Food and Agriculture Organization of the United Nations

SUSTAINABLE DEVELOPMENT GOALS

APCAS/24/A3.1

ASIA AND PACIFIC COMMISSION ON AGRICULTURAL STATISTICS

30TH SESSION

19–24 May 2024

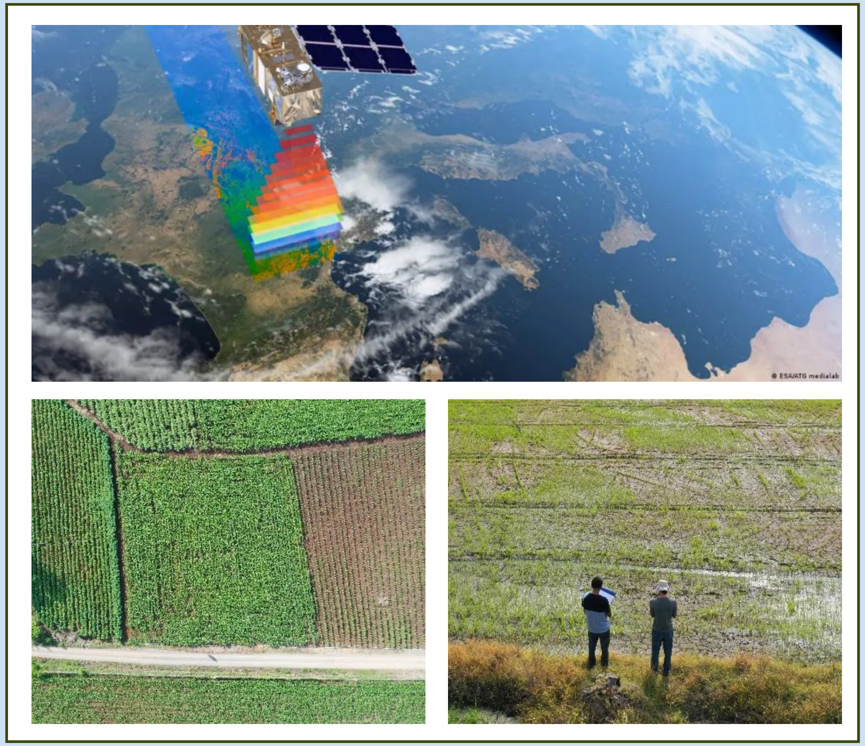
Kathmandu (Nepal)

BETTER PRODUCTION | BETTER NUTRITION | BETTER ENVIRONMENT | BETTER LIFE

SIDE EVENT A:

Indonesia Experiences with EO Data

THE USE OF EARTH OBSERVATION ON RICE STATISTICS



Presenter:
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M. Habibullah ,
Kadarmanto

Background Information – Indonesia

Lead Ministry/Agency	BPS – Statistics Indonesia, Collaboration with Ministry of Planning
Policy mandate	Moderenization of agriculture statistics
Legislative mandate (if any)	
Stakeholders involved	National Research and Innovation Agency, Ministry of Agriculture
Interagency collaborations	National Research and Innovation Agency
Privacy legislation	-
Privacy considerations	-

Background Information (cont.)– Indonesia

Satellite imagery source(s)	Sentinel - 1
Type of imagery used (optical, SAR, etc.; including satellite system)	SAR
Spatial and Temporal resolution	10m, 12 days
Ancillary data	Area Sampling Frame (ASF) survey data as data training
Data processing (infrastructure on-site or cloud-based)	Infrastructure on-site
Area covered by EO data analysis (national/sub-national)	national

Background Information (cont.) – Indonesia

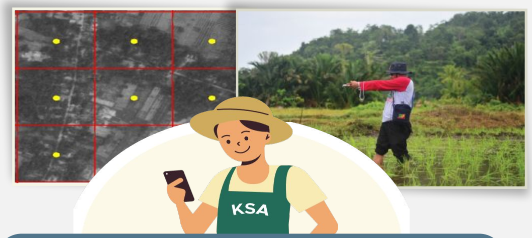
Crops covered	Paddy Fields
Statistics produced (ex. Crop type mapping, area estimation)	Area Estimation of Paddy Growth Phase (Phenology)
Frequency that statistics are produced	Monthly
Dissemination of statistics	Paddy Production Data
Size of geospatial team	16 people
Roles of geospatial team	Development of the Methodology using EO

