Irrigated Area Mapping Using EO Data and Advancing Machine Learning Techniques: The Case of Awash Valley, Ethiopia




Berhan Gessesse, Gebeyehu, A., Abraraw A., Gezahagn W. Remote sensing Department, Space Science & Geospatial Institute

A.Taravat, D. Petit, Deimos Space UK Ltd., Oxford, UK

Scientific Background and Objectives

Motivations

- Irrigation farming complements rainfed agriculture, especially in arid lowland regions of Ethiopia.
- Precise and accurate information on irrigated cropland areas is crucial for achievable Ethiopia's food security and sustainable development strategy.
- However, mapping and quantifying the existing and potential irrigated lands remains a significant challenge in the country.

Data Sources for experiments in irrigation area mapping

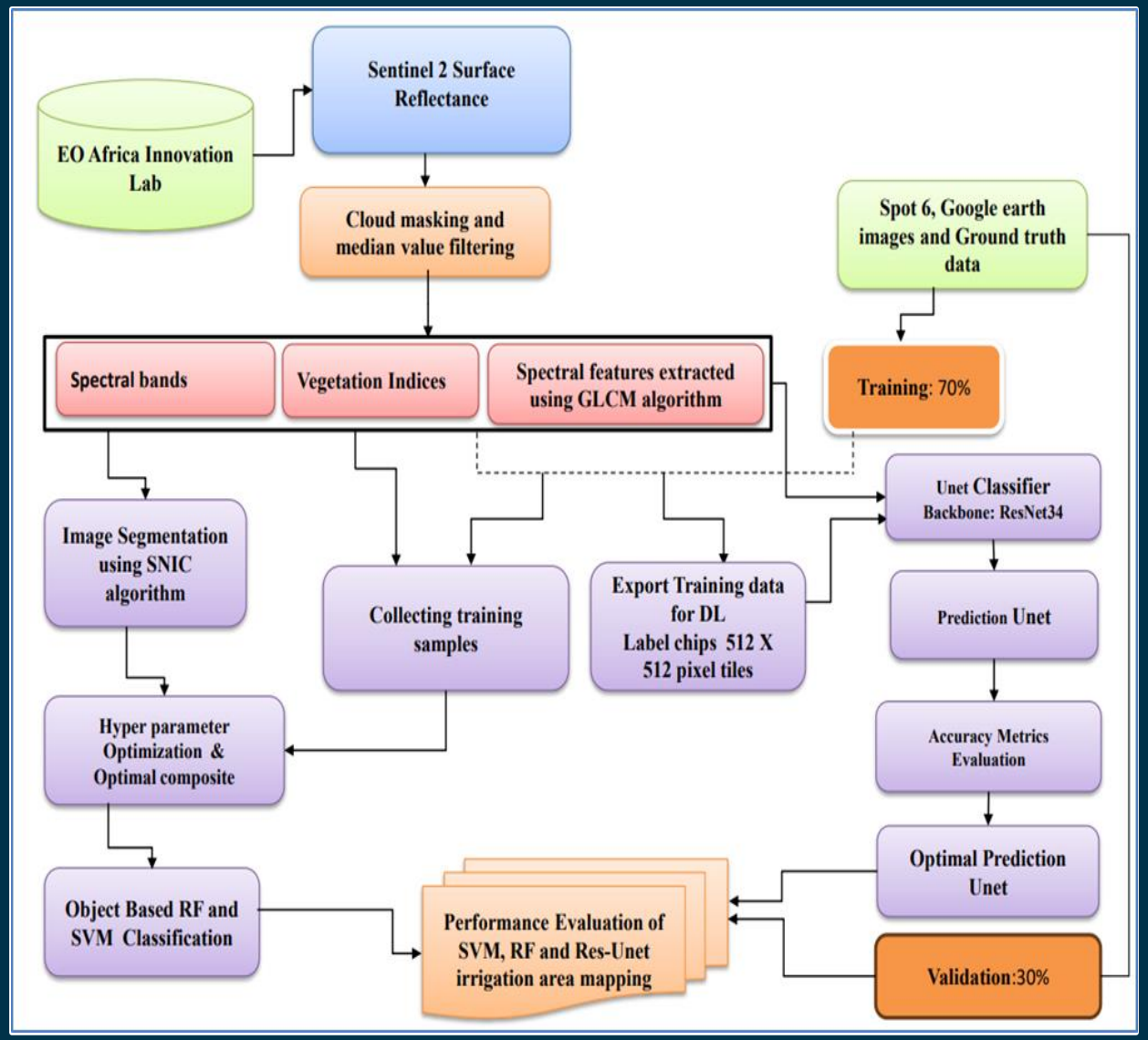
Scenario	Input bands	Description	No inputs
1	B2, B3, B4, B8, B11, B12	Visible and Near-infrared (VNIR) Shortwave infrared (SWIR)	6
2	Scenario 1 and VIs	Combined use of spectral bands from scenario 1 and vegetation Indices such as EVI, NDVI and LSWI computed from selected Sentinel 2 Surface reflectance bands	9
3	Scenario 1, 2 and spectral features	Combined use of the spectral bands and VIs from scenarios 1 and 2 respectively and the spectral features such as variance, contrast and dissimilarity computed from selected S2A Surface reflectance bands.	27
4	**Ground truth Data**		

