High-resolution multispectral and RGB dataset from UAV surveys of ten cocoa agroforestry typologies in Côte d'Ivoire

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Data Article

High-resolution multispectral and RGB dataset from UAV surveys of ten cocoa agroforestry typologies in Côte d'Ivoire

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ABSTRACT

This paper introduces a dataset of aerial imagery captured during the 2022 cocoa growing season in the central-western region of Côte d'Ivoire. The images were acquired using a multispectral camera mounted on a DJI Phantom 4 unmanned aerial vehicle (UAV). The agricultural land surveyed encompasses 10 different types of cocoa-based agroforestry systems, each ranging from 2.6 ha to 8.3 ha, totaling 7638 images and covering 30 ha. The UAV mission was conducted at an altitude of 80 m, with a side overlap of 70 % and a front overlap of 80 %. This configuration achieved ground sampling distances (GSD) ranging from 4.2 to 4.6 cm providing high-resolution detailed imagery of those lands.
These high-resolution RGB and multispectral images can be used to characterize the structural complexity of the systems as well as the abundance, and the health of the trees in these cocoa-based systems. It can be a valuable resource for researchers in the fields of ecology, agriculture, and environmental monitoring. The dataset supports a wide range of applications, from precision agriculture to sustainable cocoa

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land use management, making it a pivotal tool for enhancing agricultural practices and ecosystem management in Ivorian regions facing environmental and economic challenges.

Specifications Table

Subject	Agricultural Sciences: Agronomy and Crop Science
Specific subject area	Precision Agriculture using UAVs
Type of data	Raw RGB images (JPG) and raw multispectral images (TIFF) Image datum: WGS84
Data collection	Unmanned Aerial Vehicle: DJI Phantom4 Multispectral Sensor: 1/2.9-inch CMOS Sensor focal length: 5.74 mm Sensor size: 4.87 mm × 3.96 mm Multispectral Camera Band: Blue (B): 450 nm ± 16 nm; Green (G): 560 nm ± 16 nm; Red (R): 650 nm ± 16 nm; Red Edge (RE): 730 nm ± 16 nm; Near infrared (NIR): 840 nm ± 26 nm Overlap: Side - 70%; Front - 80% Flight altitude: 80 m above ground level (AGL) Camera angle was adjusted to −90° Autonomous flight planning software: DJI GSPro Flight monitoring interface: Apple iPad 5 Ten (10) different cocoa-based agroforestry plots were flown over in May 2022
Data source location	Institution: UFHB and CIRAD City/Town/Region: A region named Divo, in the Central-West Region of Côte d'Ivoire Country: Côte d'Ivoire Latitude and longitude for collected samples/data: latitudes between 5°51′ and 6°00′ N and longitudes between 4°51′ and 5°51′ W
Data accessibility	Repository name: CIRAD Dataverse Data identification number: DOI:10.18167/DVN1/MK2ZRG Direct URL to data: Lammoglia, Sabine Karen; Danumah, Jean Homian; Akpa, You Lucette; Assoua Brou, Yves Laurent; Kassi, N'Dja Justin, 2024, "Dataset of RGB and multispectral aerial images of cocoa agroforestry plots (Divo, Côte d'Ivoire)", https://doi.org/10.18167/DVN1/MK2ZRG, CIRAD Dataverse, V1 Instructions for accessing these data: https://dataverse.cirad.fr/dataset.xhtml?persistentId=doi:10.18167/DVN1/MK2ZRG
Related research article	

1. Value of the Data

- The dataset provides high-resolution (< 5 cm) RGB and multispectral aerial images of ten diverse types of cocoa agroforestry systems in Côte d'Ivoire, offering the opportunity to remotely characterize the biodiversity and the complexity of those systems, using photogrammetry outputs, such as, orthomosaics or digital models;
- The inclusion of spectral bands (Blue, Green, Red, Red Edge, and Near Infrared) allows for the calculation of various vegetation indices, such as NDVI. These indices are essential for assessing vegetation health, growth, and productivity, as well as detecting physiological stress caused by biotic or abiotic factors.
- Researchers from various fields can utilize this dataset to analyze vegetation structure, detect and count individual trees, quantify aerial biomass, and assess biodiversity within agroforestry systems;
- This dataset can be used to test methods for calculating Above-Ground Biomass (AGB) in agroforestry systems. For AGB calculation, RGB images can be combined with the Structure

from Motion (SfM) process to determine tree height (H) and diameter at breast height (DBH). Alternatively, multispectral images can be used to calculate the normalized difference vegetation index (NDVI).
- The dataset can also be used for satellite data validation. In this case, resampling UAV imagery to the same spatial resolution as satellite imagery will facilitate comparative analyses.