In-situ data – Indonesia

Data/survey source	Area Sampling Frame (ASF) Survey Data
Lead agency	BPS-Statistics Data
Sampling approach	Area Sampling Method
Data collection approach	On the ground survey
Variables collected	Paddy growth phase on the sample location
Frequency of data collection	Monthly

RICE PRODUCTION CALCULATION
Current Method

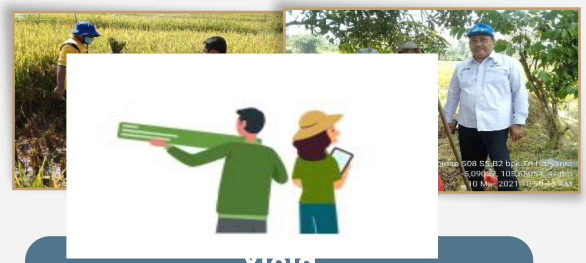
Current Method : Integrating two data collection methods



Harvested Area

Area Sampling Frame Survey (ASF)
On-the-ground-survey

×



Yield

Crop-cutting survey
Based on ASF results as a sampling frame

=

Rice Production

Dry Harvested Paddy (GKP) *(Ton)*

Objectives:

- **Observing rice crops to obtain:**
  - Paddy growth phase
  - Predicting the harvest time
  - Estimating the harvest area

Objectives:

- Weighing the weight of rice in a paddy field to estimate the rice productivity value.

Issues on Methodology

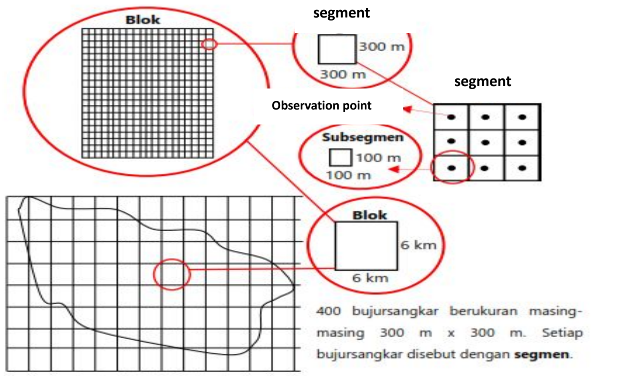
- Cost in the data collection process
- Can't capture samples in a remote area
- Risk of non-responses data

METHODOLOGY

Area Sampling Frame

Population	**Rice field in Indonesia** (including wetland and dryland paddy)
Sampling Frame	Area sampling frame □ **segment sized 300 m x 300 m with 9 points observation** in each segment
Sampling	Two phased stratified **random sampling** to choose sample segment
Number of Sample	25,493 sample segment or about **229.437-point observations**
Data Collection Method	Direct observation of rice growth phase at selected sample observation points using CAPI mode
Number of surveyor	about **6.000 surveyors**
Frequency of data collection	Monthly
Output	Harvested area, potential harvested area, area of each growth phase (including area of crop failure)
Estimation level	District/municipality and provincial level

Illustration of sample frame construction



Visualization of sample distribution of ASF segments

Observation in the field

Land Preparation

Early Vegetative

Late Vegetative

Generatife

Harvest

Farmland Planted with Other than Rice

Unplanted Agricultural Land

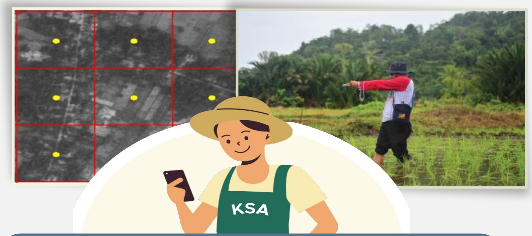
Non-Agricultural Land

Potential for Harvest Failure/Damaged

RICE PRODUCTION CALCULATION

Earth Observation Potential

Current Method : Integrating two data collection methods



Harvested Area

Area Sampling Frame Survey (ASF)
On-the-ground-survey

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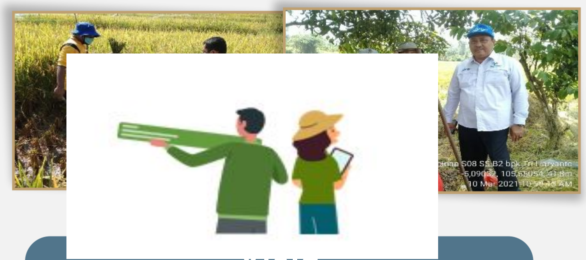


