Enhanced Remote Sensing – Machine Learning based crop insurance index product *(A case study in Ethiopia for Maize)*

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Background

- Smallholders face myriads of **climate change-induced risks**, which thwart crop productivity and lead to **migration from farming**.
- **Agricultural insurance** is vital for **climate change adaptation**, offering **financial security to smallholders**, incentivizing resilience, attracting sustainable investments, and enhancing community food security.
- However, **low adoption of crop insurance** among global south smallholders persists due to concerns about (i) insurance quality and basis risk, (ii) limited accessibility, and (iii) high transaction costs.
- Addressing these issues necessitates establishing economically viable, **low-basis-risk index-based crop insurance** to encourage smallholder participation and expand insurance product availability.

Objectives

- The research aims to design a **scalable data-driven crop insurance product**, serving as a **climate risk transfer solution** to address financial risks and sustain farmers' livelihoods amid a changing climate.
- Objectives include achieving **high accuracy, resolution, and frequency in assessing crop productivity loss indices** for Maize in Ethiopia, utilizing machine learning algorithms and satellite remote sensing data (MODIS/Landsat) to reduce design, spatial, and temporal basis risks.
- Evaluation of economic viability against conventional index-based designs aims to support (re)insurance companies in enhancing index-based insurance with decreased basis risk, **promoting accessibility, and subsidizing costs for economically viable insurance products.**

Materials and Methods

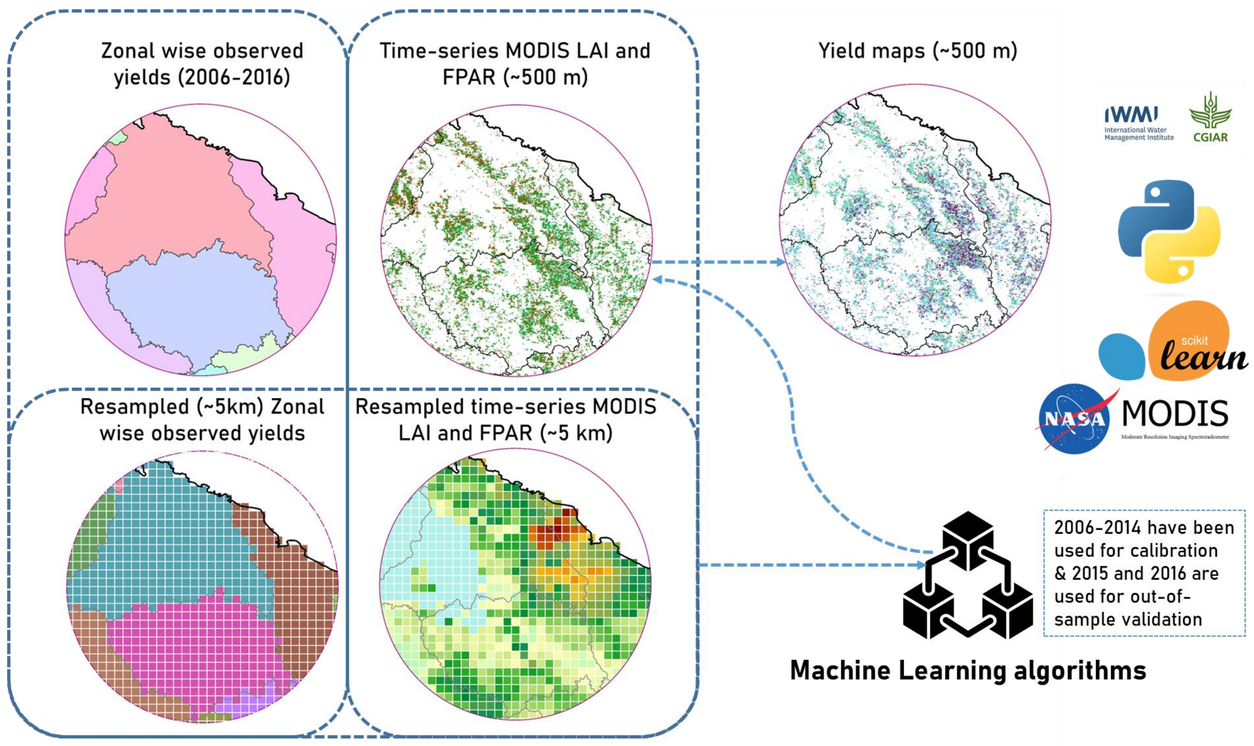

Figure 1. A flowchart for the methodology to develop yield loss products

- A crop mask from European Space Agency (ESA) has been applied to mask maize growing regions in Ethiopia.
- Masked dataset has been used to extract information from MODIS remote sensing variables as predictors to generate machine learning models.
- A comprehensive diverse machine learning predictive algorithms, including gradient-boosted regression, XG Boost, and Random Forest was employed to estimate precise high-resolution yield.
- Then high-resolution yields were aggregated to zone and validated against out of sample observations to estimate model's efficiency.