2. Background

In the context of global changes, current agricultural production systems are facing the challenge of achieving sustainability given a rapidly growing population and an increasing demand for food [1], all while coping with diminishing natural resources. Remote sensing, especially through unmanned aerial vehicles (UAVs), offers innovative solutions for vegetation monitoring and sustainable agriculture [2,5]. UAVs can operate at low altitudes, providing ultra-high spatial resolution imagery and capturing detailed data across various spectral bands, including visible, infrared, and thermal. This technology facilitates the creation of 3D digital surface models through techniques like structure-from-motion (SfM), bridging the gap between ground-based and traditional remote sensing methods. In complex ecosystems, UAVs have demonstrated their efficacy in crop monitoring, environmental management, and agroforestry applications [4,8]. They offer significant advantages over traditional methods, such as flexibility in scheduling flights high spatial resolution, and the ability to collect comprehensive data without the labor-intensive and often inconsistent results of manual fieldwork.

This study focuses on applying UAV technology in cocoa agroforestry management in the Central-West Region of Côte d'Ivoire, a critical area for cocoa production. The DJI Phantom 4 Multispectral (P4M) UAV has been employed to collect RGB and multispectral aerial images of various types of cocoa-based systems. Integrating UAV technology into cocoa agroforestry management has the potential to transform traditional practices by providing detailed, high-resolution data that enhances decision-making and improves the sustainability and productivity of cocoa production systems. This is particularly relevant in regions like Côte d'Ivoire, where cocoa production significantly contributes to socio-economic development but faces challenges such as crop diseases, climate variability, deforestation, and the need for sustainable management practices.

3. Data Description

This work describes a set of raw RGB images (JPG) and raw multispectral images (TIFF) collected using a DJI Phantom4 Multispectral UAV over ten different cocoa-based agroforestry plots located in the Central-West Region of Côte d'Ivoire. Each image file includes metadata encoded in RDF format. Each metadata includes details such as flight altitude, camera settings, flight dynamics and GPS coordinates for georeferencing.

The image datasets are organized into ten folders within the repository. Each folder corresponds to a specific cocoa-based agroforestry system, labelled from plot_B01 to plot_B10. These folders are further grouped into a series of compressed zip files [7].

Within each folder, there are two subfolders: a) "Image RGB" containing images in JPG format, and b) “mage multispectral” containing multispectral images in TIFF format. In some folders, the “Image RGB” or “Image multispectral” subfolders may include a numerical suffix (e.g., “Image multispectral 1,” "Image multispectral 2″) to distinguish between different images with identical names. Nonetheless, all images within these folders are related to the same plot.

In each folder, the images are named as DJI_XXXX.JPG or DJI_XXXX.TIFF, where XXXX ranges from 0010 to 0990 for optical (RGB) images and from 0011 to 0995 for multispectral images. For instance, if there are 90 images in the optical (RGB) folder, they are named from DJI_0010.JPG to DJI_0900.JPG. It is a consistent numbering ranging from 1 to 90 but ending in 0. In the corresponding multispectral folder, images are named from DJI_0011.TIFF to DJI_0905.TIFF. Here, the last digit (1 to 5) represents the specific spectral bands (Blue, Green, Red, Red edge, NIR), while the preceding numbers (001 to 090) remain consistent with the optical (RGB) image numbering. The total number of images in the multispectral folder will then be five times the number of optical (RGB) images. The entire dataset comprises a total of 7638 images. Fig. 1 provides sample images from the dataset.

Fig. 1. Sample images of the dataset (left) RGB image. (b) multispectral image.

