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URBAN DYNAMICS AND VULNERABILITY OF TRAINING VEGETALS OF THE CLASSIFIED FOREST OF ITCHÈDÈ-TOFFO AUSUD-EAST OF BENIN

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ABSTRACT

The population explosion observed in the urban centers of West Africa is nowadays accentuated in the secondary cities of Benin and it makes vulnerable the plant formations of these localities. The present research aims to map the urban dynamics and the vulnerability of the plant formations of the Itchèdè-Toffo classified forest in South-East Benin.

The socio-economic data were collected from the heads of households chosen in a reasoned manner in the districts of Pobè and Adja-Ouèrè where the Itchèdè-Toffo classified forest is located. The Scwhartz formula (1995) made it possible to determine the size of the sample (125 surveyed) and its pro-rata distribution of the demographic weight of the riparian villages. Landsat TM 1982 and Sentinel 2016 imagery were used as a reference. These images were the subject of a visual interpretation. The transition matrix, the average rate of expansion and the conversion rate made it possible to assess the vulnerability of plant formations while the FPEIR model made it possible to analyze the results obtained.

The results of this study showed that the Itchèdè-Toffo classified forest lost an area of 40.67 ha at the expense of agglomerations and plantations, ie 21.29% of the forest area. Similarly, the occupancy units of this forest, such as dense forest (50.95%), woodland and forest savanna (80.65%), field mosaics and fallow (99.90%) and palm groves (100%) have very high conversion rates. From 1982 to 2016, the rate of regression of the areas of the classified forest rose to 60.15% in 34 years. Urgent measures must be taken to limit the effects of urban sprawl and human activities on the Itchèdè-Toffo classified forest in particular and in general on the plant formations of the study environment.

Keywords: Urban dynamics, classified forest, vegetal formations, Itchèdè-Toffo and regression

1. INTRODUCTION

The annual growth of the urban population in sub-Saharan Africa is approaching 5%. This figure is twice that of the countries of Latin America and Asia (Hountodji, 2008). Traditional relationships between people and their environment, especially the forest, are perennial in their food and material aspects as well as in their spiritual and cultural aspects. These reports strongly

influence the dispositions and the measures that modern administrations take to define the place of the forests in the agglomerations and their periphery (Agoma, 2009) .The demographic situation and the urban extension thus constitute a strong pressure on the natural resources (Forman, 2009). For Tenté (2005), the threats that are increasingly weighing on forest formations are due to demographic growth, the expansion of rural areas and the introduction of highly space-consuming industrial crops.

Increasing pressure on it leads to widespread and growing poverty and leads to alarming rates of forest degradation, deforestation and environmental disruption (Agoma, 2009). It is from this observation that this research was initiated to evaluate the state of the Itchèdè-Toffo classified forest (one of the oldest classified forests in Benin) in relation to the demographic evolution of the riverside localities.

2. Field of study

The study area (Figure 1) straddles the towns of Pobè and Adja-Ouèrè, which are located in southeastern Benin, in the Plateau department. This Itchèdè-Toffo forest was classified by Decree No. 3778 SE of December 12, 1945 in the state forest known as "botanical reserve" and covers an area of 191 hectares (DGFRN, 2010).

