Multispectral drone image analysis for shade tree functional traits and drought response in cocoa agroforestry systems

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Background:

- Remote sensing technologies
- Cocoa agroforestry systems in Ghana
- Shade tree species characteristics
- Seasonal variations in canopy structure

Shade tree Functional Groups based on leaf Phenology

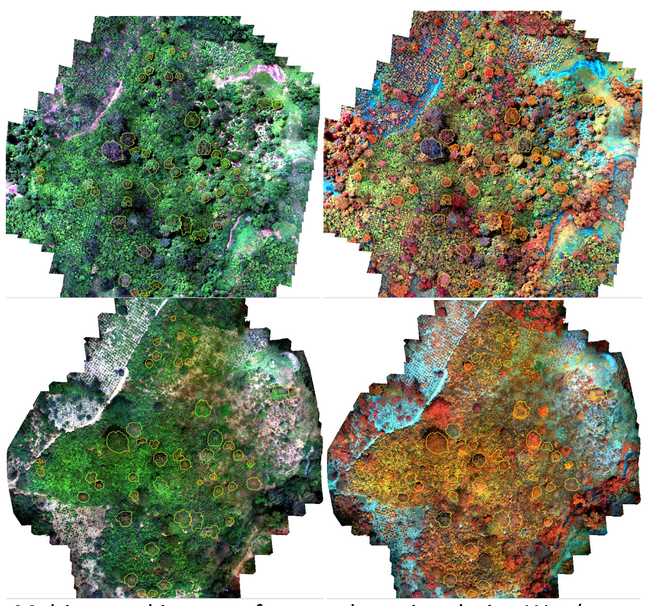
Objectives:

- Assess shade trees spectral and physiological traits relations
- Evaluate seasonal variation in spectral and physiological traits among shade tree functional groups

Methods:

- **Multispectral images** acquired using a DJI P4 Multispectral drone
- **Physiological traits (leaf stomatal conductance (gs), transpiration (E) and VPD)** with licor LI600 porometer
- Spectral traits: **Green Normalized Difference Vegetation Index (GNDVI)** to detect variations in canopy reflectance properties
- Data collected from ten smallholder cocoa plantations of similar age in Ghana.
- **Data acquired over two years in wet and dry seasons**:
  - Wet season 1 (November 2021)
  - Dry season 1 (February 2022)
  - Wet season 2 (July 2022)
  - Wet season 2 (February 2023)

Field measurements of Spectral and Physiological shade tree leaf traits



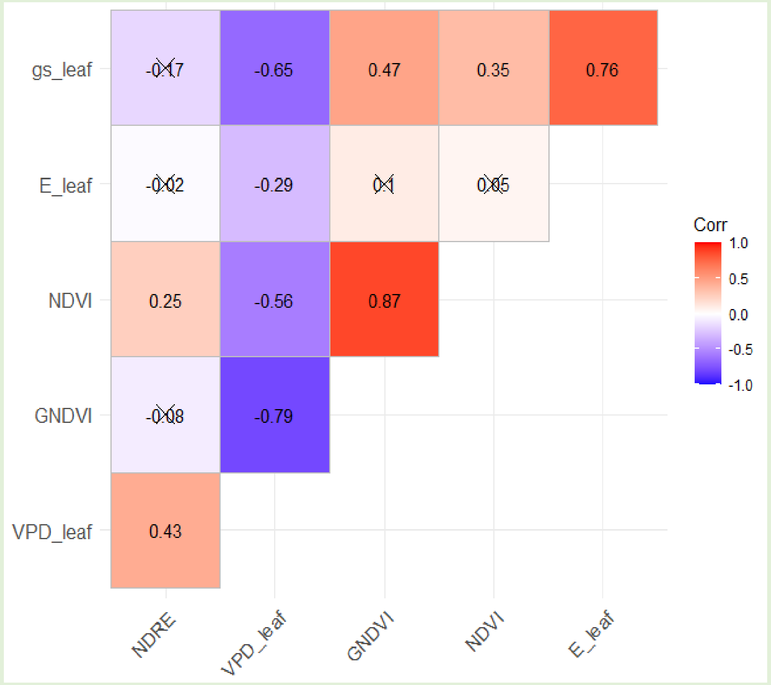
Multispectral images of cocoa plantation during Wet (upper panel) and dry (lower panel) seasons showing RGB and NIR,GB spectral bands combinations. Studied shade tree canopies digitized as polygon for spectral traits extraction

