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Preliminary Investigation on the Application of Close Range Photogrammetry for Rapid Low-cost Assessment of Land Suitability in Medium and Large-Scale Oil Palm and Rubber Tree Farming

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ABSTRACT: The foremost and very important stage of any precise farming is the choice of land. Land for oil palm and rubber tree farming usually extends into hundreds of hectares which amount to rigorous fieldwork with conventional ground surveying techniques. In recent past, satellite remote sensing and aerial photogrammetry are used in large and medium scale mapping to ascertain land suitability for these farms. However, these techniques are capital intensive haven constraints on flexibility and frequency of surveys. Image resolutions also do not attain sub-pixel accuracies. Aside from terrain topography, other variables that verify critical inferences on land suitability are colour variation, height variation, and vegetation density. This study, therefore, examines the applicability of close-range photogrammetry in aiding critical management decision for land suitability on medium and large scale oil palm and rubber tree farming. The DJI Phantom 3 standard drone was used to Survey parts of the Nigeria Institute for Oil Palm Research and part of Rubber Research Institute of Nigeria both in Benin City, Nigeria. The aim is to ascertain the effectiveness of the drone's 1/2.3" CMOS 12 Megapixel Sensor and the inbuilt GPS for providing three-dimensional high-resolution images for deciding on topography, colour variations, height variations and vegetation density. The Pix4D and Agisoft software were both used to process the images. Digital models generated have 10cm spatial resolution on a three bandwidth able to delineate the spectral reflectance of the trees. Results obtained from this initial study encourage the need for further work.

KEYWORDS: Close Range Photogrammetry, Land Suitability, Oil Palm Farming, Rubber Tree Farming.

I. INTRODUCTION

Due to crash in the global oil price, the Nigeria economy has been in recession since 2015 (Dickson and Ezirim, 2017; Egbadju and Oriavwote, 2016). For more than two decades, Nigeria depends on the oil sector to generate more than 90% of its foreign exchange and in most instances, more than 80% of its budgetary revenues (Oyedepi, 2016 and Akujuru, 2015). The Nigeria over dependence on the oil sector is described as a trauma on the nation's political and economic growth (Dickson and Ezirim, 2017; Akujuru, 2015). These are regrettably an outcry and absolute departure from a country whose major source of income was on Agriculture and solid minerals until the oil boom in the early 70's (Oyedepi, 2016 and Akujuru, 2015). Then, Nigeria made an unforgettable global impact on oil palm and rubber tree agriculture (Adams, 2016 and Akujuru, 2015). The economic impact of the rubber tree and oil palm farming in

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contemporary times is actually rewarding (Bassey, 2016) and research by Ogbebor (2013). The major challenge now is on how to diversify the Nigeria economy towards Agriculture (Adams, 2016). Rubber tree and oil palm farming are priorities in Nigeria considering glaring evidence of excellent production in the past (Bassey, 2016 and Akujuru, 2015). The need to also preserve the purported arable land for oil palm and rubber tree farming (Ofem et al, 2016) and considering the continuous impacts of environmental conditions on the land (Bassey, 2016) justifies the need for a low-cost regular evaluation of land suitability (Katsigiannis et al, 2016; Srisawat and Payakpate, 2016).

Photogrammetry is one of the geospatial technologies (Arozarena et al, 2016; DeGloria et al, 2014). Geospatial technologies are the precise methods of collecting, processing and presenting information as relates Location (Manfre et al, 2012). Other methods are remote sensing, Global Navigation Satellite System and Geographical Information System (Charvat, 2010; Manfre et al, 2012 and GIS Lounge, 2012). Precision farming is the application of geospatial technology with the aim of achieving effective Farm management (GIS Lounge, 2012). Geospatial technologies encourage cost-effectiveness while farm Land activities at all stages, easier and faster (Charvat, 2010). Close range photogrammetry refers to any photogrammetric mission where the object is not above 300 meters in altitude from the survey platform (Huang et al, 2015). This includes unmanned aerial vehicles (UAV) flying below 300m (Colomina and Molina, 2014). Land suitability describes parcels of land for specific agricultural purposes relative to the best farming conditions which include but not limited to climate, topography, landscape and soil content (Gasser et al, 2016 and Morton et al, 2016). Considering the need of saving cost, and the urgent need for optimizing oil palm and rubber tree farming, this preliminary investigation elucidates the viability of geospatial technologies more specifically close range photogrammetry in actualizing precise agriculture in terms of land suitability for oil palm and rubber tree farming.

