Herald Journal of Geography and Regional Planning Vol. 2 (1), pp. 061 - 065 April, 2013
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Full Length Research Paper

Changes in land use and socio-ecological patterns: the case of tropical rainforests in West Africa

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Accepted April 17, 2013

Ten million hectares of tropical forest have been destroyed in the course of 20th century and nearly 80% of the surface area of tropical rainforests has been assigned to food and cash crop agriculture. In the forest region of Litimé (south-west Togo), the rainforests also are a major economic resource. The aims of this study are thus to quantify the land use changes between 1986 and 2001, assess the accuracy of land uses from ecological inventories, and explain these changes with socio-economic events. By remote sensing, using SPOT satellite images from 1986 and 2001, we identified four classes of land use and quantified the evolution of their surface area. Sixty control points and ecological inventories have provided a basis for validating these classes, describing the plant species composition. In 15 years, the major class of land use, the cocoa plantations, have regressed in favour of inhabited zones and cultivated areas.The forest of Litimé has been reduced to small patches that have been cleared for the food crop agriculture and inhabited zones. This study shows that the social and economical knowledge are determinants in order to understand the temporal and spatial dynamics of the forests.

Keywords: Land use changes, Multi-functional landscapes, Socio-economic factors, Jaccard similarity index, Tropical rainforest.

INTRODUCTION

The primary forests are globally disappearing, and we are currently living through the last decades of these plant formations dating back 300 million years (Hallé, 1990). Among these, the tropical rainforests shelters more than half of the world's biodiversity (UICN, 1996; Mayaux et al., 2003; Naidoo et al., 2006; Ellis and Ramankutty, 2008). In addition to their environmental functions (maintenance of biodiversity, greenhouse effect and water cycle), the rainforests play an important socio-economic role (Catzeflis, 2004; Bobo et al., 2006; Tallis and Kareiva, 2006). The conversion of primary tropical rainforests to various types of land use has had a serious impact on floristic composition (Van Gemerden, 2004; Waltert et al., 2005) and has had a negative impact on the biodiversity (Bawa and Seilder, 1998) by disrupting the ecosystem equilibrium (Rosenzweig, 2003). In order to protect the tropical forests biodiversity, it becomes crucial to control land use changes in agreement with biodiversity conservation. However, most studies have dealt with the biodiversity into the agricultural landscapes in the tropics (Hughes et al., 2002; Schulze et al., 2004) rather than on land use changes in tropical forest ecosystems (Malaisse, 1984; Lawton et al., 1998).

In Africa, most of the tropical rainforests are located in the Congo basin (Makana and Thomas, 2006) which includes Cameroon, the Central African Republic, Gabon, Equatorial Guinea, Congo-Brazzaville and the Democratic Republic of Congo (White, 1986; Kareiva et al., 2007). These forests are of great economic and socio-cultural importance for their respective countries.

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For example, in the Central African Republic, the forestry sector represents 9.7% of the GDP (Gross Domestic Product) in Gabon, the wood industry employs 28% of the active population, and in Cameroon, 80% of the population obtains its energy from the wood biomass that represents 64% of the energy consumed in the country (FAO, 2005). In West Africa, the forests cover almost the whole of the countries of the Gulf of Guinea, namely Guinea, Sierra Leone, Liberia, Ivory Coast, Ghana, South-West Togo and Nigeria (Ojo and OlaAdams, 1996; Ruf, 2001; Michalski et al., 2008). In these countries, the high population density results in the over-exploitation of these forests for agriculture, wood construction, and wood heating (Louppe et al., 1995; Fairhead and Leach, 1998). For example, Ivory Coast is a deforestation hotspot in the Tropics with a deforestation rate of 11% per year (Puig, 2001). A diachronic analysis of land use changes suggests that between 1955 and 1988, the forest areas of Ivory Coast have extensively decreased in favour of agricultural activities (Achard et al., 1990; N'Guessan, 1993). These latter changes may be also observed in South-West Togo, particularly in the Litimé region. In this region, the forest areas have undergone transformations for agricultural purposes, for example for cocoa farming (Antheaume, 1982; Gnongbo, 2003). The financial advantages of cocoa farming have very soon resulted in a massive influx of human workforce. Then, this has engendered strong human pressures and modifications in the forests floristic composition (Bobo et al, 2006; Kusimi, 2008; Holbech, 2009). In addition, the opening up of roads and cocoa plantation access on schistous slopes exposes them to landslide (Karr, 1976; Fairhead and Leach, 1998). This speeding up of erosion is linked to the destruction of the vegetal cover, even on very steep slopes (White et al, 2001). Furthermore, immigrant populations have developed strategies for the exploitation of the forest (Antheaume and Pontie, 1990; Onyekwelu et al., 2008): clearing of forest areas for the construction of housings, extension of food crop plantations, and the development of logging activities with the introduction of chain saws. Indeed, all the cocoa production areas in West Africa are under threat of ecological modifications linked to deforestation (Malcolm and Ray, 2000; Holbech, 2005; Swaine and Agyeman, 2008). In this context, the aims of this study are to (i) quantify the land use changes in Litimé region, using satellite images in 1986 and 2001, (ii) interpret the land use classes with regard to the floristic inventories, and (iii) pinpoint the socio-economic factors behind these changes.

