Chapter

Gain and Loss of Forest Cover in Ghana's Forest Reserves in Three Selected National Parks

Kenneth Peprah, Raymond Aabeyir and Bismark Yeboah Boasu

Abstract

Forests play an important role in the ecological, environmental, socio-economic and cultural lives of people. However, human-nature-forest interactions bring imbalances in the state of these resources, hence the need to monitor and manage the forest proactively. This chapter, therefore, assessed the gains and losses of three national parks in Ghana (including Mole, Digya and Kakum) for the period 1986 and 2020. Landsat TM and Landsat8 OLI images were used for the assessment. The Digya National Park has a spatial extent of 4121.89 km^2. In 1986, the extent of the close forest cover was 88.0% of the park and it declined to 82.8% in 2020, a loss of 6.2%. The Kakum National Park covers an area of 463.42 km^2. The close forest cover was 90.15% and 89.52% of the extent of the park in 1986 and 2020, respectively. The Mole National Park covers about 4602.19 km^2. In 1986, 86.73% of the park was open forest, which was reduced to 80.83%, a loss of 5.90%. The study revealed 67% of open forest degradation, 33% loss of close forest and a reported ritual bushfire, wood harvesting and lumbering as the unsustainable practices. Reclamation of degraded areas is recommended to the Forestry Commission.

Keywords: forest cover, protected areas, forest reserves, gain, loss, degradation

1. Introduction

The forest-human and forest-nature relationships result dynamics in the state of many forests across the globe. Forest dynamics thus play a critical role in the services forests provide in support of nature and humankind. The events of climate change and its impacts have increased the need and awareness to monitor the state of forests across the global community.

In spite of the fact that it forms part of the worldwide most valuable resources, the world forests are in a state of fluidity with quickening losses in some regions and gains in others around the world [1]. Forest is a more complex concept ranging from viewpoints of administrative unit, type of land use, and/or type of land cover [2]. The land cover view is however considered for this study. Forest therefore means an ecosystem branded by extensive tree cover, frequently consisting of stands varying in features such as species composition, structure, age class, associated plantations, and wildlife [3]. In each case, forest plays a pivotal role in the development of economies of many countries worldwide [4], especially those within the African continent and particularly the sub-Saharan region where Ghana is located. Forest has been a gainful commodity to the improvement of both humankind and nations and many people have substantial value towards its restoration, conservation and management [5–7]. It provides livelihoods for people, especially the poor [8], serves as attraction for tourists, contributes to the gross domestic product (GDP) and serves as a source of revenue for socio-cultural infrastructure of many nations [9, 10] and Ghana is no exception. Thus, many Ghanaians and the rural folks in particular basically depend on forest productivities for survival and livelihood ventures.

Forest productivity is dependent on the state and nature of the forest [11]. In their study on the importance of forest structure to biodiversity-productivity relationships, for instance, [12] find various relationships (i.e. increasing, constant and decreasing) between species richness and forest productivity for different forest structure classes. This suggests that the structure of any forest including the reserves might determine its diversity. An assessment of the state in terms of gain or loss in extent and quality of forests has therefore become imperative for forest restoration, conservation and management purposes. However, the trend of forest gain and loss indicates a serious global consequence due to the continuous deterioration of forest areas [13, 14]. Hansen et al. [1] even conclude that the forest regions have experienced theatrical loss in the last three decades, when they find higher gross forest cover losses compared to the gains in their study on global forest cover based on the analysis of Landsat images across the boreal forests in some selected countries.

Although forests have generally been depleting and many of the reserves are being threatened by both natural [15–17] and anthropogenic factors worldwide [18–21], the menace has been pronounced in Ghana thwarting national commitments to the United Nations Framework Convention on Climate Change (UNFCC) and Intergovernmental Panel on Climate Change (IPCC), national development, making the livelihoods of many forest-dependent populace extremely vulnerable [22] and eventually exposing them to climate change risks in the last three decades [23]. Ghana is a net emitter of CO_2 emissions and contributes to the global imbalance of greenhouse gases and their effects on climate change [24, 25].

The situation of forest degradation even becomes more critical at the beginning of the twentieth century when the pressures posed by anthropologic activities (mainly lumbering, cocoa farming and mining) on the natural forest pushed for the demarcation of portions of the natural forests as forest reserves (protected areas). This was done to protect ecologically sensitive areas, habitat for endangered species and enhance the tourism potential of the country. Extant studies have extensively covered the conservation and management of these forest reserves [5, 26, 27]. However, assessment of the trend of gain and loss of forest reserves and potential implications of the dynamics for forest policy advancement is less studied in Ghana [28], and hence remains a niche in the literature. That is, although some countries in the world have progressed from loss to gain in forest cover [29], Ghana's situation is yet to be ascertained. Therefore, the study was aimed to assess the state of the Ghanaian forest reserves over the last three decades. To accomplish this, we focused on three major forest reserves—Mole, Digya and Kakum National Parks, and employed remote sensing and geographic information systems methods [30–32] to ascertain the trend of the gain and loss (i.e. degree of degradation) of these forest reserves and how the trend potentially influence forest policy development in Ghana and even beyond. By this, we contribute first to other scholars' proposal of integrating the political, socio-economic and methodological aspects to upscale restoration efforts in tropical forest regions around the globe [33]; forest transformation agenda [34]; and the achievements of national and international conservation goals and treaties [35]. The rest of this chapter covers methodology, findings and discussion, and conclusion.

2. The study context and methodology

2.1 Study context

Ghana is located in West Africa and lies between Latitudes 4°44′ N and 11°15′ N and longitudes 3°14′ W and 1°12′ E with an estimated area of 23.85 million ha. It is bordered to the North by Burkina Faso, to the West by Cote d'Ivoire, to the East by Togo and to the South by the Gulf of Guinea [25, 36]. The country is endowed with diverse ecosystems with a diversity of plant and animal species. There are 21 protected areas which constitute 5.6% of the country's total surface area that is being managed by the Wildlife Division of the Forestry Commission [37]. The nation's forest resources are under the pressures of mining, agricultural encroachment, legal and illegal logging, woodfuel harvesting, wildfires, and infrastructure development [38]. The deforestation and forest degradation rate as of 2017 was estimated at 3.51% annually. Protected areas are located in all the ecological zones of the country but three of these national parks were selected for the study because of their unique ecological, environmental and socio-economic characteristics. These parks are the Digya, Kakum and Mole National Parks (**Figure 1**).

