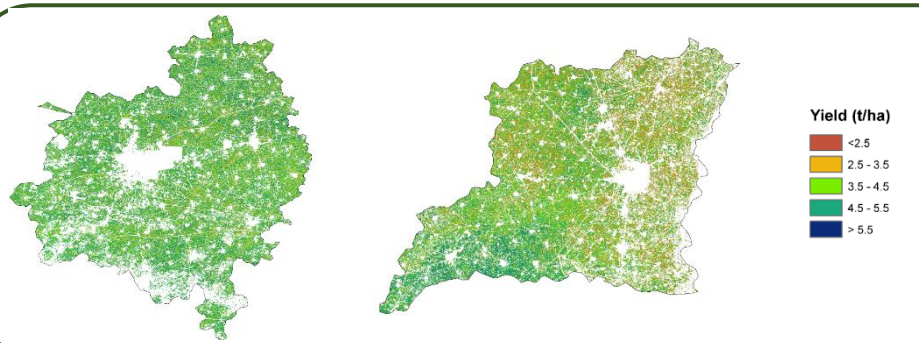
Median sowing date

Model processing

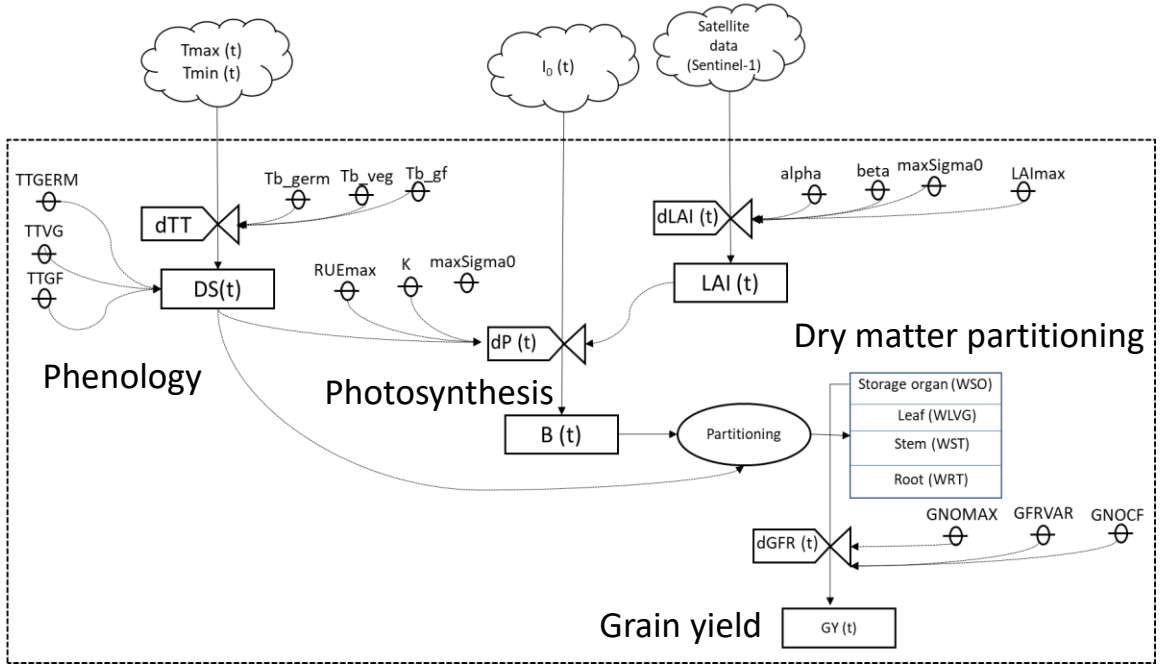
Geospatial Crop Model



Output



Relational Diagram of Geospatial Crop Model

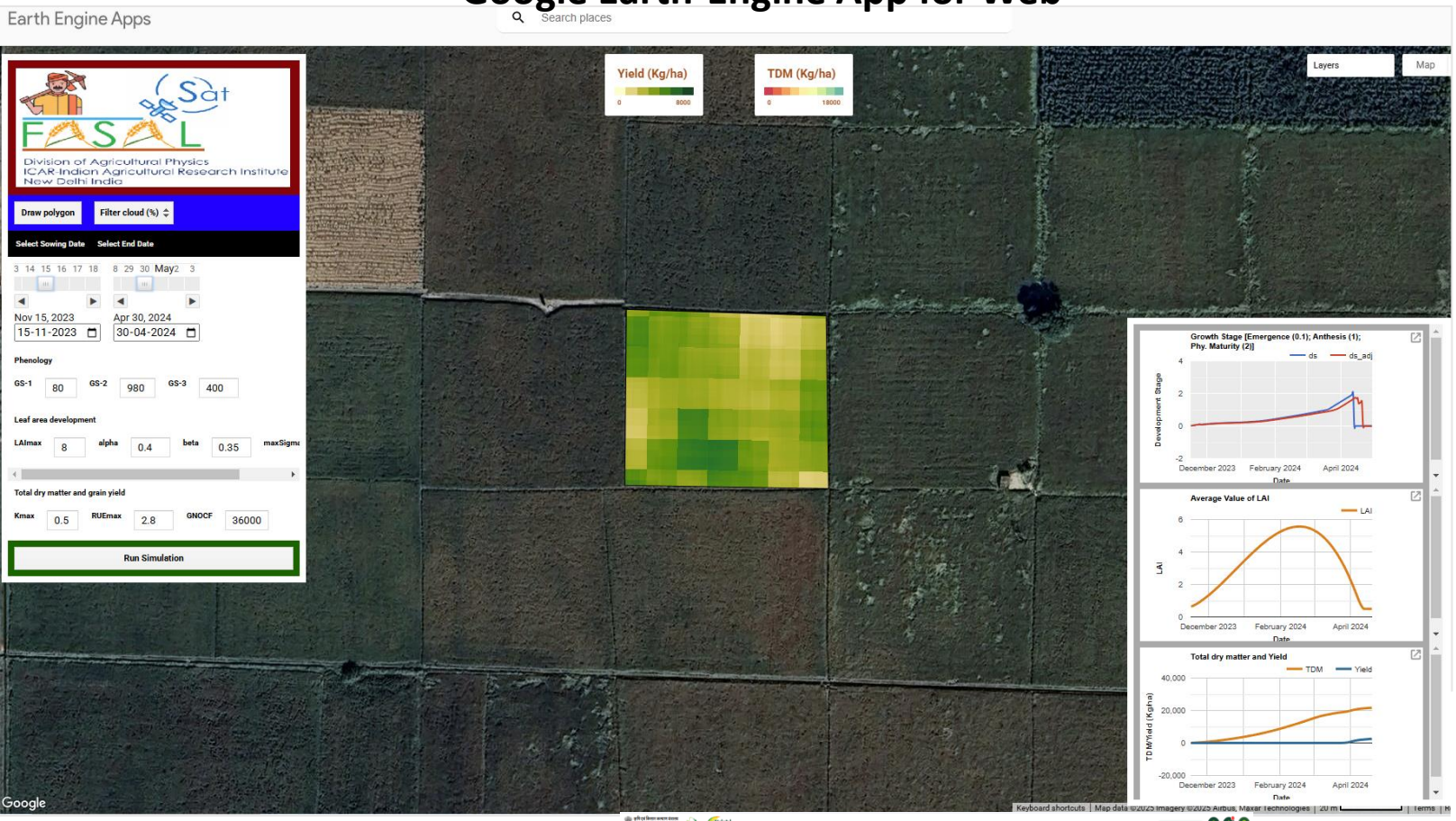


Name	Unit	Description
Explanatory variables		
Tmax (t)	°C	Daily maximum temperature on day t
Tmin (t)	°C	Daily minimum temperature on day t
I_0 (t)	MJ m^{-2} day^{-1}	Daily Solar radiation on day t
State variables		
DS (t)	0-2	Developmental stage on day t
LAI	dimensionless	Leaf Area Index on day t
B (t)	Kg/ha	Total dry matter on day t
WSO (t)	Kg/ha	Weight of storage organs on day t
WLVG (t)	Kg/ha	Weight of leaves on day t
WST (t)	Kg/ha	Weight of stems on day t
WRT (t)	Kg/ha	Weight of root on day t
GY (t)	Kg/ha	Grain yield on day t

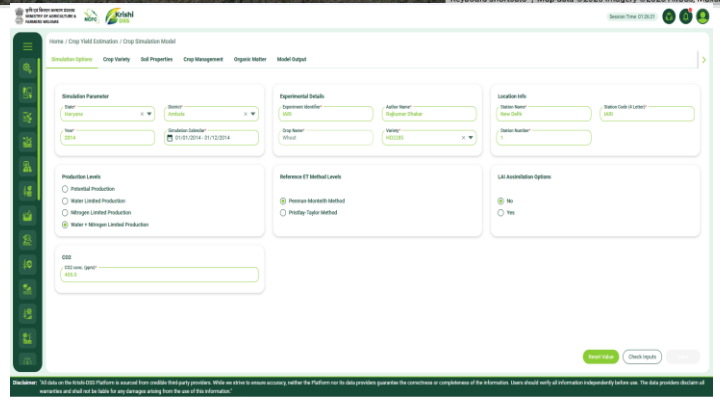
Name	Unit	Description
Model parameters		
Tb (germ, veg, gf)	°C	Base temperatures for germination, anthesis and grain development stage
TTGERM, TTVG, TTGF	°C days	Thermal time requirements for emergence, anthesis and physiological maturity stages
Alpha	dimensionless	Coefficient governing shape of logistic growth curve
Beta	dimensionless	Coefficient governing rate of logistic growth
maxSigma0	dB	Maximum backscatter
LAImax	dimensionless	
Kmax	dimensionless	Light extinction coefficient at flowering
RUEmax	g/MJ	Maximum radiation use efficiency
GFRVAR	dimensionless	Grain filling rate of a variety
GNOMAX	dimensionless	Maximum grain number
GNOCF	Storage organ/Kg/day	Slope of storage organ number/m2 to dry matter during storage organ formation

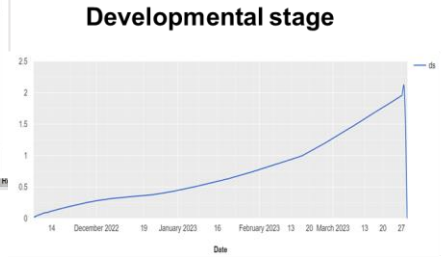
Web-based and Desktop Software Modules

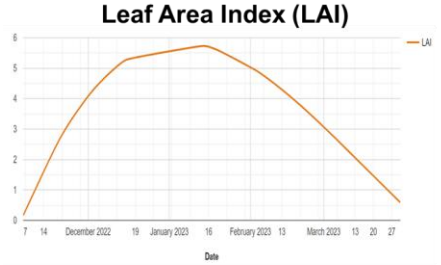
Google Earth-Engine App for Web

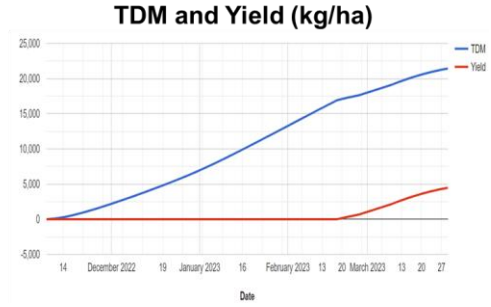


SAMARTH (Satellite-data Assimilation in Model for Agricultural resource Translation to Harvest) v1.0









Google Earth Engine

Search places and datasets...

ee-rajdhakar

SatFASAL

Division of Agricultural Physics
ICAR-Indian Agricultural Research Institute
New Delhi India

Draw polygon | Filter cloud (%)

