Social Science and Humanities Journal
Everant Journal
https:https://sshjournal.com/
Impact Factor: 2024: 6.576
2023: 5.731
ISSN: 2456-2653
Volume 08 Issue 04 April 2024
DOI: https://doi.org/10.18535/sshj.v8i04.1026

# Socio-spatial changes in the Koba classified forest in the sub-prefecture of Vavoua (central-western Côte d'Ivoire)

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*Received 06-04-2024*
*Revised 07-04-2024*
*Accepted 28-04-2024*
*Published 29-04-2024*



**Summary :**

The introduction and growth of new tree crops (cashew nuts and rubber trees) in Central and Central-Western Côte d'Ivoire as a result of global warming has exacerbated the state of degradation of the classified forests in these areas. The example of the Koba classified forest, located in the Centre-West, in the Department of Vavoua, is quite edifying. The research objective is to take stock of the spatio-temporal dynamics of the forest cover of this protected area from 1995, the year of the last study carried out by SODEFOR, to 2023. To achieve this objective, the methodology consisted of a multi-date analysis of the forest cover using Landsat optical satellite imagery (Landsat TM 1995, Landsat ETM+ 2010 and Landsat OLI-Tirs 2023) coupled with direct field observation and a questionnaire survey. The questionnaire survey focused on the route method, with 10 localities surveyed and a total population surveyed estimated at 150 people. The results show that between 1995 and 2023, the landscape initially dominated by open forest and dense forest (49%) in 1995 has been replaced by other land-use categories, the most important of which are perennial crops (46%) and mosaics of crops and fallow land (26%) in 2023. Human activities and climatic disturbances are the main determinants of these land cover dynamics.

**Key words :** Land use dynamics, mapping, Koba classified forest, anthropic pressure, socio-spatial changes

## Introduction :

In Côte d'Ivoire, more than half the forest cover (57%) has disappeared in a quarter of a century (1990-2015) (T. Ouattara, 2016, p3). Since independence, the country's economy has been based on agriculture, which is the main driver of forest loss because of its extensive nature. In 1960, the country had 16.5 million hectares, but today 80% of Côte d'Ivoire's forests have disappeared. The causes of this decline are well known: extensive farming, over-exploitation of the forests, and the failure of public institutions to enforce the laws that are supposed to protect the forests. The continuation of this trend will have dramatic consequences in the short, medium and long term, from all points of view, ecological and economic, but also social, due to the tensions

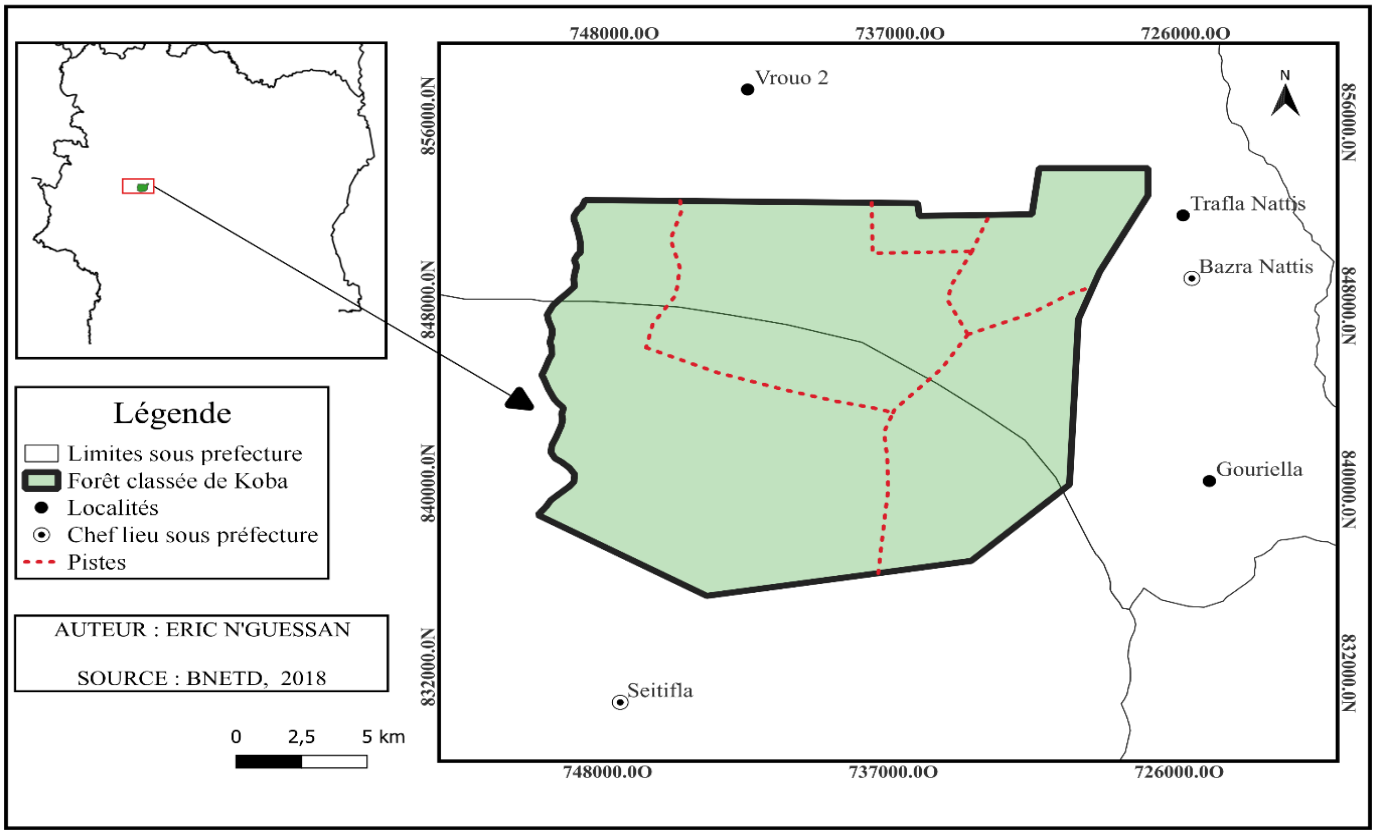
caused by the race to illegally occupy land (PNPREF, 2018, p8). The classified forests of west-central Côte d'Ivoire are not spared from the various anthropogenic pressures; this is the case of the Koba classified forest, which covers 3,130 hectares. It is suffering from deforestation, resulting in the unwarranted appropriation of its land for farming, dominated by cocoa and cashew nut crops. According to a study of this classified forest (DCGTX, 1993, p1), the area is mainly occupied by crops and fallow land. From 1993 to the present day, no other study has established the dynamics of land occupation and use within this classified forest. In view of these observations, a central question arises: What is the level of forest cover degradation in this protected area between 1995 and 2023? This study therefore aims to analyse the level of anthropisation of the Koba classified forest from 1995 to 2023, with a view to preventive management.