MATERIAL AND METHODS

Study site

The Litimé region (Figure.1) is part of Togo's ecological zone IV (Ern, 1979). With a surface area of 450 km², Litimé is located between 7°15' and 7°30' North, and between 0°30' and 0°45' East. This forest area is characterised by a subequatorial climate and contrasting relief. It benefits from mean annual rainfall ranging between 1400 and 1800 mm with considerable variations in the total rainfall. The dry season is limited to 1-2 months/year with rainfall not exceeding 20 mm in January. This dry season is also marked by a high deficit in air saturation and by the abundance of morning mists. The mean monthly temperature varies around 25°C with maxima reaching 35°C and minima sometimes dropping to 15°C. The weakness of the evapotranspiration contributes to the maintenance of the air humidity, reflected by a hygrometry between 70 to 90%. At geomorphological level, the plain in the western part (low altitude 200 to 300 m), is a schistous synclinorium of the Volta basin whereas the eastern part corresponds to the western slope of the Akposso plateau culminating at 700-900 m altitude. In the contact zone between the plain and the plateau, there are low rolling hills (400 to 500 m). In this environment of dense humid semi-deciduous forest, a long process of morphopedological evolution has developed deep ferralitic soils colonised by primary forest, today relictual.

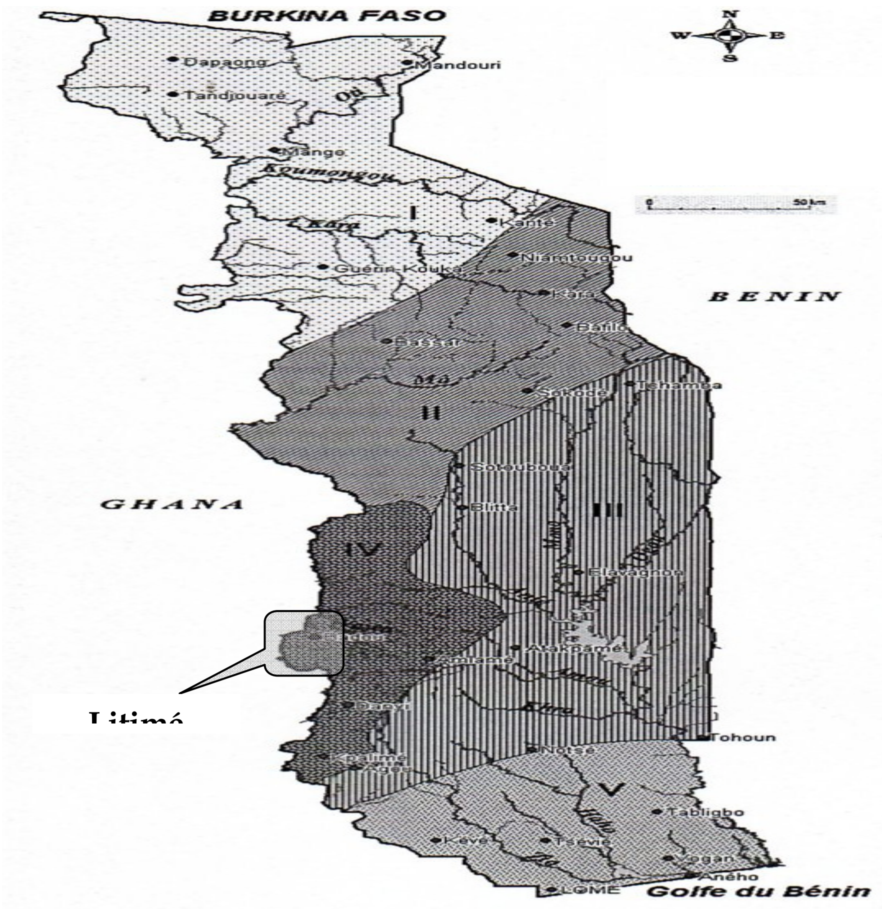
Methods

Land use changes analysis between 1986 and 2001

To quantify the land use changes, we have used two SPOT satellite images from the years 1986 (SPOT-4) and 2001 (SPOT-5) (Programme ISIS-CNES, 2006). The bands B1 (green: 0.50-0.59 µm, B2 (red: 0.61-0.68 µm), B3 (near infrared: 0.78-0.89 µm) and B4 (medium infrared: 1.58-1.75 µm) were used at spatial resolution of 20 m for the SPOT-4 image and 10 m for the SPOT-5 image. The preliminary corrections, radiometric and geometric, ortho-rectification and geo-referencing, were performed before acquisition. A non-supervised classification was performed by the ISODATA (Iterative Self-Organizing Data Analysis Techniques) method. This classification categorizes the pixels by their similarities; the pixel aggregates being divided into separate groups if the standard deviation of the initial group exceeds a predefined threshold. From the land use map obtained for the year 2001, 20 control points into each land use class were randomly chosen (3 land use classes x 20 control points = 60). The accuracy assessment of land use classes was tested by a confusion matrix and the Kappa index (Congalton, 1991) (Table 1).