Select Sowing Date | Select End Date

Jul 10, 2025 | Oct 3, 2025

10-07-2025 | 03-10-2025

Phenology

GS-1: 50 | GS-2: 1200 | GS-3: 500

Leaf area development

LAImax: 8 | alpha: 0.4 | beta: 0.35 | maxSigma

Fitting functions: Linear

Total dry matter and grain yield

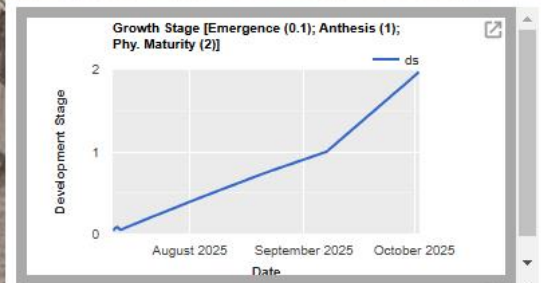
Kmax: 0.5 | RUEmax: 2.8 | GNOCF: 56000

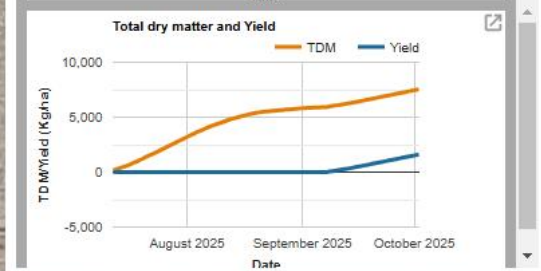
Run Simulation

Yield (Kg/ha) 0 8000

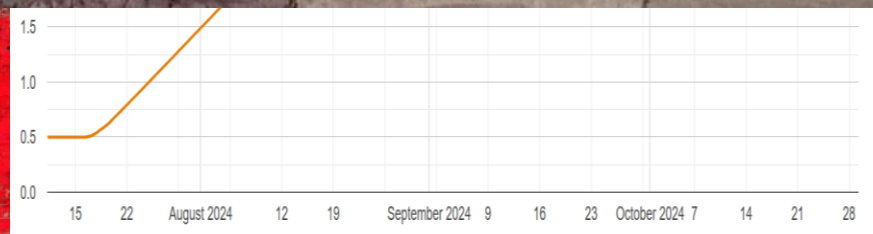
TDM (Kg/ha) 0 18000

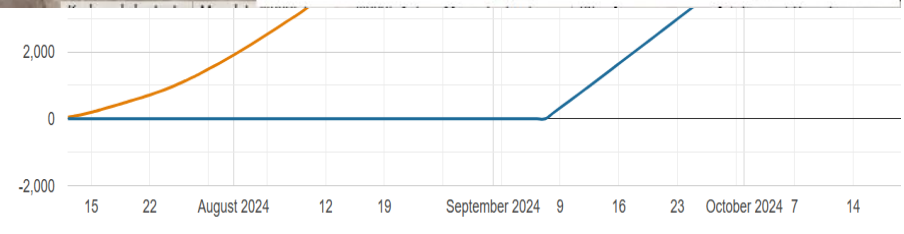
Layers | Map | Satellite



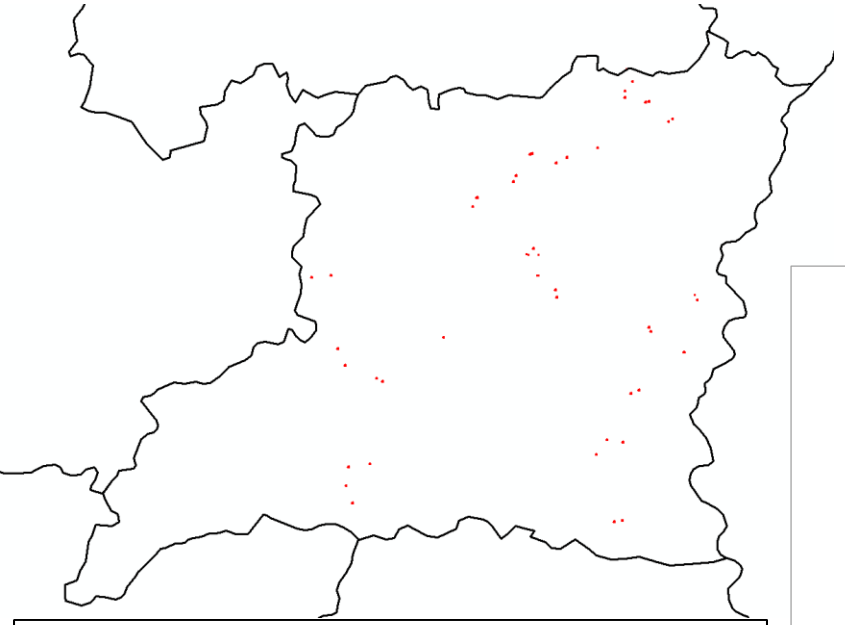


Google

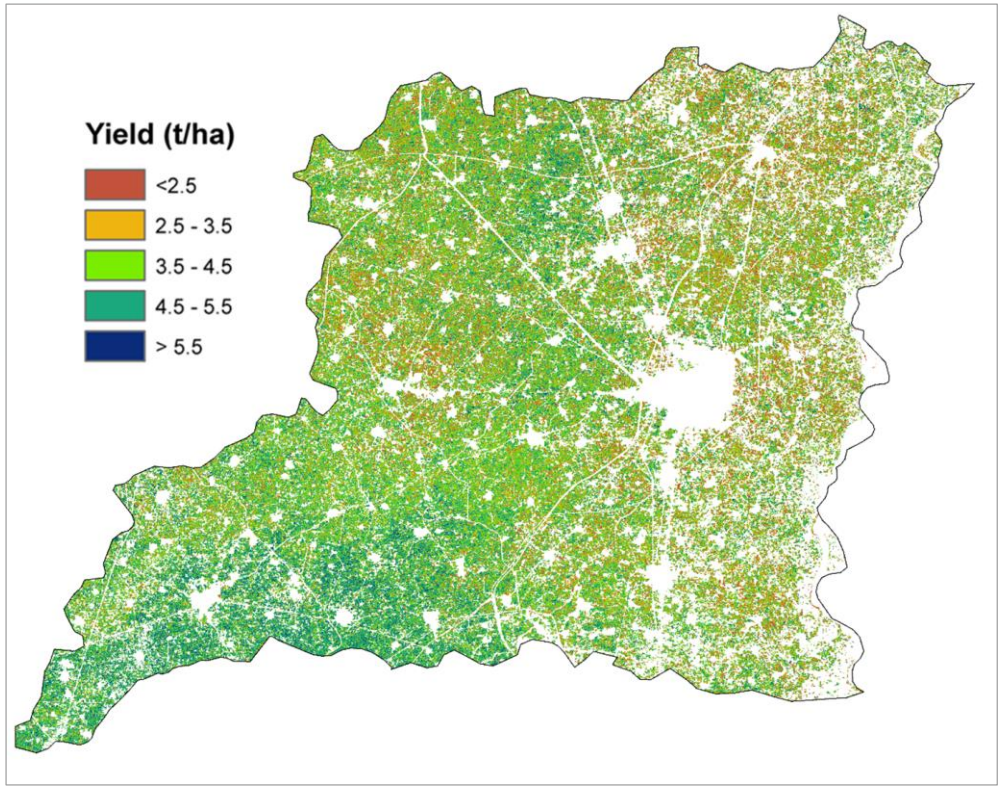


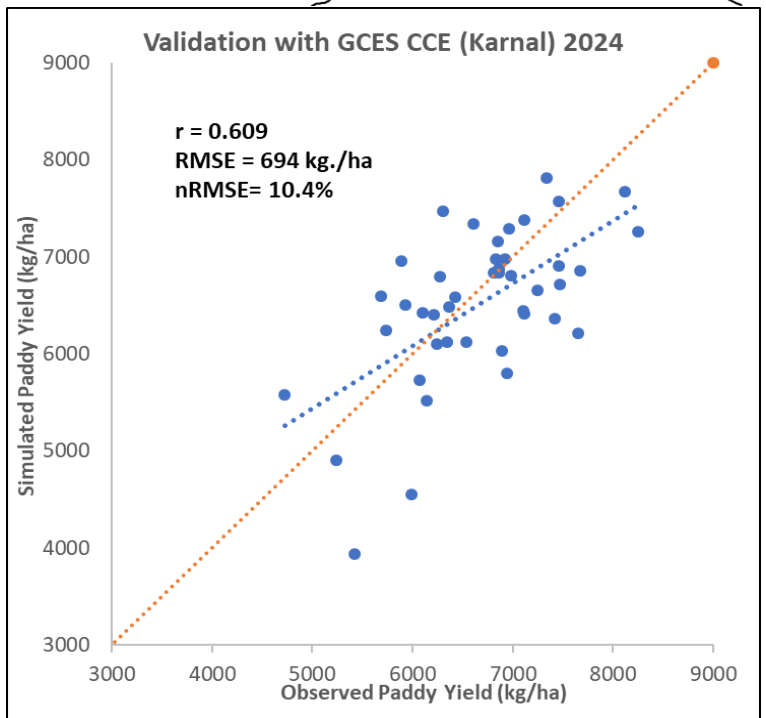


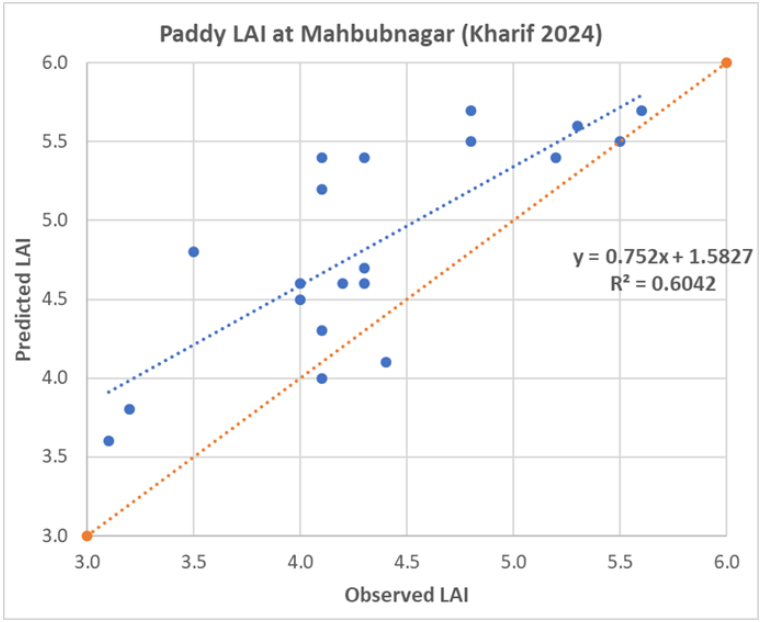
Spatial Modelling and Validation of Rice Yield (2024-25)

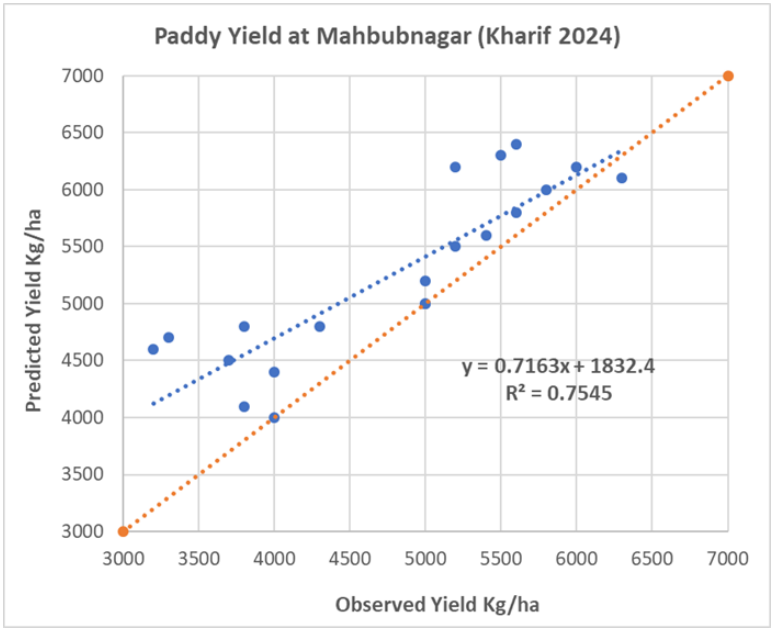


Rice Yield Map of Karnal (2024-25)

