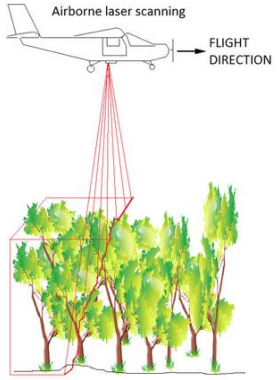
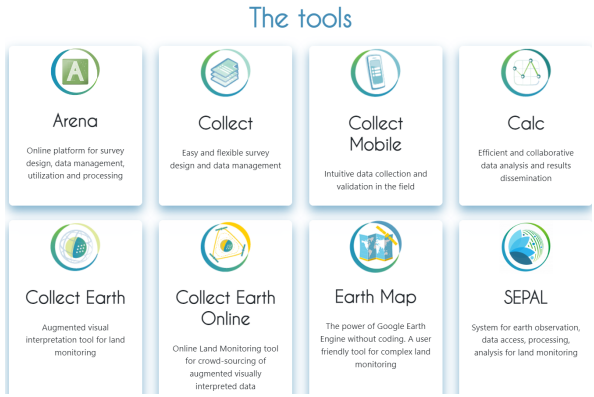
Overview of data collection methods for forest management





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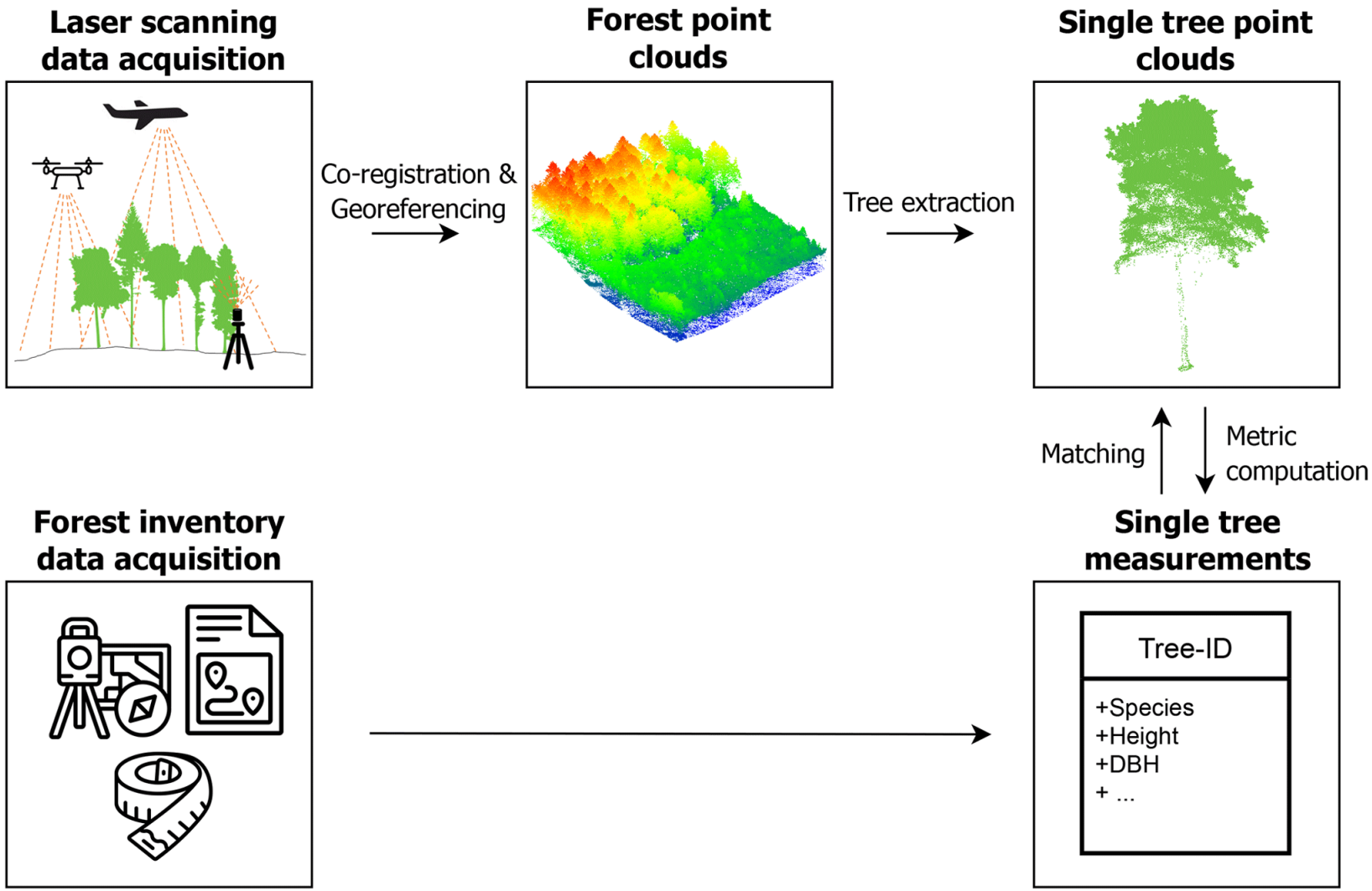
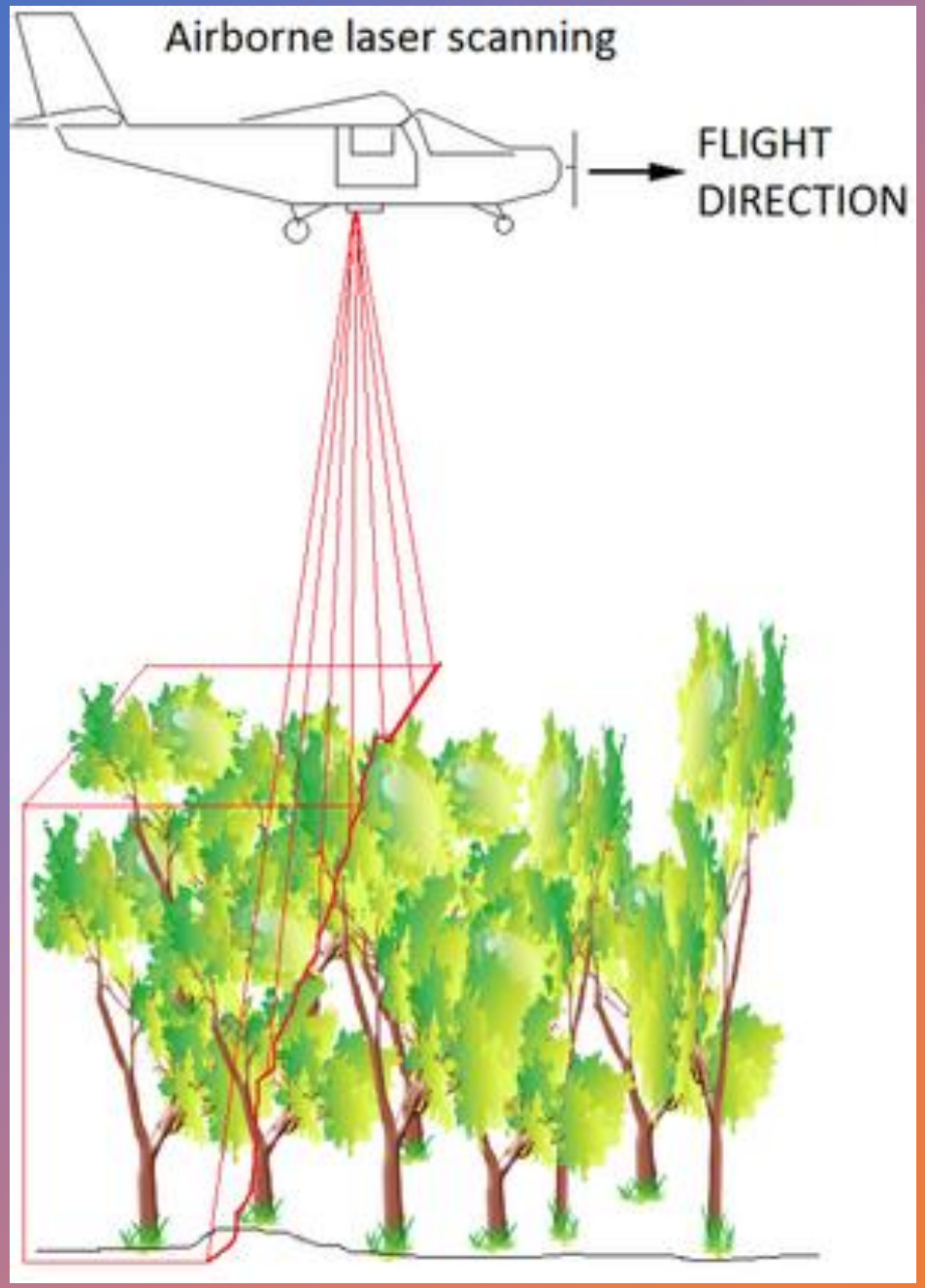
Background

- The first step in a National Forest Inventory (NFI) involves developing a national land cover map displaying different forest strata across the country.
- Next, ground-based sample plot inventories are conducted on permanent sample plots distributed across the country.
- Allometric models are then applied to estimate average biomass and carbon stocks for sample plots lying within a given stratum.
- National level carbon stock is then estimated by applying the average biomass and carbon density values across the map with the same forest strata.

