Early Detection of Illegal Settlements on Government Lands using UAV Technology - A Case Study*

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Abstract

Illegal settlements (squatter settlements) have been a persisting problem in most developing countries and even some developed countries. This has led to the loss of huge sums of money, resources, time and energy. These illegal settlements serve as hide outs for most armed robbers, drug dealers, drug addicts, murderers, rapists, prostitutes and the like. Children born in these areas are not given proper care and education hence the cycle continuous. These squatters also pollute the environment through their activities. Some squatters on government lands and mining concessions indulge in illegal mining activities and illegal logging. Large portions of government lands are unguarded, as a result, most of these squatter settlements are very difficult to detect. Unmanned Aerial Vehicle (UAV) technology has improved tremendously over the past few years and has led to increase in the number of UAVs produced and are relatively affordable. The objective of this study was to detect illegal settlements in and around the University of Mines and Technology (UMaT) boundary and other government land using UAV technology. This study used high-resolution images acquired from UAV (Phantom 4 Pro) and Agisoft Metashape to align and optimise the images and generate point clouds, digital surface models, and orthophotos. Four illegal settlements were detected in this study. Three illegal settlements were detected in Part A and one in Part B of the study area. A combined area of 0.831 acres of land has been encroached upon by illegal settlers in the study area. UAV Technology is a useful tool to detect illegal settlements in their early stages in order to avoid such settlements developing into slums. This study, therefore, recommends the use of UAV Technology to aid early detection of illegal settlements.

Keywords: Illegal settlements, UMaT, UAVs, Squatters.

1 Introduction

Illegal settlement (commonly referred to as squatter settlement) has been defined in numerous ways depending on the planning and legal structure of a given country. For the purposes of this study, illegal settlements are defined as residential buildings built on "planned" and "unplanned" areas which do not have formal planning approval. Such settlements are mostly characterised by low-quality houses and the lack of, or inadequate infrastructure and social services (Takyi *et al.* 2021; Ali and Sulaiman, 2006). Causes of illegal settlements could be as a result of poverty, rural-urban migration, poor government policies and lack of regulations regarding settlements or poor measures to detect and monitor such situations before they escalate. An illegal settlement, if left unattended for long period develops into a bigger slum which harbors criminals, contributes to environmental pollution and dents the aesthetic beauty of cities. Also, because these illegal settlements are not well structured, they may contribute to flooding, which could lead to loss of lives and property (Takyi *et al*. 2021; Texier, 2008). Ghana as a country has and is still encountering this problem, especially in its major cities and towns, which has massively retarded its development. Some squatters who find themselves on mining concessions tend to indulge in illegal mining activities *(galamsey)* and the felling of trees. Since most parts of mining concessions and forest reserves are unguarded, they mostly go unnoticed. Lots of money and resources which could have been channeled into other important projects have been spent on relocating these squatters and cleaning up their mess by government. The use of UAV technology for mapping is becoming more acceptable among survey and mapping professionals (Vallet *et al*., 2011). This study, therefore, seeks to use UAV Technology to detect such illegal settlements within and surrounding the University of Mines and Technology (UMaT) in the Tarkwa Nsuaem Municipality of Ghana.

1.1 Problem of Illegal Settlements in Ghana

Illegal and spontaneous settlements are a major part of the residential geographies of most cities of the lesser-developed world. In 2003, the United Nations Human Settlements Programme estimated that 924 million, or 31.6% of the world's population live in slums, and a good proportion of these are classified as squatter settlements (Grant, 2006; Datta and Jones, 1999). Also, according to Datta and Jones, (1999), about half of the world's urban population lives in poverty and about 800 million people

