Satellite Observations of Changes in Agriculture in the Vietnam Mekong Delta under Human and Climate Pressures

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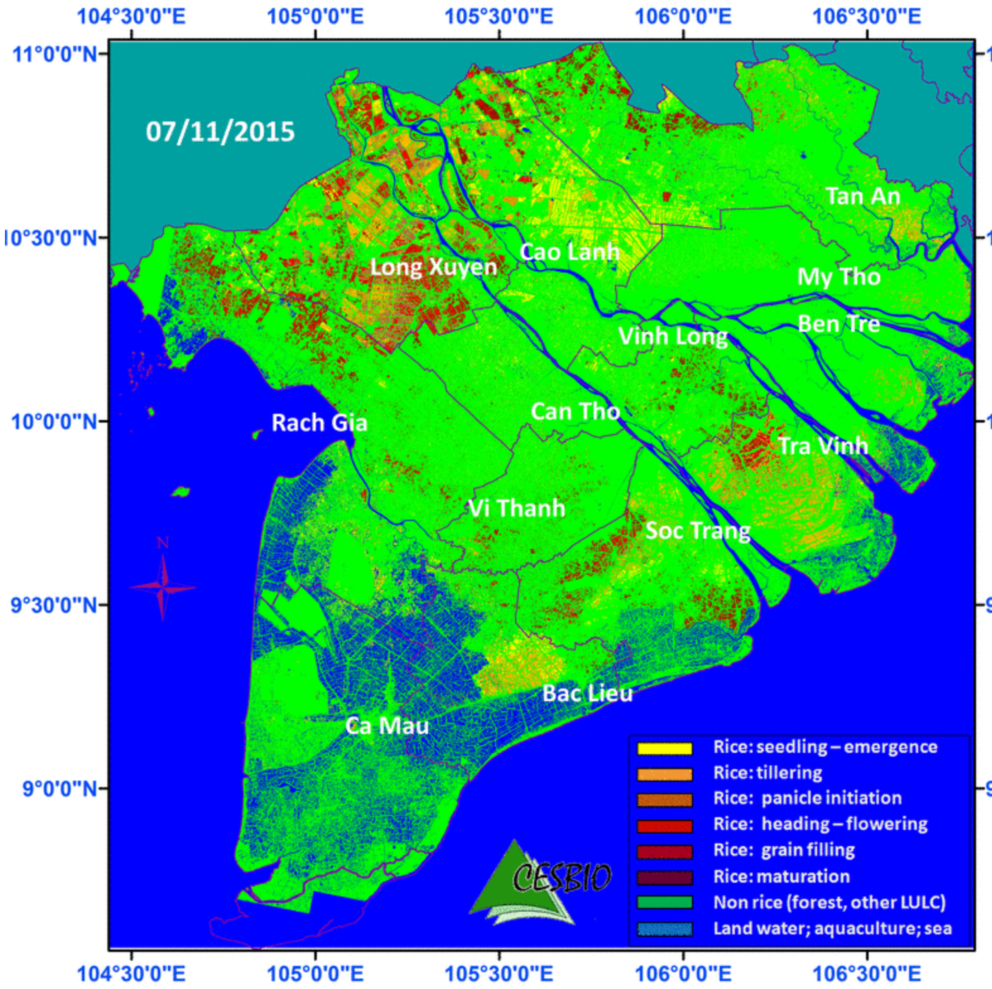
Hanoi, 1 February 2024

Scope of the study: Rice agriculture in the Vietnam Mekong Delta observed using Remote Sensing

- 80% of 17.4 million people engaged in rice production
- 56% of the country rice production
- 90 % of the country's rice export (world third-largest rice exporter)

- VMD: Covers 40.500 km2

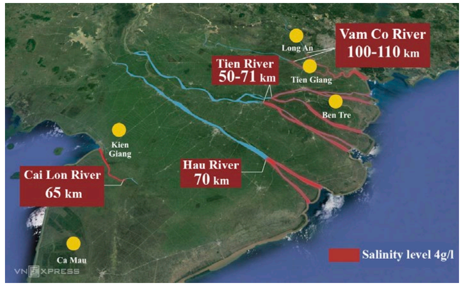


Rice phenological stages monitored using Sentinel-1

- Contributing to national food security,
- Affecting the livelihoods of farmers,
- Contributing to social security and social stability,
- Conveying ecological and cultural values in Vietnamese society.

The Mekong Delta is facing biggest challenges caused by increasing Climate Change

Droughts



Saltwater intrusion

Low-lying land, impacted by Sea Level Rise

Floods

Subsidences

The Mekong Delta is facing biggest challenges caused by increasing Climate Change and growing Human interventions

How can research help inform more sustainable agriculture policies ?

- ***Resolution No.120****/NQ-CP dated November 17, 2017 on sustainable and climate-resilient development of the Mekong River delta:*
  -to **increase the rice quality rather than the volume**
  -to **diversify rice-based farming systems**

- **Reducing GHG emissions in rice production** by adapted cultural practices in the updated 2020 **National Determined Contribution** as the national strategy for achieving **emission reduction**

- **Decision-No-555-**QD-BNN-TT-2021 on the adaptation measures to climate change for rice agriculture
  Complete warning **maps of saltwater intrusion, drought and flooding** , to provide the basis for technical solutions (e.g **adjust planting season, rice varieties, rotation rice-other land use**)

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How can research help inform more sustainable agriculture policies ?

Study objectives

1. To observe the changes in agriculture, to understand their causes, and to project future impacts under different scenarios of CC and human pressures.

2. To provide mapping information of climate and human-related risks impacting rice land, using **in situ and satellite observations** (present) and **model-based projections** (future).

3. To derive possible options for adaptation and mitigation measures to current problems and also a potential roadmap for natural solutions.

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Scientific Initiatives

Asia-RiCE Crop Estimation and Monitoring

GEOGLAM Global Agricultural Monitoring

SARI

SCO SPACE CLIMATE OBSERVATORY

Research Projects

GEORICE

AFD

GEMMES

VietSCO SPACE CLIMATE OBSERVATORY

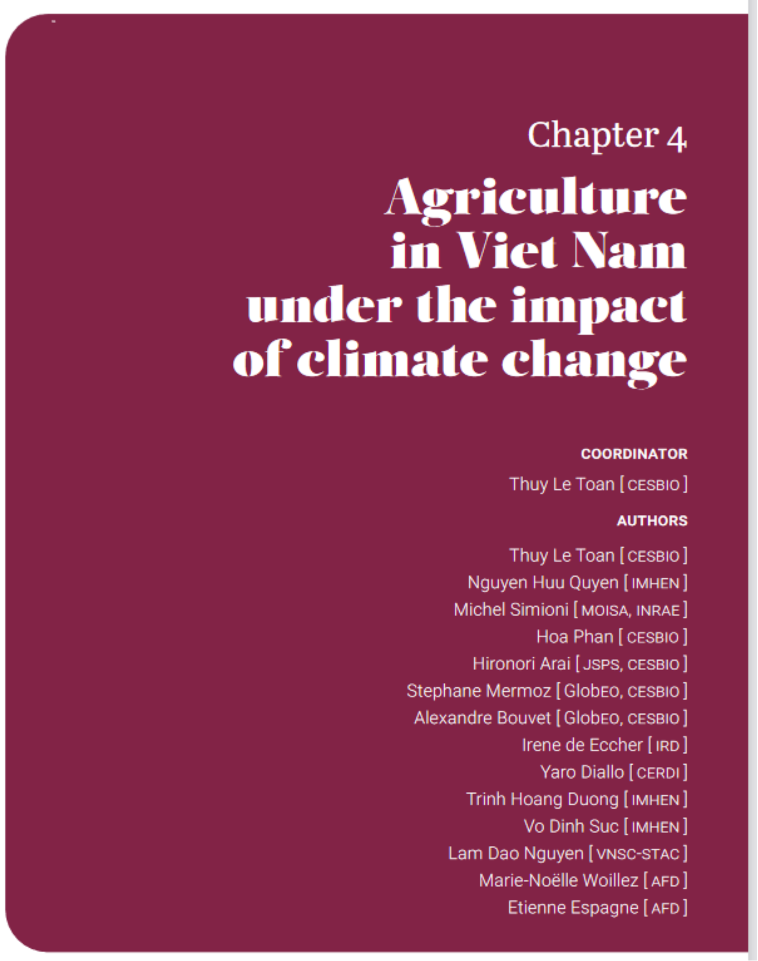
FAO FIAT PANIS

STAR-FARM

In collaboration between

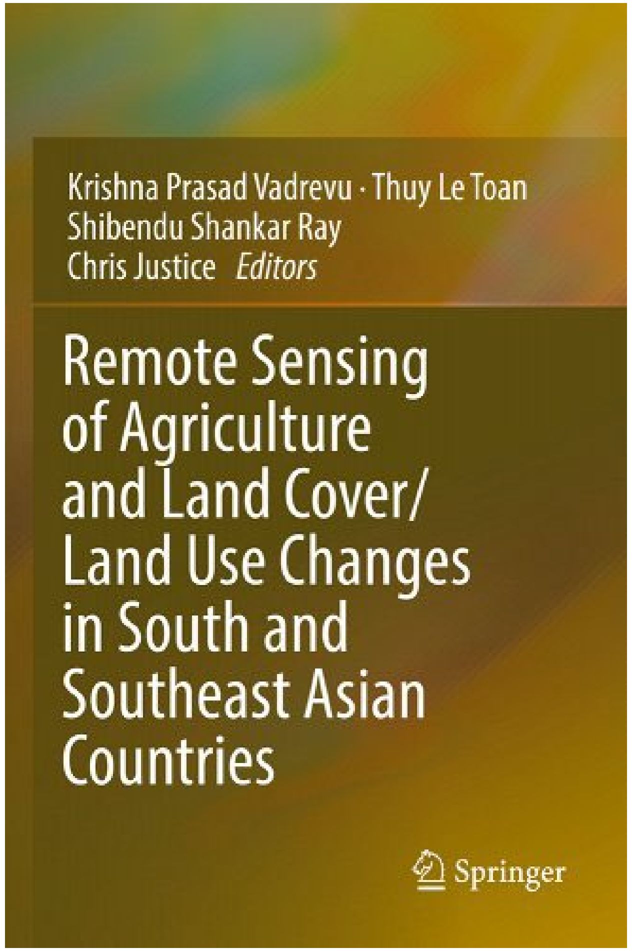
CESBIO	Thuy Le Toan
GlobEO Global Earth Observation	Stephane Mermoz
VNSC Lift-off your Dream	Lam Dao Nguyen
IMHEN	Nguyen Huu Quyen
IRRI	Hironori Arai
GISTDA	Panu Nueangjumnong

AFD book for COP 26 (2021)



AFD book for COP 27 (2022)

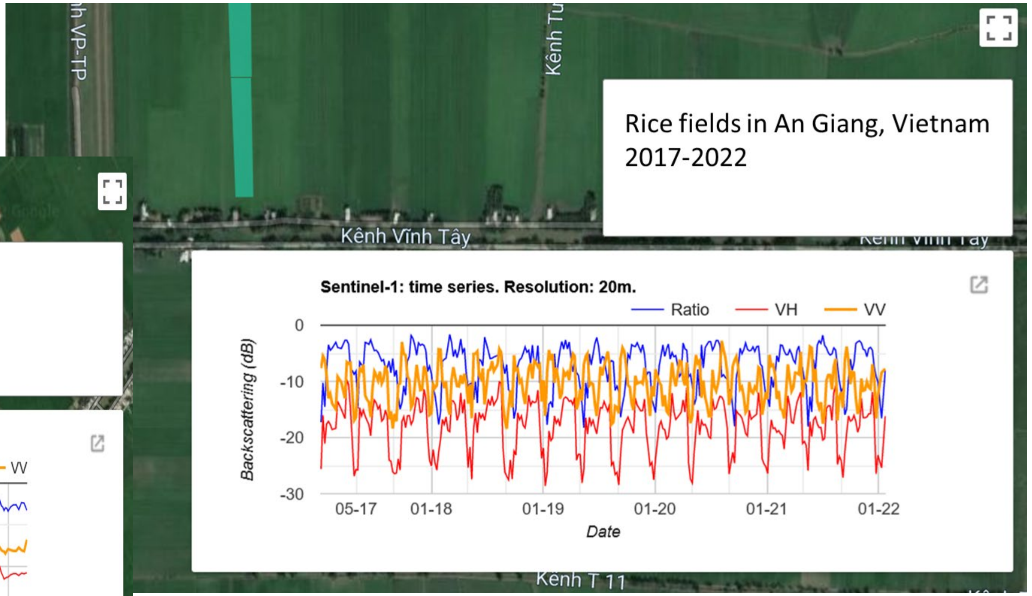
SARI publication (2022)