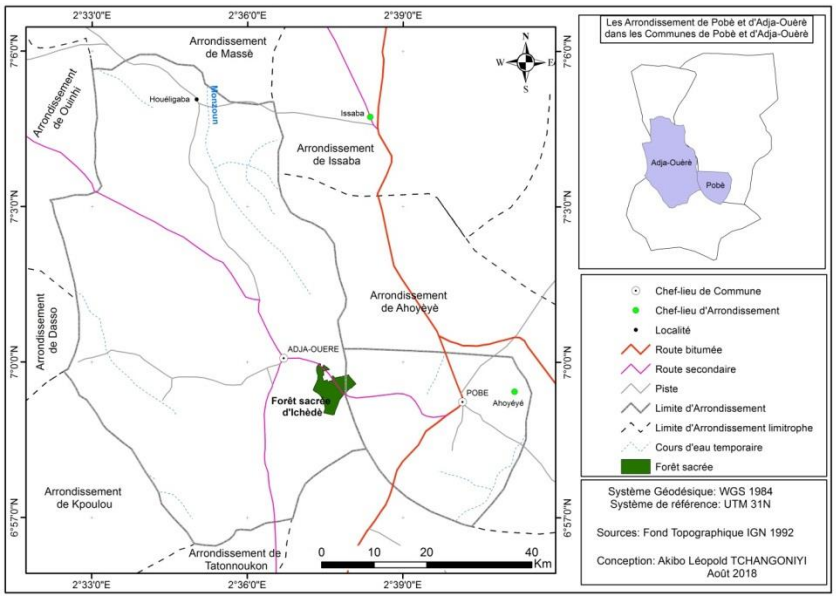

Figure 1: Geographical location of the Itchèdè-Toffo classified forest

It is located between 2 ° 37'14 " and 2 ° 38'42 " north latitude and between 6 ° 58'59 " and 7 ° 00'30 " east longitude. This forest continues to experience human pressure despite the adoption of participatory management that has been made for several years.

3. METHODS

3.1. Data collection method

Mapping of vegetation state changes is done using remote sensing data. Change detection is the implementation of techniques aimed at identifying, highlighting and quantifying in order to understand the temporal evolution or the change of state of an object or a phenomenon from a series of observations on different dates. There are several methods for detecting changes in vegetation status, namely: comparison of spectral signatures, comparison of vegetation indices and comparison of classifications (Arouna, 2012). Especially since not all the images are obtained from the same sensors, the classification comparison method has been used to study the dynamics of the land occupation of the forest and its periphery. It consisted in interpreting a multi-temporal series of satellite images and then comparing the areas of occupation classes of the forest and its periphery. This method requires that the same classification system be applied for each image.

3.2. Processing of data images

3.2.1. Interpretation of SPOT images

The object-oriented classification method was used to interpret the 6 m resolution SPOT 6 images using the eCognition Software. This software offers the advantage of considering both the spectral signature of the pixels and their pattern of distribution and layout in the process of segmentation. Once the segmentation has been completed, codes have been assigned to the different polygons resulting from the segmentation. The characteristics of these polygons were then analyzed mathematically by the eCognition Software, which made it possible to classify automatically all the other polygons, according to their belonging to the reference families. It is important to mention that the determination of the type of occupation of the reference polygons was based on the GPS points recorded during the fieldwork. Thanks to this particularity, it has been possible to define spatial analysis algorithms, in order to automatically segment the

Polygon-like territory similar to those that would have been traced by an experienced photo-interpreter. In fact, the segmentation obtained by eCognition is even more precise and detailed, because it is not limited by the agility of handling the cursor on the screen. In addition, the use of algorithms and the application of precise rules ensure a better uniformity in the segmentation of the different images that make up the search area. The preliminary digital land cover layer (polygons and identification codes) was then transferred to the Arc GIS software for mapping the land cover type.

3.2.2. Assessment of accuracy level of land cover mapping

The evaluation of forest unit maps and other land-use units from the interpretation of satellite images was done using a matrix of confusion. It is in fact a double-entry table where the classes of the maps resulting from the interpretation are in lines and the data of the control-field in

columns. On the diagonal of this table, are the forest units and other well-identified land occupancy units and on either side of this diagonal errors of omission and confusion.

