e-ISSN (Online): 2790-3230

Spatiotemporal dynamic of the Land Use Units (LUU) of the Goroubi Classified Forest (GCF) in north Benin

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Abstract

The anthropogenic pressures of the Goroubi Classified Forest (GCF) have led to changes in its occupation units. This research aims to assess the spatiotemporal dynamics of the different units of land use in this forest between 1999-2019. To achieve this, Landsat TM 1999, 2009 and Landsat OLI/Tirs 2019 satellite images were used. The diachronic analysis, the average annual rate of spatial evolution and the transition matrix made it possible to know the changes and the conversions undergone by the land cover types of the forest in association with the field controls. The classification reveals that between 1999 and 2009, out of the 05 occupation units, 04 experienced a regression (open forest and shrubby savannah, woody and shrubby savannah, swamps and waterbody). Swamps experienced the greatest regression, dropping from 252.056 ha in 1999 to 202.962 in 2009 with an average annual rate of expansion of -1.95%. On the other hand, the mosaics of farms and fallow land increased by 62.103 ha in their area, going from 123.731 ha in 1999 to 185.833 ha in 2009, that is a rate of +5.02%. In 2019, four (04) occupation units exist in the forest. Indeed, open forests and shrubby savannahs, and bodies of water have been completely converted into wooded and shrubby savannahs, and rice-growing areas. This last unit (rice-growing area) is a new unit that appeared in 2019; this indicates the strong anthropization of the forest. To control this strong anthropization, it is necessary to convert farmers to nursery activities, plantations maintenance, etc. and ensure compliance with the texts while defining a new land use policy for the GCF.

Keywords: Goroubi classified forest (GCF), spatiotemporal dynamic, land use units, Benin

Résumé

Les pressions anthropiques de la Forêt Classée de Goroubi (FCG) ont induit des changements sur ses unités d'occupation. Cette recherche vise à apprécier la dynamique spatiotemporelle des différentes unités d'occupation du sol de cette forêt entre 1999-2019. Pour y parvenir, des images satellites Landsat TM 1999, 2009 et Landsat OLI/Tirs 2019 ont été mises à contribution. L'analyse diachronique, le taux moyen annuel d'évolution spatiale et la matrice de transition ont permis de connaitre les changements et les conversions subis par les unités d'occupation du sol de la forêt en association avec les contrôles de terrain. La classification révèle qu'entre 1999 et 2009, sur les 05 unités d'occupation, 04 ont connu une régression (forêt claire et savane arbustive, savane arborée et arbustive, marécages et plan d'eau). Les marécages ont connu la plus grande régression, passant de 252,056 ha en 1999 à 202,962 en 2009 avec un taux moyen annuel d'expansion de -1,95 %. Par contre, les mosaïques de champs et jachères ont progressé de 62,103 ha de leur superficie en passant de 123,731 ha en 1999 à 185,833 ha en 2009, soit un taux de +5,02 %. En 2019, quatre (04) unités d'occupation existent dans la forêt. En effet, les forêts claires et savanes arbustives, et les plans d'eau se sont totalement convertis en savanes arborée et arbustive, et en zones de rizicole. Cette dernière unité (zone de riziculture) est une nouvelle unité apparue en 2019 ; ce qui indique la forte anthropisation de la forêt. Pour contrôler cette forte anthropisation, il faut une conversion des agriculteurs vers les activités de pépinière, d'entretien des plantations, etc. et veiller au respect des textes tout en définissant une nouvelle politique d'exploitation des terres de la FCG.

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Soumis le 30 septembre 2022 **Accepté pour publication le 15 décembre 2022**

Mots Clés : forêt classée de Goroubi (FCG), spatiotemporelle dynamique, unités d'occupation du sol, Bénin

1. Introduction

Forest ecosystems, natural or man-made, are of paramount importance to human societies through the provision of timber, non-timber products and environmental services (Dujin *et al.* quoted by Kpatinnon and Oussou, 2016). Indeed, apart from lumber, service and wood-energy which plays an important role in the economy of the countries, the forest offers many products and services having a significant weight in the life of the populations (food, traditional pharmacopoeia, hunting, recreation and cultural services, etc.) (CEREEC, 2015). Unfortunately, despite the importance of these ecosystems for communities, they are exposed to strong pressures of various kinds. For Katadjo (2014), several daily practices of men, such as the extension of plantings using the practice of slash and burn agriculture, poaching and ignorance of the value of biological resources, increase the pressure on the natural environment. Thus, each year, about 65,000 ha of forests disappear (FAO, 2009). Indeed, between 2000 and 2010, there was a net loss of forest area of 7 million hectares per year in tropical countries and a net gain in agricultural land area of 6 million hectares per year (FAO, 2016). For Sah (2009), this regression of vegetation cover is mainly linked to human activities (clearing, overexploitation, overgrazing, bush fires, etc.).