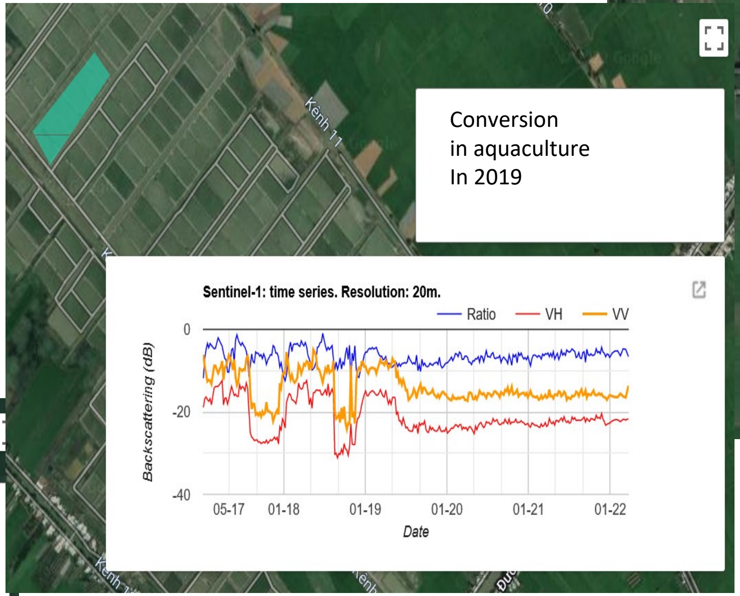


Among satellite data used, the major source is radar data (Sentinel-1) for systematic and cloud free observations

- Free of charge and available world wide data
- Derived Products: rice map, cropping density, sowing date, phenology, flooding ,
- Cf. Presentation Lam Dao Nguyen

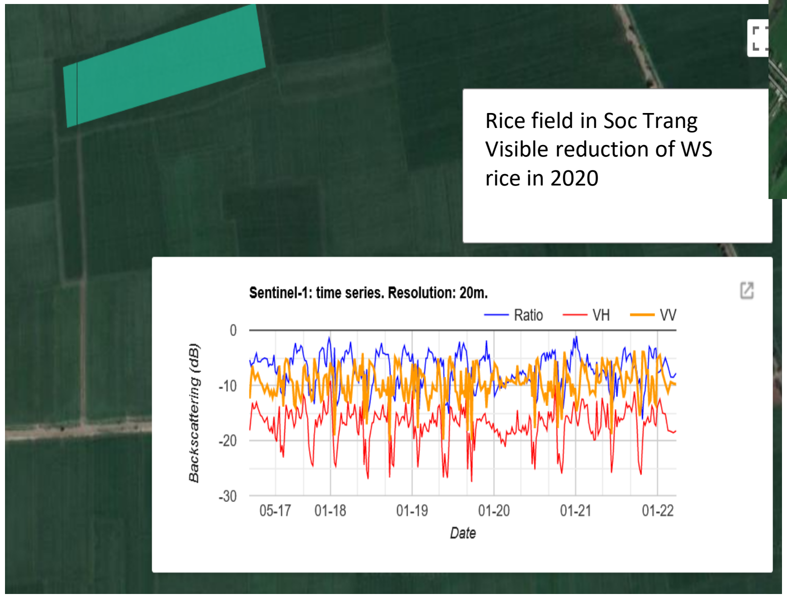
Intensive cropping: 3 crops per year





Algorithms based on time series data

Loss of WS crop in 2020 followed by change from 3 to 2 crops



Training program on the use of SAR data for crop and forest monitoring

- SARI: Hanoi (2024), PnomPenh (2023), Johor Barhu (2019), Manila (2018), Yangon (2017)…
- Vietnam School of Earth Observation (2023, 2019)
- ESA training program
- Airbus-Thailand (2022-2024)….

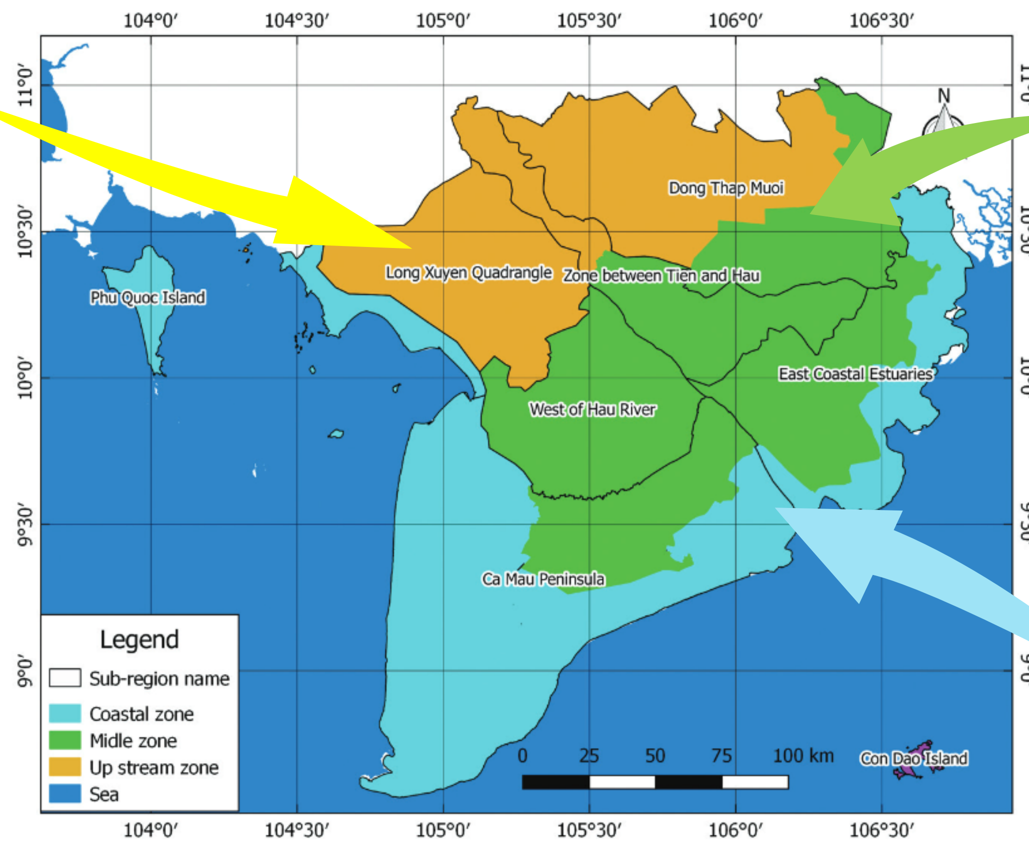
The resilient rice farming strategy

to be considered in

the three main eco-hydrological sub-regions

High flood zone

Characterized by flood ecology, intensified by the annual flooding season.



Source: Bong *et al.*, 2018.

Fresh water zone

The middle alluvial fresh water region

Coastal zone

The coastal area and Camau peninsula experience drought, salinity intrusion, and subsidence

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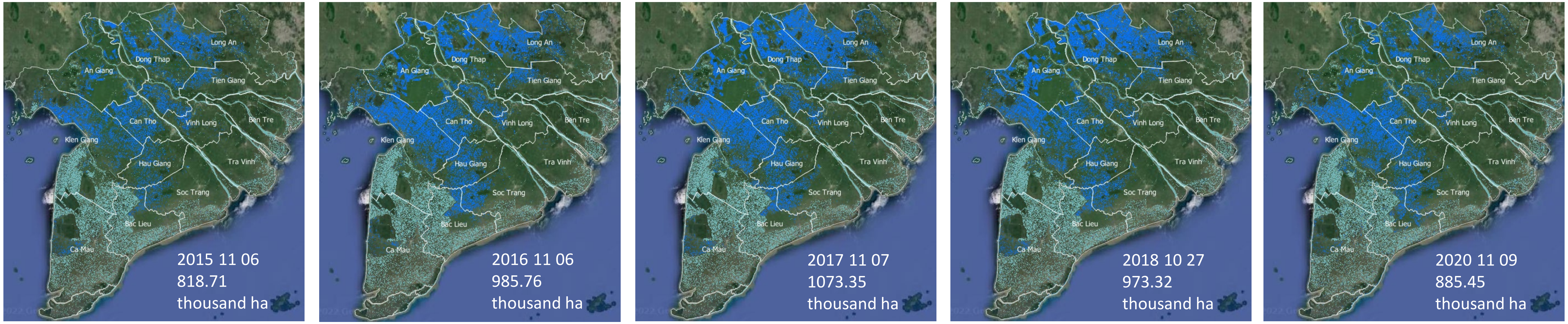
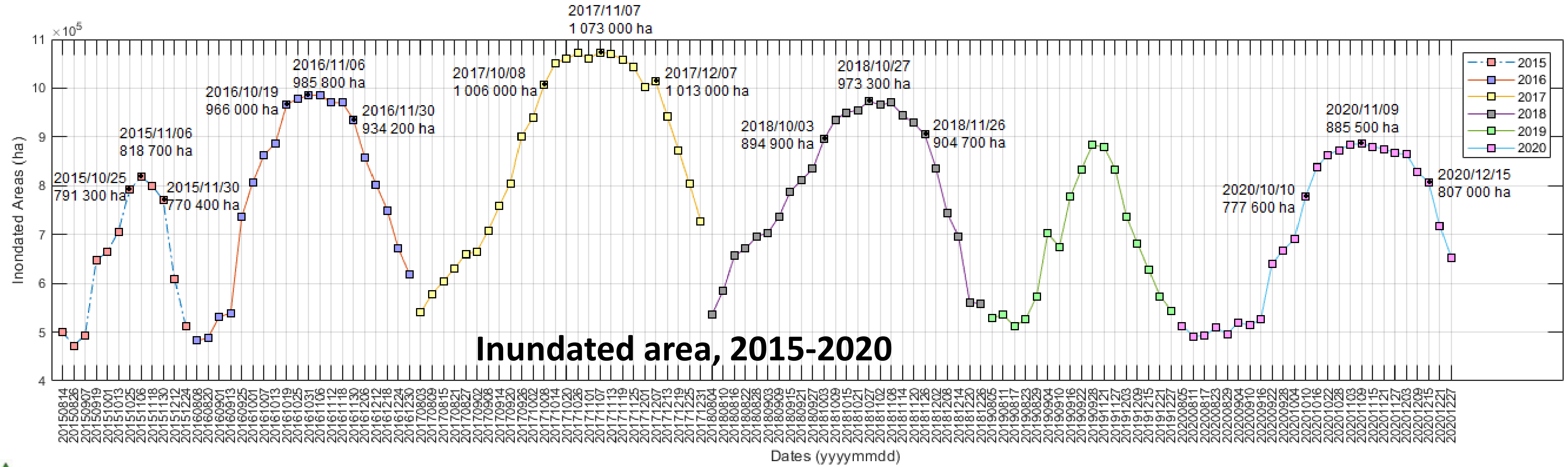
Flood extent and timing are observed to have significant interannual changes