## 1. Data and methods

### 1.1. Presentation of the geographical context of the study

The Koba classified forest is located in the department of Vavoua, in the centre-west of Côte d'Ivoire, in the Haut-Sassandra region. It lies between longitude West 6°35' and 6°40' and latitudes North 7°30' and 7°35. It is bordered by two sub-prefectures in the department of Vavoua, namely Sétifla and Bazra-Natis (Figure 1). The area was demarcated and classified as part of the State's permanent forest estate on 24 June 1978. It is the largest classified forest in the department of Vavoua, with a current surface area of 3,130 hectares.

**Figure 1Location map of the Koba classified forest**




### 1.2. Data

We used satellite images from the Landsat sensor (Landat 5 TM 1995, Landsat 7 ETM+ 2010 and Landsat 8 OLI-TIRS 2023). The images were downloaded free of charge from *http://earthexplorer.usgs.gov/* (Table 1). The choice of images was based on our objectives, but also on their availability.

**Table 1: Characteristics of the Landsat bands used**

| **Year** | **1995** | **2010** | **2023** |
|---|---|---|---|
| **Type** | Landsat5/TM | Landsat7/ETM+ | Landsat8/OLI |
| **Acquisition date** | 04/02/1995 | 16/12/2010 | 03/02/2023 |
| **Path/Row** | 193/55 | 193/55 | 193/55 |
| **Spatial resolution (m)** | 30 | 30 | 30 |

### 1.3.Data collection

Direct field observation was carried out to collect field data on land use classes and to check the waypoints of the training plots. Photographs were taken and a methodical survey of the environment was carried out to describe the types of land cover and assess the distribution of forest cover in this protected area.

We then administered a questionnaire to a survey population estimated at 130 people, using the itinerary method. To select the localities to be surveyed, we took two criteria into account (distance from the Koba classified forest and population size). There were six (6) places targeted for the survey (Table 2). Bazra is the sub-prefecture closest to the classified forest, followed by two (2) villages and two (2) camps inside the Koba classified forest.

**Table 2: Distribution of respondents by village**

| **Localities** | **Number of people surveyed** |
|---|---|
| Bazra natis | 30 |
| Sokoura | 30 |
| Five junctions | 20 |
| Petit belleville | 20 |
| Neo carefour | 15 |
| Kouakoukro | 15 |
| **Total** | 130 |

Source: our work, 2023

### 1.4.Data processing

#### 1.4.1 Processing satellite images

##### *1.4.1.1. Pre-treatment operations*

The Landsat images (Landat 5 TM 1995, Landsat 7 ETM+ 2010 and Landsat 8 OLI-TIRS 2023) underwent pre-processing operations consisting of radiometric and atmospheric corrections using ENVI. 5.3 software. Next, the normalised vegetation index (NDVI) was used to analyse the distribution of chlorophyll activity over the image as a whole; this made it easier for us to identify wooded and less wooded areas. The choice of bands (B5, B4 and B3) for the colour composition of the images enabled us to better discriminate between land-use classes. Sampling was based on the accessibility and representativeness of the waypoints selected. A total of 234 waypoints were selected, divided into 5 land-use classes (dense forest, open or secondary forest, perennial crop, annual crop and fallow, then habitat and bare soil). A field visit was made to identify these points (training plots). Field truth points were also taken.

##### *1.4.1.2. Classification operations*

In the classification performed, the distribution of pixels in each class follows a normal distribution. Each class is defined by a probability density curve. The method calculates the probability of a pixel belonging to a given class. The pixel will be assigned to the class with the highest probability. This method classifies all

pixels unless a probability threshold is applied, below which pixels with very low probabilities will not be classified. The classification process is as follows: Classification > Supervised > Maximum Likelihood.

The classification results are determined by a number of accuracy indicators such as overall accuracy, the kappa coefficient and the confusion matrix. The supervised classification of our images provided a satisfactory result above the threshold set by Pointus (1993) (80%). Thus, out of a total of 281 reference pixels, 278 pixels were correctly classified, giving an average percentage of correctly classified pixels of 90.93% and a kappa coefficient of 0.9162, i.e. 91.62%.

The classification vector file was imported into Arc-Gis 10.8 to produce land use maps and transition matrices.

### 1.4.2 Method for calculating the overall average annual rate of change in the area of land use classes

The average annual rate of change makes it possible to monitor changes in each type of land cover and also to estimate the increase or decrease in the area of each type of land cover per year (1995, 2010 and 2023).

$$\text{Tx} : \left[\left(\frac{SP2}{SP1}\right)^{1/x}\right] \times 100$$

The overall rate makes it possible to estimate the change or increase in the surface areas of the different categories of occupation in the sub-prefecture.

$$\text{Tx} \left(\frac{SP2-SP1}{SP1}\right) \times 100$$

These formulae reflect the annual and global changes in land use types

NB: Where Tx = rate, SP1 = area at date 1, SP2 = area at date 2.
- If Tx is positive, there is an increase in land use.
- If Tx is negative, there is a decline in land use.

