Satellite Prediction of SOC for Smallholder Farmers in Odisha, India

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Objective

This study proposes the utilization of satellite data to estimate soil organic carbon (SOC) on small fields in India. This study aims to dismantle two fundamental obstacles to carbon credit markets: producing a low-cost and scalable way to measure soil organic carbon using remote sensing data, so the benefits from carbon sequestration will directly benefit smallholder farmers.

Motivations

- Agriculture's role in GHG emission is significant.
- Carbon credit markets like Verra aim to reduce emissions.
- Small-scale farmers in developing countries lack access.
- Carbon credits could boost income in these regions.

Challenges for Carbon Credit Firms:

- High costs associated with monitoring and soil testing.
- Expensive contracts with smallholder farmers.

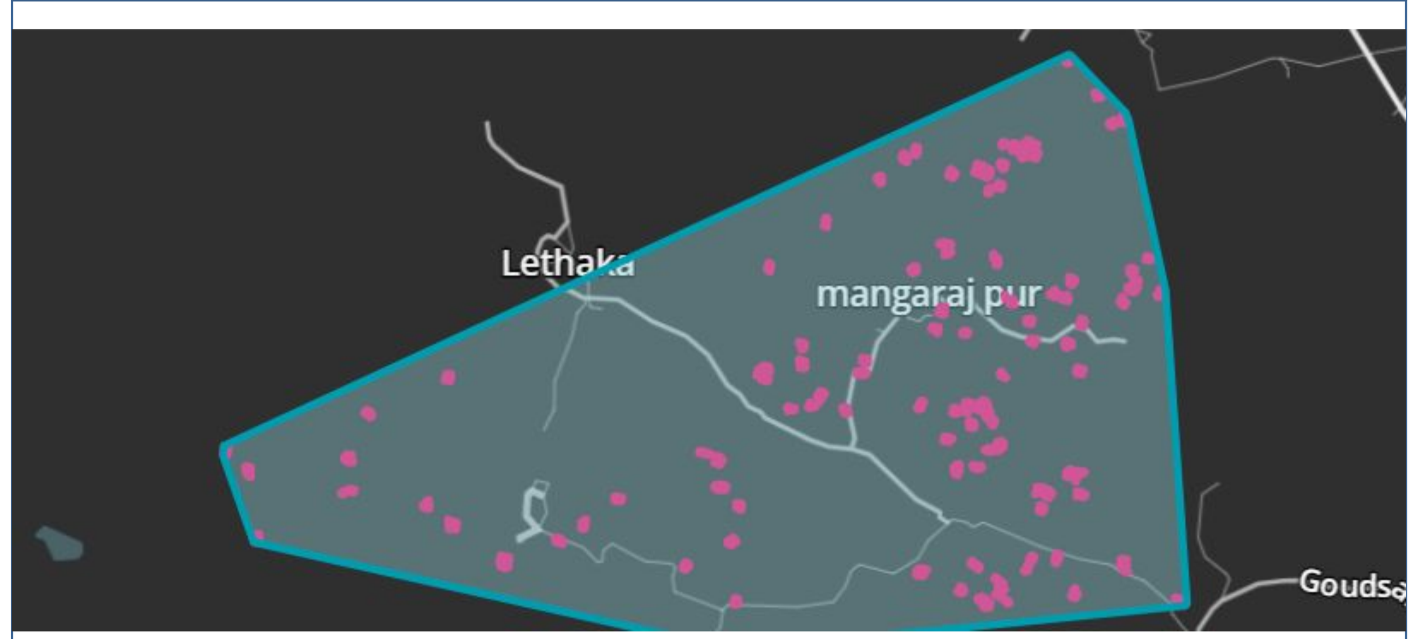
→ **Solution**: Develop a credible protocol to link smallholder farmers with the carbon credit market.

Challenges for Smallholder Farmers:

- Uncertainty about the effects on yield.
- Low willingness to adopt new practices.

→ **Solution**: Verify the impact on yield and develop a scalable method to assess both the private and the carbon credit value.