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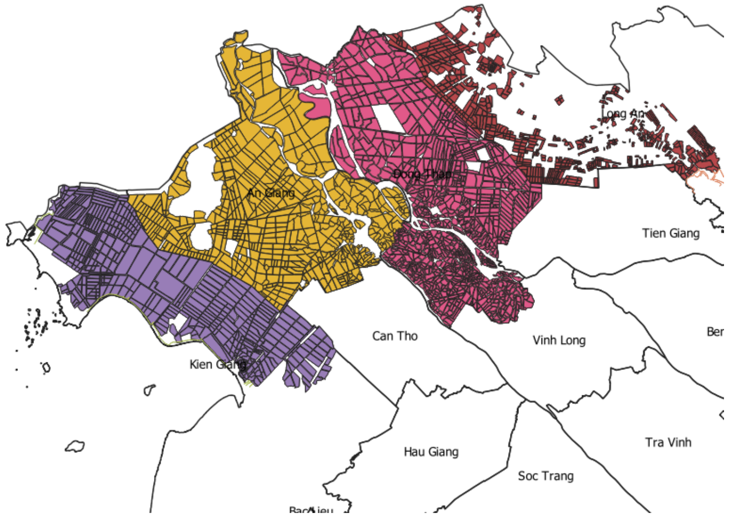
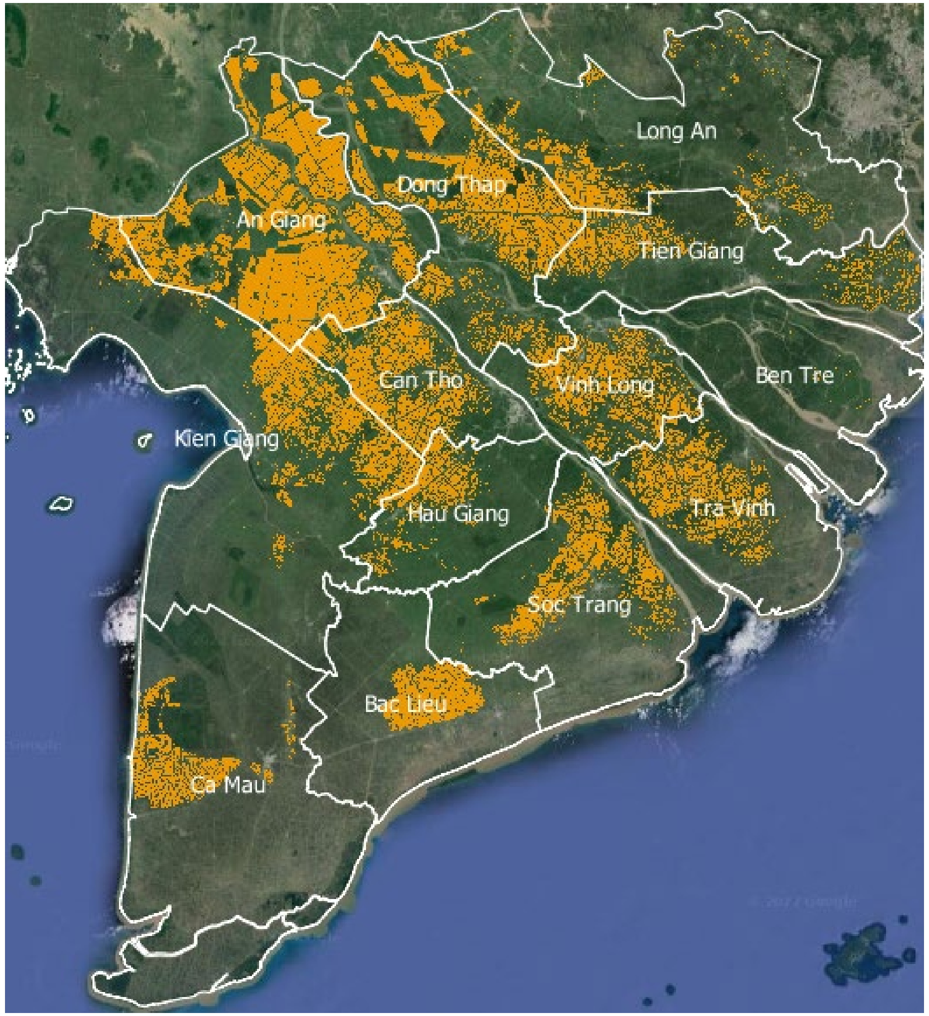
In high flood zone, high dykes systems allow flood season (AW) rice



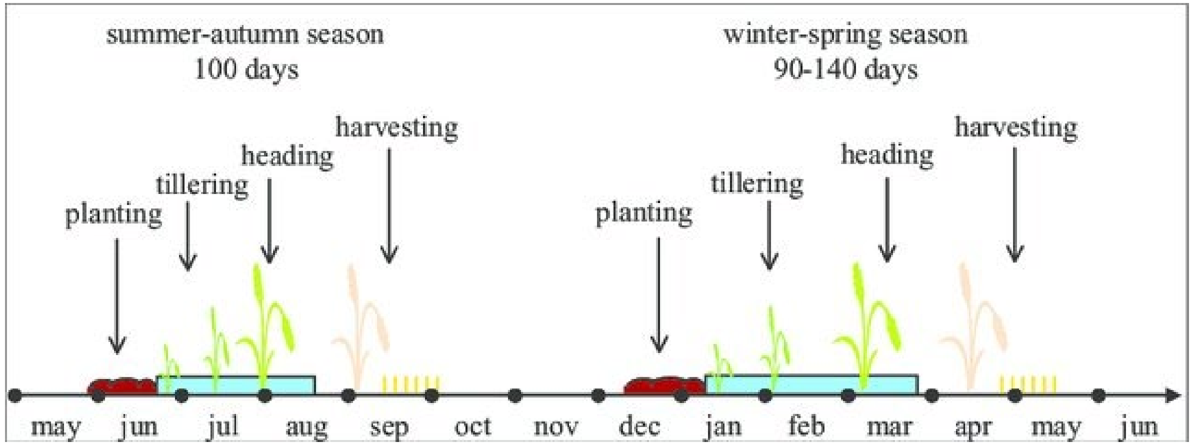
dyke rings have been built

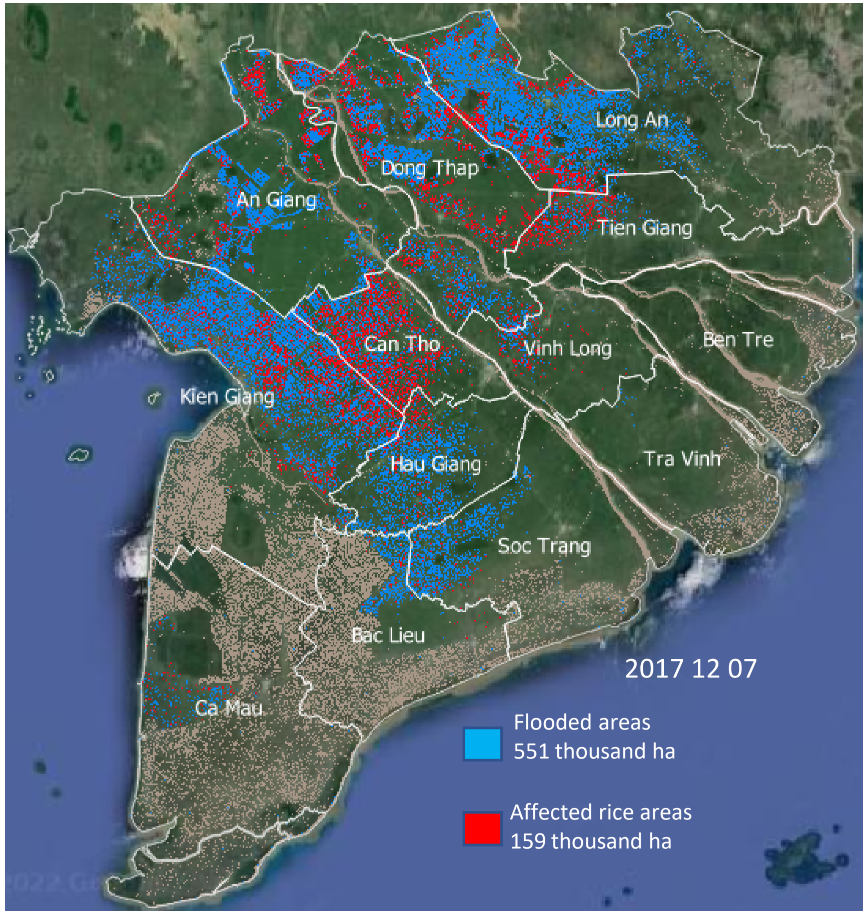


2017-2020
Detected rice area
739.600 ha

The unpredictable flood extent and timing observed to damage rice crop downstream

Flood Season

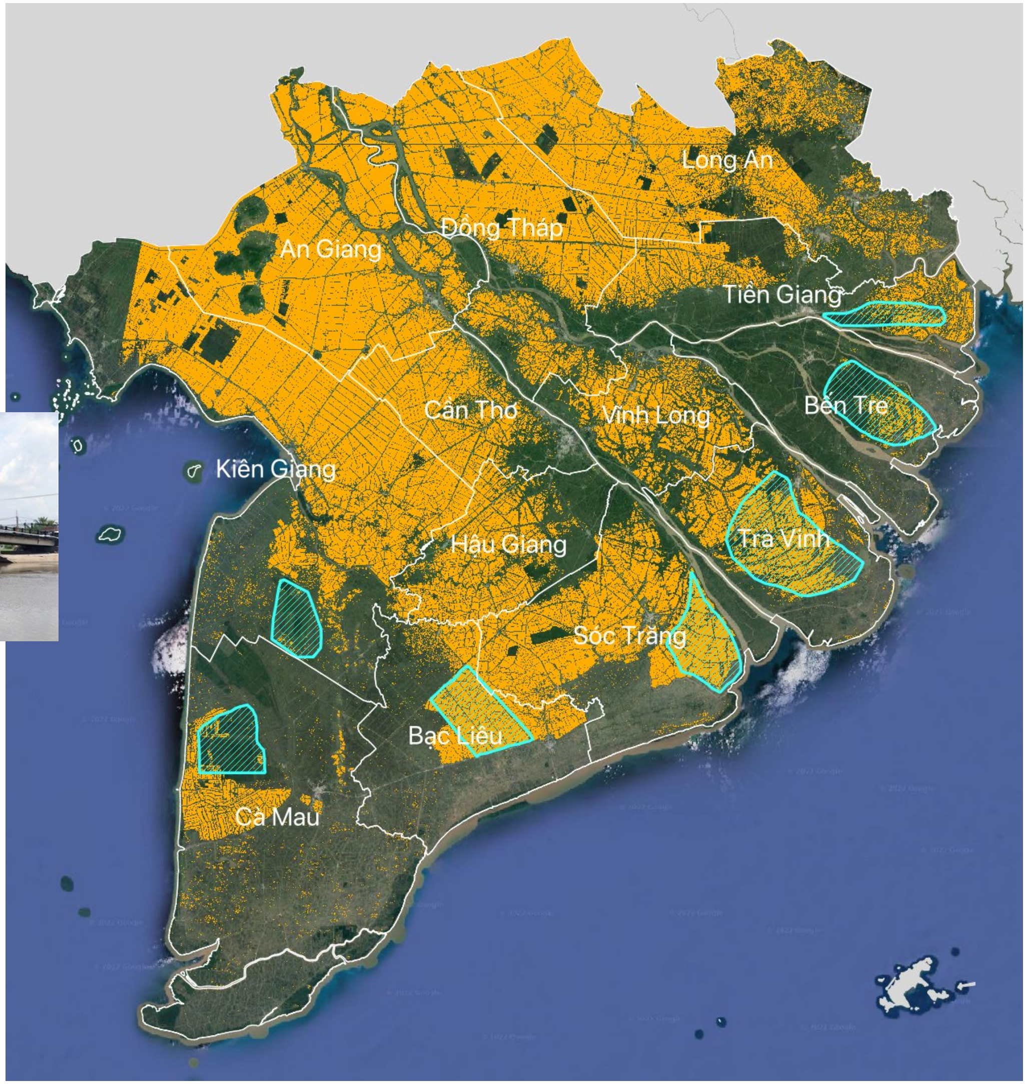




Ex: Late flood (Dec 2017) impacting Winter-Spring rice

In coastal zone, large hydraulic structures built for salt water prevention allow dry season (WS) rice

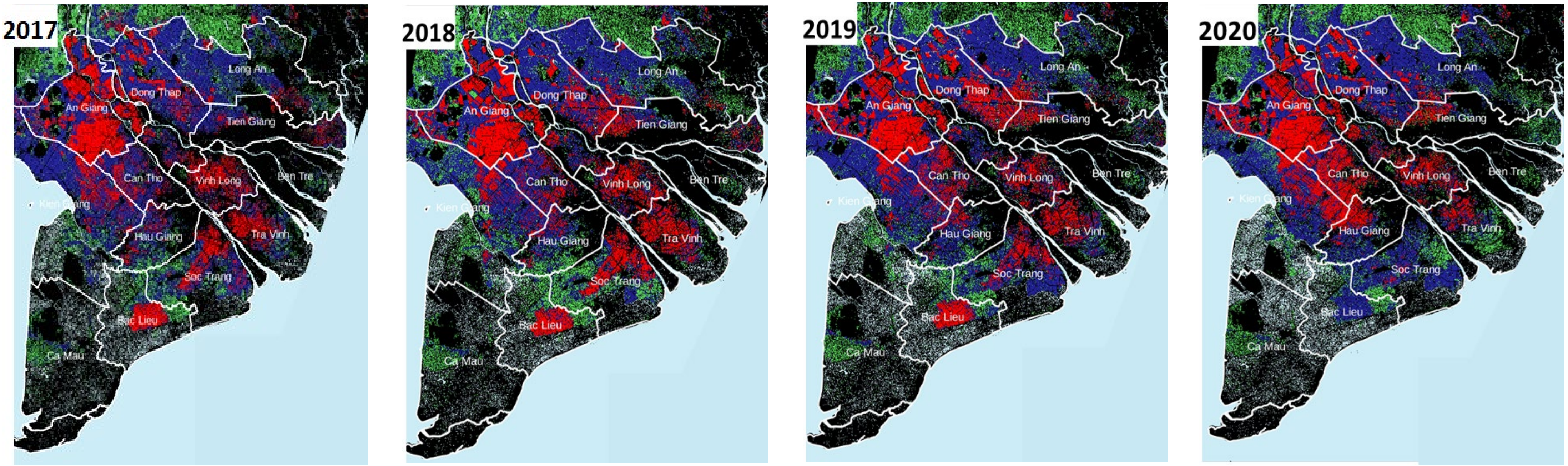
Kien Giang.



