National Aeronautics and Space Administration

Bhutan
Agriculture II

Creating a Graphical User Interface, Crop Mask, and Data Collection Protocol for Analysis of Rice Crop in Bhutan Using Remotely Sensed Data

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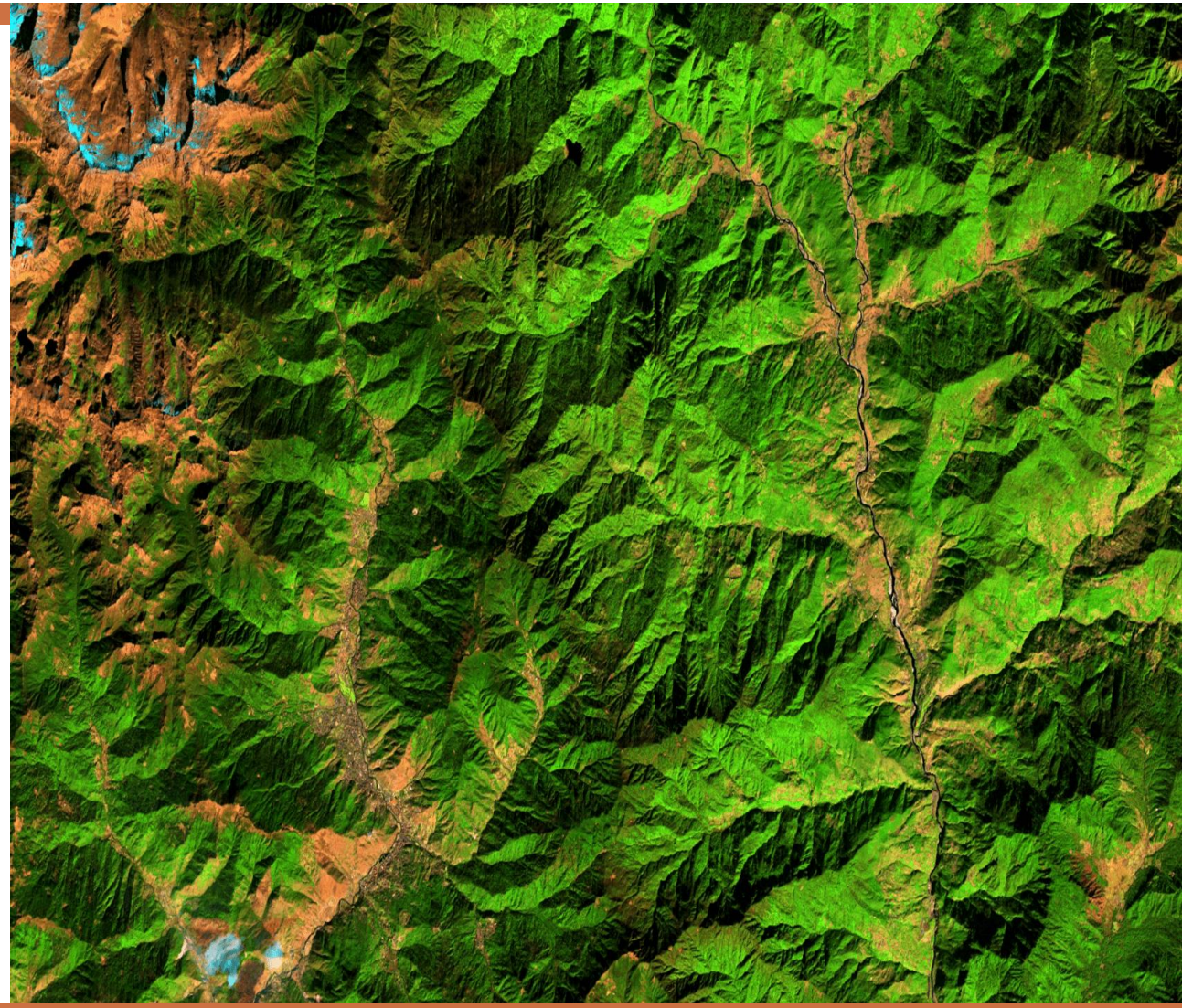


