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Agricultural Land Use Change in Central and Northeast Thailand: Effects on Biomass Emissions, Soil Quality and Rural Livelihoods

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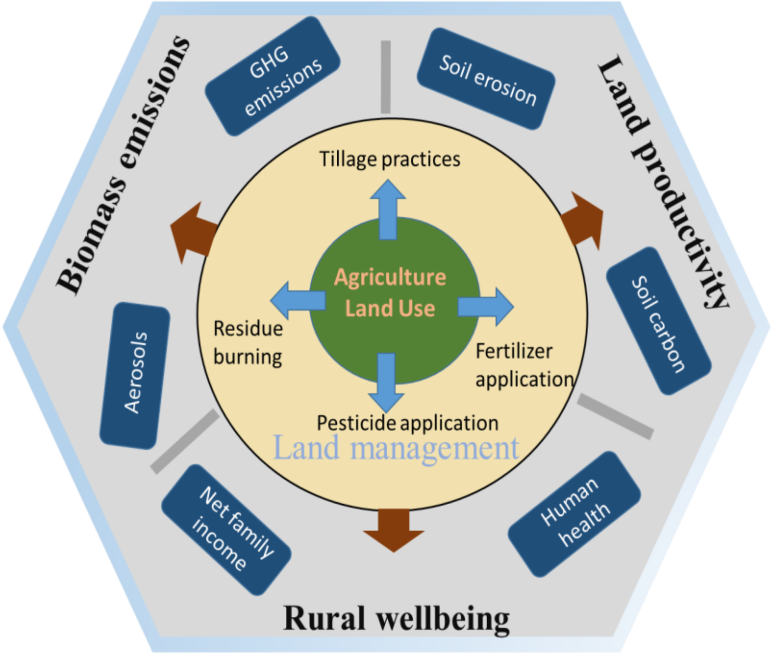
LCLUC Land-Cover / Land-Use Change Program

Project Motivation

- Agricultural landscapes are heterogeneous.
- Land use and land management decisions impact rural income, environment and food security.
- The primary obstacle - lack of frequent and sufficiently high/moderate resolution satellite observations.

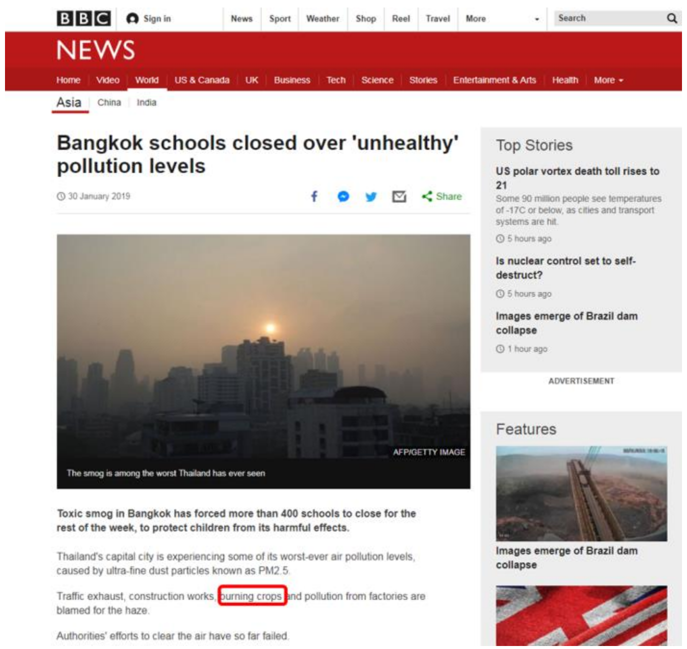
Multiple crops with in the small land area

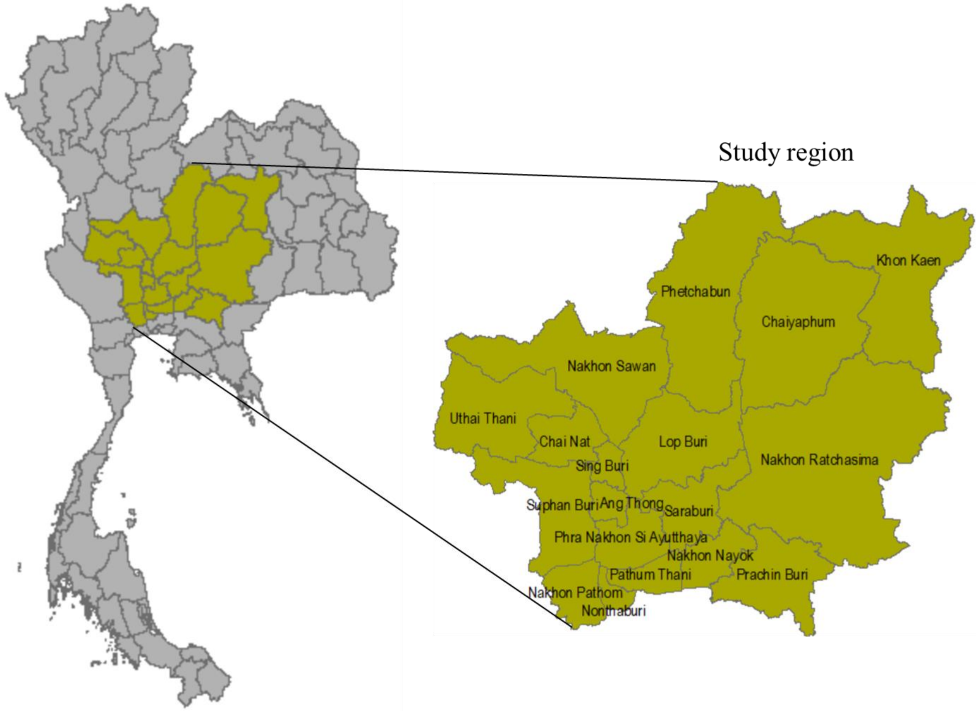


Schematic showing relationship between land use and land management and their interactive effects on biomass emissions, land productivity and rural well-being.

Study region

- Agricultural restructure program (2015-2019)
- Rice is deprioritized and sugarcane has been promoted.





Provincial map of Thailand with study region represented in olive green color.

Overall objectives

Area change in rice and sugarcane from 2014-2018 period

Residue burning in sugarcane

Residue burning in rice

Project Team

Crop Mapping

Sergii Skakun	UMD
Kristopher Lasko	UMD
Varaprasad Bandaru	UMD

Crop Modeling

Varaprasad Bandaru	UMD
Raghu Yaramasu	UMD
Jaiying He	UMD
Pallavi Chirumamilla	UMD
Roberto Izaurralde	UMD