A saltwater prevention sluice in the province of Bến Tre. – VNA/VNS Photo Công Trí

2017-2020
Detected rice area:
1.545.800 hectares

However, large variability can be observed over years on the cropping density



Drivers of the variability:

- Climate factors causing harvest loss
- Autonomous adaptation by farmers
- Regulation by local authorities
- …..

Red: 3 harvested rice crops
Blue: 2 harvested rice crops
Green: 1 harvested rice crop

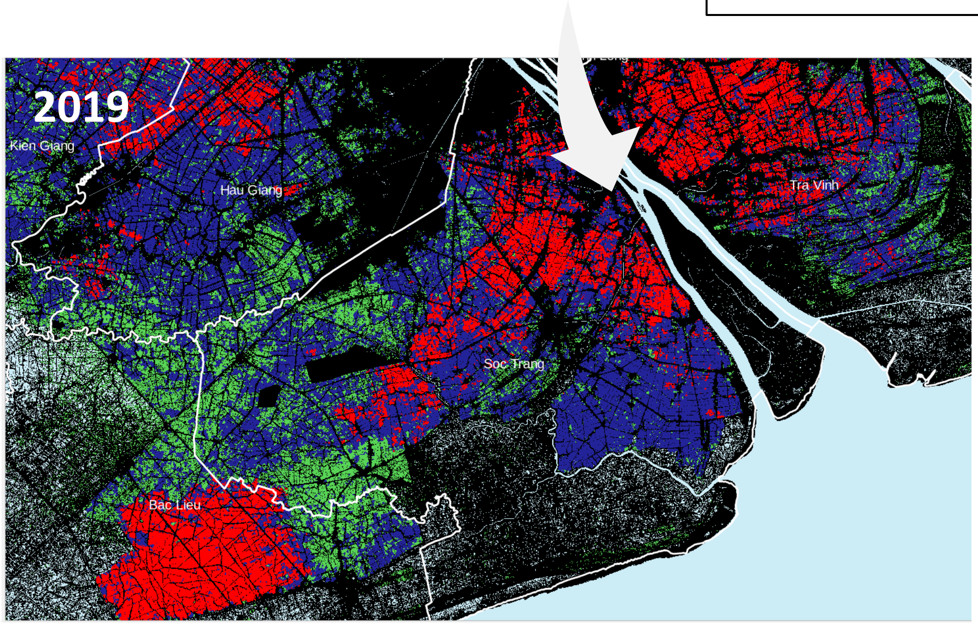
However, large variability can be observed over years on the cropping density

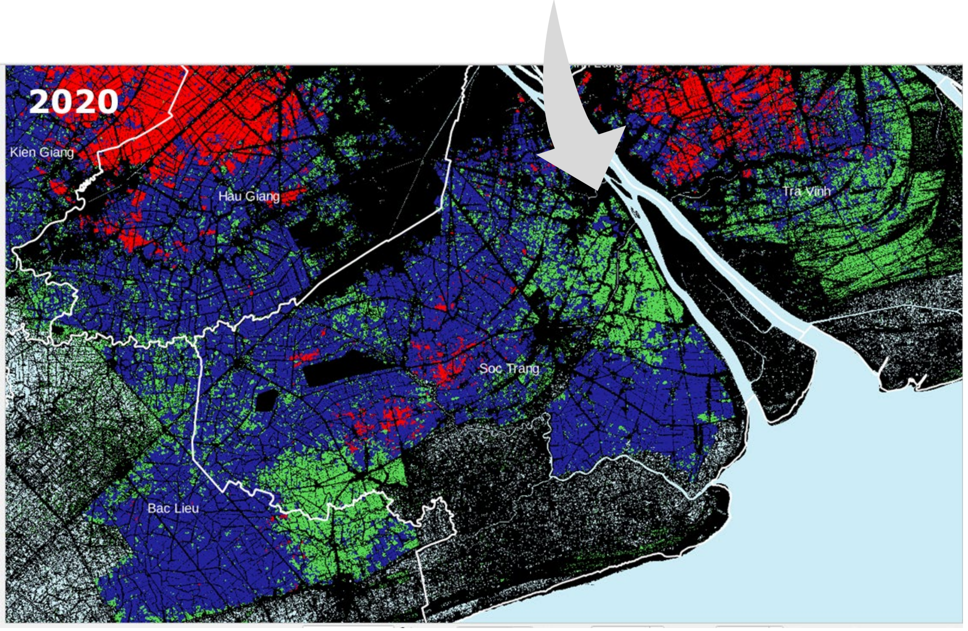
Reduction in dry season rice harvested area in 2020 as compared to 2019 (-13%)

The impacts were significant on coastal provinces

Red: 3 harvested crops
Blue: 2 harvested crops
Green: 1 harvested crop

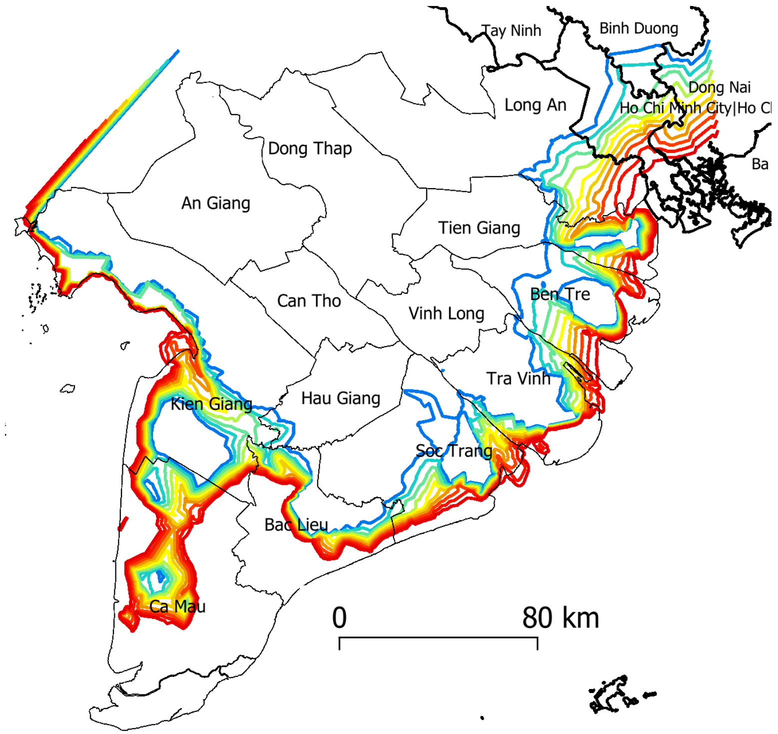
From 3 crops to 1 crop per year





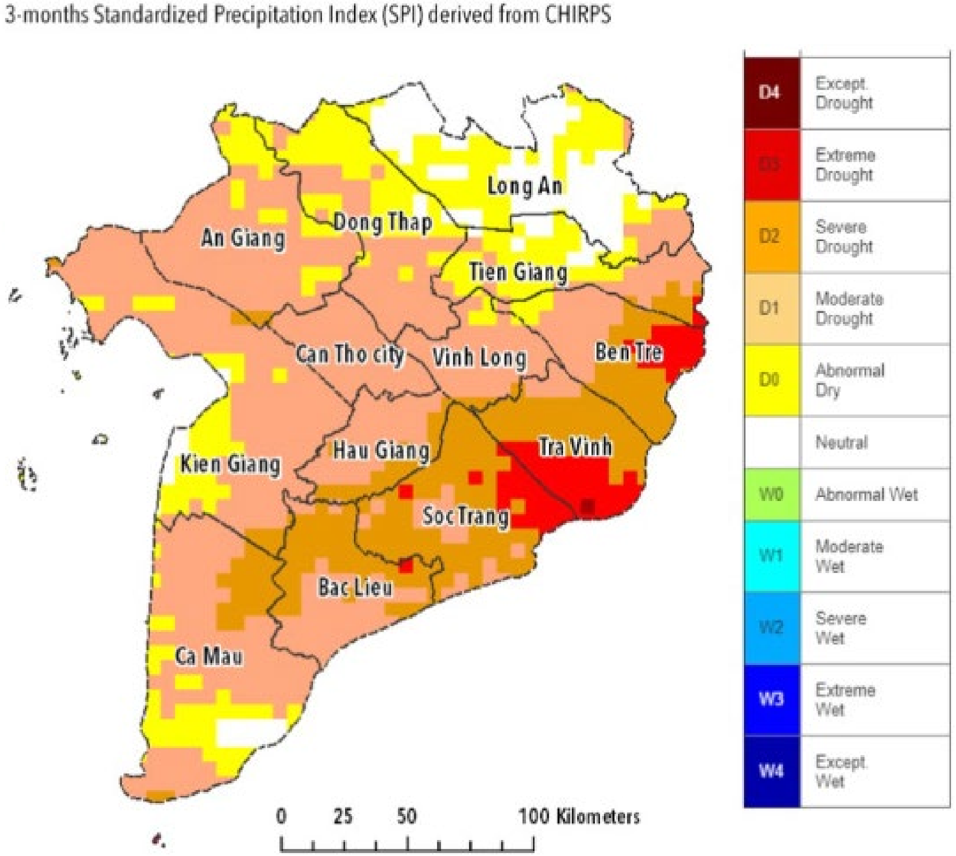
Salinity intrusion observed to increase: Sea Level Rise combined with drought and reduced river flow during dry season

Present salinity **isolines**



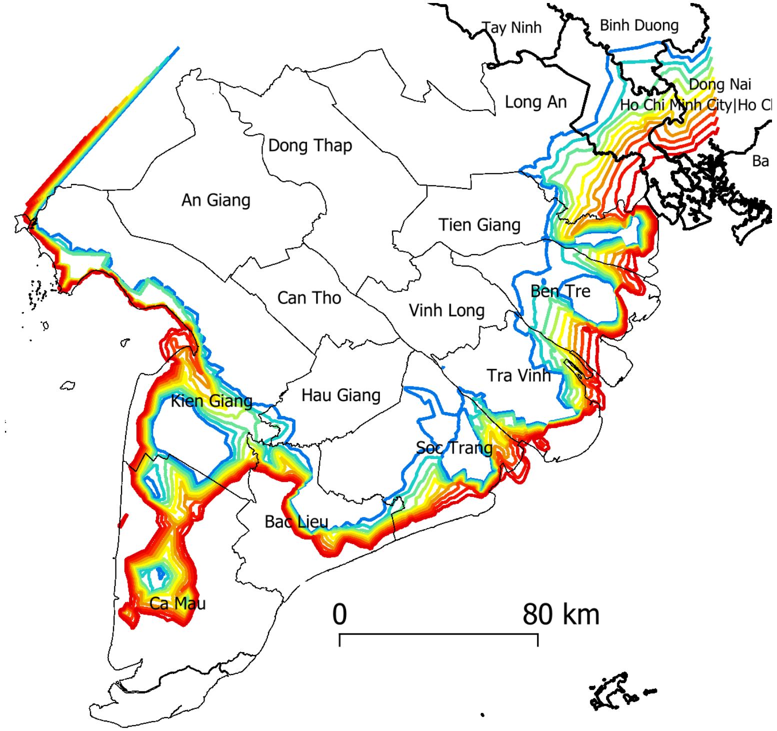
Salinity isolines of 0, 2, 3, 4, 5,… 20‰
(at 50% of the time).
Data from S. Eslami, 2021

