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EFFECT OF LAND USE DYNAMICS ON HABITAT OF TWO SYMPATRIC PRIMATES IN BOABENG-FIEMA MONKEY SANCTUARY, GHANA

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Abstract

Competition between growing human population and burgeoning number of primates were investigated at the Boabeng-Fiema monkey sanctuary (BFMS) in Ghana, to determine the effect of habitat change on primates. Remote sensing data, primarily Landsat imagery, were used to analyse the land use cover changes that have occurred over a period of 21 years (1986-2006). The data were supported by field investigations that included the administration of a questionnaire. The analysis of the satellite imagery revealed that the sanctuary was 31.3 per cent forest, 47.8 per cent savanna and agricultural fields, and 20.9 per cent build-up or degraded surfaces. By 2007, forest cover had reduced to 22.4 per cent, whislt savanna and agricultural fields, and build-up/degraded surfaces had expanded to 54.5 per cent and 23.1 per cent, respectively. Most of the respondents (93 per cent) agreed that their activities had degraded the forest, whilst seven per cent stated otherwise. The results also indicated that both the human and primate populations had increased over the years although no definite figure was obtained for the primate population, which was estimated to be approximately 4,500. The increase in the primate population was enabled by adaptation to human food coupled with traditional beliefs forbidding humans from harming primates. Cultural belief is, therefore, recognised as an integral part of environmental sustainability in the community.

Introduction

The accelerated rate of the destruction of natural habitats for animal and plant species may result in extinction if a species fails to adapt to the rate of change (Isabirye-Basuta & Lwanga, 2008). Habitat loss and land degradation may be defined as vegetation loss due to human activities such as logging, overgrazing, mining, and the expansion of agriculture and human settlements. Consequently, animals that reside in degraded habitats are prone to facing food shortages, the loss of hiding places, natural disasters, and increased predation (Wilcove, 1985; Onderdonk & Chapman, 2000; Malhi *et al*., 2008).

Unfortunately, habitat destruction can be related to economic hardship as people struggle at the expense of animals to survive. Incidentally, primate-rich countries with tropical forests are economically poor. Nine of the 15 most diverse countries are located in Africa including Uganda, Cote d'Ivoire, Cameroon, etc. (Chapman *et al.* 2006). Not only are these nations poor, but also the population pressure on the natural resources is also high as people depend on them directly for survival. For example, people clear forest to create land for agriculture, cut wood for fuel and mine the land for minerals (Isabirye-Basuta & Lwanga,

2008). It has been reported that the loss of natural habitats and the increase in human population result in conflict between people and wildlife (Hoare, 2000; Dublin & Hoare, 2004). Increase in human population and the intensification of land-use result in the degradation of wildlife habitat. This can force primates to feed on crops and destroy farms, leading to conflicts when humans retaliate (Sukumar, 1994). However, at the community level, some species may benefit from slight to intermediate disturbance (Skorupa, 1986) although a higher level of disturbance may lead to the decline of primate populations, and the subsequent extinction of species through food shortages and hunting (Ganzhorn *et al*., 1997).

Many detailed studies have examined the response of primates to human activities that alter habitat such as logging (Johns & Skorupa, 1987; Plumptre, 1996; Struhsaker, 1997; Chapman *et al.*, 2000), their effects on tree species composition (Plumptre, 1996) and primate diets (Skorupa, 1986; Chapman *et al*., 2000). Other studies have focused on the responses of primates to deforestation (Cowlishaw, 1999; Karlowski, 2006), natural disasters, such as disease (Chapman *et al*., 2000), and climate change (Borchert, 1998).

However, studies on increase in human population at the expense of wildlife habitats in general and on primates in particular have been rare. In a recent study of anthropogenic disturbance, Irwin *et al*. (2010) concluded that habitat alteration may have different (generally negative) effects even on closely related animal populations, but the mechanisms remain poorly understood. Although human impact on natural habitats can have devastating effects on inhabitants of such habitats, some species have evolved adaptations to these changes and live harmoniously with humans.

This paper contributes to the understanding of the response of primates to habitat change due to anthropogenic activities, by examining the changes that have occurred with an increase in human population in the habitat of two sympatric primates that have evolved to live with humans. It must be noted that increase in human population is accompanied by the expansion of settlements and other land uses, but the primates have no control over their habitats as their population increases.