The inhabited zones class (ZH) was assessed by visits in the villages. These control points enabled us to identify the following four land use classes:

- cocoa plantations (CP) : one kind of cocoa monoculture (Zapfack et al, 2002 ; Bobo et al, 2006) ;
- forest cocoa (FC) : semi-deciduous forests with cocoa



(Ern, 1979) and the geographical situation of the Litimé region.
Zone 1: Wooded and shrub savanna
Zone 2: Open forest and wooded savanna
Zone 3: Open forest and wooded savanna
Zone 4: Tropical rainforest
Zone 5: Savanna
Source : SOUSSOU T. (Tirée de ERN, 1979)

Table 1. Confusion matrix and Kappa index

		Mapping				Precision
		Forest Cacoa (FC)	Forest agriculture mosaïc (F-ag)	Cocoa Plantation (CP)	**Total**	
Control points	Forest Cacoa (FC)	14	3	3	20	70.0%
	Forest agriculture mosaïc (F-ag)	4	15	1	20	75.0%
	Cocoa Plantation (CP)	4	3	13	20	65.0%
	Total	22	21	17	60	
Overall mapping accuracy						70.0%
Kappa Index						57.0%

Source : SOUSSOU T. (Tirée de ERN, 1979)

Table 2 (**a**) Coefficients of abundances species following Braun-Blanquet's method (**b)** Classes of vertical vegetation

a

Coefficient	Covering species
5	species covering > 75%
4	50% < species covering < 75%
3	25% < species covering < 50%
2	10% < species covering < 25%
1	species covering < 10% or rare species

b

Coefficient	Covering vegetation by stratum
A	High Tree > 20m
B	10m<Tree<20m
C	5m<High Shrub<10m
D	2m<Shrub<5m
E	Grass<2m

cultivation in their understory;

- forest-agriculture mosaic (F-ag) or secondary forest-crop fields : mosaics of degraded semi-deciduous forests with a succession of food crop/fallow fields (Norris, 2010) ;
- inhabited zones (ZH): villages.

However, all the investigations failed for the validation of the land use classes in 1986. Only the testimony of villagers and the GPS positions of the control sites on the land use map (1/200 000^e topographical map of Togo's Atakpamé region), drawn up by the French IGN in 1986, the "Direction Nationale de la cartographie", and the "Cadastre du Togo", allowed delimiting the diverse land use classes in 1986.

Ecological samplings

Except for the inhabited zones (ZH), an ecological inventory was carried out for the 60 control points (i.e., 20 per land use class), and performed during the short dry season in August 2007. The floristic inventories were performed within 20 x 20 m quadrats. Plant species cover (Table 2) was estimated using the coefficients of abundance-dominance of Braun Blanquet (1932). Species are classified into five classes according to (i) the species cover for the most abundant plant species, and (ii) the species frequency for rare plant species (see Table 2a). Furthermore, the vertical stratification was adjusted in five classes (see Table 2b) for the forest tree height (Batawila K. and Wala K., comm. pers.).

The life form has been recorded according Raunkiaer (1934) for each plant species. A vertical forest profile (i.e., a transect crossing the centre of each quadrat) has been also carried out. The name, height and cover of each plant species have been noted along the transect, and drawn in a two-dimensional plan. Finally, the past human activities (i.e., soil and vegetation damages) were added to complete the ecological description.

Statistical analyses

First, a one-factor ANOVA was used to detect differences between the forest cocoa (FC), cocoa plantations (CP) and forest-agriculture mosaic (F-ag) land use classes. Second, a post-hoc test (Tukey's honest significance difference test: Tukey HSD test) was then carried out to test the differences between land use classes. Third, to test the similarity between land use classes, we performed a similarity index (Jaccard, 1901) from the life form types. This index is based on the ratio between the number of taxa shared between floristic inventories and the number of taxa specific of each floristic inventory following the formula: $c / (a+b+c)$, a corresponding to the number of species occurring only in survey A, b the number of species occurring only in survey B, c the number of species occurring only in survey C. Jaccard index was applied to the matrix Species x Life form type_Land use class (268 species x 16 life form types. These analyses were performed for phanerophytes (mega-, meso-, micro-, nano-) into stratum A (A > 20 m) and E (E < 2 m) to test the similarities from the life form types into the canopy and the herbaceous stratum, because these latter are particularly marked by human activities. The ANOVAs and Tuckey tests were performed using the *stats* and *agricolae* packages, and the Jaccard's index using the *vegan* package of the R program (R Developmental Core Team, 2008).

RESULTS

Land use classification

With a total validation of 70%, the classes forest cocoa (FC), forest - agriculture mosaic (F-ag) and cocoa