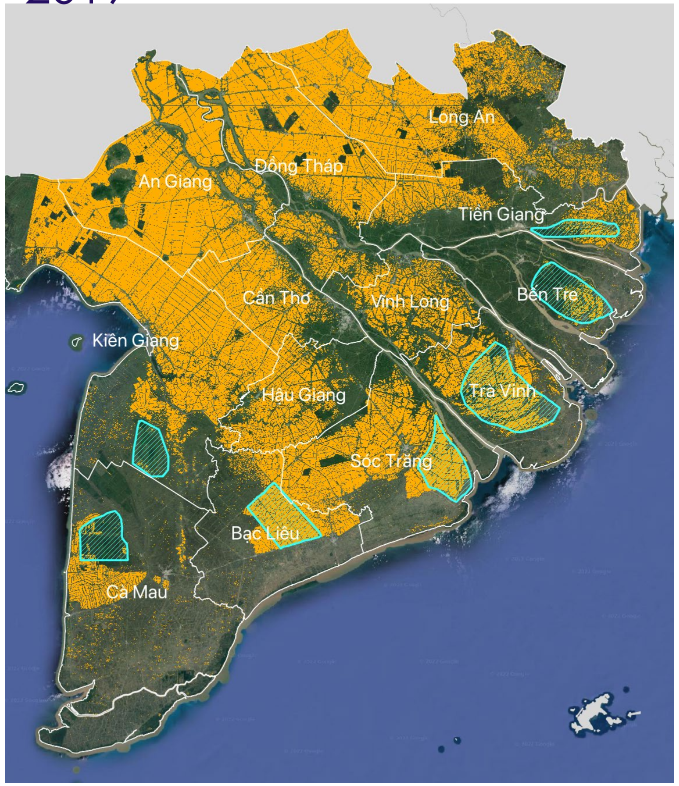
Standardized Precipitation Index



Salinity intrusion observed to increase: Sea Level Rise combined with drought and reduced river flow during dry season

Present salinity isolines vs Distribution of dry season rice 2019





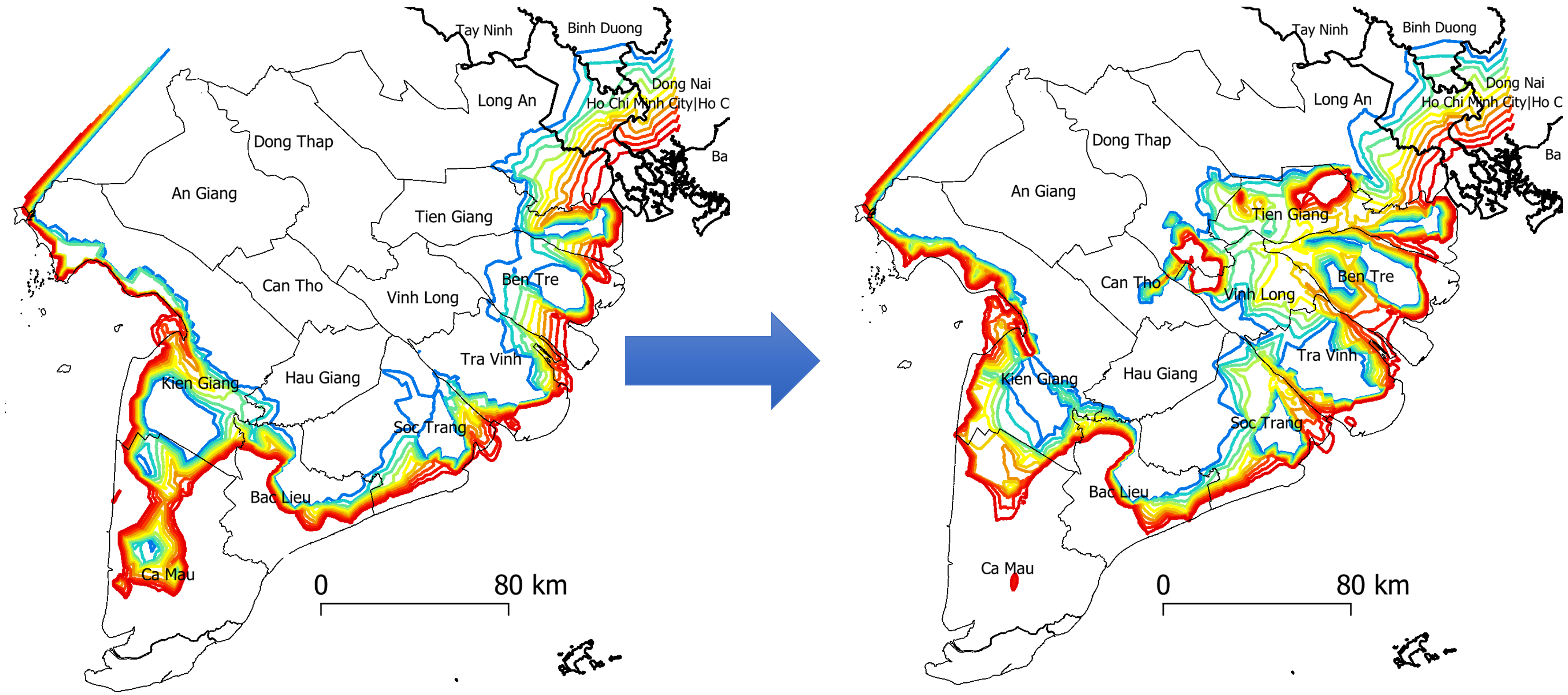
Salinity isolines of 0, 2, 3, 4, 5,… 20‰ (at 50% of the time).
Data from S. Eslami, 2021

Rice is at present reduced in coastal area, only on land with salinity <0,3%

Planning program requires understanding of the impacts in future scenarios of CC and human activities

Q: Where the land will become unsuitable to rice cultivation in future scenario of salinity intrusion ?

Present isolines **2050 Scenario**



Salinity isolines of 0, 2, 3, 4, 5,… 20‰ (at 50% of the time).

Isolines based on Data from S. Eslami, 2021

Scenario on impacted rice land

- **RCP 4.5** (Discharge and Sea level rise),
- **Moderate subsidence**,
- Riverbed level incision (5cm/year)

in 2050

Present salinity intrusion without sluice gates

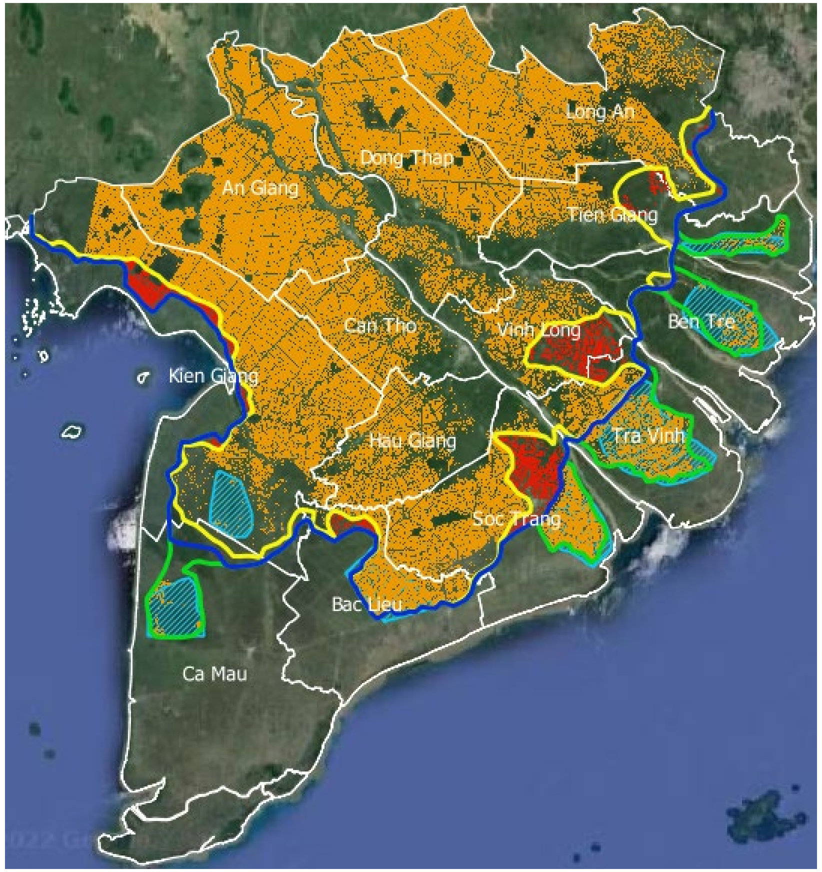
Present salinity intrusion with sluice gates

Projection salinity intrusion

Affected rice areas

(**80.48 thousand hectares**)

Non-affected rice areas



Scenario on impacted rice land

- **RCP 8.5** (Discharge and Sea level rise),
- **Extreme subsidence**
- Riverbed level incision (15cm/year)

in 2050

Present salinity intrusion without sluice gates

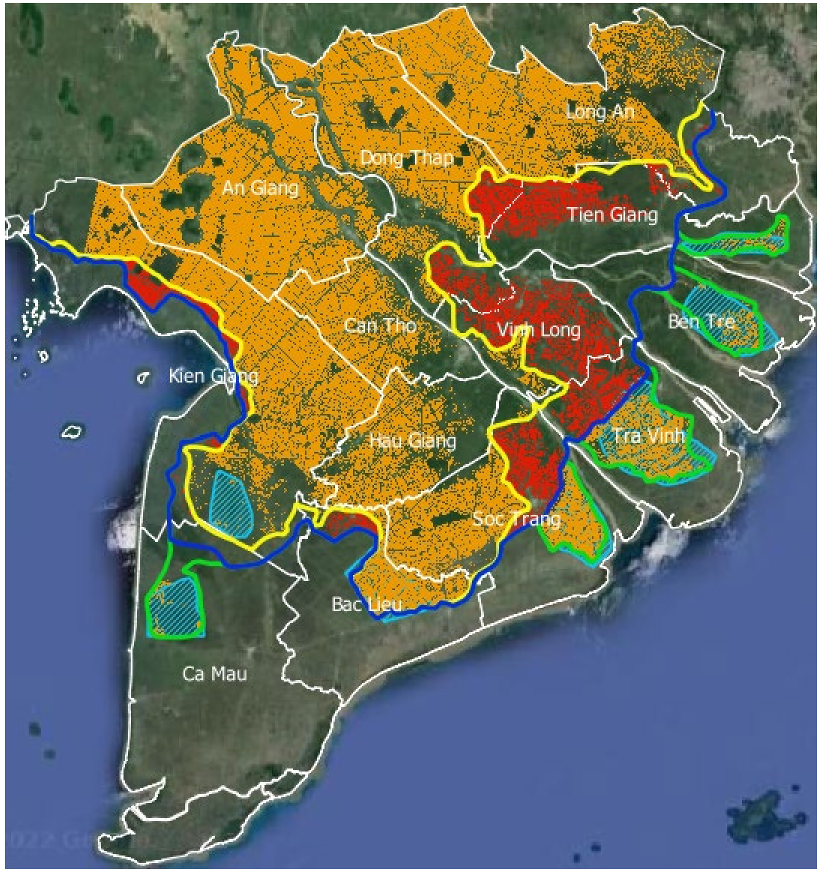
Present salinity intrusion with sluice gates

Projection salinity intrusion

Affected rice areas

(**208.07 thousand hectares**)

Non-affected rice areas



Impacts on rice area significantly increase with river bed incision caused by river sand extraction

Scenario on impacted rice land

- **RCP 8.5** (Discharge and Sea level rise),
- **Extreme subsidence**,
- Riverbed level incision (15cm/year),
- **Removing all the sluice gates in 2040**

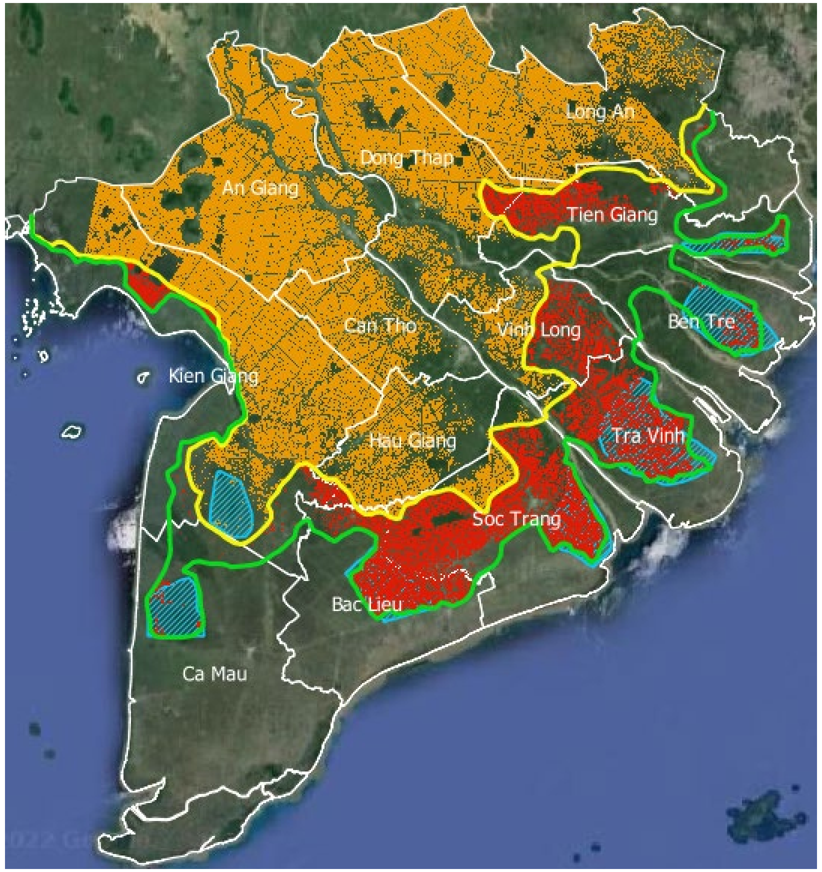
Present salinity intrusion with sluice gates