In Benin, the strong dependence of populations on forest resources has led to the fragmentation of forests and vast forest ecosystems are reduced to relict forests. The latter are the remnants of the original forests that have suffered degradation, but still retain some species to which the populations grant importance (Ali, 2014). In effect, the main consequence of agricultural practices is the destruction of flora (Ajavon *et al.,* 2018). In northern Benin, land use changes are one of the main factors, which leads to the degradation of the various plant formations to the detriment of the extension of cotton fields. This degradation is all the more worrying due to climatic conditions and demographic pressures (Djohy *et al*., 2016). In the Commune of Karimama, the most visible manifestations of environmental degradation are the decline of plant cover, the disappearance of animal species and the extension of erosion in all its forms. What are the changes undergone by this Goroubi classified forest in time and space? This research aims to assess the spatiotemporal dynamics of the land use units of the Goroubi classified forest in order to propose sustainable safeguard and conservation measures.

2. Material and Methods

2.1. Study area

Located in the district of Birni-Lafia, the Goroubi Forest classified is between 11°54'51" and 11°56'49" north latitude then between 3°15'23" and 3°16'17" longitude east in northern Benin. The district of Birni-Lafia is limited to the north by the Republic of Niger, to the south by the Commune of Malanville, to the east by the Commune of Malanville and the Republic of Niger, and to the west by the district of Karimama. This forest is placed under the forest cantonment of Goun-Goun in the Commune of Malanville and covers an area of 402 ha (figure 1). Due to its geographical location, the Commune of Karimama benefits from a unimodal Sahelo-Sudanese climate with two seasons. Annual rainfall amounts vary considerably between 600 and 1300 mm (Météo-Bénin, 2017).

