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Impacts of Anthropogenic Activities on Changes in the Land Use Patterns over a Span of Three Decades (1979 to 2010): Case of Dassa-Zoume and Glazoue in Benin

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Authors' contributions

This work was carried out in collaboration between all authors. Author KR was the main investigator and had been assisted during the protocol writing, on-site activities, data processing and analysis by authors EK, GP and HC was the supervisor of the investigation. All authors read and approved the final manuscript.

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ABSTRACT

To assess the real impact of farming activities on the environment over three decades and test the hypothesis if the various units of land use are in extension or regression or stable, the present study was carried out in Municipalities of Dassa-Zoumé and Glazoué. The method consisted of matrix analysis of the various units of land use through the vegetation maps from 1979, 1992, 2002 and 2010. The investigations were conducted with the analysis of the thematic maps and ground observations.
The results of the analysis of environmental impacts of the cultural systems in Municipalities of Dassa-Zoumé and Glazoué indicated that the natural formations disappear with time. The natural formations and the farming areas gave up place to establishment of agglomerations which continued extending. The farming areas thus increased with the growth of the population. There was a strong correlation between 0.5 and 0.8 for the gallery formations and between 0.8 and 1 for the clear forests and the woody savannas, the tree and shrub savannas. The projections estimated for 2025 revealed that if the pressure on the natural formations is maintained, gallery forests, clear forests and woody savannas, as long as tree and shrub savannas will seriously decrease. Consequently our results suggest the degradation of the soils and decrease in biodiversity.

Keywords: Environmental impacts; cultural systems; transition matrix; vegetation types; Benin.

1. INTRODUCTION

Farming is a rural activity which has as primary purpose feeding the population of a country. Among others, it involves the soil as support of the crops that will grow there [1].

However, farming remains seriously marked by environmental problems such as degradation of the vegetation cover due to strong demographic pressure. This degradation is caused by both natural and anthropological factors [2]. Actually the causes of the destruction of the vegetation are aggravated by the agricultural activities [3], which - according to some studies [4] – can only have negative effects on the natural ecosystems. Thus the surface area of farmlands increases constantly to the detriment of the vegetal cover [5].

Still, the problem of the environment and the rural development appear as a topical issue in terms of imbalance between natural resources on one hand (resources in farming land, in quality water, in woody vegetation, etc.), and on the other hand the higher needs of the growing populations in search of a general improvement of their living conditions [6].

It is noticed in the study area an increase in agricultural activities to the detriment of the vegetation types. That is why our concern goes to the environmental impacts of the agricultural production in municipalities of Dassa-Zoumé and Glazoué. This study was carried out in these two municipalities in order to bring to light the various units of land use in extension, or regression or stable in order to gauge the real impact of farming activities on the environment.

1.1 Geographical Location of the Study Area

The study area comprising the Municipalities of Dassa-Zoumé and Glazoué (Fig. 1) is situated between 1º41 ' and 2º39 ' of east longitude and between 7º27 ' and 8º31 ' of north latitude. It is bordered in the North by Municipality of Bassila in department of Donga, in the South by Municipalities of Djidja, Covê and Zagnanado in department of Zou, in the East by Municipalities of Savè and Ouèssè, and in the West by Municipalities of Bantè and Savalou, with an area of 3461 km2 and a population of 197817 inhabitants [7].

2. MATERIALS AND METHODS

2.1 Materials

An analytical and cartographic approach was adopted. The first one is based on the analysis of the dynamics of the various units of land use through the vegetation maps from 1979, 1992, 2002 and 2010. The evolution of these units of land use between these three (03) periods was estimated with the transition matrix so as to assess the various mutations of vegetation cover due to the agricultural activities. The cartographic approach, based on the use of the topographic maps at 1/200000 NGI(NATIONAL

GEOGRAPHIC INSTITUTE) Benin edited in 1955 and covering both municipalities of study allowed us to find topographic information, information on rivers, names of locality, reliefs, etc. and to use it during onsite works, namely:

- map of Dassa-Zoumé
- map of Glazoué

The most important datum is Landsat TM image with 07 resolution channels, 30 meters of 1979, 1992, 2002 and 2010 which allowed us to conduct the required interpretations.

2.2 Methods

The methodological approach used consisted of a matrix analysis of the vegetation cover and the units of land use by means of the Landsat TM images with 07 resolution channels, 30 meters of 1979, 1992, 2002 and 2010. The images were interpreted by using the classification of satellite picture which groups the image pixels in limited number by classes. Two levels of classification are considered, namely the supervised classification and that non- supervised classification. Erdas Imagine 8.2 software was used to carry out this interpretation procedure and Arc-View 3.2 was used to draw maps of land use.

➢ Transition matrix

The transition matrix allows us to highlight the various forms of conversion which the vegetable formations underwent between two instances. It is constituted of X lines and of Y columns. The number of the lines of the matrix indicates the number of vegetable formations at t_0 time; the number Y of columns of the matrix is the number of classes of vegetation converted at t_1 time and the diagonal contains the surface areas of the vegetable formations remained unchanged. The transformations are thus made lines towards columns. The surface areas of these various classes of vegetation were calculated from the crossing of the vegetation maps of two (02) data by means of the Intersect function of Arctoolbox and ArcGIS software 9.3.

➢ Conversion rate

The conversion rate of a vegetation class corresponds to the degree of transformation undergone by this class of vegetation by being converted towards other classes. It is then the quantity of changes observed at the level of a vegetable formation between two instances t0 and t1. It thus allows us to measure the degree of conversion of a vegetable formation in other units of land use.

To look for a link between the population and the units of land use, the studies of correlations between the evolution of population growth and the evolution of the natural formations (gallery forests, tree and shrubby savannas) between the two (02) municipalities are observed.