Burned Area Mapping & Emissions

Louis Giglio	UMD
Joanne Vanessa Hall	UMD
Kristopher Lasko	UMD

Socio-Economics

Klaus Hubacek	UMD
Laixiang Sun	UMD
Kuishuang Feng	UMD
Ipsita Kumar	UMD

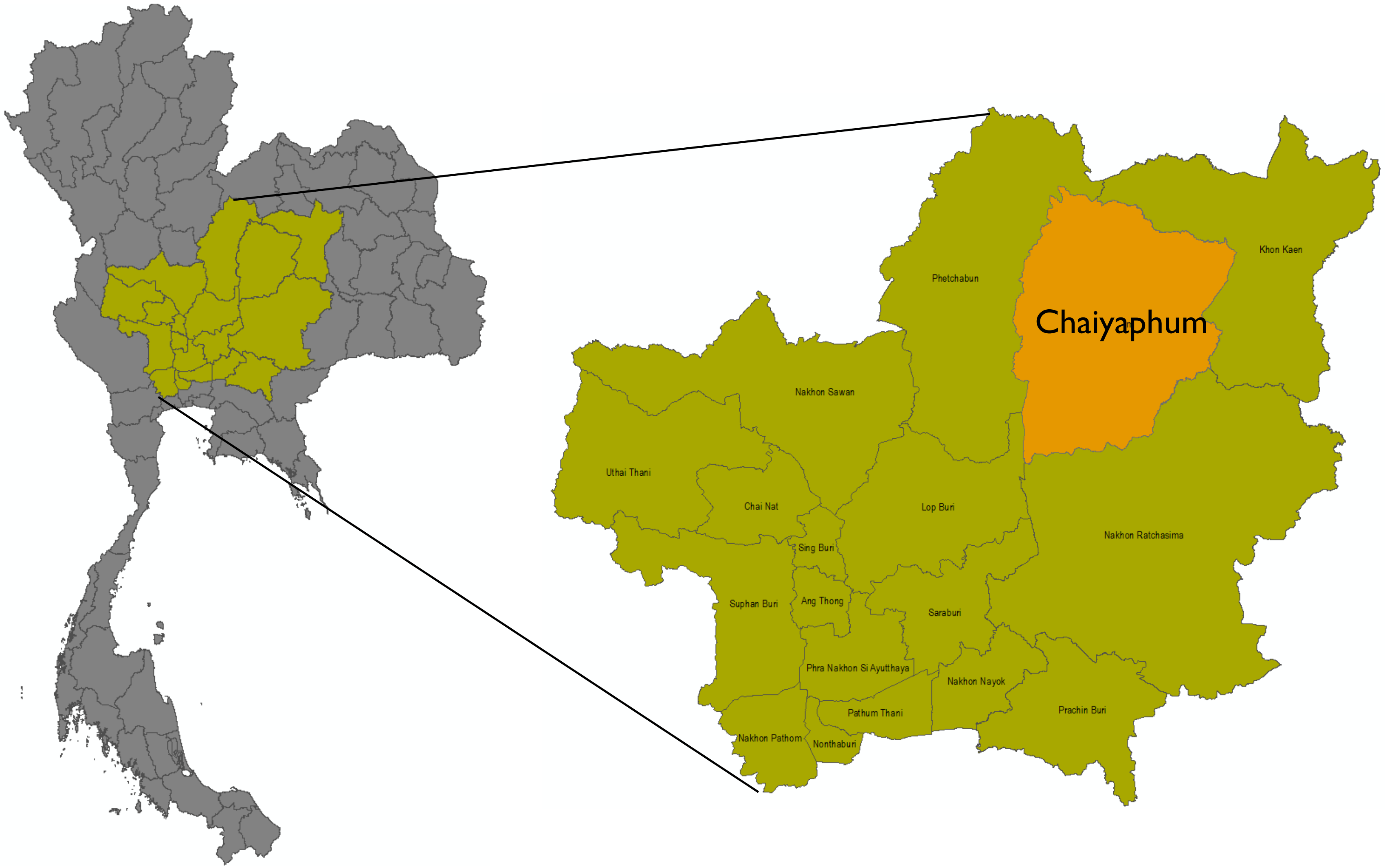
Local Thailand Partners

Sukunya Yampracha	KMITL
Lampan Khurnpoon	KMITL
Bunditt Fungtammasan	KMUTT
Vorraveerukorn Veerachit	MitrPhol

Project Tasks

TASKS	PRODUCTS	
Crop Type Mapping →	Crop type maps of major crops →	Change in crop areas
Agroecosystem Modeling →	Crop yields, water use Soil organic carbon →	Change in crop production, water use and soil carbon
Biomass Emissions Estimation →	Burned area mapping →	Biomass emissions
Socio-economic Modeling →	Impacts on economy and rural livelihood	

Testbed

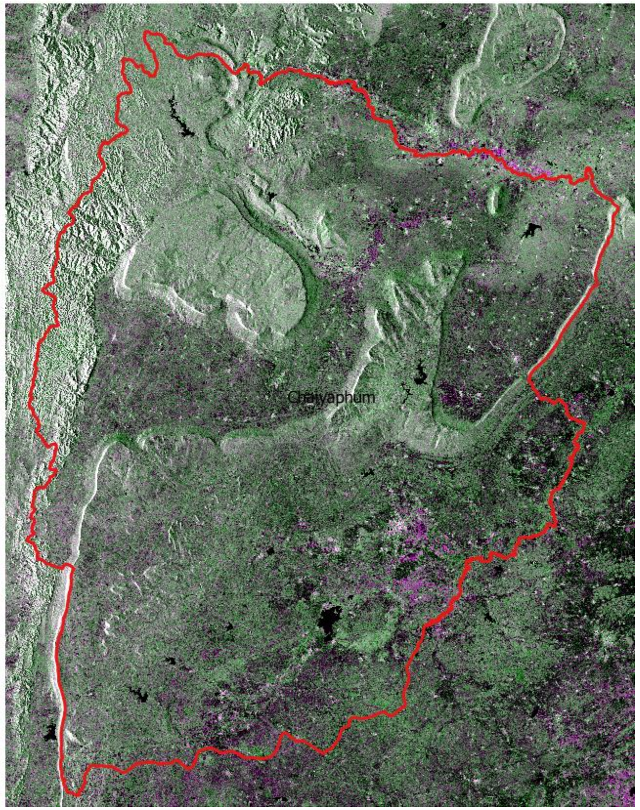


Provincial map of Thailand with study and test bed regions represented in olive green and orange colors, respectively.

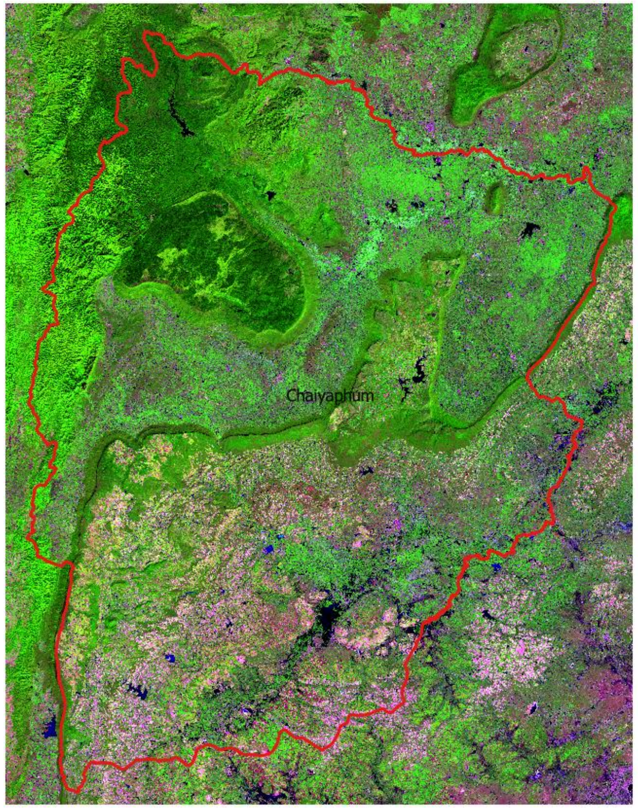
Task 1. Crop type mapping

Remote sensing data

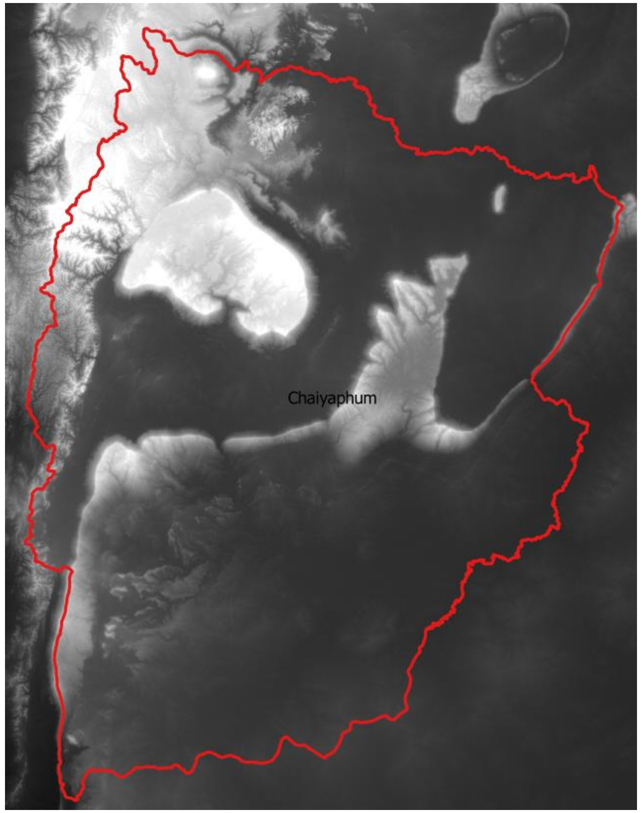
- Optical (HLS: Landsat 8 + Sentinel-2) + SAR (Sentinel-1) + DEM (SRTM)
  - L8: 161 scenes, S2: 396 scenes, S1: 324 scenes