Background

- However, comprehensive ground-based inventories are associated with high labor and operational costs hence restrictive to most developing countries
- This has prompted researchers to search for other reliable, precise but more cost-effective biomass estimation methodologies.
- A promising approach aimed at reducing labor and operational costs, as well as improving the reliability of estimated biomass in NFIs, involve **combining data from ground-based forest inventories and remote sensing**

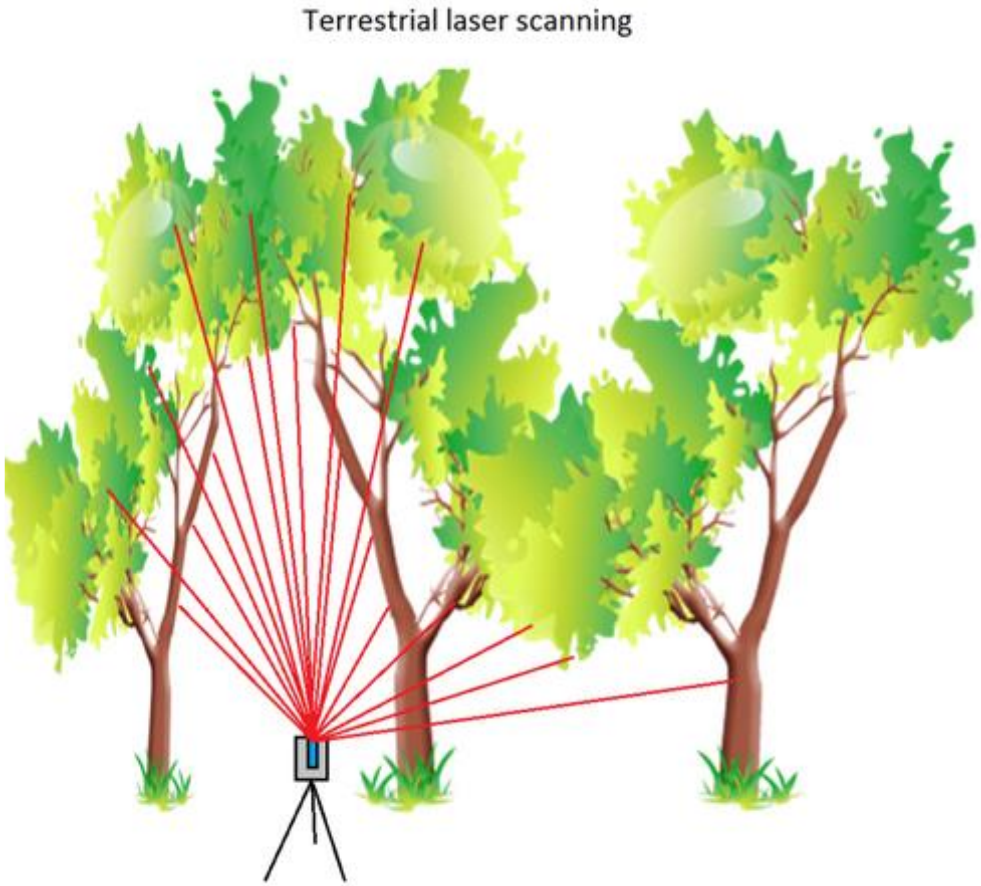

Laser scanning data acquisition
Co-registration & Georeferencing
Forest point clouds
Tree extraction
Single tree point clouds
Matching
Metric computation
Forest inventory data acquisition
Single tree measurements
Tree-ID
+Species
+Height
+DBH
+ ...



Sources of remotely sensed data

- For forestry applications, remotely sensed data are mainly sourced from three main systems, namely,
  - Airborne Laser scanning (ALS)
  - Terrestrial Laser Scanner (TLS)
  - Radio detection and ranging (RADAR) (e.g., synthetic aperture radar (SAR))
  - Optical images (e.g., satellite- or aerial images from drones).