Area of Interest (AOI)



Data

Remote Sensing Data Layers:

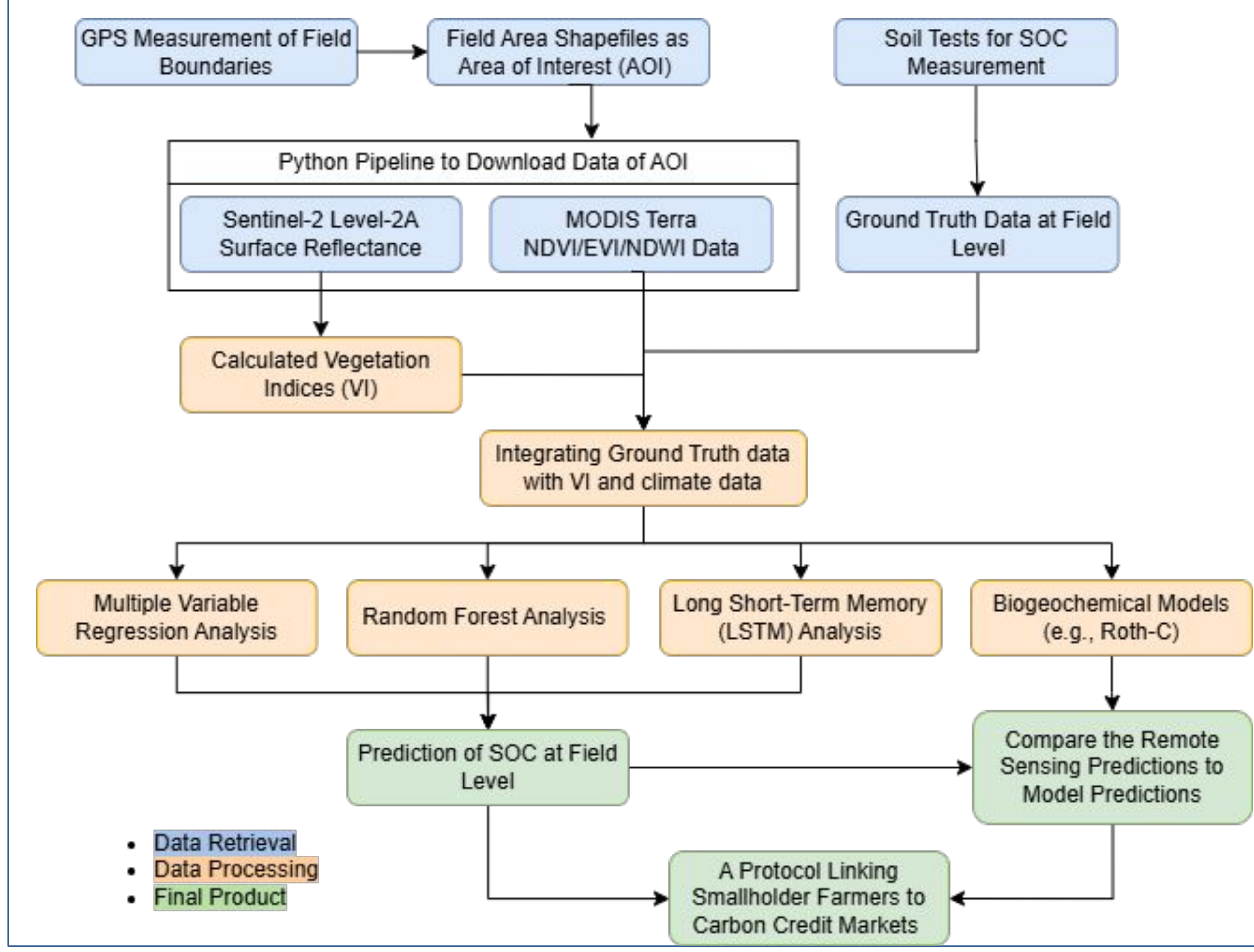
- Sentinel-2 Level-2A Surface Reflectance (10m resolution, 2017-present)
- ECMWF ERA5 (250m resolution, 1979-present)

Ground Truth Data Layers:

