Assessing Activities of Illegal Mining in the Apamprama Forest Reserve of Ghana using Unmanned Aerial Vehicle (UAV)

[1]S. Mantey and [1]E. K. Otoo
[1]University of Mines and Technology, Box 237, Tarkwa, Ghana

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Abstract

Over the years, forest reserves have been encroached by illegal mining activities carried out by local community members together with foreigners. These illegal mining activities have several consequences on the environment. The Government of Ghana (GoG) developed and subsequently implemented several developmental policy frameworks as part of the formalisation of illegal mining activities to reduce its impact on the environment. Therefore, assessing illegal mining activities on the Apamprama Forest Reserve is important in understanding the nature and cause of the impacts. In this study, Unmanned Aerial Vehicle (UAV) was used to acquire orthophotos in 2019 and Google Earth scenes of 2013 were used to assess activities of illegal mining in the Apamprama Forest Reserve over a six year-period. An estimated area of 1.68 km^2 of land has been mined and the forest cover decreased from 36.28 km^2 to 34.60 km^2 between 2013 and 2019. The study confirms that, UAV technology is vital for assessing the activities of illegal mining in our forest reserves. This study recommends that, the Forestry Commission (FC) adopts the use of UAVs to assess and monitor the activities in and around the Apamprama forest to minimise illegal mining activities.

Keywords: Apamprama Forest Reserve, Illegal Mining, UAV, Orthophotos

1 Introduction

Issues of health and environmental impacts associated with mining have a long history and these growing concerns have led to extensive research to understand the nature and cause of these impacts (Tarras-Wahlberg *et al*., 2001; Lacerda, *et al*., 2004; Hilson, 2002; Addai and Baiden, 2014). According to Tarras-Wahlberg *et al.* (2001), Amegbey *et al.* (1997) and Agyapong (1998) environmental impacts from mining operations result from two end members: That is large scale mining, where these impacts although managed, occur as a result of the size of operations, and small-scale mining which employs unconventional extraction and processing methods (Amoah, 2016). These unconventional techniques of mining suggest a general difficulty in achieving environmental quality in the country (Amegbey *et al*., 1997; Aryee *et al*., 2003; Cobbina *et al*., 2013; Eshun and Okyere, 2017). Unmanned Aerial Vehicles (UAVs) have become useful for monitoring illegal activities in the environment.

UAV systems and platforms were primarily developed for military goals and applications in the past, but have recently found a common application in the field of Geomatics for acquiring data for mapping and modelling in 3D (Remondino *et al*., 2013; Laliberte *et al*., 2010). UAV is a generic aircraft with no human pilot onboard (Anon., 2014; Remondino *et al*., 2013). Images and data generated from UAV's are a source of geospatial information for natural resource monitoring which have become significant complementary solution to terrestrial applications and satellite remote sensing (Tong, 2015; Zhuo *et al*., 2017). UAV platforms are very important alternative and solution for studying and exploring our environment (Chirico and DeWitt, 2017; Whitehead and Hugenholtz, 2014). UAV, notwithstanding the limitations and problems, are a means of significant data imaging for a large variety of applications and creates a consistent and qualitative record of activities (Lui *et al*., 2014). This research aims at applying the techniques of UAV to assess the activities of illegal mining in the Apamprama Forest Reserve of Ghana.

1.1 Study Area

Apamprama Forest Reserve is one of the four forest reserves located in the Amansie Central and Amansie West Districts in the Ashanti Region (Fig. 1). The reserve covers an area of about 36.28 km^2 and located between latitudes 06˚ 22′ 08″ N and 06˚ 17′ 14″ N and longitudes 01˚ 55′ 16″ W and 01˚ 48′ 21″ W. The districts lie in the South West part of Ashanti and have combined land area of about 2074 km^2, representing 8.5% of the regions total land surface area (Anon., 2015).