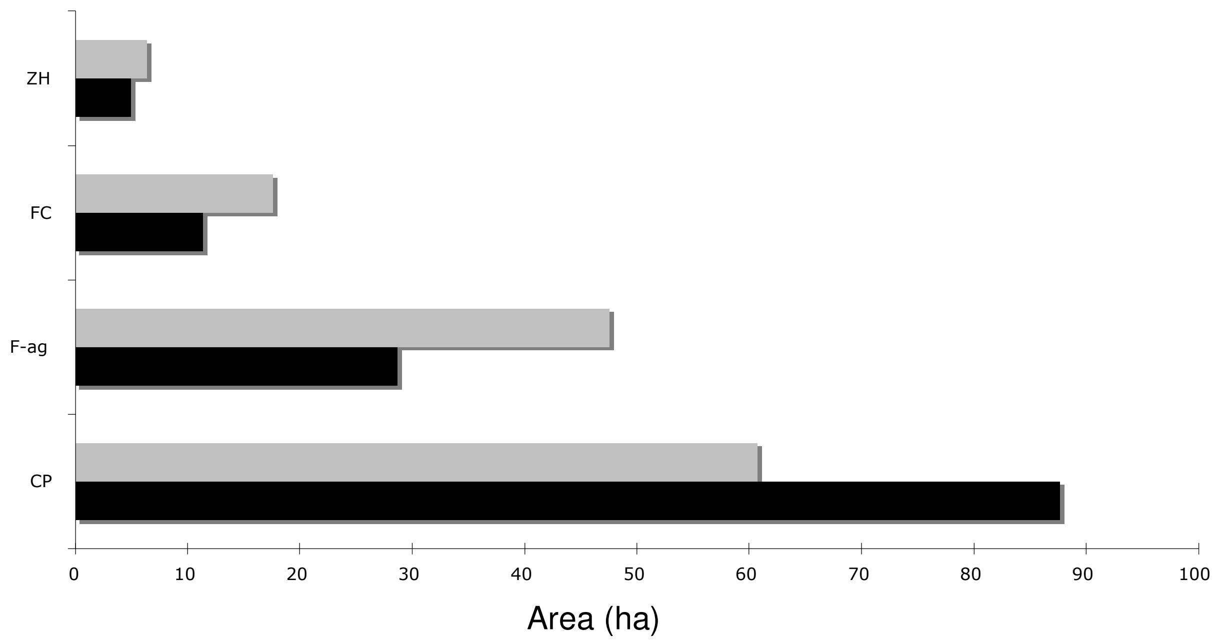


Figure 2. Evolution spatial of land uses : residential areas (ZH, villages), forest-cocoa (FC), forest-agriculture mosaic (F-ag.) and cocoa plantations (CP) between1986(■) et 2001(■).

plantation (CP) have an accuracy assessment of 70%, 75% and 65% respectively (Table 1). The forest-agriculture mosaic (F-ag) class is confused with the forest cocoa (FC) class and little with the cocoa plantation (CP) class, since the latter class represents the open-air cocoa plantations. The cocoa plantation (CP) class is confused with the forest cocoa (FC) and forest-agriculture mosaic (F-ag) classes because several plantations were abandoned and then were colonised by large trees. Indeed, the cocoa plantations (CP) were gradually colonised, since 1986, by young trees and have been replaced by food crop plantations. All these observations explain why the Kappa index validates this 2001 land use map at 57%.

Land use changes between 1986 and 2001

In 15 years, the cocoa plantation surface (CP) has declined from 876.48 ha to 607.35 ha. The forest-agriculture mosaic surface (F-ag) has increased from 286.63 ha in 1986 to 475.08 ha in 2001, and the forest cocoa surface (FC) from 113.32 ha in 1986 to 175.73 ha in 2001. On the other side, the inhabited zones (ZH) have expanded from 49.23 ha in 1986 to 63.39 ha in 2001 (Figure 2).

Furthermore, between 1986 and 2001 (Table 3), the cocoa plantation surface (CP) has declined from 876.48 ha to 607.35 ha, what represents a growth rate of -0.31.

The villages growth rate (ZH) is 0.29. Finally, to study the spatial growth of these villages, they were ordered according to their distance from Badou (i.e., *Préfecture* and main town of Litimé). Between 1986 and 2001, Badou almost doubled in surface area, increasing from 70.6 ha in 1986 to 157.7 ha in 2001 i.e., an increase of 87 ha (Figure 3).

As concerns the neighbouring villages, three growth classes were observed. A first rural ring groups the villages whose surface area has increased by 10 ha such as Agbo Kopé (10.12 ha), Akloa (12.06 ha) and Koliko Kopé (12.76 ha). A second more urban ring concerns the villages whose surface area has increased by around 15 to 20 ha. These are the villages of Badoudjindji (17.6 ha), Mémpéssaèm (14.06 ha) and Bethel (20.88 ha), half way from Badou to the border with Ghana. Two exceptions (Wobé and Mangoassé) represented by the hamlets of Wobé and Mangoassé have only increased by about 2 ha.

Plant species composition and life form types

All the phanerophytes, i.e. mega- (MP), meso- (mPha), micro- (mph) and nano- (np) phanerophytes, as well as the lianescent mesophanerophytes (LmP), are predominant in the three land use classes i.e., forest cocoa (FC), forest-agriculture mosaic (F-ag) and cocoa plantations (CP). The herbaceous species are only represented by geophytes (G) and therophytes (Th) (Figure 4).

The differences between the phanerophytes (i.e., mega-, meso-, micro-, nano-, phanerophytes) were tested for each vertical stratum (Figure 5).

This provided a basis for describing clearly the forest

Table 3. Growth rate between 1986 à 2001 ((LU$_n$ - LU$_{n-1}$) / LU$_{n-1}$) * 100; LU: Land Uses; "n" = area 2001; "n-1" = area 1986 – Online, Land Uses : urban areas (ZH) ; forest cocoa (FC) ; forest-agriculture mosaic (F-ag.) ; cocoa plantations (CP).