Yield

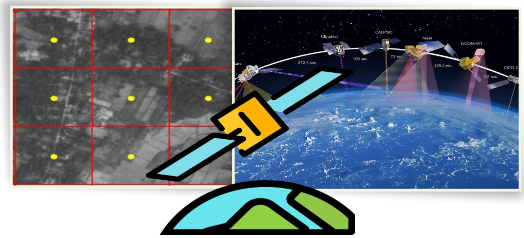
Crop-cutting survey
Based on ASF results as a sampling frame

=

Rice Production

Dry Harvested Paddy (GKP) *(Ton)*

Developing Method : Utilizing Remote Sensing for Paddy Growth Phase



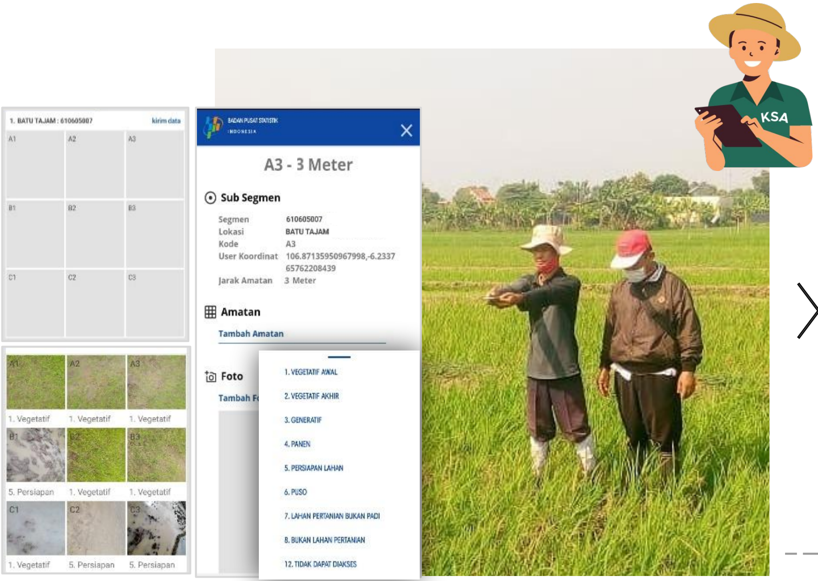
Combining Remote Sensing and ASF

Using remote sensing data for predicting paddy growth phase; by collecting, interpreting, and analyzing satellite imagery data

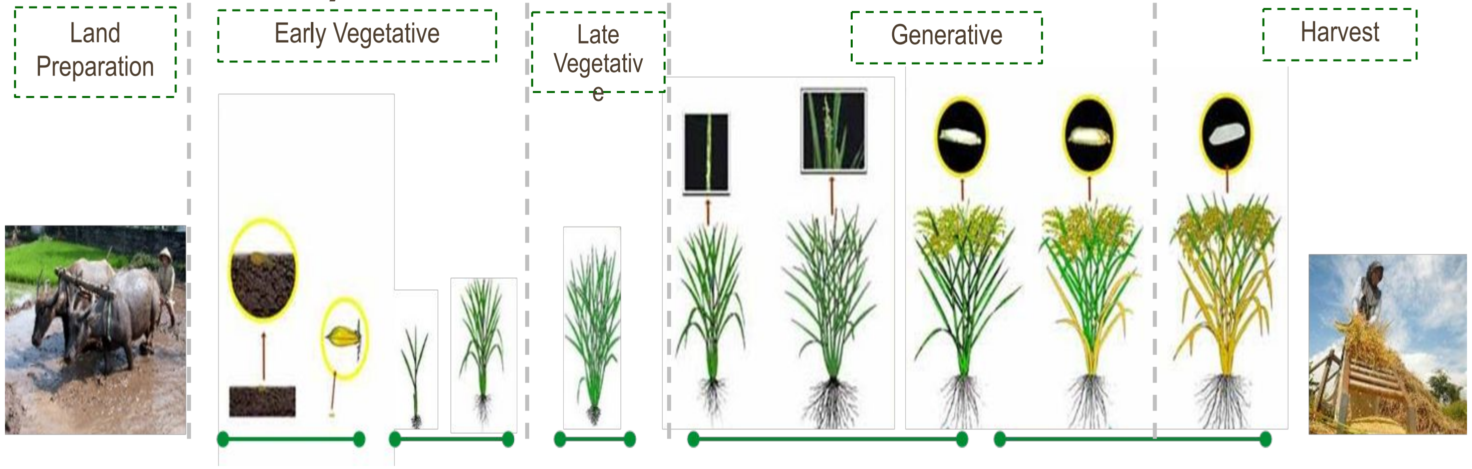
- Optimizing cost-effective data collection technology
- Capturing of remote area and filling gap of non-response data

