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The Yaya Reserve: From the Evolution of its Plant Cover to Proposals for Sustainable Management

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Abstract

The Yaya reserve, one of the biodiverse forests in Ivory Coast, faces significant threats from agricultural colonization, illegal logging, and demographic pressure, which could jeopardize its sustainability. This paper focuses on contributing to the reserve's sustainable management. To achieve this, three categories of data were collected: remote sensing data, floristic inventory data, and survey data from the neighboring populations. Remote sensing data were obtained by downloading images from the USGS earth explorer website. Floristic data were obtained through surface and itinerant survey. Survey data were collected using a structured interview. The images were processed to calculate the areas of various land use classes. The floristic data were analyzed for species richness and composition, while the survey data were analyzed to understand local perceptions of landscape dynamics, current management practices, and proposals for participatory management. The results revealed two major periods in the forest's dynamics: increased deforestation from 1986 to 2005 and subsequent restoration from 2005 to 2022. These phases of degradation and restoration are likely related to recent social and political crises and management challenges. The floristic inventory identified 167 woody species across 134 genera and 47 families. 24 species (14% of the total) are endemic to West Africa, and 21 species (12.42%) are listed on the IUCN red list, indicating a relatively good conservation of the forest. The survey data highlighted the vulnerability of the forest and underscored the importance of centralized decision-making in management. The study suggests that participatory management could be a viable alternative for protecting the reserve. The hypotheses clearly states that the active involvement of local populations in the sustainable exploitation of forest resources can improve living standards, while helping to preserve the forest from exploitative practices.

Keywords: Biodiversity, Floristic inventory, Yaya reserve, Participatory management, Remote sensing

Introduction

Côte d'Ivoire is one of the countries in sub-Saharan Africa with the highest levels of deforestation (N'Guessan, 2018). For decades, the Ivorian government has taken actions to safeguard its forest areas. After gaining independence from France, the country implemented a new forest code to replace the colonial administration's code, which had been in force since 1935. In 1966, the Forest Development Company (SODEFOR), responsible for managing classified forests, was created.

Despite all these measures, the Ivorian forest continues to disappear. This degradation is primarily due to anthropogenic activities (such as agricultural activities, logging, and the harvesting of non-timber and wood forest products) and inadequate management methods implemented by SODEFOR (Zaouri, 2022). The Yaya reserve has not escaped this extensive wave of anthropization and destruction affecting Ivorian forests. The forest has undergone a significant reduction, decreasing from 20,843ha in 1960 to 12,729ha in 1999, representing a 33% reduction in its initial area (Zaouri, 2022). Various forms of degradation are evident, including cocoa plantations and pathways used to transport produce from the forest.

To compensate for the degradation of this forest, which shelters great biodiversity, the Yaya reserve had to successively change its status and management to strengthen surveillance and protection. From independence until 1992, the forest was managed by the Alépé Forestry Administration. In 1992, management was transferred to SODEFOR by Decree No. 0033/MINAGRA of February 13, 1992. In 2019, the forest came under the

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management of the OIPR by Decree No. 2019-897 of October 30, 2019, which established the Mabi-Yaya nature reserve.

Despite these provisions, the forest remains vulnerable to the destructive actions of surrounding populations. According to Amani (2011), changing the status or management of a forest cannot significantly impact its conservation if the underlying causes of its degradation are not addressed.

The central question of this study is: How can the spatio-temporal dynamics of the reserve's forest cover inform effective sustainable management strategies?

To answer this question, the general objective is to contribute to the development of a sustainable management approach for the reserve, while also considering the concerns of the surrounding populations.

Specifically, the study aimed to: Highlight the spatio-temporal dynamics of the reserve's vegetation; assess the richness and composition of the flora through a floristic inventory; and propose sustainable management methods based on surveys of the local population.

Situation and Context of the Evolution of the Plant Cover of the Yaya Reserve

The Yaya reserve is located in the Southeast of Côte d'Ivoire, between northern latitudes 5°36’00’’ and 5°48’05’’ and western longitudes 3°40’08’’ and 3°25’07’’. It extends between the Comoé river to the East and the Kossan (or Tossan) river to the West, within the administrative division known as the Mé Region. Covering an area of 23,873 ha, the forest straddles the prefectures of Alépé to the South and Danguira to the North (Figure 1). The climate of the Yaya reserve, like that of its geographical area, is sub-humid and belongs to the mesophilic sector. The average annual temperature is 26.5°C, with rainfall ranging from 1,200 to 1,700 mm and humidity (SODEFOR, 2015).