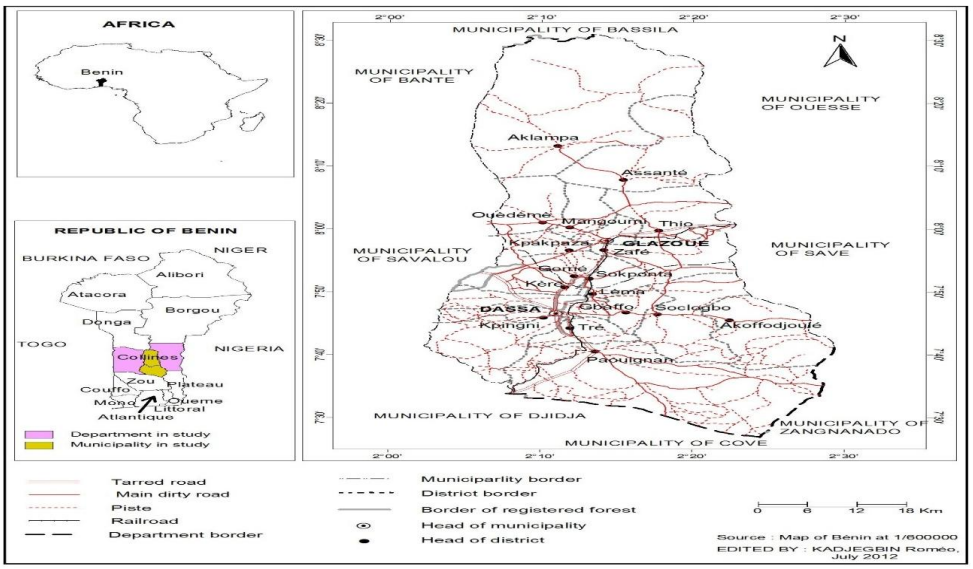

Fig. 1. Geographical location of the municipalities of Dassa-Zoumé and Glazoué

The correlation allows us to establish a link between two (02) variables without strictly defining the dependence causalities between two (02) parameters. Still, it shows the more or less big variance of the second non-constant element according to the first one, thus creating the linear function: r = f (x).

The used formula is:

$$r = \frac{COV(X,Y)}{\sigma(X) \times \sigma(Y)}$$

- **r** = correlation coefficient
- COV(X, Y**)** = covariance of x and y
- x = variable size of the population
- y = variable surface area of the units of land use
- ***σ*(x)** = standard deviation of x
- ***σ*(y)** = standard deviation of y

Its value is always between - 1 and 1.

If 0.6 < |r| < 1 then both studied characters evolve in the same way and the evolution of one of them influences the other one. In this case, the two (02) characters are strongly correlated;
If 0. 3 <|r|< 0.6, the two (02) characters evolve in an approximately identical way. They are correlated in this case averagely;
If 0 <|r|< 0.3 the two (02) characters are independent. Consequently, there is no correlation between the two (02) studied characters;

- If r < 0, the two (02) characters evolve opposite direction
- If r> 0, the two (02) characters evolve in the same direction.

Besides, the annual rate of spatial expansion was calculated between 1979 and 2010 using the formula of Bernier (1992) with the surface (S) of the natural formations as variable

$$T = \frac{(lnS_2 - lnS_1)}{tlne} \times 100$$

S1, surface area occupied by a unit in 1979;
S2, surface area occupied by the same unit in 2010;
t, the number of evolution years; Ln, natural logarithm;
e, the transcendental number (e = 2.71828)

In the same manner, the conversion rate between 1979 and 2010 was calculated according to the formula of Bernier (1992) quoted by Fangnon (2012):

$$TC = \frac{\sum ST - Ss}{\sum ST}$$

TC stands for the rate of conversion, ST surface area of land use from the conversion of a vegetal formation, Ss surface area of the same unchanged vegetal formation at t_1.

Calculation of annual mean rate of expansion allows us to extrapolate a projection at 2025 of some units of land use if the same conditions are maintained.

3. RESULTS

The study of the dynamics of the various units of land use of 1979, 1992, 2002 and 2010 through the transition matrix allowed us to estimate the various changes of the plan cover due to agricultural activities.

3.1 Land Use in 1979, 1992, 2002 and 2010

The synthesis of the land use in 1979, 1992, 2002 and in 2010 is presented in Table 1.

The appearance of the vegetation of Municipalities of Dassa-Zoumé and Glazoué in 1979 was widely dominated by tree and shrubby savannas, clear forests and woody savannas as well as crops and fallows. They represented respectively 50.29%, 23.67% and 21.93% of the total surface of the study sector (Table 1). It is also noticed that gallery forests, dense forests; saxicol savannas, plantations and urban conglomerations were present (Fig. 2).

In 1992, the appearance of the vegetation of the study area (Dassa-Zoumè and Glazoué) was dominated by tree and shrubby savannas and sprinkled with plantations (Fig. 2). Most of the units of land use or the vegetation type of the study area observed in 1979 are present in 1992 (Table 1). Still these vegetation types (natural formations) have undergone a very sensitive degradation of their units.

In 2002, the appearance of the study area was dominated by crops and fallows. Clear forests and woody savannas as well as tree and shrubby savannas were relatively dominant in the North of the study area and had become islands of clear forests and woody savannas as well as tree and shrubby savannas (Fig. 2).

Crops and fallows which represent the dominant man made vegetation (48.49%), are to be found in the North and more particularly in the South. Clear forests and the woody savannas represent 15.34% (Table 1), they are located in islands of forests in the South which are endangered by the anthropological activities and in compact forest in the North. Gallery forests are located along Ouémériver and along its tributaries and represent 0.55%. Dense forests had almost become scarce and are endangered (0.84%). Tree and shrubby savannas recovering 29.68% of the study area were noticed in both municipalities.

In 2010, the study area had an appearance widely dominated by crops and fallows constituting 65.28% of total land area. The residual natural vegetation types were represented by gallery forests, clear forests and woody savannas as well as tree and shrubby savannas (Table 1). These natural formations were endangered in the locality of Assanté up to the South of the study area, where they were almost non-existent (Fig. 2) representing 28.87% of the total land area. The slender gallery forests located along Ouémé are being more directly impacted by anthropogenic activities from Thio up to the South. Whereas, gallery forests, clear forests and woody savannas as well as tree and shrubby savannas are slightly more abundant in the North of the study area.

Fig. 2 presents the different units of land use in Table 1.

3.1.1 Dynamic of the vegetation types between 1979 and 1992

The major change of land use between 1979-1992 in Municipalities of Dassa-Zoumé and Glazoué is synthesized by transition-matrix (Table 2). In the cells of lines and columns there are respectively vegetation types of 1979 and 1992. Conversions were made from lines towards columns. The diagonal cells correspond to the surface areas of the units which remained stable between 1979 and 1992. The units which are outside the diagonal represent the changes of vegetation and the other units of land use.

The examination of the table shows 8 great classes of land use in the landscape between 1979 and 1992. These classes remained identical between these fourteen (14) years. Generally, the natural formations occupied an important surface area. On the other hand, the anthropological formations (plantations, crops, fallows and urban areas occupied a small part of the whole study area.

3.2 Synthesis of the Dynamics of the Vegetation Types between 1979 and 1992

Between 1979 and 1992, the surface area of the natural vegetation types decreased. Gallery forests, dense forests and clear forests as well as shrubby savannas decreased from 92912 ha to 66801 ha approximately, that is 11.71% regression. On the other hand it was observed a 23.02% increase followed by certain stability close to the 65.27%. In 1979, trees as well as shrubby savannas were the dominant vegetation occupying larger surface area but at the same time during this periods an increase in plantations, crops and fallows was also recorded (Fig. 3).