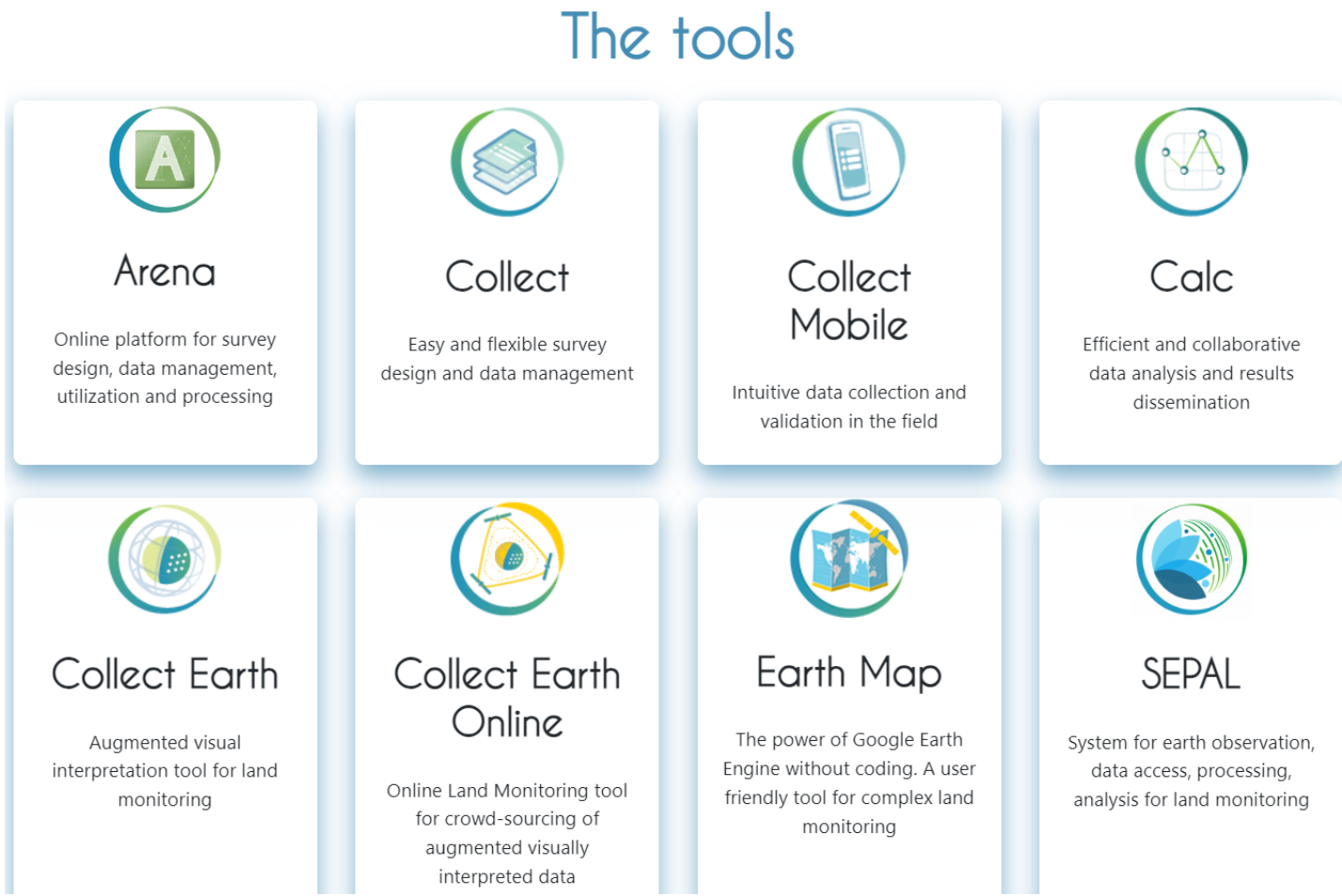
Remote sensing has been widely applied in forestry for several decades in most countries, although with **various degrees of success** due to differences in data types, forest canopy cover, geographical and environmental conditions and methods used



- Data from ALS systems have shown great potential for forest biomass estimations in different forest types including boreal, temperate and tropical forests.
- However, wide application of ALS data for large-scale forest biomass estimation has been limited **due to high data acquisition costs**.
- Integration of ALS and TLS data for estimation of tree AGB at a single-tree level has been investigated.

Open Foris (web-based)

Data Management



Next generation forest management: High detail information from laser scanning

Sep 3, 2015 | Research and releases

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LiDAR Scanning for Forest Management in African

Presented by forest mapping and measurement specialist, ArborMeta.

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What is LiDAR Scanning?

LiDAR scanning involves the use of a laser instrument that scans a physical scene, detecting objects and creating a ‘3D digital replica’ of that scene

Types of LiDAR

Terrestrial LiDAR (TLS)

- Carried by field staff
- Used to collect field plot data
- Ground-truth

Aerial LiDAR (ALS)

- Collected using a drone or aircraft
- Used to collect broad scale data (requires calibration by TLS)

Advantages over conventional methods

- Greater accuracy
- Faster surveys
- Great reliability
- Less labour
- More value for money
- Digital format
- Data richness

