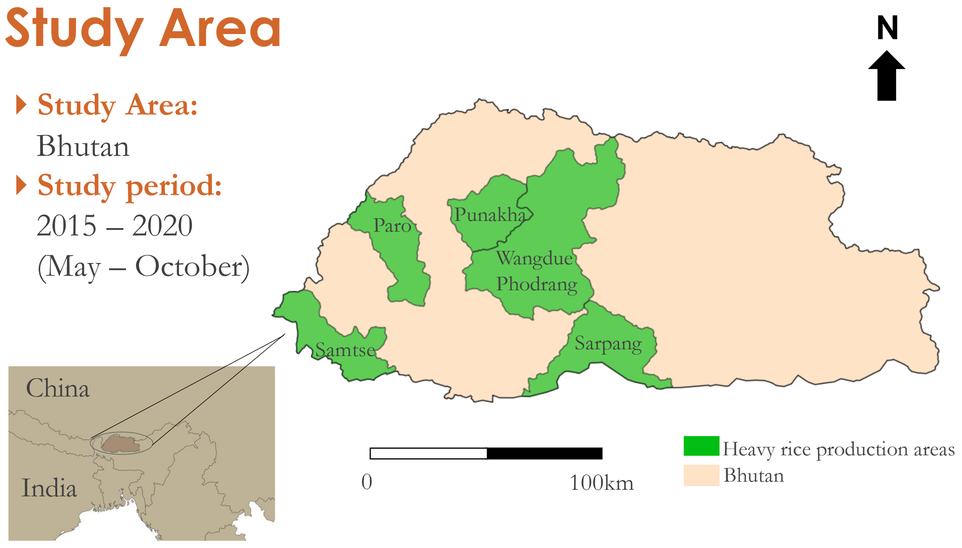
Creating a Graphical User Interface, Crop Mask, and Data Collection Protocol for Analysis of Rice Crop in Bhutan using Remotely Sensed Data

Abstract

Agriculture is an important sector in Bhutan, accounting for 19.2% of Bhutan's GDP in 2020 while also providing livelihoods for approximately 57% of the population. The Department of Agriculture (DoA) in Bhutan still relies on in-field reporting for crop monitoring, which is time-consuming and labor intensive. The team partnered with the DoA, the Bhutan Foundation, and the Ugyen Wangchuck Institute of Conservation and Environmental Research (UWICER) to explore more efficient monitoring using Earth observation data from the Landsat 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), Landsat 8 Operational Land Imager (OLI), Aqua and Terra Moderate Resolution Imaging Spectroradiometer (MODIS), Shuttle Radar Topography Mission (SRTM), and Sentinel-1 C-band Synthetic Aperture Radar (C-SAR). With the help of science advisors from NASA SERVIR, the team expanded the crop mask, created in the previous term, to the whole country of Bhutan for the time period of 2015–2020 (May–October) and streamlined the sampling protocols for applicability to any available crop data. The random forest model was trained, validated, and tested with manually classified points from Collect Earth Online (CEO) for five heavy rice production districts: Paro, Samtse, Sarpang, Punakha, and Wangdue Phodrang. The accuracy and kappa scores of the random forest model were 85.9% and 71.8%, respectively. The team also developed a graphical user interface (GUI) which provided a visual representation of current trends and rice distribution across Bhutan. This project refined the previous term's methodology to help supplement crop monitoring and increase the frequency of data collected to aid decision-making processes with the use of remote sensing data.

Study Area

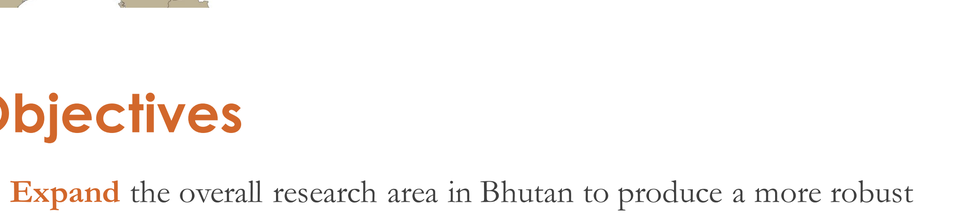
- **Study Area:** Bhutan
- **Study period:** 2015 – 2020 (May – October)



Objectives

- **Expand** the overall research area in Bhutan to produce a more robust crop mask for rice
- **Create** a Graphical User Interface (GUI) for crop analysis
- **Tune** the Random Forest model parameters to yield optimal performance in creating the crop mask
- **Streamline** the previous term's data collection protocol for ease of use and generalizability to any crop