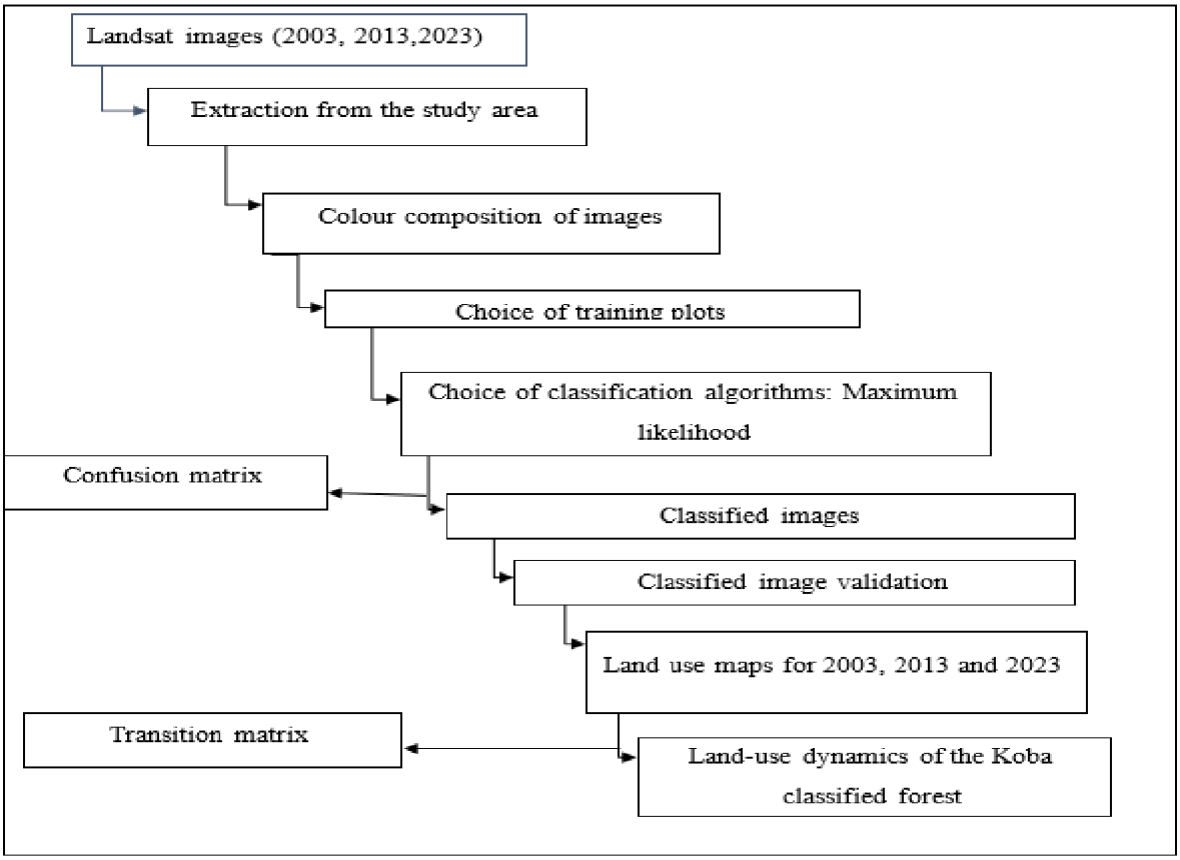



**Figure 2 : Flow chart summarising the methodology for the multi-date analysis of land use in the Koba classified forest.**

## 2. Results:

### 2.1 Land use in 1995, 2010 and 2023

Land use in 1995 showed a relatively humanised but predominantly natural environment (Figure 3). In 1995, open forest covered an area of 12069 ha, i.e. 39% of the total area of this classified forest, and was found almost everywhere. Dense forest covers 2217 ha, or 7% of the total area, and is located more in the north-east of the study area (Figure 3). Humanised areas, represented by annual crops and fallow land, occupy 1,350 ha or 36% of the area. These are planted with food crops and vegetables (cassava, bananas, yams, rice, etc.). Perennial crops account for only 3,848 ha, or around 12%, and at that time were predominantly cocoa, coffee and cotton plantations. Finally, habitats/bare soil occupy 1807 ha, or 6% of the total area of the zone.

In 2010, natural areas such as open forest accounted for 9941 ha, or 32% of the classified forest, while dense forest accounted for only 5%, or around 1470 ha. These natural areas were more concentrated in the north-east of the study area. Humanised areas such as perennial crops consist mainly of cashew nuts. Introduced timidly in the 2000s, this crop has been of increasing economic interest to the farming population in the Koba Forest since the 2010-2020 decade. Perennial crops cover an estimated 9891 ha, or 31% of the total area, and are distributed throughout the zone (Figure 4). By contrast, annual and fallow crops are spread over 3,435 ha, or 11% of the area. This decline is due to the conversion of several annual crop plantations to perennial crop plantations in order to maximise income. Settlements/bare soil occupy 6,792 ha, or 22% of the total area, an increase caused by political instability at the time and the infiltration of migrants.

In 2023, natural areas will be poorly represented, with the smallest surface area of land use. Open woodland covers 3,745 ha, or 12% of the total area, while dense woodland covers 2,266 ha, or 7%. The very few areas of forest are found in isolated locations throughout the forest area (Figure 5).

Humanised areas have a strong spatial influence. Perennial crops predominate in this land use category. Cashew orchards are expanding. Many farmers grow cashew nuts for economic and ecological reasons. According to them, cashew nut cultivation provides a more substantial income to meet all kinds of family needs. They are accompanied by cocoa and coffee plantations, which occupy a very large proportion, nearly 14,412 ha, or 46% of the total area.