Experimental

Study area

The Boabeng-Fiema monkey sanctuary lies between latitude 7° 40′ 0′′ N to 7° 44′ 10′′ N and longitude 1° 37′ 45′′ W to 1° 42′ 0′′ W, in the Nkoranza North District of the Brong Ahafo Region of Ghana (Fig. 1). It is located on a flat land 350 m above sea level, with a gentle slope (25m fall/km). The vegetation is a mixture of forest and savanna woodland and a ground spring (Fargay, 1991). The Sanctuary is within the wet semi-equatorial region of Ghana with double maxima rainfall system. The mean annual rainfall ranges between 800 mm and 120 mm. The major season occurs between March and July with the heaviest rainfall occurring in June, whilst the minor season occurs from August to November each year. The dry season starts in December and ends in March. Generally, the average temperature in the area is high (26 °C) throughout the year. This condition has given rise to a semi-deciduous forest,

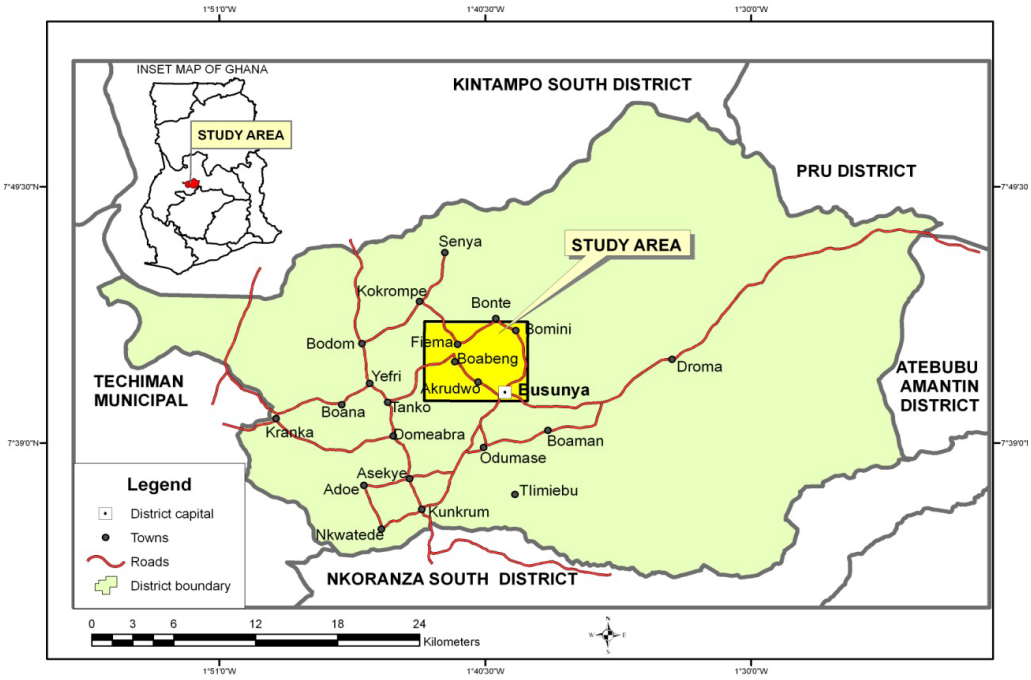


Fig. 1. Location of the study area. Source: Institute of Local Government Studies (2008)

savanna woodland, and fewer areas of savanna regrowth. It is expected that the savanna sub-climax vegetation would succeed to dry semi-deciduous forest in the absence of human disturbance and bushfire (Fargey, 1991). Farming is the main occupation of the inhabitants. The villages around the sanctuary traditionally have a taboo against the killing of black-and-white colobus (*Colobus polykomos*) and Lowe's (*Cercopithecus cambelli loweii*) monkeys, which live in the sanctuary (Fargey 1991). Over the past 150 years, the monkeys have been considered sacred by the locals, due to a story that an area chief was once mysteriously protected by some of the monkeys during a tribal war. The enemies were unable to shoot the chief because he was guarded by the monkeys. A decree was then issued that nobody should hunt, capture or kill the monkeys, and the villagers have since regarded the monkeys as totems or as sacred (Appiah-Opoku, 2007).

The two species of monkey share common resources in the area. The black-and-white colobus mainly eats fresh leaves and causes less destruction to crops, whilst the Lowe's monkey depends on a wider range of food types and can destroy human food (Fig. 2).