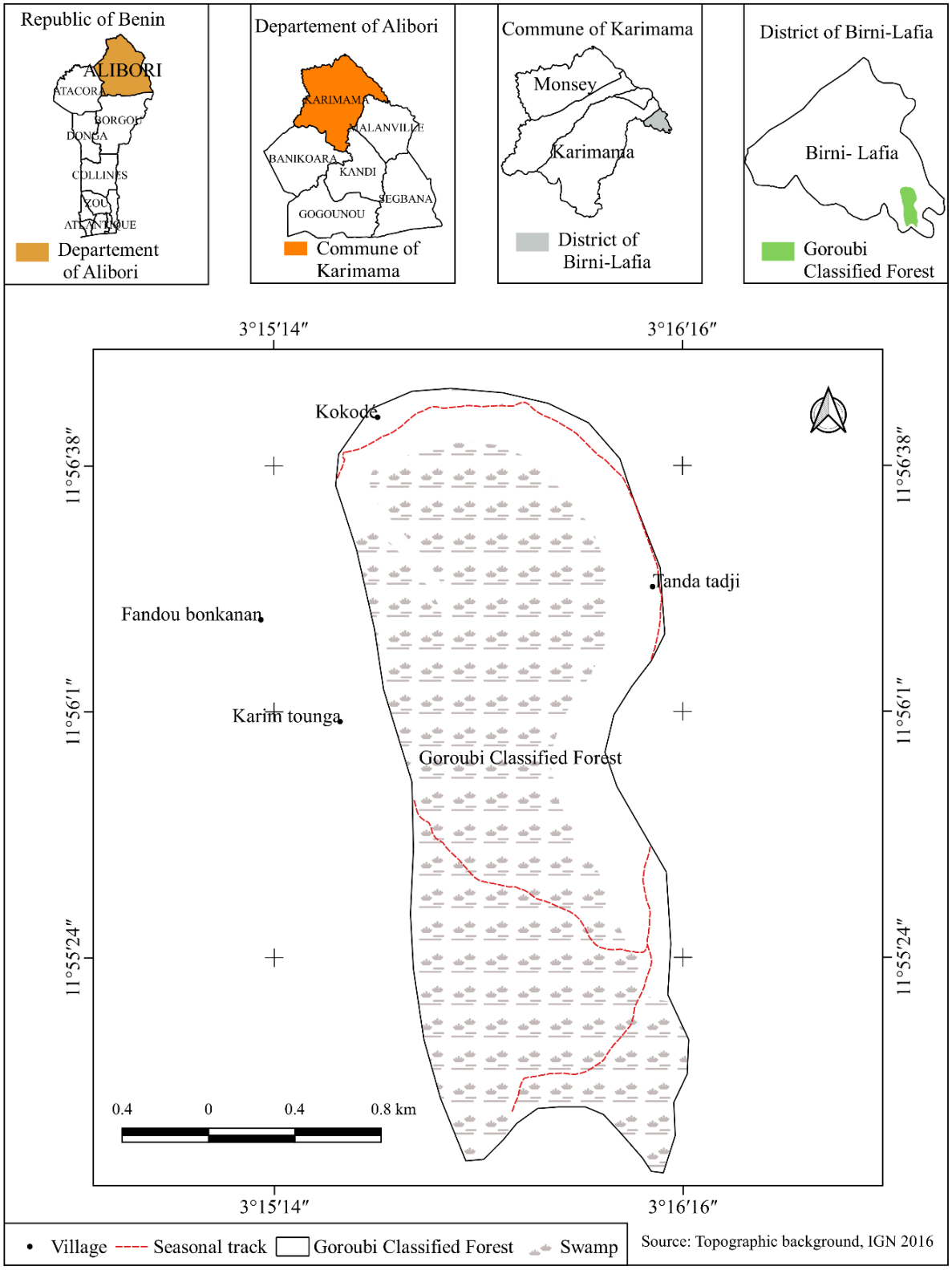


Figure 1 : Geographical location of the Goroubi classified forest

2.2. Methodology

For this research Landsat TM 1999, 2009 and Landsat OLI/Tirs 2019 satellite images were used to assess the dynamics of land use units. They were obtained from the platform https://earthexplorer.usgs.gov/ at 30 metres resolution, processed and classified. They have also been used for contrast enhancements, colour composition, study area extraction, image wedging, etc. The supervised classification of images with the colored composition "3-4-5" used the Maximum Likelihood method in Envi 5.1 software, in order to highlight the state of the land use. Finally, ArcMap 9.3 software was used for image digitisation, layer overlay, surface area calculation for each unit, data cross-referencing to detect changes, etc. which resulted in the mapping of LUU. To this is added a field check carried out in May 2019 for a better location of the LUU.

- **Diachronic analysis**

The evolution of the different LUU was assessed by the following formula:

$$\Delta\alpha = P_1 - P_0$$ (Kpatinnon and Oussou, 2016)

with $\Delta\alpha$: variation of the proportions between P_1 and P_0;

P_1 : proportion of a LUU in a time t_1 ;

P_0 : proportion of the same LUU in a time t_0.

For this LUU, three cases can arise:

- $\Delta\alpha = 0$: stability of the unit of occupation;
- $\Delta\alpha < 0$: regression of the occupation unit;
- $\Delta\alpha > 0$: progress of the occupying unit.

- **Average annual rate of spatial change**

The average annual rate of spatial change expresses the proportion of each unit of vegetation that changes per year. This annual rate (**Ta**) is calculated using the following formula:

$$Ta = \frac{S2-S1}{S2\,(t2-t1)}x100$$ Arouna (2012)

With **S1** the area of a vegetation unit at date **t1**, **S2** the area of the same vegetation unit at date **t2** and **t** the number of years between **t1** and **t2**.