Projection salinity intrusion

Affected rice areas

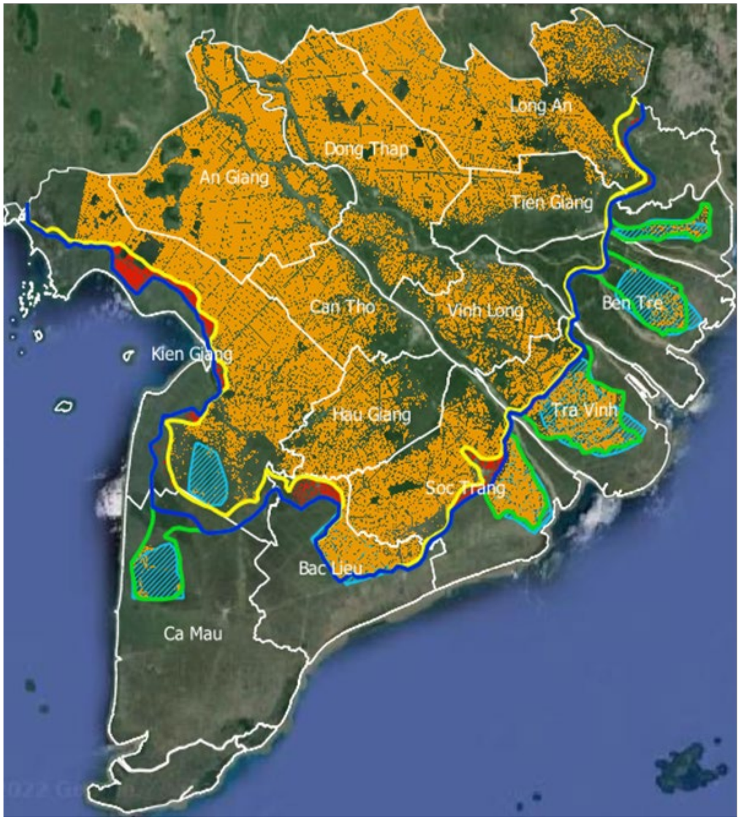
(**336.33 thousand hectares**)

Non-affected rice areas



Projected loss of rice land due to saline water intrusion

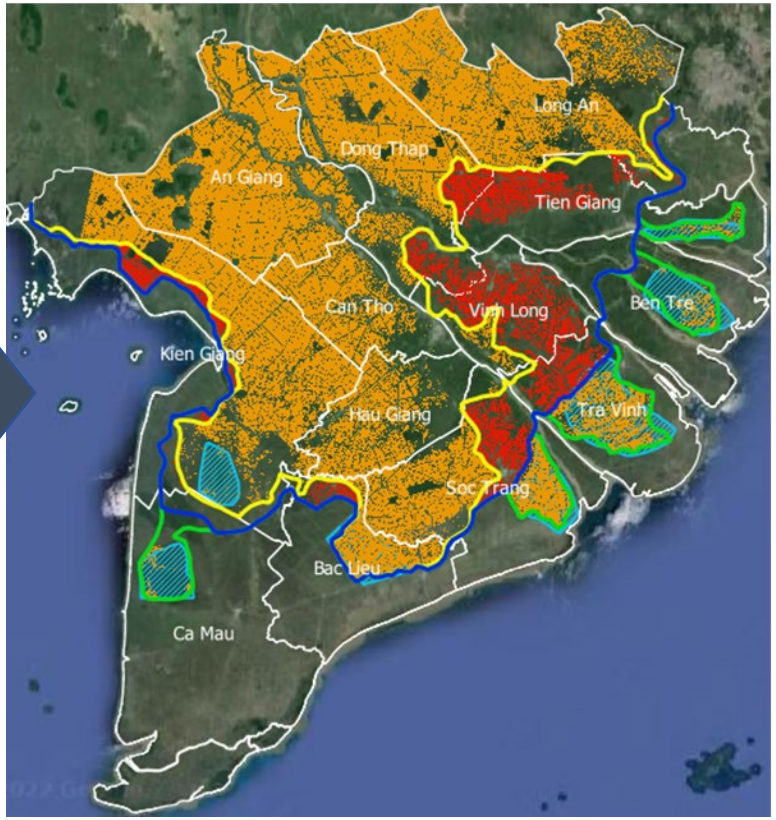
RCP 8.5, no River bed incision
Impacted rice area: 45 T ha



RCP 8.5 , by 2050

Anthropogenic changes		Sensitivity Cases		Affected rice areas	
Subsi dence	Riverbed level incision	Drought	Removing sluice gates	Thousand ha	%
				33.74	2.18
X				45.39	2.94
X	X			208.07	**13.46**
X	X	X		202.78	**13.12**
X	X		X	336.33	**21.76**

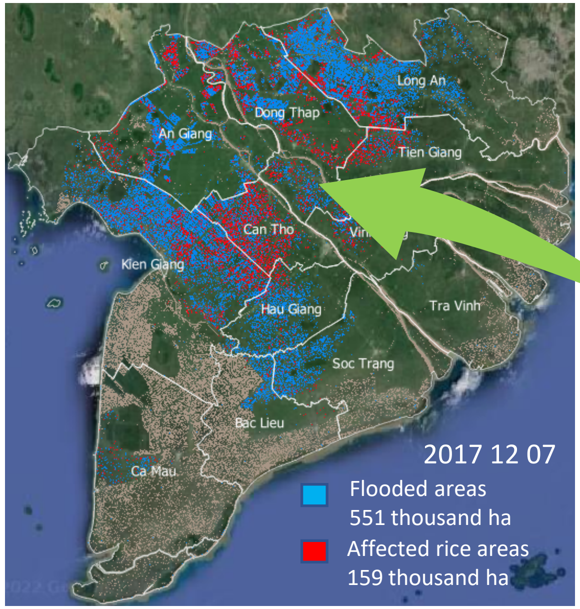
Increased sand extraction
Impact on rice area: 200 T ha



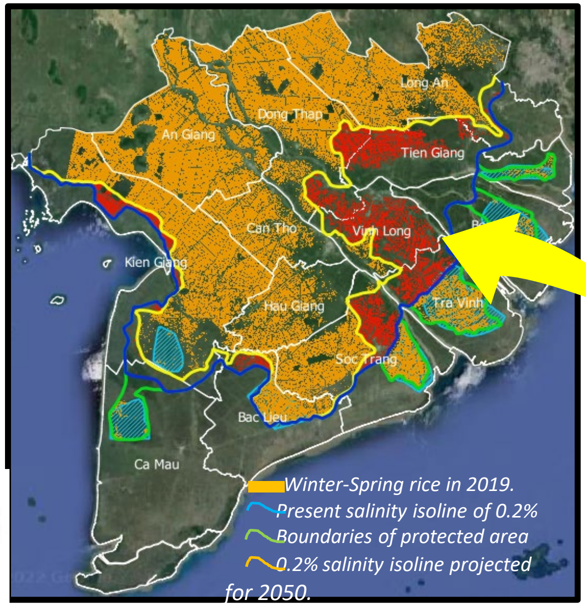
- By **2050**, with RCP 8.5 (SLR and River discharge), without sand mining, the loss of rice area by additional salinity impact as compared to present is marginal (3%)
- With river bed incision of 15 cm/year (due to sand mining) the percent of affected rice area could increase to **13%**

Options for adaptation and mitigation

Flood extent and timing



Salinity Intrusion



Adaptation

- Advance Summer Autumn rice season in semi-dyke regions

- Reduce Winter-Spring crop
- Advance WS crop season
- Conversion to other land use

Mitigation

- Regulations from upstream dams
- **Limiting flood season rice in high dyke upper regions**

- **Reduce sand extraction**

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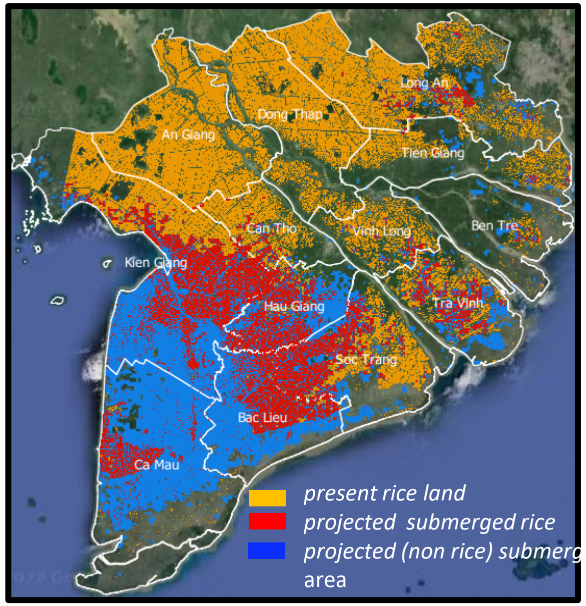
Projected submersion



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Sinking delta issues

Adaptation
- Conversion to other land use (aquaculture, mangrove)

Mitigation
- Reduce ground water extraction

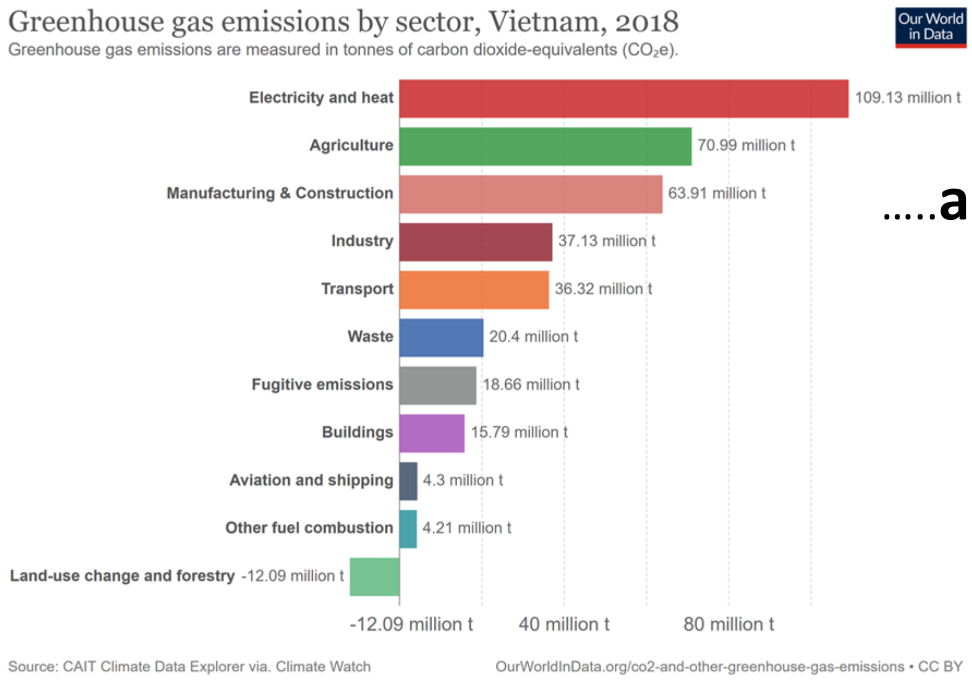
Projected production

Adaptation to decreasing yield (7-10% due to CC)
- Change in crop calendar
- Change in rice varieties