Terrestrial LiDAR Data Outputs

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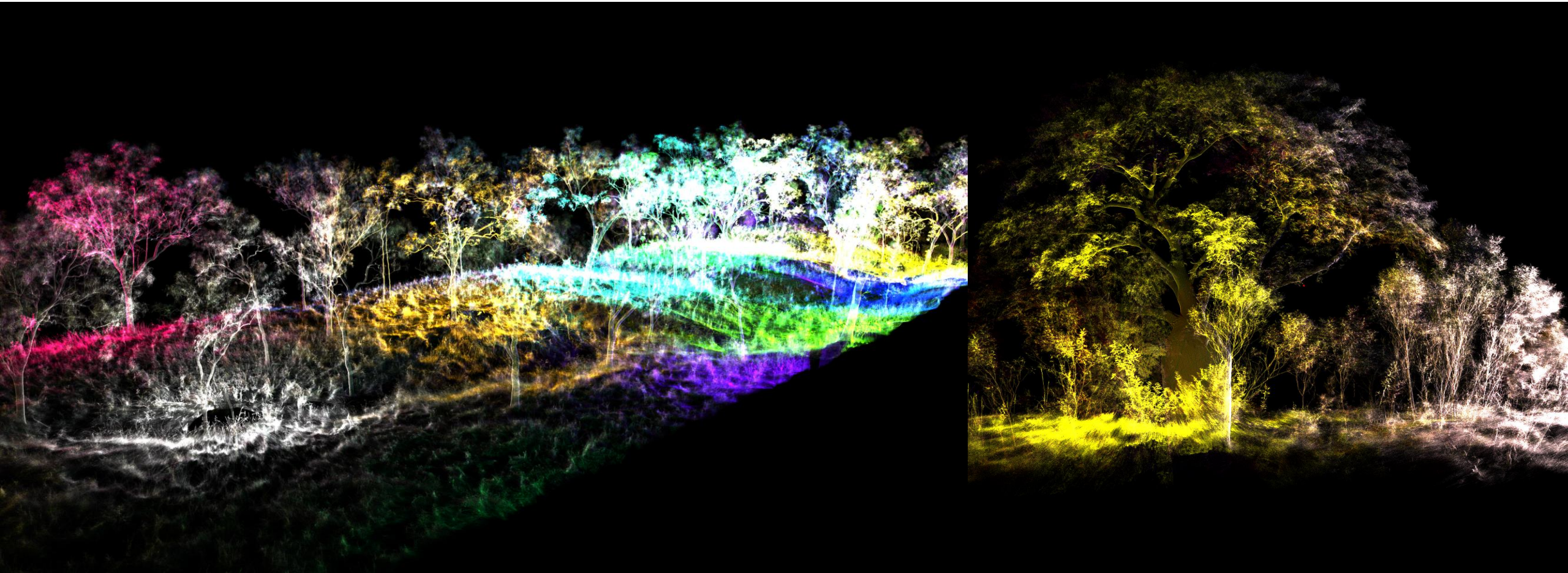
Each plot captured by Terrestrial LiDAR Scanning (TLS) can be viewed and analysed as a ‘point-cloud’. Each point-cloud perfectly captures the exact detail of each plot and can be viewed and assessed on a computer.

Terrestrial LiDAR Scanning: Savanna Woodland point-cloud and Boab tree point-cloud (Northern Territory, Australia)



Terrestrial LiDAR Data Outputs

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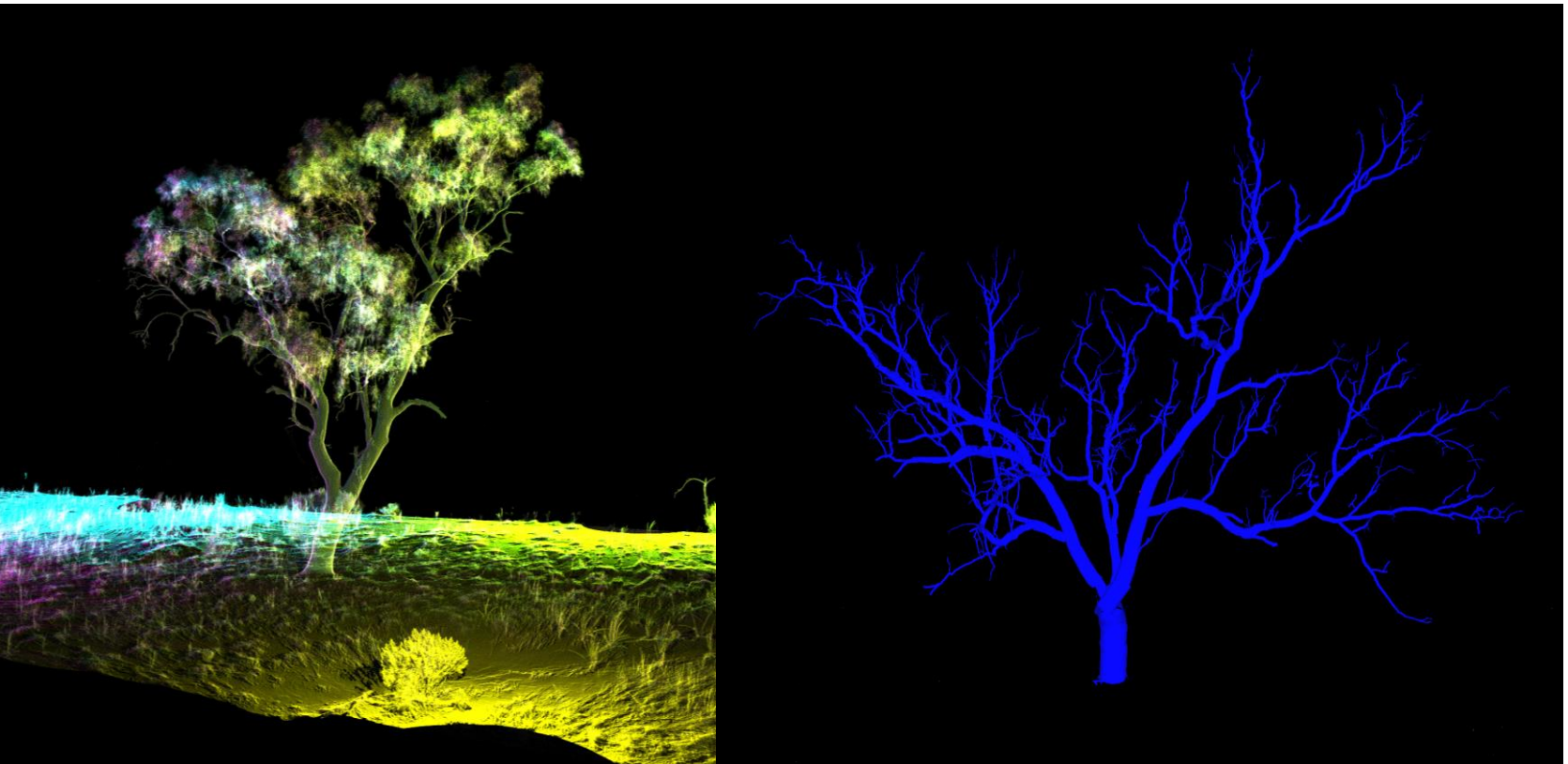
Each TLS plot's point-cloud is used to generate cylinder models of all trees present, allowing for quantitative metrics to be measured.