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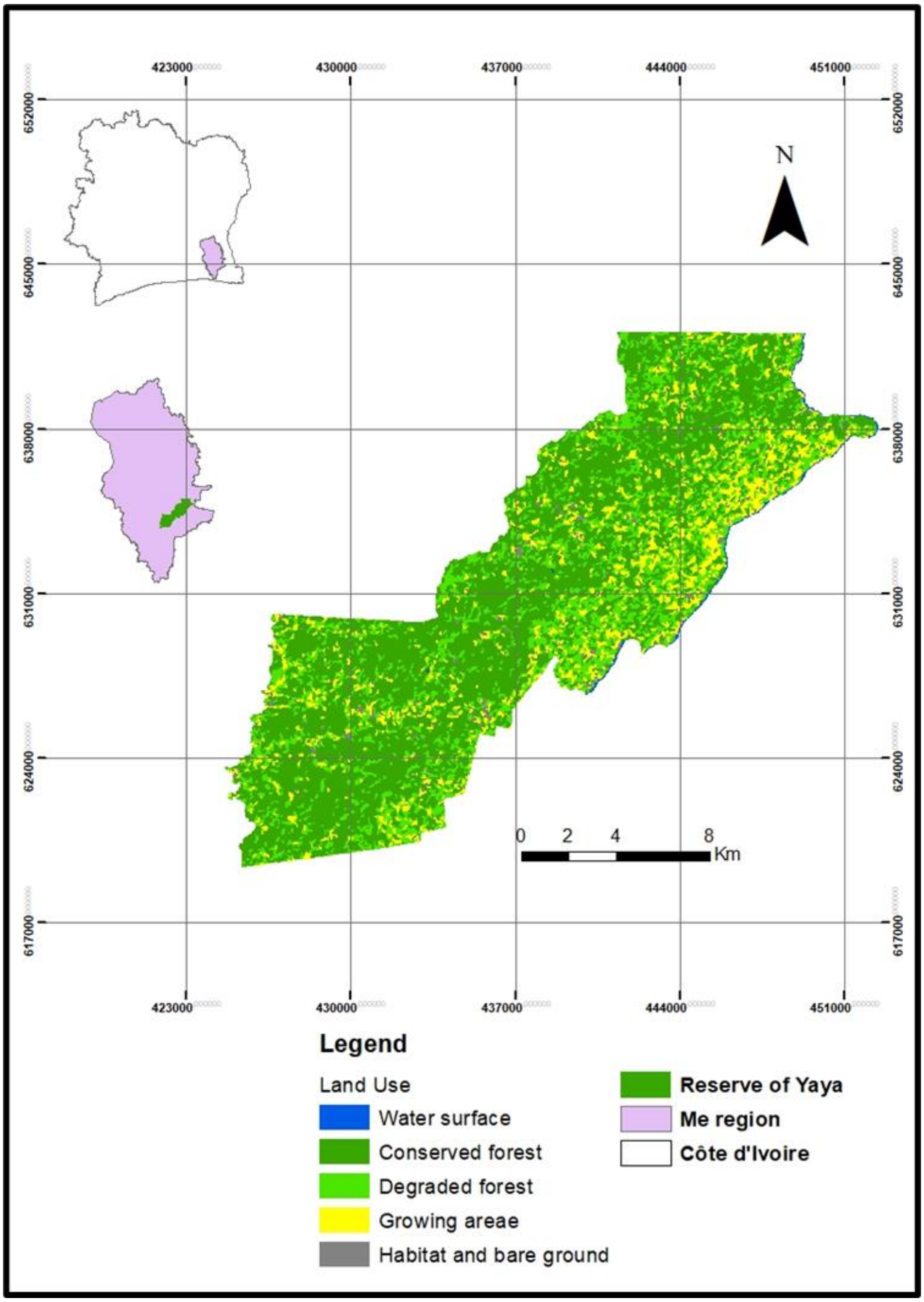

Figure 1: Location of the Yaya reserve

Over the years, this forest has faced enormous pressure owing to farming, illegal logging, and local population activities. These factors have influenced the dynamics of its vegetation, which has shrunk by 33% in the 39 years between 1960 and 1999 (Zaouri et al., 2021). However, a number of initiatives have made it possible to restore the forest while rebalancing its

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biodiversity. These include the transformation of the camp base into a management unit center, the introduction of regular patrols, the informal involvement of the local population, and the conversion of the forest into a Reserve by Decree No. 2019-897 of October 30, 2019. Unfortunately, the contribution of the local population is still insufficient, even marginal.

The evolution of this forest reflects the global challenges facing tropical forests. Conservation requires ongoing supplementary efforts to ensure its long-term survival. The reserve is limited:

- to the North by the Mabi reserve (10.7 km track);
- to the South by the village of Koutoukro (conventional limit of 8km) and the Zonkokoien campment;
- to the East by the Comoé river over a length of 26 km;
- to the Southwest by the Kossan river over a length of 20 km;
- to the West by the road to Bettié, over a length of 16 km.

II. Methodology

The methodological approach adopted in this study is structured around two key elements: data collection and technical analyses.

II.1. Data Collection

In this study, three categories of data were collected: data from satellites, a floristic inventory, and interviews with local people.

Regarding the satellite data, three scenes from the LandSat satellite (1986, 2005, and 2022) were acquired from the United States Geological Survey (USGS) website (http://glovis.usgs.gov/). These scenes allowed for a visual appreciation of the evolution of land use classes in this forest massif. The satellite images from Landsat sensors offer spectral advantages similar to those of the SPOT sensor. They are multispectral data, with six bands for the TM sensor and eight bands for ETM+, and a spatial resolution of 30 m in multispectral mode and 15 m in panchromatic mode. They are suitable for local studies, as their footprint makes it possible to map small landscape features (0.09 ha) (Guédé, 2017).

Concerning the floristic inventory, vegetation survey sites were randomly established in floristically homogeneous vegetation units based on the land use map of the Yaya reserve and supplemented by field surveys,. For surface surveys, a plot of 100 m × 20 m (2000 m^2) was delimited and marked by stakes and sisal wire. In each of the identified vegetation types, the dendrometric parameters of the different individuals were measured. Such a plot size allows for the minimum areas of plant communities to be considered (Senterre, 2005). A total of 50 rectangular plots were arranged throughout the forest during the summer. Additionally, a traveling survey was conducted,

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which made it possible to identify species not inventoried during the surface surveys (Aké-Assi, 1984).

The number of plots and their layout were based on previous studies such as those of N'Guessan (2018) in the Agbo I classified forest. The topography of the land and the physiognomy of the vegetation were also taken into account. This floristic inventory allowed for the practical assessment of the forest's state of conservation through species with special status and the calculation of some reference indices.