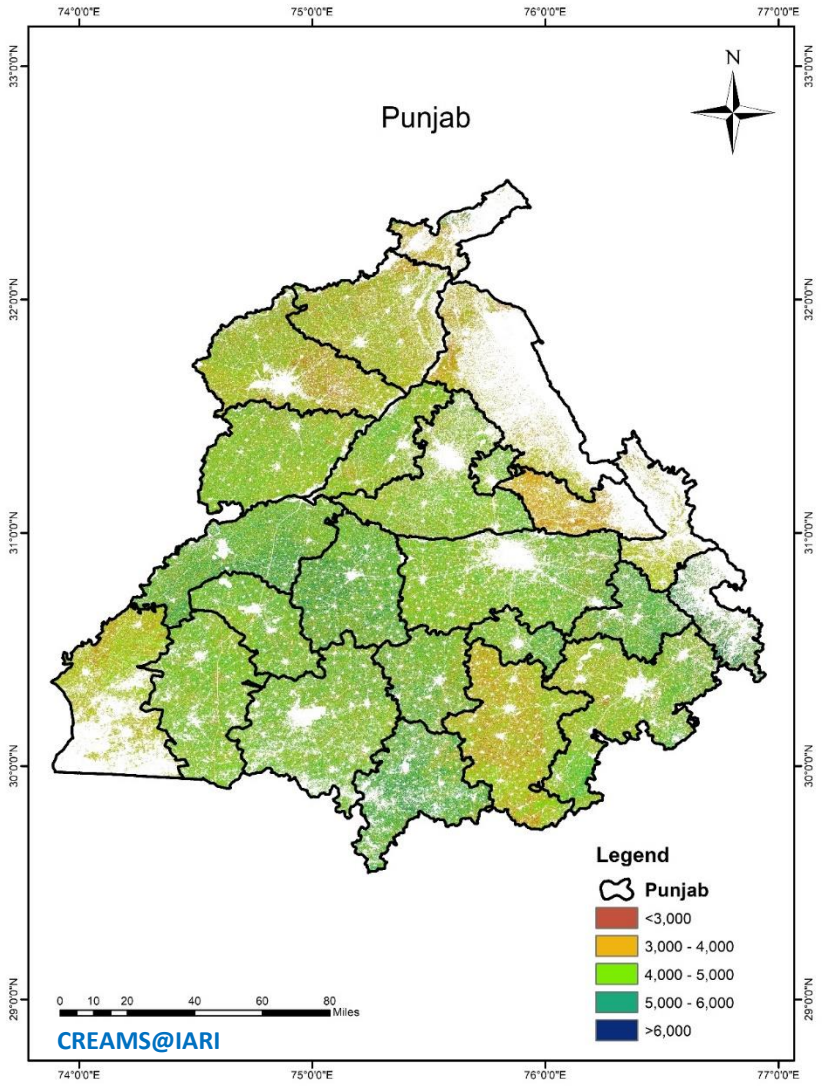


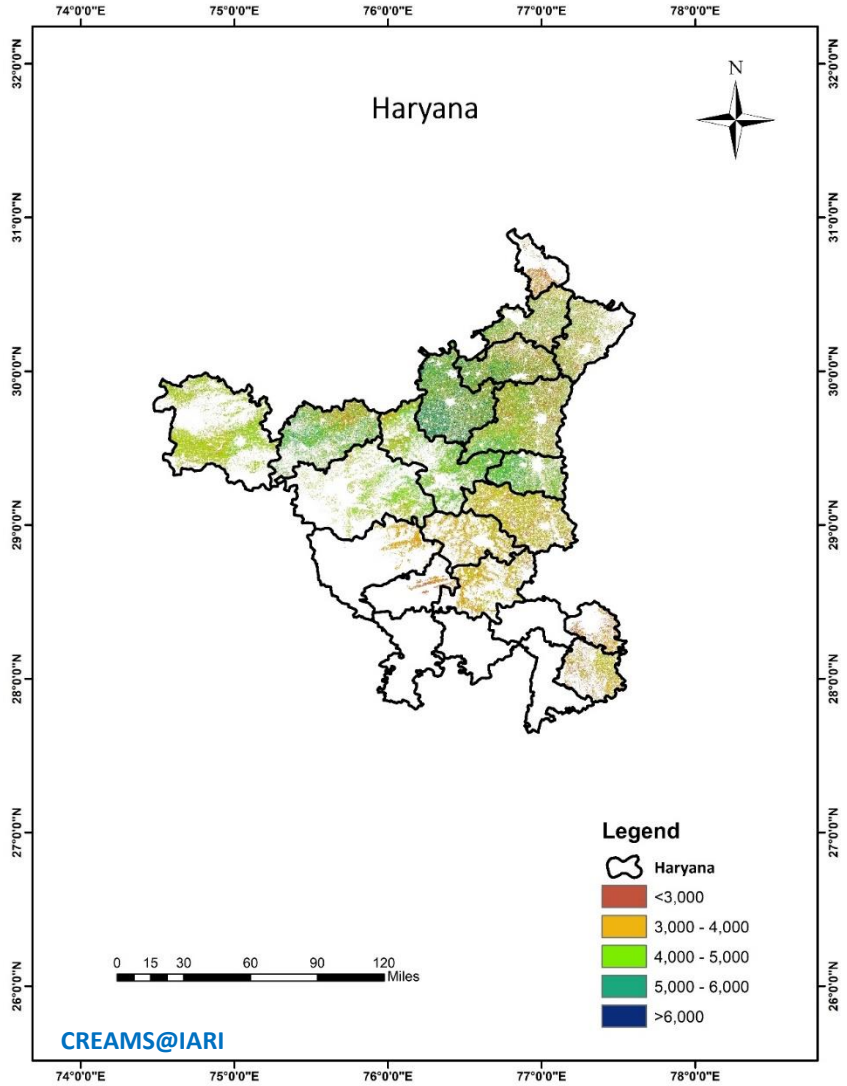


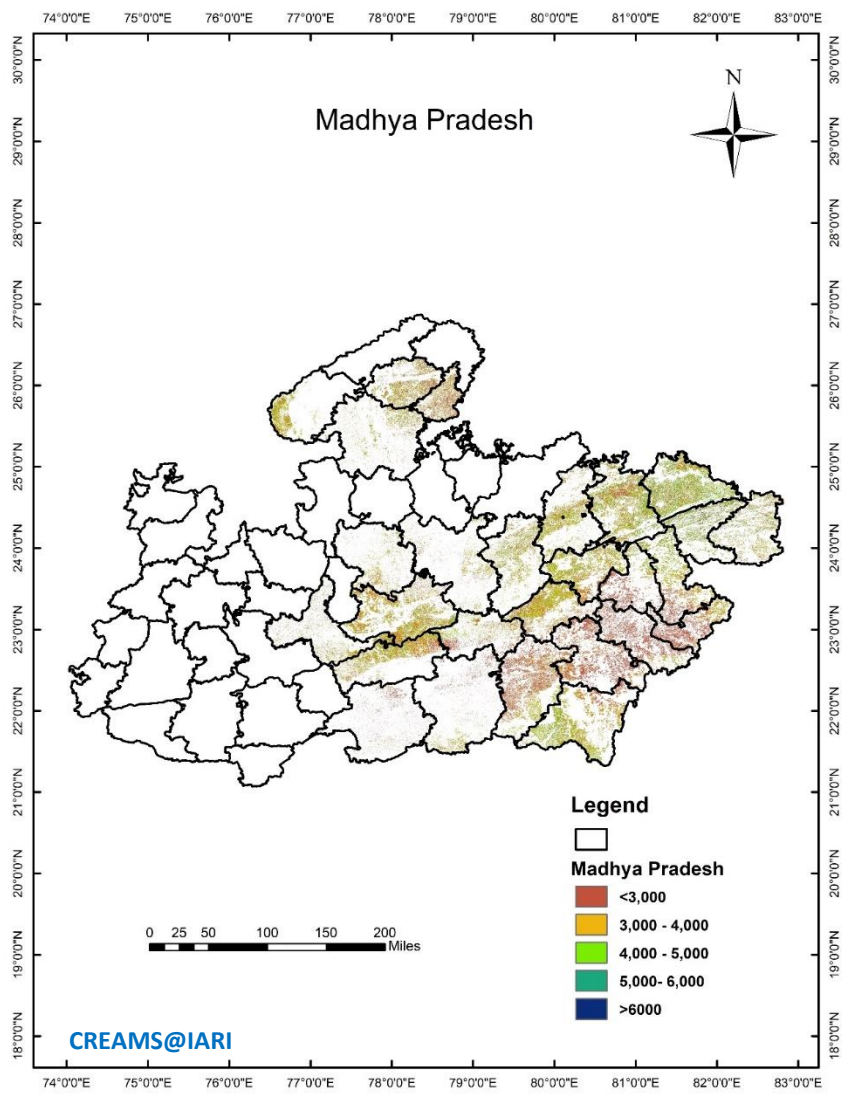




FASAL 2.0: Maps of Rice Yield (2024-25)



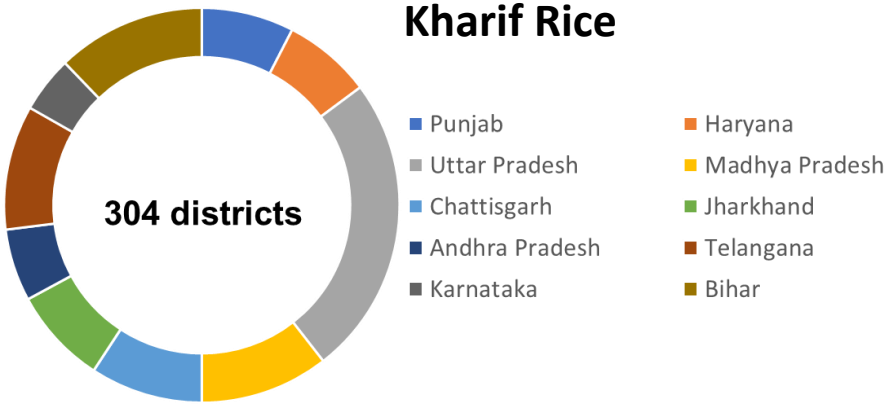


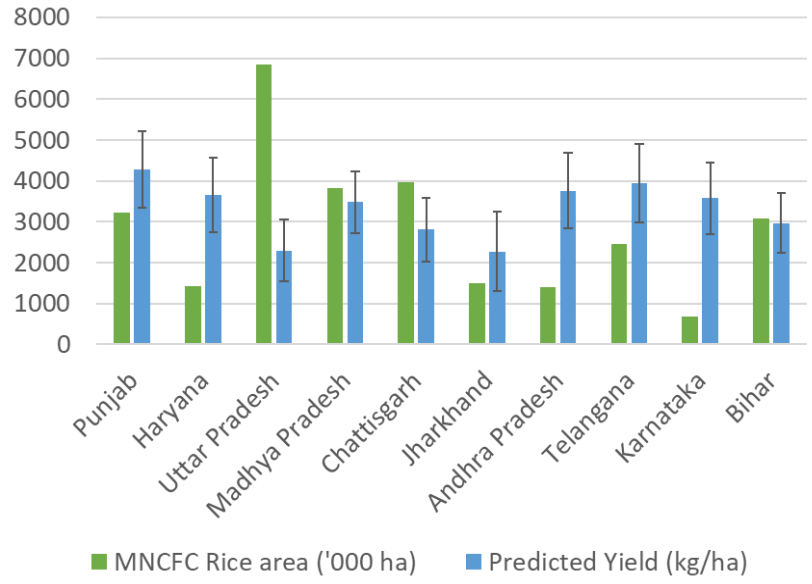


CREAMS@IARI

FASAL 2.0: Yield Forecast of Rice, Mustard and Wheat (2024-25)

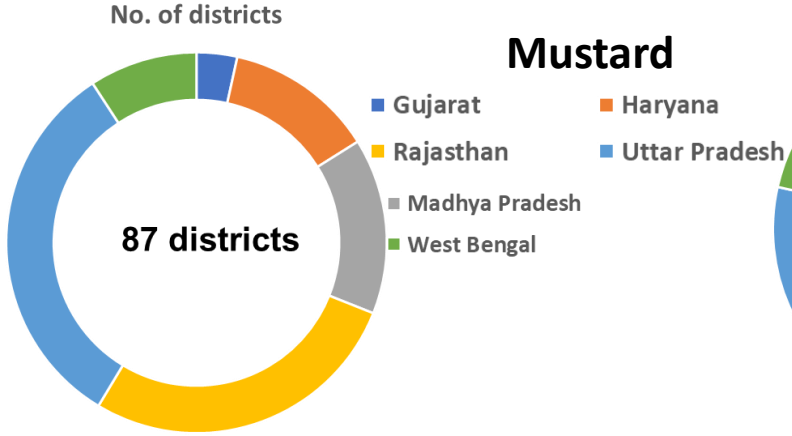
Kharif Rice

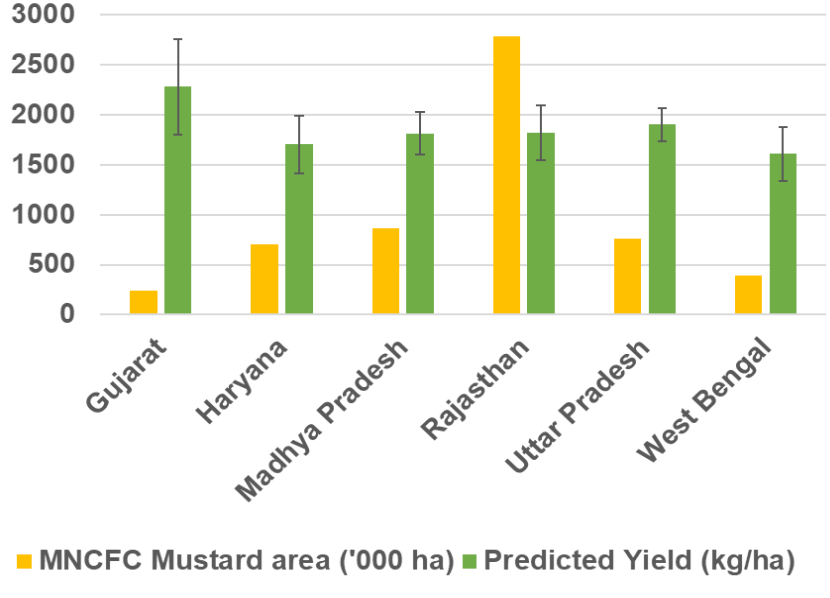




Avg. yield	% CV	Total area
3134 kg/ha	22.73	28341 ('000 ha)

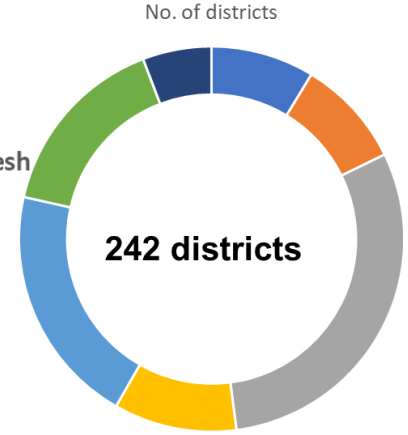
Mustard

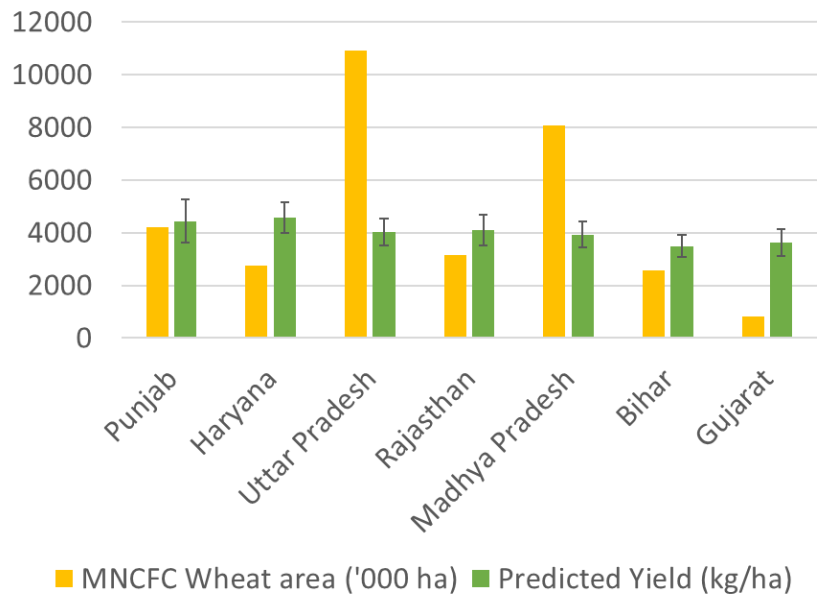




Avg. yield	% CV	Total area
1821 kg/ha	16.12	5755 ('000 ha)

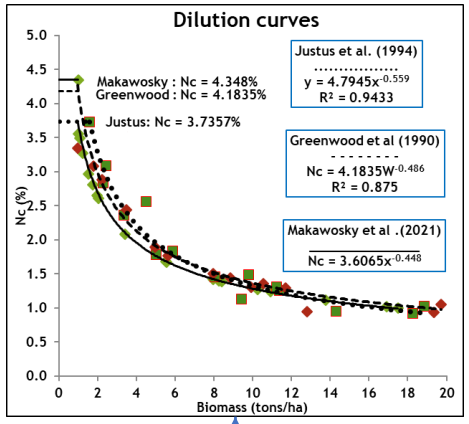
Wheat





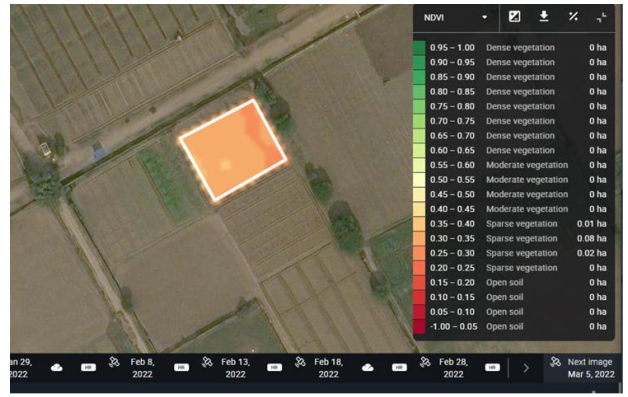
Avg. yield	% CV	Total area
4065 kg/ha	11.55	31678 ('000 ha)

Scalable Site Specific Nitrogen Fertilizer Application in Wheat



Physical RT models

Satellite RS observations



Leaf Area Index

Canopy Chlorophyll

Actual Plant N Conc.

Critical N Conc.

Biomass

Process based model InfoCrop

Data assimilation

Field & management data
Genotype/Soil
Irrigation/Fertilizer
Weather

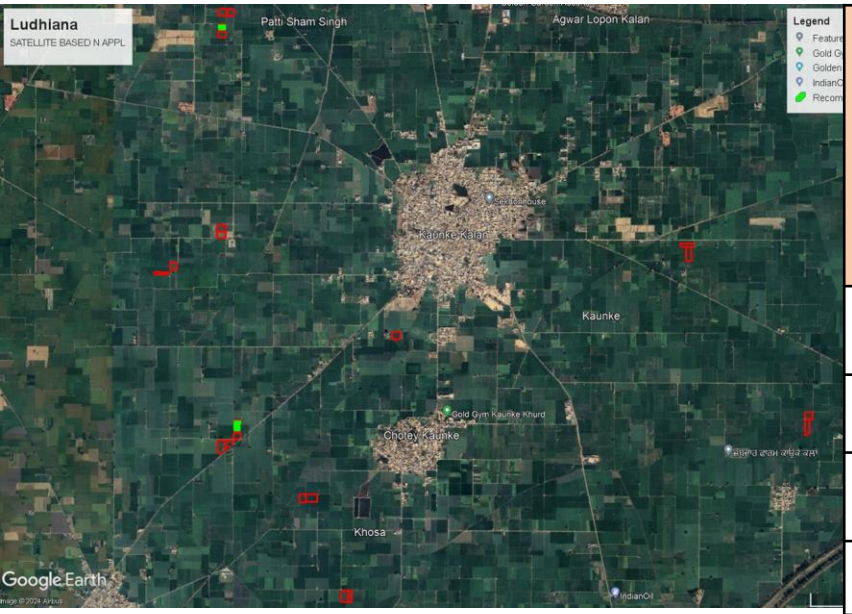
Predict

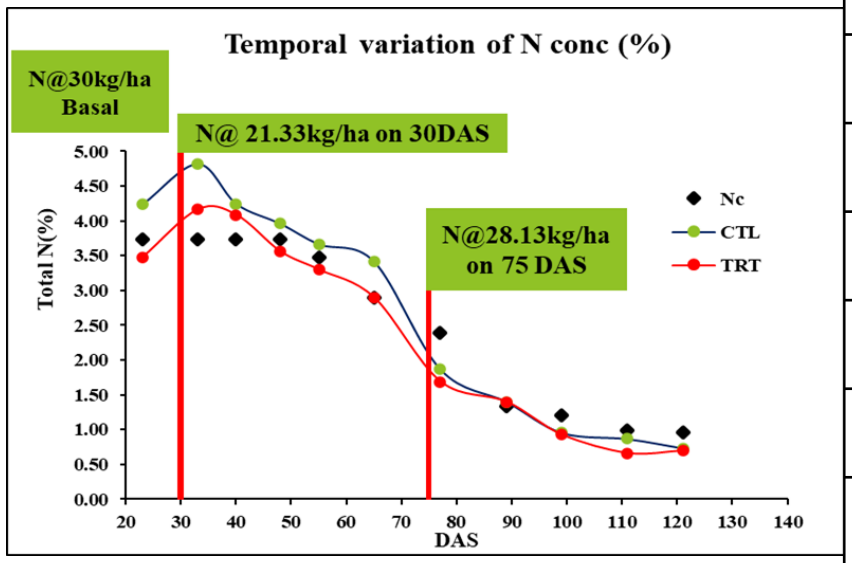
N deficit

In-season N requirement

Treatment	Fertiliser Applied (kg/ha)	Yield (t/ha)	N2O (kg/ha)	CO2 (kg/ha)	GWP (Kg CO2 eq/ha)
Recommended dose of fertiliser	120 (60 : 30 : 30)	6.27	1.32	2557	2950
Satellite based N application	95.7 (60: 17.7 : 18)	6.66	1.15	2201	2545