**Figure 3: Land use map 1995**

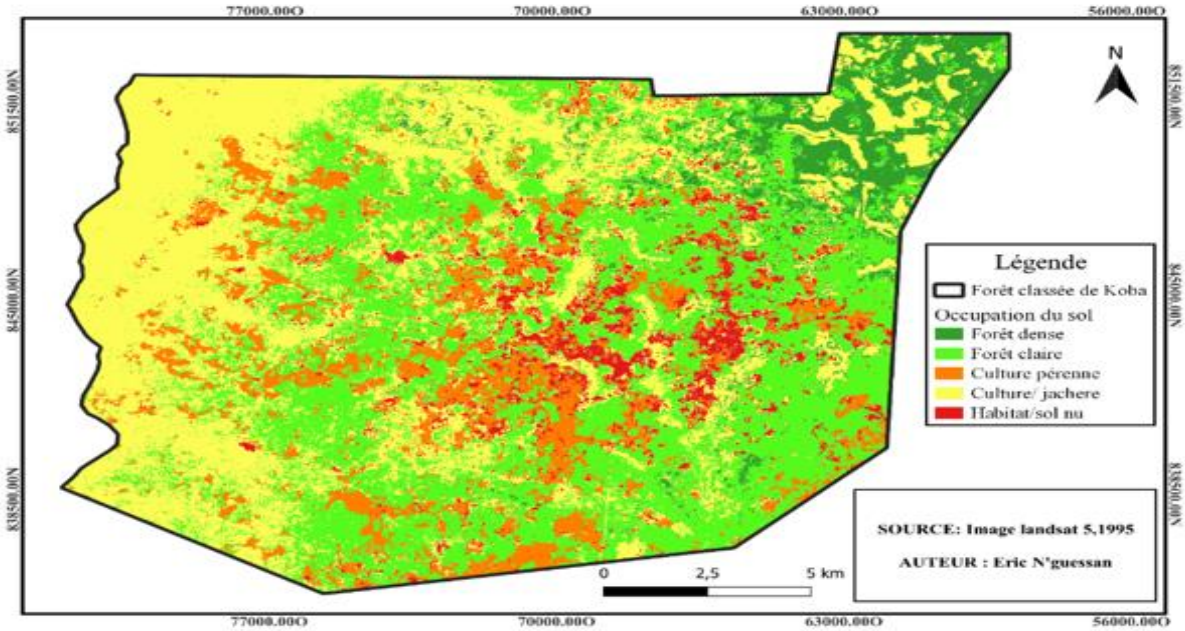


**Figure 4: 2010 land use map**

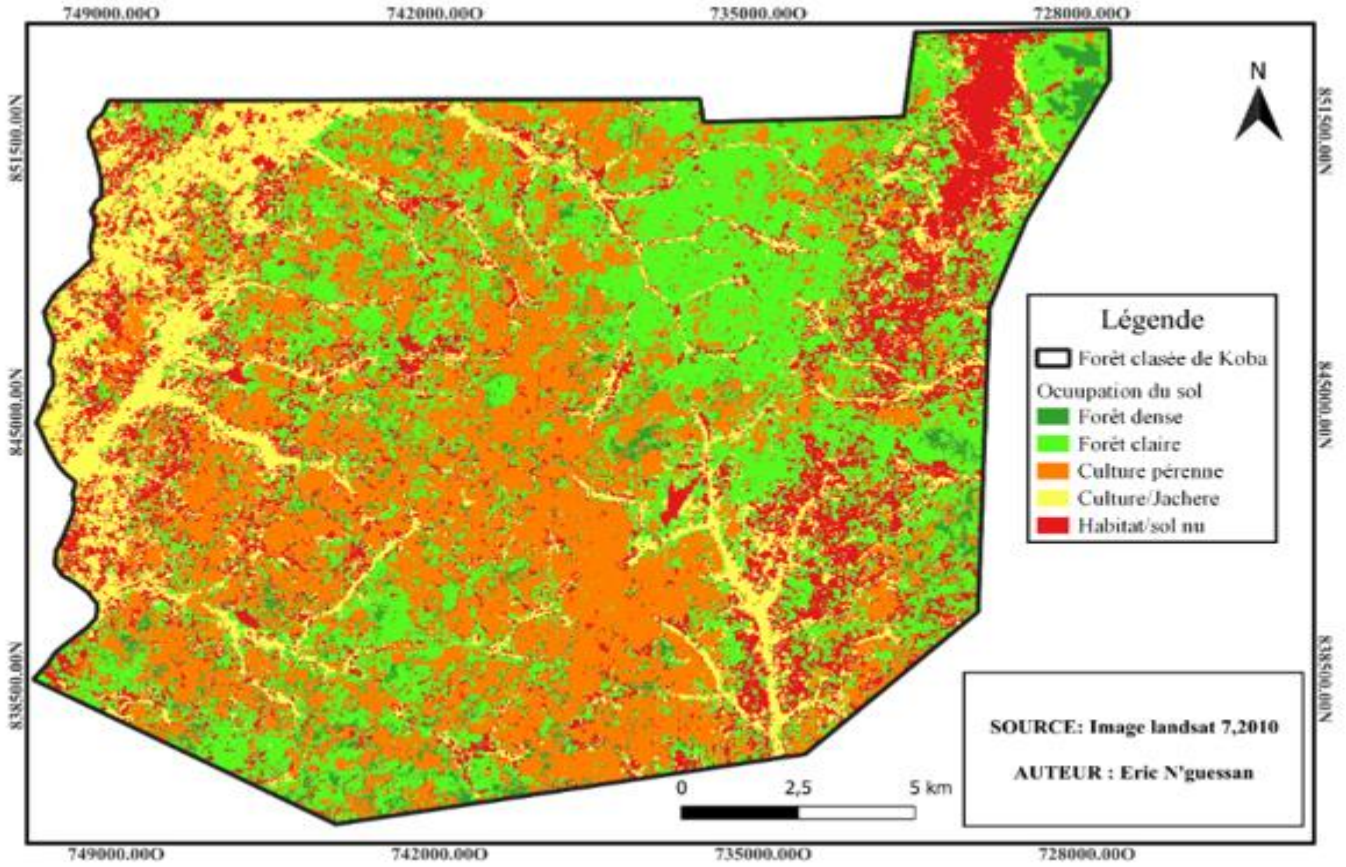
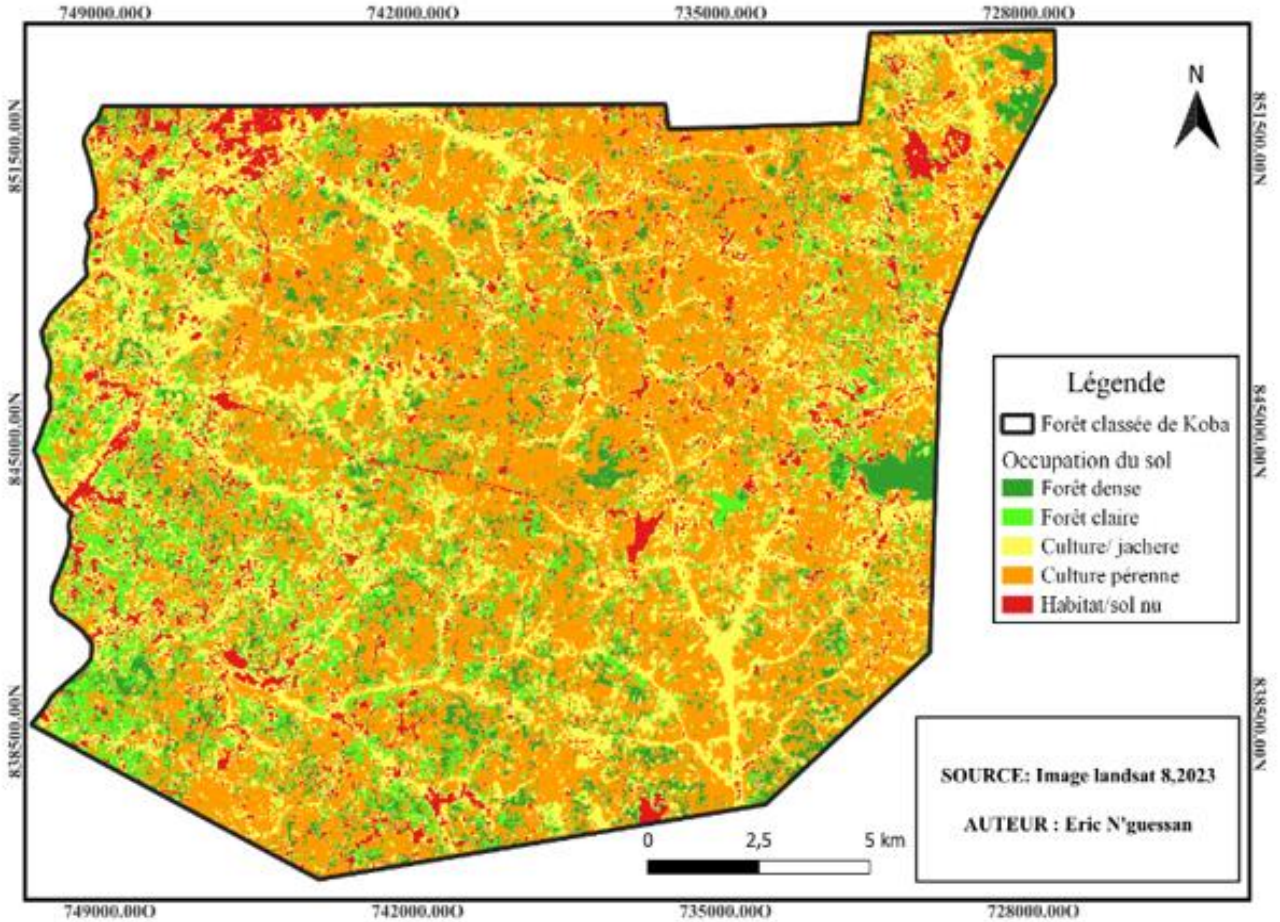