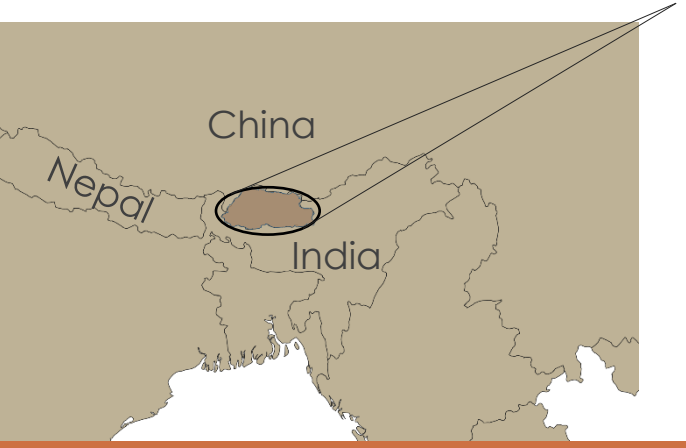
STUDY AREA AND PERIOD

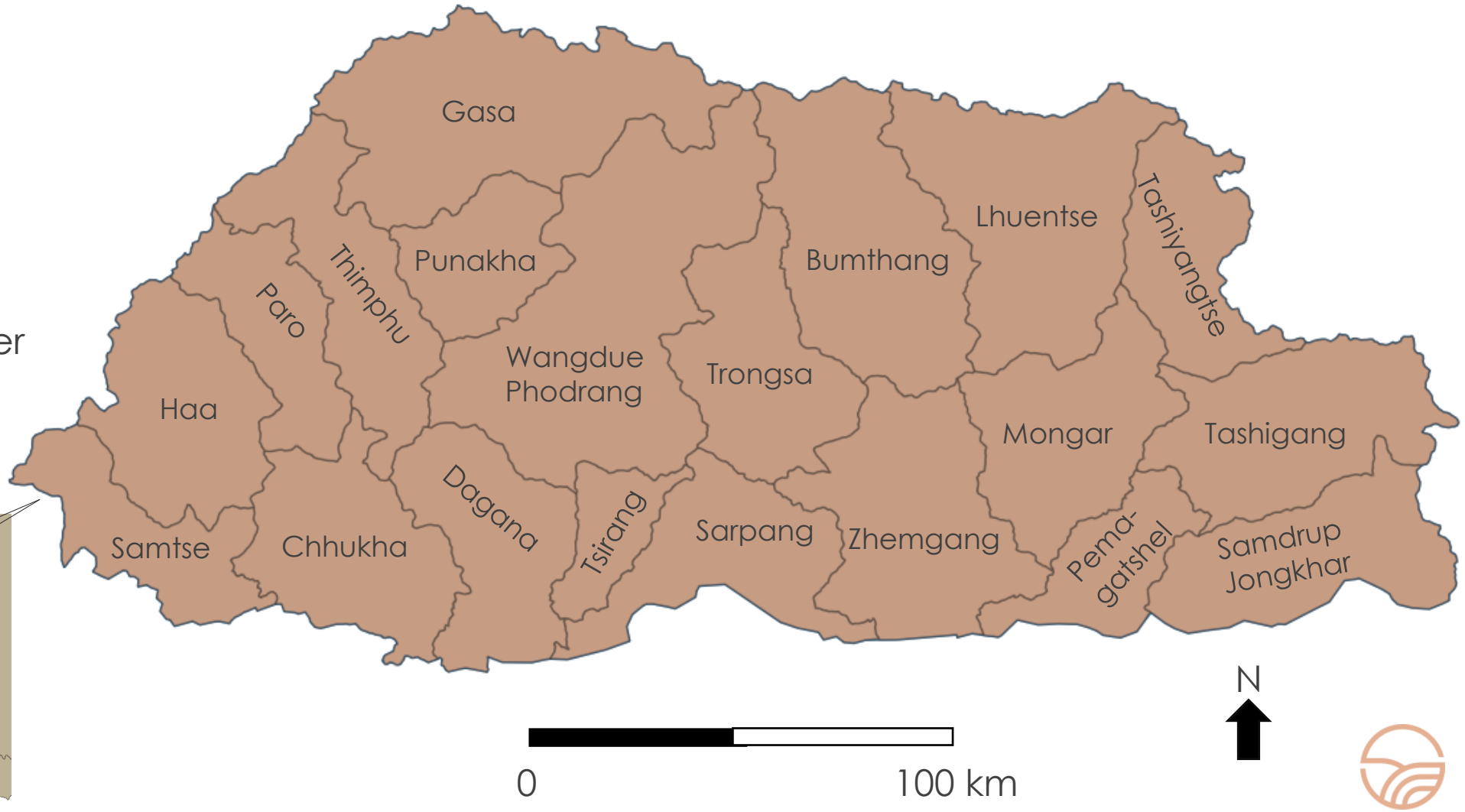
Study Area

- Bhutan
  20 Districts

Study Period

- 2015 – 2020
  May through October





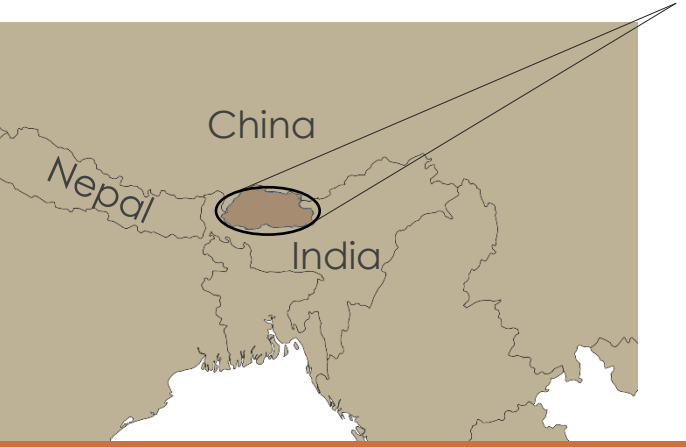
SAMPLING STUDY AREA AND PERIOD

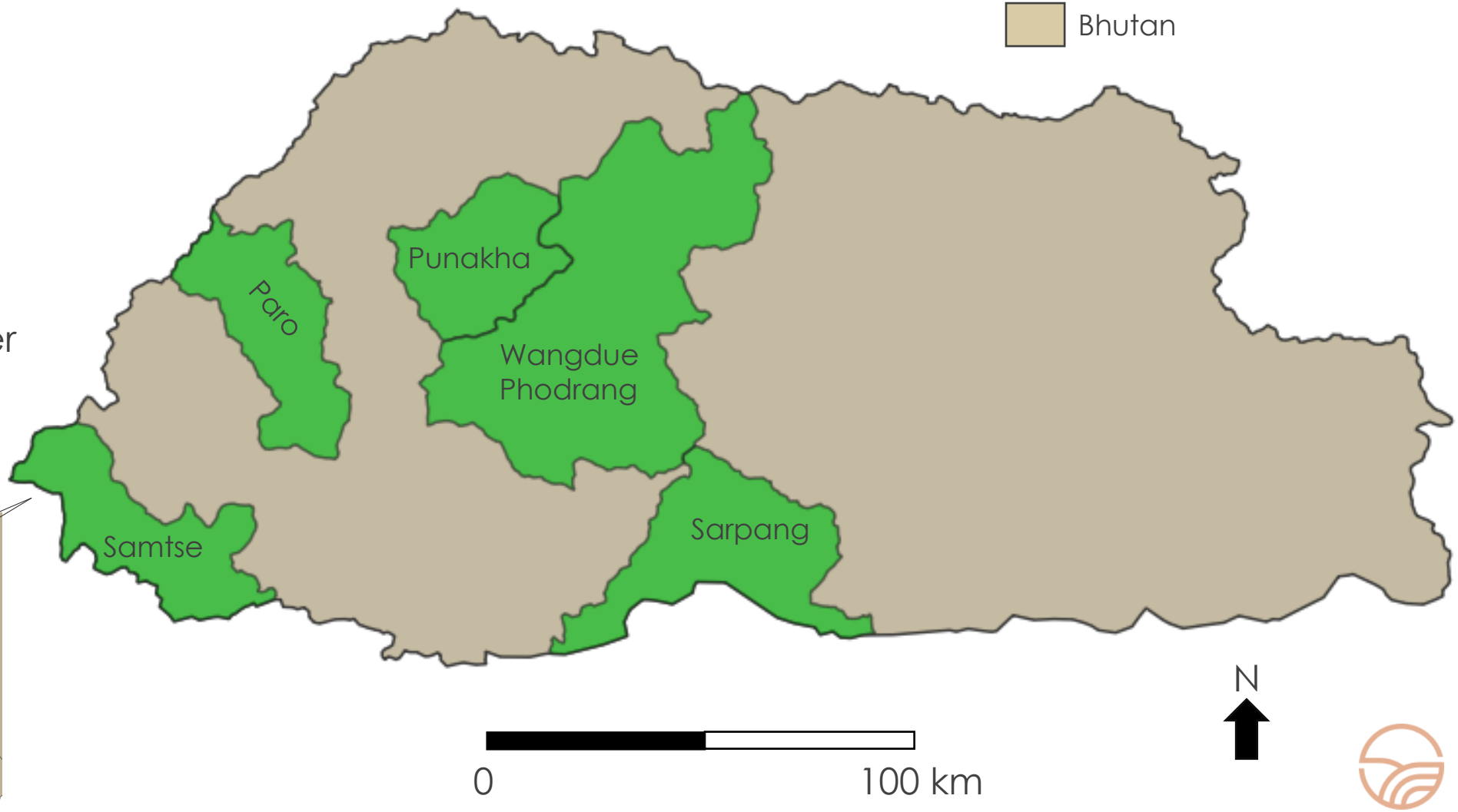
Study Area

- Bhutan
  5 Districts

Study Period

- 2015 – 2020
  May through October





PARTNERS

Image Credit: Nidup Dorji

End User

- Bhutan Department of Agriculture

Collaborators

- Bhutan Foundation
- Ugyen Wangchuck Institute for Conservation and Environmental Research (Bhutan)

COMMUNITY CONCERNS

- Mountainous ecosystems
- Low soil fertility fueling low crop yield
- Threatened food security
- Increasing threats from pests and disease
- Lack of national awareness on agriculture

Image Credit: Nidup Dorji

A SECOND TERM PROJECT: AN OVERVIEW

Fall 2021

- Created a crop mask for 8 districts in Bhutan for 2020
- Generated a sampling protocol for crop monitoring methods

Summer 2022

- Expanded the crop mask to the whole country of Bhutan