The balance assessment of the dynamics of the land use between 1979 and 1992 in the study area showed a sensitive reduction of the natural formations for the benefit of the anthropological formations (plantations, crops and fallows as well as urban areas).

The analysis of the Fig. 4 revealed that 65.27% of the study area was stable; 11.71% was in regression and 23.02% an increase. The clear conclusion is that the evolutionary tendency of the vegetation between these two years was stable.

3.2.2 Dynamics of the vegetation types between 1992 and 2002

The analysis of the evolution of the vegetation between 1992 and 2002 allowed us to draw the vegetation maps from 1992 and 2002. The dynamics of the vegetation types between 1992 and 2002 is synthesized by transition-matrix of the classes of land use (Table 3). The columns of every matrix represent the classes in 2002 and the lines those of 1992. Every value of the table corresponds to the proportion of the converted area, between 1992 and 2002, the class indicated on the line towards the class at the top of column. The units which are outside the diagonal represent the changes of vegetation and the other units of land use (urban areas, crops and fallows). The cells of the diagonal indicate the surfaces of the units which remained stable between 1992 and 2002.

Table 1. Synthesis of the land use in 1979, 1992, 2002 and 2010

Units of land use	Surface area (ha)				Proportion (%)			
	1979	1992	2002	2010	1979	1992	2002	2010
Gallery forest	4383	2291	1944	1946	1.24	0.65	0.55	0.55
Dense forest	4878	3524	2969	2964	1.38	1.00	0.84	0.84
Clear forest and woody savannas	83663	58666	54220	30204	23.67	16.60	15.34	8.55
Tree and shrubby savannas	177753	133980	104906	69895	50.29	37.91	29.68	19.77
Saxicole savannas	2686	1865	1166	1168	0.76	0.53	0.33	0.33
Plantation	2050	8577	14492	14179	0.58	2.43	4.10	4.01
Crops and fallows	77513	143185	171391	230729	21.93	40.49	48.49	65.28
Agglomeration	530	1368	2368	2371	0.15	0.39	0.67	0.67
Total	353456	353456	353456	353456	100.00	100.00	100.00	100.00

Source: Landsat TM image of 1979, 1992, 2002 and 2010

Table 2. Transition-matrix of the units of land use between 1979 and 1992

Unit 1979	GF	DF	CFWS	TSS	SS	PL	CF	AG	Total surface area 1979
GF	3227	138	265	165	0	230	352	0	4377
DF	0	3458	265	144	0	450	545	0	4862
CFWS	0	0	58230	5221	0	1428	15162	8	83673
TSS	0	0	948	136715	0	3290	35760	48	176761
SS	0	15	10	0	2640	8	4	5	2682
PL	0	0	0	0	0	2035	3	10	2048
CF	0	87	158	285	0	195	81395	25	77521
AG	0	0	0	0	0	8	16	508	532
Total surface area 1992	3227	3698	59876	142530	2640	7644	133237	604	353456

Captions: GF: gallery forest; DF: dense Forest; CFWS: clear Forest and woody savanna; TSS: tree and shrubby Savanna; SS: Saxicolesavanna; PL: plantation; CF: crops and fallows; AG: agglomeration 138: surfaces in km2

Stable surface area between 1979 and 1992, Total surface area in 1979: surface of the vegetable formations and the other units of land activities in 1979

Total surface area in 1992: surface of the vegetable formations and the other units of land activities in 1992

Analysis of the dynamics of the land use revealed expansion of crops and fallows, plantations and urban areas and a consequent reduction in the units of gallery forests, dense forests, clear forests as well as woody and shrubby savannas. Thus it was in 2002 that the unit of crops and fallows was clearly observed and dominated the whole study area.

3.3 Synthesis of the Dynamics of the Vegetation Types between 1992 and 2002

In the whole study area, the natural formations were in regression in favour of the anthropological formations (Fig. 5). Between 1992 and 2002, an average annual regression rate of 30.32 was recorded for gallery forests, dense forests, and clear forests and woody savannas, tree and shrubby savannas, and saxicoles savannas. Also, 23.02% of progress with a stability close to 65.27% was recorded for plantations, crops and fallows as well as urban areas.

The synthesis of the conversion of the vegetation types highlights the spatial influence of the activities of agricultural production and in concordance with the increase of the needs of supplementary production (new agricultural lands) in order to face the galloping population growth. This resulted in important modifications in the plant cover which take place mainly to the detriment of the woodyareas. Thus during this last decade, gallery forests, dense forests, clear forests and woody savannas,as well as tree and shrubby savannas have declined significantly in the study area. The conversion balance of the natural vegetation types and the other units of land use allowed us to make a synthesis of the degrees of regression, of stability and progression of different units (Fig. 6).
Analysis of Fig. 6 revealed that 51.92% of the sector was in stability, 30.32% was in regression, and 17.76% in progress. It was clear that the evolutionary tendency of the vegetation between these ten (10) years is averagely stable.

- **Dynamics of vegetation types between 2002 and 2010**

The conversion of the vegetation types and the other units of land use between 2002 and 2010 is synthetized by transition matrix (Table 4). In the cells of lines and columns are respectively vegetation types and other units of land use between 2002 and 2010. The conversions are made of lines towards columns. The cells of the diagonal correspond to the surfaces of the units which remained stable between 2002 and 2010. The units which are outside the diagonal represent the changes of state of the vegetation and the other units of land use.

From Table 4 it can be inferred that out of 1946 ha of existing gallery forests in 2002, 348 ha remained unchanged. The rest was transformed into clear forests and woody savannas (15 ha), in tree and shrubby savannas (25 ha), in plantations (521 ha) and in crops and fallows (1035 ha). Out of 30204 ha of clear forests and woody savannas in 2002, approximately 12823 ha remained unchanged in 2010 and more than 17381 ha were transformed into plantations and crops and fallows. Between 2002 and 2010, 45446 ha of woody and shrubby savannas remained intact while 354 ha were transformed into clear forests and woody savannas, 8615 ha in plantations, 50215 ha in crops and fallows. Saxicole savannas were transformed into plantations, crops and fallows and in built-up areas.