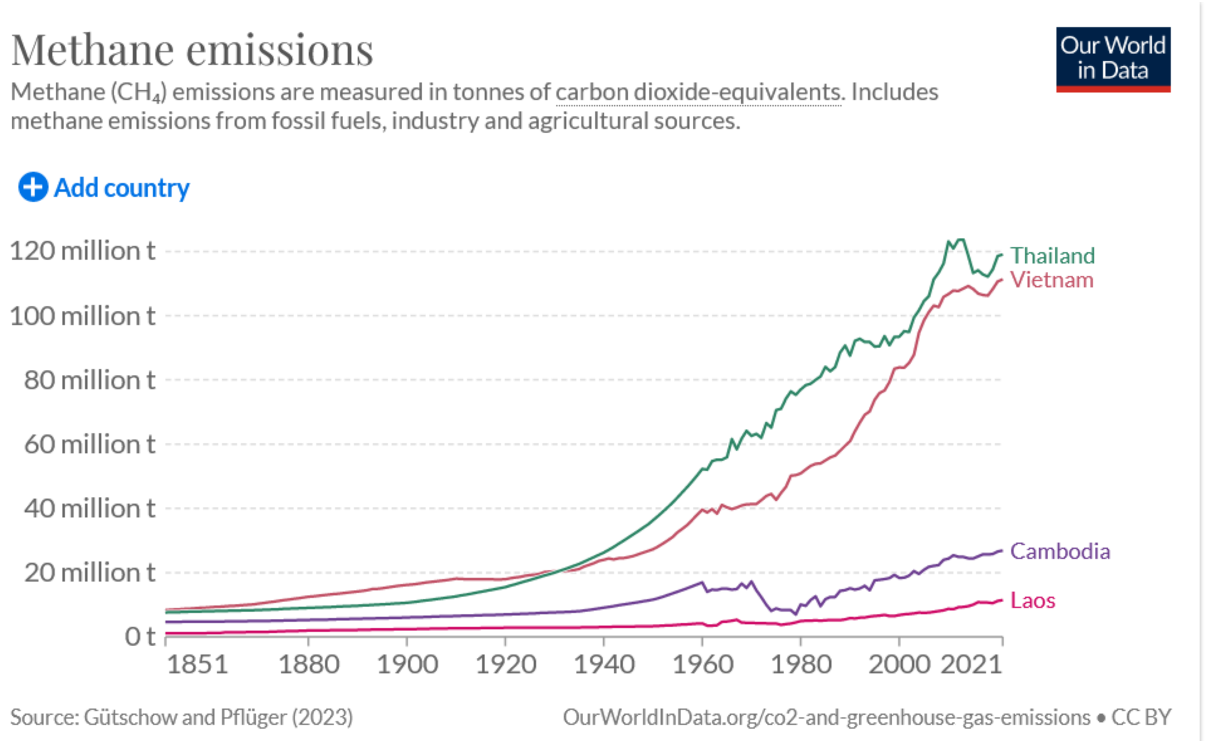
Mitigation
- **Favor quality vs quantity**
- **Crop and land use diversity**

Low carbon farming strategy

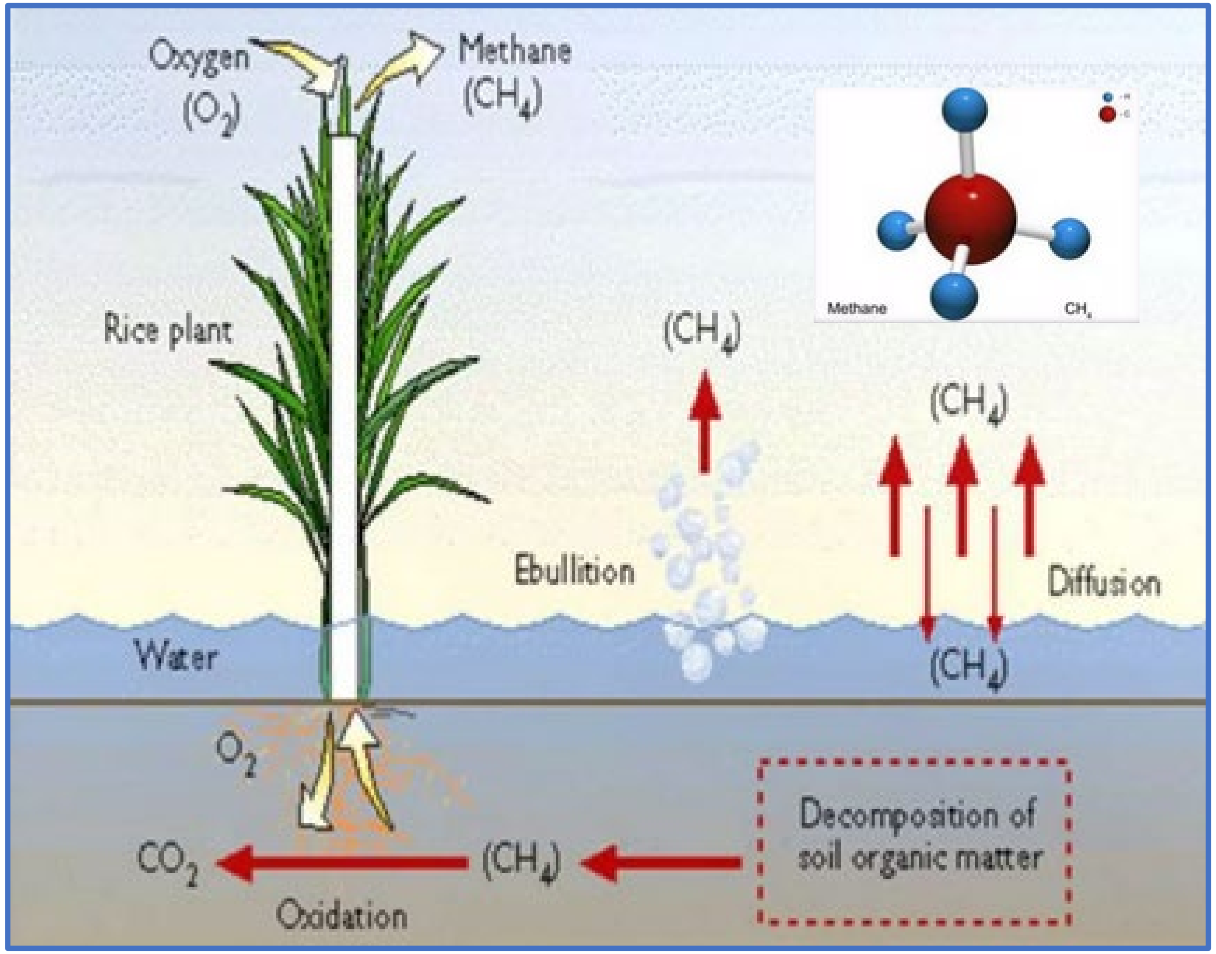
Agriculture is the second source of GHG emissions in Vietnam



.....among which the methane emissions from rice



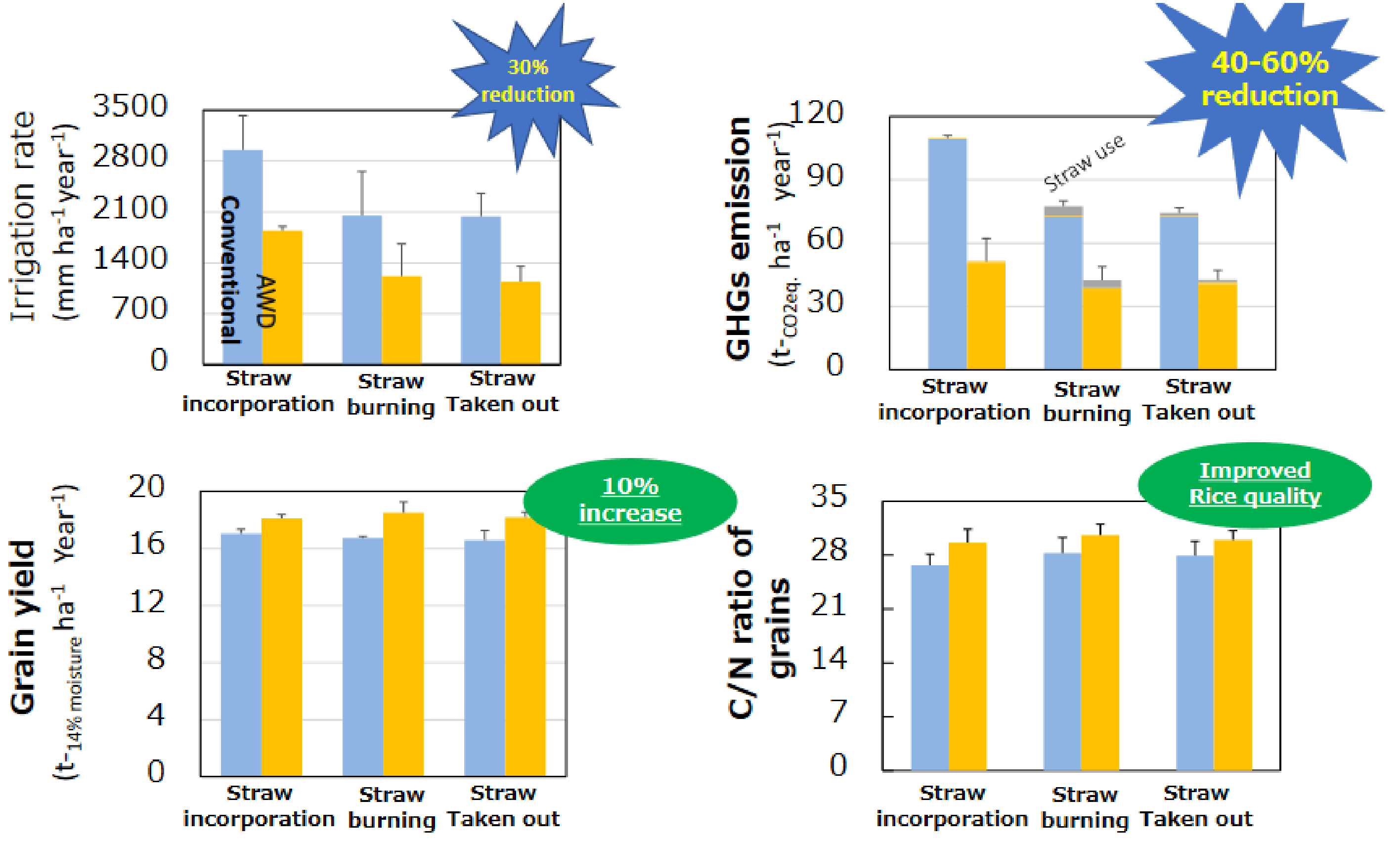
Rice paddy fields: one of the most important sources of atmospheric methane which could be reduced



- Rice paddy fields are considered one of the most important sources of atmospheric methane
- In **flooded rice fields**, anaerobic decomposition of organic matter results in production of methane
- The most effective mitigation approach is not to have continuous flooding

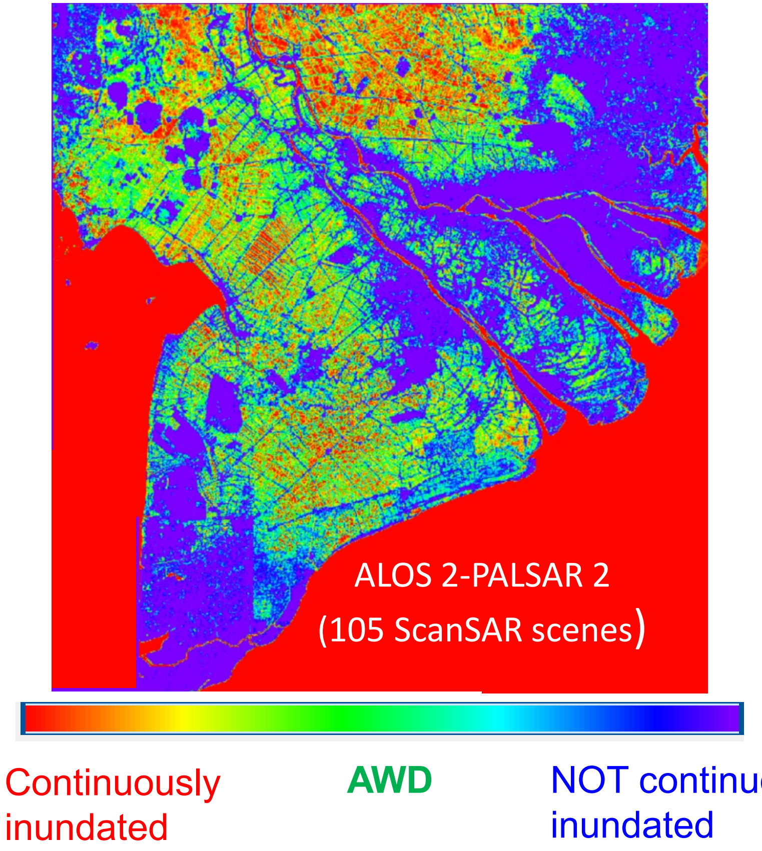
→ Intermittent drainage
e.g. **Alternate Wetting and Drying (AWD)**

AWD reduces methane emissions, water demand
Without altering grain yield and quality



Arai et al., Springer SARI-bc

Large proportion of Continuous Flooding fields where AWD could be implemented



Arai, H., Takeuchi, W., Oyoshi, K., Nguyen, L. D., Fumoto, T., Inubushi, K., & Le Toan, T. (2022). Evaluation of Rice Production and Related GHG Emissions in the Mekong Delta Integrating SAR Synthetic Aperture Radar (SAR) Data and Ground Observations. In *Remote Sensing of Agriculture and Land Cover/Land Use Changes in South and Southeast Asian Countries.* Springer International Publishing.

