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Detecting Encroachment within Wetlands using UAV Techniques -The Case of Sakumo Ramsar Site, Ghana

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Abstract
Wetlands have provided many benefits to mankind all over the world. Wetlands are a rich source of food and water security hence a crucial source of subsistence for communities. Apart from serving humanity, wetlands provide unique habitats for various types of fauna and flora. Consequently, wetlands have gained importance worldwide for conservation purposes and are designated as Ramsar Sites. However, urbanisation and subsequent population explosion has left some of our urban wetlands in deplorable and degraded conditions. The Sakumo Wetland and its catchment is one of such areas which has not been spared. This paper sought to access the level of encroachment within the Sakumo Ramsar Site, in the Accra and Tema Metropolis (Ghana) by using Unmanned Aerial Vehicle (UAV). A descriptive research design strategy was adopted supported by a mixed method approach. UAV survey was conducted to obtain orthophotos from a carefully and systematically planned aerial survey of the Ramsar Site. The UAV survey was supplemented with qualitative field data obtained from participants who live in the Sakumo community, which is the catchment of the Sakumo Wetlands. The study revealed a loss of substantial area of the wetland to encroachment. The settlement areas have compromised the natural flood control potential of the wetland as well as portions of the 100 m buffer zone have been encroached upon. The effect is the loss of about 38.3% of the wetland to encroachment. The encroachment has also resulted in loss of livelihood for fishermen and farmers within the community creating a rippling effect on sustenance of families. This paper recommends the collaboration of stakeholders and relevant city authorities to restore the degraded wetlands and adopt strategies to secure the buffer zone around the lagoon. The custodians of the Sakumo lagoon, that is the Chiefs and Traditional Priest or "Wulomo", should be actively engaged in sustainable Community Education, Participation and Awareness (CEPA) to ensure that, the Sakumo lagoon which is believed to be a goddess with a strong religious and cultural presence in the community, continues to enjoy the historical, traditional authority she is accorded within the community while yielding benefits to the inhabitants both far and near.
Keywords: Anthropogenic activities, Encroachment, Sakumo Ramsar Site, UAV survey, Wulomo
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1. Introduction

Historically, wetlands have offered many benefits to mankind worldwide. Many civilizations like the Marsh Arabs of Mesopotamia and the civilizations along the River Nile survived on the numerous benefits of their wetlands. Wetlands are a rich source of food and water security hence a crucial source of subsistence for communities. The various benefits that wetlands still provide, creates competition for their use. Apart from serving humanity, wetlands provide unique habitats for various types of fauna and flora. Wetlands also provide habitats and roosting grounds for migratory birds (Wells, 2014; Newton, 2010). Consequently, wetlands have gained importance worldwide for conservation purposes and are designated as Ramsar Sites. However, urbanisation and subsequent population explosion have left some urban wetlands in deplorable and degraded conditions (Asomani-Boateng, 2019; Nilsson and Grelsson, 1995). This is because of anthropogenic activities within communities which are springing up near urban wetlands and culminating in undesirable human activities occurring in these settlements. The Sakumo Wetland and its catchment have not escaped this degradation associated with human based activities. The fast-expanding cities of Accra and Tema, is leading to unprecedented wetland destruction and recurring environmental disasters. To mitigate and reverse the above

threats, there is an essential requirement for investigating the anthropogenic activities and understanding the physical environment of the wetland system. The aim of this study was to conduct a survey of the study area to obtain orthophotos with UAV to ascertain the extent of anthropogenic activities within the Sakumo Ramsar Site. Map of the study area is shown in Fig. 1. The study site, Sakumo Wetlands, a Ramsar site, is located near the national capital of Ghana, Accra (Koranteng *et al*. 2000). The catchment actually forms part of Accra and the Tema Metropolis and other municipal assemblies such as Ledzokuku – Krowor, Ashaiman and Ga East. In Ghana, five coastal wetlands including the Sakumo, were designated to be managed as Ramsar sites. The site was designated a Ramsar on the 14th of August 1992 and managed by the Wildlife Division of the Forestry Commission of Ghana, on behalf of the state. The Sakumo lagoon and its immediate catchment, occupies a total area of 27,634 ha. The study area lies between latitude 05.35° N to 06.40° N and longitude 00.00°W to 00.10° W, with an altitude of 86.9 m (286 ft). Three rivers, Mamahuma, Dzorwulu and Onukpawahe, flow within the Sakumo catchment, draining into the Sakumo lagoon, which empties into the sea (Koranteng *et al*. 2000). The Sakumo Ramsar site in Ghana is a roosting habitat for important migratory seashore birds (Wetland Management Regulations, 1999). Some of the threats which now plague the catchment are urbanisation resulting in population explosion, pollution and spread of mangrove (Kouassi and Biney, 1999; Finlayson *et al*., 2011). The population increased to 114,619 in 1984 then increased again to 250, 000 in 1997 within the catchment. By the year 2000 the population had increased to 506, 400 (Finlayson *et al*., 2011).

