Satellite remote sensing of Above-Ground Biomass (AGB) on Agroforestry Plots

Enhancing Income Streams through Carbon Credits

FUNDAÇÃO LEVASFLOR

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Introduction

- Smallholder agriculture essential for food security and income generation
- Field Level Monitoring of Above-Ground biomass on plot-level can be expensive

Miombo 500 Project

- Implemented by LevasFlor Foundation, NGO in Mozambique
- **GOAL:** Preserve and develop 500.000 hectares of Miombo Forest by maximizing its sustainable economic value
- **STRATEGY:** Establish Carbon Credit Project for Agroforestry Program as an opportunity for smallholder farmers to diversify

Methods

- Narrative Review; Literature search Years: 2003-2023 in Web of Science
- Official mission data from space agencies
- Comparison for application of plot-level AGB Measurements (check with AGB field data)
- Research Question:
  Which remote sensing methods can be useful for measurements of Above Ground Biomass on plot level?

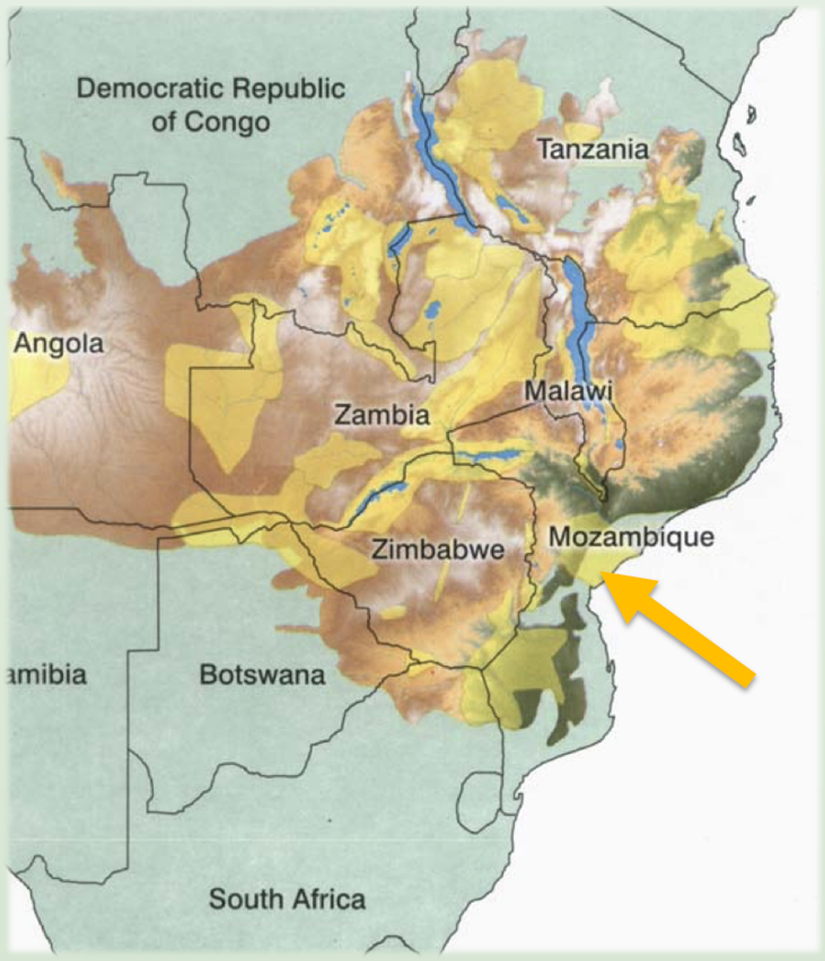

Figure 1: Map of Miombo Ecosystem in southern Africa. Pinpointing project Location

Challenges & Critics

- Carbon pools not included:
  1. Below-Ground Biomass
  2. Soil Organic Carbon
  3. Necromass (Deadwood)

Carbon Credit Project

- Carbon Storage as an ecosystem service → Product of a sustainably managed landscape
- AGB on Agroforestry and Community Forest plots shall be measured individually
- Enabling direct money transfers to a smallholder farmer/community

Conclusion

- Combined optical data and LiDAR date → most accurate results at plot level
- Remote sensing methods are available for AGB plot estimates
- Farmers can diversify income streams through carbon credit programs

Sensors	RMSE
Optical (Landsat 8)	66%
LiDAR (ICESAT2)	50%
Combination of Optical and LiDAR (Light Detection and Ranging)	49%

Results

Mission	Sensor	Spatial Resolution	Additional Resolutions	Revisit time
EnMAP	Hyperspectral	30m		27 days
HISUI	Hyperspectral	20x30m		n.a.
MOLI	LiDAR	5m	Wall-to-wall Canopy Hight & AGB	16 days
ICESAT2	LiDAR	1000m	3m global vegetation hight	91 days
GEDI	LiDAR	25m	25m AGB	n.a.
SAOCOM 1A & 1B	SAR	7 - 100 m		8 days with both satellites
ALOS-2 PALSAR-2	SAR	10m		14 days
Tandem-L	SAR	30m	50m AGB, 30m Canopy hight, AG	16 days
ALOS-4 PALSAR-3	SAR	1-3m		14 days
NISAR	SAR	7 m	annual AGB at 1 ha	12 days
BIOMASS	SAR (Syntetic Aperture Radar)	4ha	200m AGB and Canopy Hight	once every year
SENTINAL 2 A & B	Optical	10m		5 days
Landsat 7	Optical	15m	panchromatic	16 days
Landsat 8	Optical	30m		8 days with Landsat 9
Landsat 9	Optical	15m		8 days with Landsat 8
RapidEye	Optical	5m		1- 5 days
SkySat	Optical	0,9m		serveral times per day
Dove	Optical	3-5m		serveral times per day

Figure 2: Non-exhaustive List of current and future earth observation missions for Above Ground Biomass mapping

- Optical multispectral sensors (Landsat and Sentinel-2) provide valuable data
- Higher-resolution optical data from commercial constellations (RapidEye and Dove) but higher costs
- Synthetic Aperture Radar (ALOS PALSAR and Sentinel-1) permit AGB estimation in areas with persistent cloud cover
- LiDAR sensors, including ICESat-2 and GEDI, offer detailed information on the vertical distribution → enhanced precision
- Future missions:
  NASA's NISAR and ESA's BIOMASS, hold promise for improved SAR and LiDAR data

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