2.2 Methods

Remote sensing and geographic information techniques were used to assess the gain and loss in the forest cover between 1986 and 2020. These timelines were chosen based on availability and quality of images. Besides, the parks are protected areas and long-term changes are critical for sustainable management decisions. The forest reserves in the country have come under pressure to support the needs of both individuals and the nation as a whole. The same forest reserves are expected to provide ecological and climate change issues. The dynamics of the forests in terms of gain and loss are critical in informing how the current forest reserves are managed for the benefit of the people and nature. Three national parks were selected with one in the northern Savannah area (Mole National Park), one in the forest area (Digya National Park) and one in the coastal area (Kakum National Park) for the assessment of the forest dynamics in Ghana. Landsat images were obtained from the United States Geological Survey (USGS) website and used for the classification. Details of the images are described in **Table 1**. The images were classified in Erdas Imagine, and maps were processed in ArcMap. The quality of the classified images was assessed by comparing random points on the classified images with the same points on high-resolution images from Google Earth [30, 39].

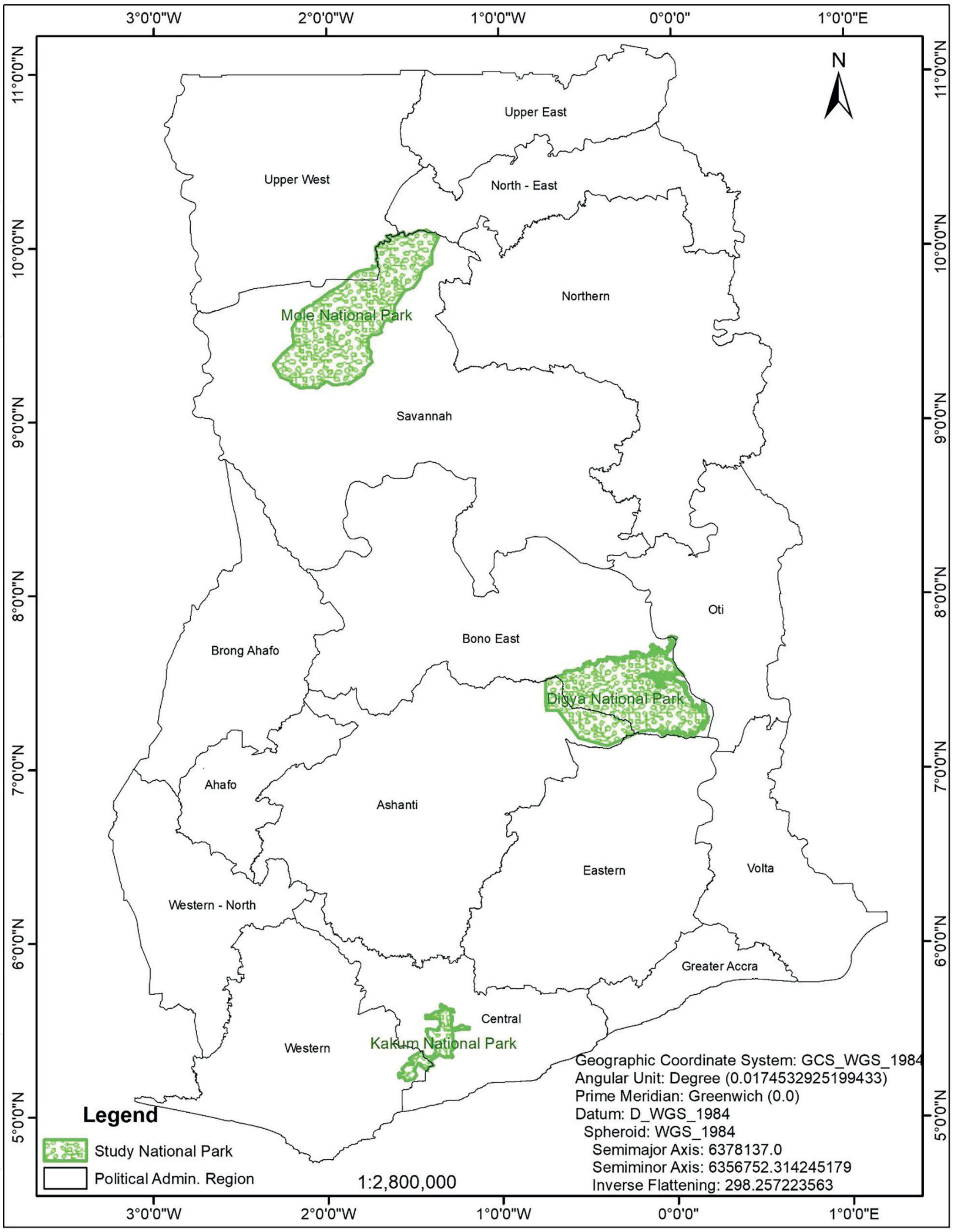

Figure 1.
The selected national parks in the national context. Source: Open-source Map, 2022.

3. Findings

3.1 State of the land cover of the forest reserves

3.1.1 Digya National Park

The Digya National Park (DNP) is the oldest and second-largest national park in Ghana. The park was established in 1909 with a spatial coverage of 650 km^2 [40].

Park	Image	Path	Row	Date	Cloud cover (%)
Digya	Landsat5_TM	193	055	11/01/1986	1.00
		194		05/02/1986	33.00
	Landsat8_OLI	193	055	03/02/2020	0.10
		194		25/01/2020	1.00
Kakum	Landsat5_TM	194	056	29/12/1986	0.00
	Landsat8_OLI			09/01/2020	27.99
Mole	Landsat8_OLI	195	053	18/01/1986	0.00
				01/02/2020	0.13
	Landsat8_OLI	195	054	03/02/1986	1.00
				01/02/2020	0.26

Source: Field survey, 2022.

Table 1.
Characteristics of satellite images used for the study.

When the Volta Lake was created in 1965, it was expanded to 3478.3 km^2 to provide protection for parts of the Lake. The Park was gazetted in 1971 as it has become an important habitat for wild animals and provides ecological benefits to Volta Lake. The park contains endangered animal species namely elephants, manatees, and black-and-white colobus. The sustainability of the park is thwarted by poaching of the animals for bush meat and ivory, large-scale grazing by cattle, bush fires initiated for hunting purposes, and logging for wood [41].

The analysis of the satellite images revealed that the park has a spatial extent of 4121.89 km^2. The variation, from what is reported in literature, is attributable to fuzziness in boundary between the park and surrounding vegetation. In 1986 and 2020, the park was dominated by close forest although the close forest has declined in extent while the open forest has increased in extent (**Figures 2** and **3**). The decrease in the extent of the close forest could be as a result of bushfires, and wood logging as observed by Dowsett-Lemaire and Dowsett [41].

Assessment of the extent of the forest cover revealed that 88.0% of the forest was close forest as of 1986 (**Figure 4**). The extent of the close forest declined to 82.8% as of 2020. The decline of 6.2% (**Figure 5**) in the close forest could be attributed to the impacts of wildfires and logging which characterized the park.