Scalable Site Specific Nitrogen Fertilizer Application in Wheat





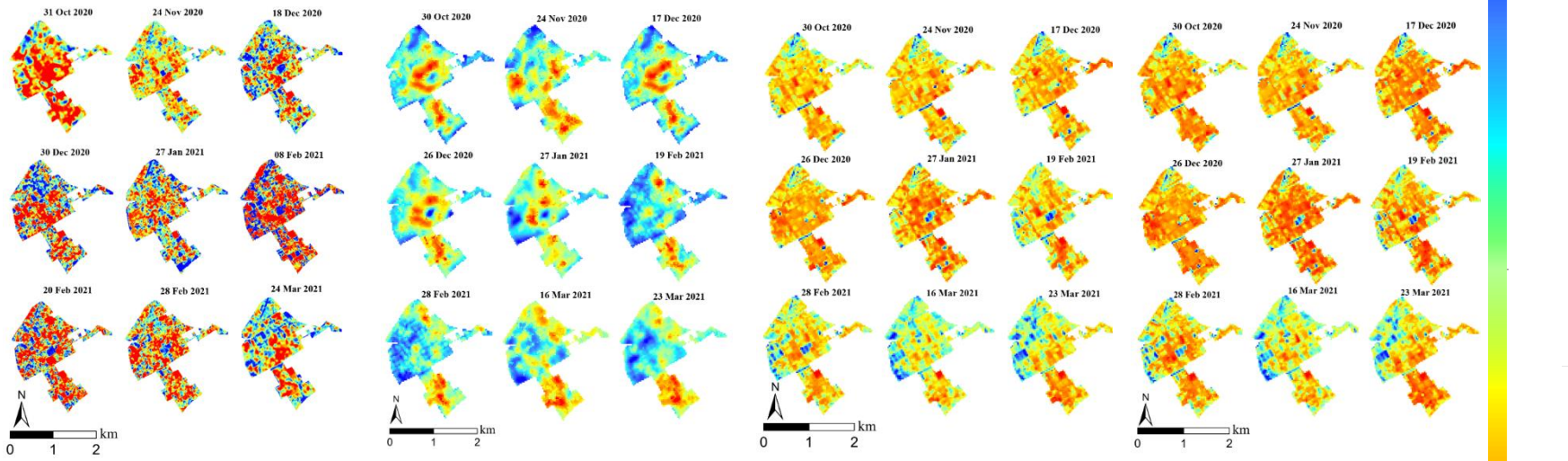
IARI ID	Farmers Name	Basal N dose (kg/ha)	1st Top dressing	2nd Top dressing	Total N applied (Kg/ha)	Farmer Reported Yield (Tons/ha)	Sampling-Yield (Tons/ha)	NUE (Partial factor productivity) (kg yield/ Kg N applied)	Approach used
			Dose (kg/ha) & Time (DAS)	Dose (kg/ha) & Time (DAS)					
43	Dilpreet singh	29.25	51.75 (34 DAS)	51.75 (48DAS)	132.75	ND	ND		Farmers' practice
41	**Sukhchain singh**	**27.00**	**51.75 (35DAS)***	**13.74 (75DAS)**	**92.49**	**5.50**	**5.50**	**59.5**	**Rs+CSM**
44	Sandeep singh	33.75	51.75 (36DAS)	51.75 (47DAS)	137.25	5.50	5.75	**40.1**	Farmers' practice
45	**Binder singh**	**33.75**	**23.39 (49DAS)**	**25.19 (75DAS)**	**82.33**	**5.75**	**6.50**	**69.8**	**Rs+CSM**
10	Mandeep Singh	33.75	51.75 (35DAS)	23 (56DAS)	108.5	5.75	5.00	**53.0**	Farmers' practice
11	Sukhchain singh	33.75	51.75 (38DAS)	34.5 (58DAS)	120	6.00	6.25	**50.0**	Farmers' practice
19	Kirpal singh	22.50	51.75 (35DAS)	40.9 (57 DAS)	115.15	ND	ND	-	Farmers' practice
12	Simran singh	33.75	51.75 (31DAS)	ND	-	ND	ND		Farmers' practice
13	Gurjepal singh	29.25	51.75 (25DAS)	51.75 (43 DAS)	132.75	ND	ND		Farmers' practice
14	Diljit singh	27.00	51.75 (21 DAS)	51.75 (40DAS)	130.5	ND	ND		Farmers' practice
15	Gurpreet singh	31.95	42.55 (34DAS)	51.75 (59DAS)	126.25	ND	ND		Farmers' practice
16	Bhupinder Singh	27.00	51.75 (27DAS)	51.75 (42 DAS)	130.5	ND	ND		Farmers' practice

Spatio-Temporal Estimation of Surface and Root-Zone Soil Moisture

MW-Optical Synergy

Optical-Thermal Synergy

Optical-SWIR Synergy

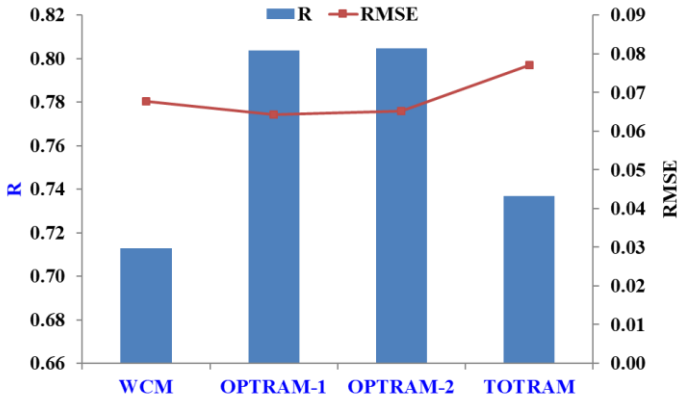


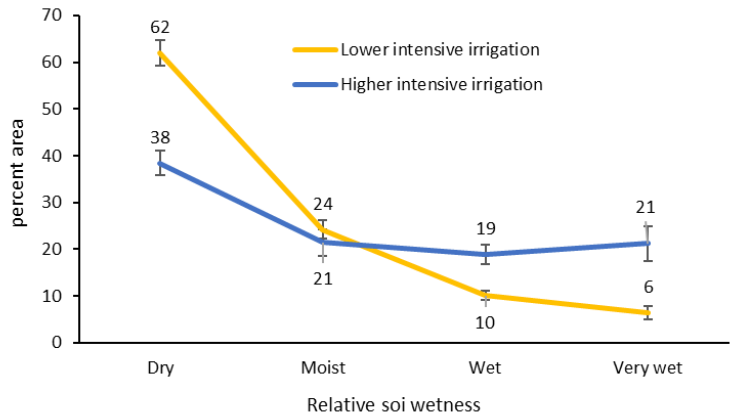
WCM (TRIS 1)
R : 0.65-0.78
RMSE : 0.05-0.09
$m^3\ m^{-3}$

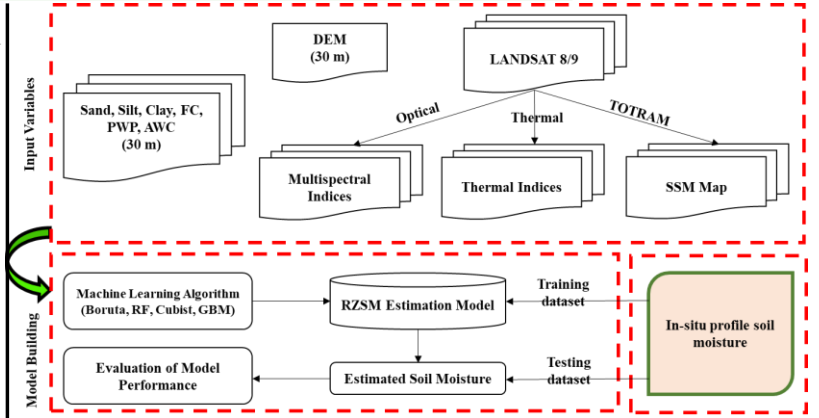
TOTRAM (TRIS 1)
R : 0.69-0.81
RMSE : 0.05-0.15
$m^3\ m^{-3}$

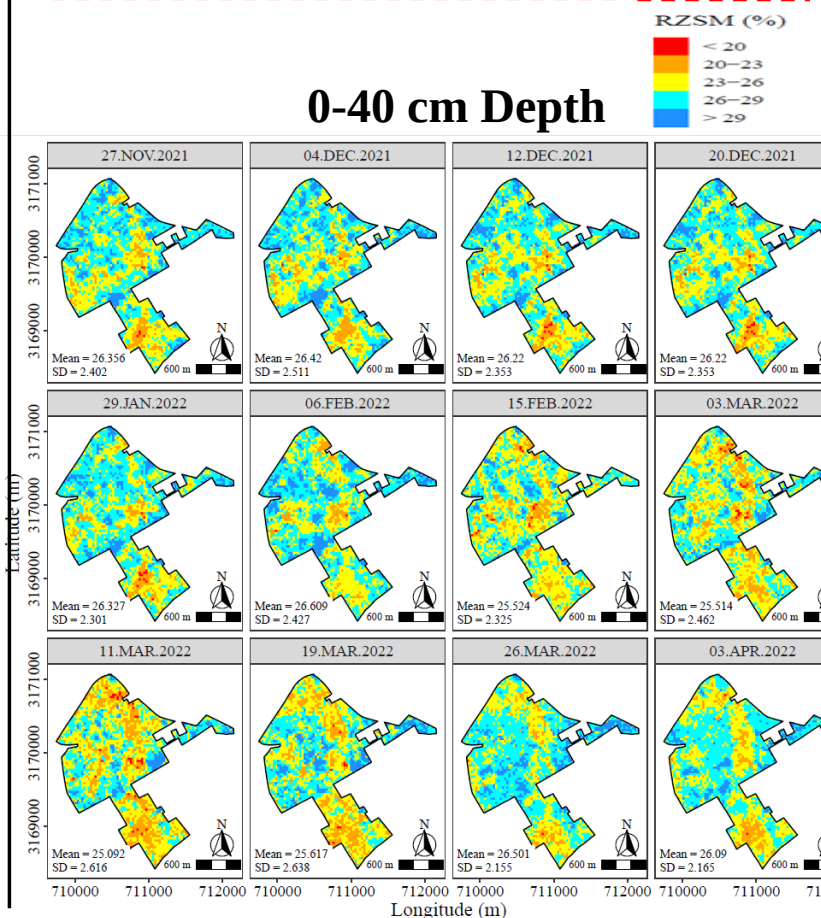
OPTRAM (SWIR 1)
R : 0.78-0.88
RMSE : 0.04-0.09
$m^3\ m^{-3}$