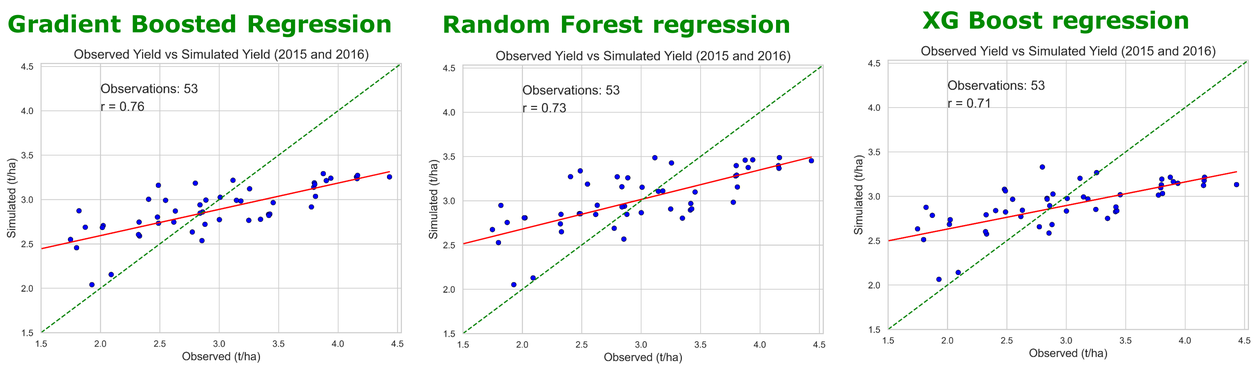

Figure 2. Model performance against out-of-sample data

Results

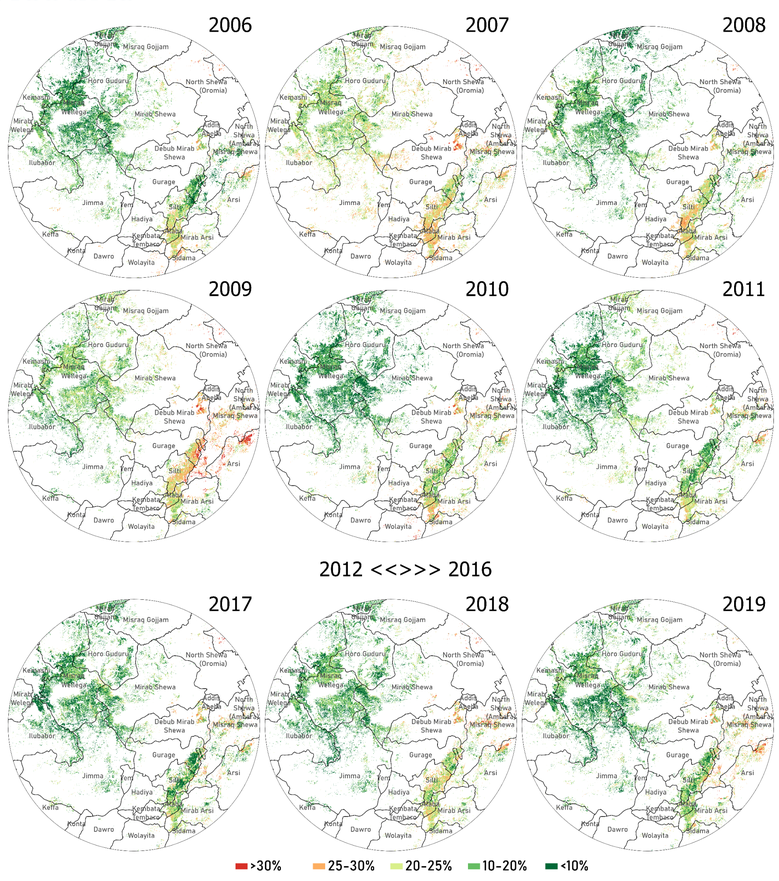

Figure 3. Yield loss information at high resolution (~500m) from ensembled machine learning models for insurance payouts

- ✓ Developed yield loss rasters by mosaicking outputs from different machine learning algorithms (GBR, RF, and XGb) utilized in the study.
- ✓ Applied machine learning algorithms (GBR, RF, XGb) to each zone and selected the algorithm with the highest accuracy for generating simulations. For example, if Zone1 demonstrated higher accuracy with GBR, its simulations were produced using the GBR algorithm.
- ✓ Utilized zone-level accuracy as a criterion for algorithm selection, ensuring that the chosen machine learning algorithm for each zone was reflective of its performance in that specific area.

Conclusions

- Successful integration of remote sensing data with machine learning algorithms for accurate crop yield estimation can be best alternative for vegetation-indices based index products for crop insurance payouts.
- High accuracy in both within-sample and out-of-sample validation, demonstrating the robustness and generalizability of the downscaling approach.
- Emphasized the potential of the downscaling approach, not relying on high-resolution ground data, making it applicable for agricultural assessments in other regions globally.

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