3.1.2 Kakum National Park

Kakum National Park (KNP), located in the coastal environs of the Central Region of Ghana, covers an area of 360 km^2 [42]. The Kakum National Park was established in 1931 as a reserve and was gazetted as a national park in 1992 [43]. The park is located about 30 km from Cape Coast, the Central Regional capital. The vegetation of the park is thick evergreen and semi-deciduous forests. Trees found in the forest include Wawa, Odum, Mahogany, bamboo, raffia palms, etc. The fauna includes the forest elephant, bongo, leopard, giant forest hog, duiker and about 200 species of birds [44]. The Park protects the headwaters of River Kakum. It is also a habitat for endangered wildlife species namely African forest elephants, Diana monkeys, yellow-back duikers, giant bongo antelopes, birds and butterflies [45].

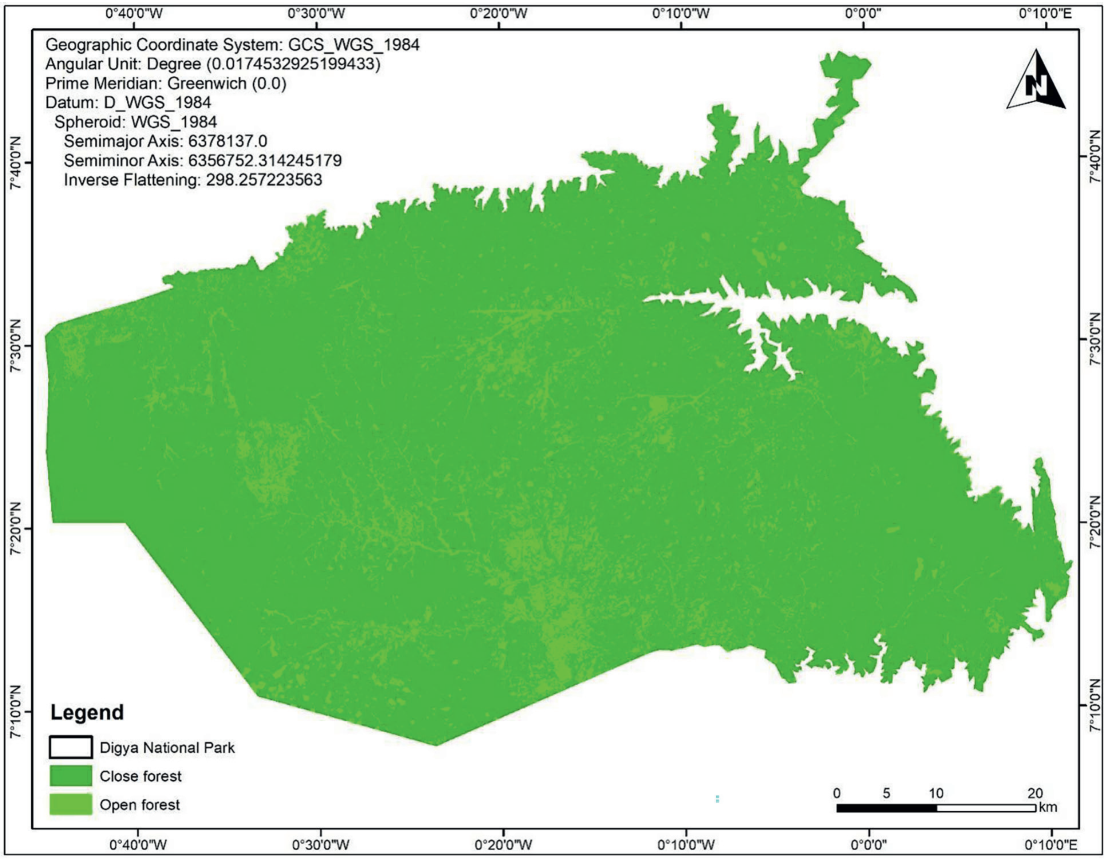

Figure 2.
The land cover state of the Digya National Park as of 1986. Source: USGS, 1986.

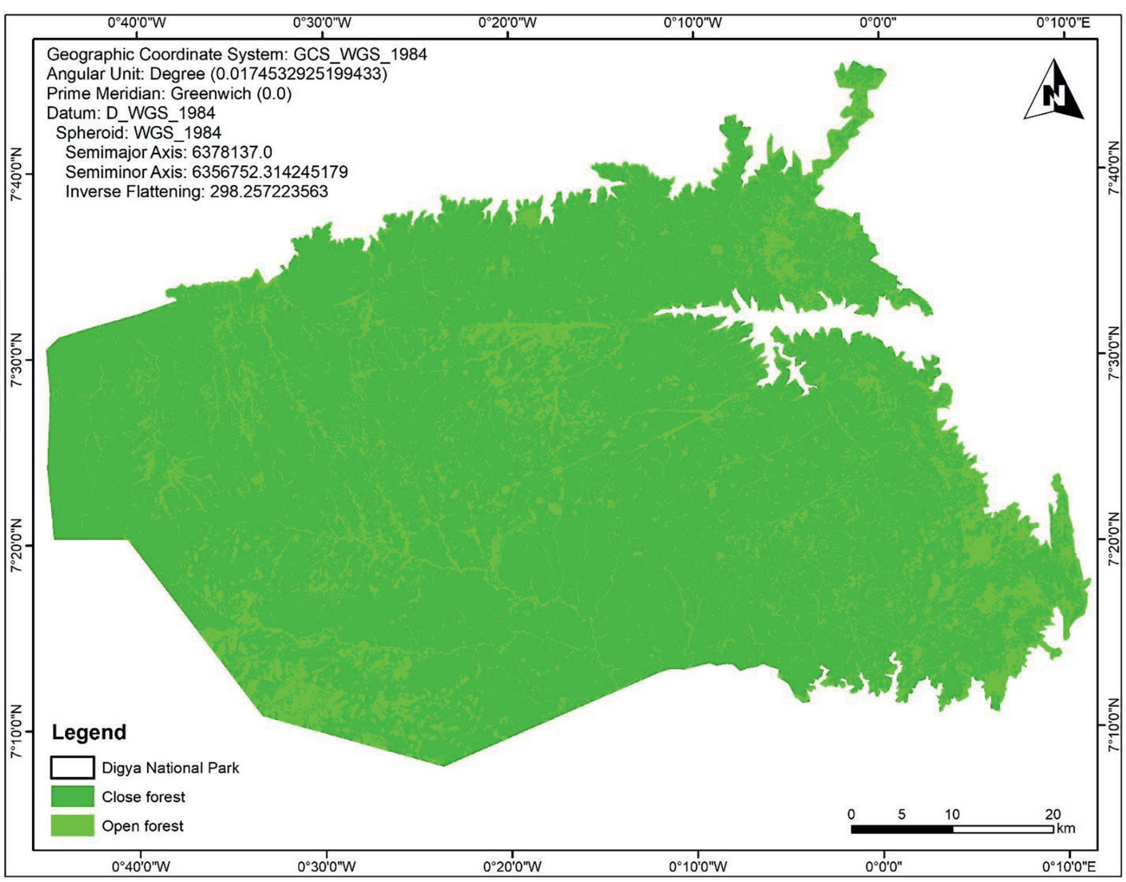

Figure 3.
The land cover state of the Digya National Park as of 2020. Source: USGS, 2022.