OPTRAM (SWIR 2)
R : 0.73-0.88
RMSE : 0.05-0.08
$m^3\ m^{-3}$

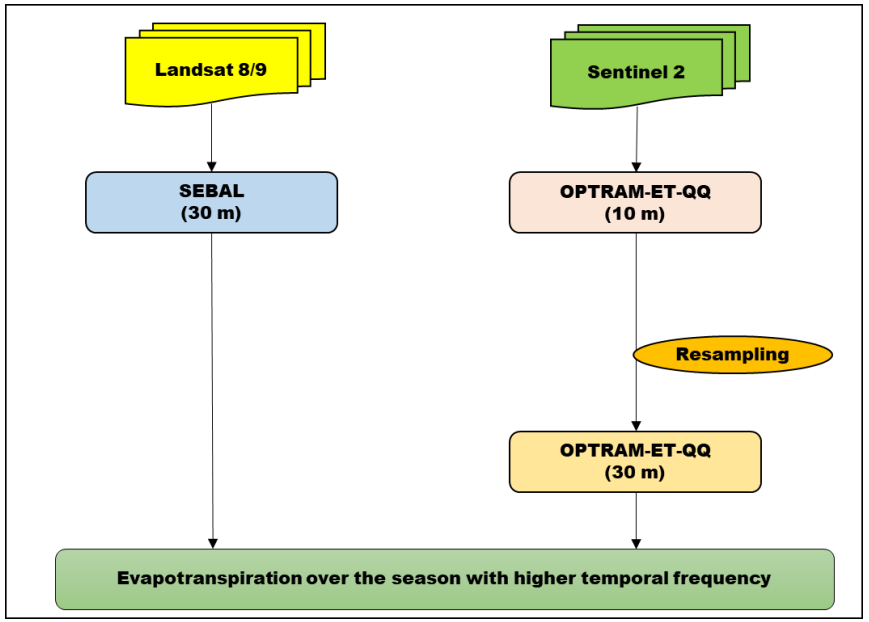




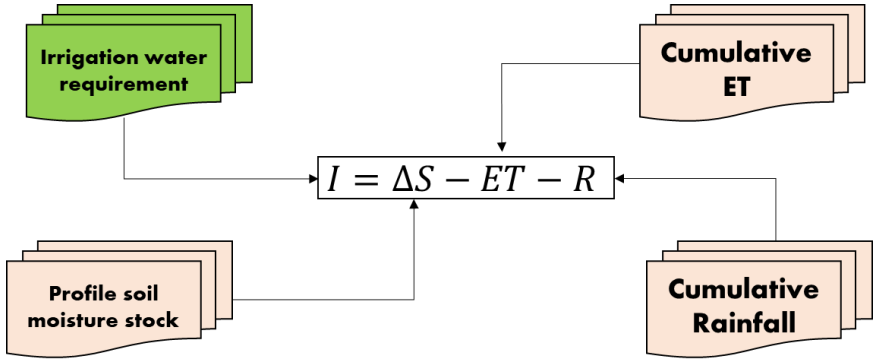


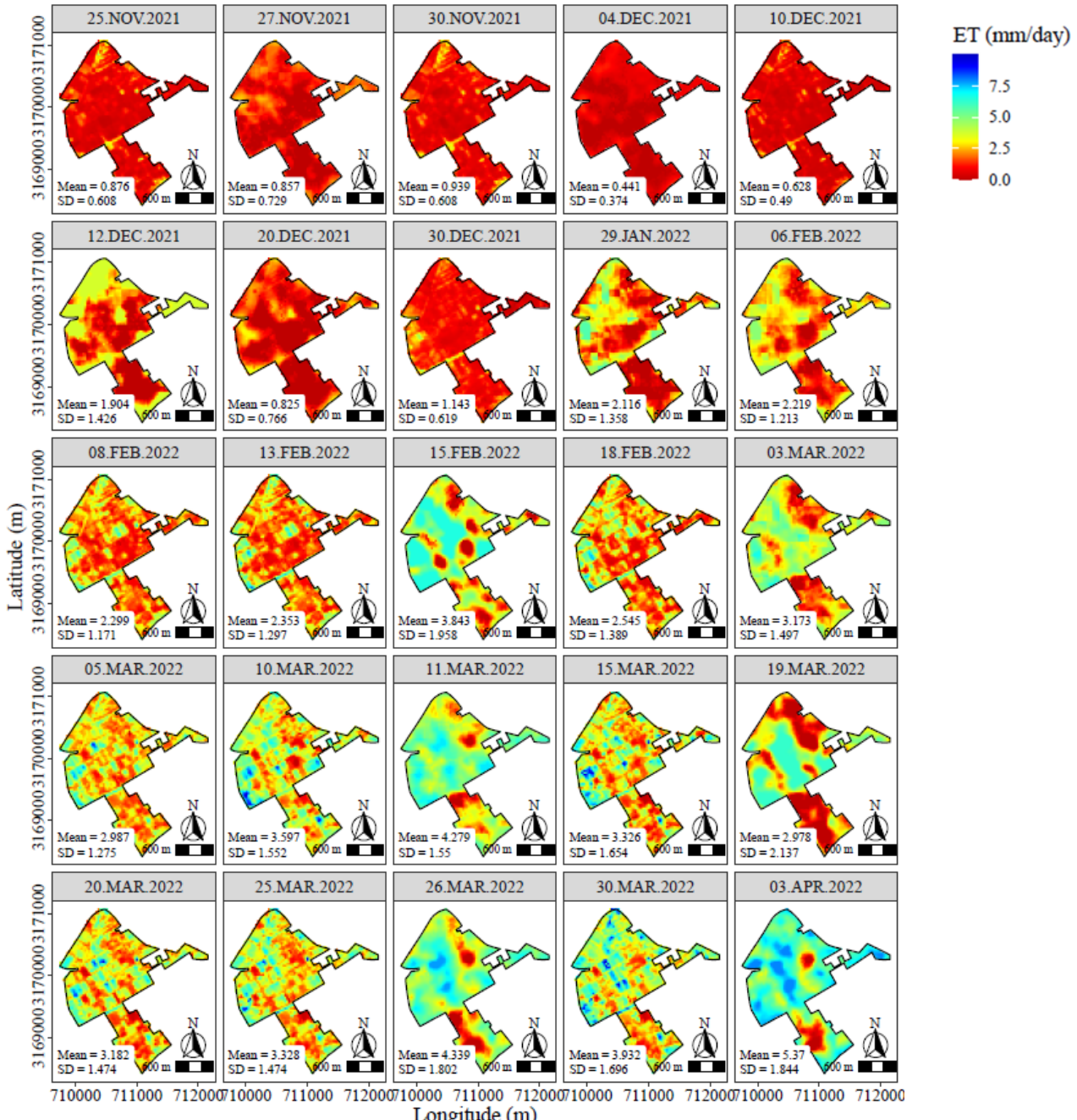


Spatio-Temporal Estimation of Crop Evapotranspiration

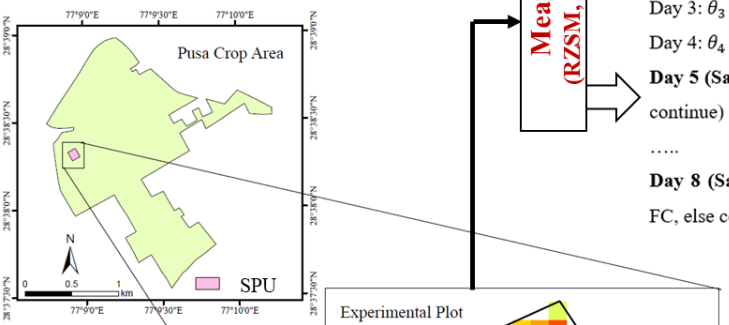


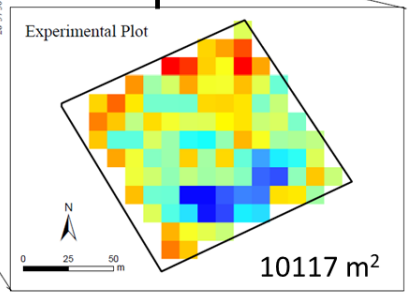
Field Water Balance Model





Irrigation Scheduling at Field Scale





Mean (RZSM, ET)

Day 1 (Satellite Overpass): $\theta_1 = RZSM_{sat} - ET_{sat}$ (if $\theta_1 < FC_{Critical}$, then irrigate up to FC, else continue)

[Day 2: $\theta_2 = \theta_1 - mET_0$ (if $\theta_2 < FC_{Critical}$, then irrigate up to FC, else continue)

Day 3: $\theta_3 = \theta_2 - mET_0$ (if $\theta_3 < FC_{Critical}$, then irrigate up to FC, else continue)

Day 4: $\theta_4 = \theta_3 - mET_0$ (if $\theta_4 < FC_{Critical}$, then irrigate up to FC, else continue)]

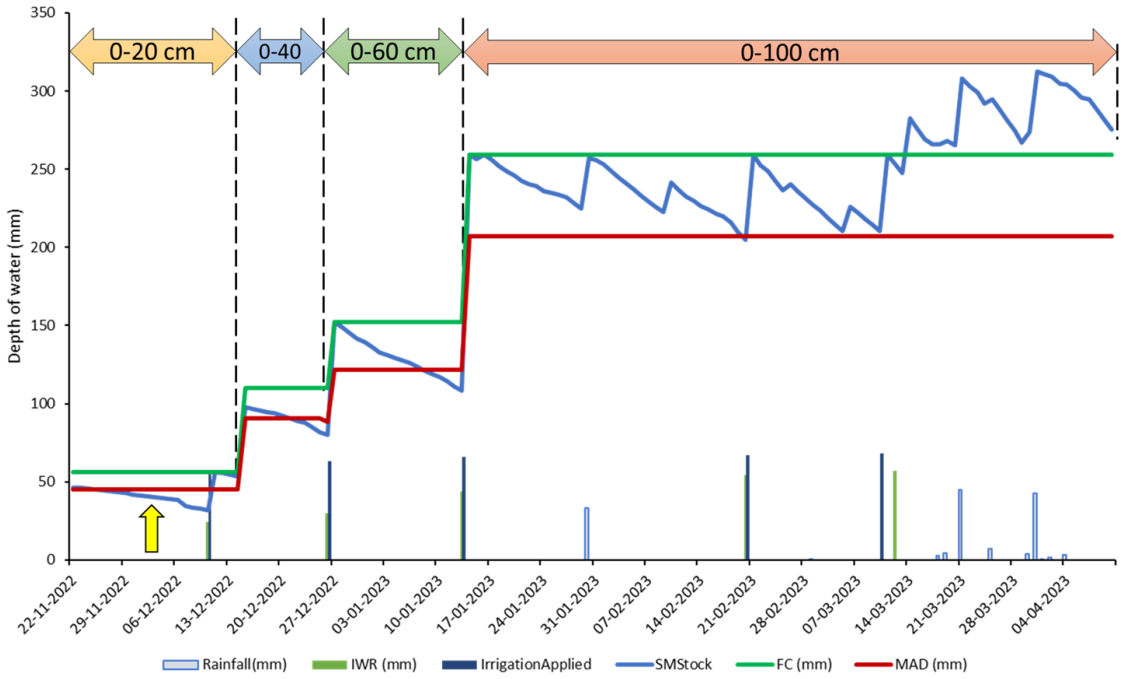
Day 5 (Satellite Overpass): $\theta_5 = \theta_4 - ET_{sat}$ (if $\theta_5 < FC_{Critical}$, then irrigate up to FC, else continue)

.....

Day 8 (Satellite Overpass): $\theta_8 = RZSM_{sat} - ET_{sat}$ (if $\theta_8 < FC_{Critical}$, then irrigate up to FC, else continue)

$ET_{sat}/ET_0 = m$

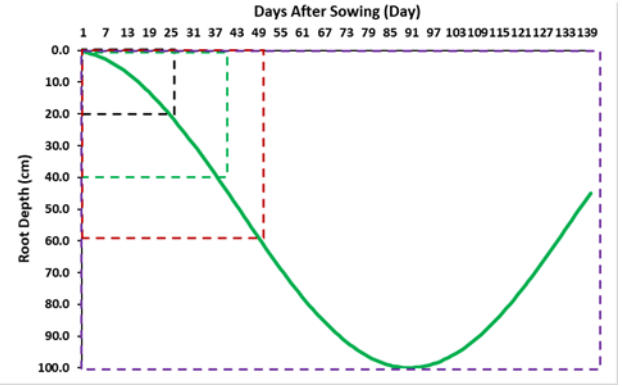
$$FC_{critical} = 20\% \; of \; FC$$



Root Growth Simulation

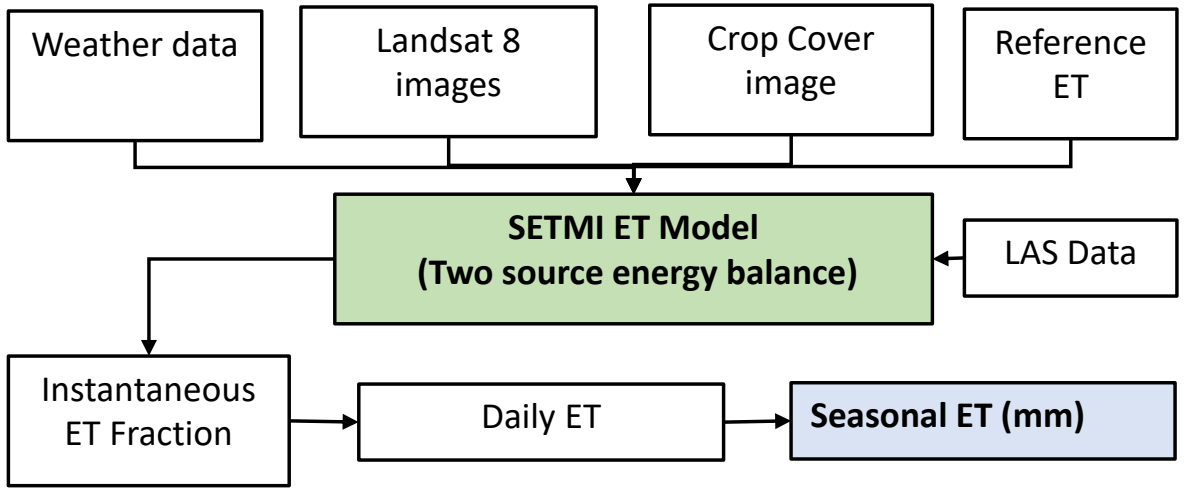
RD(IDAP)=RDM*(0.5+0.5*SIN((3.03*IDAP/MDT)-1.47))

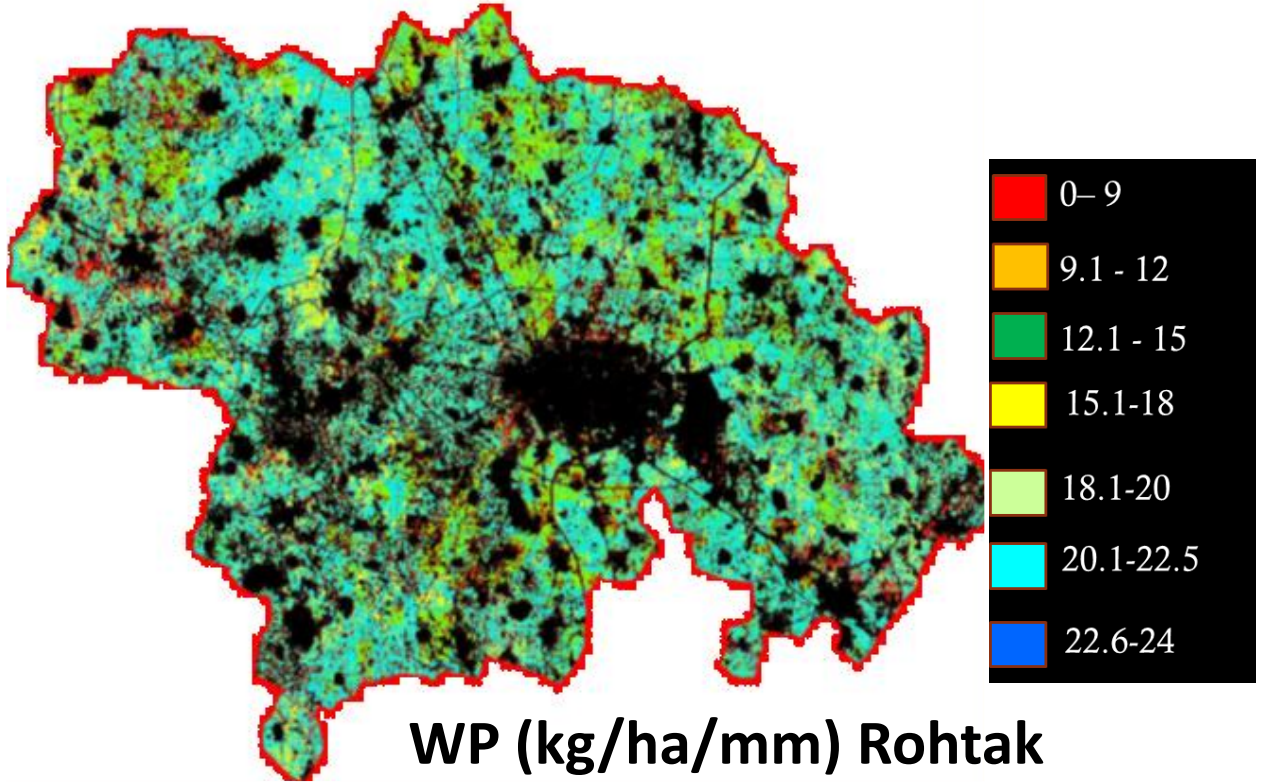
RD(IDAP)= root depth at a particular day
RDM = maximum root depth = 1 m
MDT = day at which maximum root depth reached = 90 days



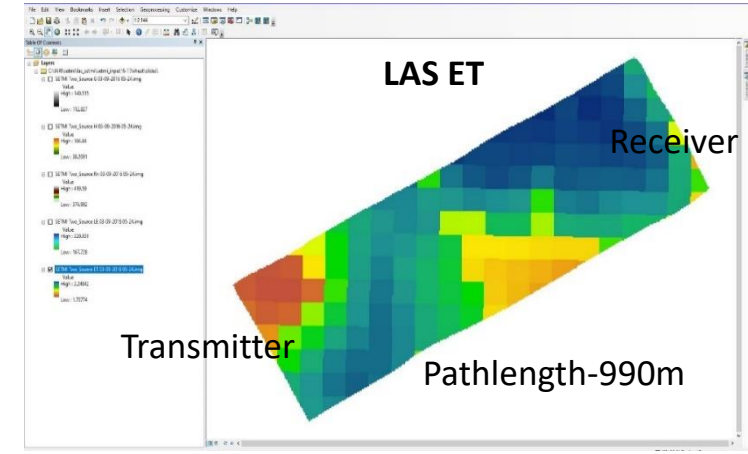
Irrigation Dates	Irrigation Applied (mm)	Irrigation Required (mm)	Water Save (mm
1. 10.12.2022	57	24	33
2. 26.12.2022	63	30	33
3. 13.01.2023	66	44	22
4. 20.02.2023	67	54	13
5. 10.03.2023	69	54	15
Total	324	206	118 (36%)