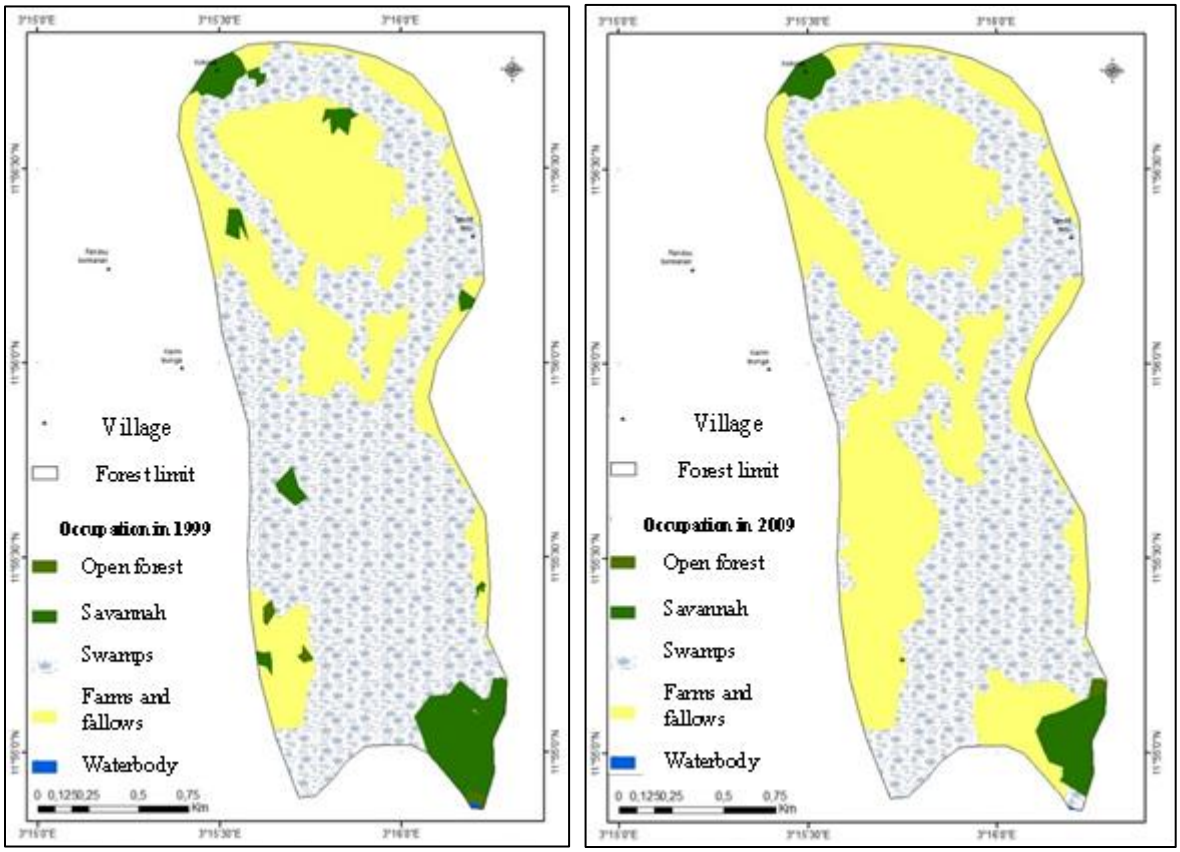
- **Transition matrix**

The transition matrix has made it possible to highlight the different forms of conversion that the plant formations have undergone between 1999, 2009 and 2019. The transition matrix is made up of X rows and Y columns. The number X of rows of the matrix indicates the number of LUU at time t0; the number Y of columns of the matrix is the number of occupation classes converted at time t1 and the diagonal contains the areas of the units which have remained unchanged. The transformations are therefore made from the rows to the columns. The areas of these units were calculated from the crossing of the occupation maps using the *Intersect* function of the *Arctoolbox* toolbox of the ArcMap 9.3 software.

3. Results

3.1. Diachronic analysis of GCF land use units between 1999 and 2009

The state of occupation of the Goroubi classified forest was mapped over the period 1999-2009. This made it possible to observe the various changes undergone by the occupation units between these two dates. Figure 2 shows the state of the forest between 1999 and 2009.



Source: GNI data, 2016 ; Landsat TM 1999 and 2009 image 2022

Figure 2: State of land use in the Goroubi classified forest between 1999 and 2009

Analysis of figure 2 reveals that in 1999, 05 occupation units are identified and they are also observed in 2009. But these units have undergone changes in time as well as in space (table I).

Table I: Statistics of land use units between 1999 and 2009

LUU	Status in 1999		Status in 2009		Balance 1999 and 2009	
	Sup in Ha	Proportion (%)	Sup in Ha	Proportion (%)	Sup in Ha	Proportion (%)
OFSS	1.338	0.33	0.620	0.15	-0.719	-0.18
WSS	25.451	6.32	13.237	3.29	-12.213	-3.03
Sw	252.056	62.59	202.962	50.40	-49.093	-12.19
MFF	123.731	30.73	185.833	46.15	+62.103	+15.42
BW	0.119	0.03	0.041	0.01	-0.078	-0.02

Total	402.693	100	402.693	100

Source: Landsat TM 1999 and 2009 images classification results

Legend: LUU: Land Use Unit; **Sup:** area; **OFSS**: Open Forest and Shrubby Savannah; **WSS**: Woody and Shrubby Savannah; **Sw**: Swamp; **MFF**: Mosaic of Farms and Fallows; **BW**: Body of Water. (-) = regression; (+) = progress

The analysis of table I shows that all the LUU of the GCF underwent great changes during the period 1999-2009. Indeed, out of the 05 occupation units, 04 experienced a regression (Open Forest and Shrubby Savannah, Woody and Shrubby Savannah, Swamps and Body of water). The Swamps experienced the greatest regression, going from 252.056 ha in 1999 to 202.962 in 2009 ha, a loss of 49.093 ha and therefore a proportion of -12.19%. On the other hand, only the Mosaics of Farms and Fallows experienced an increase of 62,103 ha of their area from 123.731 ha in 1999 to 185.833 ha in 2009, a proportion of 15.42%. Thus, the evolution of the different LUU from 1999 to 2009 was analysed through the average annual rate of spatial evolution. These rates (Ta) are calculated in table II.