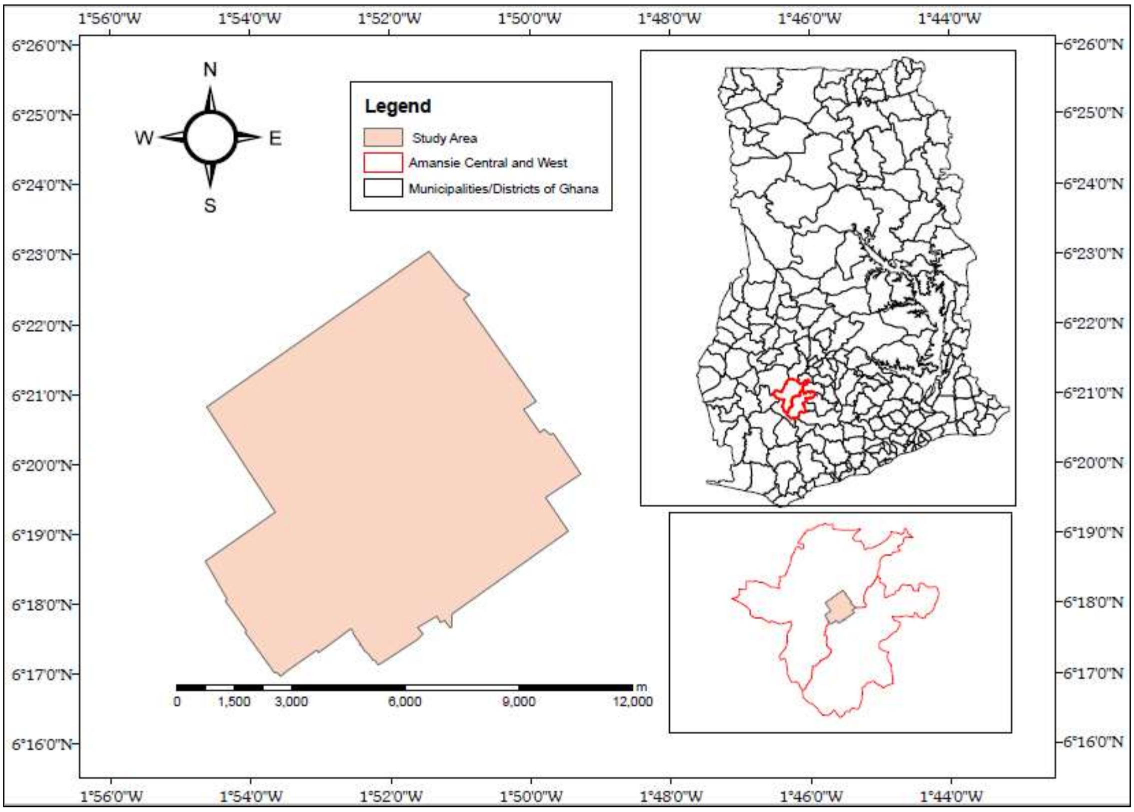

Fig. 1 Study Area

The districts are predominantly endowed with undulating plateaus with altitudes ranging from 150 m and 300 m above sea level. Average annual rainfall is about 1700 mm with semi-equatorial and wet climate and temperatures between 20 °C and 32 °C the forest is drained by River Offin.

2 Resources and Methods Used

2.1 Data and Software

Drone Deploy Software was used to plan the UAV flight and capture the images. The images were captured between 3rd to 30th January, 2019 in a pre-dominantly sunny condition with little or no wind. High Resolution Images of 2019 from DJI Phantom 4 UAV and Google Earth Scenes of 2013 were the data used for this study. Digital Image Processing (DIP) was done using Agisoft Photoscan Software whilst ArcGIS software was used to assess the activities of illegal mining and analyse the results.

2.2 Methods Used

The methods employed in the assessment of illegal mining activities included flight planning, image acquisition, image orientation, point cloud generation, digital surface model and the production of orthophotos from the UAV data. Google Earth images of the study area were also downloaded and assessed. The mined areas were detected from the generated orthophoto at a spatial resolution of 15 cm/pixel using the Canny Edge Detection Algorithm due to its large signal to noise ratio and the advantages of single edge response (Canny 1986).

2.2.1 Flight Planning

In planning the flight, Drone Deploy mobile application was launched on a mobile tablet and required parameters entered. These parameters include; the altitude (300 m), speed (15 m/s), angle (90˚ vertical), overlap (80% forward overlap and 60% side lap) and face (forward).

