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Vegetation mapping from vegetation indices using a uav-based sensor

Emmanuel Ayodele[1], Chukwuma Okolie[1], Imole Okediji*[1], Olagoke Daramola[1], Kayode Omolaye[2]

[1]University of Lagos, Faculty of Engineering, Department of Surveying and Geoinformatics, Lagos, Nigeria
[2]Geospatial Research Limited, Lagos State, Nigeria

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ABSTRACT

The current advances in technology in many fields have revolutionized conventional agricultural practices. However, the use of remotely sensed data for agricultural purposes has not been fully explored in Nigeria. This study explores this limitation to understand performance and usability. In this work, remotely sensed information in the form of UAV images were used to assess crop greenness and vegetation cover. A maize farmland of 6 hectares was captured in Ogun State using a DJI phantom 4 UAV (which operates in true colour, RGB);The 165 images acquired were mosaicked using Agisoft Metashape software. Vegetation cover and greenness were assessed through various RGB-based vegetation indices and the conclusion was that Red Green Blue Vegetation index (RGBVI) produced the best results in depicting both vegetation cover and greenness. Excessive Green Index (ExG) and Modified Green Red Vegetation Index (MGRVI) produced above-average results but were not as informative as RGBVI. From the maps of each vegetation index, information about crop greenness and vegetation cover was adequately derived. This study showed the adequacy of UAV-based sensors for vegetation mapping and is recommended.

1. Introduction

The use of Remote Sensing (RS) in the field of agriculture has been increasing in recent times. Typically, RS records the surface reflectance in the visible or near-infrared parts of the electromagnetic spectrum (Yao et al., 2011). Applying this to vegetation leads to extraction of various information ranging from greenness and external properties to the internal structure of plants. Reflectance of vegetation cover changes with biological aspects and the vegetation structure. Water content, age, stress, cover geometry, row spacing and orientation and leaf distribution in the cover alter vegetation reflectance (Bannari et al., 1995). Furthermore, reflectance is influenced by atmospheric composition, soil properties, soil brightness, and colour as well as solar illumination geometry and viewing conditions.

Vegetation indices (VIs) are developed to evaluate vegetation using spectral measurements in relation to agronomic parameters like biomass or PH (Bannari et al., 1995). They are commonly used for extracting information from RS data (Jackson and Huete, 1991). Numerous vegetation indices exist in Visible, Near Infrared and Shortwave Infrared spectral regions.

Research from the past 5 years has shown a move into the use of RGB-based vegetation indices rather than Multispectral indices. This is because RGB sensors are more affordable than Multispectral sensors (Neupane and Baysal-Gurel. 2021). This means using RGB-based indices is cheaper and more cost effective than using multispectral or hyperspectral indices. Although the near infra-red (NIR) and other multispectral bands give a better insight into biomass estimation, plant health information derivation, and other vegetation properties, RGB-based indices have also proven to be quite effective in the estimation of vegetation properties.

In this work, a maize farmland in Atan, Otta, Ogun State, Nigeria with an area of 6 hectares was captured using a DJI Phantom 4 unmanned aerial vehicle (UAV). The surface reflectance property of the crop was useful in the calculation of vegetation indices. The steps

*Corresponding Author

*(light99857@gmail.com) ORCID ID 0000-0001-6781-2669

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followed by which vegetation maps were eventually formed are given in the sub-sections below. Specifically, the focus of this work was mapping vegetation cover and greenness of the maize farmland. This is yet another example of how Remote Sensing can be applied in Agriculture for effective output and increased crop yield.

2. Methods

This section describes the instrumentation, image acquisition and image processing. The UAV employed for image capture was a DJI Phantom 4 which was manufactured in 2018. The camera attached to its payload has a resolution of 20MP, flight time is approximately 30 minutes, and it has 2 obstacle avoidance sensors with vision sensors as well. Usually, the steps involved in UAV image capture can be broadly grouped into four (4) parts: mission, flight planning, the flight, and image processing. A mission can be defined as a process that consists of one or more flights within the mission area. The number of flights per mission is estimated by the software and depends on the size of the mission area. Flight planning is done in the field according to the aerial imaging technology employed.

2.1. Image acquisition

On the 15th of November, 2020, the mission was carried out at around 1pmto capture the greenness of the vegetation in Atan Farmland, with a total size of 6 hectares. The DJI Phantom 4 UAV was flown over the farmland at an altitude of 50m with 75% front and side overlap. A total of 165 images were captured, and Ground Sampling Distance (GSD) was derived to be 1.5cm/px. The UAV compass and Inertia Measurement Unit (IMU) was calibrated before deployment to keep the UAV straight and level in the air. The software employed was Drone Deploy and all necessary settings were performed. The images were captured with 4 flight lines as pre-planned. The single flight lasted about 14 minutes and all captured images were saved on the memory card of the UAV.

2.2. Image processing

After the acquisition of the images, Agisoft Metashape was used to create an orthomosaic from the set of overlapping images with the corresponding referencing information. This involved image corrections and mosaicking. To create orthomosaic, the images had to be aligned; first, by matching points between overlapping images, estimating camera position for each photo and building sparse point cloud model and mesh. The orthomosaic was stored in TIFF format and then exported into ArcGIS 10.4.1 for further processing.

After exporting the orthomosaic to ArcGIS, layers were created and vegetation indices applied. The three vegetation indices made use of were Red Green Blue Vegetation Index (RGBVI), Modified Green Red Vegetation Index (MGRVI) and Excessive Green Vegetation Index (ExG). Each one was applied with the aid of the Raster calculator in the Spatial Analyst toolbox. These three indices were used based on their reliability shown in the existing literature. These three indices effectively highlight vegetation and soil (Ashapure et al., 2019). Also, they have the potential for the study of agricultural production and for predicting crop biomass, and are good for observing mature canopy (Bendig et al., 2015).