S1
2018-06-23
VV-VH-VV



HLS
2018-10-03
SWIR-NIR-Red

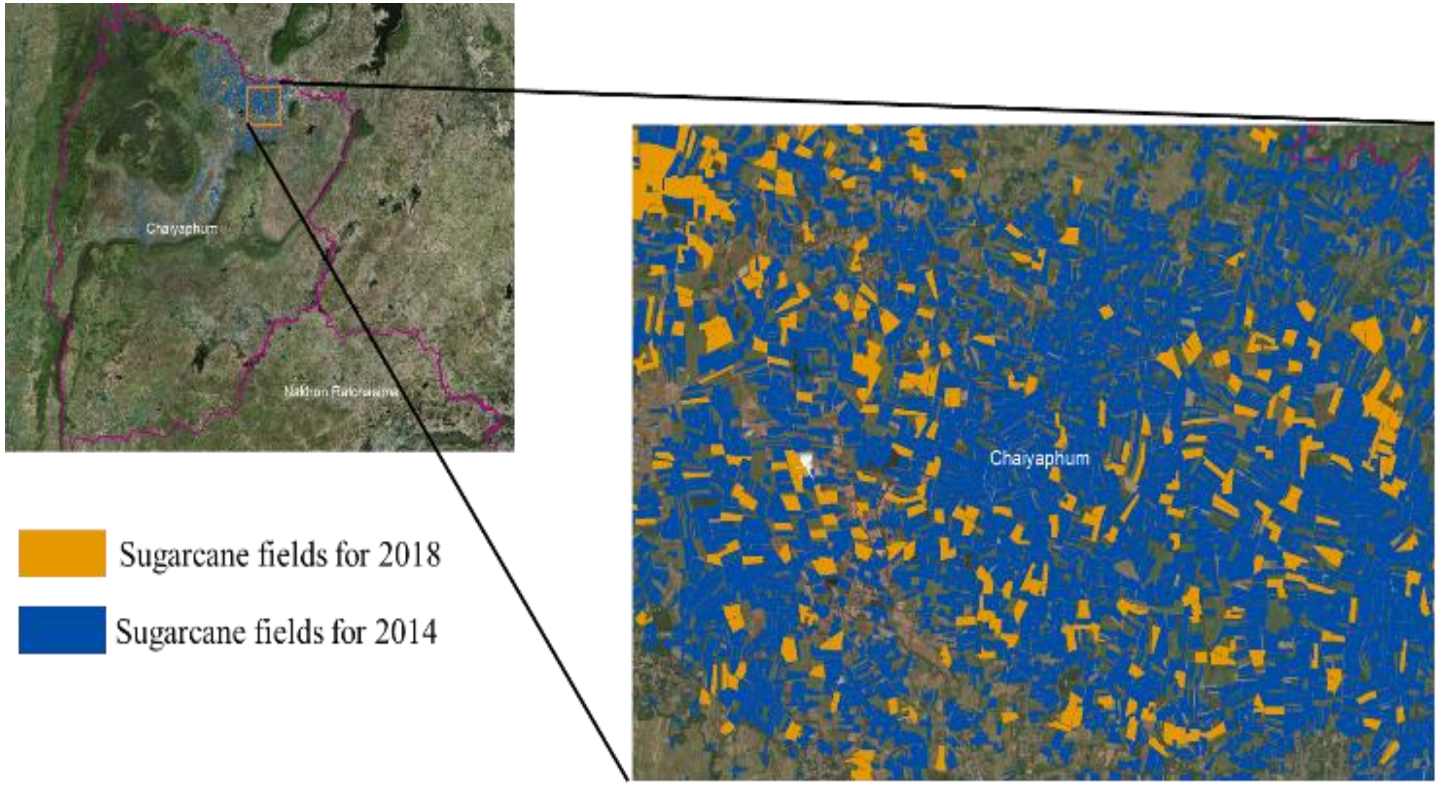


SRTM
DEM

Task 1. Crop type mapping

Reference data

- ground truth (for crops) + photointerpretation for generic land cover

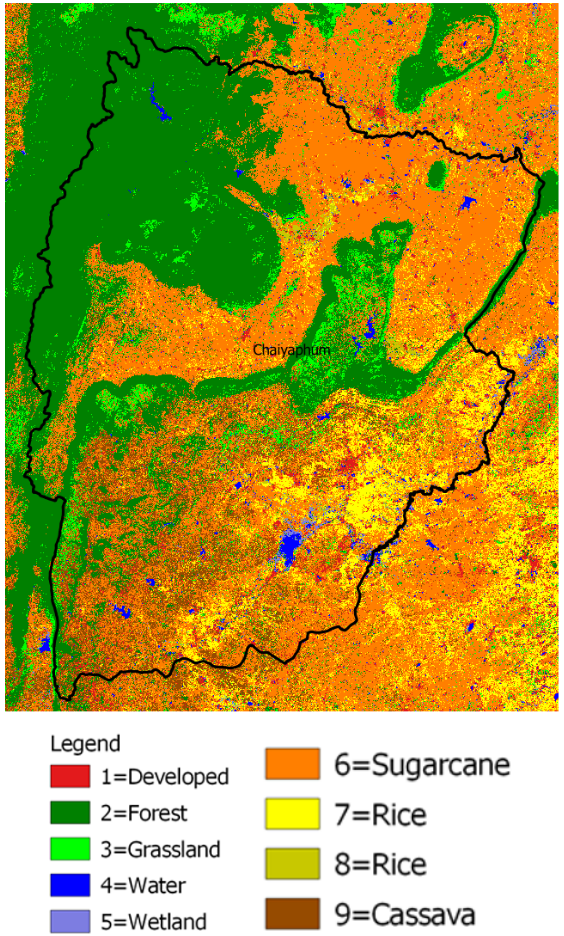


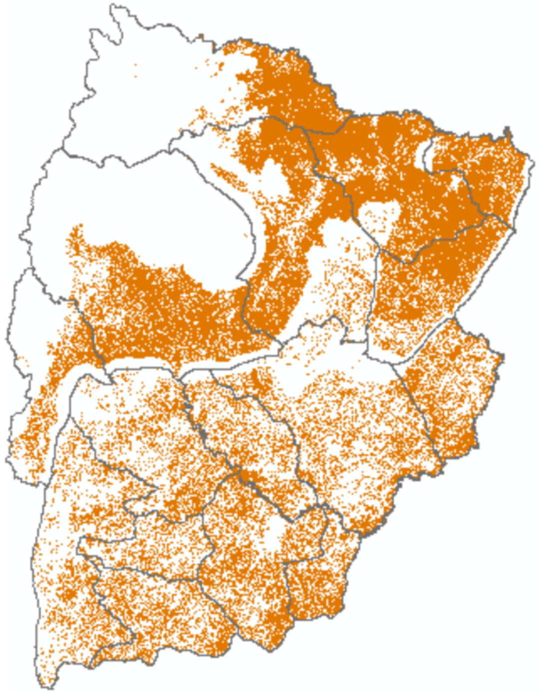
Digitized field locations with sugarcane production in 2014 and 2018 in Chaiyphum province.

Task 1. Crop type mapping

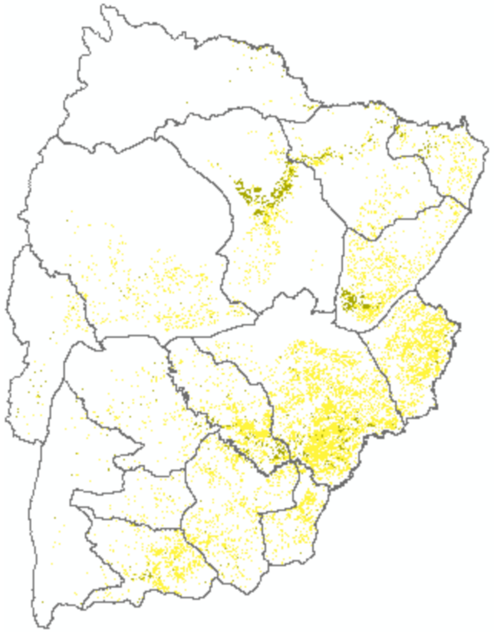
Land use classification

- Multi-layer perceptron (MLP); Architecture: 155-64-64-64-9
- Main confusions: Rice with wetlands; Grassland with crops (sugarcane and cassava)