Table II: Annual average rate of LUU spatial evolution 1999-2009

LUU	Sup in 1999 (in ha)	Sup in 2009 (in ha)	Rate (Ta) in %
OFSS	1.338	0.620	-5.37
WSS	25.451	13.237	-4.80
Sw	252.056	202.962	-1.95
MFF	123.731	185.833	+5.02
BW	0.119	0.041	-6.54
Total	**402.693**	**402.693**	

Source: Landsat TM 1999 and 2009 images classification results

Legend: LUU: Land Use Unit; **Sup:** area; **OFSS**: Open Forest and Shrubby Savannah; **WSS**: Woody and Shrubby Savannah; **Sw**: Swamp; **MFF**: Mosaic of Farms and Fallows; **BW**: Body of Water. (-) = regression; (+) = progress

From the analysis of table II, it emerges that the Open Forest and Shrubby Savannah, Woody and Shrubby Savannah and Waterbody are experiencing the greatest annual regressive changes. On the other hand, the Mosaics of Farms and Fallows which know a faster progressive annual evolution. The various conversions made between LUU were analysed.

3.2. Conversion of land use units between 1999 and 2009

The dynamics of LUU from 1999 to 2009 is synthesized by the transition matrix. In the row and column cells are respectively the LUU 1999 and 2009. Conversions are made from rows to columns (table III).

Table III: Land use transition matrix from 1999 to 2009

U 2009 / U 1999	OFSS	WSS	Sw	MFF	BW	Total 1999
OFSS	0.039	0.527	0.773	0	0	**1.338**
WSS	0.576	12.698	0.652	11.525	0	**25.451**
Sw	0.005	0.012	201.461	50.578	0	**252.056**
MFF	0	0	0	123.731	0	**123.731**
BW	0	0	0.078	0	0.041	**0.119**
Total 2009	**0.620**	**13.237**	**202.962**	**185.833**	**0.041**	**402.693**

Source: Landsat TM 1999 and 2009 images classification results

Legend: OFSS: Open Forest and Shrubby Savannah; **WSS**: Woody and Shrubby Savannah; **Sw**: Swamp; **MFF**: Mosaic of Farms and Fallows; **BW**: Body of Water.

In Table III, the cells on the diagonal (yellow color) correspond to the areas of the units that remained stable between 1999 and 2009. The areas that are outside the diagonal represent the conversions of LUU. This conversion was appreciated for each LUU.

3.3. Evolution of land use units between 1999 and 2009

From 1999 to 2009, the surface area of open forests and shrubby savannahs fell from 1.338 ha to 0.620 ha with an average annual rate of change of -5.37%. In its initial area, only 0.039 ha remained stable. The rest has been converted into woody and shrubby savannahs (0.527 ha) and swamps (0.773 ha). On the other hand, they received 0.576 ha and 0.005 ha respectively of wooded and shrubby savannahs, and swamps. Between 1999 and 2009, the area of wooded and shrubby savannahs increased from 25.451 ha to 13.237 ha; an average rate of change of -4.80%. During this period, 12.698 ha of its area remained stable. At the same time, 0.576 ha were converted into open forests and shrub savannahs. In addition, 0.652 ha have been converted to swampland and the largest conversion is made to mosaic farms and fallows (11.525 ha). These wooded and shrubby savannahs received an area of 0.012 ha of swamps and 0.527 ha of open forests and shrubby savannahs.

The wetland areas increased from 252.056 ha in 1999 to 202.962 ha in 2009. The average annual rate of change for this unit is estimated at -1.95%. During his evolution, a small part was converted into open forests and shrub savannahs (0.005 ha), wood and shrub savannahs (0.012 ha) and the large part was transformed into a mosaic of farms and fallow land (50.578 ha). These swamps have gained an area estimated at 0.078 ha from bodies of water, 0.652 ha from wooded and shrubby savannahs and 0.773 ha from open forests and shrubby savannahs.