2.2.2 UAV Image Acquisition

The drone and remote controller (RC) are switched on after the mobile tablet is connected to the RC via USB and the UAV has been set up completely. DJI GO 4 mobile application installed on the mobile tablet is launched to set and check the state of the drone before flight. The planned flight is then loaded into the Phantom 4 from the RC, the drone takes off and autonomously start and complete the flight mission.

2.2.3 Image Orientation

Orientation is very vital as far as photogrammetry is concerned. Image Orientation is basically operations carried on photogrammetric materials and products such as the camera and the interaction it has with the external environment.

Two orientations are carried out, *i.e*. interior and exterior orientations. Interior orientation determines the internal geometry of cameras whilst exterior orientation determines the relationship between camera and the real world (Barazzetti *et al*., 2010; Remondino and Fraser, 2006; Westoby *et al*., 2012). Agisoft Photoscan Professional software was launched and the images captured from the UAV were added to the workspace and photo alignment was done with respect to the spatial position of the individual images captured by the UAV.

Point cloud, digital surface model (DSM) and orthophoto were generated. Point cloud image are built from the workflow menu to generate a digital surface model and the orthophoto was finally produced from the DSM (Figure 2).

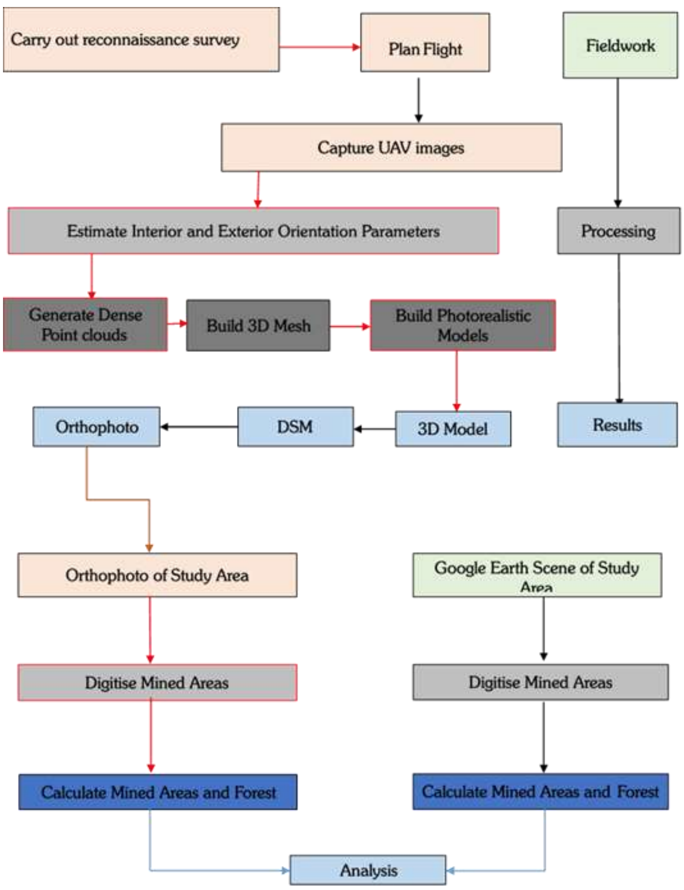

Fig. 2 Methods Used

3 Results and Discussions

3.1 Mined Areas and Forest Boundary

The mined areas of orthophoto of 2019 and google earth of 2013 are shown in Figures 3 and 4 respectively. The results from Table 1 shows that a total land area of 1.68 km^2 have been mined from 2013 to 2019. Increase in small-scale and illegal mining activities within the forest and its environs have caused a decrease in the forest vegetation cover from 36.28 km^2 to 34.60 km^2. The results of this is the conversion of primary forest to secondary forest and the increase in shrubs.