Sugarcane

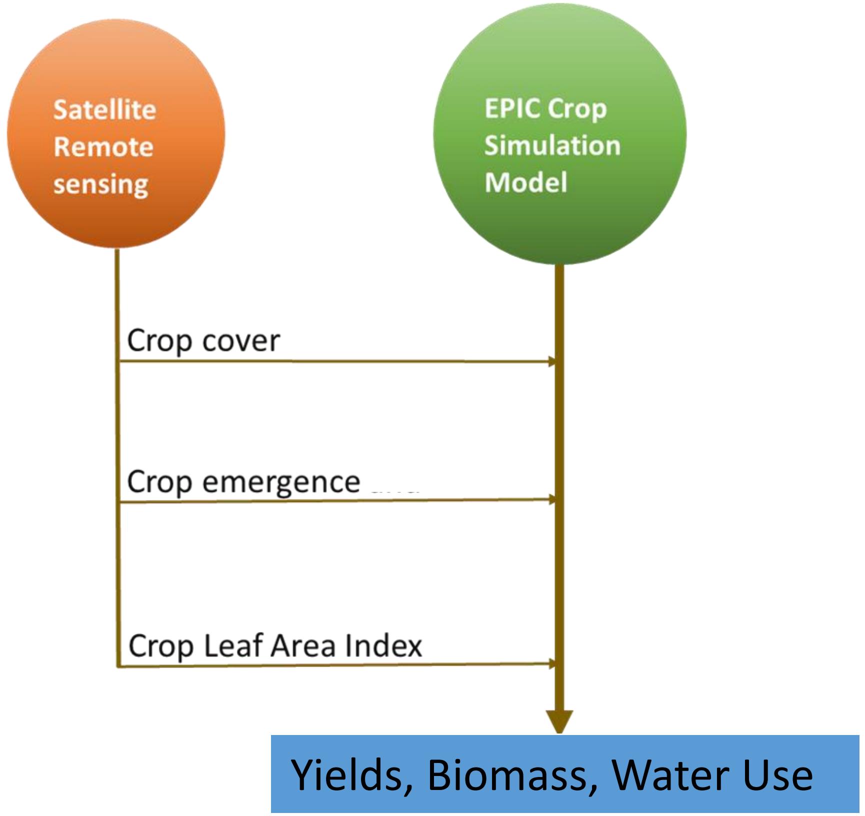


Single and double rice

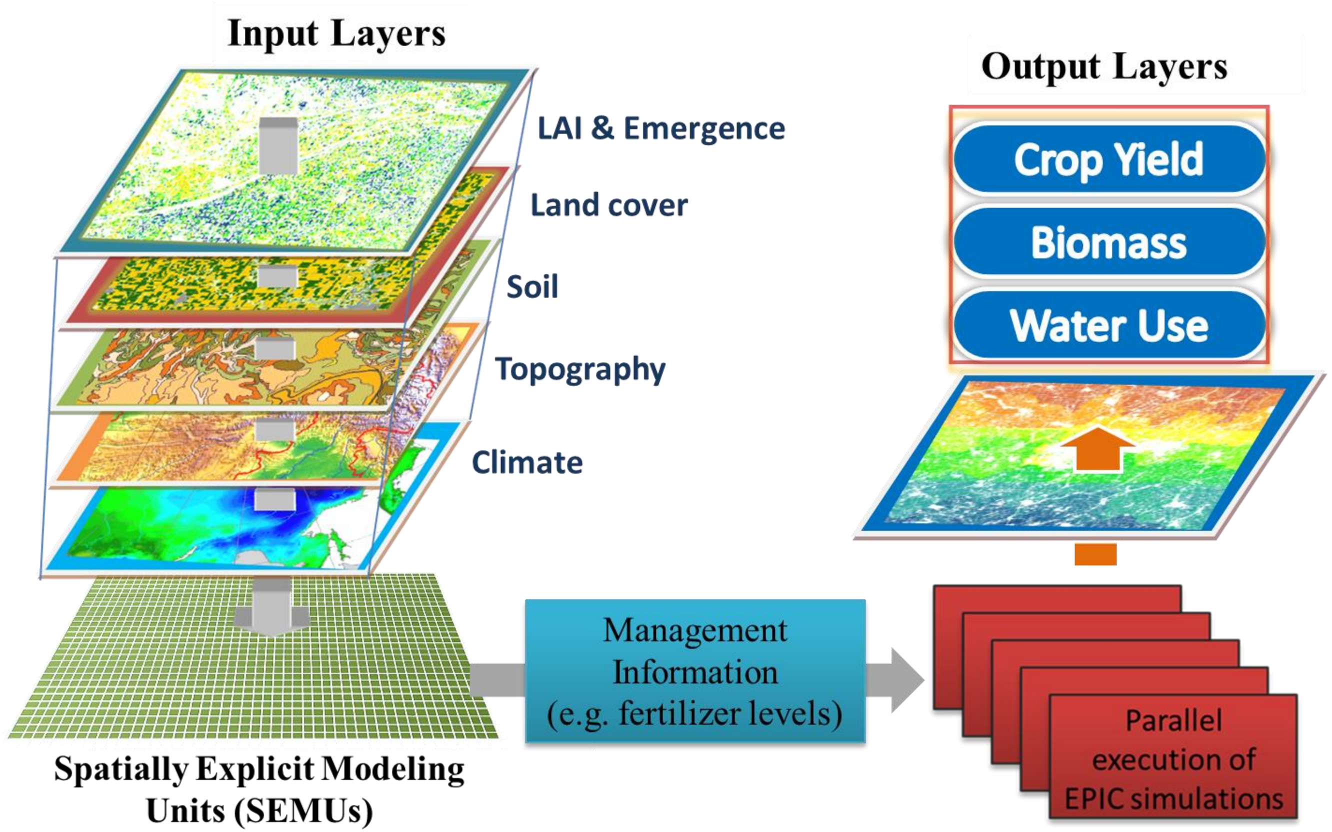
OA=96.1%		
	UA,%	PA,%
1=Developed	97	99
2=Forest	99	99
3=Grassland	55	27
4=Water	92	100
5=Wetland	68	3
6=Sugarcane	95	99
7=Rice(single)	66	97
8=Rice(double)	84	66
9=Cassava	6	80

Task 2.1 Crop yield and water use simulations

- RS-EPIC modeling framework has been used to simulate crop yields and water use for rice and sugarcane crops cultivated in 2018.