3.4 Synthesis of the Dynamics of the Vegetation Types between 2002 and 2010

Analysis of the transfers of land use between 2002 and 2010 allows us to understand the relative importance of the landscaped dynamics. The natural vegetation types represented by forests galleries, dry dense forests, clear forests, woody savannas as well as tree and shrubby savannas were mainly converted in crops and fallows (Fig. 7). The dynamics of the land use was characterized by an extension of the cultivable surface areas. The study revealed that in 2010 the cultivable surface area became the dominant land use with an increase in its total area. Between these two (02) years, it was observed that forests galleries, and dense forests were in process of disappearance. The balance of the dynamics of the vegetation types and other units of land use is presented in Fig. 8.

Analysis of Fig. 8 shows that 49.09% of the study area was in regression, 36.06% was in stability and 14.85% in progress. It was clear that the evolutionary tendency of the vegetation between these two (02) years was in net regression.

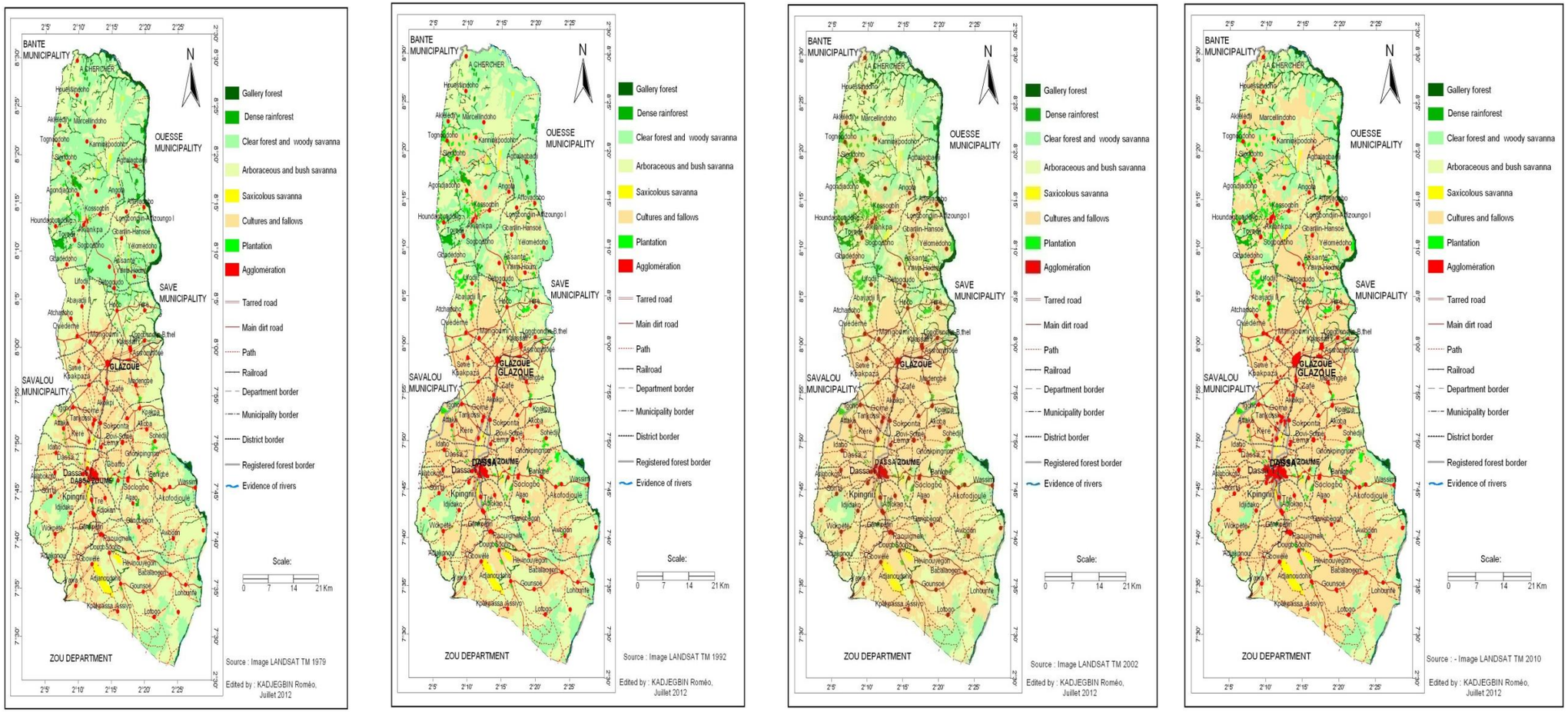

Fig. 2. Land use in municipalities of Dassa-Zoumé and Glazoué in 1979, 1992, 2002 and 2010

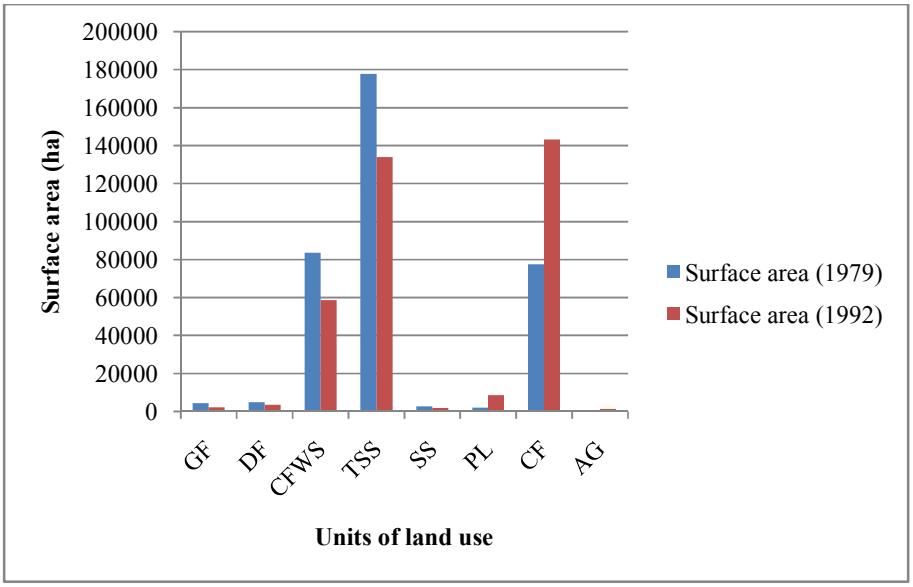

Fig. 3. Evolution of the units of land use between 1979-1992
Source: data processing of the vegetation types between 1979 and 1992
Captions: GF: gallery forest; DF: Dense Forest; CFWS: Clear Forest and Woody Savannas; TSS: Tree and Shrubby Savannas; SS: Saxicole Savannas; PL: plantation; CF: Crops and Fallows ; AG: Agglomeration

To better assess the possible relations between the increase of the population and the decrease of the natural formations, it is important to establish the link.