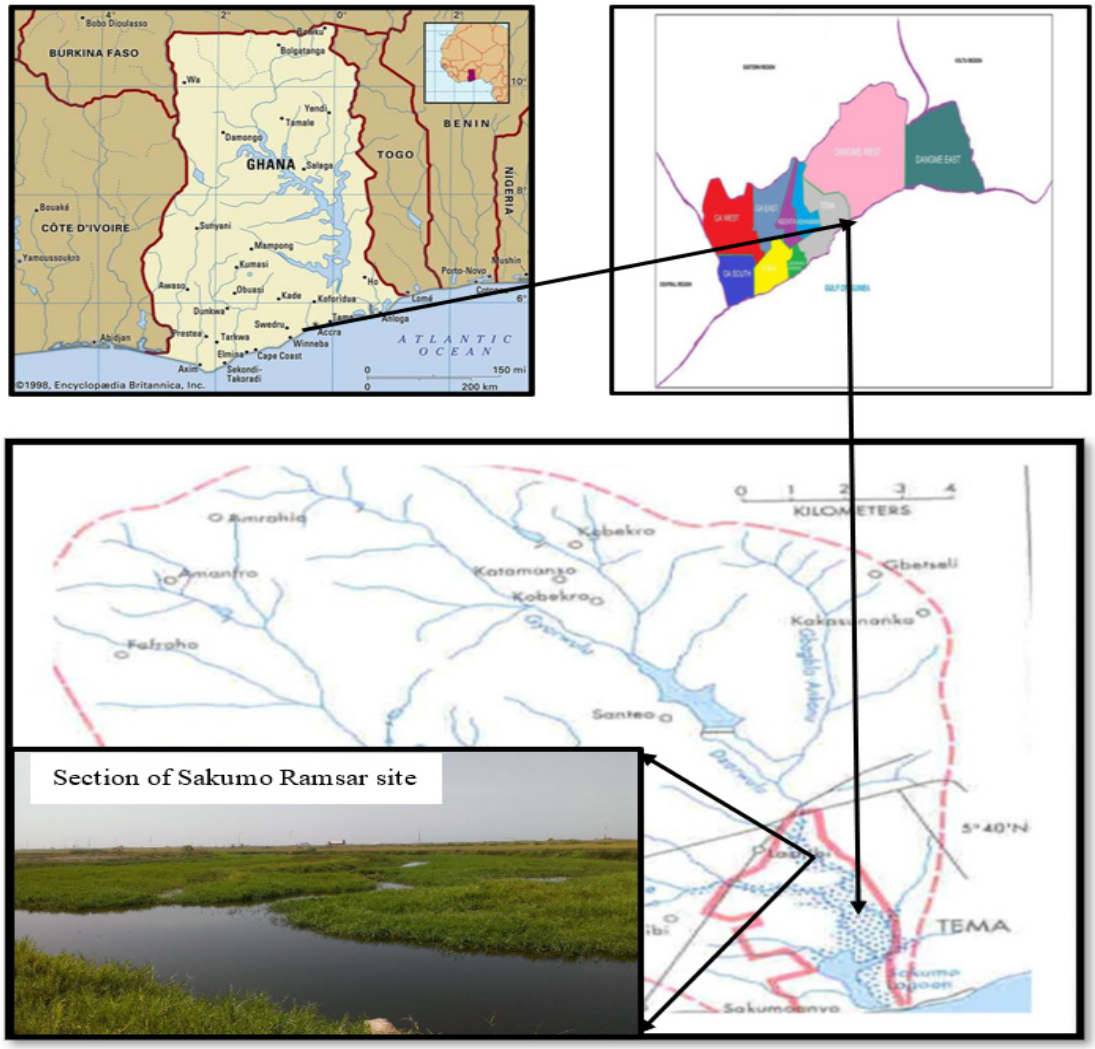

Figure 1: Map of Sakumo Study Site – Accra, Ghana (Source: Laar *et al*., 2011)

According to Nartey *et al*., (2011), land use practices prevalent at Sakumo include stone quarrying, farming, sand winning and building construction. In order to ascertain the extent of these anthropogenic activities, a drone survey was conducted within the site under study, to determine the extent of encroachment.