II. STATEMENT OF PROBLEM

Correct affirmation of land suitability will help develop the best farming practices (Srisawat and Payakpate, 2016). According to research by Ogbebor (2013), Nigeria is blessed with abundance of arable land but not all land is compatible with every kind of crop species (Molor et al, 2016; Samarappuli et al, 2014 and Lupia, 2012) even as every land condition is not appropriate for cross-breeding (Molor et al, 2016). Crop-land suitability analysis is therefore necessary for effective land and farm management (Gasser et al, 2016 and Morton et al, 2016). It also helps to understand the impact of climatic changes on the crops (Gasser et al, 2016). Prasetia et al (2016) emphasized that topography and soil properties are primarily key components for assessing land suitability for oil palm plantation. A limiting factor in the application of photogrammetry and remote sensing data in determining land suitability for Agricultural purpose is the cost (Katsigiannis et al, 2016). Land suitability studies would require regular surveys, flexibility on the exact farm location and flexibility on the scale of the mapping (Katsigiannis et al, 2016 and Wójtowicz et al, 2016). The images acquired must also be of excellent spectral and spectral resolution (Wójtowicz et al, 2016). Another factor to be considered for regular farm surveys in considering land suitability is the availability of photogrammetric and other GIS software to process the field data (Psirofonina et al, 2017). This study, therefore, examines the potential application of close-range photogrammetry and low-cost photogrammetric software in the rapid low-cost evaluation of land suitability in medium and large-scale oil palm and rubber tree farming.

III. REMOTE SENSING AND PHOTOGRAMMETRY TECHNIQUES IN MONITORING LAND SUITABILITY FOR OIL PALM AND RUBBER TREE FARMING

Geospatial data with high spatial and spectral resolution is evidently required for the management of oil palm (Rokhmana, 2015 and Sari et al, 2015) and rubber tree plantations (Li and Fox, 2011). Due to the heights of these trees, there are often “canopy dwelling species” which makes their land use pattern very sensitive (Bohnert et al, 2016). Young rubber trees, for instance, are predominantly dominated by several land situations (Li and Fox, 2011). Both plants, therefore, has critical concerns about landscaping in their overall performances (Hardanto et al, 2017). In most instances, Land assessment by ground surveying methods is not feasible as these plantations cover the large expanse of land (Razali et al, 2016). For precise scientific purposes, land suitability is best inferred from accurate geospatial data

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as the spatial and spectral propensities of existing land cover undergoes thorough analytical evaluation (Das et al, 2016; Momeni et al, 2016). Aside from the land cover analysis, land suitability assessment will also involve the precise topographical survey and maps of the terrain (Mansor et al, 2012). In the past, satellite imageries and aerial photographs are used to monitor and assess land suitability for oil and rubber plantations (Razali et al, 2014). Satellite imageries and aerial photos are expensive and often limit farm managers on the frequencies and extent of surveys (Razali et al, 2014). In other instances, farm managers would settle for imageries on smaller scales which could result to poor spatial and spectral resolution (Jannoura et al, 2015). There is also evidence of poor or no balance between the spatial and temporal resolution (Li and Fox, 2011). LiDAR and Radar generate better digital surface models and could contain brilliant pictorial information needed to effectively categorize vegetation with other soil surface components (Chong et al, 2017 and Joshi et al, 2016). These technologies, however, being expensive, also lacks flexibility and ease of data collection (Abram et al, 2014).

In the past decade, close-range photogrammetry has become an effective tool for precise plantation (Hassaan et al, 2016 and Rokhmana, 2015). Precision agriculture involves considerations for topography and detailed terrain analysis (Rokhmana, 2015). Such analysis is periodical with regular and most times real-time remote sensing data (Chong et al, 2017 and Rendana et al, 2015). The varied topographical nature of oil palm and rubber tree plantations (Hardanto et al, 2017) therefore necessitate for precise agriculture (Hardanto et al, 2017). Chong et al (2017) and Candiago et al (2015) elucidate the potentials of UAVs as a realistic technique in assessing land suitability for oil palm plantations. Land suitability is also assessed from considerations on soil components inferred from high-resolution digital images (Rendana et al 2015). To optimize oil palm production, close-range photogrammetry is now a technique for precise agriculture (Shamshiri et al, 2017). In all these applications, none of the studies develop a hypothesis from tree colour variation, tree height variation, vegetation density, and topography.