3.2.3. Transition Matrix

It corresponds to a square matrix describing in a condensed manner, the changes of state of the elements of a system during a given period. The cells in the matrix contain the value of a variable or unit of land use that has passed from an initial class i to a final class j during the period t1 to t2 (Bamba et al, 2008) . Indeed, the matrix consists of x rows and y columns. The number x of rows of the matrix indicates the number of landscape units present at the date t1 while the number y of columns of the matrix indicates the number of landscape units converted at the date t2. As for the diagonal, it contains the areas of the landscape units that have remained unchanged (Arouna, 2012). In this matrix, transformations are rows to columns. The areas of these different classes of landscape units were calculated from the crossings of the 1982 and 2016 maps using the "intersect" function of the "Arctoolbox" toolbox of the ArcGis 9.3 software. the matrix indicate the land use status in 1982 and the lines correspond to the states in 2016.

3.2.4. Average annual rate of spatial expansion

The average annual rate of spatial expansion expresses the proportion of each unit of natural vegetation that changes annually. This annual rate Ta is calculated from the following formula: ^{Ta} = (S2-S1) / (S1 × (t1-t2)) × 100, With S1 the area of a vegetation unit at the date t1, S2 la area of the same vegetation unit at date t2 and t the number of years between t1 and t2.

3.2.5. Conversion rate

The conversion rate of a landscape unit class corresponds to the degree of transformation experienced by this class by converting to other classes (Arouna, 2012). It is then the amount of changes observed at the level of a landscape unit between the dates t1 and t2. It has made it possible to measure the degree of conversion of a given unit into other landscape units. It is obtained from the transition matrix according to the formula: 〖T〗 _c = (S_it-S_is) / S_it × 100, Sit: Area of the landscape unit i at the initial date t; Sis: Area of the same unit remained stable at date t1.

4. RESULTS

4.1. Dynamics of the population

4.1.1. Sociolinguistic groups

The urban population with a right of use on this forest consists mainly of two sociolinguistic groups, namely: the Nago (85%) and the Fon (15%) (INSAE, 2013). They are all in search of fertile land for agriculture or attracted by logging and gainful activities, which requires the acquisition of other vital spaces and a strong pressure on forest resources.

4.1.2. Demographic evolution of the study area

The cities of Pobè and Adja-Ouèrè experienced a population explosion from 1979 to 2013 (Figure 2).

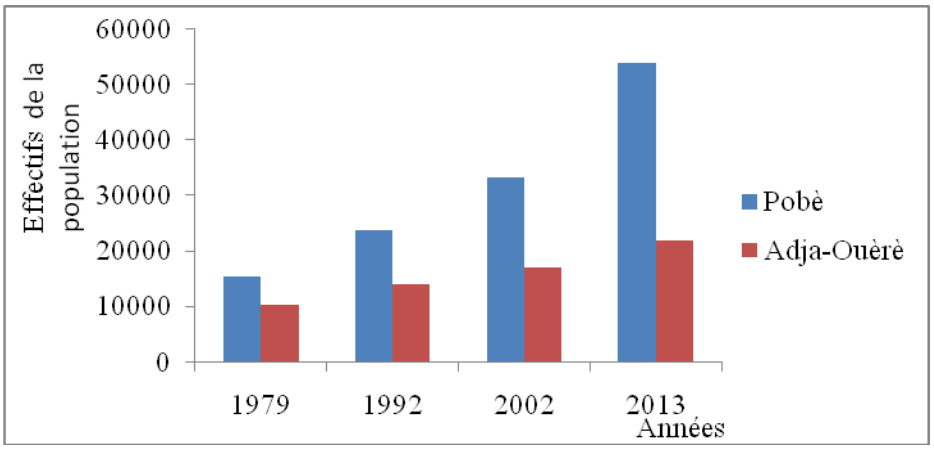

Figure 2: Number of population in the districts of Pobè and Adja-Ouèrède 1979 to 2013

Source: INSAE, 1979, 1992, 2002 and 2013

Figure 2 shows that the city of Pobè has grown from 15350 to 53861 inhabitants, and that of Adja-Ouèrè has increased from 10152 to 21968 inhabitants. This high population growth will exacerbate the pressure on the wood resources of the Itchèdè-Toffo classified forest. Thus, from 1982 to 2016, a large area of the forest is converted into agglomeration and plantation, making this plant formation more vulnerable (Figure 3 and 4). Thus, the expansion of these two units causes its vulnerability and its periphery.