Satellite image selection for mapping land use cover

An increasing population exerts pressure on land resources in any environment (Richards, 1986; Mishra, 2002). Consequently, there have been substantial land

Fig. 2. A.: Black and white colobus; B.: Lowe's monkey.

use and cover changes in the BFMS, which have been attributed to an increasing human population. To quantify these changes, two different types of satellite imagery covering a period of 21 years were analysed (Table 1) notably Landsat TM (1986) and Landsat ETM+ (2002 & 2007). The analysis of the imagery provided land use and land cover statistics for an area of 45.4 km^2 for 1986, 2002 and 2007, which were supplemented with census statistics (GSS, 2005) for the same period at the settlement level for Boabeng and Fiema.

Image interpretation, land-use and cover mapping

The Landsat images were downloaded from the internet and first imported into Copenhagen image processing software (WinChips 4.7) for display and enhancement, and the study area was a subset of each scene (Campbell & Wynne, 2011). Using the two study communities as reference points, an area of 45.4 km^2 was defined and subset.

In the study, the term 'land use' is defined as human activities associated with the land (Burley, 1961; Anderson, Hardy & Roach, 1972), hence, it is based on function. It refers to the purpose for which land is used (e.g.

TABLE 1

Characteristics of the satellite imaery

Imagery	*Path*	*Row*	*Date*	*Spatial resolution*	*Coordinate system*
Landsat TM	194	55	11/01/1986	30 m	UTM
Landsat ETM+	″	″	20/03/2002	″	″
Landsat ETM+	″	″	13/01/2007	″	″

Source: NASA Landsat Program, 1986 Landsat TM, 2002, Landsat ETM+ scene L71008058_05820031026, SLC-Off, USGS, Sioux Falls, 10/26/2003; www.landcover.org.

farming), whilst 'land cover' denotes the physical cover as observed from the ground or through remote sensing (Burley, 1961; Clawson & Stewart, 1965).

Based on the set of objectives (land use cover changes), the visual interpretation of the imagery, and the assumption that classifications are developed to suit the needs of the user (Anderson, Hardy & Roach, 1972), three broad land cover classes were identified: (1) Forest vegetation, (2) savanna vegetation and (3) agricultural fields and built-up or degraded surfaces. A supervised classification was performed in Idrisi Kilimanjaro using a maximum likelihood algorithm after delineating the training areas for the respective land use and land cover categories. A 3 × 3 kennel filtering was then applied to smoothen the classified images after which land use and cover maps were produced for the three periods (Fig. 3 & 4), and the associated statistics were generated. Classification accuracy was evaluated using field data (Jensen, 2004).

In addition to the analysis of the satellite imagery, semi-structured questionnaires were used to gather information from the inhabitants of the two communities regarding their perceptions of the primate population as the habitat was being disturbed. A simple random sampling method was used, and the Oxford Brookes University Code of Practice on ethical standards was followed. A total of 100 heads of households were interviewed, which included 60 from Boabeng and 40 from Fiema. In addition, the manager of the sanctuary and opinion leaders from each community, as well as the chief's representatives, were also interviewed. Four research assistants, one from each community, were engaged to administer the questionnaire, and as recommended by Christensen (1992), the respondents were informed that sensitive and personal information would be excluded in the final reporting.

Further image analysis was performed on Boaben and Fiema settlements to assess the extent of spatial expansion during the study period. Through visual interpretation, the settlements were delineated in false colour composite images (bands 5, 4, and 3). The resulting vector polygons were exported into ArcGIS 9.3, and the topology was assessed and area statistics generated.

Results and discussion

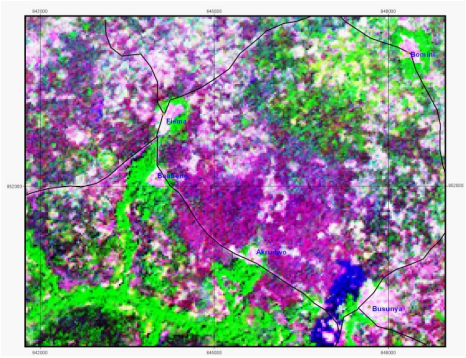
Land use and land cover change

Analysis of the satellite imagery revealed some trends in land use and land cover from 1986-2007 (Fig. 3&4). In 1986, the santuary was 31.3 per cent forest, 47.8 per cent savanna and 20.9 per cent build-up/degraded surfaces. By 2007, forest cover had reduced to 22.4 per cent whilst agricultural fields and build-up/degraded areas had expanded to 54.5 per cent and 23.1 per cent, respectively (Table 2). Most of the respondents (93%) agreed that their activities had degraded the forest, whilst seven per cent stated otherwise. It can be inferred from the analysis that all the land use categories experienced some changes during the study period.