2. Importance of UAVs for Encroachment Surveys

The ability to maintain long term series of data for the purposes of evaluating the effect of anthropogenic

activities and change on protected areas is fundamentally dependent on ecological monitoring programs. Drones, otherwise known as UAVs, provide a robust method of surveys of otherwise inaccessible flooded or marshy areas within wetlands (Afán *et al*., 2018). UAVs offer flexible and cost-effective approach to investigating changes in ecosystems (Doughty and Cavanaugh, 2019).

Since the advent of technologies such as the aerial and terrestrial photogrammetry, it has become possible to employ UAV technology as a tool for digital preservation of 3D data of research sites under study (Mantey and Tagoe, 2019). According to Choroma' nski *et al*. (2019), this has been made possible as a result of the following: laser scanning and Global Navigation Satellite System (GNSS) which can preserve sites digitally by creating realistic models in the form of 3D images which are true to scale, Digital Surface Models (DSM) and orthophotos. This technology, as reported by Mantey and Tagoe (2019), has been successfully used by the Ghana Museums and Monuments Board (GMMB) for the preservation of heritage sites of cultural importance because it is low-cost, effective and produces swift results. The UAV technology is invaluable for collecting 3D data for sites to overcome cost and time constraints (Mantey and Tagoe, 2019).

3. Materials and Methods

3.1 Materials

A DJI Phantom 4 UAV (Fig. 2) was used to capture aerial images of the study area. The Phantom 4 UAV was fitted with a payload which captures images in the visible region (RGB) of the electromagnet spectrum. The properties of the payload are tabulated in Table 1. The Ground Control Points (GCPs) were carefully designed so that the most exact centre of the marker could be determined with a very high degree of accuracy (Fig. 3). Furthermore, South S86 GPS (Fig. 4) was used to determine coordinates on GCPs to provide photo control. The GPS unit has static horizontal and vertical accuracies of 3mm+0.5ppm RMS and 5mm+0.5ppm RMS respectively. The centering position of the GPS was given an error margin of + or – 2 cm due to the error of the exact centre not determined as the same as the UAV.

Figure 2: DJI Phantom 4 UAV

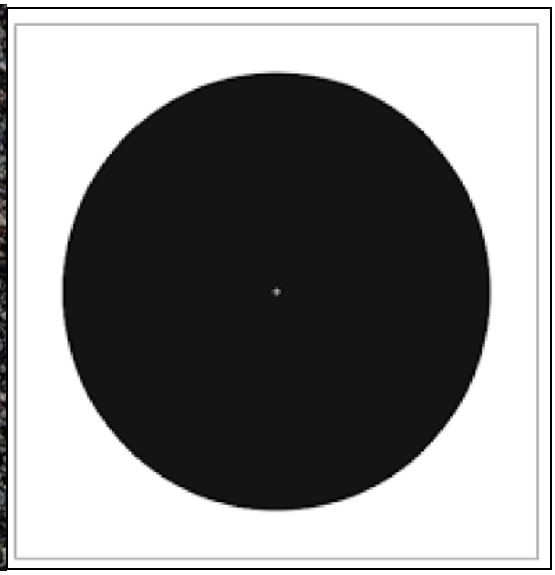

Figure 3: A Sample of GCP

Table 1 Payload Properties of the DJI Phantom 4 UAV

Camera Model	Resolution	Focal Length	Pixel Size	Pre-Calibrated
FC330 (3.61 mm)	4000 x 3000	3.61 mm	1.56 x 1.56 µm	No

Figure 4: A S86 GPS

3.2 Methods

The flowchart of the methods used in the UAV survey is outlined in Fig. 5. First, a reconnaissance survey was carried out to help determine the terrain of the study area and also to help decide the optimum height to fly.