- Created a Graphical User Interface (GUI) for crop analysis

OBJECTIVES

Create a graphical user interface (GUI) for crop analysis

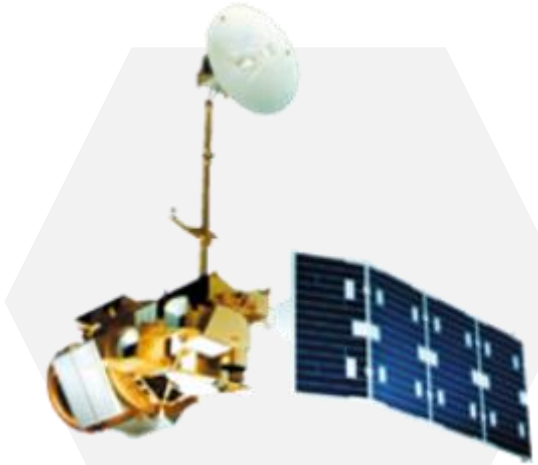
Expand the overall research area in Bhutan to produce a more robust crop mask for rice

Refine the random forest parameters to yield optimal performance in creating the crop mask

Streamline previous term's data collection protocol for feasible use and generalizability to any crop

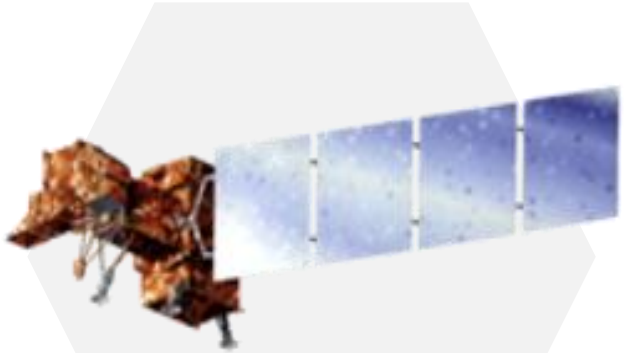
Aid Crop Monitoring and Agricultural Decision-Making for the Bhutan DoA

EARTH OBSERVATIONS: Collect Earth Online



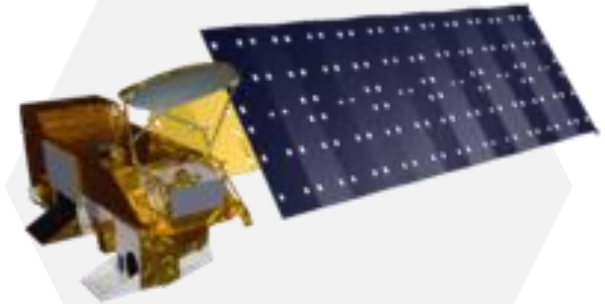
Landsat 5

Thematic Mapper



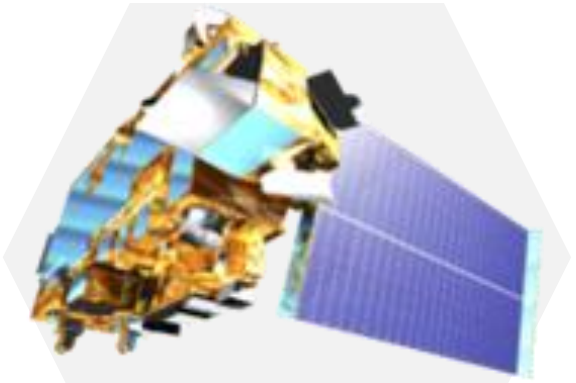
Landsat 7

Enhanced Thematic Mapper Plus



Aqua

Moderate Resolution Imaging Spectroradiometer



Terra

Moderate Resolution Imaging Spectroradiometer

Image Credits: NASA & ESA

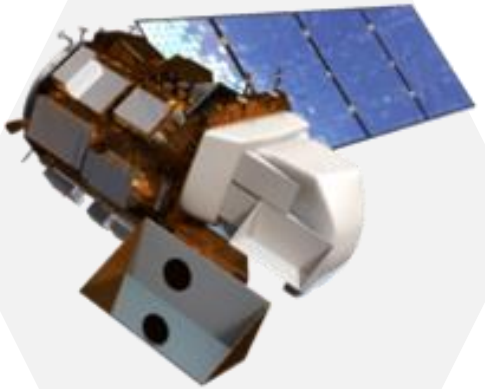
EARTH OBSERVATIONS: Google Earth Engine

Endeavour

Shuttle Radar Topography Mission

Sentinel-1

C-Band Synthetic Aperture Radar (SAR)