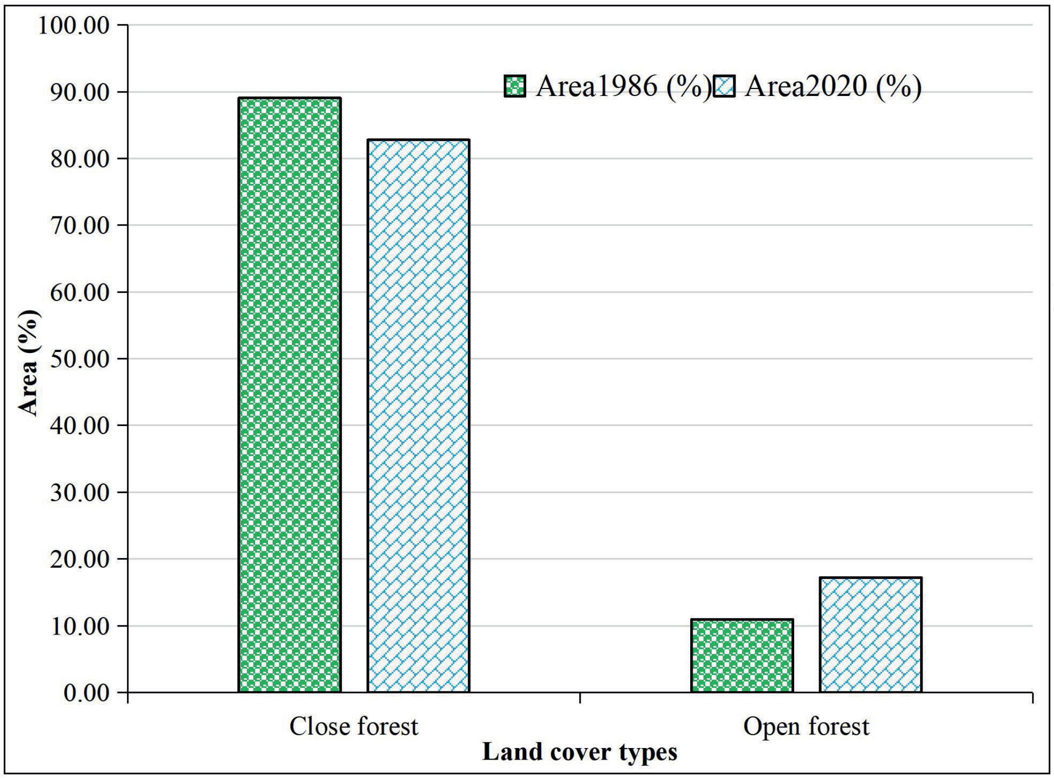

Figure 4.
Comparison of extent of the land cover types of the Digya National Park in 1986 and 2020. Source: Authors' construct, 2022.

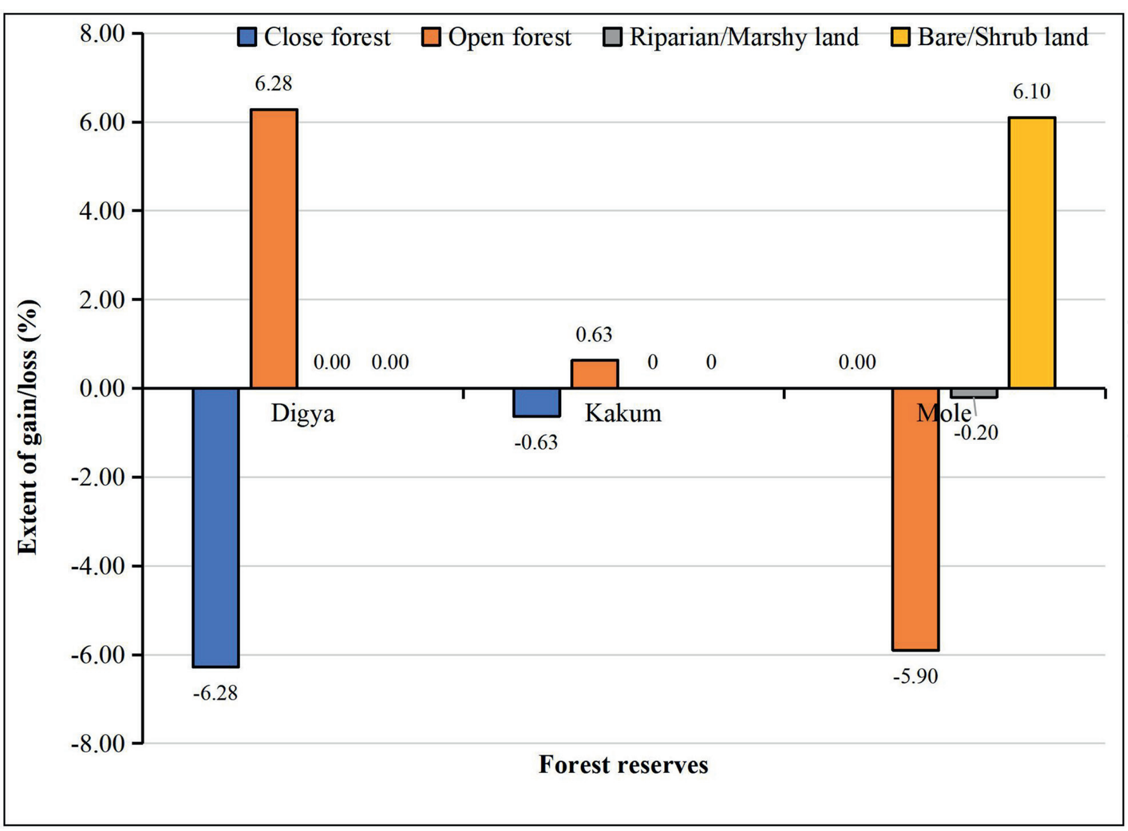

Figure 5.
The gain and loss in the land cover types in Digya, Kakum and Mole National Parks for the period 1986 to 2020. Source: Authors' construct, 2022.