The interviews were carried out using an interview guide. A total of 140 individuals living on the outskirts and having a direct link with the forest were interviewed. The survey was conducted using a questionnaire (Singh et al., 2003) and a guided interview. The questionnaire was designed based on the state of conservation of the forest, as determined by mapping, and the expected objectives of the study. The interviews identified the cause of landscape dynamics, the anthropogenic activities carried out in the reserve, and the solutions for sustainable management of the reserve.

The number of people interviewed follows the principle of purposive sampling, aimed at individuals with a direct relationship with the forest (e.g., plantations near or within the reserve). A total of three localities were visited: 45 people in Mopodji, 40 in Kossandji, and 55 in Zongokoi. This population significantly contributes to the degradation of the forest cover. The choice of purposive sampling is based on previous studies by researchers such as N'guessan (2021) and Eblin (2019).

II.2. Data Processing and Analysis

Regarding the processing and analysis of data from satellite images, the data went through a preprocessing phase. This involved performing an atmospheric correction, as the scenes were corrected radiometrically and geometrically. The aim of this preprocessing was to optimize the readability and expressiveness of the data in relation to the desired objectives, allowing easy interpretation and leading to better extraction of information (Guédé, 2017). This pre-processing consisted of correcting and performing an initial reflectance calibration of the data.

For each of the image channels used, corrections were made using a satellite signal stimulation model in the solar spectrum developed by the Optics and Atmosphere Laboratory (LOA). This programme predicts the satellite signal between 0.25 and 4.0 µ for a cloud-free atmosphere (Yao, 2005). The corrections take into account absorption by water vapour, carbon dioxide, oxygen, and ozone, as well as scattering by molecules and aerosols (Robin, 1998). At the end of the atmospheric correction process, images are obtained that have been partially corrected for atmospheric effects and whose reflectances have been equalised, making it possible to compare different

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channels from different dates. This allows the different images to be superimposed.

After preprocessing the scenes, the study area was extracted and colored compositions were created to better discriminate between the different types of land uses. These compositions, known as "coloured compositions", display a combination of three relevant greyscale channels assigned a primary colour from the RGB (Red, Green, Blue) system used in video colour coding. This approach facilitates information extraction, as the resulting colours represent different types of land use (N'Da et al., 2008). Software such as Envi version 5.3 was used to process the images, and ArcGIS 10.8 was used to design the maps.

Maps were designed for the years 1986, 2005, and 2022 using automatic image classification based on the maximum likelihood algorithm, commonly used by researchers (Guyot, 1989; Ducrot, 2005; Barima, 2007). This method is effective for creating land use maps based on the real-world terrain.

The spatio-temporal evolution of the land cover of the Yaya reserve was primarily analyzed by comparing land cover data from different periods. The analysis of the dynamics is quantitative, allowing for the estimation of areas occupied by each land use class. After calculating the approximate areas of each class for the periods 1986, 2005, and 2022, the Global Evolution Rate (TEG) for each land use class was calculated. This rate, expressed as a percentage, is used in studies of land use dynamics to measure the evolution of land use units over time and space (Coulibaly et al., 2016).

$$T.E.G = \frac{Final\ surface\ area - Initial\ area}{Initial\ area} \times 100$$

T.E.G: Global Evolution Rate reflects an advance in land use units when positive and a loss of surface area when negative (Guede, 2017).
However, the annual average spatial expansion rate estimates the evolution of the areas of each type of spatial unit per year between two periods. It also indicates the proportion of forest area lost each year in a given territory. This rate is expressed in relative value and is calculated using the following formula (Guede, 2017).

$$TESMA = \frac{\ln S2 - \ln S1}{t \times \ln e} \times 100$$

t is the number of years of evolution,
S1 and S2 are respectively the initial and final areas
ln, the natural logarithm
e, the base of natural logarithms (e = 2.71828)

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Regarding the data from the floristic inventory, several parameters were considered to assess the state of conservation of the Yaya reserve. The first step was to evaluate the floristic richness, which provided insight into the variety of ecological niches on the site (Rocklin, 2003). Next, the ecological affinity of the encountered species was defined to distinguish between pioneer species (Pi), non-pioneer species, and undergrowth and shade species (Sb). This distinction aimed to evaluate the rate of disturbance of forest vegetation (Adou Yao, 2005). Finally, species with special status (threatened and/or vulnerable species) were highlighted to assess the floristic quality of the reserve (Adingra, 2017).

For the interview data, thematic content analysis and descriptive analyses were employed. This approach highlighted the factors explaining the evolution of the plant cover in the Yaya reserve and proposed solutions for the sustainable management of the forest massif. To analyse the qualitative data (from the semi-structured interviews), thematic content analysis was used. This method involves identifying themes and analysing the corpus of interviews using a cross-sectional approach rather than analyzing each interview individually (Karoui, 2012). A theme is defined as "an expression or phrase that identifies what a unit of data is about or what it means" (Saldana, 2009). It represents a focal point of the researcher's interest in relation to the issue being studied.

More specifically, thematic content analysis allows for "the identification of recurring general themes in verbal or textual expressions which appear under various more concrete contents" (Mucchielli, 1996). In other words, thematic analysis facilitates "moving from an approach centered on the coherence of each individual during fieldwork to a transversal approach centered on the thematic coherence of all the data collected" (Alami et al., 2009). This method transformed the raw data into a thematically organised corpus.

The data was organised thematically using the open coding approach. This approach involved listing all the interview transcripts and labeling (coding) all text fragments from the interviews. This process led to the construction of a thematic tree, with central themes grouping complementary and divergent themes. In summary, thematic content analysis enabled coding, classification, and categorisation of respondents’ comment to analyse key issues in the stakeholders' discourse.