4.2. State of the forest lands and its periphery

4.2.1. State of the lands of the Itchèdè-Toffo classified forest and its periphery in 1982

In 1982, the Itchèdè-Toffo classified forest consisted of seven units (Figure 3), namely: dense forest, clear forests and wooded savannas, plantations and settlements.

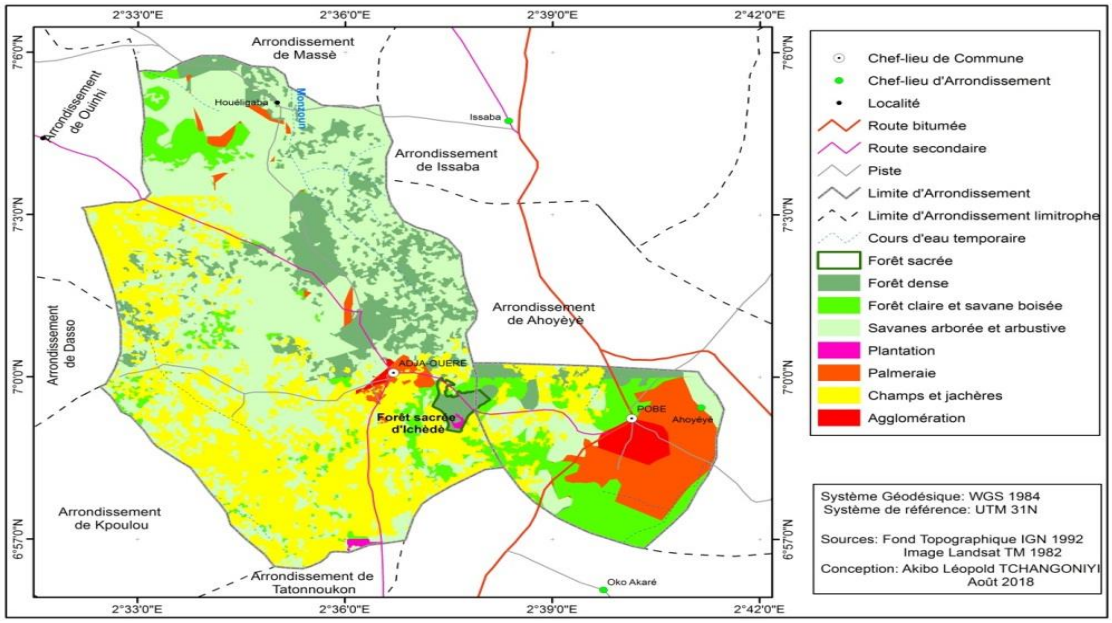

Figure 3: State of the Itchèdè-Toffo classified forest and its periphery in 1982

Source: IGN Topographic Fund 1992, Landsat TM Images 1982

Figure 3 shows the seven units of occupation of the Itchèdè-Toffo classified forest in 1982. At that time, it was strongly dominated by a dense forest followed by wooded and shrub savannas. Fields and fallow land, palm groves, woodland and savannah forest and settlements are less representative units. The frequency of each unit of occupation is shown in Table I.

Table I: Vegetation formations and other units of land occupation of the Itchèdè-Toffo classified forest in 1982

Formations végétales	Superficie (ha)	Proportion (%)
FD	62,86	32,81
FCSB	23,68	12,36
SAA	59,71	31,17
PLT	0,28	0,14
MCJP	10,51	5,48
MCJ	32,2	16,81
AGG	2,28	1,19
Total	191,53	100

Source: 1982 Landsat TM Image Interpretations

The examination of Table I shows that it consists largely of dense forest (32.81%), savannah and shrub (31.17%). At that date, the agglomerations occupied only 1.19% of the area of the forest. This testifies that the cities of Pobè and Adja-Ouèrè had a small extension on the area of this one at that date.