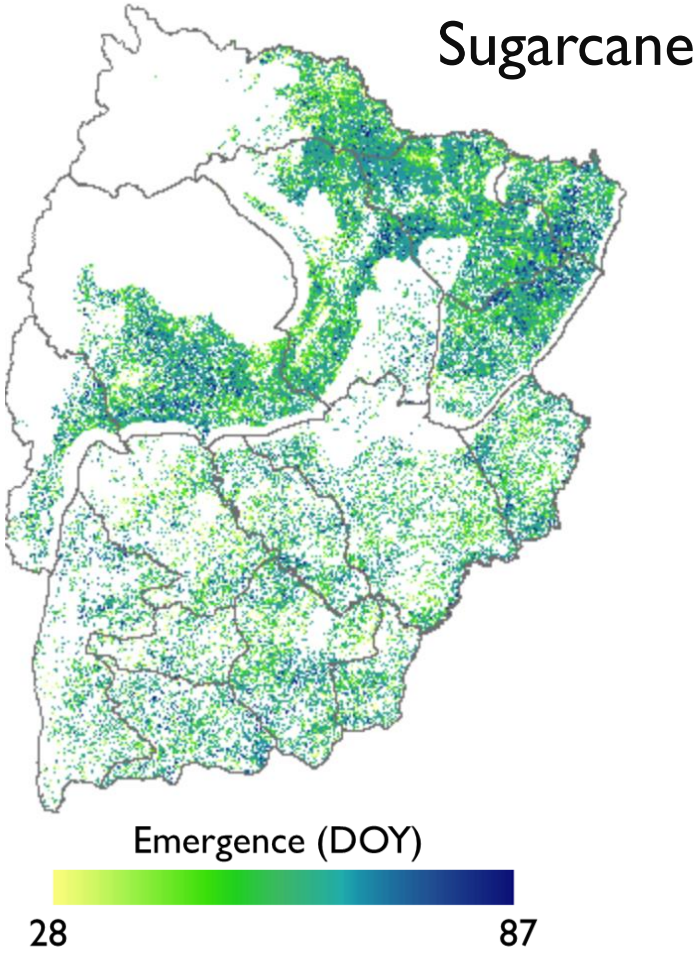
Elements of RS-EPIC

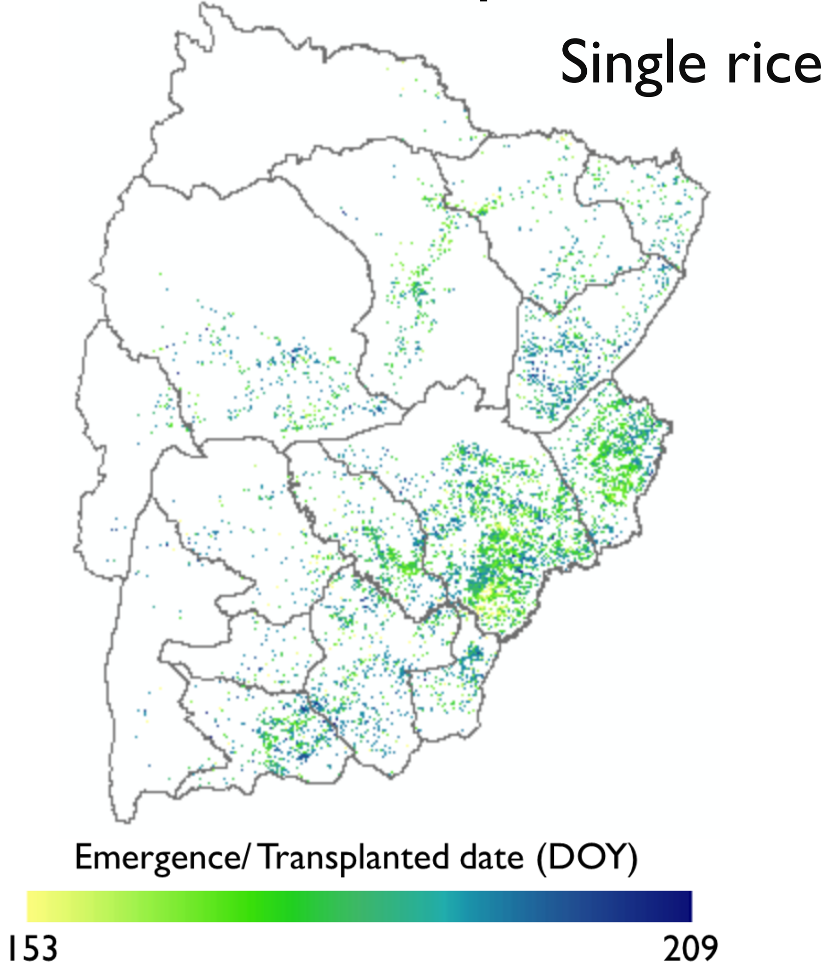


Task 2. 1 Crop yield and water use simulations

Crop emergence/transplanted dates

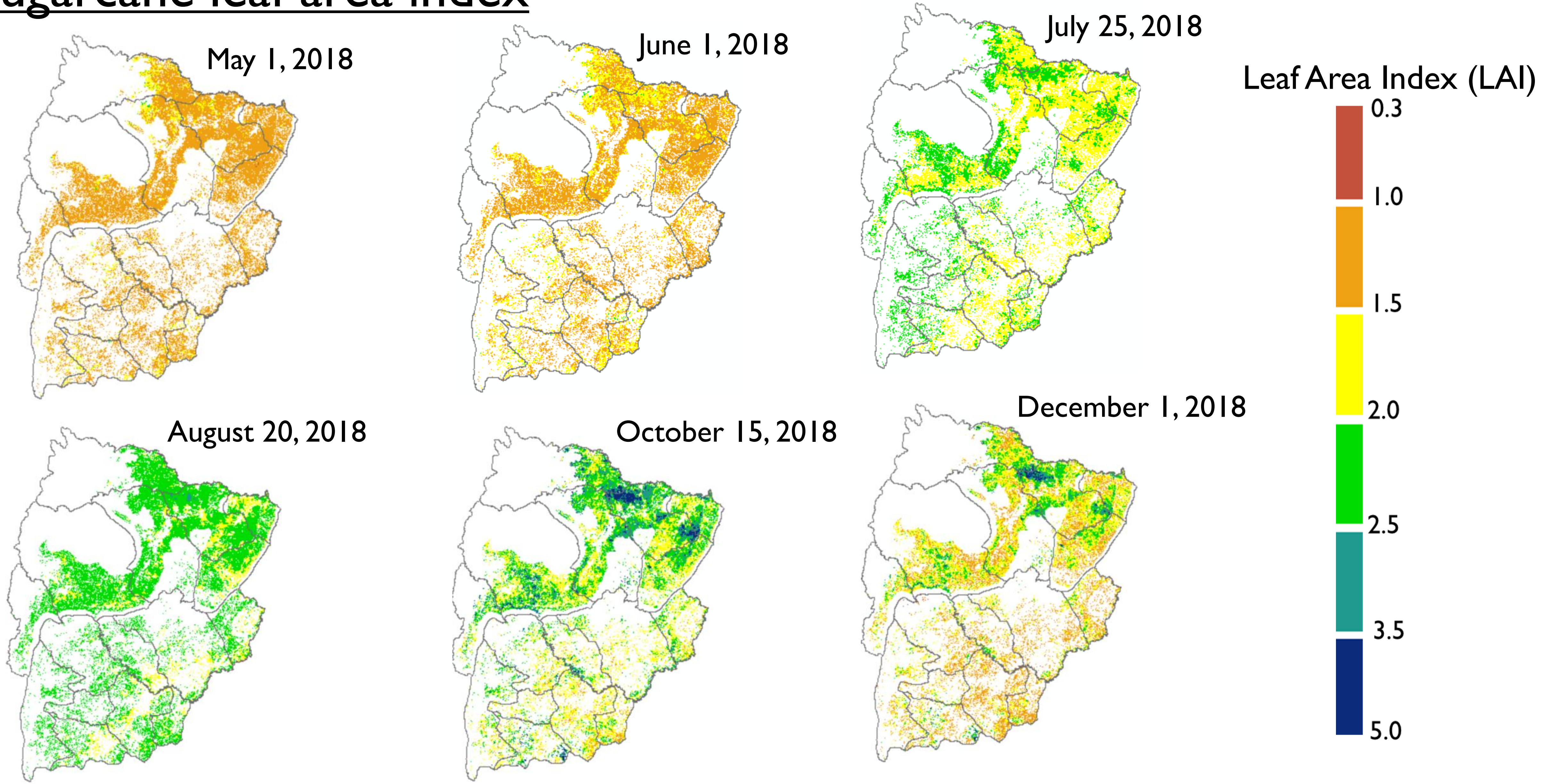
- PhenoCrop framework was used to estimate crop emergence/transplanted dates using downscaled MODIS data based on HLS product.