While there are few instances of applications in the assessment of land suitability in oil palm plantations (Shamshiri et al, 2017) close range photogrammetry is basically for other usages in the rubber tree plantations. The study by Stark et al (2017) on managing a rubber tree plantation does not include evaluations for terrain topology. Close range photogrammetry has also been developed to generate automosaics with excellent spatial and temporal resolutions for epidemiological studies of rubber tree plantations (Kaewwaen and Bhumiratana, 2015; Fornace et al, 2014). Automosaics from close range photogrammetry is used to evaluate land characterization and land use patterns resulting from the expansion of rubber tree plantations (Traisasongko, 2017; Kaewwaen and Bhumiratana, 2015). The contextual and spectral propensities of close-range digital images compared to other remote sensing techniques makes it more favorable in the study of biological organisms present in rubber tree plantations (Duan et al, 2017; Fornace et al, 2014). None of these studies, however, is specifically on determining land suitability in the management of rubber tree plantations. Effective considerations of land suitability for oil palm and rubber tree farming will involve continuous assessment of climatic, topographical and biophysical components (Singha and Swain, 2016). This is because of the hydrological life cycle of both trees greatly influenced by both climatic and topographical factors (Hardanto et al, 2017). An in-depth consideration of their transpiration cycle is Management priority and only determined by land suitability. The study, therefore, addresses the aforementioned shortcomings in the previous studies as encapsulated in the aim and objectives of the project.

IV. AIM AND OBJECTIVES OF THIS PRELIMINARY INVESTIGATION

4.1 Aim of the Study

To investigate the possibility of creating a low-cost photogrammetric technique for Rapid Low-cost Assessment of Land Suitability in Medium and large-Scale Oil Palm and Rubber Tree Farming

4.2 Objectives of Study

To rapidly carry out some close range photogrammetry in an oil palm and rubber tree plantation, visualize results and determine the following;

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1. The capability of the platform in capturing versed area of the plantation
2. The performance of the camera sensor in generating high-resolution digital images for both plantations
3. To test the workflow of the respective photogrammetric software
4. To ascertain the level of accuracies without ground control points
5. To ascertain the performances of the digital models in the assessment of land suitability for both plants