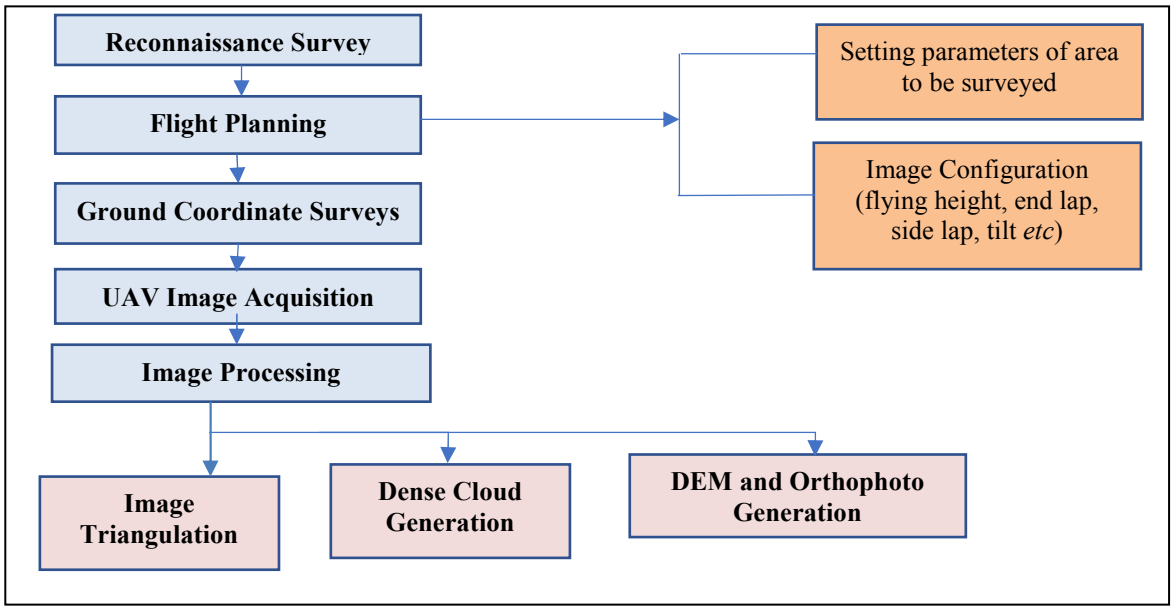

Figure 5: Flowchart of Methods Used

3.2.1 UAV Flight Planning

To acquire the requisite information needed to plan a successful flight, a reconnaissance survey of the area under study was conducted. The Drone Deploy Software was then used to plan the flight. Care was taken to determine suitable location without shade which could cause an obstruction to the Ground Control Points (GCPs). The image scale, the area of interest (AOI), the required ground sample distance (GSD) and the flying height were set for the UAV to operate in an autonomous mode instead of the manual mode. The study area was divided into sixteen (16) smaller areas with the smallest having an area of 21.05 ha, this was done to ensure the UAV operated within visual line of sight (VLOS). The UAV was flown at a flying height of 156 m and the flight plans had forward and side overlaps of 80% and 60% respectively to achieve a 5 cm GSD. A total of 2,848 geotagged images were captured within 8 hours of flight.

Agisoft Photoscan was then used to generate the final orthophoto as shown in Fig. 6.