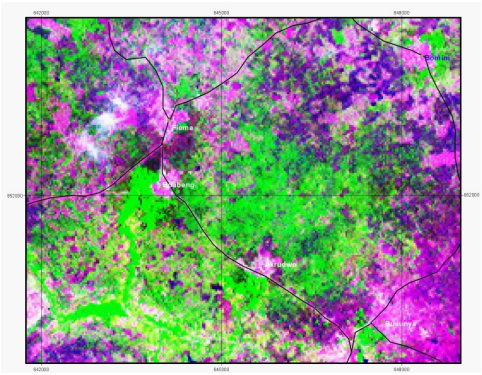
Human settlement

Humankind has continued to remove biomass, especially trees, to create space for habitation and to grow food to survive. Discussing such interactions between humans and the environment, Evans (1983, described deforestation as concomitant of

Landsat TM (1986)



Landsat ETM (2002)



Landsat ETM (2007)

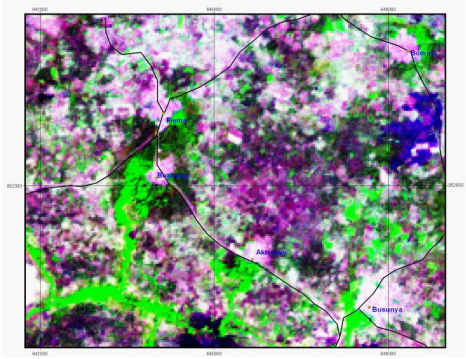
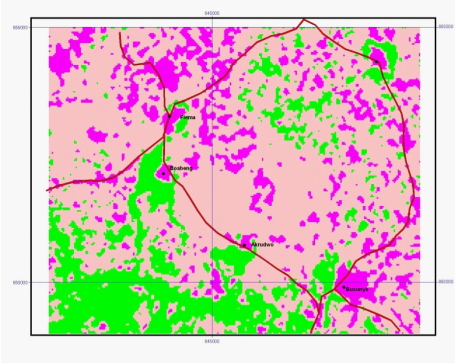
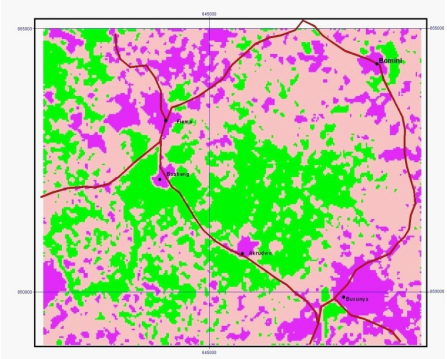


Fig. 3. False colour composite: Bands 5, 4 and 3.

Landuse and landcover 1986



Landuse and landcover 2002



Landuse and landcover 2007

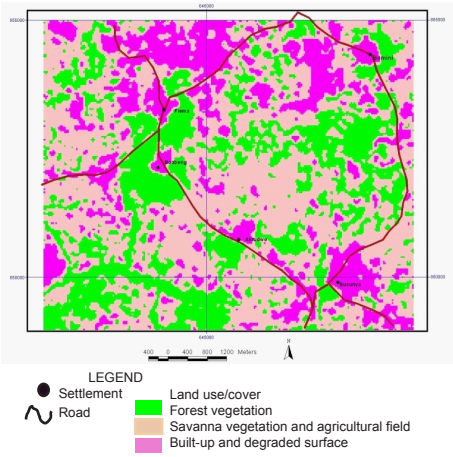


Fig. 4. Classified land use and cover map.

TABLE 2

Land-use/cover changes

Land-use/cover	*1986 (sq km)*	*2002 (sq km)*	*2007 (sq km)*
Forest vegetation	10.2 (22.5%)	14.2 (31.3%)	13.6 (30.1%)
Savanna & agricultural fields	26.8 (59.0%)	22.2 (48.9%)	21.7(47.7%)
Built-up/degraded areas	8.4 (18.5%)	9.0 (19.8%)	10.1(22.2%)
Total	45.4 (100%)	45.4 (100%)	45.4 (100%)

Source: Landsat satellite imagery (1986, 2000, 2007)

civilization. As early as 500 BC, the Greeks and Romans complained about the disappearance of forests, which were an essential source of timber for building and fuel.