4.2.2. State of the lands of the Itchèdè-Toffo classified forest and its periphery in 2016

In 2016, the Itchèdè-Toffo classified forest grew to five units (Figure 4), namely: dense forest, plantations, mosaics of fields and fallows, field and fallow under palm and agglomeration.

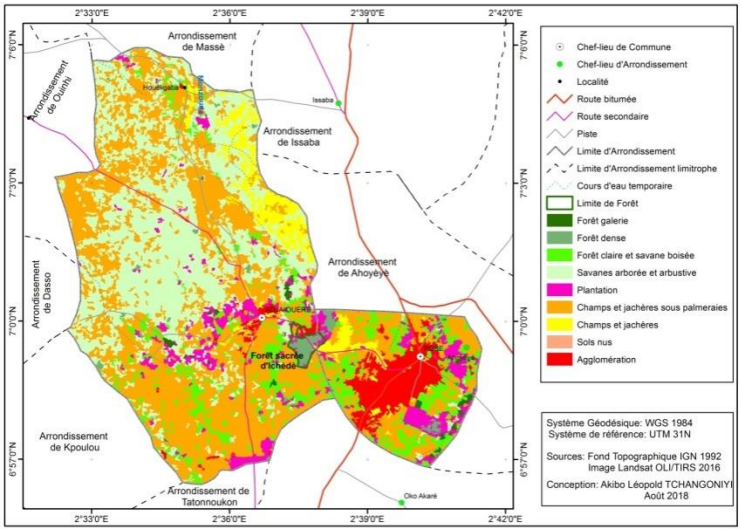

Figure 4: Evolution of the lands of the Itchèdè-Toffo classified forest and its periphery in 2016

Source: IGN Topographic Fund 1992, Sentinel Images 2016

Lafigure 4 presents the same units as those of 1982, but with a sharp decrease in the dense forest to the detriment of plantations, classified forests and wooded savannas and agglomerations. This confirms the extension of the agglomerations of the cities of Pobè and Adja-Ouèrè on the domain of the classified forest. The frequency of each unit of land occupancy in this forest is shown in Table II.

Table 2: Distribution of land occupation units of the Itchèdè-Toffo classified forest in 2016

Formations végétales	Superficie (ha)	Proportion (%)
FD	30,83	16,16
FCSB	8,43	4,40
SAA	50,56	26,39
PLT	31,61	16,50

MCJP	52,7	27,51
MCJ	8,24	4,30
AGG	9,15	4,77
Total	191,53	100

Source : Interprétations des Images Sentinelles de 2016

The examination of Table II shows that plant formation is dominated by mosaics of fields and fallow under palm trees followed by savannahs and shrubs, and the agglomerations have also grown considerably. This testifies to an explosion of demography, one of the consequences of which is the extension of these two cities on the domain of the said forest.

4.3. Dynamics of the Itchèdè-Toffo Classified Forest

The dynamics of the classified forest were analyzed simultaneously with the vegetation formations through the transition matrix and the conversion rate.

4.3.1. Dynamics of the Itchèdè-Toffo Classified Forest from 1982 to 2016

The evolution of the Itchèdè-Toffo classified forest from 1982 to 2016 is summarized by the transition matrix (Table III). The diagonal cells correspond to the areas of units that remained stable from 1982 to 2016. Units that are outside the diagonal represent vegetation changes and other land use units.

Table3: Matrix of transition of land occupation of the Itchèdè-Toffo classified forest and its periphery from 1982 to 2016.