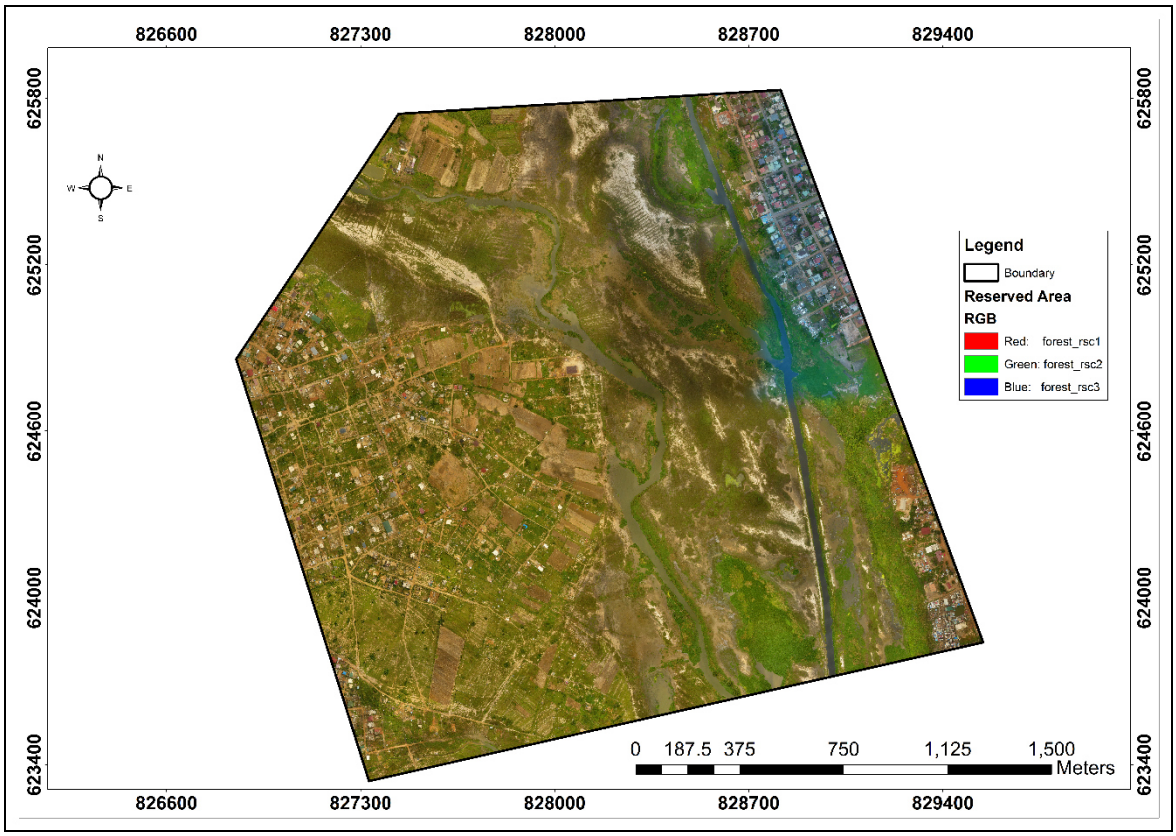

Figure 6: Orthophoto of Study Area

4. Results and Discussions

From the orthophoto, the areas which had been disturbed due to anthropogenic activities were mapped out and labeled as settlements or built-up areas shown in Fig. 7. It is evident from the orthophotos that building construction works are currently going on close to the buffer zone which was appropriately created around the lagoon to protect it from external interference. This in effect was to keep all human based activities 100 m away from the lagoon for its protection and conservation. The total area of the settlement in this study was computed as 1.8 sq.km. Besides, sections of the study area which has been encroached upon, has close proximity to the lagoon and water lodged areas as shown in Figs. 7 and 8 respectively. The study revealed that 38.3% of the total wetland has also been encroached.