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III. Results

III.1. Diachronic study of land use in the Yaya reserve

III.1.1. Land use classes of the Yaya reserve

The processing of satellite images identified five land use classes in the Yaya reserve: preserved forest, cultivation areas, degraded forest areas, bodies of water, and bare habitats and soils (Figure 2).

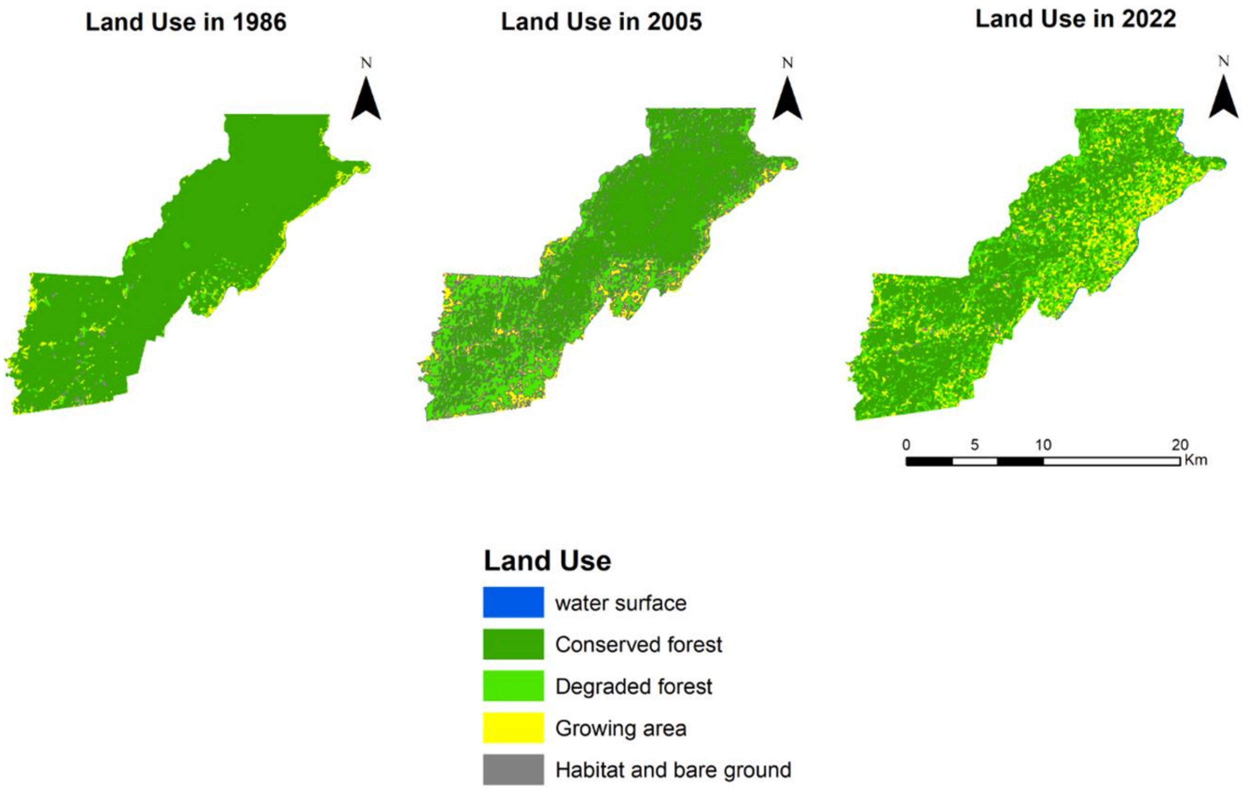

Figure 2: Land use maps of the Yaya reserve for 1986, 2005 and 2022

III.1.2. Area of land use classes in the Yaya reserve for the years 1986, 2005, and 2019

III.1.2.1. Year 1986

In 1986, the reserve's land was 86% covered by dense forest (Figure 3). This extensive dense forest indicates that, during that period, the massif was well preserved. Although the classes of degraded forest (6%), cultivation areas (4%), and bare habitats and soils (3%) were relatively small, they suggest that forest infiltration had already started. This is supported by a local resident who stated: “Before the arrival of the forestry administration, some people had fields in the forest”.

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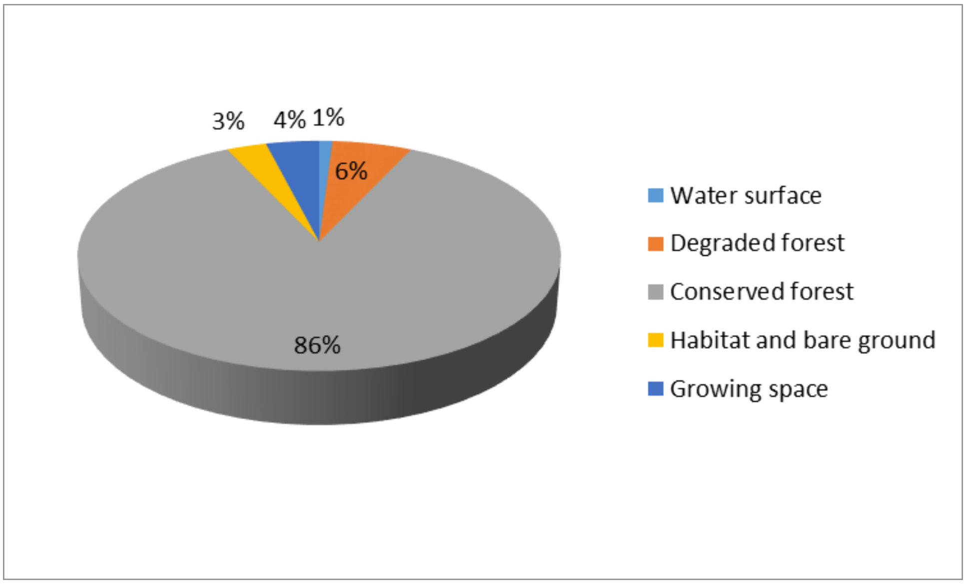

Figure 3: Spectrum of different land-use units in the Yaya Classified Forest in 1986

III.1.2.2. Year 2005

In 2005, the area of dense forest in the reserve decreased significantly. The dense forest cover fell from 86% in 1986 to 60% in 2005 (Figure 4), representing a 26% loss of vegetation cover. The areas of degraded forest and crops increased to 20% and 16%, respectively, indicating intensified infiltration and exploitation of the reserve during this period.