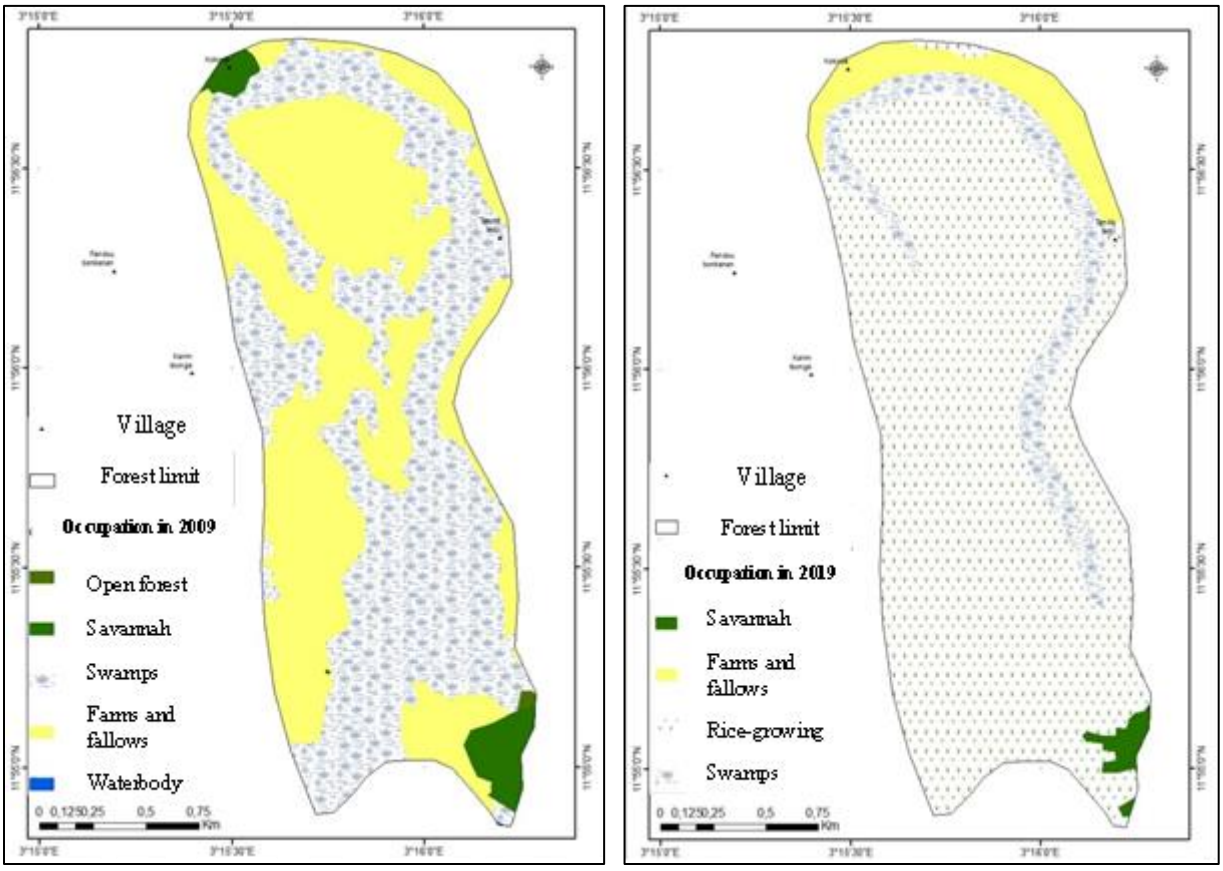
The mosaics of farms and fallows experienced no loss during the period 1999-2009. On the contrary, they won not only wooded and shrubby savannahs (11.525 ha), but also swamps (50.578 ha). They therefore went from an area of 123.731 ha in 1999 to 185.833 ha in 2009, an average annual rate of change of 5.02%.

This area gained is the largest conversion observed between the two dates and therefore proves that the forest has become a main cultivation area.

Water bodies occupied an area of 0.119 ha in 1999 and were reduced to 0.041 ha in 2009, an average annual rate of change of -6.54%. The area lost (0.078 ha) is converted to swamps. This unit (water bodies) experienced no gain between 1999 and 2009.

3.4. Diachronic analysis of GCF land use units between 2009 and 2019

The occupation of the Goroubi classified forest between 2009 and 2019 was mapped in order to observe the changes of the different occupation units. Figure 3 shows the occupation states of this forest between 2009 and 2019.



Source: GNI data, 2016; Landsat TM 2009 and Landsat OLI/Tirs 2009 image, May 2022

Figure 3: State of land use in the Goroubi classified forest between 2009 and 2019

The analysis of figure 3 shows that in 2009, 05 units are identified, but in 2019, 04 units are obtained with the appearance of a new unit (rice-growing area). These units thus underwent changes during the two dates. Table IV presents the statistics of the different units between 2009 and 2019.