Terrestrial LiDAR Scanning: Savanna Woodland tree point-cloud and tree QSM



Quantitative metrics include:
For every tree above 5cm:

- Woody volume
- Diameter at Breast Height (DBH)
- Tree height
- Basal area
- Canopy area
- Biomass (tdm)
- Carbon stock (tCO2e-)
- Species Identification

Plot level metrics:

- Carbon stock per hectare
- Canopy cover area per hectare
- Tree count
- Litter
- Deadwood % per hectare

Details

TLS Instrument, Operations, and Processing

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TLS Instrument (Riegl VZ-400i)

- Instrument weight = 11kg
- Inbuilt GNSS receiver
- No base station needed
- No gradient error
- Point accuracy = ~2 mm
- Battery life = 5 hours
- Setup time = 5 minutes
- Scan accuracy independent of canopy density
- Other consumables = tripod, navigation phone, GPS receiver for phone.

Operations

- No. technicians required to conduct scan = 1
- For woodland = Use external GPS for plot navigation
- For rainforest = use manual compass and flagging for plot navigation

- 1-hectare plot woodland = 45 minutes scan time

Processing

- Specialised processing software required (open-source and/or proprietary)
- Requires multiple servers and high-capacity computer equipment
- Software engineers and trained data processors required.

- 1 hectare woodland plot processing time
  - Labour = 1-2 hours (1 person)

Riegl VZ-600i

- *Faster scanning*
- *Lighter*
- *More expensive*
- *Durability untested*

Q: Do you need Aerial LiDAR?

A: Aerial LiDAR can be used to build a biomass map across a broad area, reducing number the ground field plots needed. This is the 'model-assisted' approach, known as Multi-Scale LiDAR Biomass Mapping

Q: Does LiDAR account for different carbon in tree species?

A: ArborMeta has developed a tree-identification tool to ascribe species to trees so specific wood density factors may be used. AI species identification is in development.

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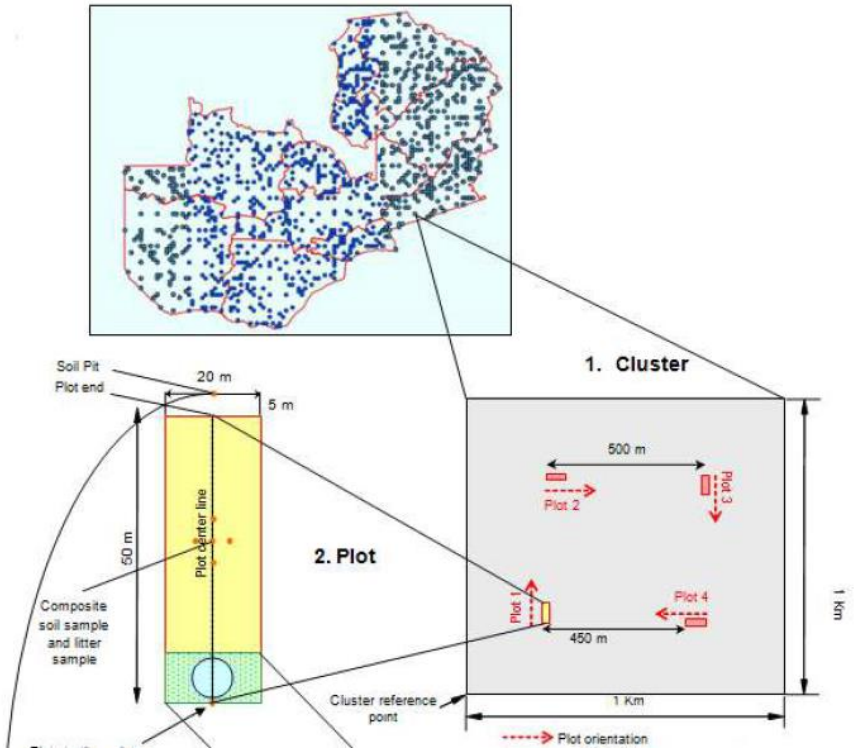
National Forest Inventory