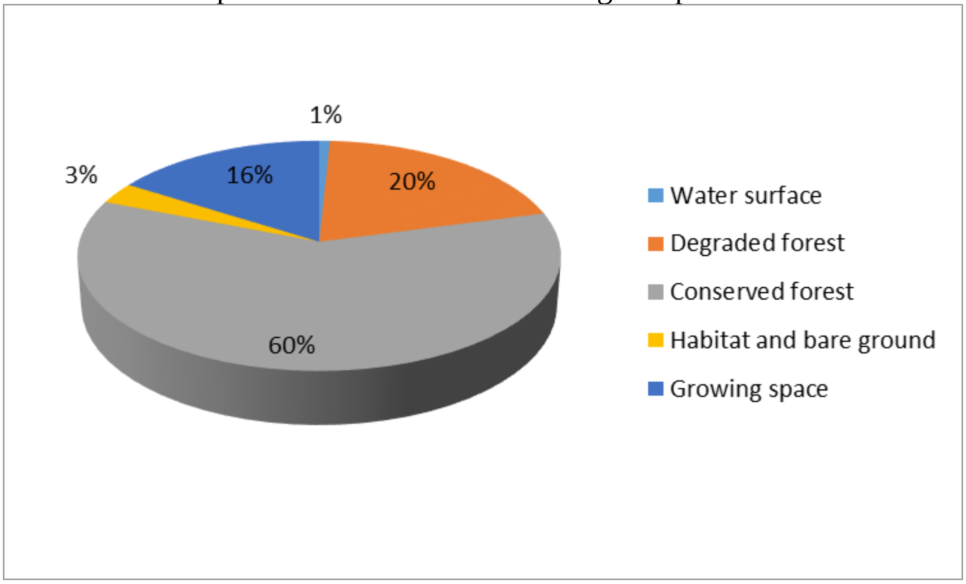

Figure 4: Spectrum of different land-use units in the Yaya Classified Forest in 2005

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This significant loss of plant cover can be attributed to the political crisis in Cote d'Ivoire in 2002, which led to the abandonment of the reserve by SODEFOR agents. During this period of instability, loggers and farmers exploited the forest's resources and established agricultural concessions. A respondent's comment highlights this situation: "(…) in the year when the rebels came to Côte d'Ivoire, we noticed people had fields in the forest. We also saw a lot of logging trucks going in there."

III.1.2.3. Year 2022

The period from 2005 to 2022 was marked by a major socio-political crisis in Côte d'Ivoire. This crisis caused forestry agents to abandon protected areas, leading to widespread plundering and agricultural infiltration. This resulted in a severe reduction in the Ivorian plant cover. Despite the serious crisis of the 1986-2005 period, which led to 26% loss in forest cover, the situation in 2022 shows an 11% recovery in plant cover (Figure 5). According to local populations, the 2011 conflict related to the post-electoral crisis favoured forest regeneration by driving non-nationals away from peripheral villages, leading to the abandonment of several plantations in the reserve. This allowed the forest to recover, as reflected in a local's statement: "(…) in 2011, when we chased foreigners from our villages, the forest recovered because the fields of these foreigners remained in the bush (…)."

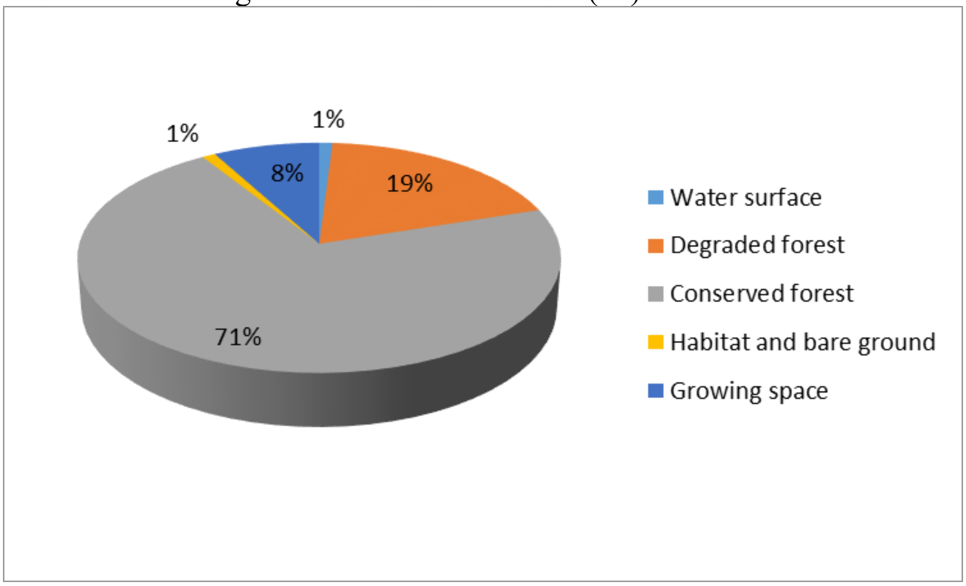

Figure 5: Spectrum of different land-use units in the Yaya 2022 classified forest

In addition, the management measures implemented by SODEFOR after the post-electoral crisis, which included increasing surveillance through regular patrols, led to the destruction of several plantations. Enhanced

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monitoring also forced many infiltrators to abandon their concessions within the reserve, contributing to the forest's regeneration and increasing forest cover from 60% in 2005 to 71% in 2022.