***Table 1**: 19 shade tree species, representing different functional groups, based on leaf phenology*

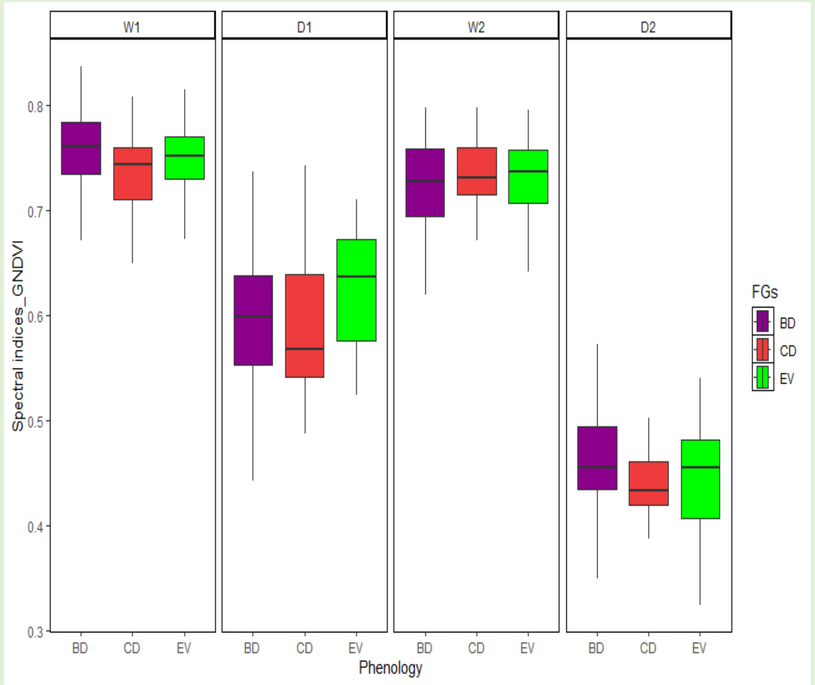
ID	Tree Species	Local Name	Family
1	*Albizia ferruginea*	Awiemfoasamina	Fabaceae
2	*Albizia zygia*	Okoro	Fabaceae
3	*Alstonia boonei*	Sinuro/Nvamedua	Apocynaceae
4	*Amphimas pterocarpoides*	Yaya	Fabaceae
5	*Antiaris toxicaria*	Kyenkyen	Moraceae
6	*Bombax buonopozense*	Akata	Malvaceae
7	*Cola gigantea*	Watapuo	Malvaceae
8	*Ficus capensis*	Odoma	Moraceae
9	*Holarrhea floribunda*	Sese	Apocynaceae
10	*Magnifera indica*	Mango	Anacardiaceae
11	*Milicia excelsa*	Odum	Moraceae
12	*Morinda lucida*	Konkroma	Rubiaceae
13	*Persea americana*	Avocado	Lauraceae
14	*Pycnanthus angolensis*	Otie	Magnoliales
15	*Ricinodendron heudelotii*	Wama	Euphorbiaceae
16	*Spathodea campanulate*	Akuokuoninsio	Bignoniaceae
17	*Sterculia tragacantha*	Sofo	Malvaceae
18	*Terminalia ivorensis*	Emere	Combretaceae
19	*Terminalia superba*	Ofram	Combretaceae

- Species categorized into leaf phenological groups of Brevi-deciduous (**BD**), Complete deciduous (**CD**) and Evergreen (**EV**)

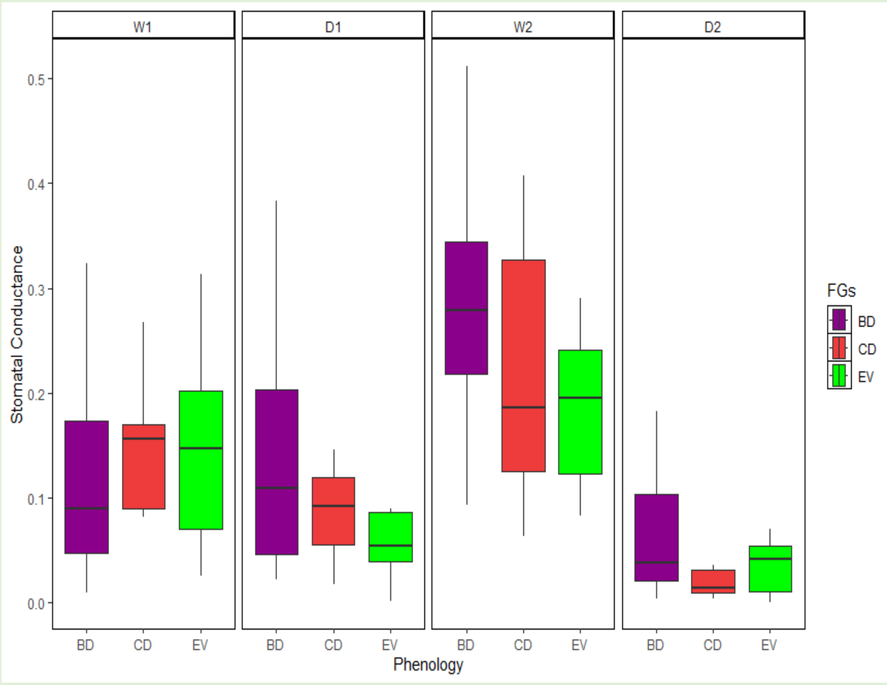
Results:



Correlations between Spectral and Physiological traits



Seasonal variations in Spectral traits (GNDVI) among shade tree functional groups (FGs)



Seasonal variations in Physiological traits (Stomatal conductance, gs) among shade tree functional groups (FGs)

- Significant correlations observed between spectral (GNDVI and NDVI) and Physiological (leaf gs, E and VPD) traits
- Partial Least Squares Regression model established to quantify and potentially predict seasonal specific physiological traits from spectral data from

Conclusion: Linking spectral (UAV sensing) and physiological (in situ) traits offers cost effective and high spatial resolution ecophysiological measurements for climate resilience research in cocoa agroforestry systems

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