Land Uses	Growth rate
Urban areas (ZH)	0.287
Forest-cocoa (FC)	0.550
Forest-agriculture mosaic (F-ag.)	0.657
Cocoa plantations (CP)	-0.307

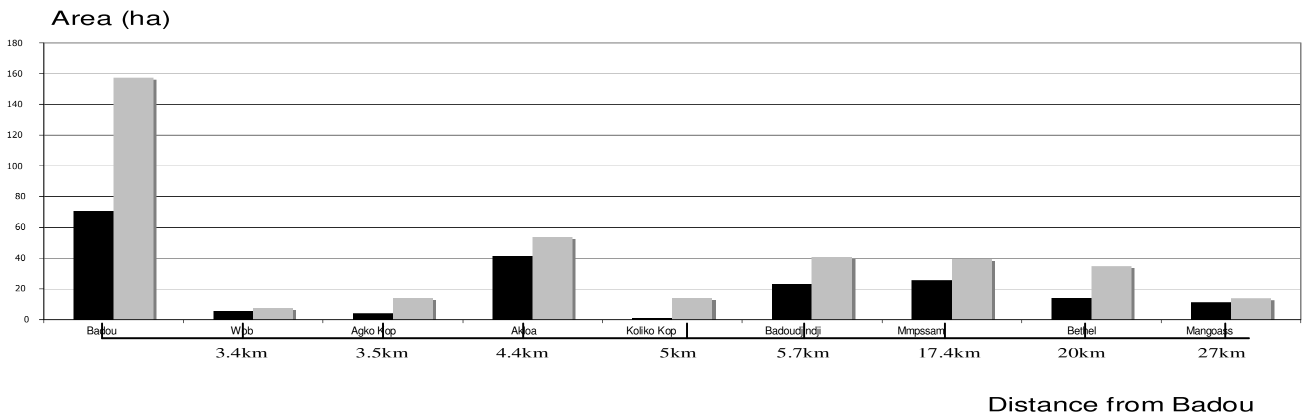


Figure 3. Disposal of villages by distance (km) from Badou, the main town of Litimé and diachronic evolution between 1986 (■) and 2001 (■).

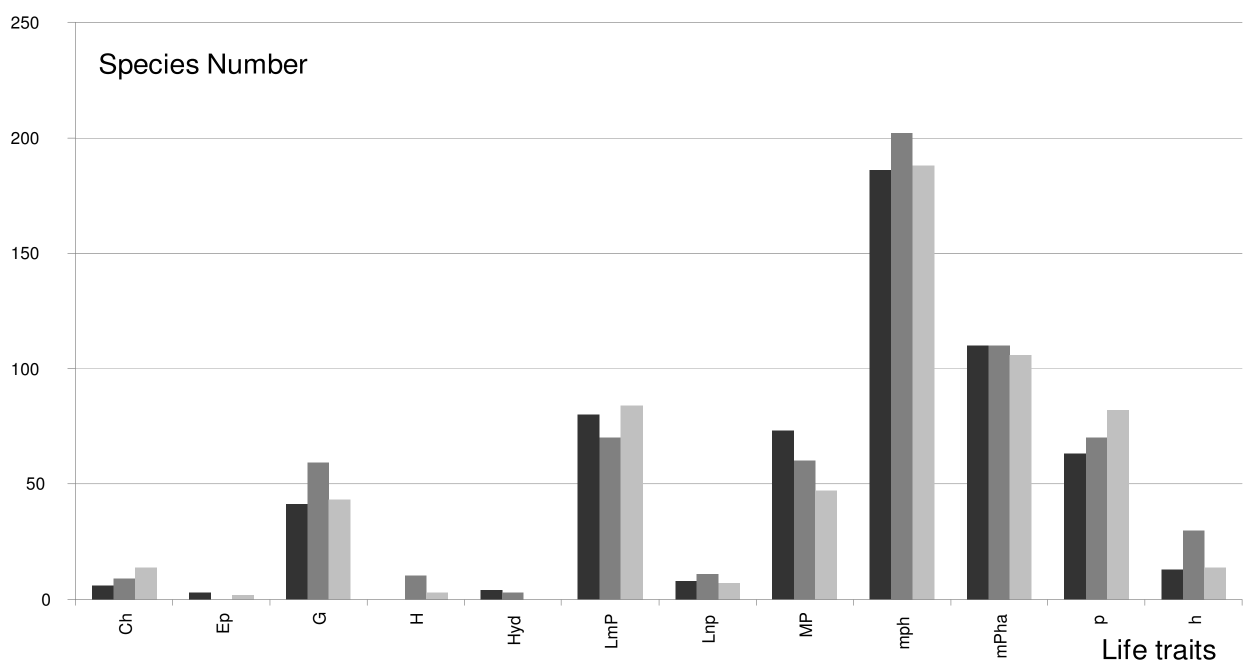


Figure 4. Number of species in relation to the types of biological Raunkiaer according to three land uses such as forest-cocoa (FC) (■); forest-agriculture mosaic (F-ag.) (■) ; cocoa plantations (CP) (■).
Ch : Chamaephytes; Ep : Epiphytes; G : Geophytes; H : Hemicryptophytes ; Hyd : Hydrophytes ; LmP : Mesophanerophytes lianescents ; Lnp : Nanophanerophytes lianescents ; MP : Megaphanerophytes ; mph : Microphanerophytes ; mPha : Mesophanerophytes ; np : Nanophanerophytes ; Th : Therophytes