Earth Observations



Team Members

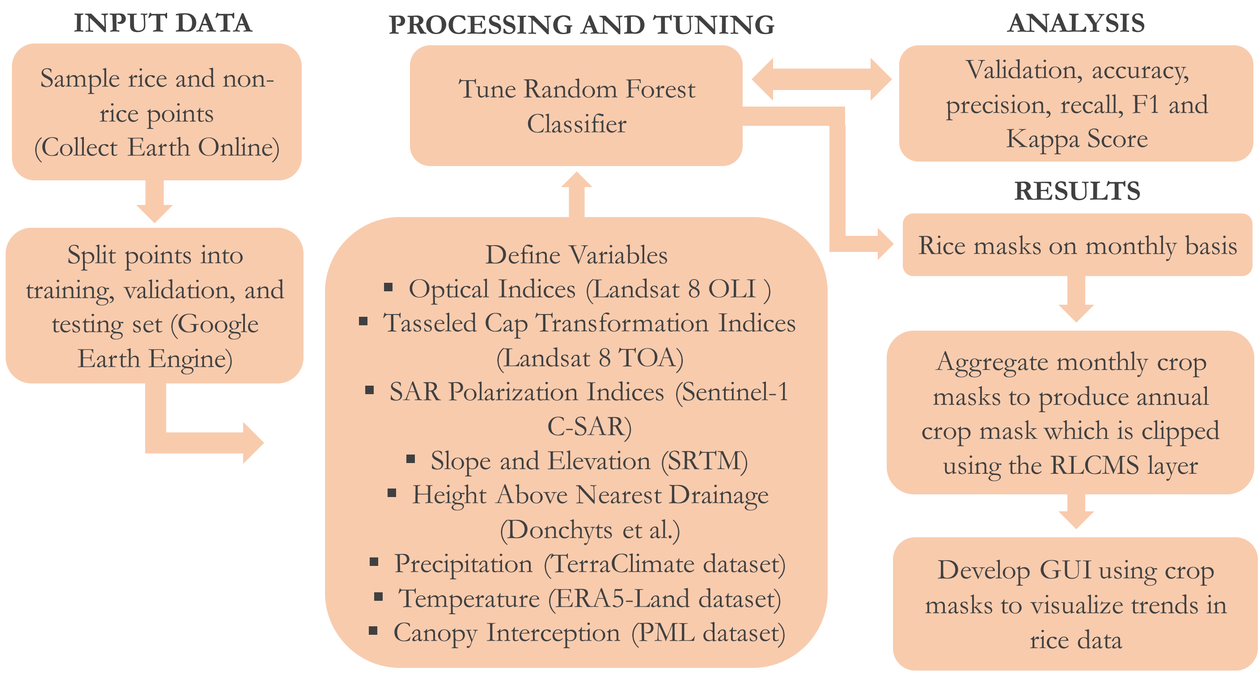
Wangdrak Dorji (Project Co-Lead)

Tenzin Wangmo (Project Co-Lead)

Karma Dorjee

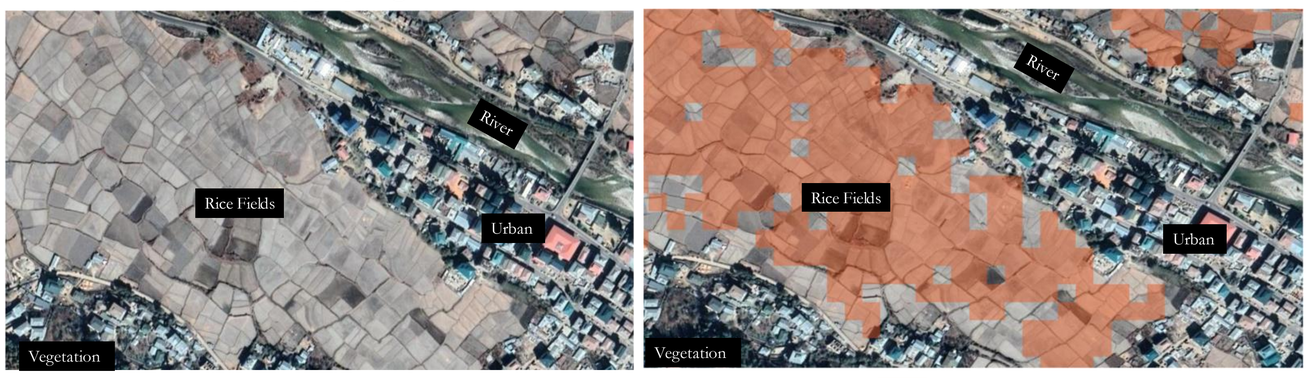
Sonam S Tshering

Methodology



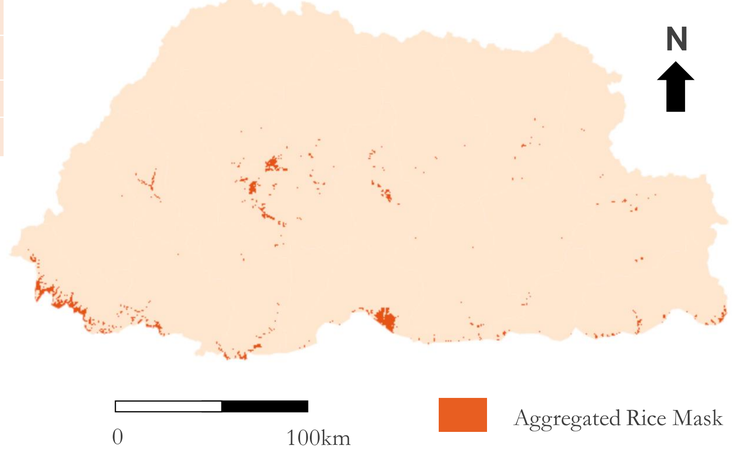
Results

Applying the Random Forest Classification Model



Accuracy score	0.8589
Kappa Score	0.7186
Testing Precision	0.8943
Testing Recall	0.8097
F1 Score	0.8593

GUI:



Conclusions

- 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%.

Acknowledgements

The team would like to thank everyone for their help with the project:

Past contributors: Sherab Dolma, Yeshey Seldon, Kusal Khandal

Fellow: Paxton LaJoie (NASA DEVELOP)

Science Advisors: Sean McCartney (NASA Goddard Space Flight Center), Dr. Kenton Ross (NASA Langley Research Center), Dr. Robert Griffin (The University of Alabama Huntsville), Dr. Jeffrey Luvall (NASA Marshall Space Flight Center), and the NASA SERVIR team: Tim Mayer, Filoteo Gomez-Martinez, Biplov Bhandari, Stephanie Jimenez, Meryl Kruskopf, Kaitlin Walker, and Micky Maganini

This material contains modified Copernicus Sentinel data (2015-2020), processed by ESA.

Bhutan Agriculture II