PADDY GROWTH PHASE PREDICTION USING EO

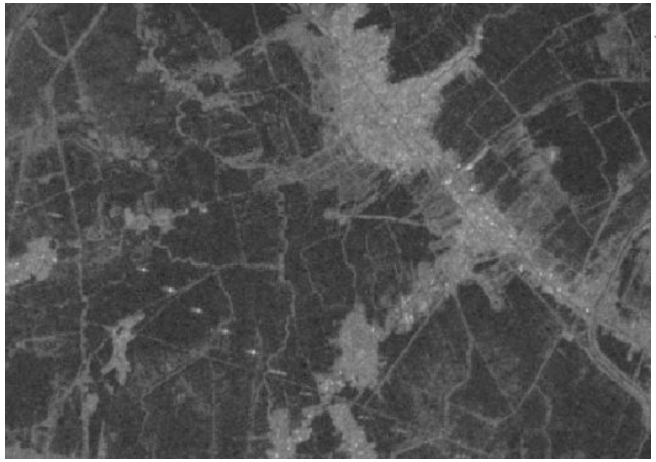
Remote Sensing Potential

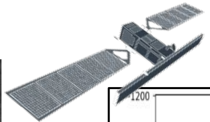


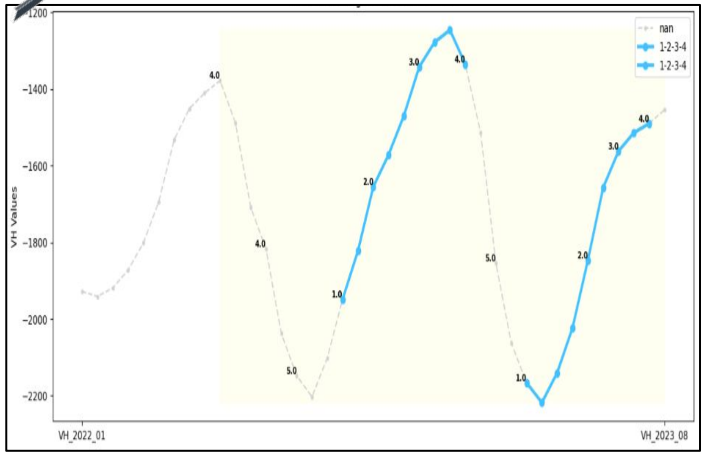
Paddy Growth Phase based on ASF data

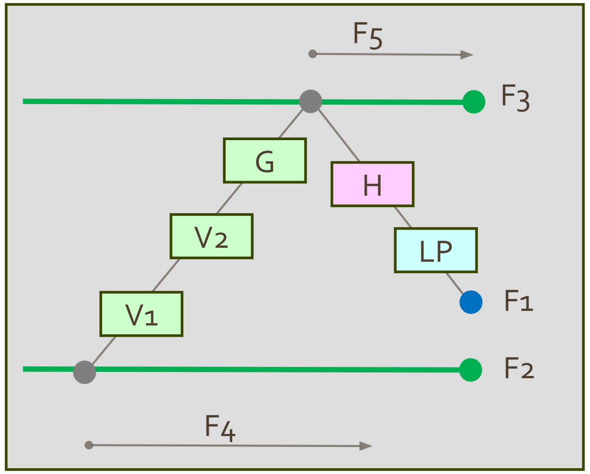


Paddy Growth Phase based on EO









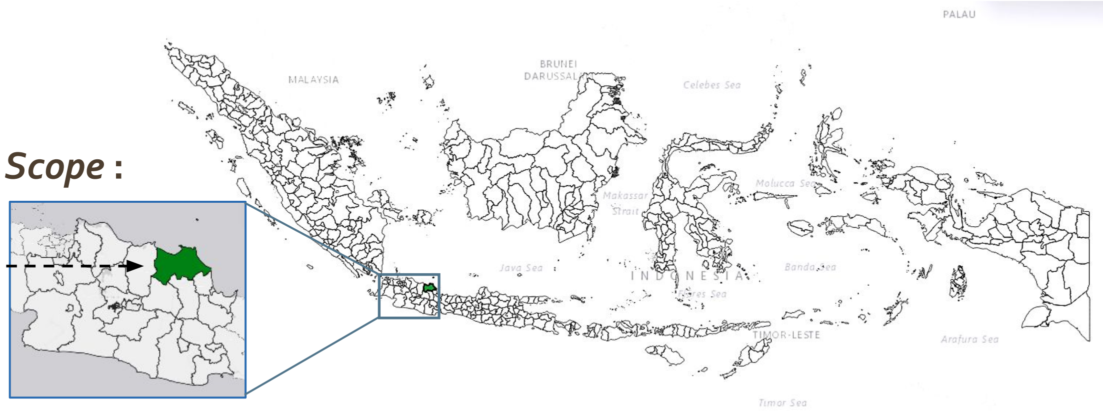
V1: Early Vegetative,
V2: Late Vegetative,
G: Generatif,
H: Harvest,
LP: Land preparation

GROUND TRUTH SURVEY (ASF) AS TRAINING DATA

Area Sampling Frame Survey (ASF) Data

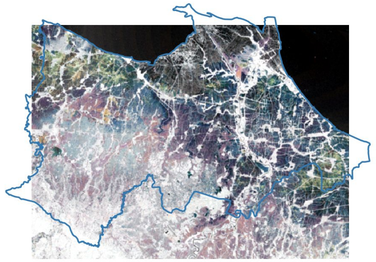
1. The label data used is **acquired from the ASF survey** and is undergoing modification for modeling purposes (details are **described in the table**).
2. The ASF data utilized spans from **April 2022 to March 2023**.
3. The selected area is the **West Java** region, with a specific focus on **Indramayu**.
4. There are **22,445 ASF points**, each labeled for **12 time points within a one-year period**.

Scope :



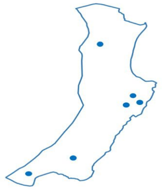
Label obtained from ASF Survey		Label for ML Modeling	
Label	**Description**	**Label**	**Description**
1	Early Vegetative	1	Early Vegetative
2	Late Vegetative	2	Late Vegetative
3	Generative	3	Generative
4	Harvest	4	Harvest
5	Land Preparation	5	Land Preparation
6	Potential for Harvest Failure/Demeged		
7	Farmland Planted with other than rice or unplanted agricultural land	0	Non-Paddy
8	Non-agricultural Land		

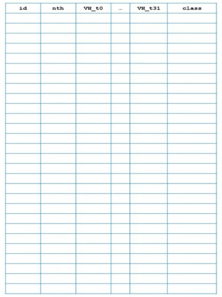
Sentinel-1 Satellite Imagery



Obtained through Google Earth Engine (GEE) and corrected by the national space agency.

- Sentinel-1 satellite imagery data
- Temporal resolution: **Every 12 days**
- Spatial resolution: **10 meters**