Landsat 8

Operational Land Imager

Image Credits: NASA & ESA

METHODOLOGY: INPUT DATA AND PROCESSING

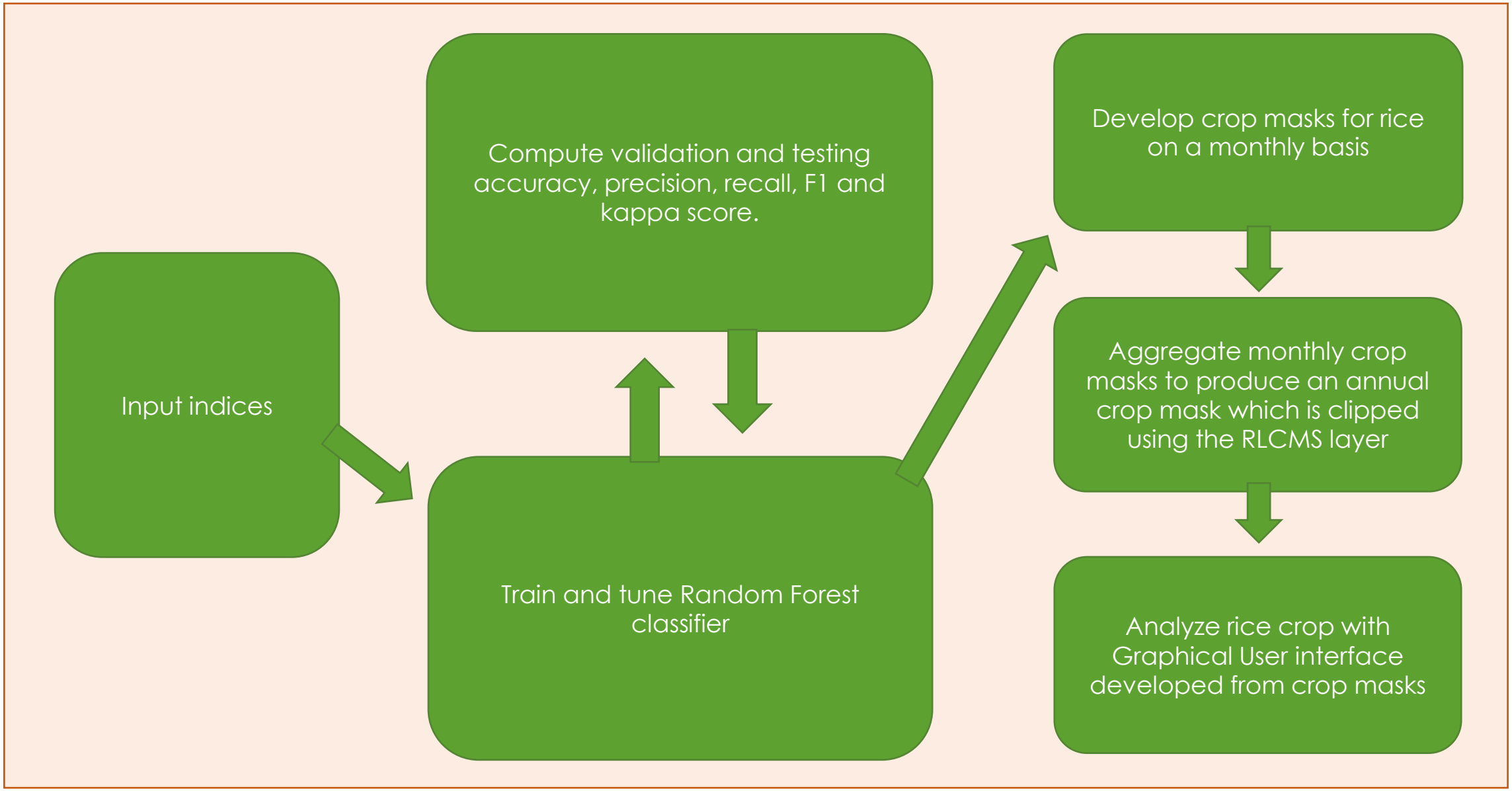
Sampling rice and non-rice points using Collect Earth Online

Splitting points intro training, validation, and testing set in Google Earth Engine