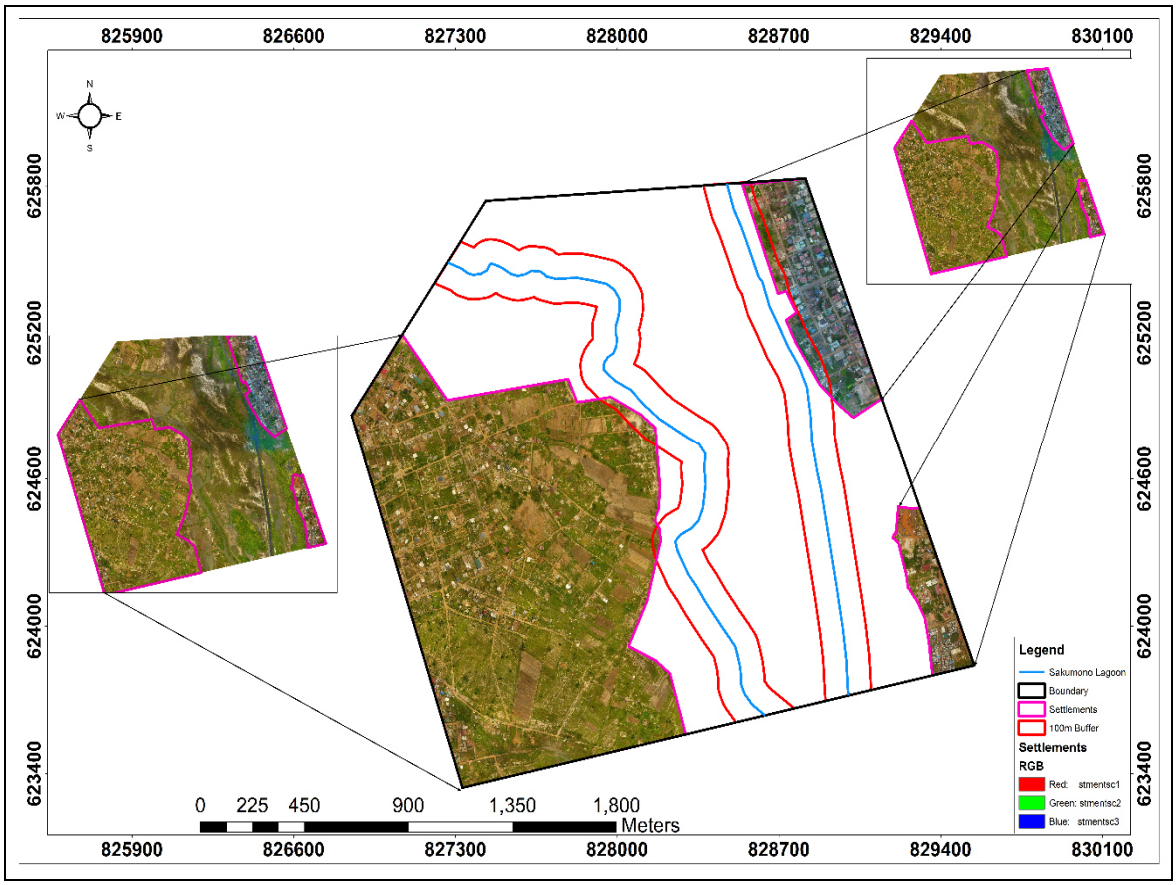

Figure 7: Sections of Settlements/Built-Up Areas

The encroachment is against the Ramsar Conservation practice which advocates protection of Ramsar Sites. This is a contravention of the Ramsar Convention and is a wakeup call, which needs to be addressed by the Wildlife Division of the Forestry Commission of Ghana and the planning authorities responsible for regulation of building construction within that municipality.