An increasing human population is associated with the development of infrastructure, and in a rural context, the emergence of huts and hamlets is unavoidable ((Alig, & Healy, 1987; Verburg, Veldkamp & Bouma, 1999). Boabeng and Fiema show an increasing population from 1970 to 2000 (Fig. 4). Whilst the population of Boabeng increased steadily over the years, that of Fiema rose sharply from 797 in 1970 to 1,450 in 1984 and then steadily to 1,589 in 2000.

The creation and expansion of settlements due to an increasing population was identified as one of the factors that have modified the vegetative cover of the area. Spatio-temporal analysis of the two settlements (Fiema and Boabeng) using Landsat imagery from 1986, 2000 and 2007 shows an expansion of the land area under settlement (Fig. 5). Whilst there was rapid expansion in Boabeng from 1986 to 2002 (a period of 12 years), the settlement area in Fiema gradually declined over the same period. However, Fiema rapidly expanded from 2002 to 2007, whilst the reverse was observed in Boabeng

Primate-human relationship

The primate-human relationship is crucial in the two communities as both populations expand. Human population growth in the BFMS is leading to an increased demand for food and shelter, so more land is being claimed for agriculture and huts, which is destroying the natural vegetative cover that serves as habitat for the primates. Most respondents (93%) were of the view that human activities, mainly agriculture, had degraded the forest, whilst seven per cent believed in the contrary. Various authors (Decker, 1994; Menon & Poirier, 1996; Gonzalez-Kirchner, 1999; Tutin, 1999; Onderdonk & Chapman, 2000; Sing *et al*., 2001; Clarke *et al*., 2002; Struhasaker *et al*., 2004; Wong & Sicotte, 2006) have noted that forest fragmentation and habitat disturbance affect primate populations because primates are vulnerable to forest fragmentation. However, this was not the case in the BFMS, so the study examined the villagers' perceptions about the primate population over the years. Of the 100 respondents, 91 per cent indicated that the primate population had been increasing compared to nine per cent who thought otherwise (Table 3). However, respondents aged 50 years and above (33%) indicated

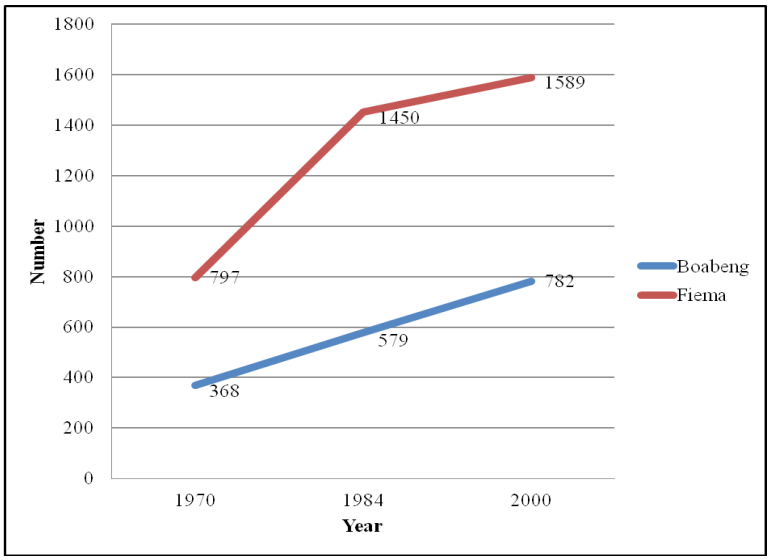


Fig. 4. Population trends for Boabeng and Fiema (1970 – 2000)
Source: Ghana Statistical Service (2005)

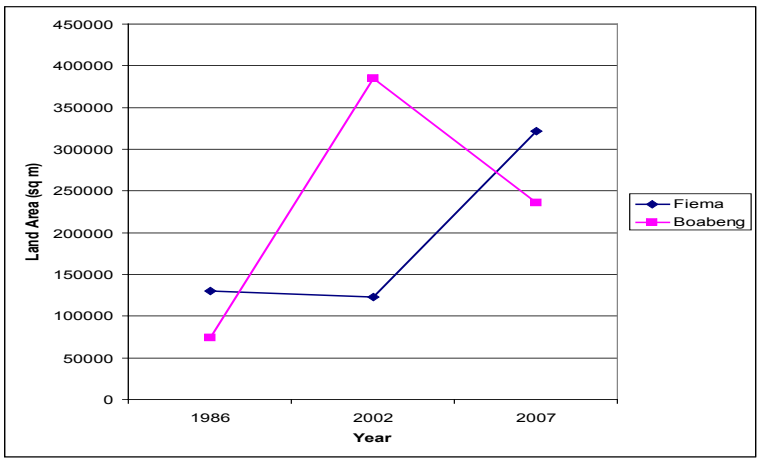


Fig. 5. Spatial analysis of the settlement area.
Source: Analysed Landsat imagery (1986, 2002 and 2009)