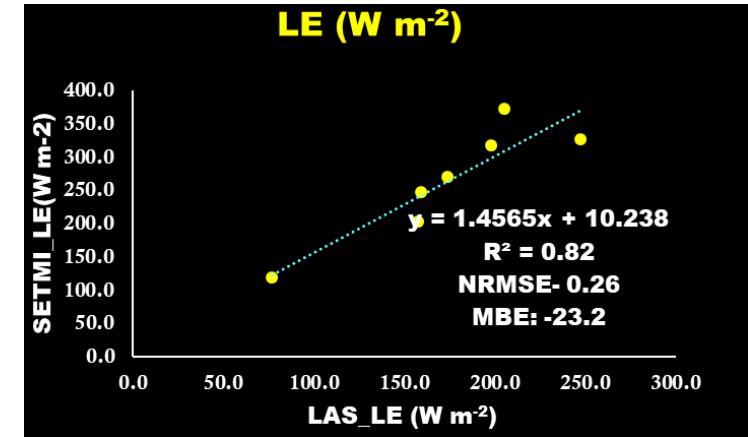
ET and Water Productivity Mapping of Wheat

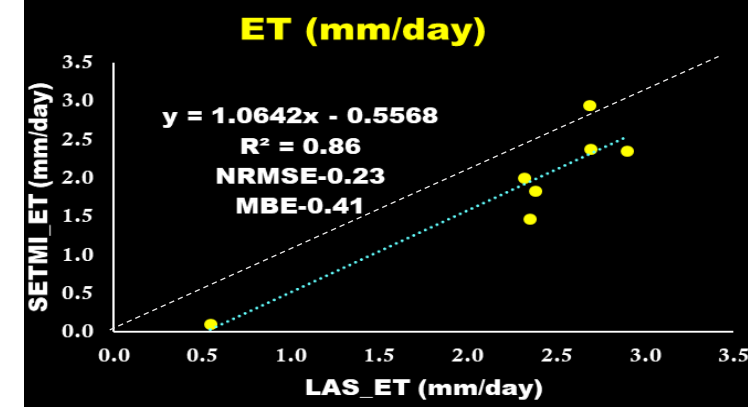


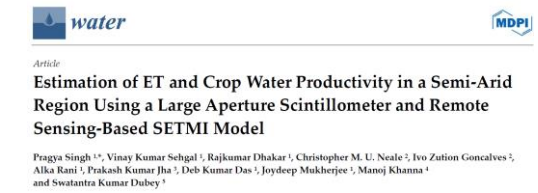


WP (kg/ha/mm) Rohtak









water

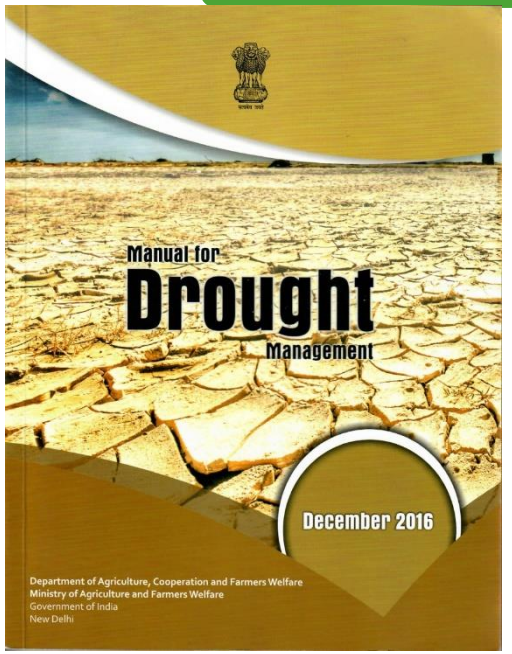
MDPI

Article

Estimation of ET and Crop Water Productivity in a Semi-Arid Region Using a Large Aperture Scintillometer and Remote Sensing-Based SETMI Model

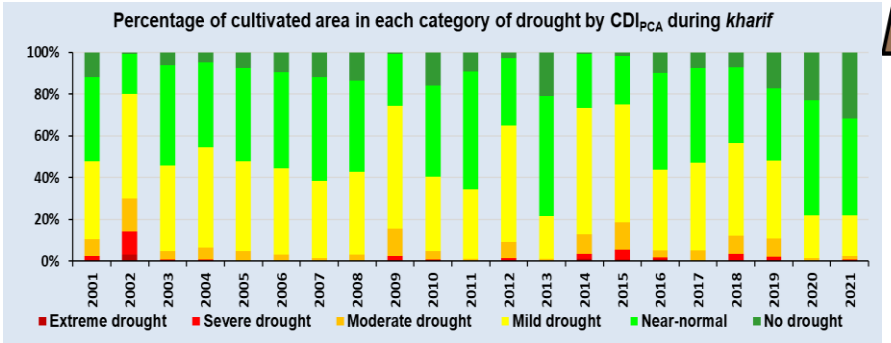
Pragya Singh [1,*], Vinay Kumar Sehgal [1], Rajkumar Dhakar [1], Christopher M. U. Neale [2], Ivo Zution Goncalves [2], Alka Rani [1], Prakash Kumar Jha [3], Deb Kumar Das [3], Joydeep Mukherjee [3], Manoj Khanna [4] and Swatantra Kumar Dubey [3]

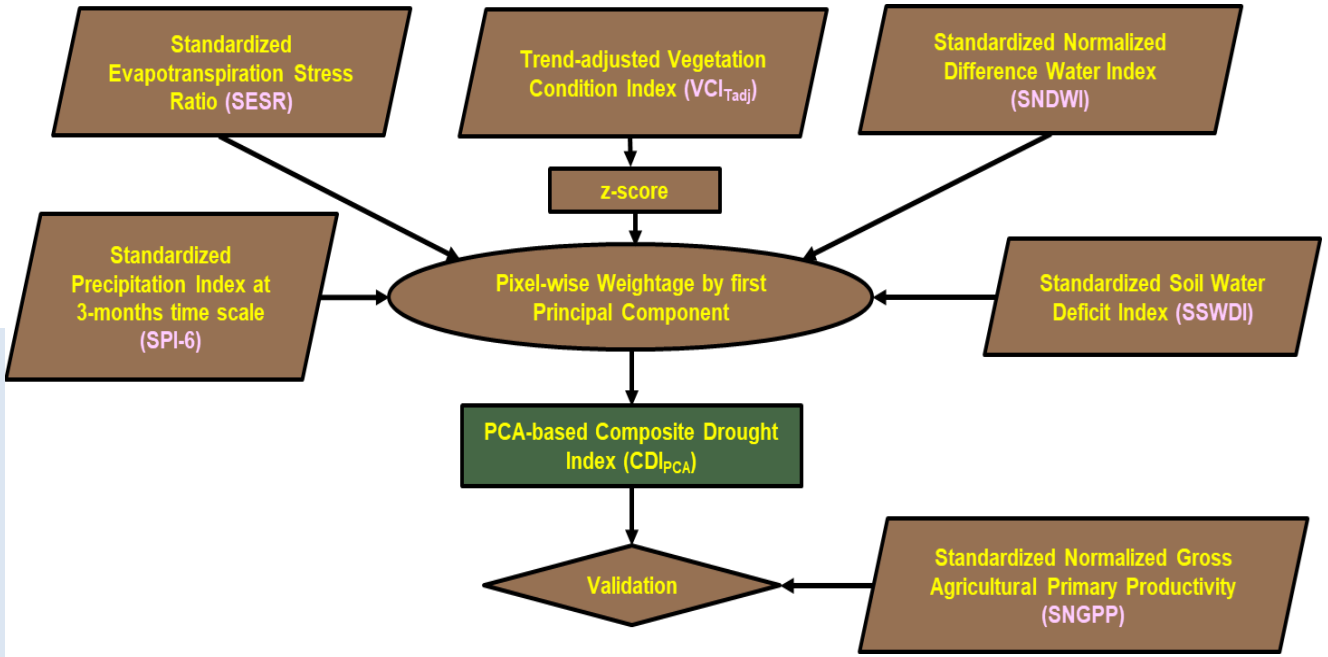
Agricultural Drought Monitoring: Composite Drought Index



S.N	Index	Formula	Inputs	Period / Interval
1	Trend-adjusted Vegetation Condition Index (VCITadj)	$(\frac{NorNDVI_i - NorNDVI_{min}}{NorNDVI_{max} - NorNDVI_{min}}) \times 100$	Terra MODIS NDVI L3product	2001 – 2021 16 day, 250m
2	Standardized Precipitation Index (SPI)	$SPI_i = \frac{X_i - X_{mean}}{\sigma}$	CHIRPS ver 2.0	2001 – 2021 1 day, ~ 5 km
3	Normalized Difference Water Index (NDWI)	$\frac{NIR - SWIR}{NIR + SWIR}$	Terra MODIS Reflectance L2	2001 – 2021 8 days, 500m
4	Soil Water Deficit Index (SWDI)	$\left(\frac{SM_i - FC}{FC - PWP}\right) \times 10$	SMAP L4 product	2001 – 2021 1 day, , ~ 9 km
5	Evaporative Stress Ratio (SESR)	ET/PET	Terra MODIS L3 product	2001 – 2021 8 days, 500m

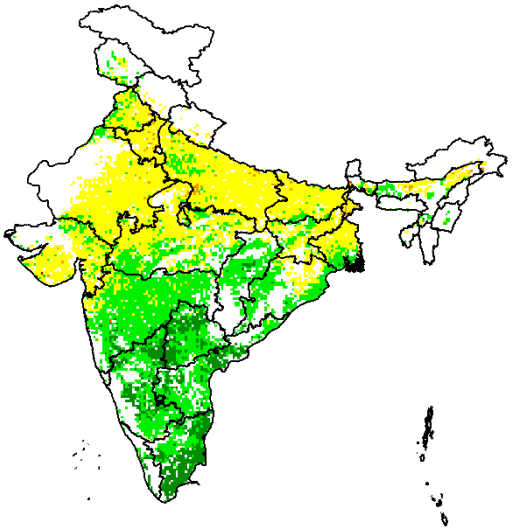
- **Trigger1**
  - Cause
  - Rainfall based
- **Trigger 2**
  - Impacts
  - Crop, Soil moisture, **Remote Sensing**, Hydrology
- **Ground Info**
  - Verification from ground situation
- **Declaration**



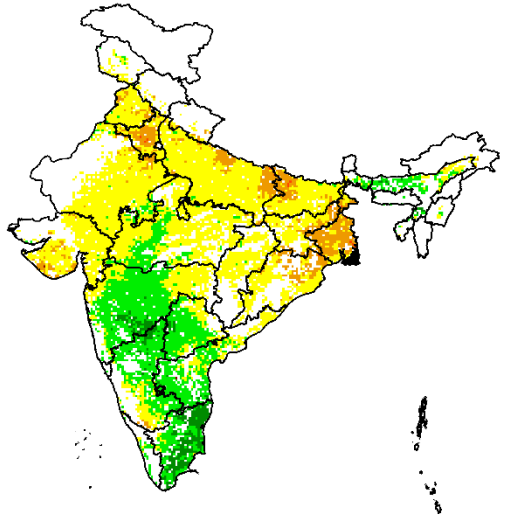


Composite Drought Index (2024-25): 1km Grid every 16-days

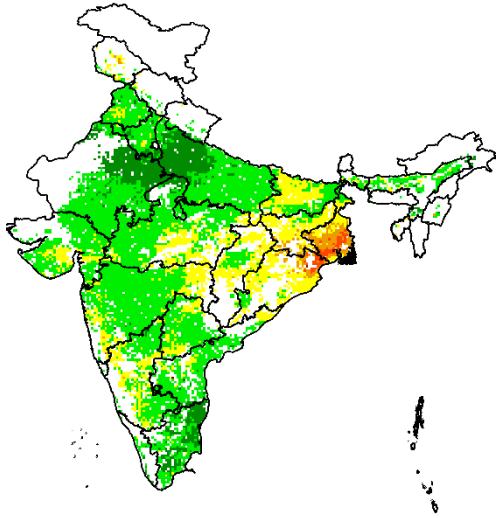
(25/5/2024 to 9/6/2024)



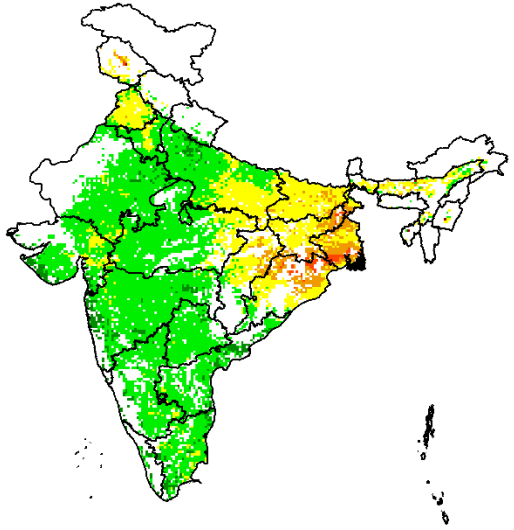
(10/6/2024 to 25/6/2024)



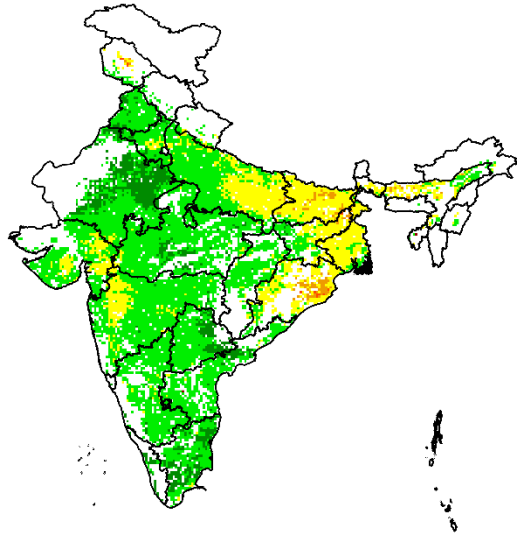
(26/6/2024 to 11/7/2024)



(12/7/2024 to 27/7/2024)

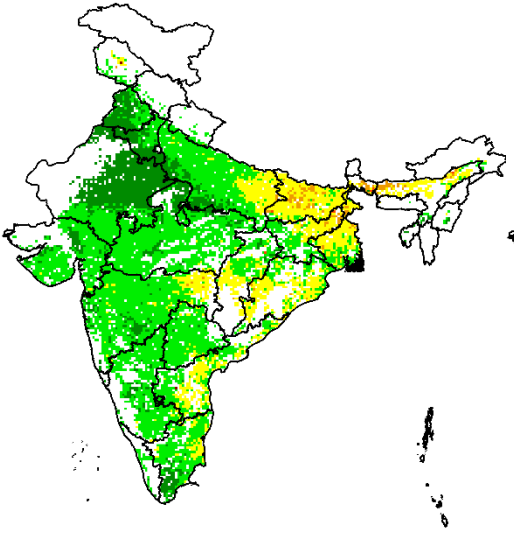


(28/7/2024 to 12/8/2024)