Define Variables

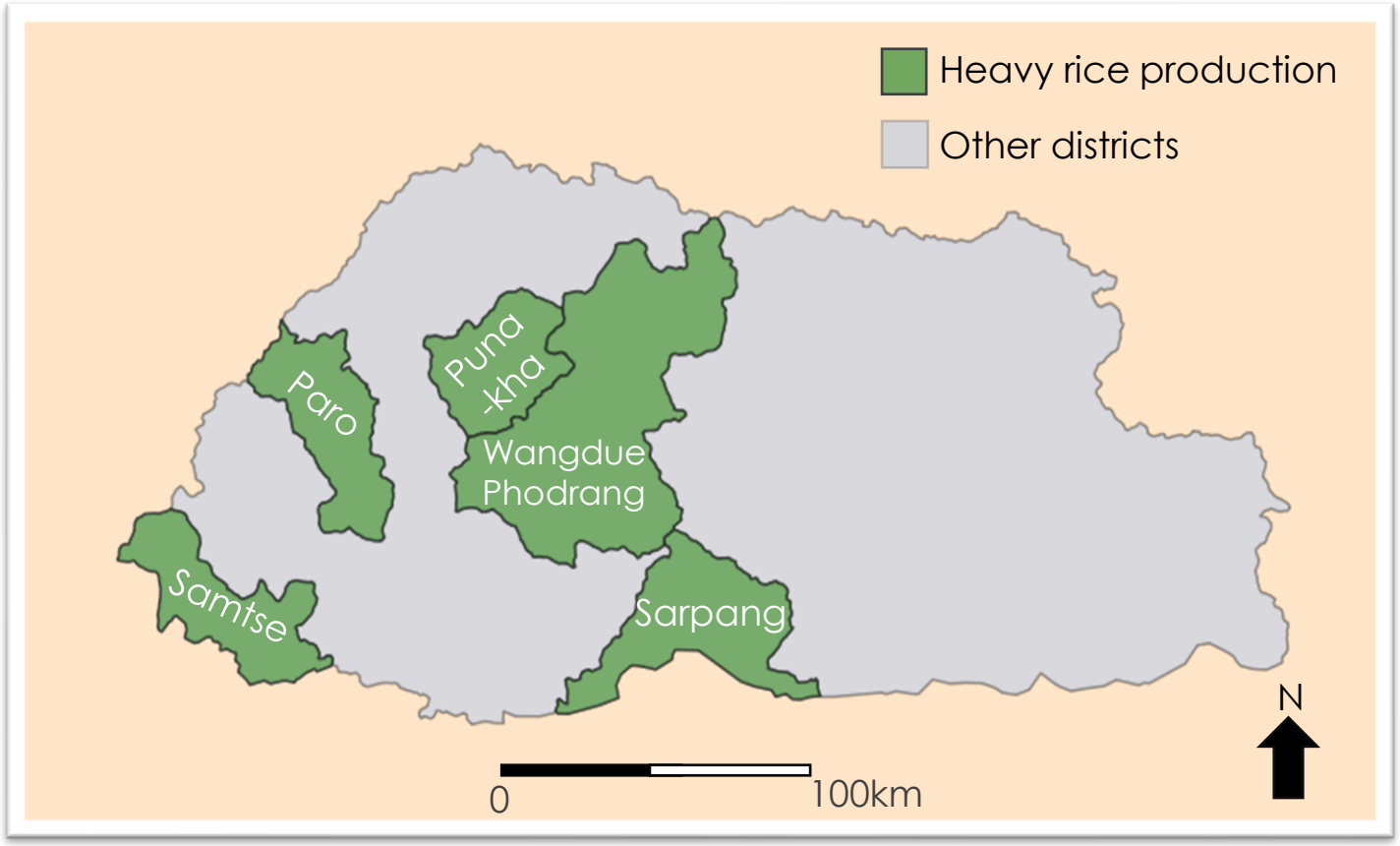
- Optical Indices: NDVI, MNDWI, SAVI, NDWI, NDBI, and NDMI (Landsat 8 OLI)
- Brightness, Greenness, Wetness, Fourth, Fifth, and Sixth (Landsat 8 Tasseled Cap Transformation – TCT)
- Descending and ascending SAR polarization indices: VH, VV, VV, and VH ratio, normalized difference between VV and VH (Sentinel-1 C-SAR)
- Slope and Elevation (SRTM)
- Height Above Nearest Drainage
- Precipitation (TerraClimate dataset)
- Temperature (ERA5-Land dataset)
- Canopy Interception (PML dataset)

METHODOLOGY: TUNING AND ANALYSIS

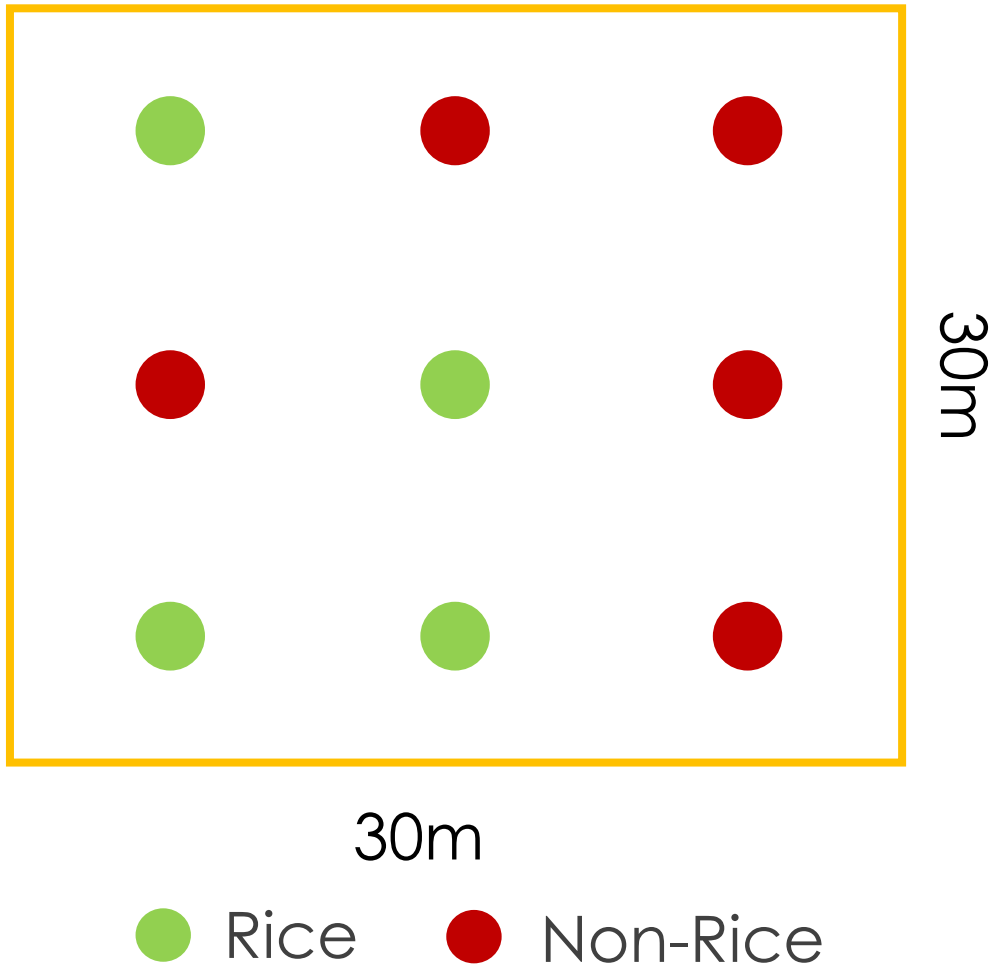


DATA PRE-PROPRECESSING: Collect Earth Online

- 1000 training points each for five districts with heavy rice production: Paro, Punakha, Wangdue Phodrang, Samtse, and Sarpang
- Collected a total of 1000 training points manually for the other 15 districts of Bhutan