The spatial assessment of the Kakum National Park showed that the park is about 463.424 km^2, which is not so different from the 360km^2 that is reported by Monney and Dakwa [42]. Two main land cover types were identifiable on the raw images of both 1986 and 2020: close and open forests. The close forest cover 327.637 km^2 while the open forest covered 35.787 km^2 (**Figure 6**). The spatial distribution of the land cover of the Kakum National Park in 1986 revealed that the park is a large close forest with patches of secondary forest dominated in the

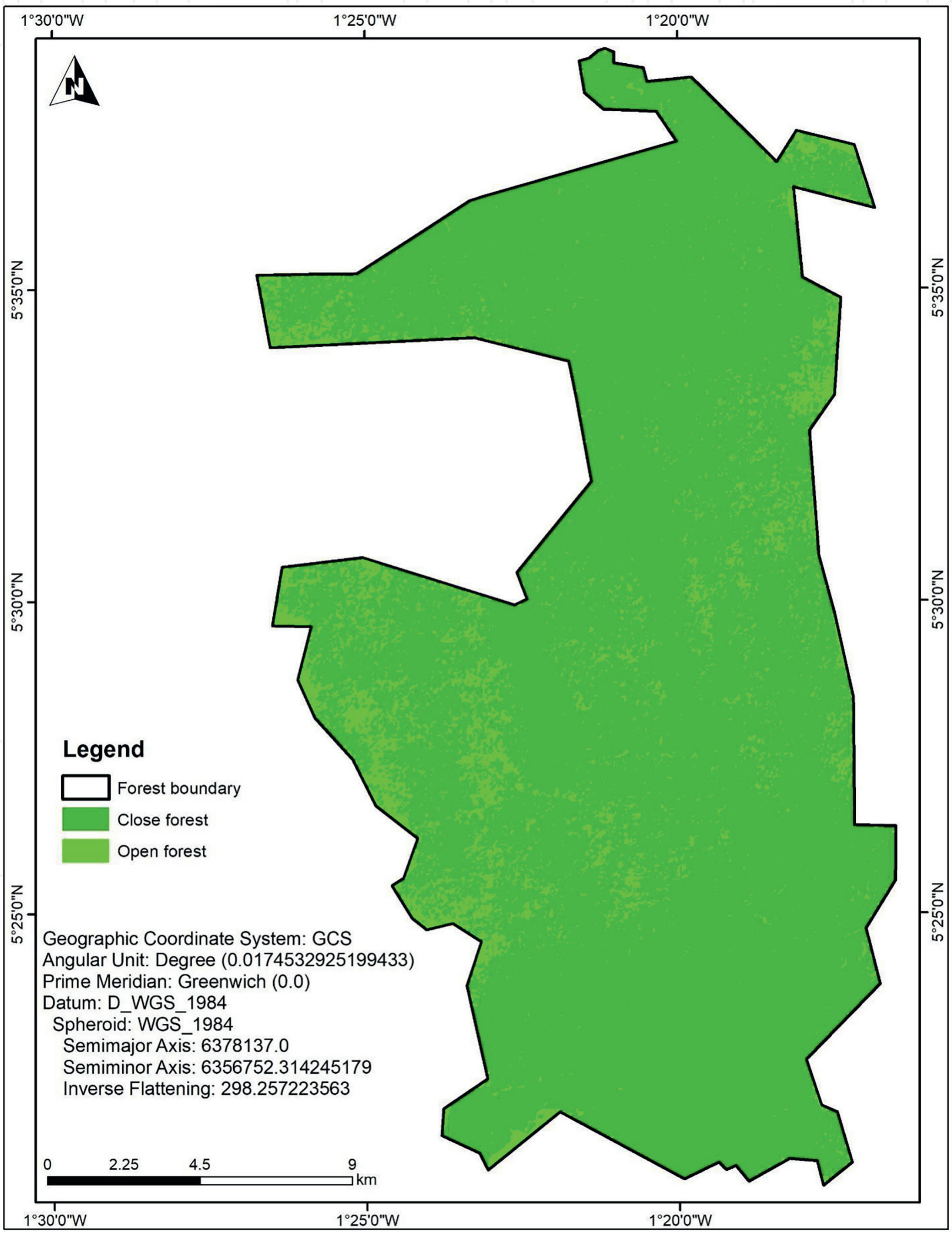

Figure 6.
State of the land cover of the Kakum National Park in 1986. Source: USGS, 1986.

eastern, middle and western parts of the park. As of 2020, the spatial distribution of the land cover of the park was not too different from that was in 1986 (**Figure 7**). However, the dominance of the open forest was in the north-eastern and -western parts of the park.

The relatively stable nature of the Kakum National Park in terms of the two land cover types is attributable to two main anthropogenic pressures that influence the state of vegetation cover in Ghana. These are land conversion and bushfires. This is