Unités d'occupation	Superficies en 2016							Superficies totales 1982
	FD	FCSB	SAA	PLT	MCJP	MCJ	AGG	
FD	30,83	1,06	7,13	15,34	6,34	2,06	0,11	62,86
FCSB	0,00	4,58	3,77	8,58	3,62	0,74	2,38	23,68
SAA	0,00	0,00	38,85	5,16	8,28	5,16	2,26	59,71
PLT	0,00	0,00	0,00	0,28	0,00	0,00	0,00	0,28
PAL	0,00	2,79	0,81	2,26	2,30	0,24	2,12	10,51
MCJ	0,00	0,00	0,00	0,00	32,17	0,03	0,00	32,20
AGG	0,00	0,00	0,00	0,00	0,00	0,00	2,28	2,28
Total	30,83	8,43	50,56	31,61	52,70	8,24	9,15	191,53

Source: Results from field surveys, December 2017

Examination of Table III shows that dense forest, open woodland and wooded savannas, tree and shrub savannahs and mosaics of fields and fallow land have declined, while plantations and agglomerations have increased.

4.3.1.1. Evolution of the dense forest

In 1982, dense forest occupied nearly 62.86 ha, or 32.81% of the forest area, but in 2016 it increased to 30.83 ha, or 16.16%. In fact, it experienced a decline of 50.95% of the conversion rate. The areas of the dense forest were transformed strongly into savannah with trees and shrubs (7.13 ha), plantations (15.34 ha) and mosaics of fields. and fallow under palm trees (6.34 ha). This unit was weakly converted to agglomeration (0.11 ha). These transformations observed at the level of the dense forest prove that it is experiencing a mainly regressive evolution. With this regressive trend, this unit is endangered despite the existence of two modes of management.

4.3.1.2 Evolution of the woodland and wooded savannah

The woodland and savanna woodland was 23.68 ha in 1982, but rose to 8.43 ha in 2016, representing a conversion rate of 80.65%. Thus, the area of woodland and savanna woodland has been converted into plantations (8.58 ha), savannah trees and shrubs (3.77 ha) into field mosaics and fallow land (3.62 ha) then into agglomerations (2 , 38 ha). This unit was severely degraded by the extension of dwellings of the cities of Pobè and Adja-Ouèrè.

4.3.1.3 Evolution of tree and shrub savannas

From 1982 to 2016, the area of tree and shrub savannas increased from 59.71 to 50.56 ha, representing a conversion rate of 34.93%. The area of this unit has been transformed into plantations (5.16 ha), field mosaics and fallow under palm trees (8.28 ha), field mosaics and fallow (5.16 ha) and then agglomeration (2 , 26 ha). Indeed, this unit suffered a degradation related to the peri-urbanization of the cities of Pobè and Adja-Ouèrè.

4.3.1.4 Evolution of the areas of plantations and agglomerations

From 1982 to 2016, agglomerations and plantations grew from 2.28 ha to 0.28 ha to 9.15 ha and 31.61 ha, respectively. With a relatively high conversion rate (Table IV), the Itchèdè-Toffo classified forest is losing more and more these old units to the detriment of the urban thrust that makes it vulnerable.

Table IV: Conversion rate of units of occupation of the lands of the classified forest

Unités d'occupation de la forêt	Taux de conversion (%)
Forêt dense	50,95
FCSB	80,65
Plantations	0
Savanes arborées et arbustives	34,93
Mosaïques de champs et jachère	99,90

Palmeraies	100
Agglomérations	0

Source: Field Survey Results, December 2016

Table IV shows that palm groves (100%), field meadows and fallow (99.90%) and woodland and savanna woodland (80.65%) have a very high rate; dense forest (50.95%) and tree and shrub savannas (34.93%) have an average conversion rate while plantations and agglomerations have 0% conversion rate. have a high conversion rate suffer a strong degradation by the extension of agglomerations.

4.3.1.5. Synthesis of the dynamics of the Itchèdè-Toffo classified forest from 1982 to 2016

The land-use units of the Itchèdè-Toffo classified forest experienced a decline in their areas outside plantations and agglomerations which experienced strong growth (Figure 5).