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occupy low-standard housing. However, this had not always been the case, as prior to 1990, illegal settlements were rare in urban West Africa. This could be attributed to the fact that people at that time believed in the superintending role of the spirits (hovering around the properties of their families and capable of bringing harm to those who might wrongfully or unjustifiably occupy this land) coupled with the fact that land and houses were affordable for the greater percentage of people meant that land was protected and illegal settlements kept at the minimum (Konadu-Agyemang, 1991). An excellent illustration of the absorption capacity of the land systems prior to 1991 occurred when over 1 million Ghanaians were repatriated from Nigeria in 1983, yet it did not create any significant large squatter settlements (Grant, 2006). However, since 2001, illegal settlements have been increasing at an alarming rate in the major cities and towns in Ghana. One of the largest illegal settlements in Ghana was the Agbogbloshie/Old Fadama, infamously called "Sodom and Gomorrah". The designation, "Sodom and Gomorrah" reflects the kind of living the people in the biblical story captured in the book of Genesis. The media described the settlement as "out of place," "a no-man's land" as well as "a hideout for armed robbers, prostitutes, drug pushers and all kinds of people who were threat to societal peace and harmony" (Grant, 2006). The government of Ghana advocated a politics of non-recognition toward the settlers, arguing that the settlement's existence undermines an adjacent environmental project; the Korle Lagoon Ecological Restoration Project (KLERP), and noting that the proximity of its location to the Central Business District (CBD) of the capital was an eye sore as well as a major source of pollution (Afenah, 2009). Another area where government land has been encroached upon is Frafraha in the Adentan Municipal Assembly (AdMA) in Accra. Of the 1300 acres of government land for the Council for Scientific and Industrial Research (CSIR), more than 900 acres has been encroached upon. The Greater Accra Regional Minister on June 22, 2022 lead a team of Regional Security Council (REGSEC) to demolish illegal structures on encroached land at Fafraha (Figs. 1, 2 and 3), acting on the Local Governance Act, 2016 (Act 936) in section 97 which stipulates the enforcement against unauthorised development in respect of community right of space.

Government lands in the Tarkwa Nsuaem Municipality has also been encroached upon as detected in this study using the University of Mines and Technology as a case study.

Fig. 1 Demolition Exercise at Fafraha

Fig. 2 Demolition Exercise at Fafraha

Fig. 3 Demolition Exercise at Fafraha

1.2 Relevant Information about the Study Area

The University of Mines and Technology is in the Tarkwa Nsuaem Municipality. The Tarkwa Nsuaem Municipality is one of the Municipalities in the Western Region of Ghana and is located between latitudes 05º20´00´´N and 04º10´00´´N of the equator and longitudes 01º50´00´´W and 02º0´00´´W (Fig. 4). It is bounded to the north by Wassa Amenfi East District, to the south by Ahanta West District, to the West by Nzema East Municipal and to the East by Mpohor Wassa East. The Tarkwa Nsuaem Municipal covers a total land area of 905.2 sq.km.

The Administrative Capital is Tarkwa (Anon., 2014a). The municipality is within the South-

Western Equatorial climatic zone. Temperature ranges between 26 ℃ in August and 30 ℃ in March. The relative humidity is generally high throughout the year, between 70% - 80% in the dry season and 75% -78% in the wet season (Anon., 2014a) (Fig. 4).

2 Resources and Methods Used

2.1 Resources

The resources used in this study include: Unmanned Aerial Vehicle (UAV) and accessories; Ground Control Points (GCPs); Hi-Target Dual Frequency GPS Receiver and Google Earth image of the University of Mines and Technology and its environs in the Tarkwa Nsuaem Municipality.

2.2 Methods Used

Methods used in this study include; reconnaissance survey, UAV image acquisition, orthophoto generation and superimposition of Google Earth and Orthophoto. The flow chart of the methods used is shown in Fig. 5.

2.2.1 Reconnaissance

A familiarisation tour was carried-out in the study area prior to the flight. This was to help plan the flight mission taking into consideration the elevation, accessibility and other factors in order to set the right altitude and flight directions and also identify suitable locations for the GCPs as well as set home point for the flight.

2.2.2 UAV Image Acquisition

The flight was autonomously planned using DroneDeploy mapping application. The following parameters were set as follows; altitude of 70 m, camera angle of 90 degrees vertical, forward overlap of 80% and side lap of 60%. The conditions of the UAV as well as the progress of the mission were monitored during the flight for the image acquisition. Prior to the image acquisition, coordinates of GCPs were acquired using the Hi-Target Dual Frequency GPS Receiver in the WGS 84 Coordinate System.

2.2.3 Image Orientation (Align Photos) and Point Cloud Generation

The images acquired were downloaded and aligned using Agisoft Metashape. Tie points were then established. Based on the estimated camera positions, the depth information was calculated for each camera position to be combined into a single dense point cloud to generate the digital surface model.

2.2.4 Digital Surface Model (DSM) and Orthophoto Generation

Digital surface model was generated based on the dense cloud or mesh model. Generating DSM from dense point clouds is mostly preferred because it provides more accurate and smooth DSMs and allows for faster processing. The “Build DEM” command from the workflow menu in Agisoft Metashape was selected and the requisite parameters set to build the DSM, which is required to build the orthophoto. The “Build Orthomosaic” command was then used from the workflow menu and all the required parameters were set to also generate the orthophoto.