2.3. Quantitative analysis

After applying the vegetation indices, the fishnet tool was used to do a point spread over the images, and the txt file was exported into Microsoft Excel. Statistical analysis was carried out and correlation coefficient table was derived.

3. Results

Figure 1 presents the orthomosaic of the study area. There is an inter-mingling of sparsely vegetated areas and averagely vegetated areas for the maize crop.

Figure 1. Orthomosaic of the study area

Summarily, the RGB orthomosaic gives a rough estimation of the extent of canopy cover, and helps to differentiate between sparse and dense vegetation. It also aids the identification and differentiation of various surface elements such as soil, water body, buildings, and vegetation.

The MGRVI map (Figure 2) ranges from -1 to 1. Densely vegetated areas were in the positive range of 0.51 to 1, sparsely vegetated areas fell in the range of 0.01 to 0.5, while the soil and bare grounds were in the negative range of -0.51 to 0.RGBVI (Figure 3) also ranges from -1 to 1, while ExG ranges from -1 to 2 as observed in Figure 4. A distinctive property of the indices was vegetation classification according to their respective ranges.

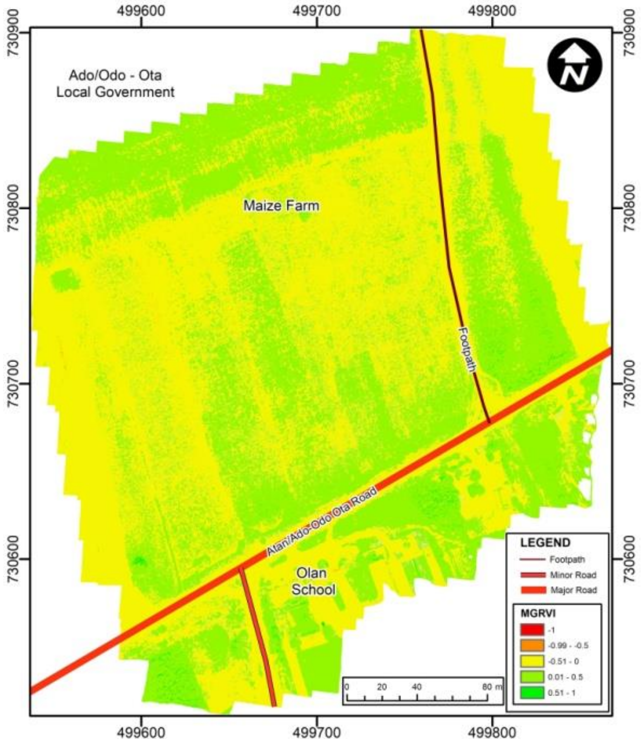

Figure 2. MGRVI map of the maize farmland

Figure 3. RGBVI map of the maize farmland

4. Discussion

From each map, the extent of vegetation cover and greenness was portrayed. However, the best approximation out of the vegetation index maps is the RGBVI map; it does not over or under-estimate the extent of vegetation cover, and the areas with sparse and dense vegetation are better delineated. This is in tandem with what has been recorded in literature and the RGBVI map can be relied upon by both farmers and mapping professionals as well. Also, there is a high correlation between the three indices but between RGBVI and ExG, the correlation is highest (0.97).

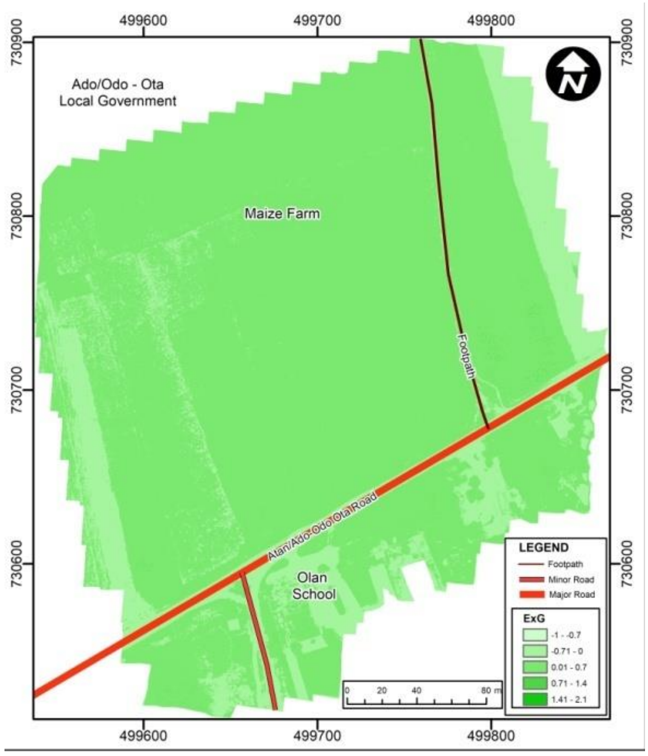

Figure 4. ExG map of the maize farmland

Table 1 shows the coefficients of correlation between the indices, which potrayed a strong positive correlation between all indices.

Table 1. Correlation coefficient of vegetation indices

	MGRVI	RGBVI	ExG
MGRVI	1		
RGBVI	0.705	1	
ExG	0.828	0.974	1

5. Conclusion

This study has examined the use of Unmanned Aerial Vehicle (UAV) sensor for vegetation mapping using vegetation indices. It can be concluded that RGB-based vegetation indices have the potential for estimating vegetation cover and greenness in a farmland. The use of RGB-based indices presents a cost-effective method for crop mapping. Accordingly, the outcome of this study justifies the need for further work and any future investments to improve agricultural production.

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