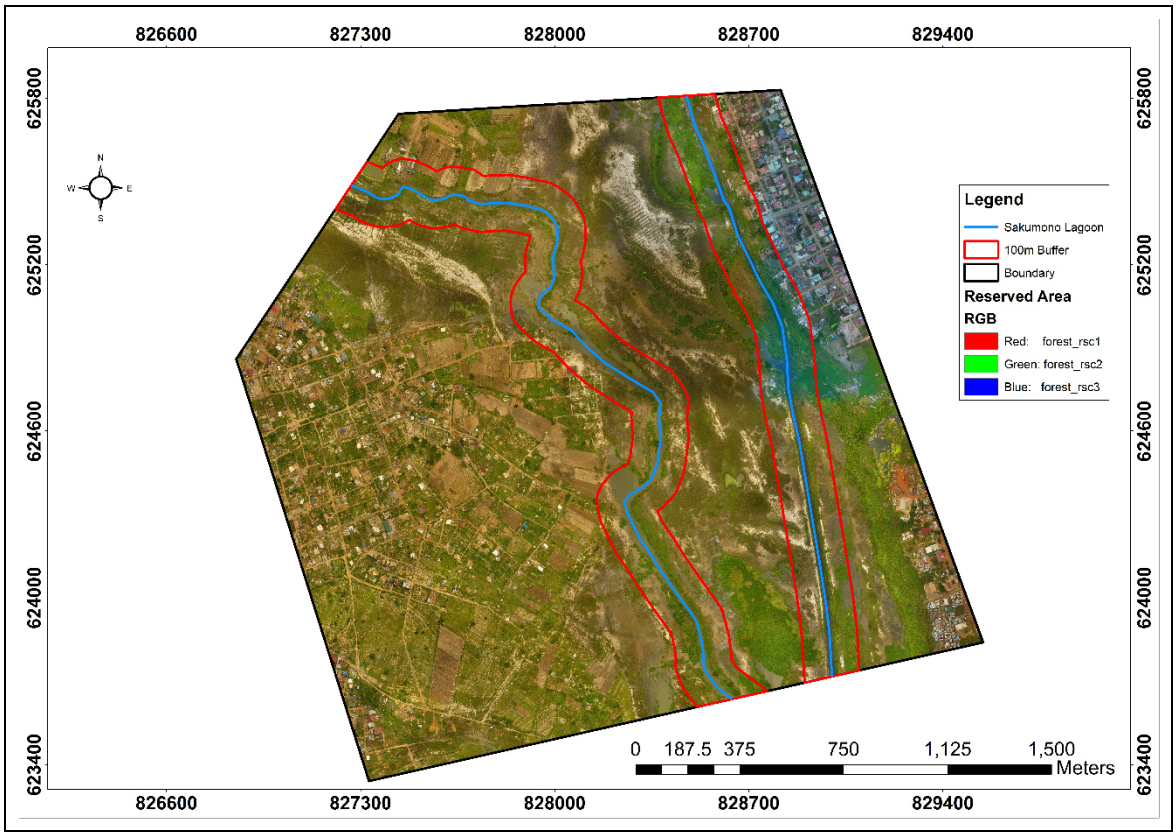

Figure 8: 100 m Buffer around Lagoon

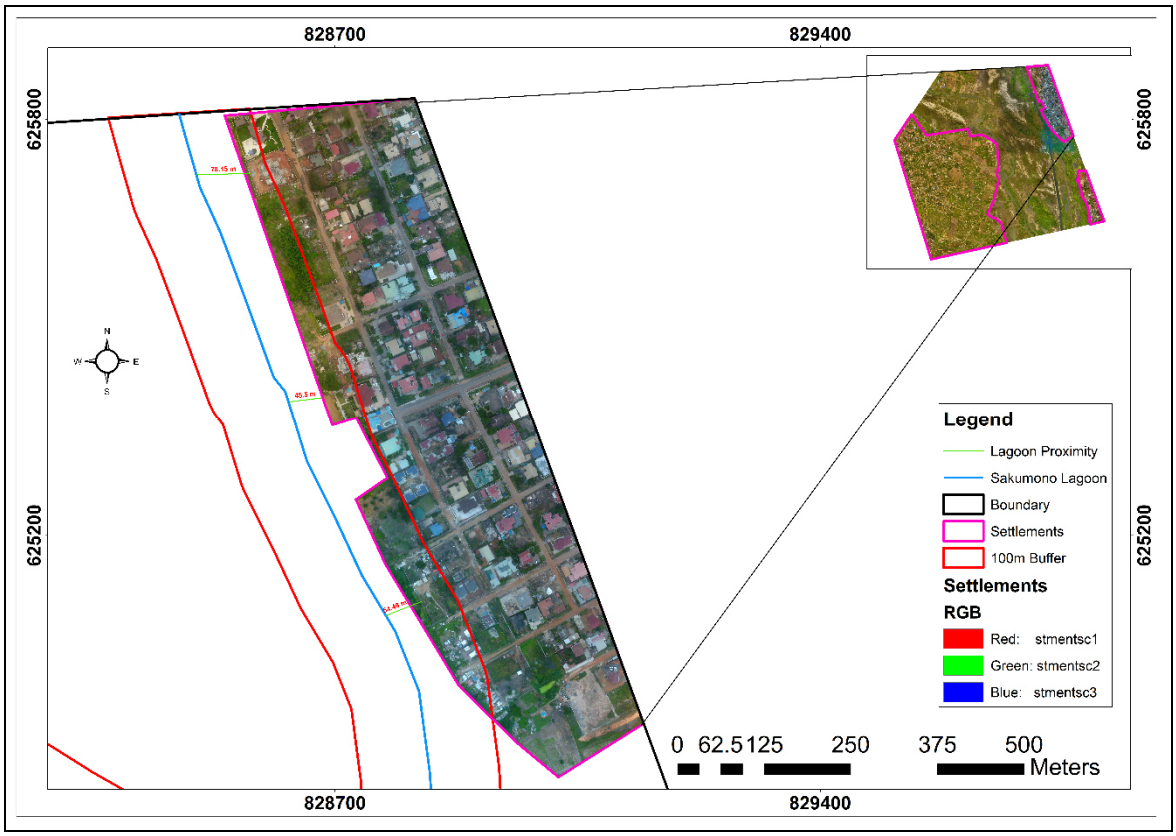

Figure 9: Proximity of a Portion of the Settlement Areas to the Lagoon

Fig. 9 shows the extent of encroachment into the buffer zone of the lagoon. This encroachment is in the form of building construction. This was confirmed by the submissions of one of the executive members of the

Sakumono Wildlife Protection Club,

"…. to fill the belly of the river and they are putting on buildings, you will complain ahh but there is nothing we can do" (A male participant, executive member of The Sakumono Wildlife club, focus group discussion, Accra, Ghana).