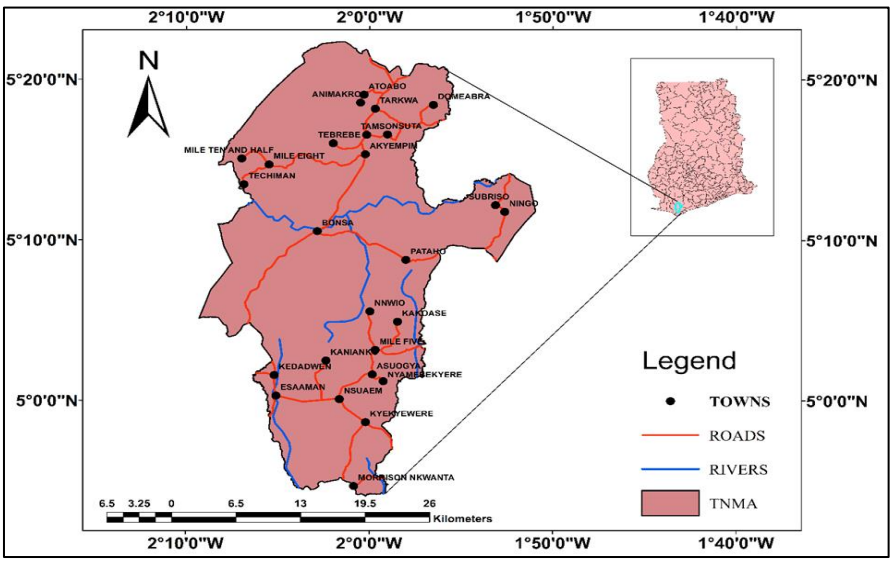

Fig. 4 Location of Study Area

2.2.5 Superimposition of Google Earth and the Orthophoto

The google earth image of the study area and the UAV orthophoto generated were imported and superimposed. The areas of land occupied by each illegal settlement were digitised.

The areas of land (in acres, hectares and square kilometers) occupied by illegal settlements were computed (Table 1).

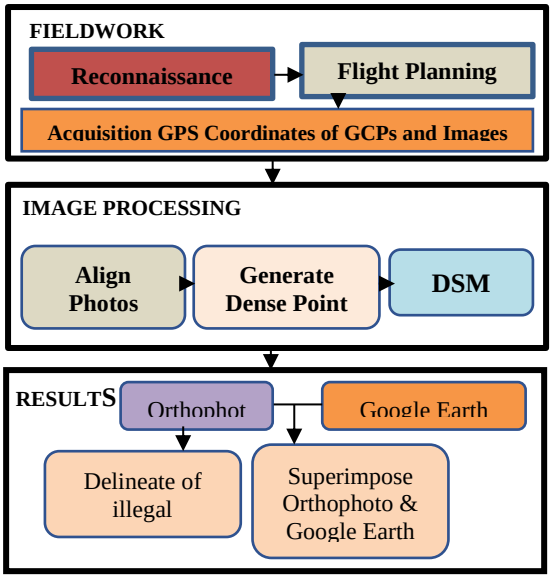

Fig. 5 Flow Chart of Methods Used

3 Results and Discussion

3.1 Results

3.1.1 Existing Google Earth Image of Study Area

Fig. 6, shows the existing google image (with lower resolution compared to the UAV orthophoto) of the study area. The two structures circled in blue were suspected to be illegal settlements on the land. The structure in the upper circle is situated between the Lecturers' Bungalows and the Pump Station (along the Government Hill Road in UMaT). The structure in the lower circle is also situated around UMaT and AngloGold Ashanti Iduapriem Limited boundary. But the resolution of the google earth image was low, hence the image was not clear and did not provide much detail on the suspected illegal settlements.

3.2 Google Earth and UAV Orthophoto

From the google earth image and the UAV orthophoto (Figs. 6 and 7), four structures were detected to be illegal settlements. The three illegal settlements were detected between UMaT and other government land named ***Part A*** and one structure was detected between the Lecturers' Bungalows and the Pump Station named ***Part B***. Figs 8 and 12 show closer views of *Part A* and *Part B* respectively. Figs. 9, 10, 11 and 13 show closer views of settlements 1, 2, 3 and 4 respectively. Settlements 1, 2 and 3 are found in ***Part A*** while Settlement 4 is found in ***Part B.***