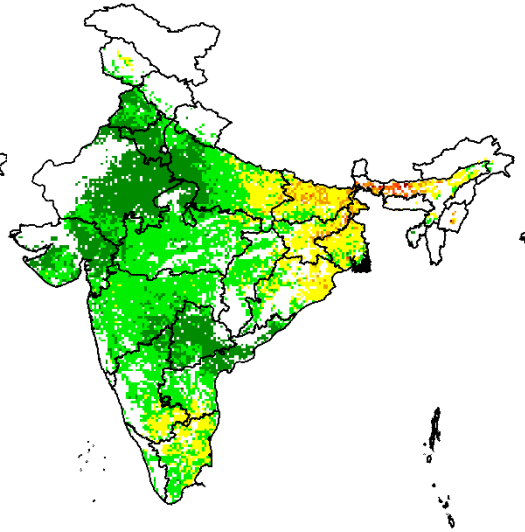


Non-crop Normal Near-normal Mild Moderate Severe Extreme

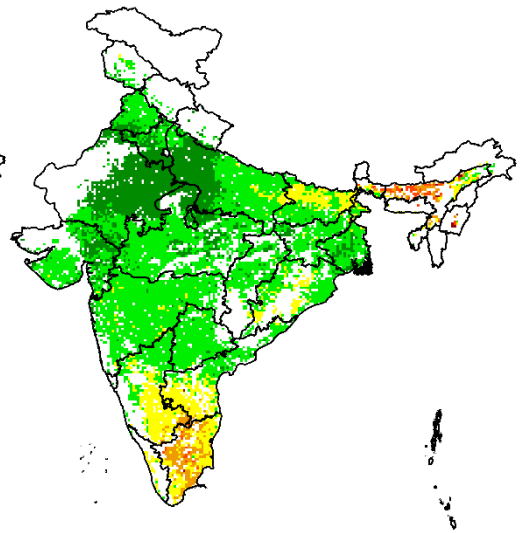
(13/8/2024 to 28/8/2024)



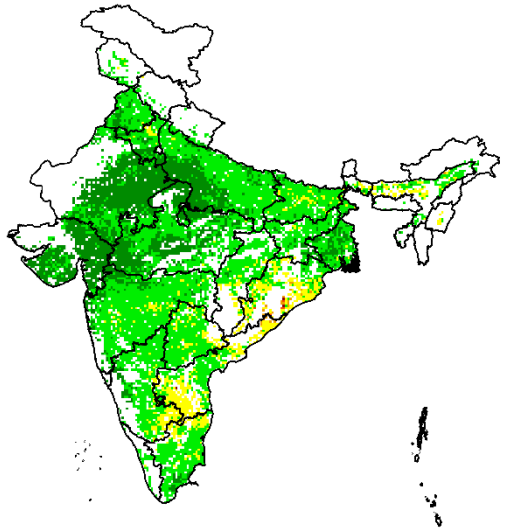
(29/8/2024 to 13/9/2024)



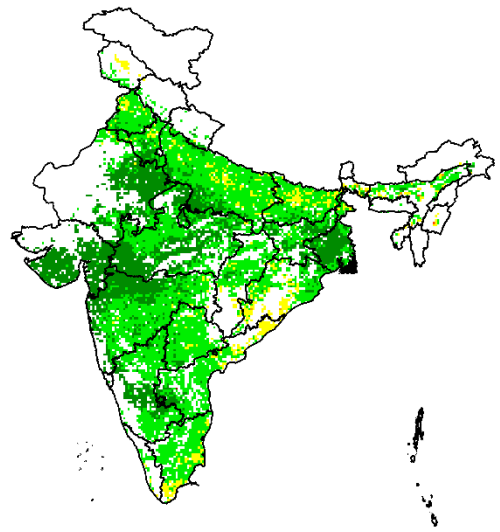
(14/9/2024 to 29/9/2024)



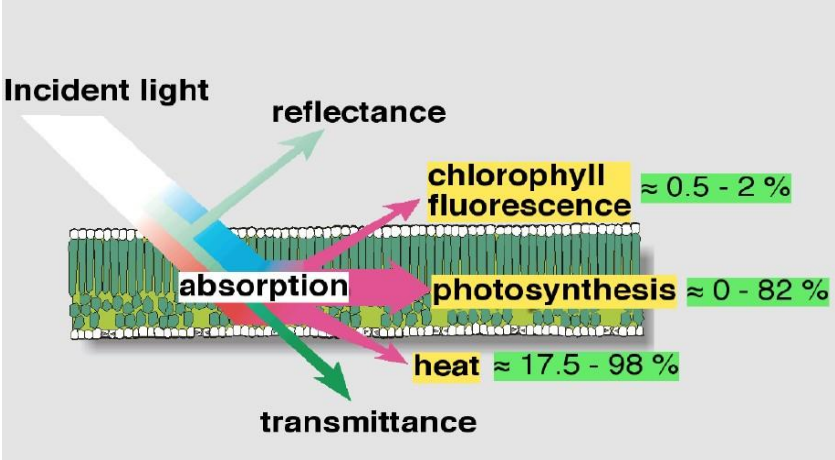
(30/9/2024 to 15/10/2024)

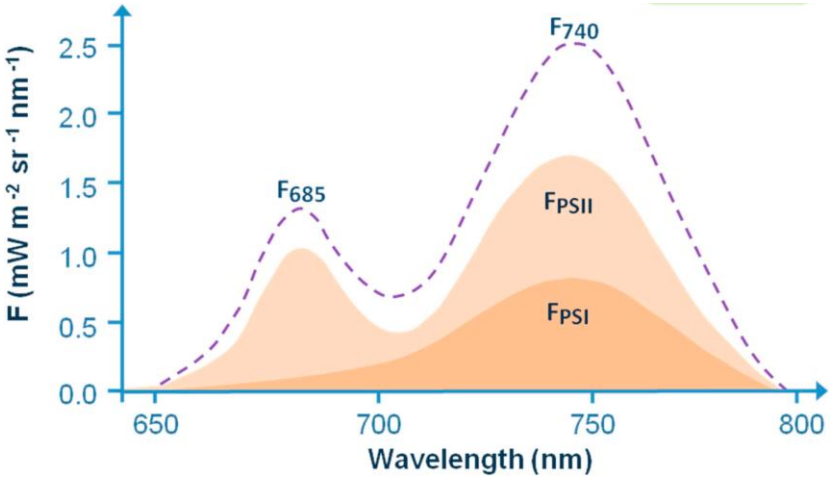


(16/10/2024 to 31/10/2024)



Abiotic Stress: Sun Induced Fluorescence (SIF) Modelling





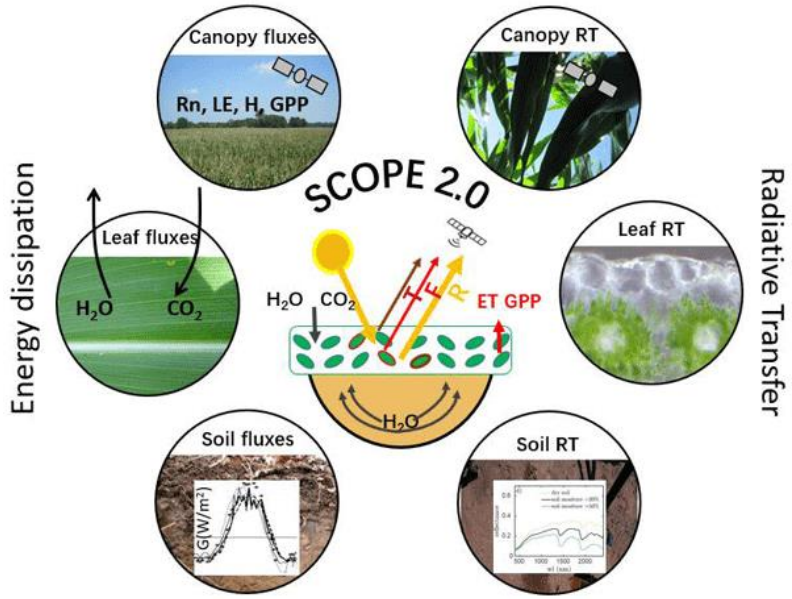
Solar-induced fluorescence (SIF) is an innovative measurement that serves as a proxy of plant photosynthetic activity.

Treatments

N dose	interpretation
N0	0 kg N ha^{-1}
N60	60 kg N ha^{-1}
N120	120 kg N ha^{-1}
N150	150 kg N ha^{-1}
Irrigation	**interpretation**
I1	1 irrigation
I3	3 irrigations
I5	5 irrigations

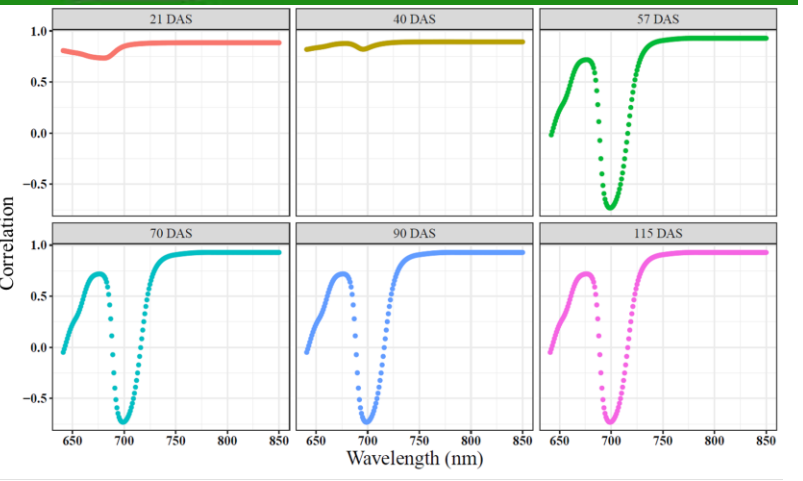
Parameter	Method
Chlorophyll content	DMSO-method (Hiscox and Israelstam, 1979)
Carotenoid content	DMSO-method (Hiscox and Israelstam, 1979)
Soil Moisture	Gravimetric method
Incident PAR / Intercepted PAR	Point Quantum / Line quantum sensor
Biomass	Destructive sampling (30cm)
Leaf area index	Plant Canopy analyzer (Li-2200c)
Total N	Kjeldalh Method (Kjeldahl, 1883)
Leaf area	leaf area meter
Fv/Fm	Pulse Modulated Chlorophyll Fluorometer (OS5p+)
Crop height	Meter scale
Leaf width	Meter scale
Micrometeorological parameters	EC flux tower / AWS

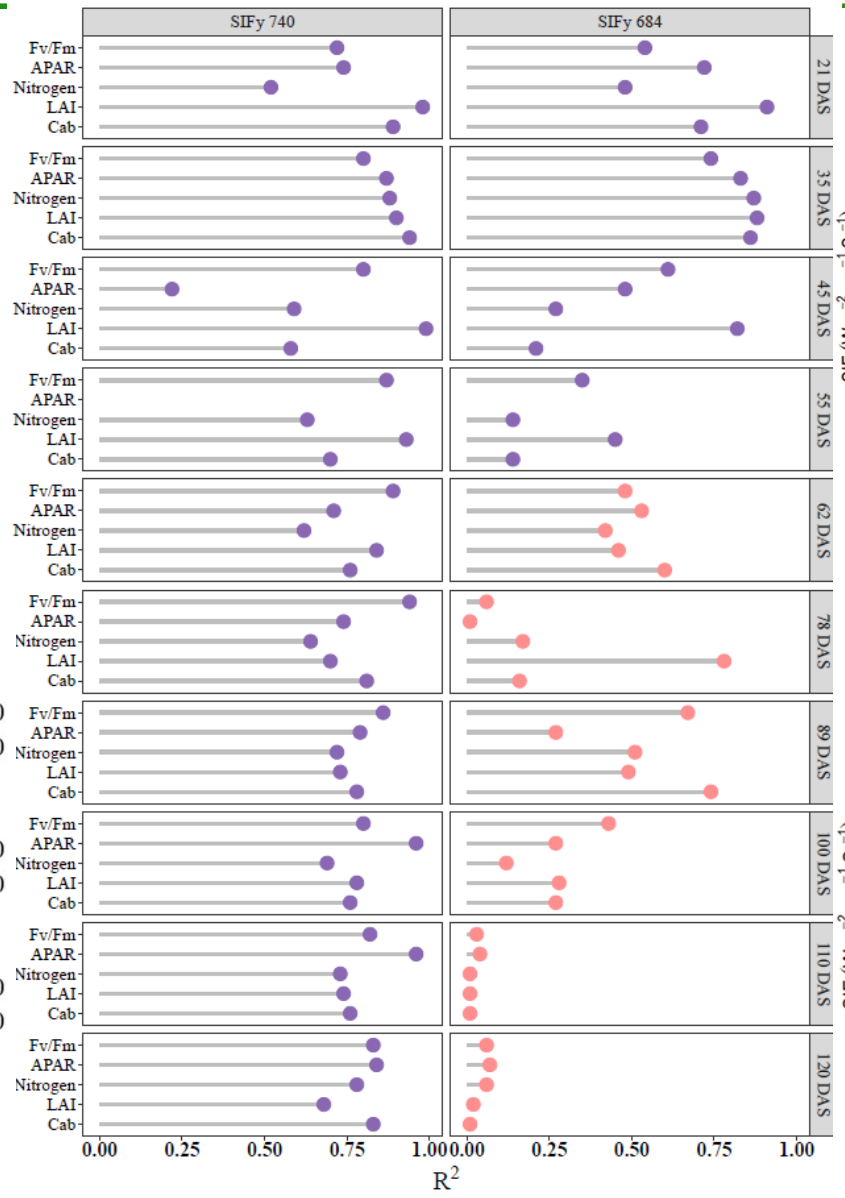
Soil Canopy Observation, Photosynthesis, and Energy fluxes (SCOPE)