The northern portion of the north-eastern side of the lagoon, has only a distance of 78.15 m of undisturbed buffer to the bank of the river as shown in Fig. 9. This means that 24.85 m of the buffer zone has been lost to encroachment. The eastern banks of the lagoon, 54.4 m of buffer is undisturbed, implying 45.6 m of the buffer zone has been lost to anthropogenic activities. Similarly, within the middle belt of the northeast of the lagoon, 45.5 m of the buffer zone remains untouched, suggesting that 54.5 m of the buffer has been encroached upon by developers, also evidence of one of the farmers expressing concern and desire to reclaim the encroached portion of the buffer zone.

"….so, the core area and the buffer and all those things we need it back, we need it back……". (Another male participant, also an executive member of Sakumono Wildlife Club, focus group discussion, Accra, Ghana).

The remaining stretches of untouched buffer zones must be protected to prevent further encroachment. The built-up areas have come very close to the lagoon bank as expressed by another executive member.

"You see, some gorge there, the river used to come and sweep, sweep under that place, when its going, it goes, it will go gradually, gradually and that place becomes, we used to come and play football, running athletics. When we were not having a good park, we used to demarcate these areas and run on it but now look at the whole place and continuously when you go to the other side there, oh my God, they are filling, they are buying armoured stones and filling it" (Executive member of Sakumono Wildlife Club, focus group discussion, Accra, Ghana).

This is a recipe for disaster, namely flooding during the rainy season as was expressed by another participant.

"……I'd say land use and land cover has changed, yes, a lot of land degradation you know, clearing of, you know land for sale, encroachment, a major change we've also realized is the lagoon, heavy siltation" (Farmer, a participant of focus group discussion, Klagon, Accra, Ghana).

The lagoon is overgrown with weeds such as "taifa" grass and other species of plants, as reported by another participant,

"…. and then taifa reeds have also invaded the area, water hyacinth, also other plants another part of it. Ahaa, so all these things you know ehh, are part of some of the changes that you see on the lagoon…." (Farmer, also a participant, focus group discussion, Klagon, Accra, Ghana).

This suggests that the lagoon is silted. This is also an indication, that the sluice gate, which is supposed to drain the wetland into the sea, could also be choked with silt and weeds. The presence of silt and overgrown weeds are indications that the wetland may have lost its flood control potential. This will become evident during the rainy season and eventually result in flooding, and consequently an environmental disaster.

5. Conclusions and Recommendations

The results from this study suggest that UAV survey could improve research within wetland areas. The georeferenced high-resolution UAV images produced precise information about the extent of anthropogenic activities within the wetland. With the UAV images, it is easy to see and appreciate the extent of encroachment within the Ramsar site. Use of UAVs are affordable and time-saving on the field while providing high quality information about wetland areas which would have been otherwise inaccessible. The findings of the study revealed a loss of substantial area of the wetland to encroachment. The settlement areas have compromised the natural flood control potential of the wetland. Portions of the 100 m buffer zone have been encroached upon. The effect is the loss of about 38.3% of the wetland to encroachment. This has also resulted in loss of livelihood for fishermen and farmers within the community creating a rippling effect on sustenance of families. It is recommended that stakeholders should collaborate with the relevant city authorities to restore the degraded wetlands and adopt strategies to secure the buffer zone around the lagoon. The custodians of the Sakumo lagoon, that is the Chiefs and traditional priest or "Wulomo", should be actively engaged in sustainable community education, CEPA to ensure that, the Sakumo lagoon which is believed to be a goddess with a strong religious and cultural presence in the community, continues to enjoy the historical, traditional authority she is accorded within the community while yielding benefits to the inhabitants both far and near.

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