In the dataset [7], the JPG and TIFF files are exactly as obtained from the drone, without any additional manipulation. However, each folder containing all images (both optical RGB in JPG format and multispectral in TIFF format) for a given cocoa-based agroforestry system was archived and compressed using the open-source and freely accessible compression software, 7-Zip. First, a tar archive was created, involving no compression, only the grouping of files. This tar archive was then compressed using a normal compression level and the deflate compression method, resulting in a tar.gz archive. The final compressed size is approximately 62 % to 64 % of the initial uncompressed size. Since both tar and gzip are lossless compression algorithms, the image quality remains consistent through the compression and decompression cycles, preserving the original quality when the files are decompressed.

4. Experimental Design, Materials and Methods

4.1. Study area

The images of this dataset were collected in the Central-West Region of Côte d'Ivoire, located at Latitude 5°53′N and Longitude 5°13′W. Historically, this region was a significant part of the "cocoa belts", known for its extensive cocoa production but also for a high rate of deforestation. The area presents a highly fragmented landscape, characterized by a mix of forests, cocoa plantations, fallow lands, and various food crops. The region experiences a tropical climate with average annual temperatures ranging between 24 °C and 28 °C and an average annual rainfall of 1218 mm [2,3]. The soil in this area is predominantly ferralitic, known for its depth, acidity, and low saturation of exchangeable bases [6].

4.2. Selection of cocoa-plots

The ten distinct cocoa production plots presented in this dataset cover a total area of 30 ha. They have been selected to represent a diversity of cocoa-based agroforestry systems in the region. The selection criteria for these 10 cocoa plots included their structural complexity, their age and their yield. The structural complexity ranged from cocoa monocrops to complex cocoa agroforests, the age of the plots varied from young to mature, and the yield of the cocoa trees spanned from less productive to highly productive plots.

4.3. Equipment

The DJI Phantom 4 Multispectral (P4M) quadcopter was used to acquire UAV images. It is an advanced aerial survey vehicle designed to capture high-resolution, real-time RGB and multispectral imagery with its six cameras: one RGB color sensor for visible light and five monochrome sensors spanning various spectral bands, including red (R), green (G), blue (B), red edge (RE), and near-infrared (NIR). Key specifications of the P4M camera include a focal length of 5.74 mm, an image resolution of 1600 × 1300 pixels, and a sensor size of 4.87 mm × 3.96 mm. Additionally, it features a sunshine sensor for lighting correction, although direct reflectance data capture is not possible. The spectral response function and multispectral band-specific details are summarized in Table 1.

Table 1
Characteristics of the phantom 4 multispectral imaging system.

Bands	Wavelength
Blue	450 ± 16 nm
Green	560 ± 16 nm
Red	650 ± 16 nm
Red edge	730 ± 16 nm
NIR	840 ± 26 nm
Focal length	5.74 mm
Sensor size	4.87 mm × 3.96 mm
Image size	1600 × 1300
Sunshine sensor	Yes

The DJI Phantom 4 Multispectral (P4M) has an autonomous UAV platform, enabling independent data collection with an average flight duration of 27 min and a takeoff weight of 1487 g. It has a sophisticated onboard flight controller which integrates navigational and stability sensors, including a compass, inertial measurement unit, gyroscopic sensors, barometer, and GPS system, ensuring precise and stable flight patterns. The drone is operated from the ground via a radio connection control connected to a smartphone or iPad using a DJI app wing operators to monitor flight parameters such as battery status, wind conditions, and drone speed. The built-in GPS system allows for autonomous flights based on pre-set flight plans, streamlining the data collection process.

4.4. UAV data collection

The UAV field campaign was conducted over a period of 2 days, from May 4th 2022 to May 5th 2022. To maintain consistent lighting conditions, all images were captured between 10AM and 2PM (UTC). Flight plans were created using the DJI GSPro software, and the adjusted flight parameters included the flight altitude, intervals between image captures, total number of images per flight, flight direction, fixed camera angle of 90°, and configuration of flight strips. These flight strips were designed to achieve 70 % side overlap and 80 % front overlap. The UAV operated at an altitude of 80 m. This setup resulted in ground sampling distances (GSD) between 4.2 cm and 4.6 cm (Table 2). These GSD values indicate that the dataset is high-resolution, offering detailed and precise images suitable for various analyses. During each flight session, each of the six sensors on the drone captured between 50 and 244 RGB images per plot. This planning and execution resulted in a collection of 1373 RGB images and 6365 multispectral images.