**Figure 5: Land use map 2023**

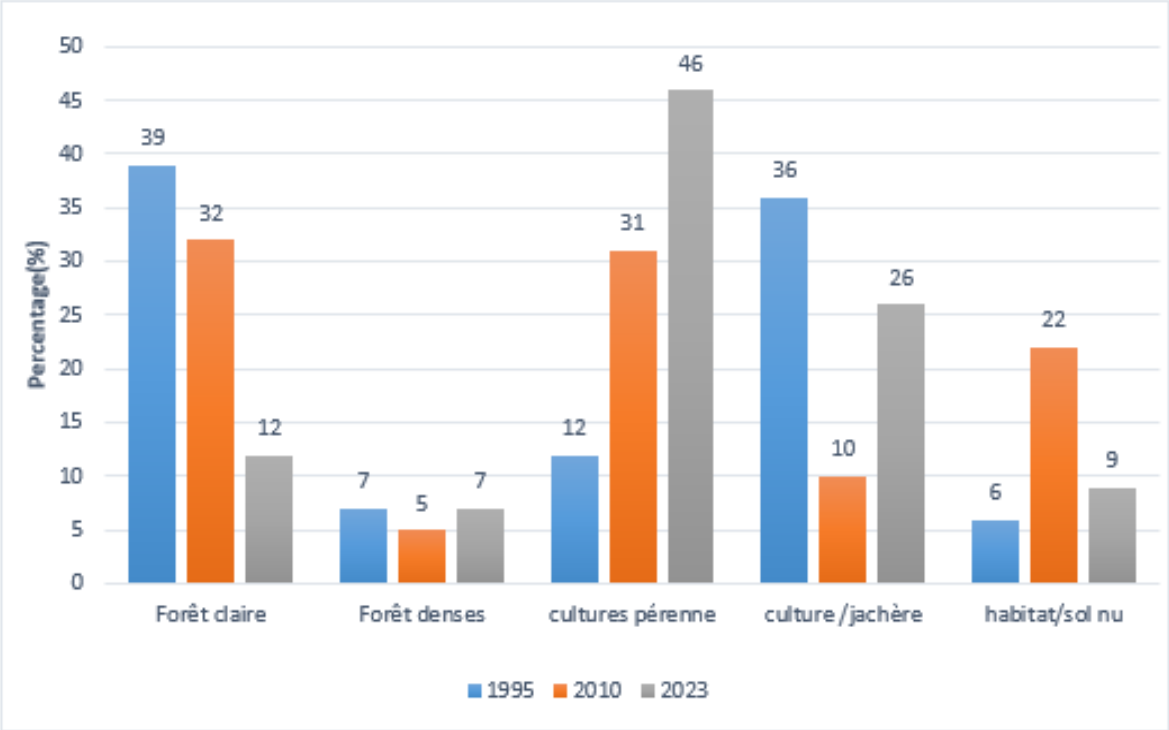


### 2.2 Spatial dynamics of land use in the koba classified forest

#### 2.2.1 Change in the spatial coverage rate of land use classes from 2002 to 2021

The assessment of changes in land use highlights the changes that have taken place between the different periods: 1995-2010; 2010-2023 and 1995-2023.