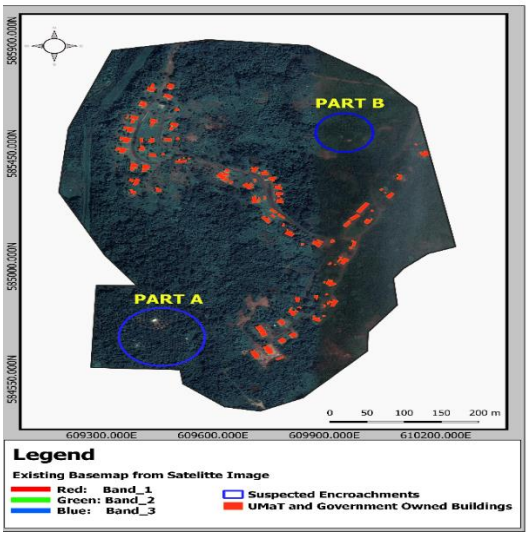

Fig. 6 Google Image showing Suspected Illegal Settlements

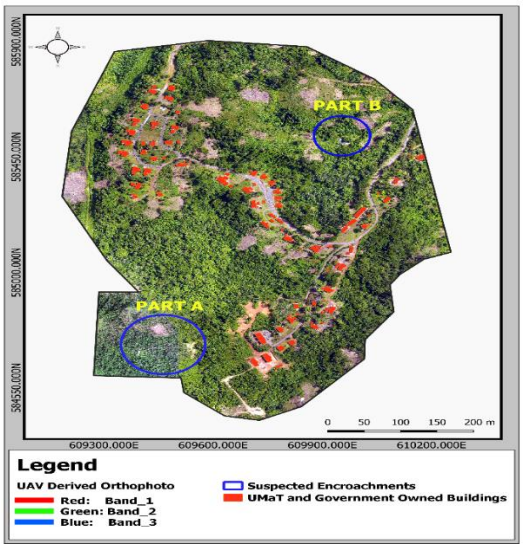

Fig. 7 UAV Derived Orthophoto

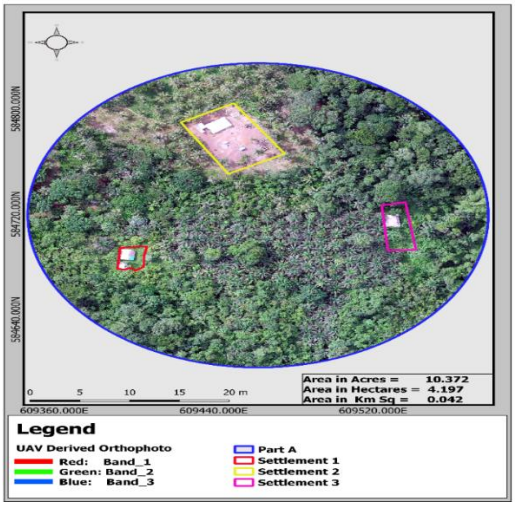

Fig. 8 UAV Orthophoto of Part A

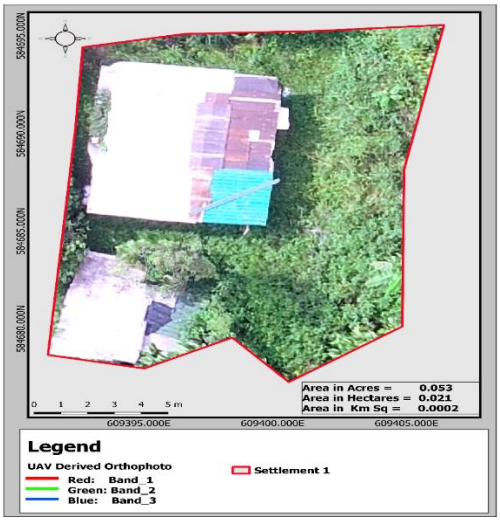

Fig. 9 Closer View of Settlement 1 (Part A)

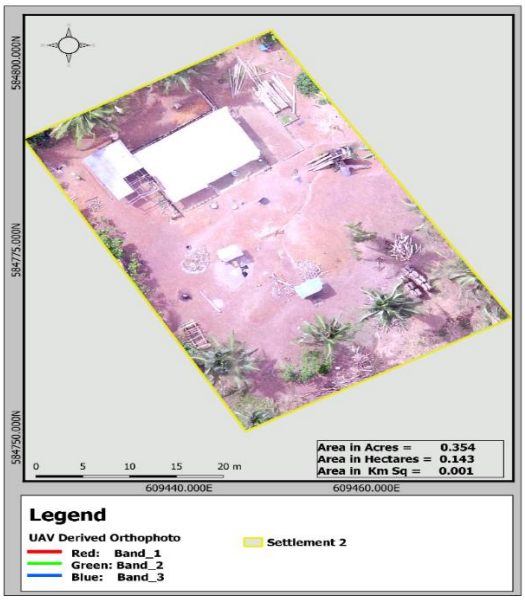

Fig. 10 Closer View of Settlement 2 (Part A)