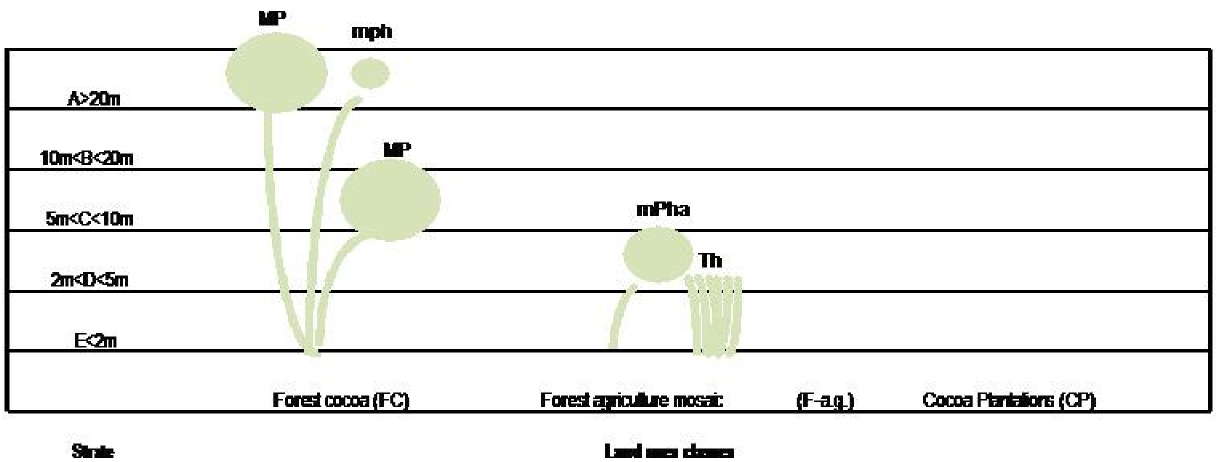


Figure 5. Synthetic diagram describing the different faces according to the three land uses such as forest-cocoa (FC); forest-agriculture mosaic (F-ag.); cocoa plantations (CP)
MP : Megaphanerophytes ; mph : Microphanerophytes ; mPha : Mesophanerophytes ; Th : Therophytes

vertical profile of these three land use classes. The stratum A (A > 20 m) differs on the megaphanerophytes (one-way ANOVA, $F_{2,57}$ = 3.6312; p = 0.05) and microphanerophytes (one-way ANOVA, $F_{2,57}$ = 5.8415; p = 0.01) between the three land use classes. The megaphanerophytes are significantly more frequent within the forest cocoa (mean±SD : 1.57±0.14, Tukey's HSD test, p = 0.05) than in the cocoa plantations (mean±SD : 1.01±0.19, Tukey's HSD test, p = 0.05) (Fig. 6a), whereas the microphanerophytes are significantly more frequent within the forest cocoa (mean±SD : 1.33±0.13, Tukey's HSD test, p = 0.05) than in the forest-agriculture mosaic (mean±SD : 0.59±0.16) (Fig. 6b). The stratum C (5 m < C < 10 m) differs between the three land use classes for the megaphanerophytes alone (one-way ANOVA, $F_{2,57}$ = 2.7434 ; p = 0.05). For this stratum, the megaphanerophytes are more frequent within the forest cocoa (mean±SD : 1.82±0.12, Tukey's HSD test, p = 0.08) than in the cocoa plantations (mean±SD : 1.1.34±0.13) (Fig. 6c). The stratum D (2 m < D < 5 m) only differs for the mesophanerophytes between the three land use classes (one-way ANOVA, $F_{2,57}$ = 2.695 ; p = 0.05). For this stratum, the mesophanerophytes are more frequent within the forest-agriculture mosaic (mean±SD : 1.24±0.13, Tukey's HSD test, p = 0.09) than in the cocoa plantations (mean±SD : 0.78±0.16) (Fig. 6d). For the stratum B (10 m < B < 20 m) and E (E < 2 m), the life forms of the group of phanerophytes do not differ between the three land use classes. Finally, the therophytes of all the strata differ according to the three land use classes (One-way ANOVA, $F_{2,57}$ = 5.8889 ; p = 0.01) i.e., they are better represented in the forest-agriculture mosaic (mean±SD : 1.12±0.12, Tukey's HSD test, p = 0.05) than in the forest cocoa (mean±SD : 0.56±0.13) and the cocoa plantations (mean±SD : 0.60±0.13) (Figure 6e).

Similarity of floristic assemblages between the land use classes

At the canopy (stratum A > 20 m), the Jaccard index indicates a very low similarity (J = 0.263) between the megaphanerophytes of the forest-agriculture mosaic (MP-F-ag) and those of the cocoa plantations (MP-CP). The meso-, micro- and nano-phanerophytes differ little between the three land use classes (FC, F-ag, CP). At the herbaceous stratum (E < 2 m), the indices of similarity for all the phanerophytes (i.e., mega-, meso-, micro- and nano-) differ little between the three land use classes and have high values (similarity of 60% to 90%). These results highlight the differences between the remote sensing results and the sampling results, i.e. remote sensing assesses the green vegetation canopy whereas floristic inventories describe the forest understory. Furthermore, at the herbaceous stratum, the forest cocoa chamaephytes (Ch-FC) differ for about half of those of the forest-agriculture mosaic (Ch-F-ag) (J = 0.5) whereas there is no difference in chamaephytes between the cocoa plantations (Ch-CP) and the forest-agriculture mosaic (Ch-F-ag) (J = 0.789), and those of the forest cocoa (FC) (J = 0.750). The geophytes of the cocoa plantations (G-PC) differ for about half of those of the forest-agriculture mosaic (G-F-ag) (J = 0.478) whereas there is no difference between the geophytes (e.g., *Xanthozoma mafaffa, Anchomanes difformis, Costus afer*) in the forest cocoa (G-FC), forest-agriculture mosaic (G-F-ag) (J = 0.837), and cocoa plantations (G-CP) (J = 0.800). *Xanthozoma mafaffa,* namely '*taro'*, is widely used by man as food. The same is the case for certain chamaephytes such as *Ananas comosus* and *Abelmoschus esculentus*. The megaphanerophytes (MP) of the stratum A significantly characterise the differences Between the forest - agriculture mosaic (F-ag) and the