METHODOLOGY

1 Area Clustering / Regionalization

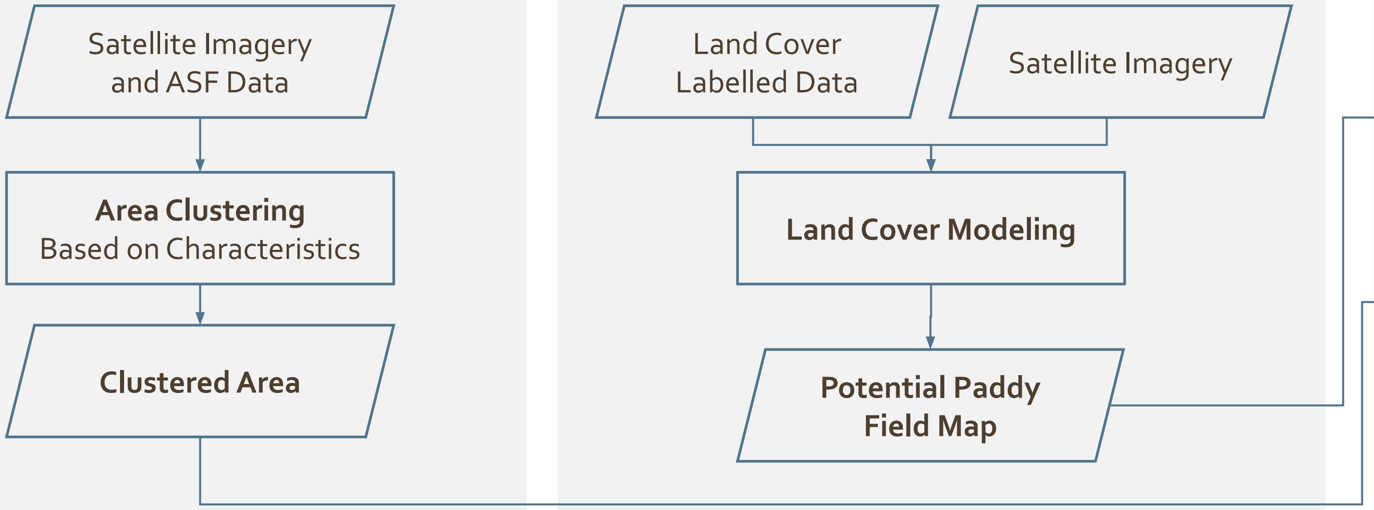
Objective: to capture the homogenous areas based on the topological, physical terrain, paddy planting patterns, climate, etc.

Expected Output: Area clustering for model separation.

2 Paddy-Non Paddy Classification

Objective: to classify areas as either paddy fields or non-paddy fields serves as a constraint for a paddy growth phase model.

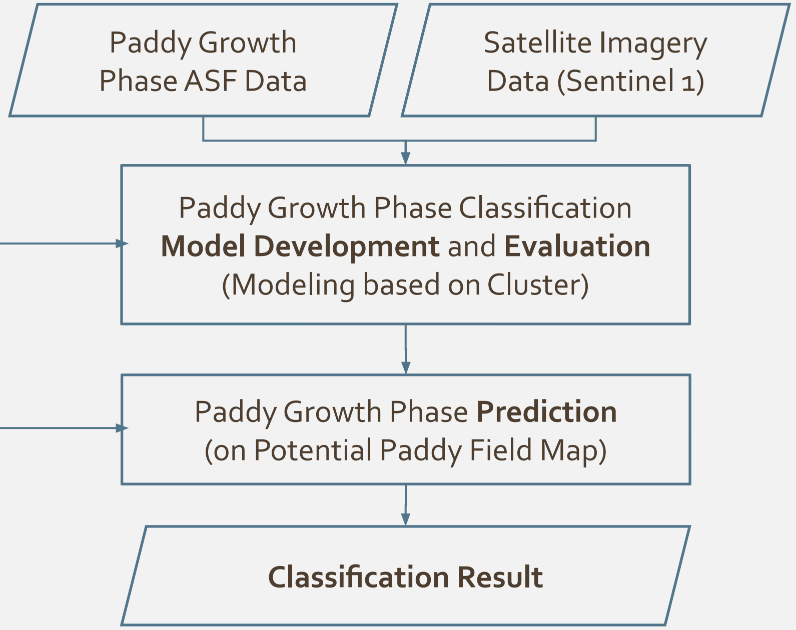
Expected Output: Potential Paddy Field Map for Paddy Growth Phase Classification Model



3 Paddy Growth Phase Modeling

Objective: classify areas for each paddy growth phase.

Expected Output: Paddy Growth Phase Classification



MACHINE LEARNING MODEL RESULT

Model Description:

0: *Variables=[9 Extracted Feature, nth], Spatial Res: 10m*
1: *Variables=[9 Extracted Feature, nth], Spatial Res: 50m*
2: *Variables=[31 Series of VH Value, nth], Spatial Res: 10m*
3: *Variables=[31 Series of VH Value, nth], Spatial Res: 50m*

	Model	Pred Time	Fit Time	Mean Accuracy Train (5-fold CV)	Mean Accuracy Test (5-fold CV)	Accuracy Validation Pred
0	CatBoost	0.012192	7.301360	0.822599	0.794576	0.823051
1	CatBoost	0.012807	7.171480	0.799096	0.774915	0.797288
2	CatBoost	0.013085	7.283956	0.856045	0.816949	0.861695
3	CatBoost	0.013710	7.076196	0.830508	0.789153	0.834576