3.5 Link between Evolution of the Units of Land Use and Population Size

Figs. 9 (a b, c) present the evolution of the population and the natural formations (gallery forests, clear forests and woody savannas, as well as tree and shrubby savannas.
Analysis of Figs. 9 (a, b, c) highlights correlation coefficients of 0.63; 0.93 and respectively 0.97 for the gallery forests, clear forests and the woody savannas, as well as the tree ad shrubby savannas.

In the case of gallery forests, the correlation coefficient ranged between 0.5 and 0.8. Thus the obvious conclusion is that there is a strong correlation between gallery forests and evolution of the population there. As regards to other vegetation types (clear forests and woody savannas, tree and shrubby savannas), the correlation coefficient ranged between 0.8 and 1. We could thus conclude that the surface area of these two (02) natural formations and the size of the population are very strongly correlated. In these conditions, the more the size of the population grows, the more the natural formations decrease in surface area. It was thus necessary to calculate the annual rate of regression and to make projections over 2025 when the population of the two (02) municipalities would reach 354242 inhabitants (Table 5). This projection was made by referring to the formula [8] presented in the methodology. Table 6 presents the vegetation types with their annual rate of regression.

Analysis of the Table 6 shows that if the pressure on natural formations is maintained, before the year 2025 they will be reduced in two (02) municipalities. Thus gallery forests, clear forests and woody savannas, as well as tree and shrubby savannas will be reduced respectively to 1323.67 ha, 18071.05 ha and 44180.63 ha.

4. DISCUSSION

The study of the environmental impacts of the cultural systems in the Municipalities of Dassa-Zoumé and Glazoué showed that the natural vegetation types are in process of disappearance for the benefit of crops, plantations and built-up areas. These results are similar to others; [9,10,11,12] who reported that the natural formations give place to farming and urban areas that continue to expand.

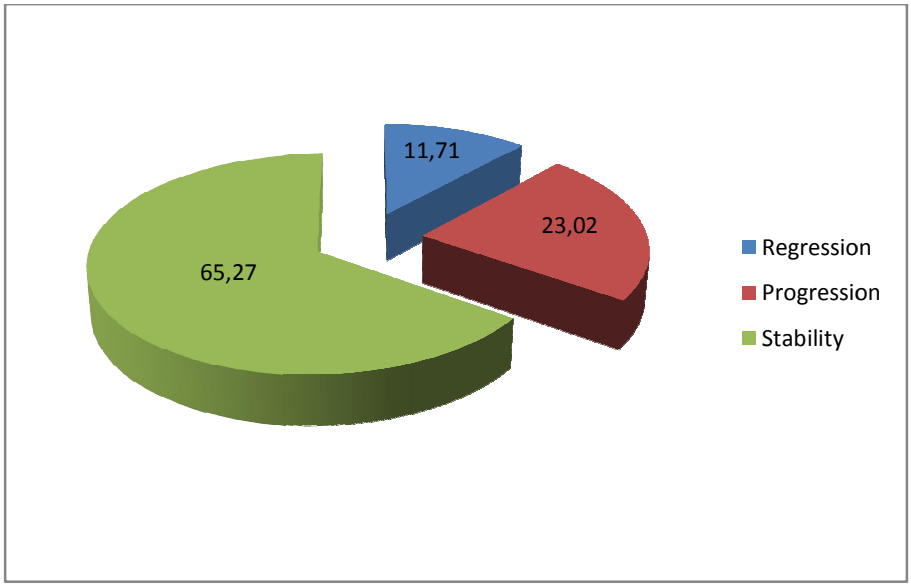

Fig. 4. Balance assessment of the evolution of vegetation types and units of land use between 1979 and 1992

Source: data processing of vegetation types between 1979 and 1992

Table 3. Transition-matrix of units of land use between 1992 and 2002

Units 1992	GF	DF	CFWS	TSS	SS	PL	CF	AG	Total surface 1992
GF	1215	15	37	75	0	334	615	0	2291
DF	0	1226	70	58	0	966	1204	0	3524
CFWS	0	0	23358	1586	0	5133	28574	15	58666
TSS	0	0	596	82945	0	7088	43260	91	133980
SS	0	0	2	0	1809	26	25	3	1865
PL	0	0	10	25	0	7220	1277	45	8577
CF	0	26	24	85	0	8786	134108	156	143185
AG	0	0	0	0	0	25	45	1298	1368
Total surface 2002	1215	1267	24097	84774	1809	29578	209108	1608	353456

Captions: GF: gallery forest; DF: dense Forest; CFWS: clear Forest and woody savanna; TSS: tree and shrubby Savanna; SS: Saxicolesavanna; PL: plantation; CF: crops and fallows; AG: agglomeration. 15: surface area in ha, Stable surface area between 1992 and 2002, Total surface area of the vegetation types and the other units of land use in 1992 , Total surface area in 2002: surface of the vegetation types and the other units of land use in 2002

Table 4. Transition matrix of the vegetation types and other units of land use between 2002 and 2010

Units 2010 Units 2002	GF	DF	CFWS	TSS	SS	PL	CF	AG	Total surface 2002
GF	348	0	15	25	0	521	1035	2	1946
DF	0	450	65	85	0	1016	1340	8	2964
CFWS	0	0	12823	0	0	6316	35020	45	30204
TSS	0	0	354	45446	0	8615	50215	265	69895
SS	0	0	0	0	1108	16	38	6	1168
PL	0	0	0	0	0	12568	1535	76	14179
CF	0	0	0	0	0	15178	215255	296	230729
AG	0	0	0	0	0	25	42	2304	2371
Total surface 2010	348	450	13257	45556	1108	44255	304480	3002	353456

Captions: GF: gallery forest; DF: dense Forest; CFWS: clear Forest and woody savannas; TSS: tree and shrubby Savannas; SS: Saxicole savannas; PL: plantation; CF: crops and fallows CF; AG: agglomeration.15: surfaces ha, Stable surface area between 2002 and 2010, Total surface area in 2002: surface of vegetation types and other units of land use in 2002, Total surface area in 2010: surface of vegetation types and other units of land use in 2010