Figure 6

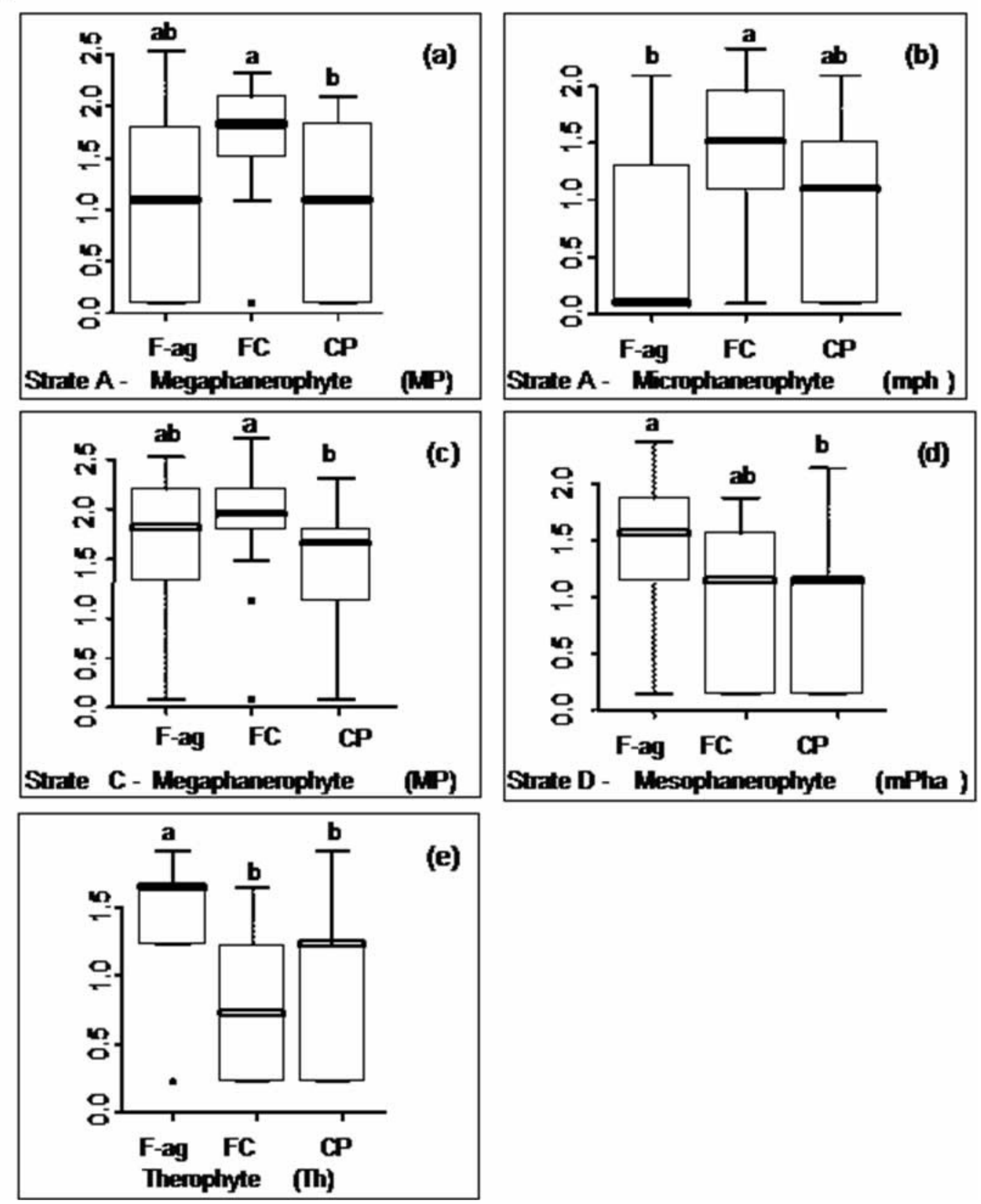


Figure 6. Boxplots of Raunkiaer's life forms according to three land use classes: forest cocoa (FC), forest-agriculture mosaic (F-ag), and cocoa plantations (CP) for **6a:** Megaphanerophytes (MP) at the stratum A, **6b:** Microphanerophytes (mph) at the stratum A, **6c:** Megaphanerophytes (MP) at the level of stratum C, **6d:** Mesophanerophytes (mPha) at the stratum D, and **6e:** Therophytes (Th) of all strata.
Boxplot: median (black line); first quartile (lower base of the box); third quartile (upper base of the box), minimum value (lower line); maximum value (upper line); extreme value (circle). Boxplots with the same letters (a,b) are not significantly different (Test of Tukey).

cocoa plantations (CP) and forest cocoa (FC).