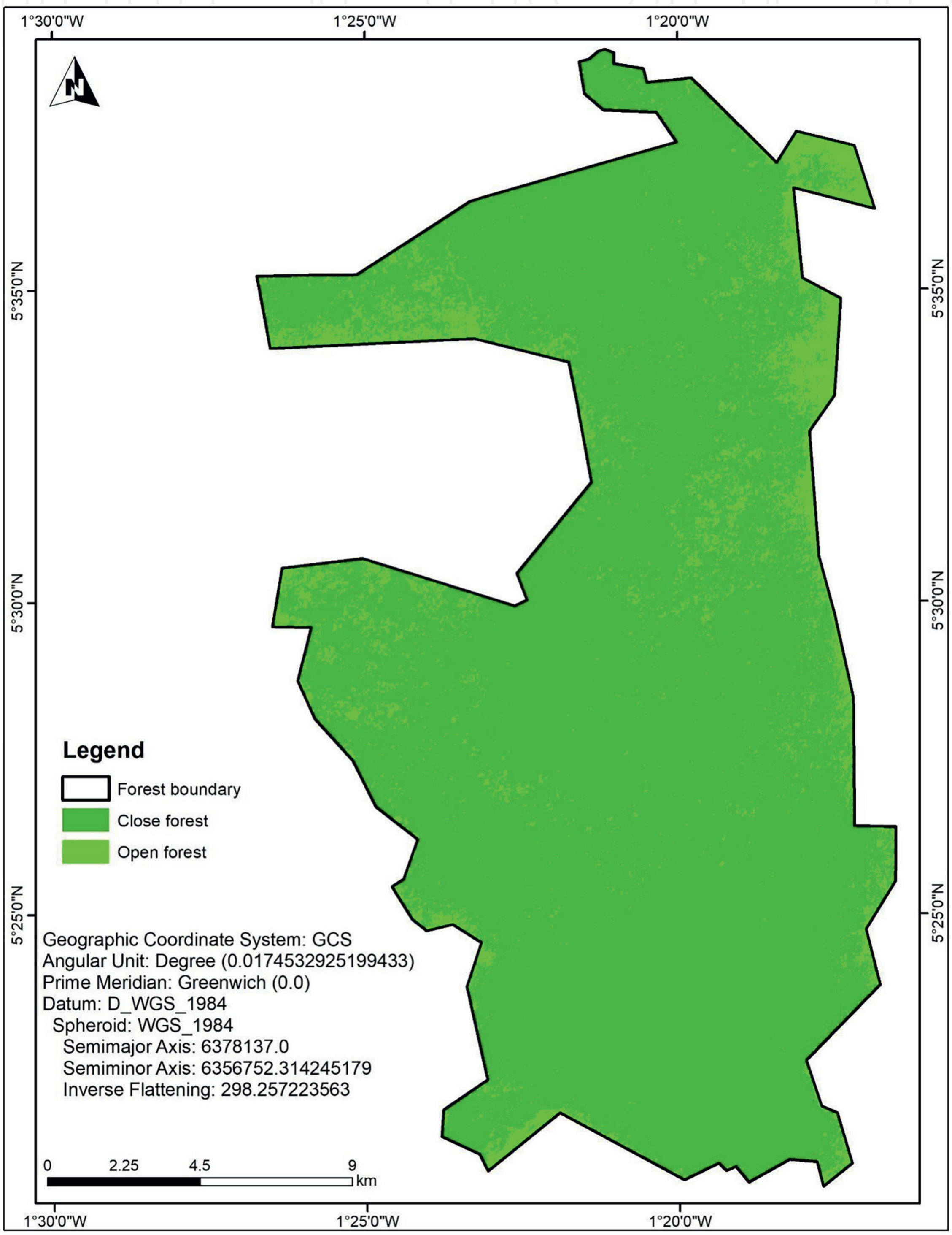

Figure 7.
State of the land cover of the Kakum National Park in 2020. Source: USGS, 2020.

reported by the International Union for Conservation of Nature [37]. In their report, these pressures were absent in the park. However, the main pressure in the park is poaching of game.

In **Figure 8**, the close forest cover was 90.153% and 89.523% for 1986 and 2020 respectively. In **Figure 9**, the gain and loss were 0.63% equally.

3.1.3 Mole National Park

The Mole National Park (MNP) is the largest national park in Ghana. Mole National Park covers about 4577 km^2 and lies between latitudes 9°11′ and 10°10′N and longitudes 1°22′ and 2°13′W [46]. The Park is situated in the West Gonja Municipality of the Savannah Region of Ghana. It is about 20 km north of Damongo, the capital of the Municipality and the Region. It was gazetted as a national park in 1971 for its outstanding wildlife. The park contains a wide range of wildlife species which include elephants, hartebeests, kobs, waterbucks, bushbucks, warthogs, roan antelopes, duikers, oribis, baboons, patas monkeys, vervet monkeys, red-throated bee-eaters, Abyssinia ground hornbills, saddle-billed storks, agama lizards, crocodiles and bush snakes [47]. The Park is also rich in Baobab (Adansonia Digitata), Dawadawa (Parkia biglobosa), Silk Cotton (*Ceiba pentrandra*), *Burkea Africana, Lannea acida,* Shea tree (*Vitellaria paradoxa*), *Burkea africana* and *Tcrminalia aviccnnioides*. This indicates the ecological and biodiversity importance of the park.

The spatial distribution of the land cover types in 1986 is shown in **Figure 10** and that of 2020 is in **Figure 11**. The total estimated area of the park from the image is 4602.185 km^2. The difference in area is attributed to differences in the definition of the boundary of the park. The park is dominated by open forest. The other classes are patches of riparian forest, marshy areas, bare grounds and shrubland.

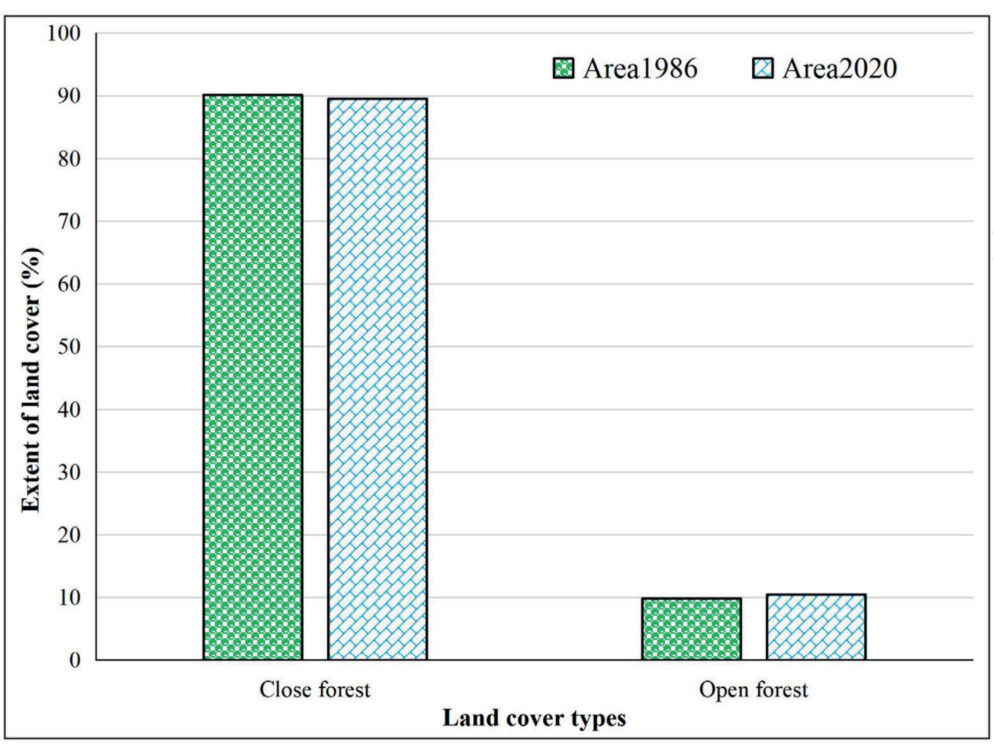

Figure 8.
Comparison of the extent of the land cover types of the Kakum National Park for 1986 and 2020. Source: Authors' construct, 2022.