**.Figure 6: Evolution of land-use classes in the Koba classified forest from 1995 to 2023**




Source : Our work, 2023

In detail, it can be seen that open forest has greatly diminished in the area, from 39% of the area in 1995 to just 6% in 2023. This decline is entirely normal given the pressure on forest areas in the region. The disappearance of forested areas has prompted farmers to move into areas where there is still forest. The classified forests represent the relict areas of primary forest in the country. Crops and fallow land have also declined, from 36% in 1995 to 26% in 2023. This decline is largely due to the increasing scarcity of fallow land.

Perennial crops have increased in 2023. In 1995, perennial crops accounted for just 12% of the total area, but by 2023 they will account for almost 46%. This increase is due to the prices offered by buyers between 2008 and 2017. Perennial crops, mainly cocoa, coffee and cashew nuts, have grown over large areas in order to provide some financial security.

Finally, habitats and bare soil have also seen an increase in 2023. In 1995, this class occupied only 6%, but in 2023 its proportion is estimated at 9%. This increase is due to problems with the demarcation of the forest and the post-military crisis, which led to a wave of migration within the classified forest.

### 2.3 Spatial changes in land-use classes within the Koba classified forest

#### *2.3.1 Surface areas remain stable from 1995 to 2021*

This land use analysis study is based on different dates: 1995, 2010 and 2023. Over this period (1995-2010), we observed variations in the surface area of land use units.

Between 1995 and 2010 (Table 3), only around 9991.35 ha (31%) of the area studied remained unchanged. In more detailed terms, however, the crop/fallow, dense forest and perennial crop classes are fairly stable, at

27%, 35% and 55% respectively. On the other hand, the open forest, habitat and bare soil classes showed low levels of stability at 4% and 22% respectively.

**Table 3: Stable surface area 1995-2010**

| | | Housing/bare ground | Perennial crops | Crop/fallow | Clear forest | Dense forest | total |
|---|---|---|---|---|---|---|---|
| STABLE SURFACE | ha | 399,96 | 2121,3 | 3074,22 | 95,31 | 4300,56 | 9991,35 |
| | % | 22 | 55 | 27 | 4 | 35 | 31 |

Source: Our work, 2023

From 2010 to 2023 (over 13 years), an area of 9281.269 ha out of 31430 ha remained stable, i.e. 29% stable (Table 4). More specifically, the crop/fallow, perennial crop and dense forest classes are moderately stable, at 53%, 52% and 35% respectively. The open forest and habitat/bare soil classes, on the other hand, showed low stability rates of 11% and 14% respectively.

**Table 4: Stable surface area from 2010-2023**

| | | Housing/bare ground | Perennial crops | Crop/fallow | Clear forest | Dense forest | total |
|---|---|---|---|---|---|---|---|
| STABLE SURFACE | ha | 884,14 | 4692,94 | 2369,222 | 987,707 | 347.26 | 9281,269 |
| | % | 14 | 52 | 53 | 11 | 35 | 29 |

Source: Our work, 2023

Finally, from 1995 to 2023 (over 28 years), an area of 7576.81 ha out of 31430 ha remained stable, i.e. 26% stable (Table 5). The crop/fallow and perennial crop classes are moderately stable at 35% and 54% respectively. In contrast, the open forest, dense forest and habitat and bare soil classes recorded a low rate of stability (8%, 12% and 11%).

**Table 5: Stable surface area 1995-2023**

| | | Housing/bare ground | Perennial crops | Crop/fallow | Clear forest | Dense forest | total |
|---|---|---|---|---|---|---|---|
| STABLE SURFACE | ha | 195,12 | 2060 | 3806,26 | 166,87 | 1348,56 | 7576,81 |
| | % | 11 | 54 | 35 | 8 | 12 | 26 |

Source: Our work, 2023

### 2.4.1 Areas that have changed land use

Between 1995 and 2023, the areas of the Koba classified forest underwent general changes. Several land uses have become unstable.

From 1995 to 2010, an area of 21328.05 ha out of 31430 ha was considered unstable, i.e. 69% of the forest (Table 6). The open forest, inhabita/bare soil, crop and fallow and dense forest classes are highly unstable, with 96%, 78%, 73% and 65% respectively. The perennial crop class is moderately unstable at 45%.

**Table 6 : Unstable surface from 1995-2010**

| | | Housing/bare ground | Perennial crops | Crop/fallow | Clear forest | Dense forest | total |
|---|---|---|---|---|---|---|---|
| UNSTABLE SURFACE | ha | 1409,04 | 1729,22 | 8286,7 | 2123,69 | 7779,4 | 21328,05 |
| | % | 78 | 45 | 73 | 96 | 65 | 69 |

Source : Our work, 2023

Then, from 2010 to 2023 (over 13 years), an area of 22001.04 ha out of 31430 ha, with an instability rate of 70% (Table 7). The open forest, habitat/bare soil and dense forest classes are highly unstable, with rates of 90%, 86% and 65%, while the perennial crop and crop/fallow occupancy classes are moderately unstable, with rates of 48% and 47%.

**Table 7 : Unstable surface from 2010-2023**

| | | Housing/bare ground | Perennial crops | Crop/fallow | Clear forest | Dense forest | total |
|---|---|---|---|---|---|---|---|
| UNSTABLE SURFACE | ha | 5907,14 | 4355 | 2162,32 | 8903,32 | 673.26 | 22001,04 |
| | % | 86 | 48 | 47 | 90 | 65 | 70 |

Source: Our work, 2023

Finally, from 1995 to 2023 (over 28 years) an area of 23424.97 ha out of 31430 ha, an instability rate of 74% (table 8). The open forest, habitat/bare soil, dense forest and fallow crop classes are highly unstable, with rates of 65%, 89%, 88% and 65% respectively. On the other hand, the perennial crop occupancy class is moderately unstable at 48%.