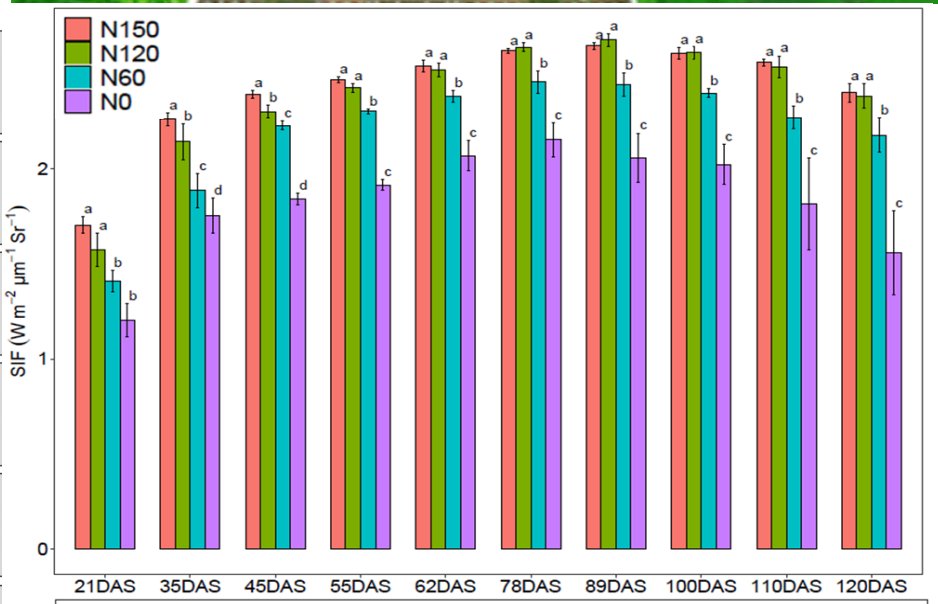


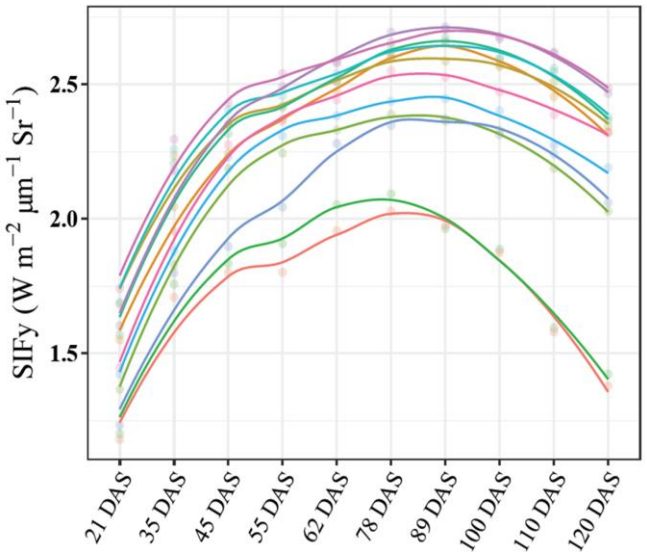
European Space Agency Mission

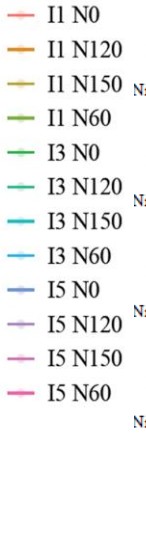
SIFy Relation with Crop Biophysical Parameters

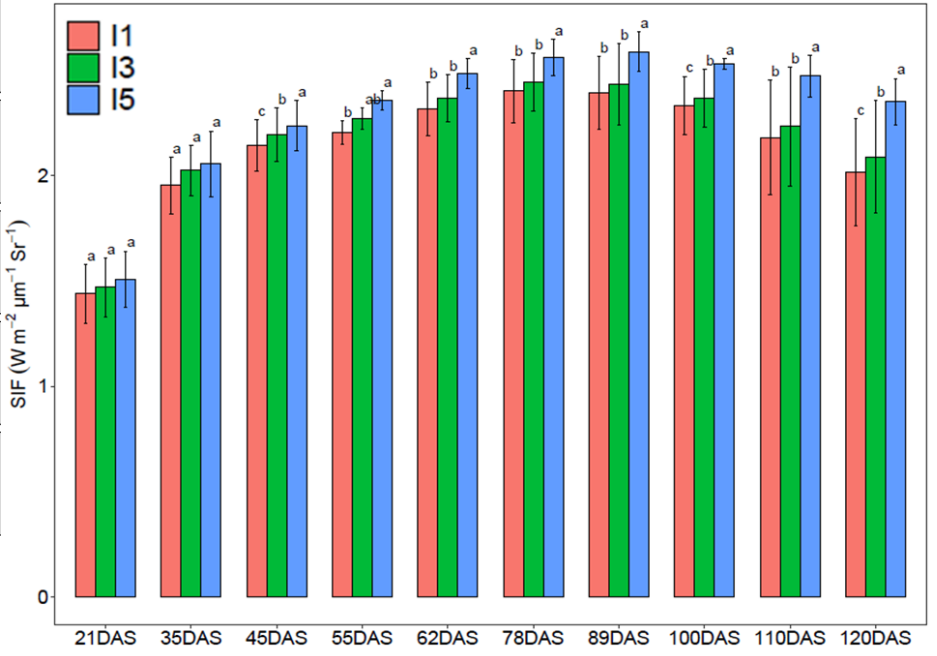




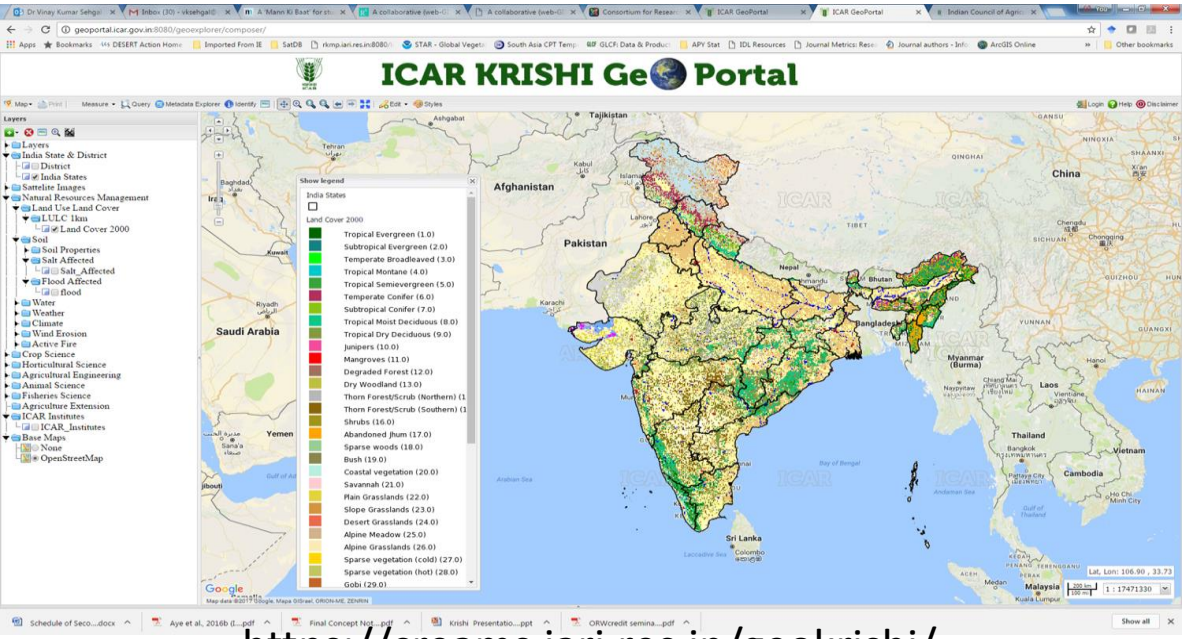




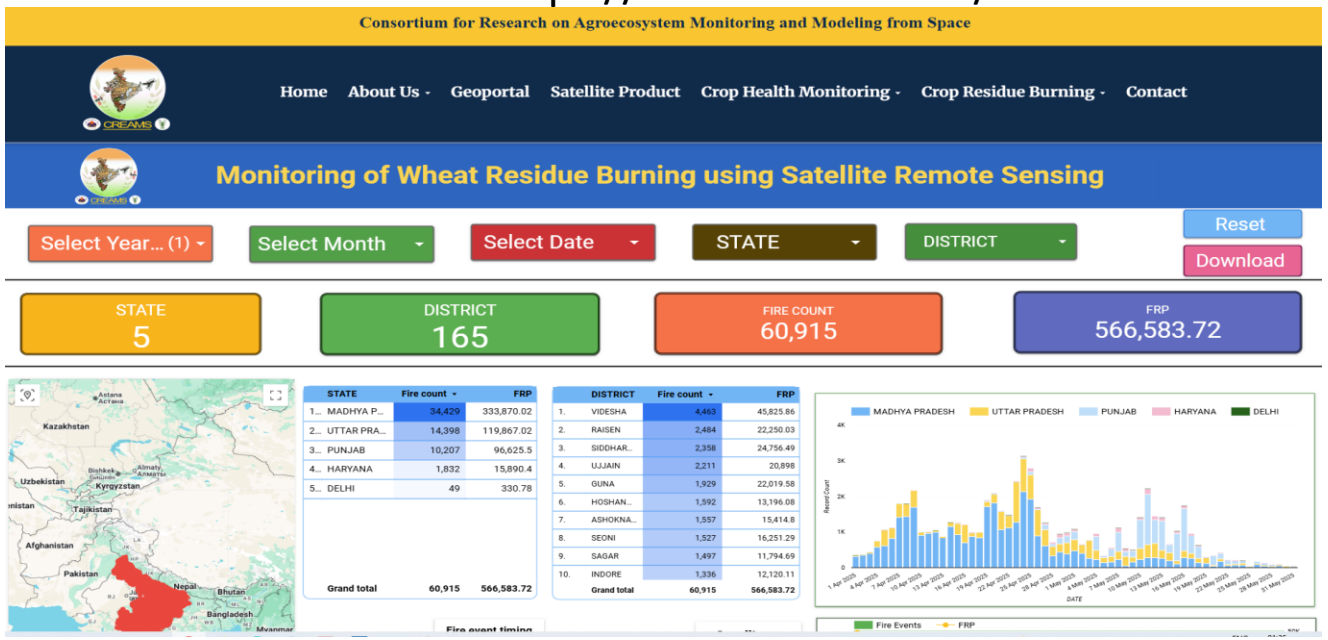




Web Geo-Portals for Dissemination of Research Outputs among Stakeholders



https://creams.iari.res.in/



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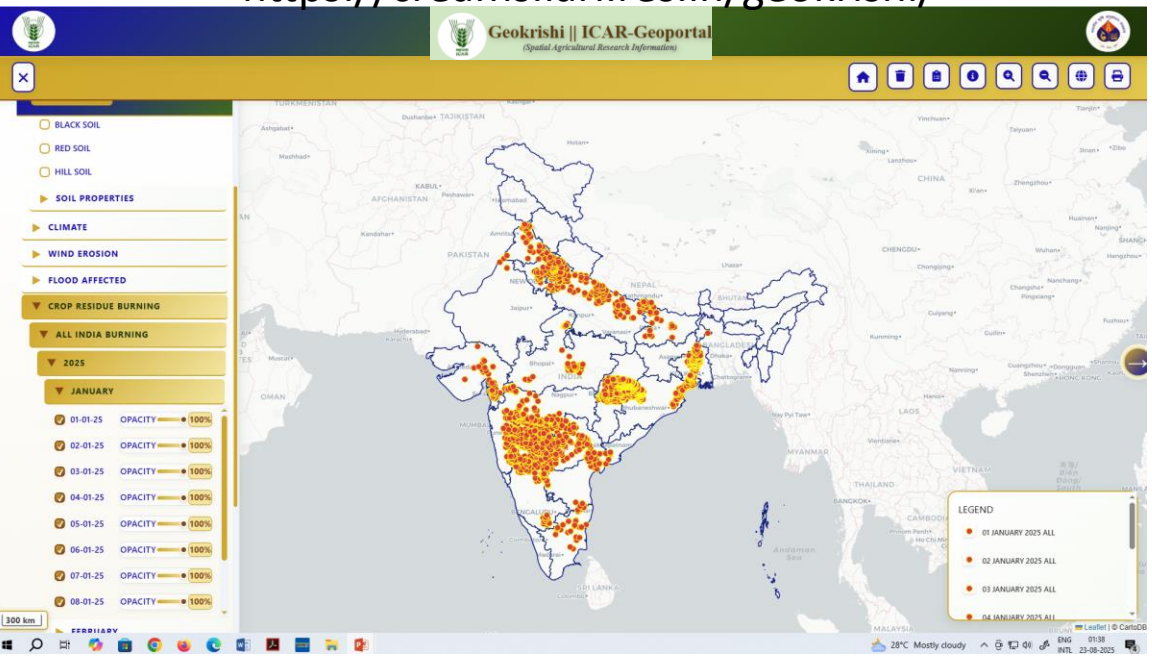

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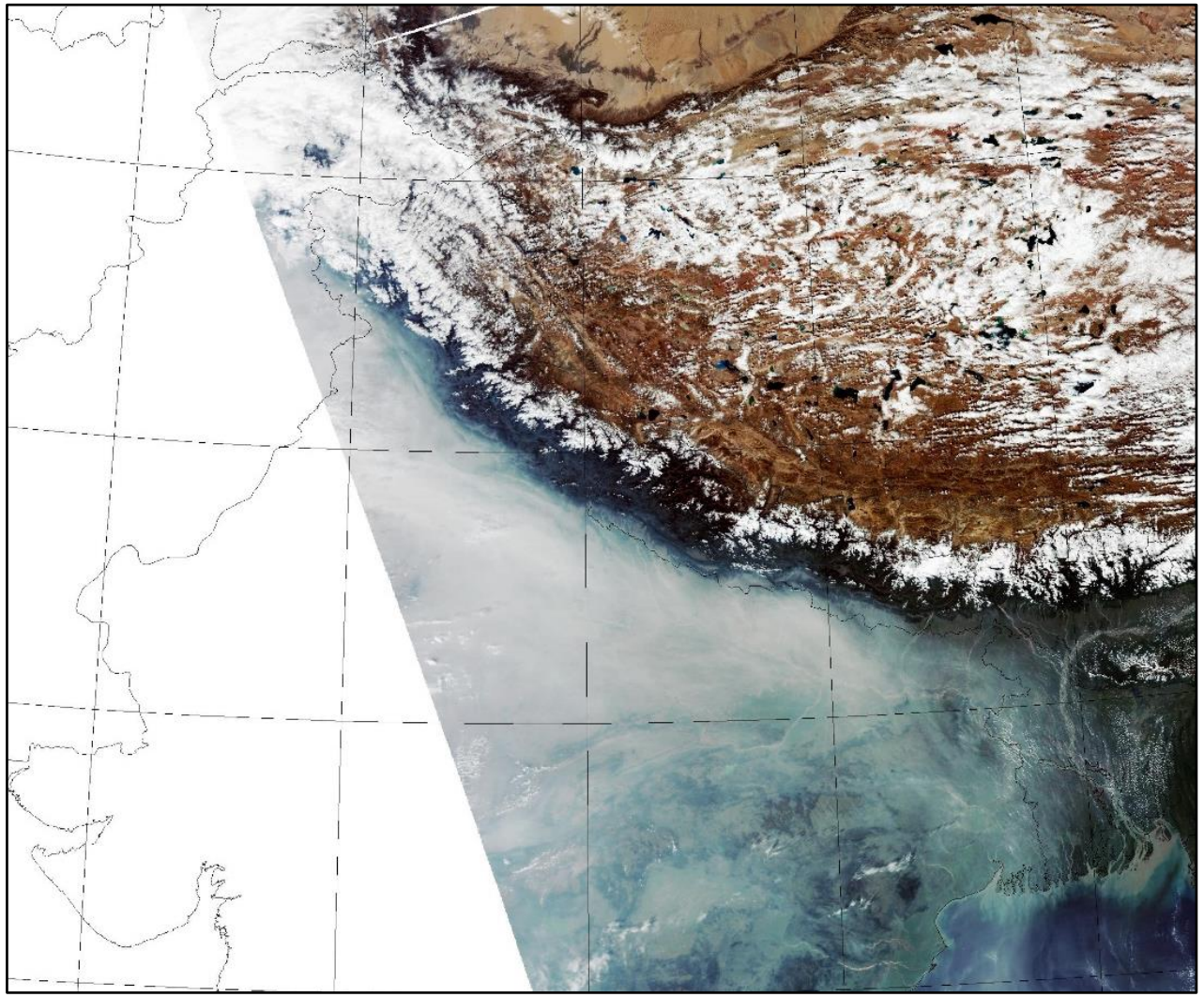

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- **Technical staff**
- **Students**
- **Project Staff**
- **Supporting staff**