Task 2. Crop yield and water use simulations

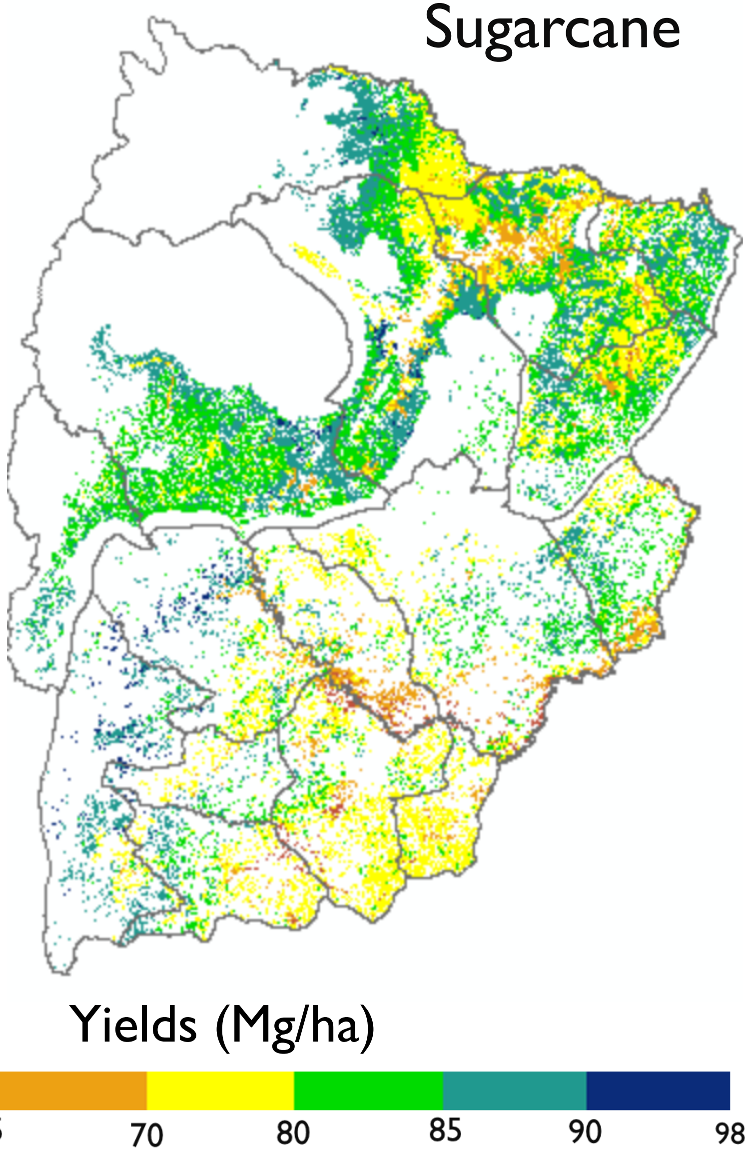
Sugarcane leaf area index



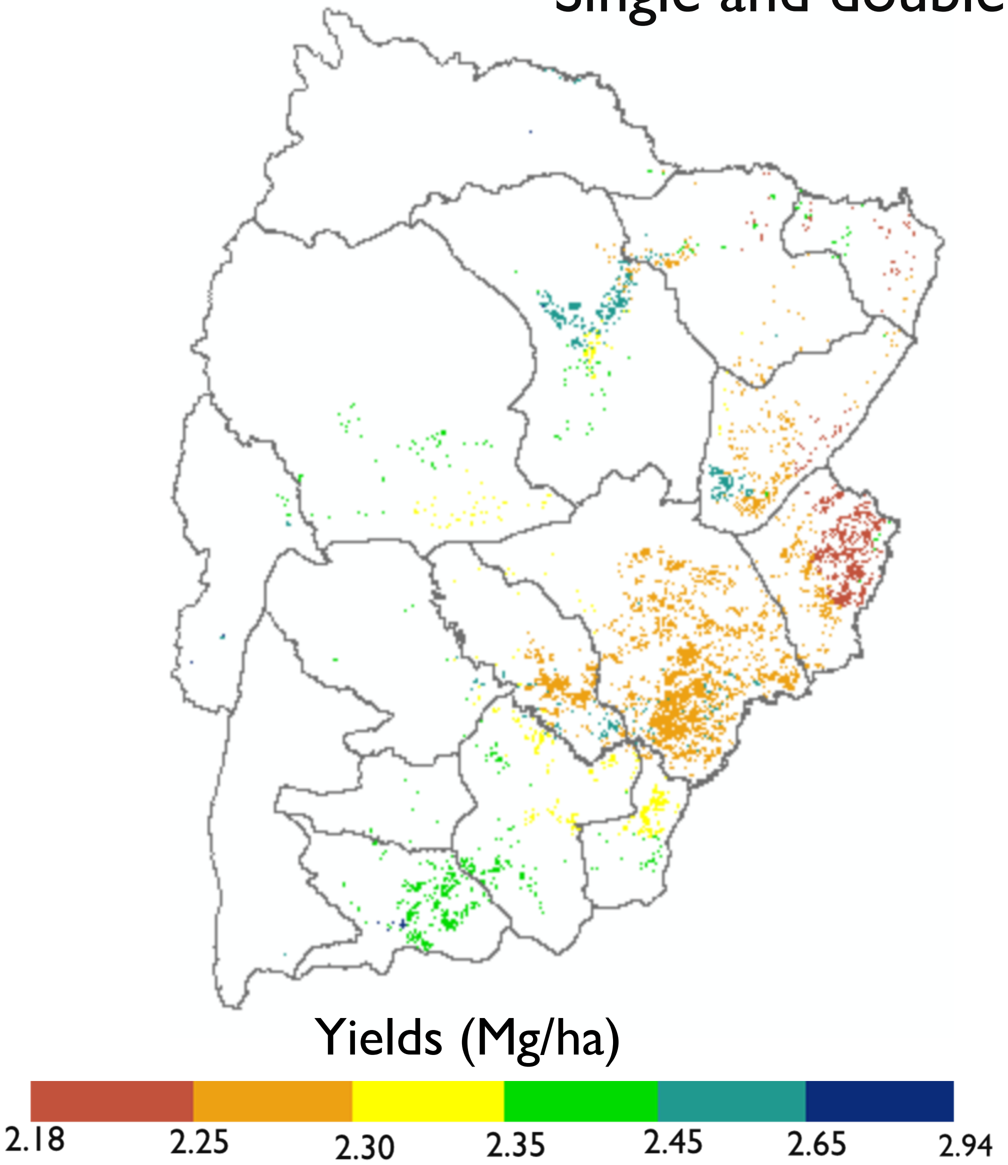
Task 2. Crop yield and water use simulations

Crop Yields

Sugarcane



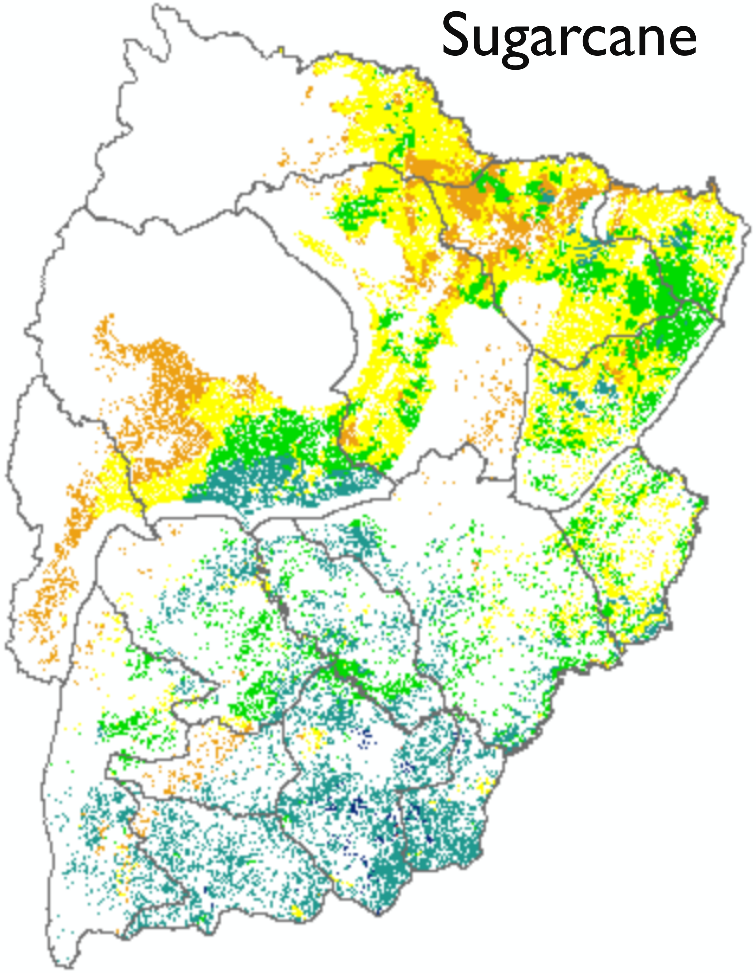
Single and double rice



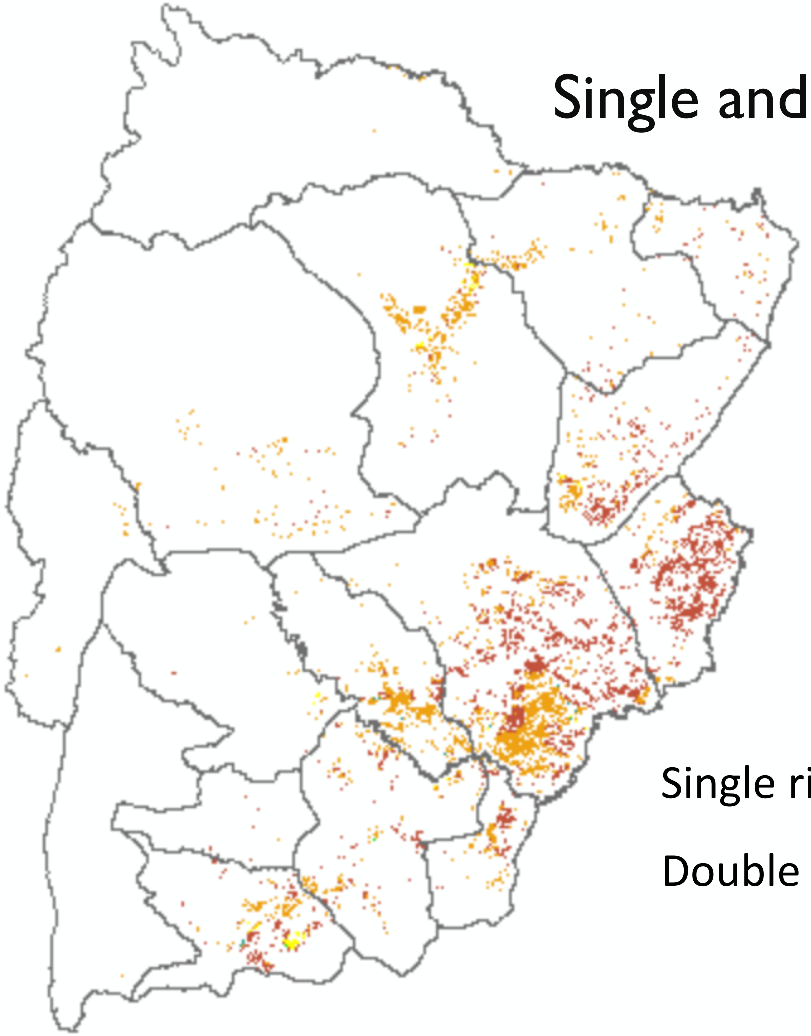
Task 2.1 Crop yield and water use simulations