Fig. 11 Closer View of Settlement 3 (Part A)

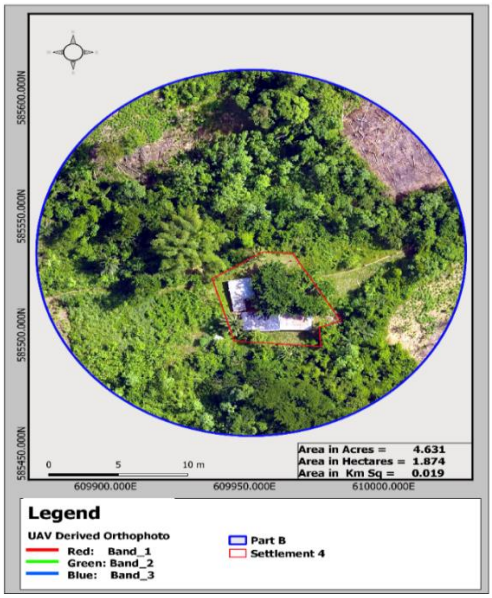

Fig. 12 UAV Orthophoto of Part B

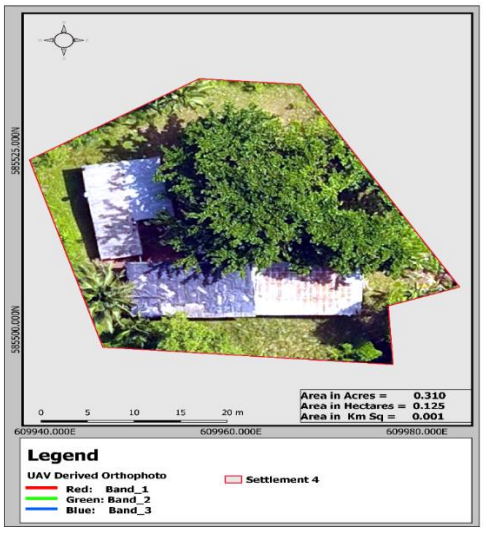

Fig. 13 Closer View of Settlement 4 (Part B)

3.2.1 Land Encroached by the Illegal Settlements 1, 2, 3 and 4

Table 1 shows the land areas encroached by illegal settlers as detected in settlements 1, 2, 3 and 4. A combined area of 0.831 acres of land has been encroached upon by these illegal settlers.

Table 1 Area of Land Encroached

Settlement	Area (Acres)	Area (Hectares)	Area (Sq. Kms)
1	0.053	0.021	0.0002
2	0.354	0.143	0.001
3	0.114	0.046	0.005
4	0.310	0.125	0.001
Total	**0.831**	**0.335**	**0.0072**

3.3 Discussion

From Fig. 6, Parts A and B were observed from google earth image as suspected areas of illegal settlements in obscured and inaccessible areas within the government land. In order to have a better view, a high-resolution orthophoto derived from UAV images from the same area was analysed. From Fig. 8 the total land area currently encroached in Part A is 0.521 acres. However, an estimated land area of 10 acres would have been encroached if the University of Mines and Technology authorities had not deployed periodic UAV surveys in the study area to check the encroachment. Also, the encroached land area in Part B is currently 0.31 acres could have been 4.631 acres had it not been checked by the authorities. From Figs. 6 to 13 it could be observed that illegal settlements start small and develops into slums. From this study an initial total land area of 0.831 acres of government land was detected to have been encroached upon. Early detection and appropriate action would avert the emergence and re-emergence of this menace.

4 Conclusions and Recommendation

This study successfully detected illegal settlements within government lands in the study area. Four settlements were detected to be illegal. It was also established that settlements 1, 2, 3 and 4 occupied 0.053 acres, 0.354 acres, 0.114 acres and 0.310 acres of land respectively. A combined area of 0.831 acres of land has been encroached by illegal settlers. This study recommends that UAV surveys be carried out periodically in order to detect early illegal settlements on government lands as is being carried out by the authorities of the University of Mines and Technology.

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