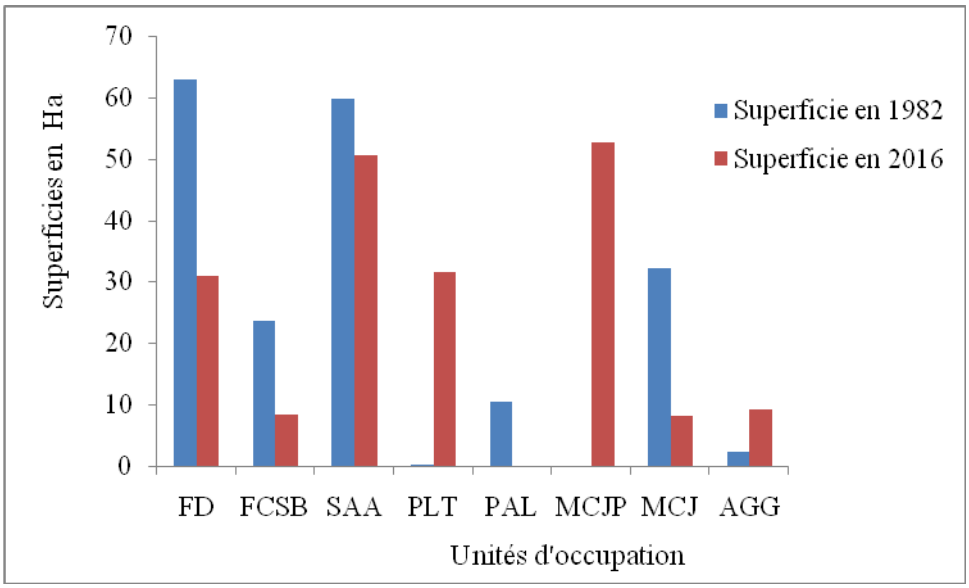

Figure 5: Evolution of the units of occupation of the lands of the classified forest between 1982 and 2016

Source: Landsat 1982 and Sentinel 2016 Interpretation Results

(Legend: FD: Forest Dense, FCSB: Clear Forest and Wooded Savannah, SAA: Tree and Shrub Savanna, PLT: Plantation, MCJP: Field Mosaic and Fallow under Palm, MCJ: Field Mosaic and Fallow, AGG: Agglomeration)

Figure 5 shows that dense forest, forested woodland and savannah, tree and shrub savannah, field mosaic and fallow land have declined sharply, while plantations and agglomerations have experienced strong growth. In addition, the palm groves have disappeared to the detriment of the other occupations units of the lands of the said forest. Thus, the Itchèdè-Toffo classified forest is degraded in the face of anthropogenic actions and urban growth. The balance of changes in the units of occupation reveals three categories of surfaces: stability, regression and progression (Figure

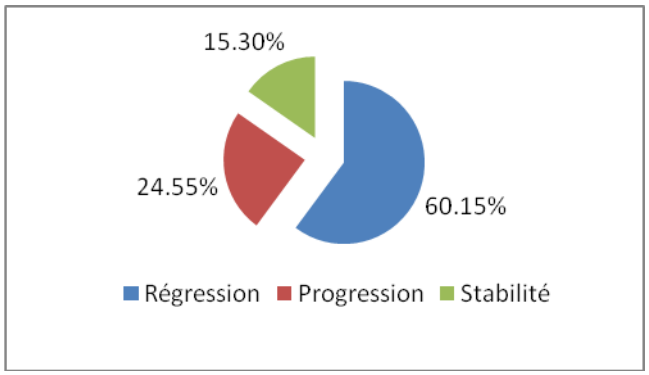

Figure 6: Assessment of the evolution of land occupation units of the Itchèdè Toffo classified forest from 1982 to 2016

Source: Field Survey Results, December 2016

Looking at Figure 6 shows that 60.15% of the units are in decline and 24.55% are increasing, against 15.30% of the forest area remains stable. It is clear that the evolutionary trend of the Itchèdè-Toffo classified forest between 1982 and 2016 is strongly regressive. Nowadays, about two hectares are reserved for the cultivation of rice in the marsh area of the classified forest (plate 1).