DISCUSSION

The first important feature of this study concerns the discrimination of four land use classes i.e., forest cocoa (FC), cocoa plantations (CP), forest-agriculture mosaic (F-ag) and villages (ZH) from satellite images. In 15 years, the land use changes demonstrated that the cocoa plantations (CP) have extensively decreased in favour of other land uses (876.48 ha in 1986 as against 475.08 ha in 2001, hence 401.40 ha of cocoa plantations abandoned). The accuracy assessment of cocoa plantations class (65%) also highlights this regression. Cocoa plantations have been progressively converted to forest-agriculture mosaic, forest cocoa and inhabited zones. These changes are due to the impact of the international crisis and of the decrease of cocoa prices on the world market i.e., between 1970 and 1989, cocoa production dropped from 29 361 tonnes in 1971 to 8 700 tonnes in 1989 (Nyassogbo et al., 1995).

Moreover, uncontrolled clearing for arable lands cultivation and anarchic felling of trees for the urban constructions and roads have reduced the humic horizons (Gnongbo, 2003). This engendered a second important feature consisting in an alteration of the vegetation structure. For example, the cocoa plantations (CP) and forest-agriculture mosaic (F-ag) are lesser composed of phanerophytes (mega- (MP), meso- (mPha), micro- (mph) and nano- (np) phanerophytes) than shrub species (stratum 2m < D < 5m). Only the forest cocoa class (FC) is characterised by large trees (mega- (stratum A > 20 m, MP and micro- (mph) phanerophytes), and shrub species (5 m < C < 10 m). The microphanerophytes (mph) at the tree stratum (A > 20 m) characterise an open forest i.e., a forest with less tree and tall shrub. In addition, the composition species and vegetation structure is close to those described by Jongkind et al, (2004) in open forests composed of shrub and herbaceous species with a few large trees such as *Piptadeniastrum africanum, Terminalia superba, Triplochiton scleroxylon.* The low similarity (J = 0.263), between the megaphanerophytes in the forest-agriculture mosaic (MP-F-ag) and those of the cocoa plantations (MP-CP) at the canopy level (stratum A > 20 m), assigns the megaphanerophytes as the main forest-agriculture mosaic characteristic. It suggests that the impact of deforestation on tropical forests has not yet reached its threshold of desertion although the megaphanerophytes (*Ceiba pentandra*, *Cola gigantea*, *Milicia excelsa*, *Bombax buenopozense*, *Canarium schweinfurthii*, *Alstonia boonei*, *Irvingia gabonensis*) are widely used by population (i.e., heating, food, housing, phytotherapy, construction, agro-forestry, shade).

A third feature concerns the two-fold expansion of the inhabited zones (Fig. 3). The population flux between Badou and the other villages (e.g., Agbo Kopé, Koliko Kopé) was encouraged by the transformation of Badou into a *Préfecture* in 1974. Badou has changed with almost 83% of land occupied by cocoa plantations. This small town which had an estimated population of 479 inhabitants in 1932, had risen to 6 500 inhabitants in 1960. Despite the low annual growth rate of 1.9% recorded in the 1970 and 1981 censuses, the population of Badou rose from 8 000 in 1981 to 11 000 in 1997 (Nyassogbo, 2003). Furthermore, after the independence of Togo in 1960, in Litimé region, the collect and transport of the cocoa towards the port of Lomé, has required to open up this small geographical area, which is of major economic and strategic interest for Togo. With almost 150 km of roads for a surface area of 450 km², the Litimé region is the densest road infrastructure in Togo, with 1 km/3 km² as against 1 km/7 km² for the country. This important road network has had a major socio-economic impact on the trans-frontier exchanges between the two countries (Gozo and Ogoundé, 1989), and modified the forests in this region as highlighted here. In South-West Togo, spatial dynamic in the forest of Litimé is not very different from the other countries of West Africa, as the small-holding cocoa plantations in Cameroon (Dounias, 2000; Sonwa et al., 2007), the plantations of cocoa under shade in Ivory Coast (Herzog, 1984) or the coffee plantations of Guinea (Camara, 2007 ; Diabaté et al., 2007 ; Lamanda et al., 2007). The agroforests have been progressively modified by initial ecosystem *via* the plantation of trees and the management of the natural vegetation. In the West African rainforest zones, the plantations of perennial commercial crops (e.g., coffee, cocoa, oil palm, rubber.) are often associated with ecosystem services (i.e., trees mixed and/or conserved plantations). These plantations managed on long term basis, are occupied on an individual or familial basis, and rarely exploited intensively. In their mature phase (i.e., productive), these systems are characterised by a complex vegetation structure, diverse plant species (i.e., trees, small plants, shrubs, lianas, herbaceous species), and an ecological functioning similar to that observed for the forests (e.g., nutrients cycle, dispersal, regeneration).

Finally, this study shows that the social and economical knowledge are determinants in order to understand the temporal and spatial dynamics of the forests of West Africa. Development schemes for the rural territory should also take these parameters into account.

ACKNOWLEDGEMENTS

We are grateful to the Institut Méditerranéen de Biodiversité et d'Ecologie marine et continentale (IMBE, Aix – Marseille Université) and the *Laboratoire de Recherches Biogéographiques et d'Etudes Environnementales* (LaRBE, Université de Lomé – Togo) for logistics and assistance. We thank the *Services de Coopération et d'Action Culturelle* (SCAC) for their financial support, and the inhabitants of Litimé for ethno-botanical surveys.

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