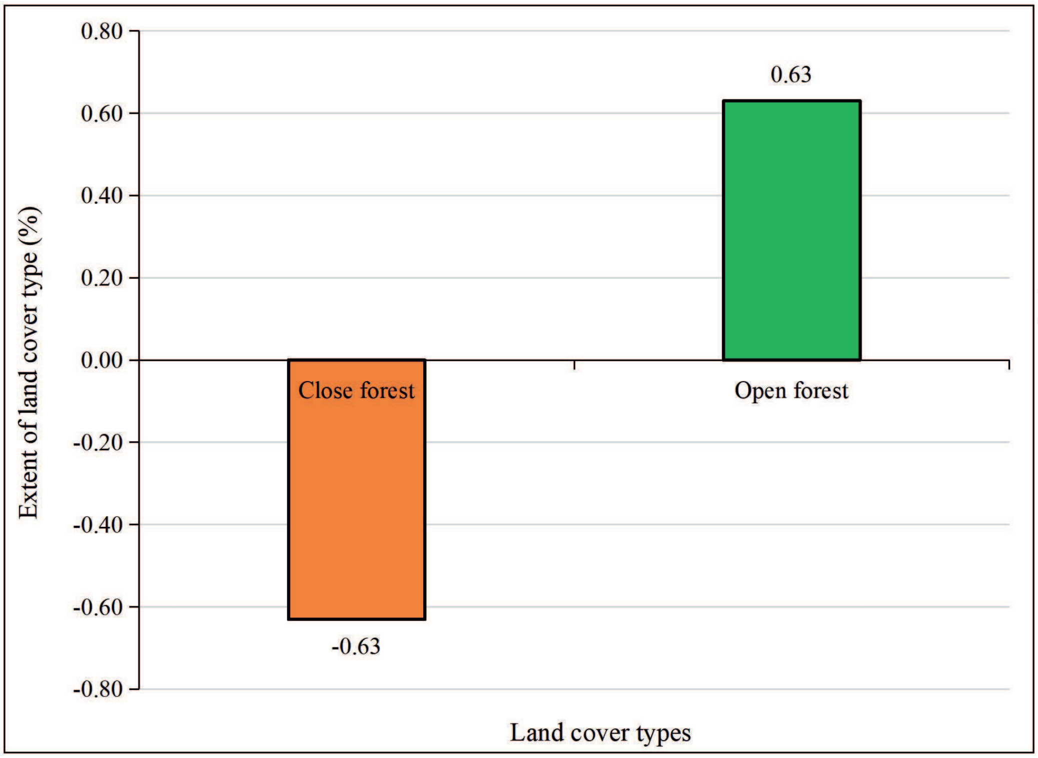

Figure 9.
Gain and loss in the land cover types of the Kakum National Park for the period 1986 to 2020. Source: Authors' construct, 2022.

In the year 1986, 86.73% of the park was open forest with the rest of the extent being riparian/marshy land, bare land and shrubland (**Figure 5**). By 2020, the total forest area constituted about 80.83%, a loss in open forest area of 5.90% (271 km^2) (**Figure 5**). The difference in the extent of the due to the human pressures of woodland conversion, bushfires, and logging for local timber and charcoal production. IUCN [37] rated woodland conversion and annual bushfires high among the pressures that influence the state of the park negatively.

4. Discussion

The study found that about 67% of the national parks use unsustainable conservation practices leading to a high forest cover loss as exemplified in Digya and Mole National Parks. In the case of Mole National Park, located in the interior savannah ecological zone, managers face the problems of annual bushfire, forest conversion to farmland, wood harvesting for charcoal production, and timber exploitation for local building material and export. Similarly, the Digya National Park, situated in the forest-savannah ecotone, suffers related pressures such as bushfire, logging for fuel wood, and intensive grazing by cattle [37]. The impacts of these pressures are the conversion of close forest to open forest and bare ground, particularly in the Mole National Park. The most affected tree species are rosewood (*Pterocarpus erinaceus)* (lumbering and export), *Burkea africana* (charcoal production) and *Kaya senegalensis* (roofing). There is harvesting of rosewood resulting in a decline in the close/open forest cover in the Digya and Mole National Parks making the rosewood an endangered species [48]. Also, there are 33% unsustainable conservation measures resulting in a minimal close forest cover loss of 0.63% in the Kakum National Park. The reasons for