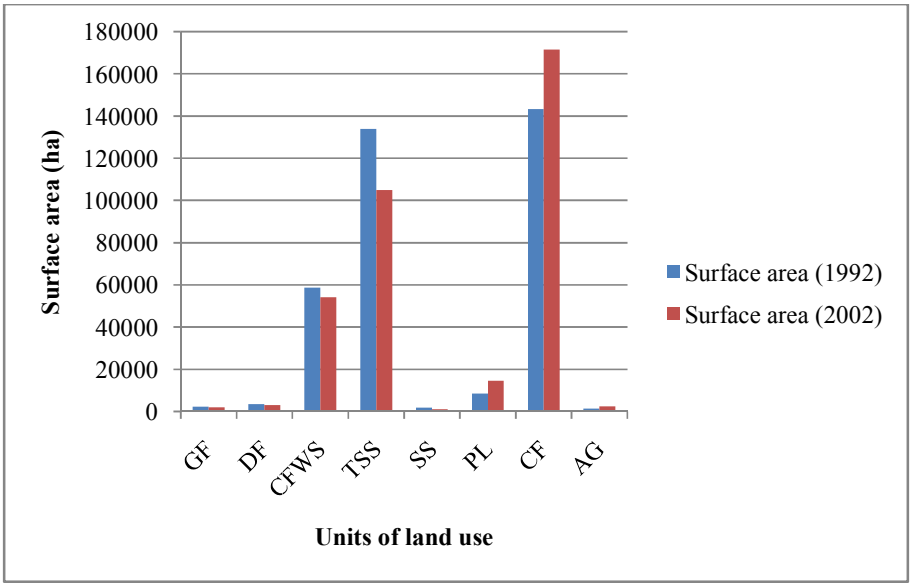

Fig. 5. Evolution of the units of land use between 1992 and 2002

Source: data processing of the vegetation types between 1992 and 2002

Captions: GF: gallery forest; DF: dense Forest; CFWS: clear Forest and woody savannas; TSS: tree and shrubby Savannas; SS: Saxicolesavannas; PL: plantation; CF: crops and fallows; AG: agglomeration

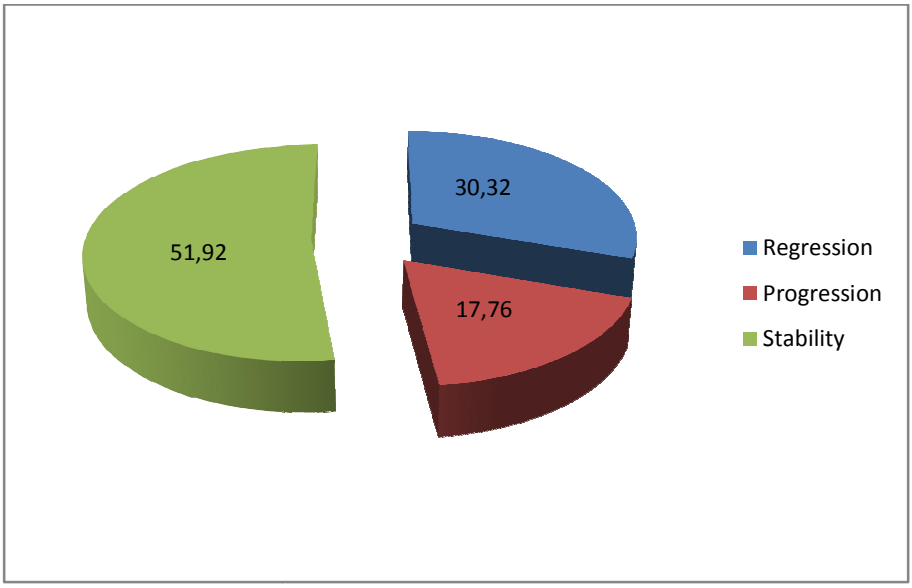

Fig. 6. Balance assessment of the evolution of vegetation types and units of land use between 1992 and 2002

Source: data processing of vegetation types between 1992 and 2002

These results are also in accordance with others [13] who reported that the analysis of the dynamics of the units of land use in Municipalities of Dassa-Zoumé and Glazoué reveals a regression of natural formations for the benefit of anthropological formations (crops and fallows). The same observation was reported by Oloukoi et al. [14], in the Department of Collines (1998), in the headquarters of Zou and even in the plateau of Abomey [15] who reported an increase of agricultural surface area, savannas which influences agricultural and built-up areas to the detriment of other categories of units of land use.

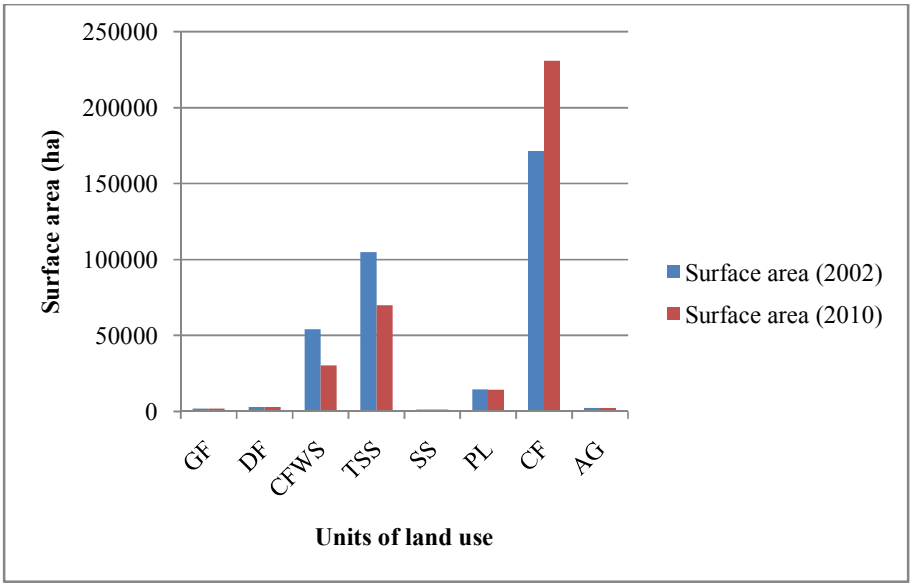

Fig. 7. Evolution of the units of land use between 2002-2010

Source: data processing of the vegetation types between 2002 and 2010

Figs. 6 and 7 express different ideas. Fig. 6 represents the changes in balance assessment of vegetation types and units of land use between 1972-1992 whereas Fig. 7 presents the evolution of surface areas between 2002-2010,Captions: GF: gallery forest; DF: dense Forest; CFWS: clear Forest and woody savanna; TSS: tree and shrubby Savanna; SS: Saxicole savanna; PL: plantation; CF: crops and fallows; AG: agglomeration

Table 5. Rate of evolution and conversion of the vegetation types and other units of land use between 1979 and 2010