Plate 1: Space reserved for growing rice inside the classified forest

Source: Fieldwork Survey Results, December 2016

Plate 1 shows spaces left fallow. Photo 1.1 is a part of this space left fallow for about 2 years and photo 1.2, is set fallow for 1 year. The population is increasingly exploiting the periphery of the classified forest for agricultural activities (Plate 2).

Plate 2: Fields created in the peripheries of the Itchèdè-Toffo classified forest

Source: Fieldwork Survey Results, December 2016

Plate 2 shows manioc fields created in the periphery of the forest. These photos are the proof of the anthropic actions that make the classified forest more and more vulnerable. Indeed, on this periphery the direction of the chief post office was built (photo 1).

Photo 1: Administrative building of the chief forestry station built in the periphery of the Itchèdè-Toffo classified forest

Source: Field Survey Results, December 2016

Photo 1 shows the administrative building in which the Chief Post Office is housed. This building was built on the estate (one hectare) of the Itchèdè-Toffo classified forest. The periphery of the Itchèdè-Toffo classified forest is increasingly exploited for planting (Plate 3

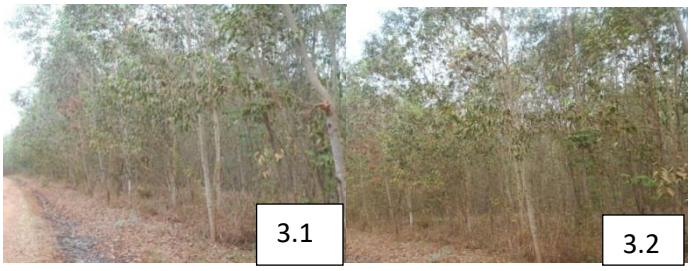

Plate 3: Acacia auriculiformis plantation

Source: Fieldwork Survey Results, December 2016

Plate 3 shows plantations of acacia auriculiformis in the periphery of the Itchèdè-Toffo classified forest. Photo 3.1 is a plantation made at the entrance to the village of Toffo in the area of the said forest. In addition, that of photo 3.2 is a plantation on the outskirts of the said forest on the village side of Akouho. Thus, the occupying units of the periphery of the classified forest are destroyed to the detriment of the plantations thus making it vulnerable.

5. DISCUSSION

This strong regression (60.15%) of the units of occupation of the classified forest, during this period (1982 to 2016), reveals the vulnerability of the latter and its periphery due to anthropogenic actions. This proves that the hypothesis concerning the dynamics of land occupation of the classified forest and its periphery is verified. These results are in phase with the research of Agossou (2011), on the cartography of the spatio-temporal changes of the natural plant formations of Bamèzoun, Itchèdè-Toffo and Kodjizoun. In his research, he concluded that the regressive evolution of plant formations is due to the strong anthropic pressure (logging, research: farmland, humus and shrubs for the nursery). This regression of forest formations according to Kokou and Soukpon, (2006), is recorded only on the periphery of forests. A study conducted in Côte d'Ivoire in the Sudano-Guinean zone by Barima et al., (2009) on landscape dynamics, based on satellite images, also concluded the conversion of dense forests into anthropogenic formations. This shows a regression of plant formations in the sub-region. Projections by Oloukoï et al., (2006), relating to the future of plant formation towards a horizon of 2010 and 2020 from the land use maps of the sub-region. 1978 and 1998 in the Department of Hills in Benin, have shown that agglomerations, fields and fallows will experience an increase in their area at the expense of clear forests and woodland, gallery forests and savannahs and shrubs.

6.CONCLUSION

The strong population growth observed in the riparian zones of the Itchèdè-Toffo classified forest resulted in the deep conversion of the occupation units of this forest. The areas of agglomerations and plantations have increased considerably to the detriment of natural vegetation formations. Despite the implementation of the participative management method adopted for this forest, it is still exposed to the throes of urban dynamics and human actions.

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