**Table 8 : Unstable surface from 1995-2023**

| | | Housing/bare ground | Perennial crops | Crop/fallow | Clear forest | Dense forest | total |
|---|---|---|---|---|---|---|---|
| UNSTABLE SURFACE | ha | 1612,64 | 1787,56 | 7253,86 | 2049,86 | 10721,051 | 23424,971 |
| | % | 89 | 46 | 65 | 92 | 88 | 74 |

Source : Our work, 2023

To better illustrate the tables of unstable surfaces, we have produced maps of instability from 1995 to 2010, from 2010 to 2023 and finally from 1995 to 2023.

### 2.4.3 Conversion and modification of land use classes between 1995 and 2010

Analysis of the 1995-2010 transition matrix reveals a transformation from open forest to other land-use classes. Only 4300.56 ha, or 35%, remained unchanged. However, 7779.4 ha or 65% changed to other land use classes between 1995 and 2010. Thus, 3992.58 ha of open forest became perennial crops, 2278.44 ha became habitat/bare soil, 959.4 ha became annual crops/fallow and 548.42 ha became dense forest. For the dense forest class, 95.31 ha or 4% ha remained intact, but 772.02 ha became habitat/bare ground, 243 ha perennial crop, 224.1 crop/fallow and 884.79 ha open forest.

On the other hand, the perennial crop classes 2121.3 ha or 55% remained stable, while the unstable 1729.22 ha or 45% were transformed into other classes.941 ha were modified into open forest, 485.82 ha became habitats/bare ground and 155.25 ha into crop/ fallow land (Table 9).

The crop/fallow class remained stable at 3074.22 ha (27%). 8286.7 ha, or 73%, became 2862.09 ha of habitat/bare soil, 3103.38 ha of open forest, 2121.3 ha of perennial crops and 199.35 ha of dense forest respectively. 399.96 ha of the bare soil habitat class remained unchanged, but 556 ha were transformed into perennial crops. 669.24 ha were transformed into open forest and 122.67 ha into crops/fallow.

**Table 9: 1995-2010 transition matrix**

| | 2010 | | | | | |
|---|---|---|---|---|---|---|
| 1995 | Housing/bare ground | Perennial crops | Crop/fallow | Dense forest | Clear forest | total |
| Housing/bare ground | 399,96 | 556,74 | 122,67 | 0 | 669,24 | 1809,45 |
| Perennial crops | 485,82 | 2121,3 | 155,25 | 0 | 941 | 3850,52 |
| Crop/fallow | 2862,09 | 2121,3 | 3074,22 | 199,35 | 3103,38 | 11360,34 |
| Dense forest | 772,02 | 243 | 224,1 | 95,31 | 884,79 | 2219,22 |
| Clear forest | 2278,44 | 3992,58 | 959,4 | 548,42 | 4300,56 | 12079,4 |
| total | 6798,33 | 9034,92 | 4535,64 | 1051,07 | 9898,97 | 31430 |

Source : cross-referencing of occupancy map data 1995-2010

### 2.4.4 Conversion and modification of land use classes between 2010 and 2023

The matrix of changes generated by cross-referencing the 2010 and 2023 land use maps for the study area shows the various changes that have taken place in each land use category (Table 10). The natural space classes of open woodland, 987.707 ha, remained stable over the period from 2010 to 2023, i.e. 11%. The other transformations were in favour of 5475.29 ha of perennial crops, 2000 ha of crop/ fallow land, 695.81 ha of habitat/bare soil and 732.21 ha of dense forest.

From 2010 to 2023, 4,692 ha of perennial crops remained stable, i.e. 52%, while the other transformations took place at the expense of 1,518 ha of crops/ fallow land, 1,545.53 ha of open forest, 994 ha of dense forest and 276 ha of habitat/bare ground.

During the same period, 236922 ha of crop/ fallow land remained stable. However, 2162.32 ha (47%) were transformed, 978.72 ha into perennial crops, 710.5 ha into habitat/bare ground, 421.58 ha into open forest and 51.52 ha into dense forest.

As for the habitat/bare soil class, 884.14 ha, or 14%, did not change into other classes. 5907.14 ha or 86% were converted to other classes. 2787.95 ha were converted to perennial crops, 2341.99 ha to crops/fallow and 636.39 ha to open forest.

**Table 10 : Transition matrix 2010-2023**

| | 2023 | | | | | |
|---|---|---|---|---|---|---|
| 2010 | Housing/bare ground | Perennial crops | Crop/fallow | Dense forest | Clear forest | total |
| Housing/bare ground | 884,14 | 2787,95 | 2341,99 | 0 | 636,39 | 6792,36 |
| Perennial crops | 276,06 | 4692,94 | 1518,623 | 0 | 1545,53 | 9027,153 |
| Crop/fallow | 710,5 | 978,72 | 2369,222 | 51,52 | 421,58 | 4531,542 |
| Dense forest | 43,16 | 347,22 | 129,12 | 347,26 | 153,76 | 1020,52 |
| Clear forest | 695,813 | 5475,29 | 2000 | 732,215 | 987,70 | 9891,025 |
| total | 2609,673 | 14282,12 | 8358,955 | 2266,885 | 3744,967 | 31430 |

Source : cross-referencing of data from the 2010-2023 occupancy maps

### 2.4.5 Conversion and modification of land use classes between 1995 and 2023

Analysis of table 11 shows that between 1995 and 2023, areas of natural vegetation were transformed into areas of agricultural activity or urban space. Overall, three types of change are observed: progression, regression and stability.

Between 1995 and 2023, only 1348.56 ha of open woodland remained stable, i.e. 7%. 10,721.05 ha, or 93%, underwent changes. The most significant changes to the open forest are to 6178.12 ha of perennial crops, 2764ha of dense forest, 1105.21ha of crops/fallow and 673.58ha of habitat/bare ground.

As for crops and fallow land, 3,806.26 ha remained stable, almost 34%; the other changes were in favour of 4,022.1 ha of perennial crops and 1,421.81 ha of bare soil habitat.

195.12 ha of habitat/bare land remained unchanged. However, 1,612.64 ha (89%) were converted to other classes. 944.14 ha were transformed into perennial crops, 378.55 ha into fallow crops and 165.36 ha into open forest.