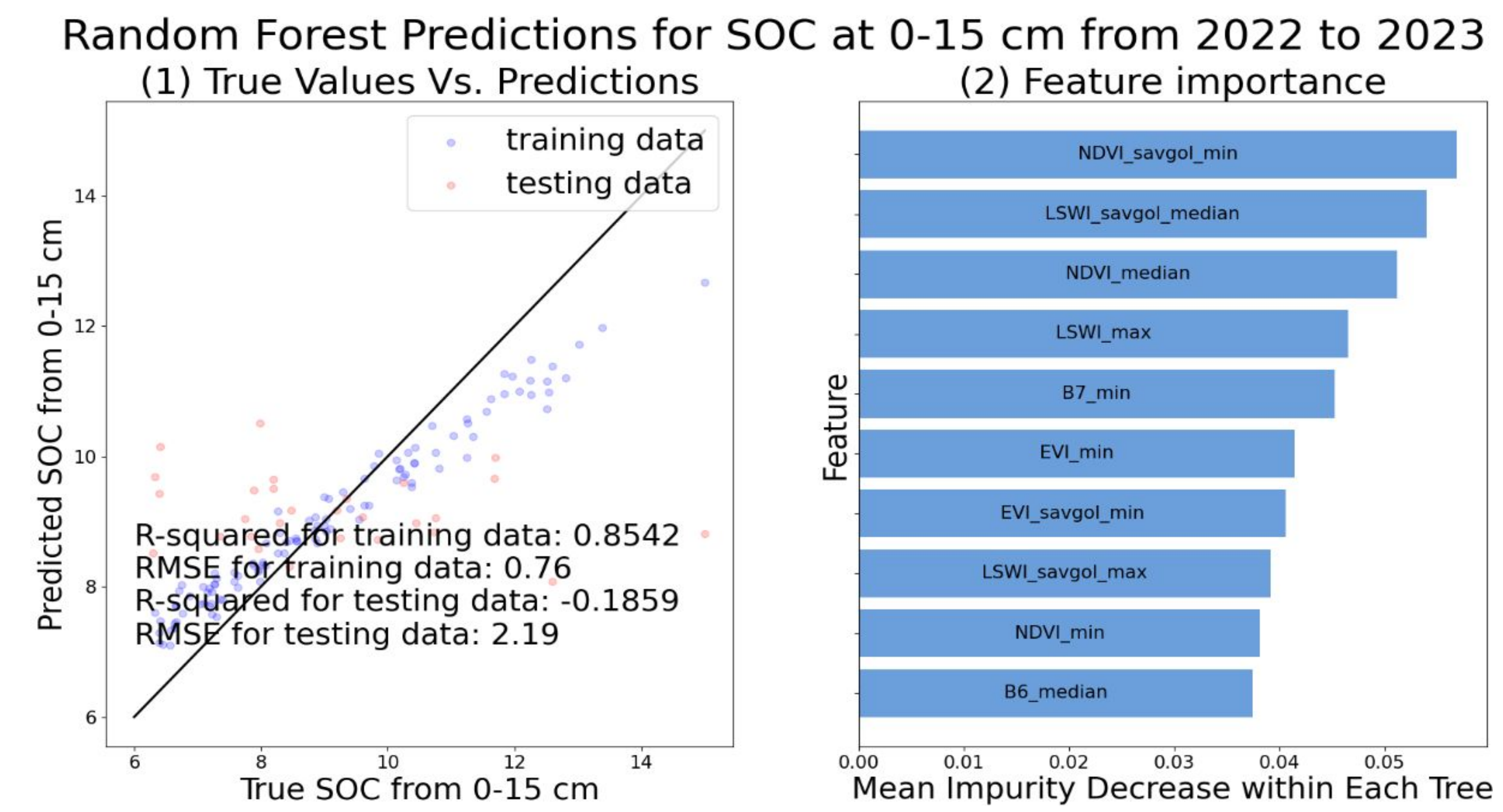
- SOC measurements from 2022 soil tests following random sampling approach (Brus & Saby, 2016)
- Yield measurements from crop cutting experiments based on the sampling of small subplots within cultivated fields (Ahmad et al., 2021)
- Self-reported yield measurements