Vegetation types and other units of land use	Annual average evolution rate (%)			Convertion rate (%)		
	1979 to 1992	1992 to 2002	2002 to 2010	1979 to 1992	1992 to 2002	2002 to 2010
Gallery forests	-2.34	-6.34	-17.21	1.47	0.12	0.78
Dense forests	-2.10	-10.22	-18.85	1.46	0.46	0.82
Clear forests and woody savannas	-5.50	-8.89	-8.23	1.66	0.33	0.69
Saxicolesavannas	-0.12	-0.30	-0.52	61.85	31.3	18.10
Tree and shrubby savannas	-1.65	-4.57	-4.28	2.41	0.62	0.23
Plantations	10.13	12.37	11.38	155.53	4.32	06.80
Crops and fallows	4.16	3.78	1.12	107.52	13.77	12.89
* Farming area	12.64	11.58	8.22	265.46	18.71	19.46
Built-up areas	8.73	1.61	2.35	20.16	17.54	33.38
Average convertion rate				44	25.91	9.21

*Source: CENATEL processed data and our calculations, * Farming areas group gathering the tree and shrubby savannas, the crops and fallows, as well as plantations*

Table 6. Annual rate of regression and projection for 2025

Natural formations	Surface area in1979 (ha)	Surface area in 2012 (ha)	Annual rate of regression (%)	Surface area in 2025 (ha)
Gallery forests	4383	1946	2,46	1323,67
Clear forests and woody savannas	83663	30204	3,09	18071,05
Tree and shrubby savannas	177753	69895	2,83	44180,63

Source: Landsat TM Image 1979- 2012 and our calculations

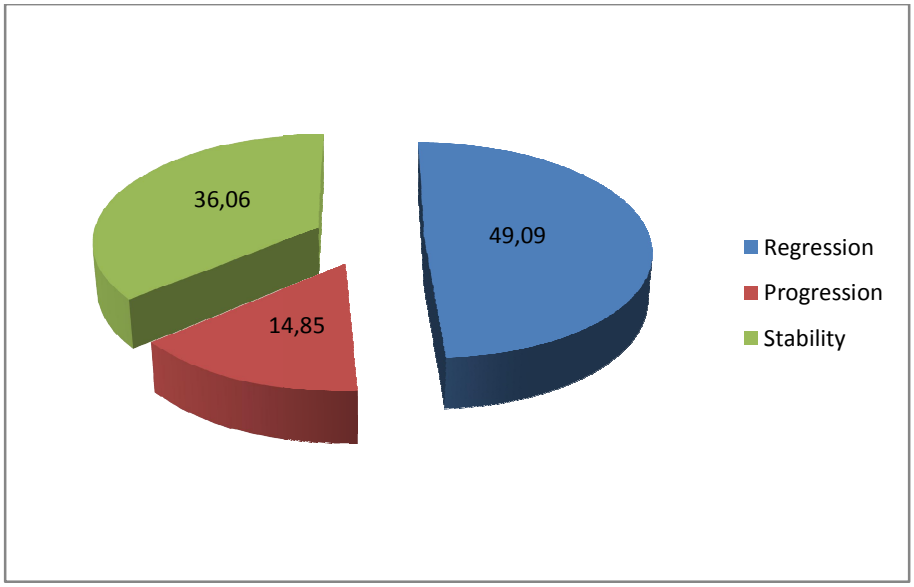

Fig. 8. Balance assessment of the evolution of vegetation types and units of land use between 2002 and 2010

Source: data processing of vegetation types between 2002 and 2010

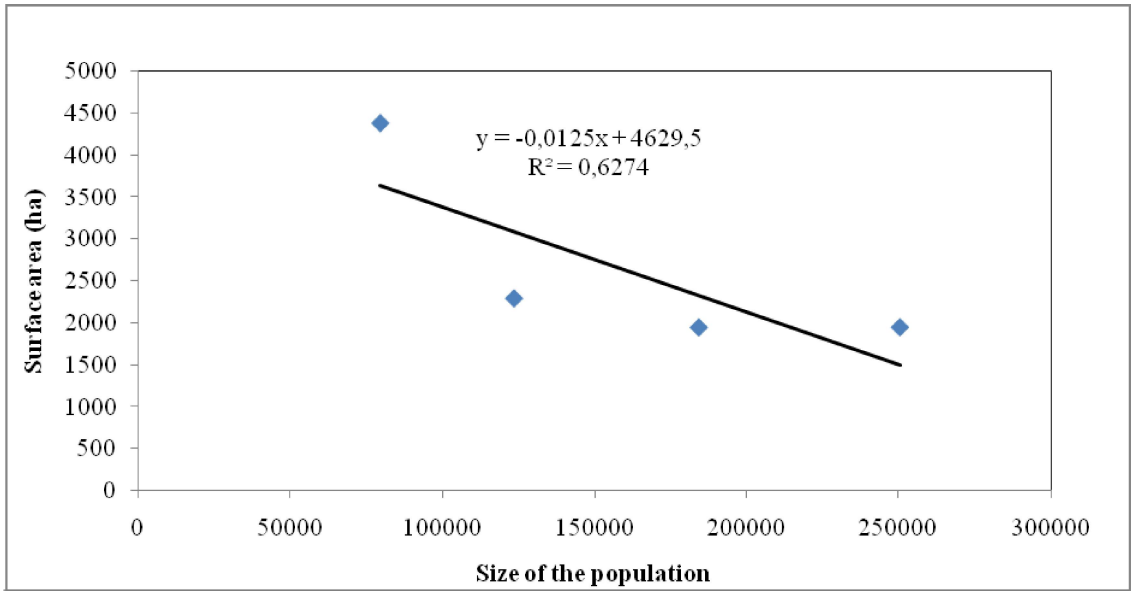

Fig. 9a. Evolution of the gallery forests versus size of population between 1979 and 2012

Also, the connection established between the evolution of the units of land use and the progress of the number of the population highlighted that the more the size of the population grows, the more the natural formations lose surface. These results are in accordance with those obtained by other scientists [16,17,18,19,20] who reported that the natural space disappears with time and that the farming areas increase with the evolution of the size of the population. Mama and Houndagba (1991) also reported that the demographic pressure entails the destruction of about 100 000 ha of natural vegetations every year in Benin.

The strong stability of the units between 1979 and 1992 can be explained by a low population growth and the weak speculation of food and industrial products.