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Cf. Presentation Hironori Arai

Low carbon option : Expand water saving practices

At present, low methane emissions practices are not widely adopted in Viet Nam.

The challenge now lies in how to introduce mitigation options to all farmers across Viet Nam.

In practice, the adoption of AWD by farmers is constrained by several factors (distance from the irrigation canal/drainage, heterogeneous water management practices for optimum opening/closing schedules of sluice gates ..)

This highlights the fact that investments are needed to enable controlled water management.

Viet Nam's participation in the methane reduction pledge represents an opportunity to obtain climate financing.

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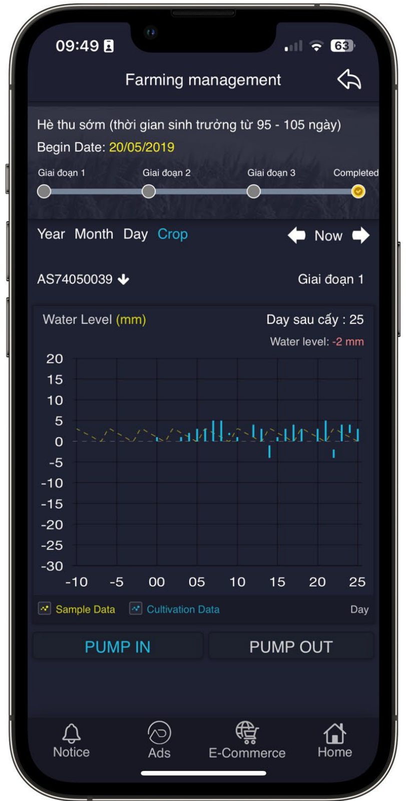
On going work on methane emissions from paddy rice

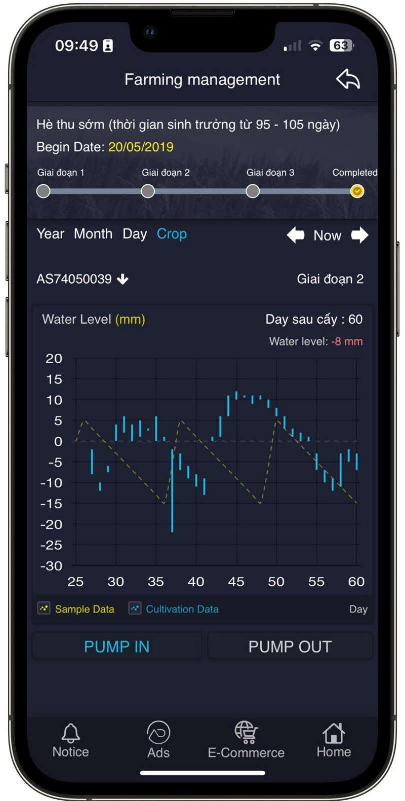
CH4Rice (AsiaRice/SAFE)   VietSCO (CNES)

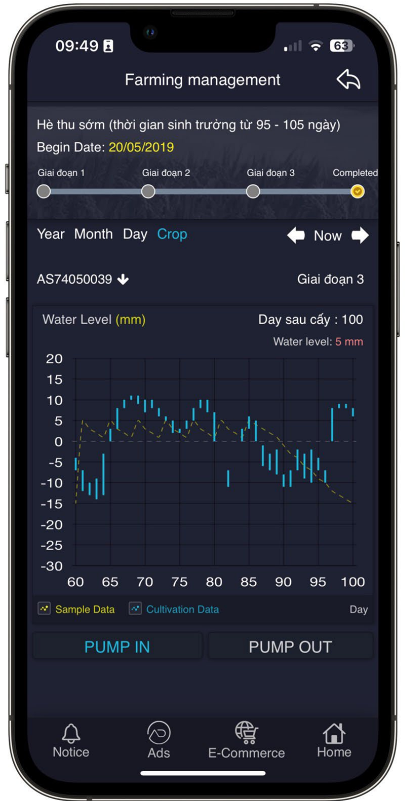
Project team members: CESBIO & GlobEO, VNSC-STAC, An Giang Univ. , Bac Lieu Univ., Rynan Technologies.

30 automatic water level monitoring stations implemented

6 September 2023

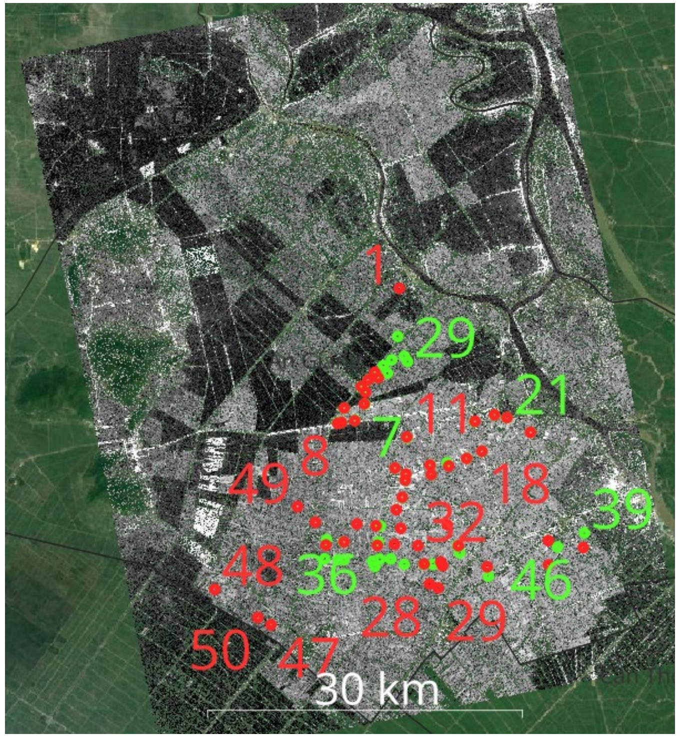


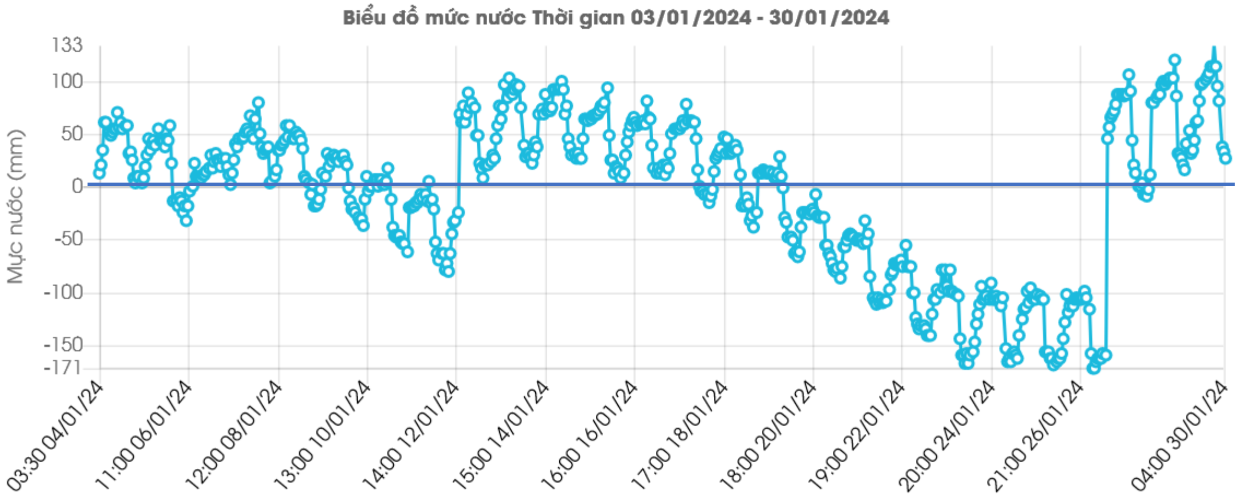




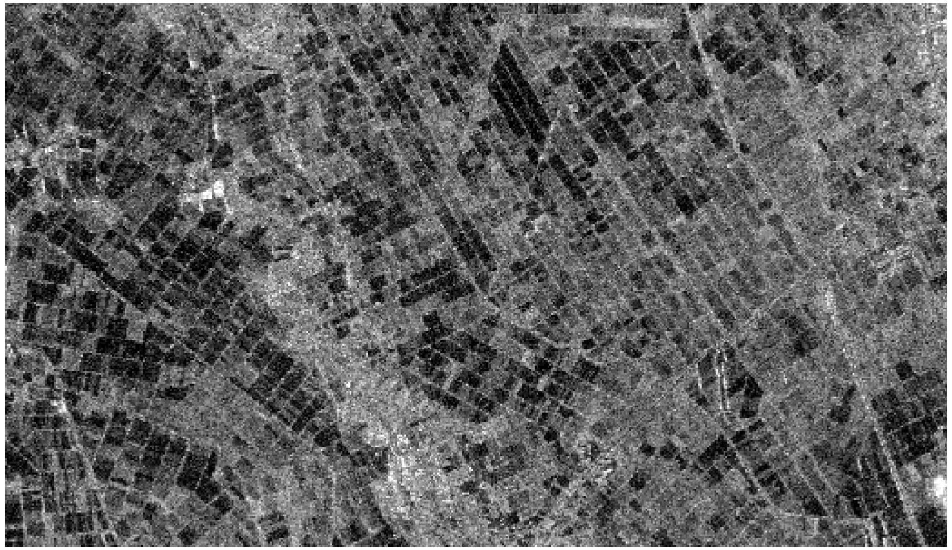
Record from 1 of 30 automatic water level stations

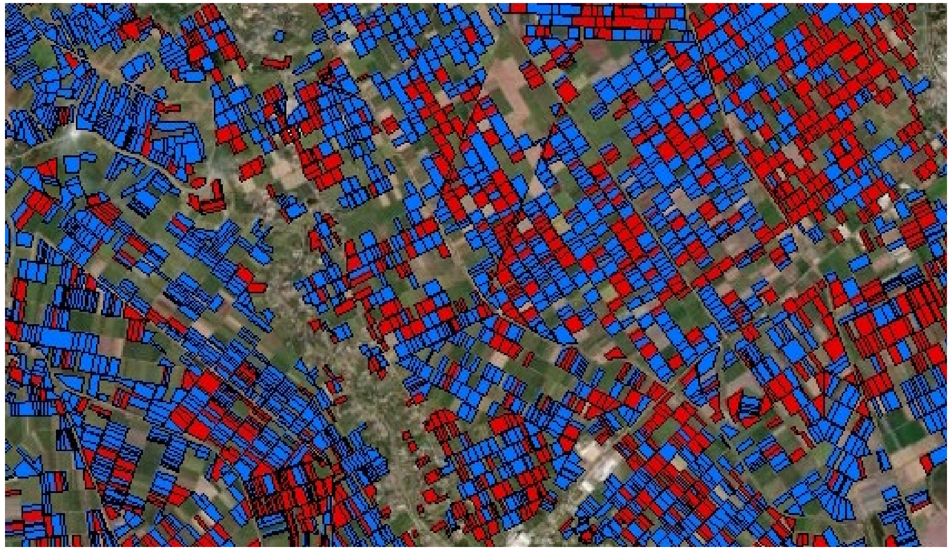
Mutitemporal ALOS-PALSAR data provided by JAXA for CH4Rice (AsiaRice/SAFE)





Work in collaboration with GISTDA, for AIP-Methane emission





CH_4 EMISSIONS FROM RICE CULTIVATION

$$CH_{4\ Rice} = \sum_{i,j,k} (EF_{i,j,k} \bullet t_{i,j,k} \bullet A_{i,j,k} \bullet 10^{-6})$$

EF 20 mg CH_4 m^{-2} hr^{-1}

SF Continuously flood = 1

Intermittently = 0.52

T 2,880 hrs. (120 days)

A Inundated = 40,970,986 m2

Non-inundated = 25,581,259 m2

Assessment of CH4 from rice at province scale

Inundated	**2,359,929 Kg**
Intermittently inundated	**766,210 Kg**

Summary and concluding remarks

- Understanding the impacts of Climate Change and human activities would help to take measures for adaptation and mitigation,
- Understanding needs integrated observations at regional scale, but actions need to be taken also at local scale,
- EO data can provide useful tool for 'taking the pulse' of rice agriculture at national to local scale,
- We also need models for projection, for long term strategy,
- Our ambition is to provide tools to stakeholders for testing different scenarios of CC and human activities,
- The studies indicate that there is a need to: 1)adapt to climate change , 2) reduce human pressure on the environment : e.g. reduce intensive agriculture, reduce GHG from rice, halt over-exploitation of ground water, halt over-extraction of river sand.

- Need to integrate socio-economic dimensions in further works.

Collaboration welcome !

Thank you