Table 2
Summary of UAV data collection for ten typologies of cocoa agroforestry plots.

	Date of images collection	Area Covered (ha)	Average Ground Sampling Distance, GSD (cm)	Images captured by each sensor (N)
Plot1	04/05/2022	5.50	4.36	133
Plot2	04/05/2022	5.52	4.52	132
Plot3	05/05/2022	2.62	4.49	50
Plot4	05/05/2022	3.16	4.20	67
Plot5	05/05/2022	8.33	4.48	244
Plot6	04/05/2022	5.75	4.58	160
Plot7	04/05/2022	8.12	4.49	204
Plot8	05/05/2022	5.50	4.66	122
Plot9	05/05/2022	4.74	4.64	109
Plot10	05/05/2022	2.85	4.62	52

Limitations

None.

Ethics Statement

The authors have read and followed the ethical requirements for publication in Data in Brief and confirm that the current work does not involve human subjects, animal experiments, or any data collected from social media platforms.

Data Availability

Dataset of RGB and multispectral aerial images of cocoa agroforestry plots (Divo, Côte d'Ivoire) (Original data) (dataverse.cirad.fr).

CRediT Author Statement

Sabine-Karen Lammoglia: Conceptualization, Funding acquisition, Methodology, Investigation, Visualization, Writing – original draft; **You Lucette Akpa:** Conceptualization, Investigation, Visualization, Supervision, Writing – review & editing; **Jean Homian Danumah:** Conceptualization, Investigation, Visualization, Data curation, Supervision; **Yves Laurent Assoua Brou:** Investigation, Visualization; **Justin N'Dja Kassi:** Supervision, Writing – review & editing.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] D. Tilman, C. Balzer, J. Hill, B.L. Befort, Global food demand and the sustainable intensification of agriculture, Proceed. Nat. Acad. Sci 108 (50) (2011) 20260–20264.

[2] A. Ahmad, J. Ordoñez, P. Cartujo, V. Martos, Remotely piloted aircraft (RPA) in agriculture: a pursuit of sustainability, Agronomy 11 (1) (2020) 7.

[3] J.N. Ehounou (2021) Manifestations Des Changements Climatiques En Zone Forestière De Côte d'Ivoire Et Impacts Sur La Disponibilité En Eau Pour Une Cacaoculture durable: Cas De Trois Secteurs Agroécologiques. Thèse de Doctorat unique, UFR STRM, Université de Cocody, Abidjan, Côte d'Ivoire, p 287.

[4] S. Getzin, K. Wiegand, I. Schöning, Assessing biodiversity in forests using very high-resolution images and unmanned aerial vehicles, Methods Ecol. Evol 3 (2) (2012) 397–404.

[5] V. Martos, A. Ahmad, P. Cartujo, J. Ordoñez, Ensuring agricultural sustainability through remote sensing in the era of agriculture 5.0, Appl. Sci. 11 (13) (2021) 5911.

[6] K.E. Kassin (2009) Etudes De Conditions Pédoclimatiques Pour La Replantation Cacaoyère Au Centre-Ouest De La Côte d'Ivoire : Cas Des Départements De Divo et Gagnoa. Thèse de Doctorat unique, UFR STRM, Université de Cocody, Abidjan, Côte d'Ivoire, p 112.

[7] S.K. Lammoglia, Y.L. Akpa, J.H. Danumah, Y. L. Assoua Brou, J. Kassi, (2024). Dataset of RGB and multispectral aerial images of cocoa agroforestry plots (Divo, Côte d'Ivoire). doi:10.18167/DVN1/MK2ZRG,CIRADDataverse

[8] L. Pádua, J. Vanko, J. Hruška, T. Adão, J.J. Sousa, E. Peres, R. Morais, UAS, sensors, and data processing in agroforestry: a review towards practical applications, Int. J. Rem. Sens 38 (8–10) (2017) 2349–2391.