Model include non-paddy class (class: 0,1,2,3,4,5)

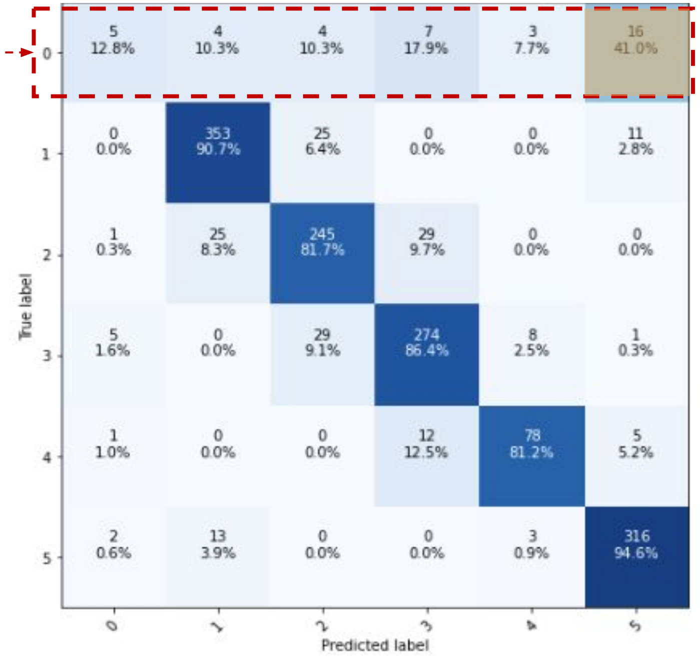
	Model	Pred Time	Fit Time	Mean Accuracy Train (5-fold CV)	Mean Accuracy Test (5-fold CV)	Accuracy Validation Pred
0	CatBoost	0.010637	4.891682	0.834611	0.835540	0.851671
1	CatBoost	0.013360	5.170701	0.808595	0.811847	0.825209
2	CatBoost	0.011519	5.947832	0.876655	0.860627	0.887883
3	CatBoost	0.012332	6.069428	0.842509	0.829965	0.865599

Model for paddy field only (class: 1,2,3,4,5)

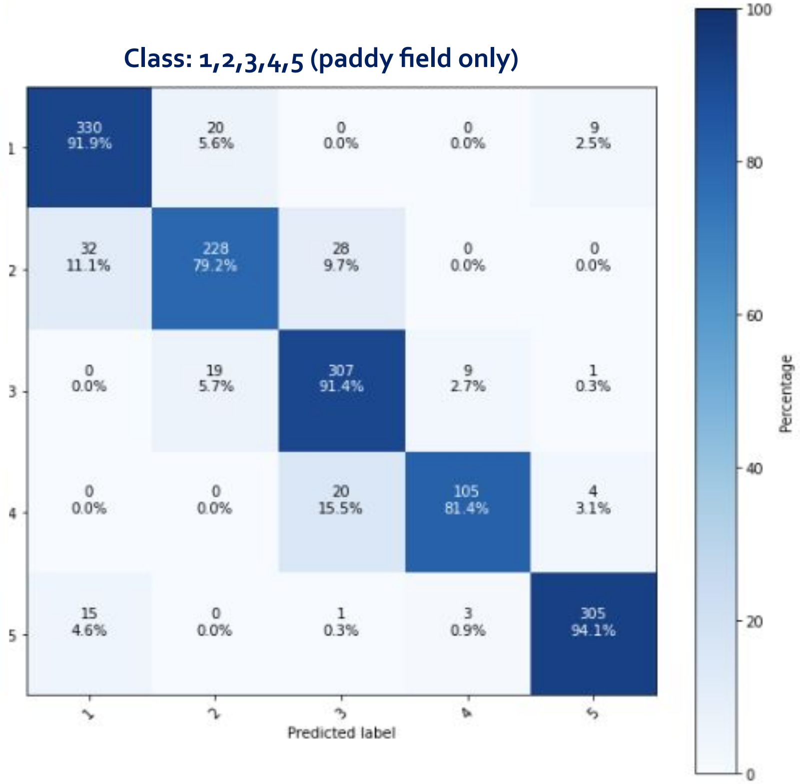
Findings

1. The modeling results indicate that using the **backscatter VH time series** in modeling produces **better accuracy** compared to using extracted features (with the differences around **2-3%**).
2. Modeling results using satellite images with a **spatial resolution of 10m** yield **better accuracy** than those with 50m resolution (with the differences around **3-4%**).
3. The model incorporating the non-paddy class has not been able to predict the non-paddy class optimally, likely due to the limited number of observation samples.
4. The non-paddy class (0) tends to be misclassified as the land preparation class (5).