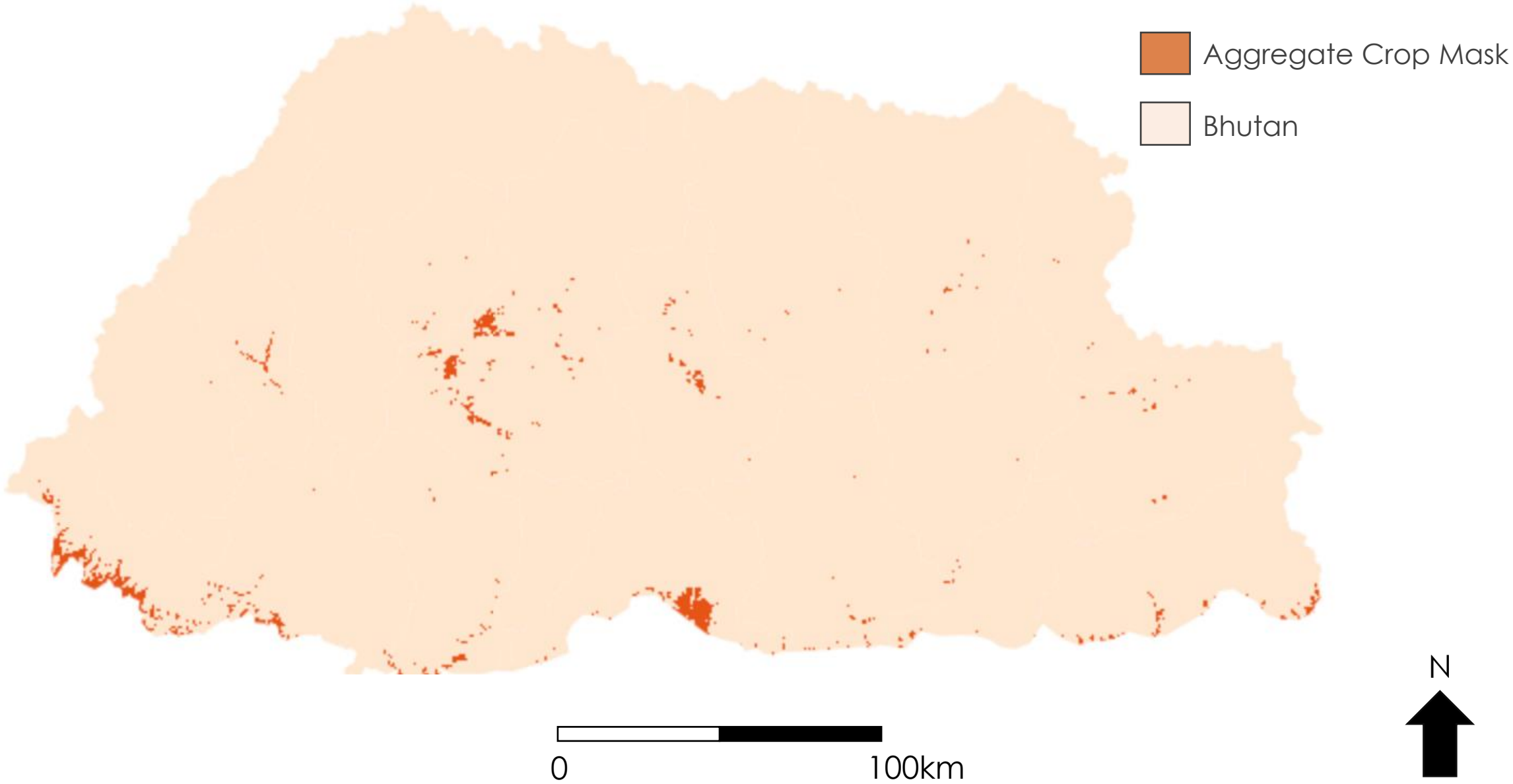
DATA PRE-PROPRECESSING: Collect Earth Online



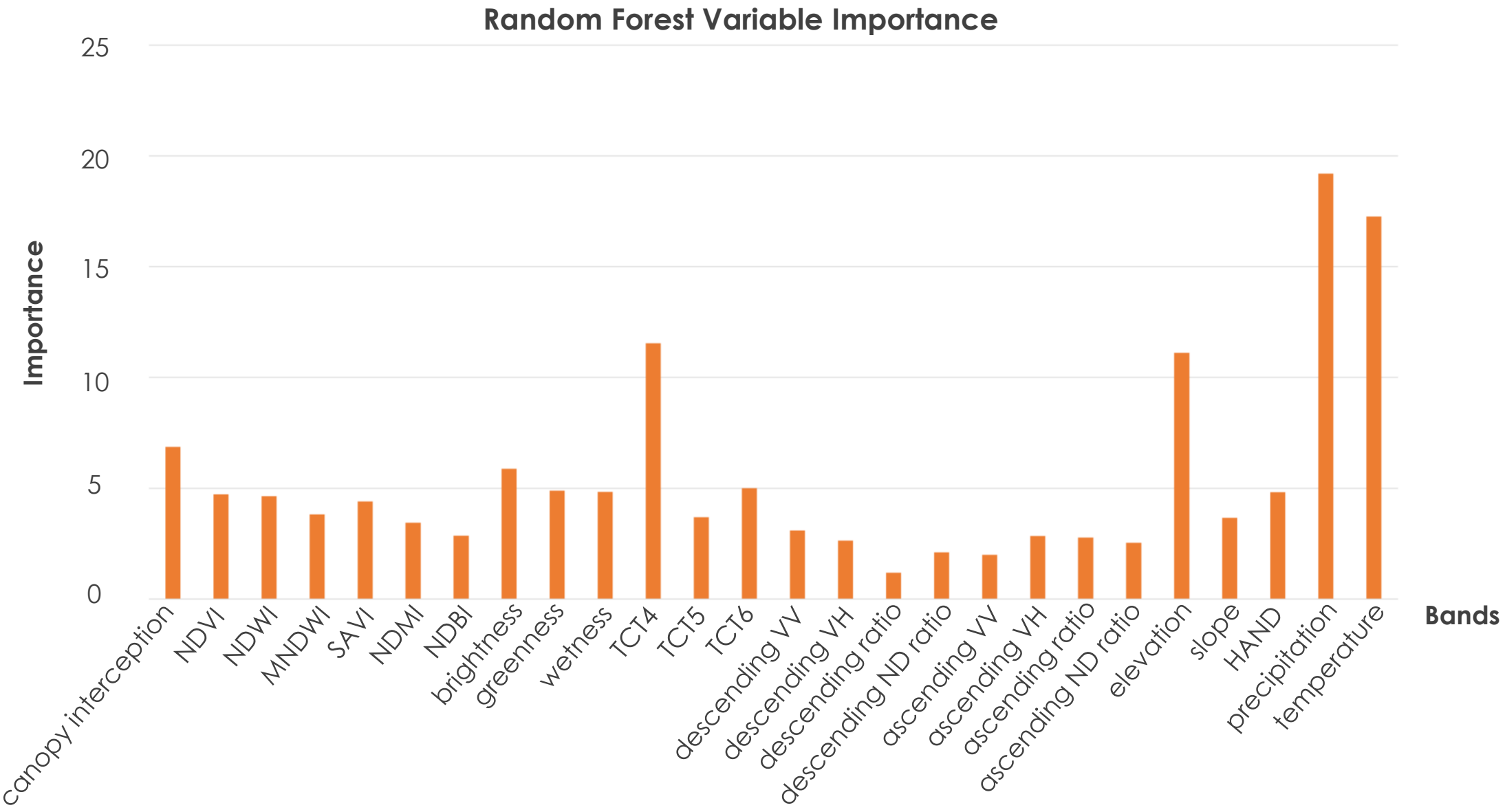
- Training points determined whether the randomly selected plot point was rice or not
- Each plot contained 9 equidistant points