Table IV : Statistics of land occupation units between 2009 and 2019

LUU	Status in 2009		Status in 2019		Balance 2009 and 2019	
	Sup in Ha	Proportion (%)	Sup in Ha	Proportion (%)	Sup in Ha	Proportion (%)

OFSS	0.620	0.15		0	-0.620	-0.15
WSS	13.237	3.29	4.488	1.11	-8.7490	-2.17
Sw	202.962	50.40	44.049	10.94	-158.913	-39.46
MFF	185.833	46.15	26.396	6.55	-159.437	-39.59
BW	0.041	0.01		0	-0.041	-0.01
RF			327.760	81.39	+327.760	+81.39
Total	402.693	100	402.694	100		

Source: Classification results of Landsat TM 2009 and Landsat OLI/Tirs 2019 images
Legend: LUU: Land Use Unit; **Sup:** area; **OFSS**: Open Forest and Shrubby Savannah; **WSS**: Woody and Shrubby Savannah; **Sw**: Swamp; **MFF**: Mosaic of Farms and Fallows; **BW**: Body of Water; **RF**: Rice fields. (-) = regression; (+) = progress

It emerges from the analysis of table IV that all the LUU of the GCF underwent major transformations in 2019. Indeed, all the 05 occupation units of the initial date (Open Forest and Shrubby Savannah, Woody and Shrubby Savannah, Swamps, Mosaic of Farms and Fallows and Body of Water) experienced a regression. The swamps and the Mosaics of Farms and Fallows are the occupation units that have experienced the greatest regressions. The units have therefore undergone changes and the average annual rate of spatial evolution are summarised in table V.

Table V: Annual average rate of spatial evolution of LUU 2009-2019

LUU	Sup in 2009 (in ha)	Sup in 2019 (in ha)	Rate (Ta) in %
OFSS	0.620	0	-10
WSS	13.237	4.488	-6.61
Sw	202.962	44.049	-7.83
MFF	185.833	26.396	-8.59
BW	0.041	0	-10
RF		327.760	+32.78
Total	**402.693**	**402,69**	

Source: Classification results of Landsat TM 2009 and Landsat OLI/Tirs 2019 images
Legend: LUU: Land Use Unit; **Sup:** area; **OFSS**: Open Forest and Shrubby Savannah; **WSS**: Woody and Shrubby Savannah; **Sw**: Swamp; **MFF**: Mosaic of Farms and Fallows; **BW**: Body of Water; **RF**: Rice fields. (-) = regression; (+) = progress

It emerges from the analysis of table V that open forests and shrubby savannahs, wooded and shrubby savannahs, mosaics of farms and fallow land and bodies of water have experienced the most severe annual regressive changes. It is only the new occupation unit that appeared in 2019 (rice-growing area) that has increased each year.

3.5. Conversion of land use units between 2009 and 2019

The conversions observed between LUU from 2009 to 2019 are summarised in the transition matrix (table VI).

Table VI: Land use transition matrix between 2009 and 2019

U 2019 / U 2009	WSS	Sw	MFF	RF	Total 2009
OFSS	0.002	0	0	0.618	**0.620**
WSS	4.486	0	3.470	5.281	**13.237**
Sw	0	44.049	11.629	147.284	**202.962**
MFF	0	0	11.309	174.524	**185.833**
BW	0	0	0	0.041	**0.041**
Total 2019	**4.488**	**44.049**	**26.408**	**327.747**	**402.693**

Source: Classification results of Landsat TM 2009 and Landsat OLI/Tirs 2019 images

Legend: FCSA: Open Forest and Shrubby Savannah; **SASa**: Woody and Shrubby Savannah; **MAR**: Swamp; **MCJ**: Mosaic of Farms and Fallows; **PE**: Body of Water; **RF**: Rice fields.

Analysis of table VI reveals 05 LUU in 2009 and 04 LUU in 2019. This difference in the number of occupation units is linked not only to the total conversion of two occupancy units (the open forests and shrubby savannahs and the water bodies) observed in 2009 only and the appearance of a new occupation unit (rice-growing areas) in 2019.

3.6. Evolution of land use units between 2009 and 2019

In 2009, the area of open forests and shrubby savannahs was 0.620 ha. In 2019, this unit completely converted. It gave way to wooded and shrubby savannahs (0.002 ha) and rice-growing area (0.618 ha) with an average annual rate of change of -10%.
Between 2009 and 2019, wooded and shrubby savannahs increased from 13.237 ha to 4.488 ha. During this period, 4.486 ha of its area remained stable. But 3.470 ha of their areas have been converted into a mosaic of farms and fallow land and 5.281 ha have been converted into rice-growing areas. These wooded and shrubby savannahs initially received 0.002 ha of open forests and shrub savannahs. Its average annual rate of change is -6.61%.

The area of swamps increased from 202.962 ha to 44.049 ha between 2009 and 2019; an average annual rate of change of -7.83%. Between the two dates, the large area of this unit is converted into distinct rice-growing areas (147.284 ha) and a small area (11.629 ha) has become a mosaic of farms and fallows. The area that remained unchanged during the period is estimated at 44.049 ha without the minimum gain.