EXAMPLE: Zambia NFI

Sampling Design

Dominant vegetation: Miombo woodland
Plot clusters: 986 (4 plots per cluster)
Plot size = 0.1 hectares



Zambia NFI plot collection using Terrestrial LiDAR

- 1 field officer will take ~13 minutes to scan a 20x50 metre plot
- Equals 216 hours of scan time to complete 1000 plots
- Or 36 six-hour workdays

If measuring 1-hectare plots, will take ~125 six-hour workdays to survey 1000 plots

LiDAR Scanning can be used for data collection for the following purposes:

- National Forest Inventory
- National Forest Monitoring System
- Verra REDD+
- Gold Standard Reforestation/Afforestation
- ART Tree's REDD+
- Jurisdictional REDD+

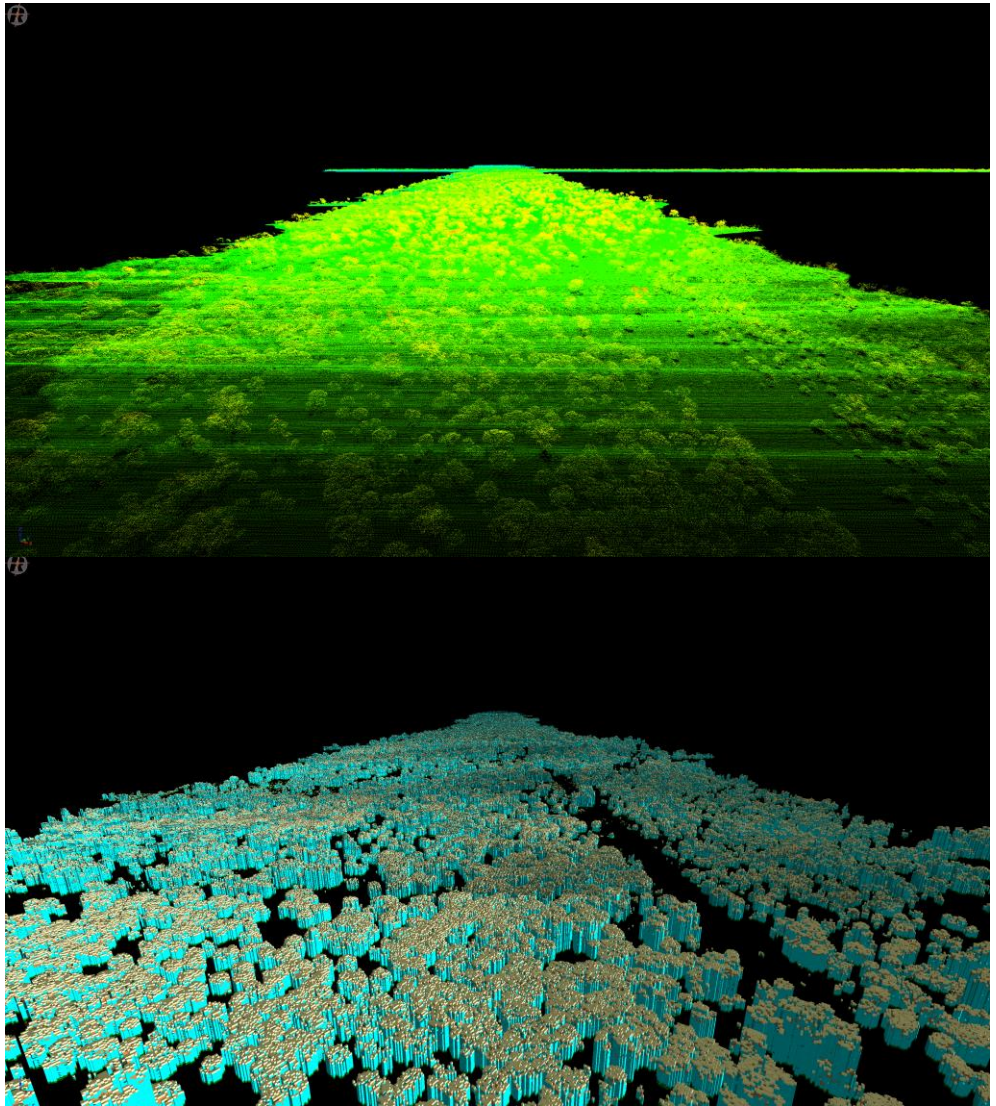
Multi-Scale LiDAR Carbon Mapping

Model-assisted Methodology

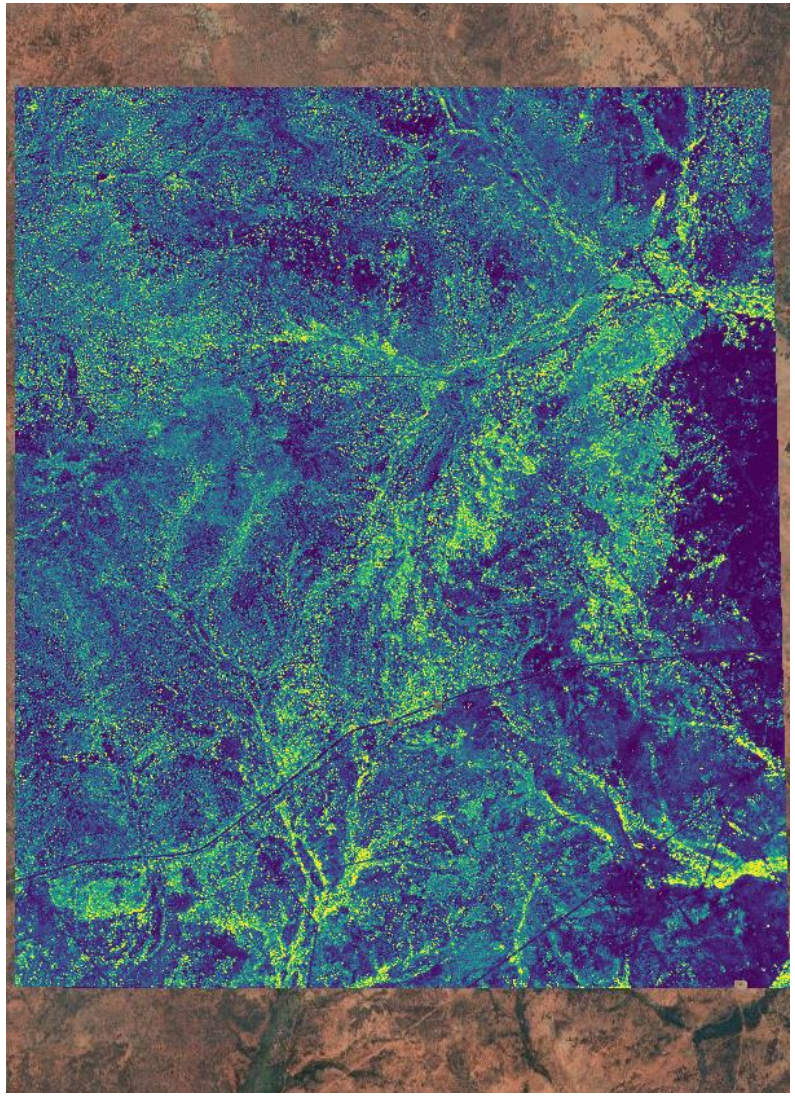
Sampling Design Methodology

Terrestrial LiDAR Scanning (0.1 – 1 hectare)

Aerial LiDAR Scanning (50 – 5000 hectare)



Satellite Biomass Modelling (5000 – 1,000,000-hectare)



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LiDAR for African Forestry Management