NB: EVI= Enhanced Vegetation Index; NDVI= Normalized Difference Vegetation Index and LSWI=

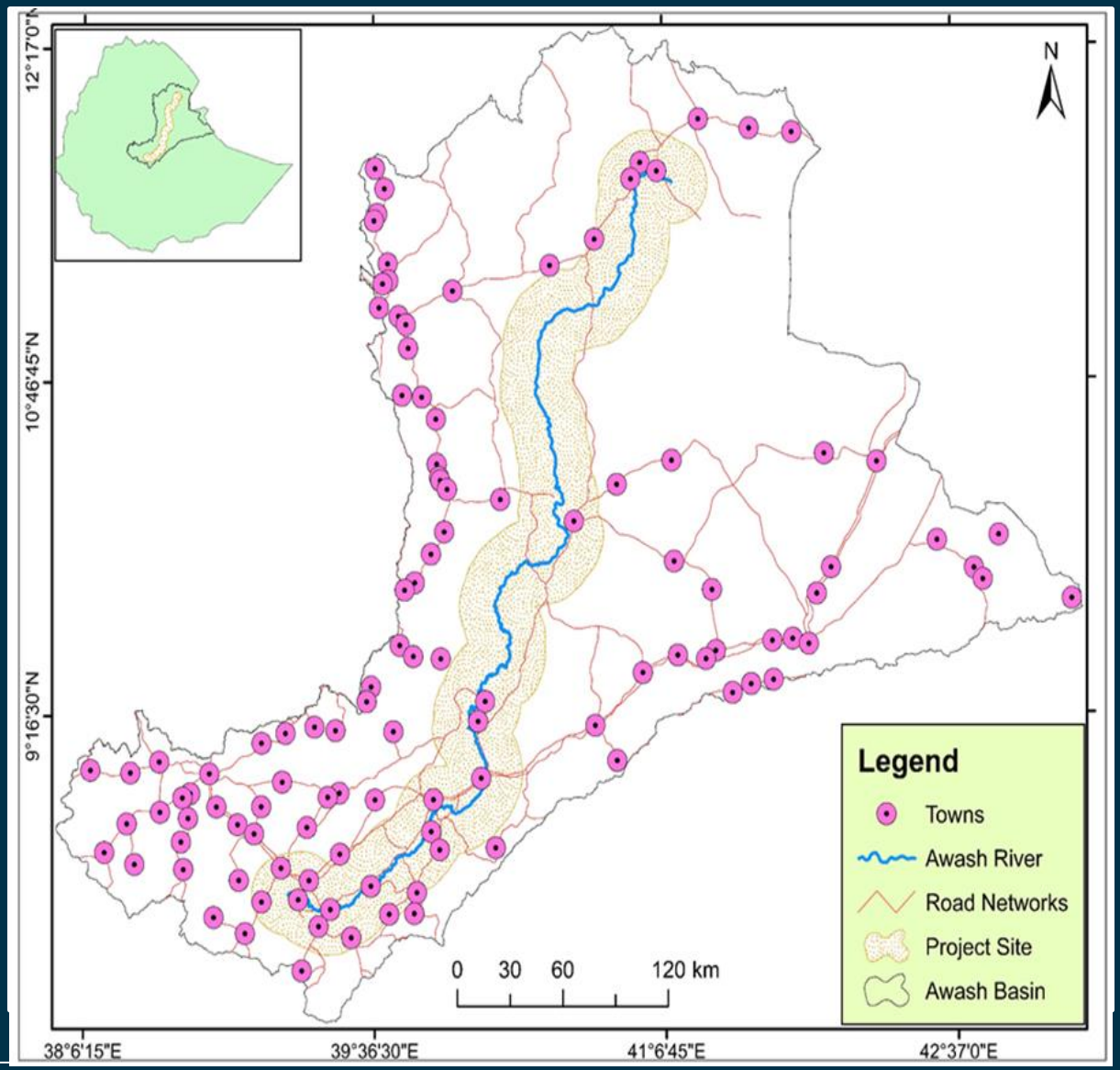
Objective

- The objective of the study was to evaluate the performance of advanced machine learning techniques, including Support Vector Machine (SVM), Random Forest (RF), and ResUNet deep learning model, and leveraging Earth Observation (EO) data to accurately map and visualize irrigation farming areas in the Awash Valley of Ethiopia.

Research Outline



Study Area

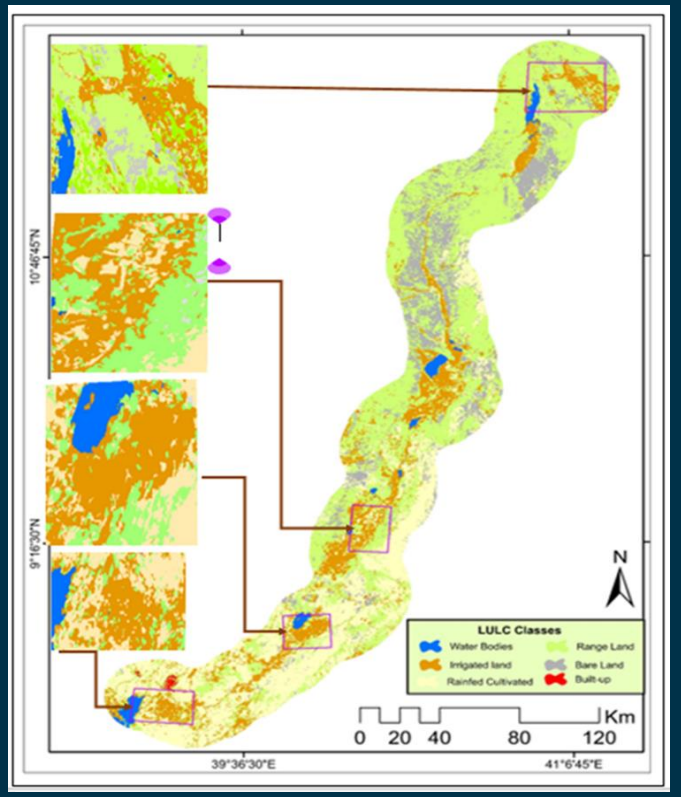


Results

Summary statistics of the accuracy assessment analysis results

Models	Indices	S2A Bands	S2A Bands + VIs	S2A Bands+ VIs + Spectral Features
SVM	Overall accuracy (%)	66.75	64.91	67.54
	Kappa Coefficient	0.57	0.55	0.59
	F1 Score (Statistics)	0.58	0.62	0.65
RF	Overall accuracy (%)	77.72	77.88	82.33
	Kappa Coefficient	0.721	0.72	0.81
	F1 Score (Statistics)	0.78	0.78	0.86
ResUnet (8,15,256 X256)	Overall accuracy (%)	79.12	83.42	84.13
ResUnet (10,19,256 X256)	Kappa Coefficient	0.76	0.79	0.83
	F1 Score (Statistics)	0.81	0.86	0.87

NB: SVM= Support Vector Machine, RF= Random Forest, ReSUnit= Residual Unet deep learning Mode



Computed Irrigated Areas in the entire Project site

	Scenario 1		Scenario 2		Scenario 3		
	SVM	RF	SVM	RF	SVM	RF	ResUNet
Irregated Areas	Area(Km²)	Area(Km²)	Area(Km²)	Area(Km²)	Area(Km²)	Area(Km²)	Area(Km²)
	5375.68	4938.87	3565.83	3774.47	5026.65	2929.31	3102.83

Insights & Further work

The EO4Africa project has established a foundation for future research in agricultural land monitoring using EO data and the EO-Africa Research and Development Innovation Lab. The study confirmed the effectiveness of Sentinel-2 imagery and the ResUNet model for irrigated area mapping. The ResUNet model, which achieved an average F1 score of 0.87, outperforming the RF and SVM models with F1 scores of 0.86 and 0.65, respectively. However, further refinement of satellite data processing and investment in deep learning model training and validation are needed to expand methodological impact on sustainable agriculture strategy intervention in Ethiopia.