III.1.3. Dynamics of Each Land Use Class

The land use classes experienced fluctuations in their surface areas during the different periods of the study (Table I). From 1986 to 2005, the land under cultivation increased remarkably by 305%. Furthermore, the degraded forest area expanded by 224.70%. This expansion was at the expense of the conserved forest area, which lost 267% of its initial surface area. During this period, the average annual spatial expansion rate of the cultivation area was 8.09%, while the conserved forest area lost 0.093.80% of its surface area per year.

Table 1: Evolution of land use and global changes in the Yaya Classified Forest from 1986 to 2022

			Land use classes				
			OS1	**OS2**	**OS3**	**OS4**	**OS5**
Surface area of occupancy classes per year	1986	Ha	153,47	657,20	951,41	20843,90	1484,05
		%	1	3	4	86	6
	2005	Ha	115,36	600,20	3854,49	14454,31	4818,82
		%	0,8	3	16	60	20
	2022	Ha	151,95	236,03	1934,44	17168,17	4594,30
		%	1	1	8	71	19
(TEG)	1986-2005	%	-24,83	-8,67	305,23	-30,65	224,70
	1986-2022	%	-0,994	-64,08	103,32	-17,63	209,57
	2005-2022	%	31,71	-60,67	49,81	18,77	-4,65
TESMA	1986-2005	%	-2,19	-0,69	7,89	0,09	8,09
	1986-2022	%	-0,03	-3,20	0,01	-0,05	0,031
	2005-2022	%	1,44	-4,92	-0,04	0,9	0 ,002

Legend: ha: hectare; %: Percentage; OS1: Stretch of water; OS2: Habitats and bare soil; OS3: Cultivated areas; OS4: Conserved forest; OS5: Degraded forest; TEG: Overall rate of change; TESMA: Average annual spatial expansion rate.

The second period (2005 to 2022) was more favourable for the forest, with an overall rate of change of 18.77% in the conserved forest area. Cultivated areas and degraded forest areas lost 60.67% and 4.65% of their initial areas, respectively. During this time, the conserved forest area gained 0.9% of its surface area each year, while the cultivated and degraded forest areas decreased. Given the current percentage of forest cover (67%) in the Yaya reserve, it can be stated that this forest contains numerous floristic

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resources, as observed through a floristic inventory detailed in the following section.

III.2. Floristic Inventory in the Yaya reserve

III.2.1. Floristic Richness

The woody floristic richness of the Yaya reserve is estimated at 167 woody species, classified into 134 genera and distributed among 47 families. The total number of woody species inventoried varies across different plant formations (Table II). The dominant families are Fabaceae, Malvaceae and Euphorbiaceae.

Table 2: Floristic richness and mean values of species richness (SF) of the different forest types in the Yaya Classified Forest

	Types of vegetation	Specific richness	Number of types	Number of families	average specific richness
All individuals	Degraded forest	95	82	35	47,5 ±1,48[a]
	Conserved forest	162	130	47	52,33± 5,42[a]
	Reforested cultivated area	117	99	39	55,83 ±3,83[a]

III.2.2. Ecological Affinity

Guineo-Congolese (GC) species are strongly represented, comprising more than 70% of the species throughout the Yaya reserve (Figure 6). In the conserved forest zone, they represent 95.67% of the species, compared to 4.32% for those transitioning between the Guinea-Congolese and Sudano-Zambezian zones. In areas of degraded forest, GC species represent 96.84%, while 95.72% of the species in other areas are GC, compared to 4.27% of the Guineo-Congolese and Sudano-Zambezian transition species.

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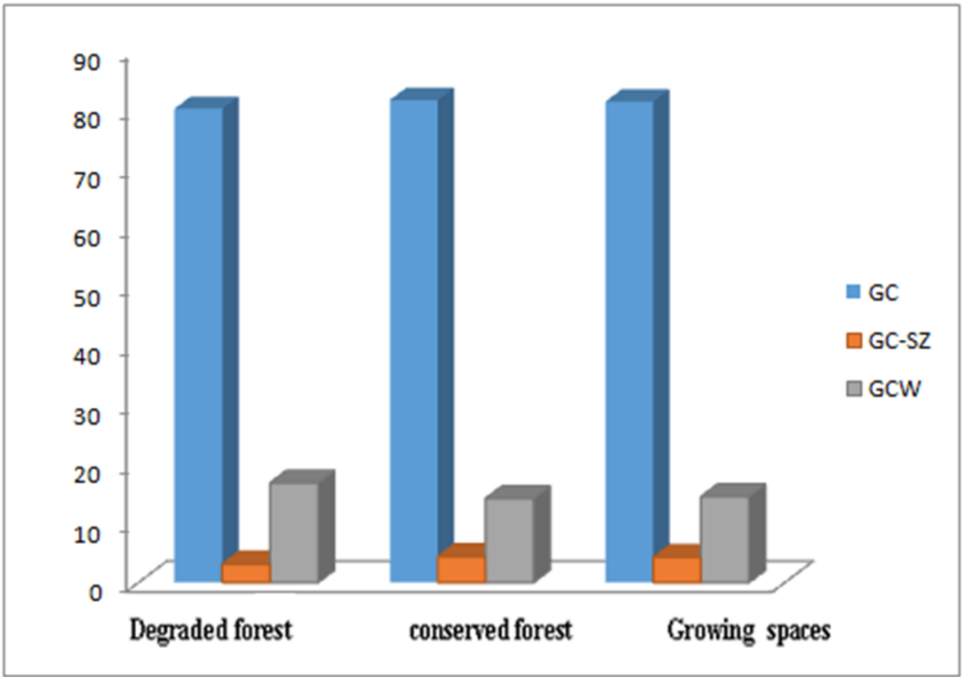
Figure 6: Proportions of chorological affinities in the different vegetation types of the Yaya Forest



Legend: GC: Guineo-Congolese species, GC-SZ: species from the transition zone between the Guineo-Congolese and Sudano-Zambezian regions; GCW: West African endemic species.