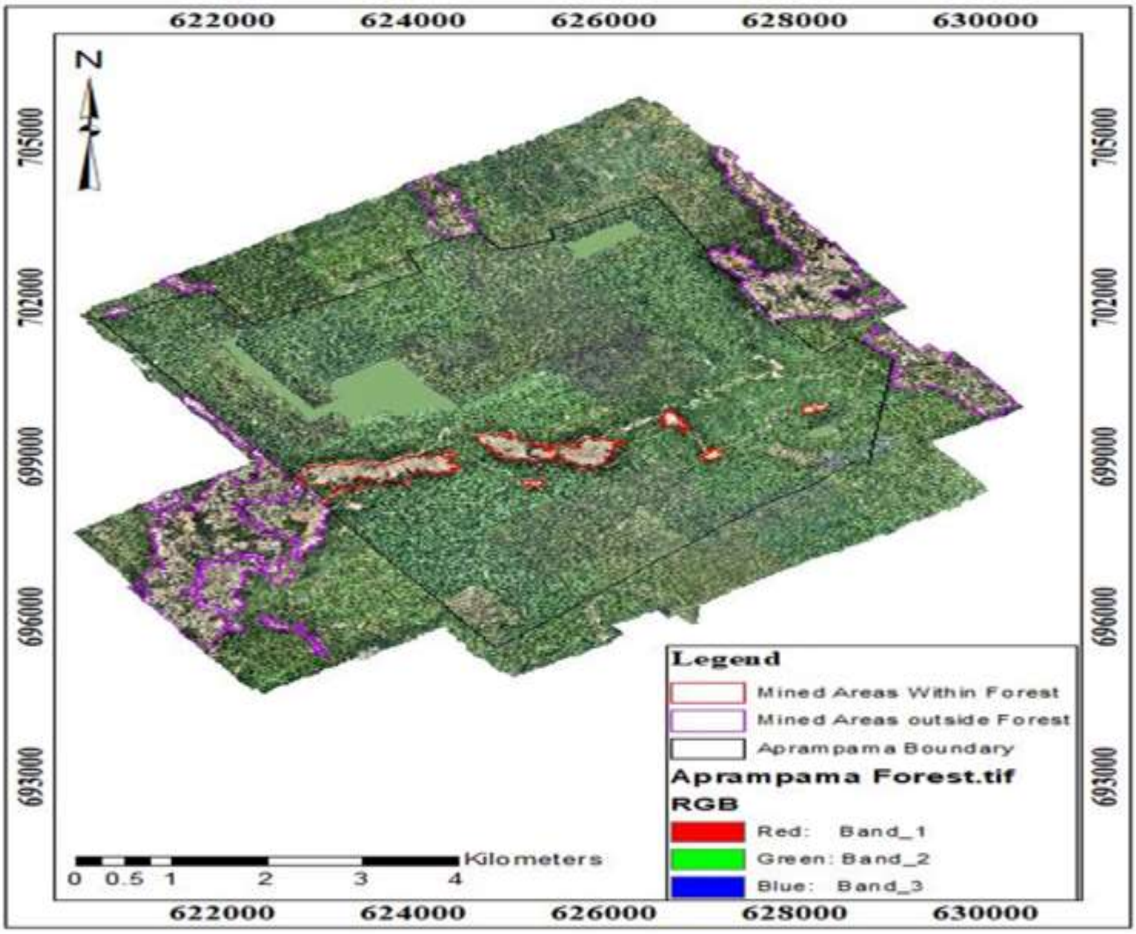

Fig. 3 Digitised Orthophoto of 2019

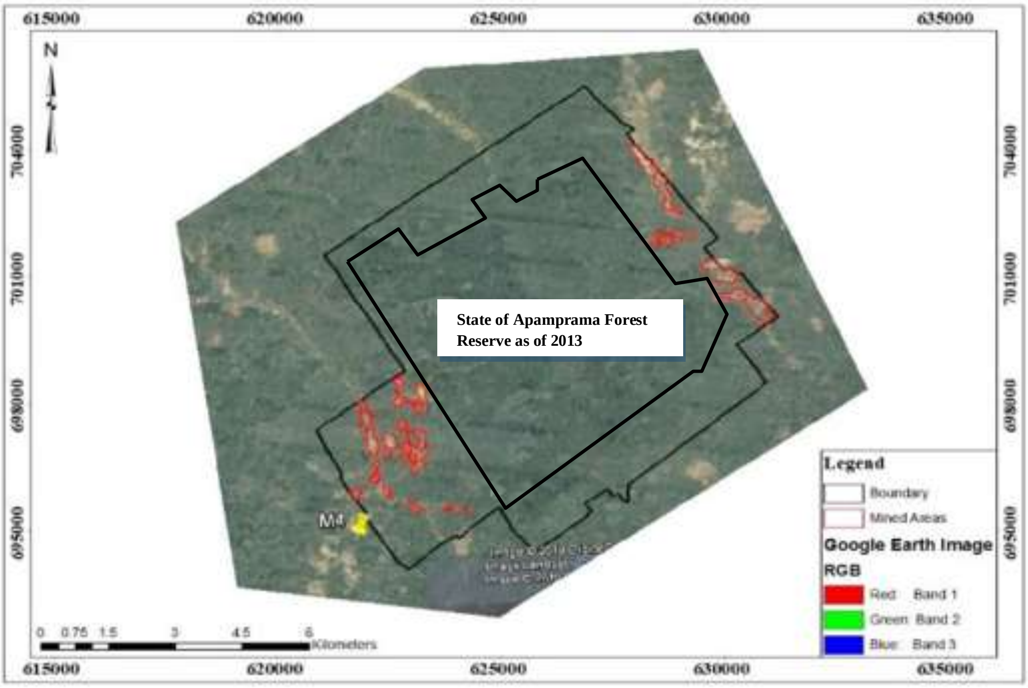

Fig. 4 Google Earth of 2013

Table 1 Apamprama Classes from 2013 to 2019

2013 to 2019		
Class	**Area (km^2)**	**Area (%)**
Forest cover	34.60	95.37
Mined area	1.68	4.63

From Figures 3, 4 and 5, it can be observed that illegal mining activities is gradually eroding the forest cover. Large tracts of land have been left with large dug-outs and may pose danger to surrounding communities.

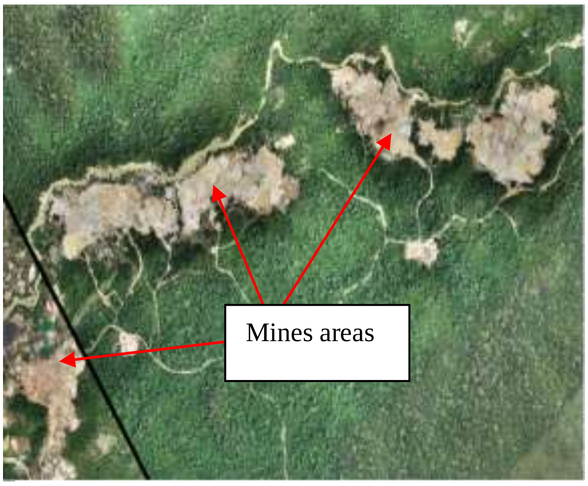

Fig. 5 Some Mined Areas in Apamprama

The proximity of the mining operations to the banks of the rivers have also caused the release of solid suspension and mercury into the water bodies which are major pollutants. The members of the community and nearby towns may suffer from this pollution since the water body is used for most of their domestic and commercial activities and may also affect them when these pollutants get into their bodies.

Abandoned mined out areas have been filled with stagnant water which may become breeding sites for mosquitoes and other insects. The proximity of mined areas to the communities may cause health problems to the people living in these communities as they may be infected with malaria from mosquito bites.

4 Conclusions and Recommendations

4.1 Conclusions

The study has confirmed that, the UAV technology is vital for assessing the activities of illegal mining activities in the study area. Illegal mining activities have destroyed land and forest cover and also caused damages to water bodies which may affect the health of people.

4.2 Recommendations

The study recommends that, the Forestry Commission uses UAV technology to increase surveillance in and around the forest reserve to prevent encroachment. Environmental laws regulating mining activities should be enforced by EPA and regular monitoring should also be undertaken.

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Authors

Saviour Mantey is a Senior Lecturer at the Department of Geomatic Engineering of the University of Mines and Technology (UMaT), Tarkwa, Ghana. He holds a BSc degree in Geodetic Engineering from KNUST, Ghana. He obtained his Master of Philosophy degree and Doctor of Philosophy from University of Cambridge and University of Mines and Technology respectively. His research interest includes application of Remote Sensing and GIS in Health and Environmental Analysis, UAVs and Web GIS applications.

Ebenezer Kobina Otoo is a Teaching and Research Assistant at the Department of Geomatic Engineering of the University of Mines and Technology (UMaT), Tarkwa, Ghana. He holds a BSc degree in Geomatic Engineering from UMaT, Ghana. His research interest includes application of Remote Sensing and GIS in Health and Environmental Analysis and UAVs.