V. STUDY AREA

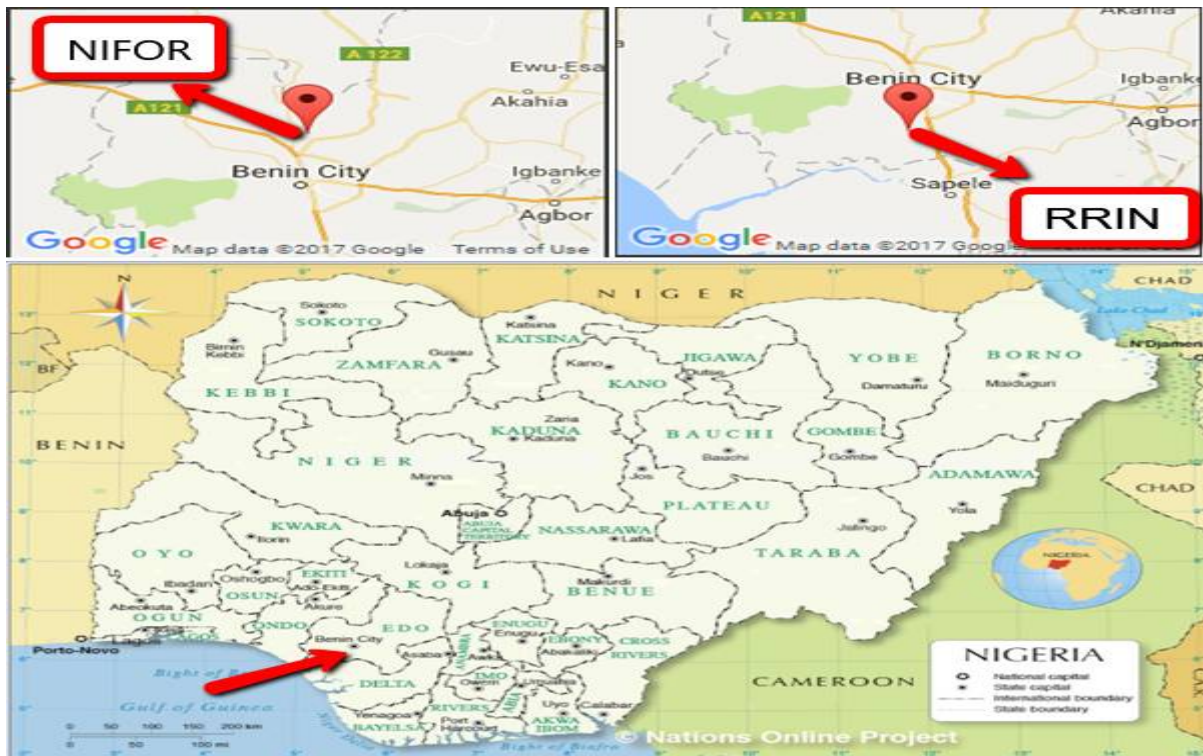


Fig. 1 Study Locations (Google Earth and National Ordinance Map)

The Rubber Research Institute of Nigeria (RRIN) is at Iyanomo, Benin city on 6.16° Latitude and 5.59° Longitude while the Nigeria Institute for Oil Palm Research (NIFOR) is at NIFOR, Near Benin city with the geographical location of 6.56° Latitude and 5.62° Longitude. For each survey at both locations, the drone's camera was positioned to capture vertical, near vertical and oblique photographs. For this preliminary investigation, the average of the areas captured for both plantations is between 1hectare (fig. 8) to 160 hectares (fig.13) of land.

VI. DATA ACQUISITION AND PROCESSING

The surveys were carried out using the DJI Phantom 3 standard. All the flying heights were below 130m from the ground. The camera sensor is 12megapixel. The camera fixed focal length is 3.6mm and colour space RGB. All flight times were between 12 to 18 minutes. The drone was flown manually using the DJI GO app. The drone was intentionally flown manually to ascertain the quality of the automosaic as the primary aim is to test for rapid acquisition of digital images. Care was taken to ensure that all the forward overlap is above 80% and lateral overlap above 70% as required for dense vegetation (Pix4D Support, 2012 -2017). The aircraft has an inbuilt GPS for positioning. The processing was done using the low-cost commercial AgisoftPhotoscan photogrammetric software.

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Fig 2.research Group with the Drone



Fig. 3.data collection in one of the study Centre



Fig. 4. medium scale horizontal mapping of Palm oil plantation

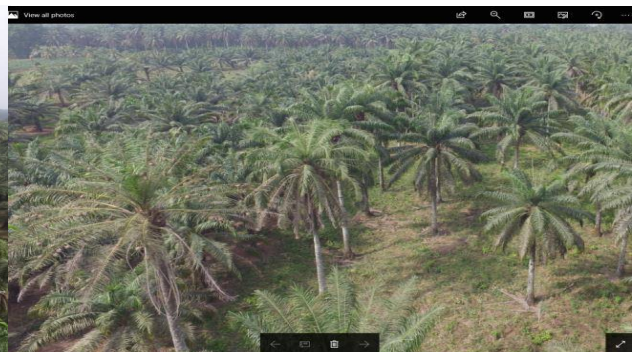


Fig. 5.medium scale low horizontal mapping of Palm oil plantation



Fig. 6. DSM of Oil Palm Plantation



Fig. 7. DSM of Rubber Tree Plantation

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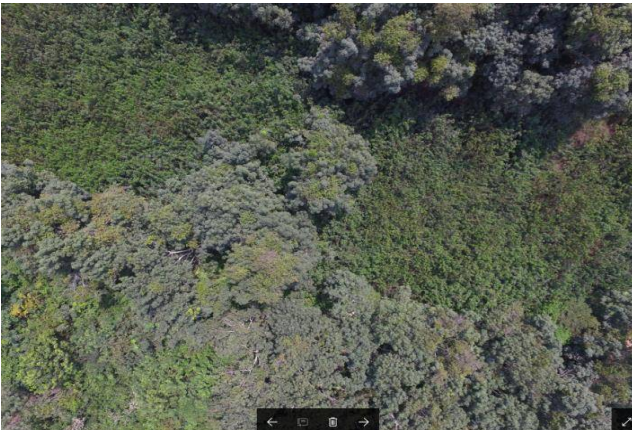