The mosaics of farms and fallows gained an area of 11.629 ha of swamps and 3.470 ha of wooded and shrubby savannahs during the period 2009-2019. Unfortunately, they have mostly turned into well-demarcated rice-growing areas (174.524 ha). Only 11.309 ha of their areas remained unchanged during the period, an average annual rate of change of -8.59%.

Like open forests and shrubby savannahs, bodies of water which occupied an area of 0.041 ha in 2009 were completely converted in 2019, an average annual rate of change of -10%. They are completely converted into rice-growing areas.

The rice-growing areas appeared in 2019 and therefore had no area in 2009. They therefore only increased over the period 2009-2019. On the one hand, the rice-growing areas are the results of the small conversion of open forests and shrub savannahs (0.620 ha), wooded and shrubby savannahs (5.281 ha) and water bodies (0.041 Ha). On the other hand, they are the results of the great conversion of swamps (147.284 ha) and mosaics of farms and fallows (174.524 ha). In 2019, this unit is clearly demarcated from swamps and mosaics of farms and fallow land. Its average annual growth rate is +32.78%.
These conversions of the different LUU show that in 20 years (between 1999 and 2019), the classified forest of Goroubi is completely dominated by anthropogenic units. To reverse this trend, it is necessary to initiate projects for the reforestation of species (especially indigenous ones) to restore the forest identity of Goroubi and to produce annual reports on the state of management of these resources. Also, it is necessary to identify the farmers having their farms in the grip of the forest to form a co-management committee in order to convert them to other trades such as the production of nurseries, the maintenance of plantations, etc. Likewise, it is necessary to ensure compliance with the laws governing forests and carry out regular supervision and patrols in order to sanction dishonesty.

4. Discussion

The analyzes carried out show that the open forests and shrub savannahs, and the bodies of water which were present in 1999 experienced a total conversion in 2019. They were mainly converted into wood and shrub savannahs, mosaics of farms and fallows, swamp, etc. This conversion is linked to illegal harvesting and the extension of arable land. The natural formations are therefore in a regressive evolution unlike the anthropogenic formations in the GCF. Similar observations are made by Arouna *et al.,* (2010) and Awokou (2015), where natural formations are in decline in favour of anthropogenic formations respectively in the Communes of Djidja and Glazoue. Between 1999 and 2019, all the occupation units of the GCF have

undergone major conversions revealing a rice field, an entirely anthropic unit to meet food needs. On the other hand, in the Communes of Banikoara, it is the extension of cotton-growing areas for marketing purposes that increases the use of agrarian space (d'Oliveira *et al.,* 2011). However, these two units (rice-growing areas and cotton-growing areas) have a common identity: agriculture; which is nothing other than the response to satisfying the increasingly growing needs of populations. One of the visible consequences of these practices is the degradation of plant cover (Arouna *et al,* 2010; Ajavon *et al.,* 2018).

The case of the GCF is mainly linked to the absence of forest agents in this forest. Indeed, the forest cantonment of the GCF is housed in the Commune of Malanville and the visits of the forest agents are almost non-existent in the forest. In the FCAS, abusive exploitation is partly favoured by the laxity of the forest administration and the non-respect of the texts in force by the authorities at various levels (Toko Imorou *et al.,* 2010). Similarly, after the reforestation projects ended in 2011 in the Abomey reforestation perimeter, the local populations, thanks to certain human conditions, took advantage of the inertia of the forestry administration, which lacked its role of raising awareness and development, to launch a real assault against this perimeter through practices that have considerably degraded its resources (Kpatinnon and Oussou, 2016). Thus, spatiotemporal changes in land modify the structural parameters of vegetation (Arouna *et al.,* 2010).

5. Conclusion

This research made it possible to appreciate the dynamics of the occupation units of the Goroubi classified forest between 1999 and 2019. At the end of the cartographic work, it appears that in 1999, five (05) LUU are present in GCF in different proportions. These are open forests and shrubby savannahs, wooded and shrubby savannahs, swamps, mosaics of farms and fallows and bodies of water. In 2009, all these units are present while undergoing conversions between them. These units increased to four (04) in 2019 with a total conversion of open forests and shrubby savannahs, and water bodies, then the appearance of the rice-growing area. This rice-growing area is the result not only of the conversion open forests and shrubby savannahs, wooded and shrubby savannahs, bodies of water, but also and above all swamps and mosaics of farms and fallow land. Currently, the GCF is almost converted into a rice-growing area. At present, many efforts must be made through reforestation projects, compliance with the texts in force, patrols to better control the degradation of this forest.

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