that primate numbers had increased the most, whilst only five per cent of those aged less than 20 years were of the view that the population was increasing. The perceptions of the respondents as to whether the primate population had increased did not differ with the age distribution ($\chi^2 = 20.0$, $P = 0.22$). Similarly, these was no difference between the perceptions of people in different age groups as to whether the population has decreased ($\chi^2 = 10.0$, $P = 0.27$). This rejects the hypothesis that older respondents perceive a greater population increase while younger respondents perceive a greater decrease.

Primates in the area wake up between 5:30 A.M and 6:00 A.M. depending on the time of first light and retire to sleep between 17:30 P.M. and 18:00 P.M. depending on the time of dusk. Therefore, a sizeable number of primates can be observed between 6:00 A.M. and 10:00 A.M. when the villagers are setting off to their farms. The primates emerge in groups and troupe during this period and invade the hamlets for food, after which they engage in what can be described as 'socio-rest' (i.e. grooming, playing, jumping, teaching the young, etc.) between 10:00 A.M. and 15:00 P.M. (Wiafe & Arku, 2012). Variations were observed in the average number of primates

TABLE 3

Household perception of primate population by age group in the two communities

Age group	*Population increase (%)*	*Population decrease (%)*
> 20	5	3
20 - 29	15	1
30 - 39	13	2
40 - 49	25	1
50 +	33	2
Total	91	9

TABLE 4

Average number of primates seen per day by gender

No. of primates	*Male (%)*	*Female (%)*
> 5	10	2
6 - 10	3	38
11 - 20	3	25
> 20	2	17
Total	18	82

seen during the day by gender. As shown in Table 4, 38 per cent of women observed between six and 10 primates, 25 per cent observed between 11 and 20, and 17 per cent observed more than 20 primates. In contrast, 10 per cent of men observed fewer than five primates on average (Table 4). Interestingly, the analysis showed that more women (82%) observed primates than men (18%), which is likely due to their role as housekeepers. They have the opportunity to see the primates within their compound, as they undertake their daily chores.

The analysis also showed that the primate population has increased over the years through adaptation to both the human-modified environment and the inhabitants of the communities. The exact number of primates is unknown (Appiah-Opoku, 2007), but in-depth interviews indicated a number between 3,000 and 4,000, whilst the game wardens indicated 3,700 to 5,000 and the respondents estimated 4,000 to 6,000. Despite these inconsistencies, the primate population is currently much larger compared to the estimates of Wong & Sicotte (2006), which were between 217 and 241 in 2003, and Appiah-Opoku (2007) which were between 600 and 1,000. After 14 years, it can be concluded that the number had increased to approximately 4,500 primates at the time of the study.

As noted by Tuffour (1991) and Gordon (1992, the BFMS is regarded as one of the few sacred groves scattered throughout the country, where belief systems and taboos have led to their preservation and role as sanctuaries for primates. It also confirms earlier findings by Sayer *et. al*, (1992) that local customs, practices and taboos have conserved wildlife in Ghana. The primates have adapted to human food to survive and reproduce even though their natural environment is being destroyed (Wiafe & Arku, 2012).

Conclusion

Satellite imagery technology has made it possible to analyse changes to the landscape over a period of 21 years, which showed that the vegetative cover in the study area had declined. Remote sensing is, therefore, a useful tool for land use and land cover monitoring. Whilst there are many complex causes of these changes, human population growth over the years was found to be the major factor. The population growth in the area has

led to increasing demands for food and the need for more land for food production and shelter, which has destroyed primate habitat.

The primate population has also increased over the years, which has been made possible through adaptation to the changing environment as the primates compete with humans for food. The cultural beliefs of the people in the two settlements forbid them from harming the primates, so the villagers and primates coexist. Because it is a taboo to kill these primates, their population continue to increase. Environmentalists, wildlife officials and forestry managers should collaborate to ensure the rejuvenation of the forest and provide alternative livelihoods to the communities. Such initiatives would complement the cultural beliefs of the people and ensure continued coexistence with the primates.

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