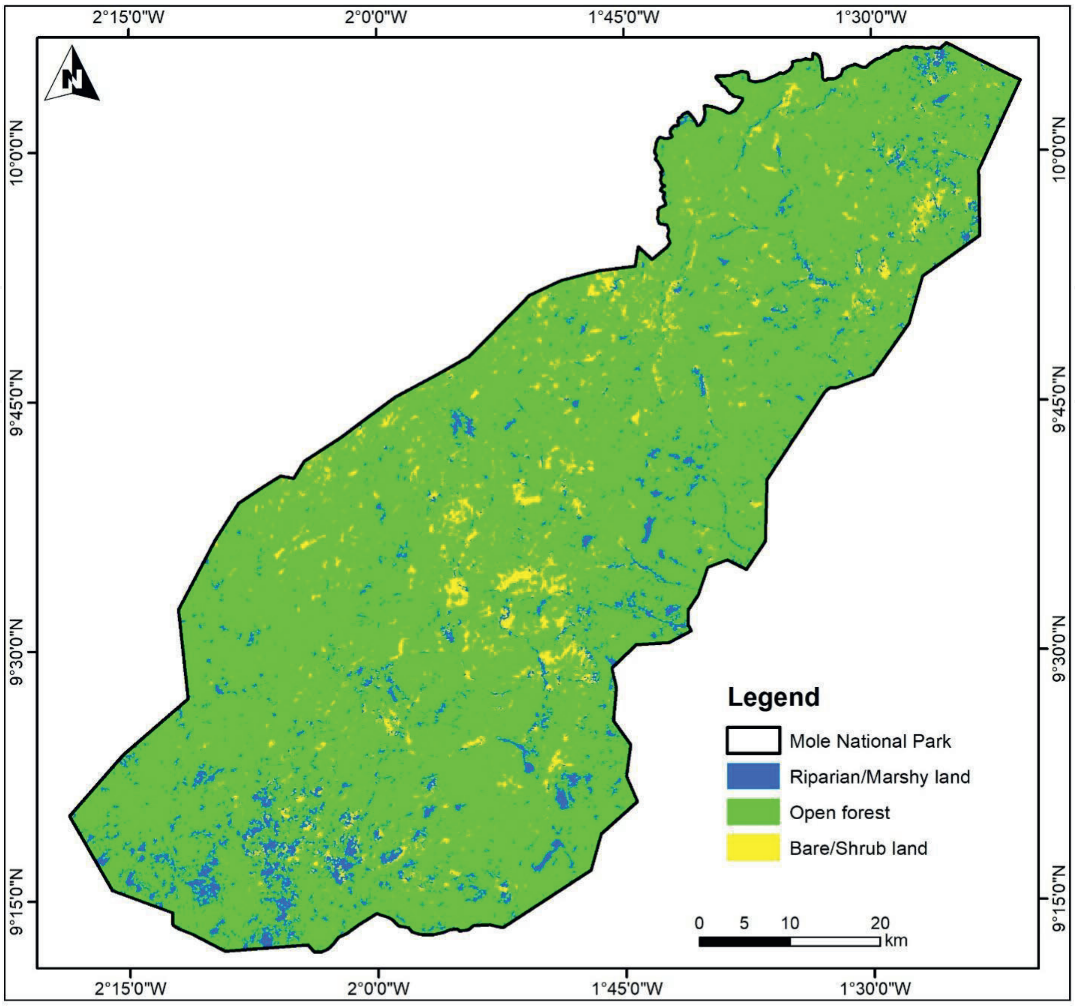

Figure 10.
State of land cover of mole National Park in 1986. Source: USGS, 1986.

the low forest cover loss are that the communities surrounding the Kakum National Park appear to observe protected area arrangement. There is also strict enforcement of protective regulations due to the importance of the Park to national tourism development. Furthermore, the site of the Kakum National Park close to the rainforest makes natural regeneration and shedding of leaves happen simultaneously. Hence, the forest cover loss is minimal. Another finding is that the forest cover change is not only attributed to anthropogenic factors but climatic and ecological factors as well. For example, the bare grounds in the Mole National Park result from insufficient natural regeneration due to the prolonged dry season (climate-induced).

5. Conclusion

This chapter assessed the gain and loss in the forest cover of three selected national parks in Ghana. The Mole National Park was in the northern Savannah zone, the Digya National in the middle zone and the Kakum National Park in the coastal zone. These parks have unique ecological, environmental and socio-economic characteristics. Excessive disturbance in the forest cover state will compromise these characteristics. The analysis of the gain and loss in the forest cover is of relevance for the effective management of these natural resources. As expected, each of the parks

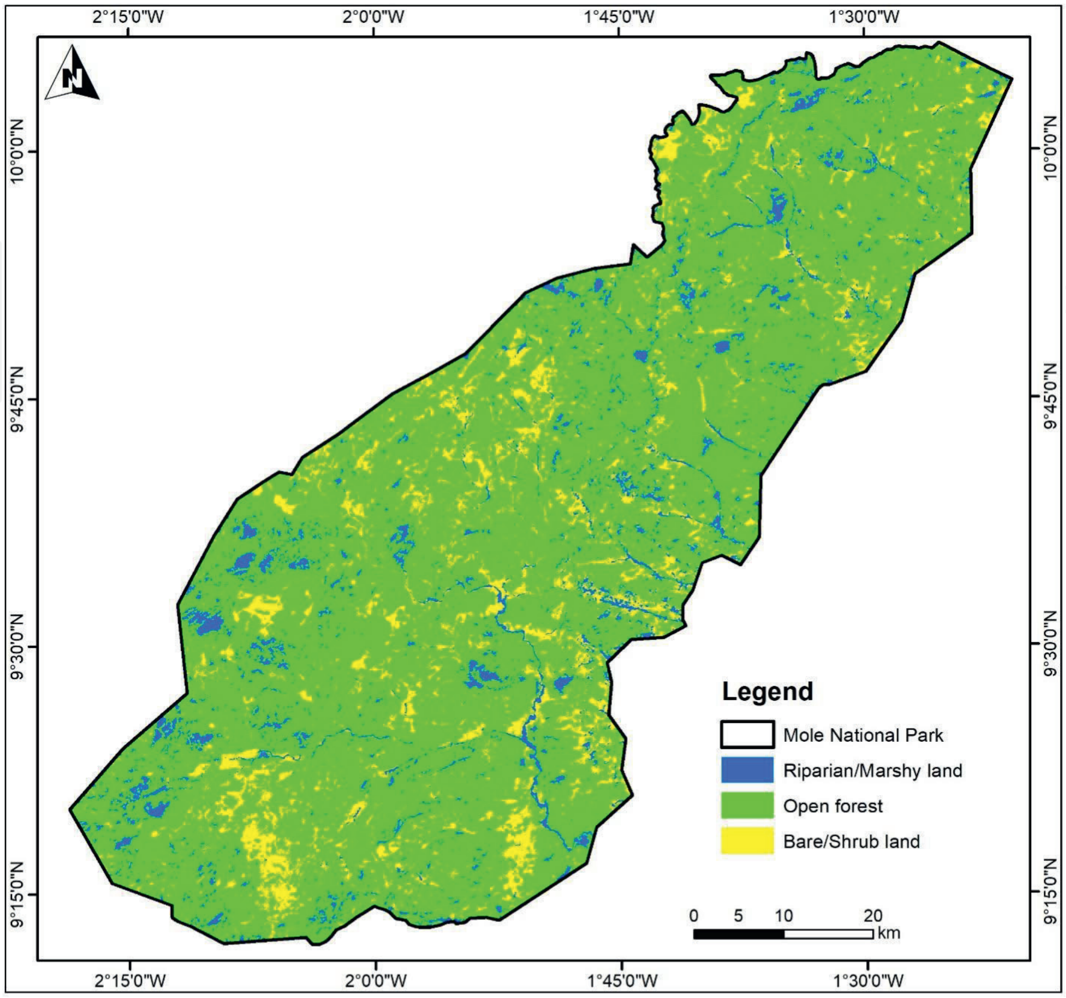

Figure 11.
State of land cover of mole National Park in 2020. Source: USGS, 2020.

exhibited dynamism in terms of gains and losses for the period 1986 to 2020. No detectable grass/bare areas were found in the Digya and the Kakum National Parks. Detectable grass/bare areas were recorded in the Mole National Park.

The Digya National Park experienced the largest extent of gain and loss. The close forest lost 6.28% of its initial cover to open forest. The Kakum National Park experienced the least of changes. The park lost 0.63% of its close forest to open forest for the period.

The Mole National Park experienced the most critical gains and losses in the forest cover. Bare/shrubland gained over open forest. The bare/shrubland gained a little above 6%. The losses forest cover in each of these parks may appear small but they make the parks vulnerable to the pressures of deforestation and degradation. It is therefore recommended that Forestry Commission of Ghana through its divisions should initiate plantation activities in the degraded areas of the park or strengthen the protective measures to allow and maximize natural regeneration in the parks. It is further recommended that similar studies be conducted in the other parks to ascertain the forest cover dynamism for effective management decisions.

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