Crop water use (ET)

Sugarcane



Single and double rice

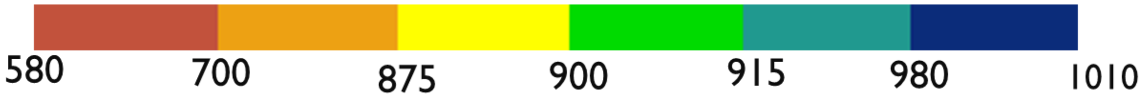


Single rice mean = 664 mm

Double rice mean = 791 mm

Mean = 905 mm

Water use (mm)



Task 2.2 Soil carbon dynamics

Soil sampling and analysis

- Collected 12 soil samples in three provinces on fields having history of various residue management practices (e.g. residue burning and no residue burning) in rice and sugarcane.

Sugarcane field – no residue burning

Sugarcane field – residue burning

Rice field – no residue burning

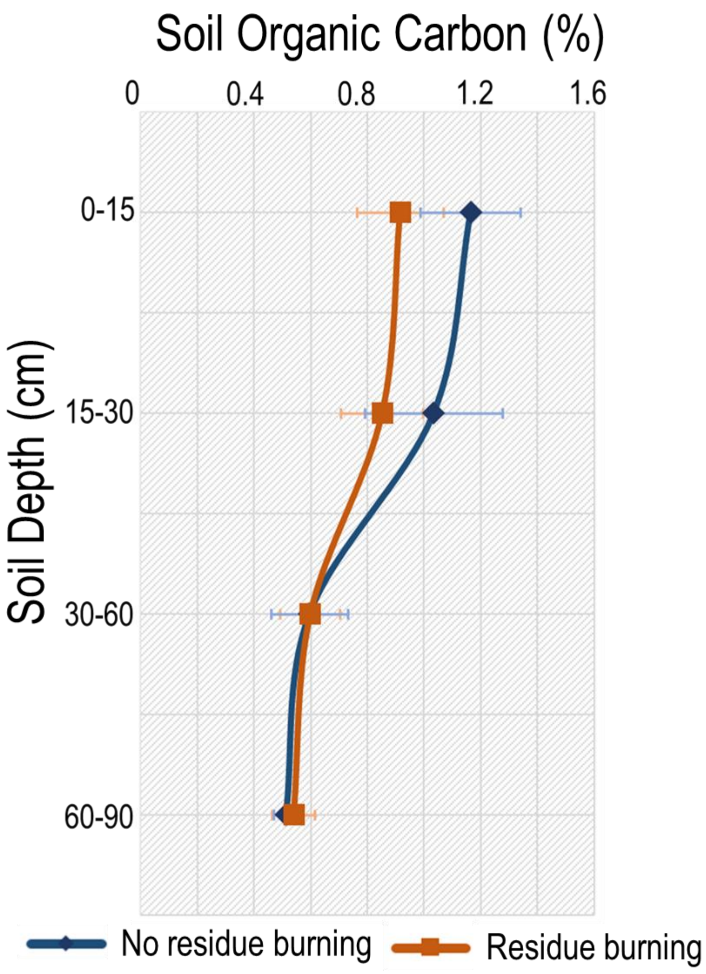
Rice field - residue burning

- Visual interpretation of soil profiles suggested that soils with no residue burning practice are apparently darker (high organic carbon) compared to the soils subjected to residue burning in both rice and sugarcane.

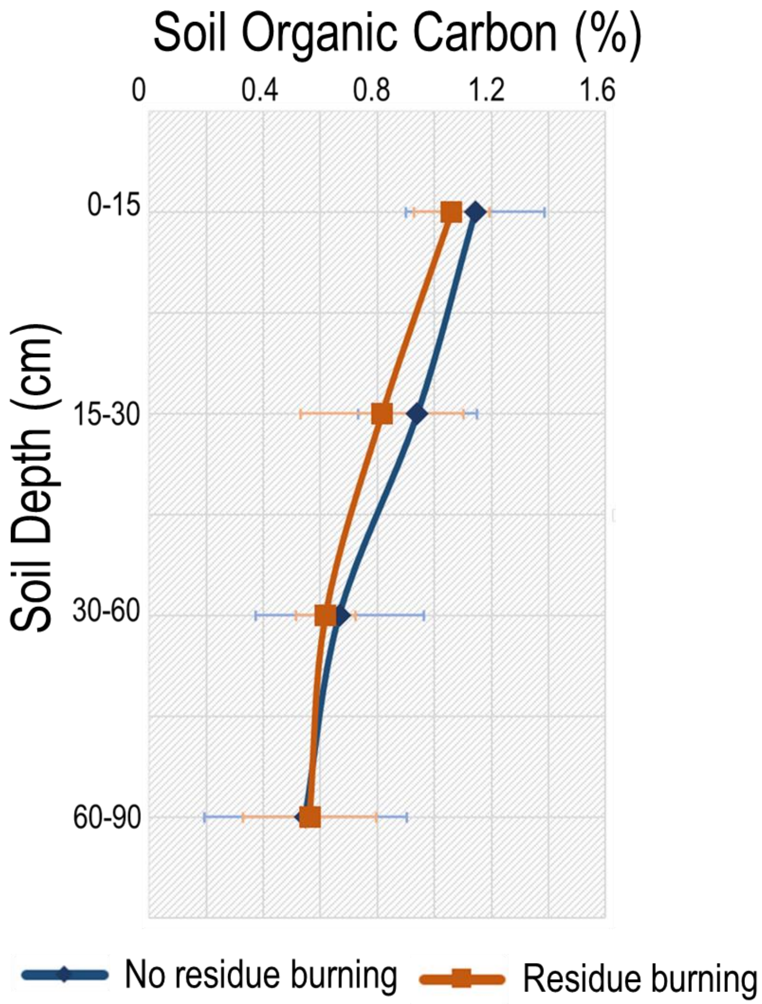
Task 2.3 Soil carbon dynamics

Soil sampling and analysis

Sugarcane



Rice



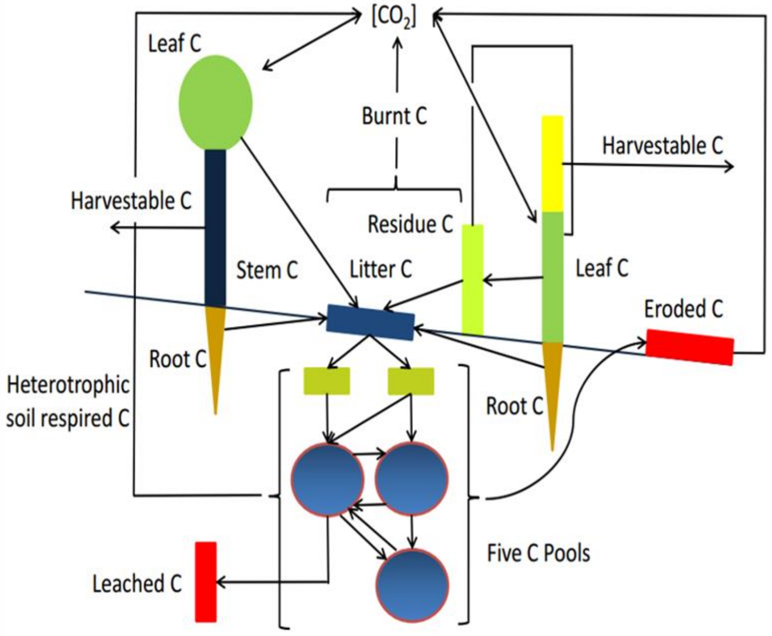
Task 2.3 Soil carbon dynamics

Land use change and residue management scenarios

Scenarios	Land use change	Change in residue management
Scenario-1	Sugarcane	No burning & no residue removal TO Burning
Scenario-2	Sugarcane	Burning TO No burning & no residue removal
Scenario-3	Sugarcane	Burning TO no burning & 50% residue removal
Scenario-4	Sugarcane	Burning TO no burning & 75% residue removal
Scenario-5	Single rice TO Sugarcane	No burning& no residue removal TO burning
Scenario-6	Single rice TO Sugarcane	No burning TO no burning & no residue removal
Scenario-7	Double rice TO Sugarcane	Burning TO burning
Scenario-8	Double rice TO Sugarcane	Burning TO No burning & no residue removal
Scenario-9	Double rice TO Sugarcane	Burning TO no burning & 50% residue removal
Scenario-10	Double rice TO Sugarcane	Burning TO no burning & 75% residue removal

- EPIC has detailed representation of various carbon pools and accounts both vertical and lateral fluxes.