III.2.3. Species with Special Status

Among the species recorded in the Yaya Classified Forest, 24 species (14% of the species richness) are endemic to West African GCW. Analysis of the general list of woody species shows that 21 species (12.42%) appear on the IUCN red list (2020). Among these, 15 species have a conservation status and fall into the vulnerable category (Table III).. The floristic list of the forest also includes 4 species (2.36%) listed on Aké-Assi (1984) list of Rare Plants Endangered: *Garcinia afzelii* Engl, *Garcinia kola* Heckel, *Gilletiodendron kisantuense* (Vermoesen ex de Wild.) J. L, and *Milicia excelsa* (C. C. Berg).
In summary, the floristic richness, ecological affinity, and numerous species with special status indicate that the Yaya reserve has exceptional biodiversity that should be preserved sustainably. However, the percentages of cultivation space (8%) and degraded forest (19%) indicate that this protected area is still under threat from local populations. To achieve sustainable conservation, several proposals have been described by local populations.

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Table 3: List of special-status species recorded in the Yaya reserve.

N0	SPECIES	Families	Chorological affinities	UICN (2020)	Aké ASSI (1998)
1	*Albizia adianthifolia* (Schumach.)	Fabaceae	GC	LC	
2	*Anopyxis klaineana* (Pierre) Engl.	Rhizophoraceae	GC	LC	
3	*Antrocaryon micraster* A.Chev. & Guill.	Anacardiaceae	GC	VU	
4	*Baphia nitida* Lodd.	Fabaceae	GC	LC	
5	*Copaifera salikounda* Heckel	Fabaceae	GCW	VU	
6	*Cordia platythyrsa* Bak.	Boraginaceae	GCW	VU	
7	*Entandrophragma angolense* (Welw.)	Meliaceae	GC	VU	
8	*Garcinia afzelii* Engl.	Clusiaceae	GC-SZ	VU	PRE
9	*Garcinia Kola* Heckel	Clusiaceae	GC		PRE
10	*Gilletiodendron kisantuense* (Vermoesen ex de Wild.) J. L	Fabaceae	GC		PRE
11	*Glumea ivorensis*Aubrév. et Pellegr.	Sapotaceae	GC	VU	
12	*Guarea cedrata* (A. Chev.) Pellgr.	Meliaceae	GC	VU	
13	*Guarea thompsonii* Sprague et Hutch.	Meliaceae	GC	VU	
14	*Khaya ivorensis A*. Chev.	Meliaceae	GC	VU	
15	*Lophira alata* Banks ex Gaertn. f.	Ochnaceae	GC	VU	
16	*Milicia excelsa* (C. C. Berg)	Moraceae	GC	LR/nt	PRE
17	*Mitragyna ledermannii* (K. Krause) Ridsdale	Rubiaceae	GC	VU	
18	*Nauclea diderrichii* (De Wild. & T. Durand) Merr.	Rubiaceae	GC	VU	
19	*Placodiscus bancoensis*Aubrév&Pellegr	Sapindaceae	GC	VU	
20	*Pterygota bequaertii* de Wild.	Malvaceae	GC	VU	
21	*Terminalia ivorensis* A. Chev.	Combretaceae	GC	VU	

Legend: GCW = West African endemic species; GC-SZ = Taxon from the transition zone between the Guinéo-Congolese and SoudanoZambezian regions; VU = Vulnerable; LC = Least Concern; LR /nt= Low Risk; PRE= Rare Plant in danger of Extinction

III.3. Proposals for Sustainable Management of the Yaya Reserve

Interviews with the populations revealed three key proposals for the sustainable management of the Yaya reserve: materialization of the reserve

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boundaries, relocation of populations outside the buffer zone, and involvement of peripheral populations in reserve management (Table IV).

Table 4: Population proposals for sustainable forest management

Respondents' suggestions	Proportions (%)
Marking the boundaries of the forest	46
Involving local people in management	60
Relocating populations outside the buffer zone	55

III.3.1. Materialization of the Boundaries of the Yaya Reserve

The materialization of boundaries is crucial for controlling and monitoring a resource, as it allows both managers and populations to know the limits. This removes ambiguities between the protected area and the rural environment. At the Yaya reserve, there is controversy between locals and non-locals over the boundaries of the reserve. Locals blame non-locals for having their cocoa plantations within the reserve perimeter, while the latter believe their agricultural concessions are in the rural environment. This situation highlights the need for clearly marked boundaries to prevent infiltration and avoid conflicts between managers and populations over the reserve's boundaries.

III.3.2. Relocation of Populations Outside the Buffer Zone

In the effective management strategy of a protected area, the buffer zone is essential, as it keeps populations at a reasonable distance from the protected site. At the Yaya reserve, the presence of camps is noted about one meter from the forest. As evidenced by a local person who states:

> "(…) here, we have non-locals who live less than a meter from the forest. As long as they are at this distance from the forest, they will continue to degrade the forest by creating plantations and by cutting down tree species."

This statement indicates that the presence of populations in the buffer zone poses a risk to the forest's survival. To avoid this situation, it would be wise to relocate all the populations living in this area to the outlying villages to prevent infiltration of the reserve.