However, 2060.4 ha of perennial crops remained stable, i.e. 53%. The other changes in this class were at the expense of 778.46 ha of crop/fallow, 523.98 ha of open forest and 195.4 ha of habitat/bare ground.

**Table 11 : Transition matrix 1995-2023**

| | 2023 | | | | | |
|---|---|---|---|---|---|---|
| 1995 | Housing/bare ground | Perennial crops | Crop/fallow | Dense forest | Clear forest | total |
| Housing/bare ground | 195,12 | 944,14 | 378,55 | 0 | 165,36 | 1807,79 |
| Perennial crops | 195,4 | 2060,4 | 778,46 | 0 | 523,98 | 3847,96 |
| Crop/fallow | 1421,81 | 4022,1 | 3806,26 | 289,72 | 1520,23 | 11060,12 |
| Dense forest | 124,34 | 1107,28 | 631,14 | 166,87 | 187,1 | 2216,73 |
| Clear forest | 673,58 | 6178,12 | 1105,21 | 2764,141 | 1348,56 | 12069,611 |
| total | 2610,25 | 14312,04 | 6699,62 | 3635,071 | 3745,23 | 31430 |

Source : cross-referencing of data from 1995-2023 occupancy maps

**Discussion :**

Spectral recognition analysis of satellite images has identified five (5) categories of land use, including (dense forests; open forests; habitats/bare soil; crops/fallow and perennial crops). However, the separability of the forest classes (dense forests, open forests and perennial crops) is not very rigorous due to the similar spectral responses of these plant formations. These difficulties have been pointed out by several authors, such as J. Avakoudjo et al (2014, p.7) and Zanguin et al (2022, p. 14). However, despite these difficulties, the results obtained remain satisfactory in terms of the overall high accuracy of the treatment assessment. The classification of the 1995, 2010 and 2023 images produced kappa indices of 0.91, 0.89 and 0.90 respectively. These cartographic accuracies are in the same orders of magnitude as the values obtained by several authors, notably, T. A. Ouattara (2017, p.9) in his study of land use in the Mé region and K. E. Konan et al (2022, p42) on the spatio-temporal evolution of the Anguededou classified forest.

According to R.G Pontius (2000), a land cover study can be validated if the image classification results are greater than 0.75. From the same perspective, the present classifications are good and usable.

This study highlighted the dynamics of land use and changes in the Koba classified forest in the department of Vavoua. The evaluation of spatio-temporal changes in land use in this forest from 1995 to 2023 shows that

forest formations (dense forests and open forests) have decreased by 67%, while the areas under fields, perennial crops, annual crops and fallow have increased by 249% respectively over the 28 years. This decline in forest resources in favour of agricultural areas is a phenomenon that has been on the increase in recent decades in West Africa. These results are similar to those of H.D. N'da et al (2008), on their remote sensing and monitoring of deforestation in the Marahoué National Park and H. Diallo et al (2011), in their study of the evolutionary dynamics of the vegetation of the Fina reserve in Mali. In their respective studies, they highlighted a rate of forest degradation in favour of agricultural activities. This process of degradation of natural vegetation is generally linked to the extensive development of the plantation economy.

According to J Avakoudjo et al (2011, p.6), the increase in the area under perennial crops (cocoa, coffee, cashew nuts) and annual crop fields is taking place in order to feed an ever-growing population, which justifies the reduction in the length of fallow periods and the year-on-year increase in anthropised areas. This phenomenon can be observed in several regions of West Africa, particularly in Burkina Faso, as indicated by H. Sawadogo et al (2008, P.5) in their study of the evolution of land use in the Yatenga region. This is also the case in Benin, in the Commune of Karimama in the north of the country, which is occupied by the W National Park, but the increasing scarcity of arable land is forcing farmers to direct the agricultural front towards the interior of the W National Park (SNV, 2004, p.11), which accelerates the fall in the physico-chemical parameters of the soil in the face of this over-exploitation of the land's potential. This degraded land produces less food, reduces the availability of biomass fuel, makes ecosystems more resistant, and increases malnutrition and susceptibility to disease among local populations.

These changes are due to the spread of perennial crops, which are the main source of income for people living near the Koba classified forest. There is also the saturation of rural areas, which is pushing people to seek out new land suitable for agriculture. It is through this that natural plant formations are converted into artificial plant formations. These results corroborate those of S. Bigot et al (2005), who showed that changes to forest landscapes occur as a result of degradation. For A.G.Adou et al (2018,p47) in their work on Anthropisation du milieu et dynamique forestière : cas de la forêt classée du Haut-Sassandra (Centre-Ouest de la Côte d'Ivoire). They admit that the dense forest lost 17561 ha (32.56%), 5680 ha (10.53%) and 1123 ha (2%) respectively between 2000 and 2018 to the benefit of secondary forest, crops and fallow land, a result that confirms our findings. This study therefore makes it possible to identify man's hold on this protected area and to assess the extent of its degradation. The cartographic data obtained will enable the structures responsible for its protection to develop strategies for better management of this heritage.

**Conclusion :**

This study made it possible to monitor and understand spatio-temporal changes in the landscape of the Koba classified forest using remote sensing images, field data and digital mapping tools. The various land-use maps and transition matrices were used to monitor changes in land-use dynamics. On the other hand, the stability and instability maps highlight the various transformations that have occurred in the Koba classified forest over the last 28 years. This monitoring shows that the state of its vegetation cover and its evolution between 1995 and 2023 seem alarming, with a rapid expansion of agricultural areas to the detriment of forest formations. Major transformations or changes in the Koba classified forest in the department of Vavoua were thus determined thanks to the various processing and analysis possibilities offered by remote sensing and GIS. Between 1995 and 2023, major spatial changes were observed in the direction of progressive degradation of the plant cover. Farmers in Koba and the surrounding area are virtually destroying the dense forest and open woodland classes in favour of perennial and annual crops. The various changes observed in the classified forest can be explained by both human and natural factors. The main factors behind these spatial changes are extensive agriculture, population growth, human activities and rainfall variability, which is in one way or

another dependent on human activities. For decades, the Koba classified forest has been subject to migratory movements for agricultural purposes, making the locality the scene of all kinds of agricultural practices.

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