Class: 0,1,2,3,4,5 (include non-paddy)



Class: 1,2,3,4,5 (paddy field only)



CHALLENGE OF EARTH OBSERVATION FOR PADDY GROWTH PHASE IDENTIFICATION

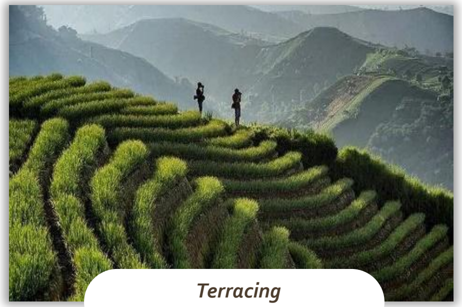
! Challenges

How to capture the heterogeneity of field characteristics in Indonesia

- Paddy fields are not always continuously planted with paddy.

  After the harvest, the land may be planted with non-paddy crops.
- Lands in Indonesia tend to be small in size, giving rise to issues related to mixed pixels.
- land that is located in mountainous areas, which also presents a similar mixed pixels problem
- The diverse characteristics of fields such as irrigated fields, swampy fields, and dryland fields require specific models.

- **Ground Checking** to ensure the model reflects real-world conditions,
- Identify the **potential regions** for remote sensing implementation


Terracing


Mixed crops


Irrigation field

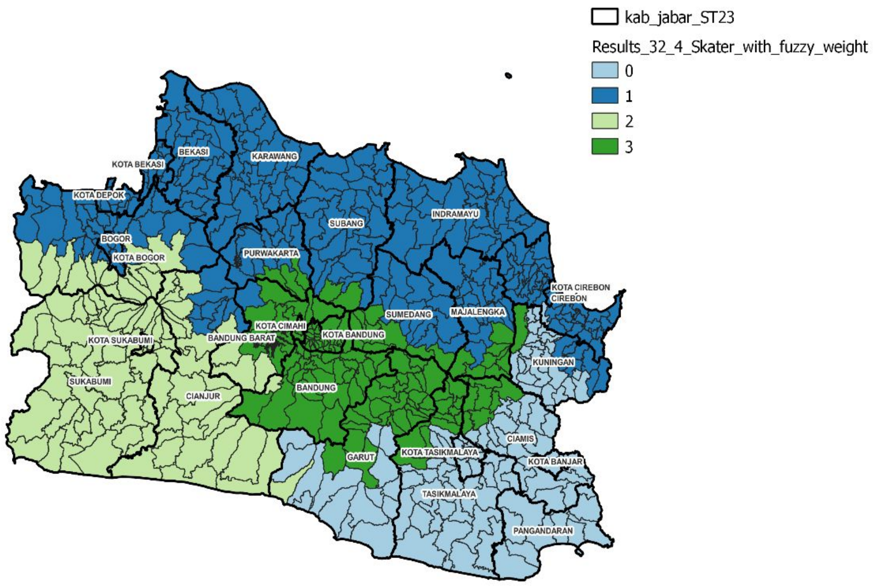

Dryland field


Swamp field

RECOMMENDATIONS

Recommendations

- The use of national-scale Earth Observation (EO) requires **robust infrastructure**, as numerous satellite images need to be processed for modeling. Therefore, **Data Cube** is considered as one of the recommendations to facilitate the data preparation process.
- Due to the diverse characteristics of land, **a single model may not suffice**, necessitating pre-processing steps like regional **clustering** to identify areas with similar characteristics.
- In model development, it is not sufficient to solely pursue accuracy but also to consider how the model can **be applicable when used on a large scale area**.
- Model evaluation with **ground truth** to ensure the robustness of the model.



regions	dem_elevation	stl1_VV	stl1_VH	et_ET	lst_LST \
0	369.194122	-7.911404	-14.694691	319.525888	15074.974794
1	103.606820	-8.919001	-15.795404	219.225025	15290.528617
2	588.625892	-7.977457	-14.534776	312.600665	15079.192499
3	832.209800	-8.033194	-14.559723	247.508643	15155.669778

Thank you for your attention!

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