- Alternative practices in the place of residue burning include 1) retaining residue on the field 2) removing for bioenergy.

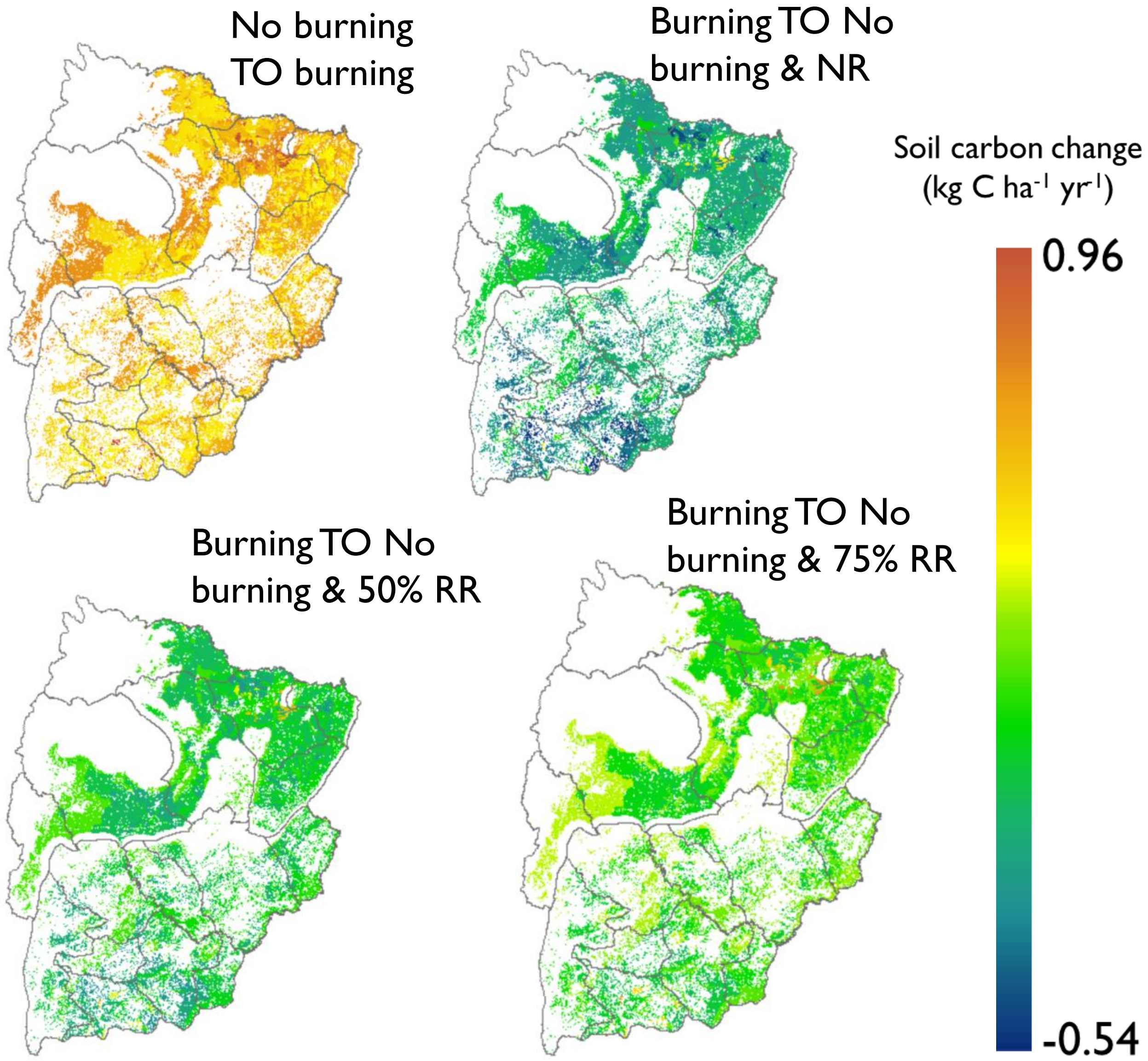


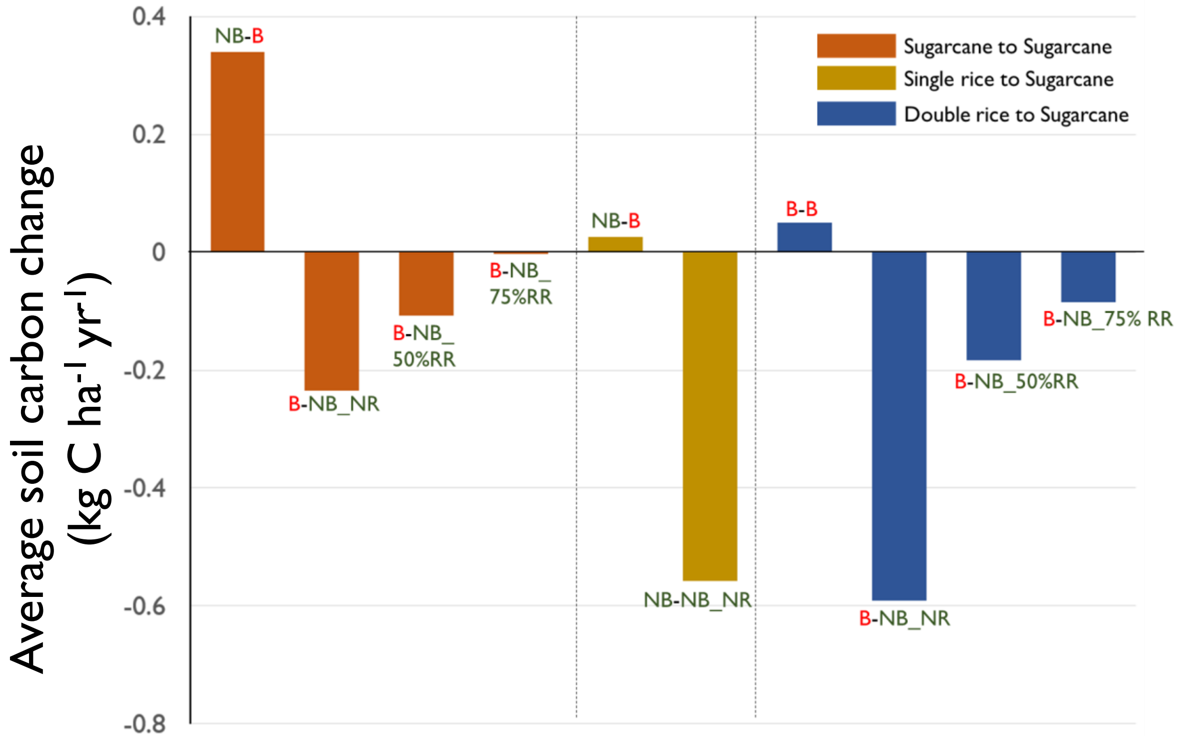
Representation of carbon pools in EPIC model

Residue collection for bio-power plant

Task 2.3 Soil carbon change dynamics

Regional soil carbon change





Average soil carbon change under different scenarios.

Conclusions and future work

- Crop type maps with high accuracy for 2018 were produced using HLS and sentinel-1 SAR data.
- Crop yields and water use under rice and sugarcane systems were estimated using RS EPIC spatial modeling framework.
- Soil organic carbon was shown to decline with residue burning in the top soil layers.
- We estimated regional soil carbon change under combination of different land use change and residue management practices.
- Conversion to no-residue burning irrespective of residue removal up to 75% was shown to increase the carbon sequestration.
- We combine survey data, crop type maps and other satellite observations to improve the burn area mapping and use pixel level residue to improve estimates of greenhouse gas emissions.

Thank You.