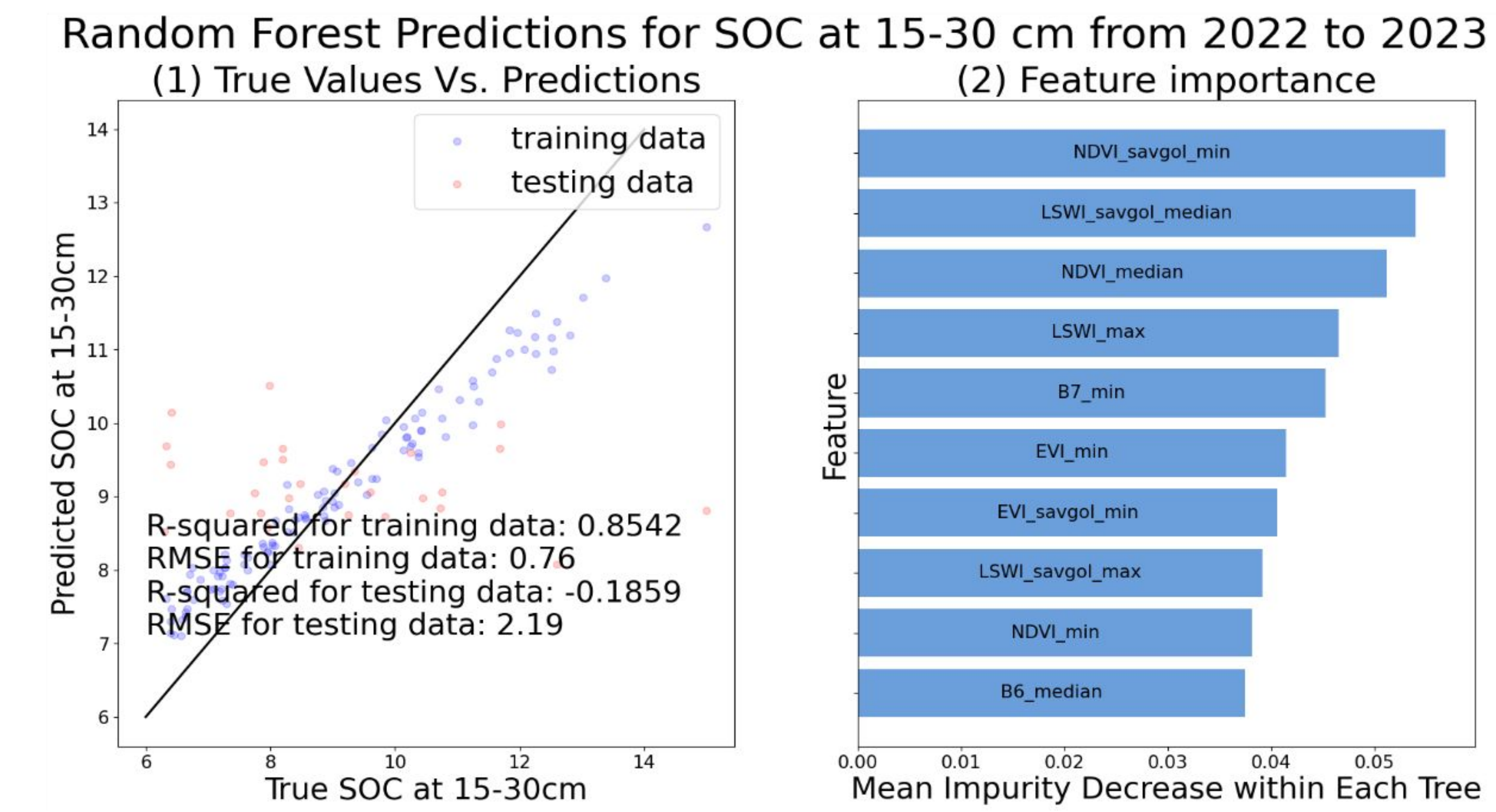
Methodology

- Update Random Forest and Long Short Term Memory (LSTM) ML tools to our context, utilizing our soil analyses as training data
- Explore potential of different satellite data feature layers for validating adoption and impact of regenerative agricultural practices.



Results





The RF model's optimal parameters were 100 trees and a depth of 17.
The two most important features were minimum Normalized Difference Vegetation Index (NDVI) and median Land Surface Water Index (LSWI).

- NDVI measures vegetation density and plant/soil health.
- LSWI represents vegetation and soil water content.

Future Research

➔ Reconstruct input variables for Long Short Term Memory Model (LSTM)
➔ Use 2022 SOC and bulk density data to predict 2023 SOC.
➔ Explore an alternative Convolutional (CNN) model or a hybrid LSTM-CNN model.
➔ Test a new spatial interpolation method: Random Kriging.

References

Oldfield, E. E., Eagle, A. J., Rubin, R. L., Rudek, J., Sanderman, J., & Gordon, D. R. (2022). Crediting agricultural soil carbon sequestration. Science, 375(6586), 1222–1225. https://doi.org/10.1126/science.abl7991

Padarian, J., Minasny, B. and McBratney, A.B., 2019. Using deep learning for digital soil mapping. Soil, 5(1), pp.79-89.

Smith, P., Soussana, J.F., Angers, D., Schipper, L., Chenu, C., Rasse, D.P., Batjes, N.H., Van Egmond, F., McNeill, S., Kuhnert, M. and Arias-Navarro, C., 2020. How to measure, report and verify soil carbon change to realize the potential of soil carbon sequestration for atmospheric greenhouse gas removal. Global Change Biology, 26(1), pp.219-241.

Yang, M., Xu, D., Chen, S., Li, H. and Shi, Z., 2019. Evaluation of machine learning approaches to predict soil organic matter and pH using Vis-NIR spectra. Sensors, 19(2), p.263.

Zhao, Z., Yang, Q., Sun, D., Ding, X. and Meng, F.R., 2020. Extended model prediction of high-resolution soil organic matter over a large area using limited number of field samples. Computers and electronics in agriculture, 169, p.105172.

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