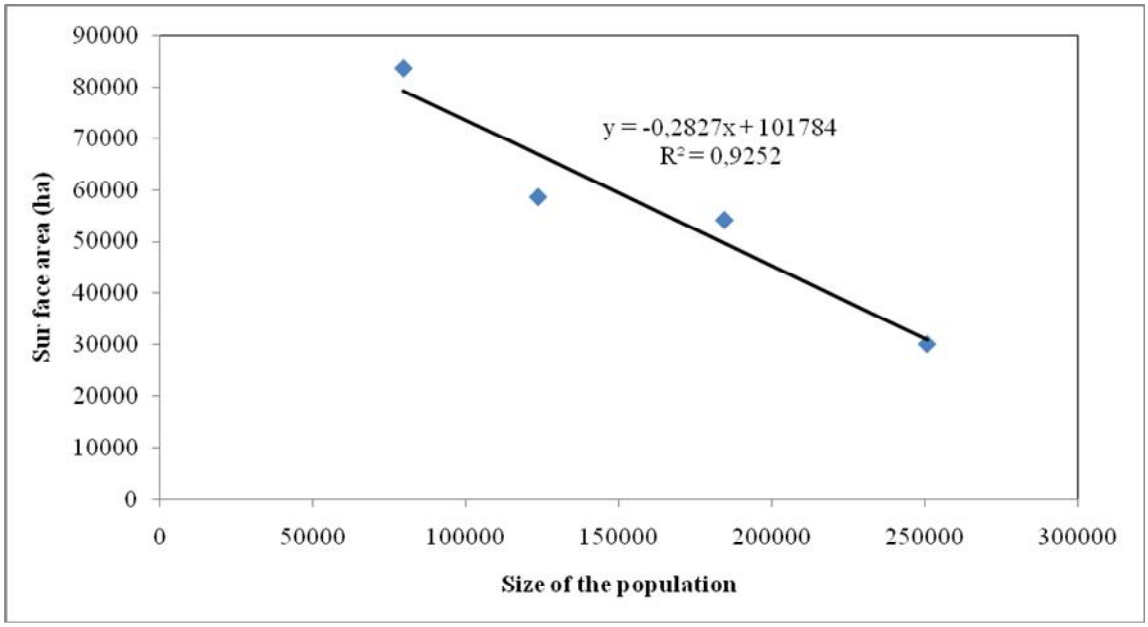

Fig. 9b. Evolution of clear forests and woody savannas versus size of population between 1979-2012

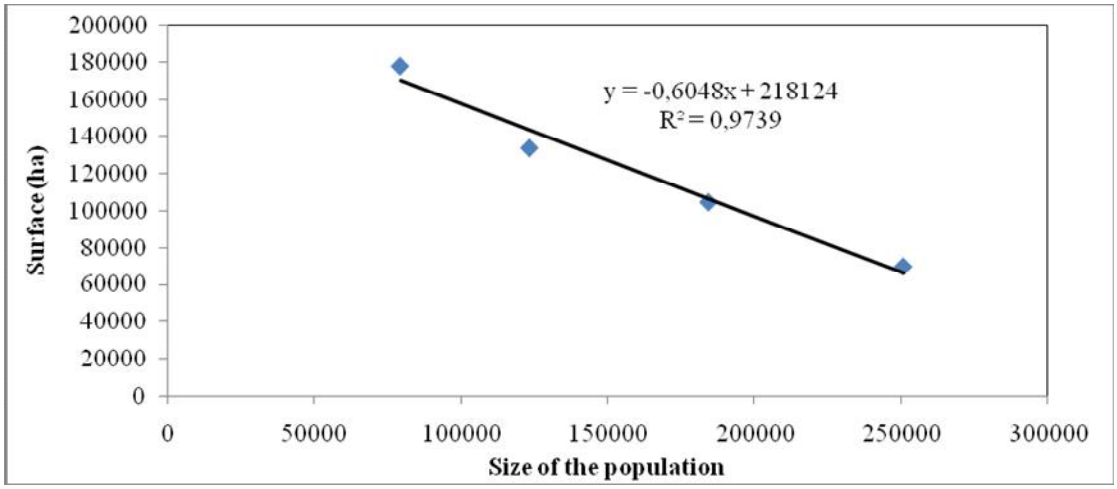

Fig. 9c. Evolution of tree forests and shrubby savannas versus size of population between 1979-2012

These results were similar to those of Mama and Houndagba [21], FAO [22] and Adjahossou [23] who reported that the increase in population growth make shorter the fallows and triggers an increase of arable crop area. That result in the degradation of ecosystems with immediate consequences such as destruction of the vegetation and erosion of soils. FAO [22] reported that the vegetation types are under increasing pressure due to agricultural activities, forest exploitation and urbanization.

Adam and Boko [24] also reported the degradation of Southern Beninese plateaux. In fact, from the coast up to Setto latitude, the primary natural vegetable formation has almost disappeared. According to Toko and da MathaSant' Anna [25] and Arouna et al. [26], human activities dominated by agriculture constitute the major causes of this degradation. Additionally, Carr et al. [27], Vissin [20], Vodounou [28] and Arouna et al. [26] also demonstrated in their investigations that the

population growth is the first factor of degradation of the vegetation and the natural resources.

A study carried out in Ivory Coast in the soudano-Guinean area by Barima et al. [29] on the landscaped dynamics with satellite images also reached the conclusion that the dense forests were converted in anthropological formations. Arouna [30] in the study of the mapping of the dynamics of the vegetable formations and the other units of land use of 1974, 1986 and 2010 in the Municipality of Djidja, reported that several factors are involved in the degradation of the plant cover in that municipality of where agriculture is impulsed by the population growth. These conclusions are similar to those found in the Municipalities of Dassa-Zoumé and Glazoué.

The results of the evolution of land use for agricultural to the detriment of land use for habitation and natural vegetation in the Municipalities of Dassa-Zoumé and Glazoué can be also correlated to those of Abdoulaye et al. [31] who reported in their diachronic study of the occupation of the outskirts of the W National park that land use for agriculture and habitation increased to the detriment of that for natural vegetation between 1995-2006 and that evolution concerned 30,37% of the whole sector of study. Kombienou [32] also concorded to the same results in the villages of Boukoumbé in the northwest of Benin where he concluded that the natural vegetation knew an exponential regression because of the agricultural activities and that the soils were impoverished due to the agricultural methods based on the extension of the land use for agriculture and this could compromise the existence of the populations. The drop in the vegetation types recorded in Dassa-Zoumé and Glazoué is also confirmed by Gibigaye et al. [33] who reported a regression of the vegetable formations in the municipality of Toucountouna due to the anarchic clearings for agricultural purposes. All this contribute to the degradation of the soils.

5. CONCLUSION

This study based on the importance of the analysis of the satellite images allowed us to understand the deep modifications of the vegetation and the land use because of the farming. It also allowed us to establish the existing correlations between the evolution of the size of the population and the various vegetation types as well as to comprehend the future aspects of 2025 of these various vegetation types in case tendency is maintained.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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