Fig. 8 chlorophyll of Rubber Tree Leaves
(near vertical photograph)



Fig. 9 chlorophyll of Rubber Tree Leaves
(vertical photograph)



Fig. 10 chlorophyll of Oil Palm Trees
(vertical photograph)



Fig. 11 Horizontal Photo showing large
plantation of young palm tree



Fig. 12 Close range photo showing the
Base and trunk of Palm Tree



Fig. 13 Horizontal Photo showing a large
expanse of Rubber Tree plantation

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VII. RESULTS AND DISCUSSIONS

The result from the study is shown in Table 1 below.

Table 1. Summary of Results Obtained

Platform	Sensor	Average Spectral resolution	Average Spatial resolution	Absolute Accuracy
DJI Phantom 3 Standard	A 1/2.3" effective pixels of 12 megapixel	3 active bands (RGB) 0.5nm min to 0.5nm max	10cm	Since there was no definite flying height it was not possible to determine a common ground sampling distance

Explains the accuracies of the initial surveys

7.1 Discussions on Outcome of Preliminary Investigation and Further Work

Figures 4 and 5 depict the various life stages of the palm trees. From a high-resolution automosaics, managers are able to visualize and appreciate their performances at various life cycles. For sparsely populated plantations, this methodology is also able to categorize the various stages of land formations and patterns as displayed in their digital surface models above (**figures 6 and 7**). **Figures 11 and 13** give explanations to a very common concern in the Agriculture and Photogrammetric Sciences. This is the on-going discussions on the expanse of farmland close range platforms can capture on a single survey with excellent spatial and spectral resolutions (Malinverni et al, 2017; Avellar et al, 2015; Fornace et al, 2014). From this initial outcome using the 12-megapixel RGB digital camera (table 1), the researchers envisage higher resolution automosaics using digital cameras with higher resolutions. This is, however, relative to environmental factors as would be explained in our next publication(s). Finally, **figure 12** displays the base and trunk of palm trees. Where there are ground control points, this implies contours could be generated for the base of the plantation for deciding on landscaping, fertilizers, irrigation, and probably on mixed cropping patterns.

Figures 6 and 7 are Digital Surface Models (DSM) for both plantations. This is achieved using the AgisoftPhotoscan photogrammetric software to process the digital images. In this preliminary investigation, there are no existing ground control points and the cameras were also not calibrated in order to enable for a regular inner, external, and absolute orientation parameters (Damon et al, 2016; Pix4D Mapper 2.0, 2016). Generally, this process of aligning digital images and creating a 3D model conforms to the basic principles of photogrammetry which is by the reconstruction of bundles of light rays from the object space unto the image space in order to exactly recover the X, Y and Z coordinates of ground points (Masaad and Omer, 2014; Neale et al., 2011).

Figures 8, 9, and 10 shows chlorophyll of oil palm and rubber trees. The analysis of the figures shows it could be possible to relate the chlorophyll content of the plants with their respective soil components as the colour of trees are as a result of weather, sunlight and soil moisture content (Singha and Swain, 2016; Rendana et al, 2015). As explained in section 3, the overall performances of both plants are greatly influenced by soil moisture content (Hardanto et al, 2017). It is therefore imperative to have an evaluative mechanism from assertions on their leaf colourations as a quick way of determining the plant's soil components and performances (Rendana et al, 2015).

VIII. CONCLUSIONS

The focus of this on-going research is to develop a well-defined low-cost methodology for the continuous assessment of colour variation, height variation, vegetation density and topography of both the oil palm and rubber tree. The researchers intend to create a digital spatial management base for the everyday managing of both plants considering

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their high positive economic impact in the society. Land suitability for these economic plants is not only for their overall performance, there are also concerns that poor land management of the oil palm and rubber tree plantations could impact negatively in their immediate environment (Hardanto et al, 2017). This project will, therefore, help to sustain the natural resource base of the environment. Land if properly managed could also lead to agricultural diversification using the same technology to maximize the use of land. Another component of the digital spatial management base for land evaluation is the nutrient distribution map based on the biophysical properties of soil and the spectral reflectance of leaves as analyzed from digital image processing

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