Working opportunities

Short Term

ArborMeta can deliver

- TLS Field data collection assistance
- Training of field technicians
- Provision of equipment (rent or sale)
- Data processing and analysis
- Forest plot data (all relevant outputs)

Long term

ArborMeta can deliver

- Provision of equipment (rent or sale)
- Data processing and analysis
- Forest plot data (all relevant outputs)
- General assistance

As the technology and software matures, forestry departments may eventually perform data collection and processing in-house.

In the interim period, ArborMeta offers their pioneering expertise and infrastructure for data processing and delivery.

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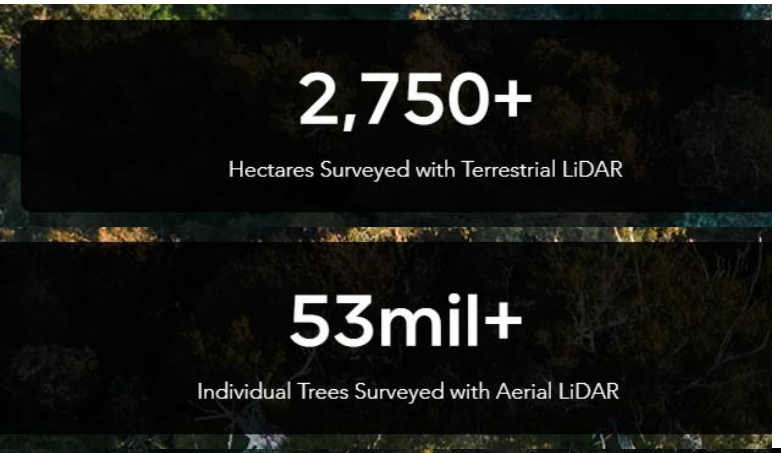
ArborMeta's Progress



- ArborMeta has comprehensively scanned the rainforests and rangelands of Australia

- We are now working with the FAO in neighbouring jurisdictions to provide Terrestrial LiDAR data collection services for the National forest Inventory