RESULTS

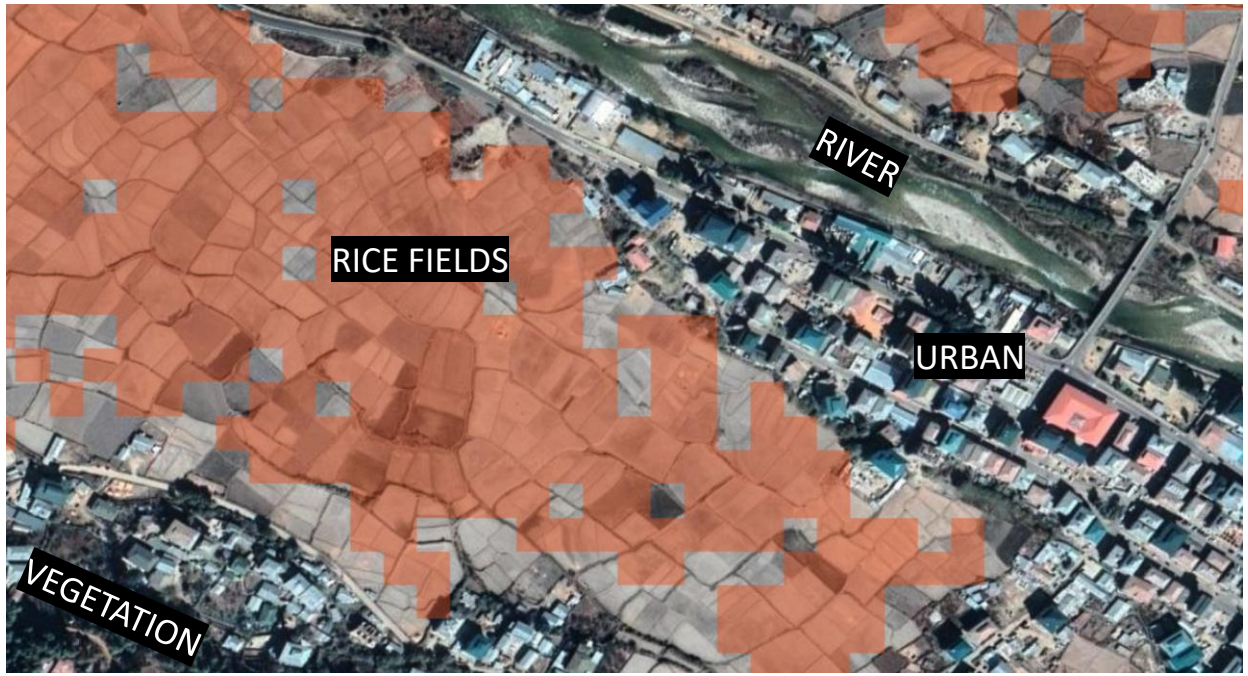
Rice Crop in 2020



RF MODEL VARIABLE IMPORTANCE GRAPH

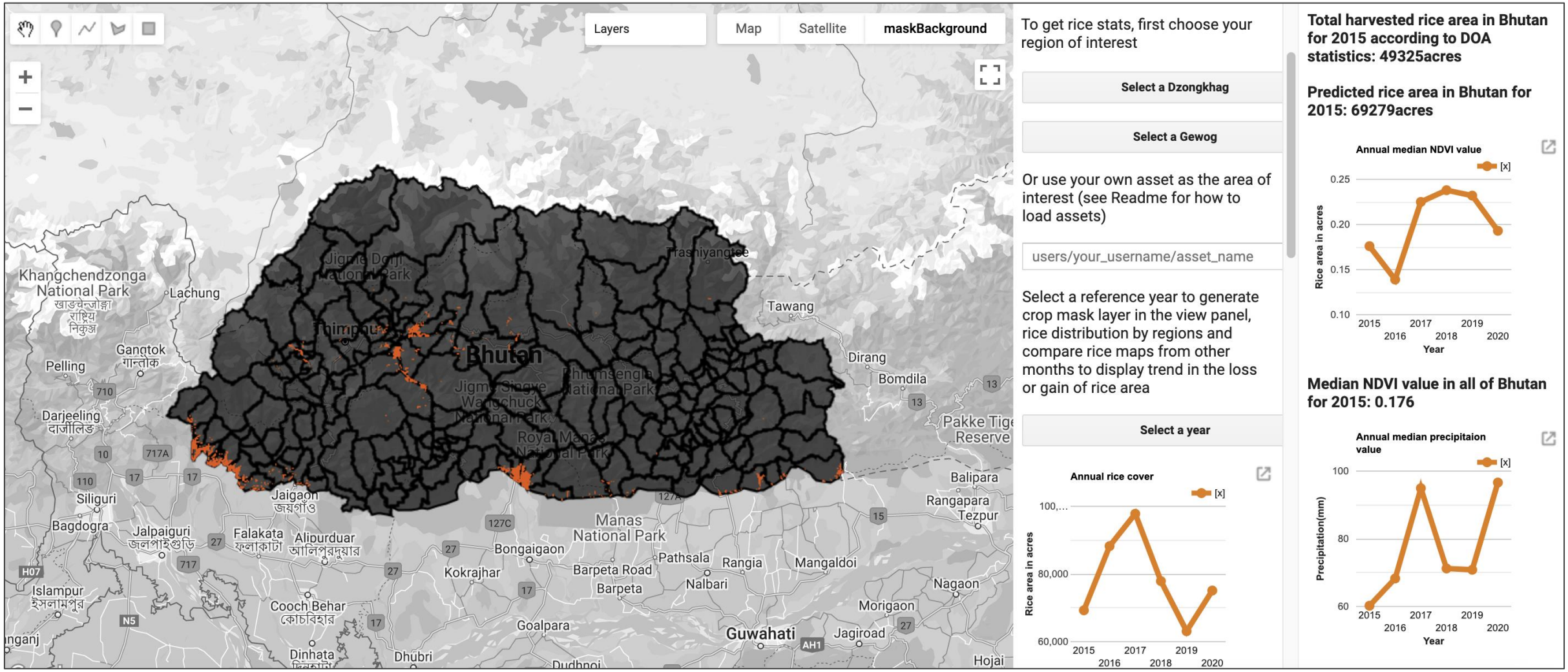


APPLYING RANDOM FOREST MODEL

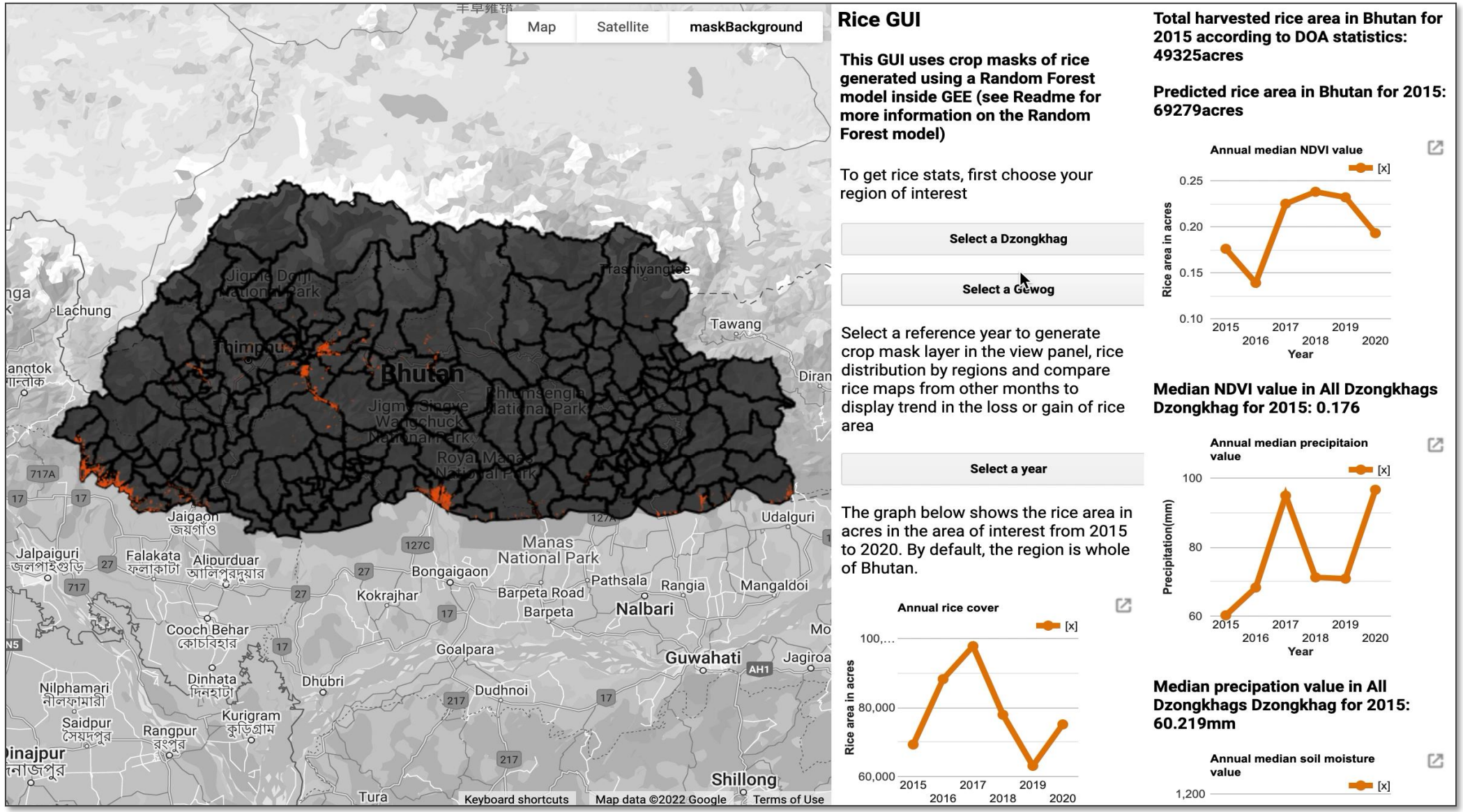


Rice Mask

GRAPHICAL USER INTERFACE



GRAPHICAL USER INTERFACE: VIDEO DEMO



CONFUSION MATRICES RESULTS

Model's predicted label

True label	Rice	Non-Rice
Rice	True positive	False positive
Non-Rice	False negative	True negative

Model's predicted label

True label	Rice	Non-Rice
Rice	432	30
Non-Rice	100	481

STATISTICAL MEASUREMENTS FOR TESTING DATA

Statistical method	Score
Accuracy	85.9
F1 score	85.9
Kappa score	71.8

CONCLUSIONS

Image Credit: Nidup Dorji

- This methodology coupled with support from NASA SERVIR created significantly accurate aggregated crop masks for each year from 2015 to 2020 using the Random Forest classifier.
- The model predicted an increase in rice area from 2015 to 2017, but a gradual decrease through 2019 before increasing again in 2020.
- Model predictions indicated 2019 to have the lowest rice area of 63,098 acres and 2017 to have the highest rice area of 97,789 acres.
- The model had an average accuracy of 85.9% and a kappa score of 71.8%.

ERRORS AND UNCERTAINTIES

- Limitations of a RF model specialized for crop conditions of 2015 to 2020
- Difficulties in isolating variable significance for rice classification
- Assumption of rice crop as a single variety; different varieties have different growth periods and climate conditions.
- Human errors such as biases and random errors

Image Credit: Nidup Dorji

Future Work

Image Credit: Nidup Dorji

- **Expand** the current GUI to have more functionality
- **Determine** the productivity and yield of crops in different districts of Bhutan
- **Separate** the rice crop mask into different varieties specific to each region
- **Discern** abandoned farmlands

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