III.3.3. Involvement of Populations in the Management of the Yaya Reserve

Monitoring is the essential element in the management of a protected area, guaranteeing the sustainability of the resource when carried out rigorously. At the Yaya reserve, although surveillance patrols deter agricultural colonization of the forest, there is a noted weakness in the management unit staff (7 agents) who struggle to cover the entire protected space.

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This situation constitutes a flaw in the management strategy and makes monitoring ineffective, leading to the observation of cocoa plantations in several forest areas. To compensate for this deficit, the populations, particularly the indigenous people, propose to be involved in management through the establishment of village committees to monitor the reserve in all the peripheral villages. Since the locals do not have any plantations in the reserve, the creation of these committees would likely help resolve the surveillance problem.

IV. Discussion

The Yaya reserve is an Ivorian forest that has evolved from the status of a simple forest to that of a classified forest and then to a reserve. This change in status is linked to its exceptional wealth, state of conservation, and the government's new national policy. Facing the reduction in the country's forested areas, the Côte d'Ivoire government adopted a policy May 23, 2018, to preserve, rehabilitate, and extend its forests, making the future of Côte d'Ivoire's forests a priority (MINEF, 2019).

According to the inventory carried out, the woody floristic richness of the Yaya reserve is estimated at 167 woody species, classified into 134 genera and 47 families. These results establish an initial outline of the woody floristic catalogue for the area. The dominant families are Fabaceae, Euphorbiacea, and Malvaceae. These families are very common in most forests in Côte d'Ivoire and forests in Sonké, Africa (1998).There are also several species with special status, comprising 24 species endemic to the West African zone. Twenty-one species of this forest are listed on the IUCN red list (2020). The high rate of endemism and the high percentage of species with special status leads to the conclusion that this forest has not lost its specificity and is well conserved (White, 1983). However, the degraded surface area comprising 32% (22% degraded forest, 9% cultivation space, and 1% habitat and bare soil) indicates that the forest's wealth is under threat from populations infiltrating it for the establishment of perennial crops, primarily cocoa. This activity involves clearing land, which reduces plant cover.

Konan et al. (2006) highlight that anthropogenic activities, specifically agriculture and logging, are responsible for the decline in forest areas in Côte d'Ivoire. This view is supported by Balac (2000) whose study indicates that cocoa cultivation has contributed to the deforestation of Côte d'Ivoire's pioneer fronts. In response, the Ivorian government adopted a Forest Preservation, Rehabilitation, and Extension Policy (PPREF) in 2018, aiming to restore national forest cover to at least 20% by 2030 (MINEF, 2019).

Local populations identify three essential reasons for the agricultural colonization of this protected area: the presence of certain communities in the buffer zone, the lack of clear boundaries for the reserve, and the exclusion of

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local populations from management and surveillance strategy. These reasons highlight management flaws in the reserve, which have been noted by several authors, including Eblin and Goulin (2022), Pétanhangui et al. (2022), Goh (2015), and Amani (2011), who link forest degradation in Cote d'Ivoire to shortcomings in the management system.

To address these management challenges and achieve sustainable and effective management, local populations near the Yaya reserve have proposed three major solutions. Constantin (1998) argues that when communities are excluded from forest management, they may undermine the management efforts, while Eblin et al. (2022) suggest that lack of involvement leads to actions opposing conservation efforts.

The growth of the surrounding population, particularly in Zongokoi, contributes to the sprawl into forested areas close to the reserve, leading to artificialization of the landscape over time. Protecting agricultural land and forest biodiversity remains a significant concern for the Ivorian government (MINEF, 2019).

Currently, the forest is relatively well-preserved and continues to provide timber and non-timber forest products to local populations (Zaouri, 2022). However, its ability to continue offering these benefits is uncertain due to the increasing population pressure and the shortcomings in its management. Although government measures and increased patrolling may reduce some constraints, the future of Côte d'Ivoire's forests remains uncertain and potentially bleak.

Despite significant progress, the technical and organisational frameworks for forest management are not yet consolidated. Given these technical, organizational, and legal issues, establishing a public action strategy is crucial. Participatory management emerges as a promising alternative that could be effectively developed and implemented to protect the remaining forest areas.

The hypotheses clearly shows that actively involving local communities in the sustainable exploitation of forest resources will improve living standards and help preserve the forest from exploitative practices. A participatory approach allows local populations to benefit sustainably from the forest through a contract based on a management plan signed with the State. To ensure equitable benefit-sharing, the legal and institutional framework must be transparent and involve clear agreements between the parties involved.

Conclusion

This study demonstrates that the Yaya reserve, prior to its status change from a classified forest in 1992 to a reserve in 2019, experienced significant alterations in its vegetation cover between 1986 and 2022. The

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dense (well-preserved) vegetation cover decreased from 86% in 1986 to 60% in 2005, before increasing to 71% in 2022. Several factors contribute to this trend. The military-political crises of 1999 and 2002, along with the post-electoral crises of 2010, led to the abandonment of the reserve by forestry officials.

Consequently, the forest was colonised by farmers, and its wood resources were plundered, resulting in a 36% loss of vegetation cover in 2005. By 2022, the forest had regained 11% of the area lost in 2005. This regeneration is linked to the departure of foreign communities from indigenous villages following the indigenous-foreign conflict related to the 2010 post-electoral crisis, as well as to deterrent patrols and the destruction of crops conducted by forestry officers in response to the post-electoral crisis.

To ensure the long term preservation of this reserve, it is important to involve local populations in its management by setting up village monitoring committees, relocate communities living within the buffer zone, and clearly demarcate the reserve's boundaries to make them visible to both local residents and managers.

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