DYNAMICS OF THE OCCUPATION OF SACRED WOOD IN THE NORTH WEST OF THE ATACORA DEPARTMENT IN BENIN

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ABSTRACT

In Benin, sacred wood take on particular importance of ecological and socio economic second sight. But following the example of other natural formations, the sacred forests are degraded and their surface is reduced in a disturbing way because of human actions. The present research is particularly interested in the dynamics of the land use and its incidences on sacred wood in the north west of Atacora' department. The CENATEL vegetation's map 1990 and the satellite images of 13/01/1990, 31/01/2006 and 09/11/2014 obtained on the web site GLCF/USA were used. The data collection was made through the documentation, the download of images from internet and the map of vegetation. The data processing consisted at first time in the processing of landsat satellite images, then in meadow processing and in the extraction of the study sector and finally in the geometrical correction of the downloaded images.

The results reveal that the surface of the sacred wood of the study sector is reduced between 1990, 2000 and 2014 periods because of the anthropological activities (rural works, vegetation, the town planning, the forestry development etc.). This degradation passed from 99,1 ha in 2000 to 91,03 ha in 2014 with e variations from less -0,14 % to less -1,87 %. This situation could be mastered if the pressures on sacred wood are reduced. In the opposite case, we shall observe the disappearance of most of sacred wood of the territory of research on the horizon 2050.

Keywords: Atacora (Benin), Occupation of soil, Sacred woods, Dynamic, variation

Introduction

Throughout the world, traditional societies have long established sacred natural sites which they try to preserve from all forms of aggression. Considered by some to be truly protected areas, these forests have been recognized as belonging to different IUCN categories in 2008 (IUCN, 2008) following several meetings of the IUCN World Commission on Protected Areas. Among

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these sacred sites, sacred forests are the only witnesses to existing original vegetation in some areas marked by massive deforestation (Bhagwat et al., 2006).

In Benin, the decline in forest cover due to anthropogenic pressure and agricultural production systems poses a serious threat to the ecological balance of Benin. Indeed, in the absence of a diversification of domestic energy sources, 80% of the Beninese population are dependent on firewood and charcoal for their culinary activities, which come mainly from natural formations and fallow land.

A total of 2,940 sacred groves covering an aggregate area of 18,360 ha or 0.2% of the total area of the country were recorded in 1998 by Agbo and Sokpon. Access to the majority of these sacred forests remains forbidden to uninitiated or non-native people from neigh boring villages. It is in fact, for the villagers, places of residence of ancestors or protective geniuses. Thus, the beliefs of the people are such that any profanation of this place would cause curses (diseases, drought, infertility) on the community.

However, these examples of local management of biodiversity are subject to many pressures today due to the scarcity of land, soil depletion, high population growth, and so on. The most spectacular of these is logging, which is made without any distinction between the sacred and non-sacred nature of the sites (Ibo, 2005).

The analysis of the dynamics of the sacred woods of the Atacora Department from data such as cartography and Geographic Information Systems, and modelling is now a promising path for the conservation of vegetation. Have been carried out using this systemic approach with certain achievements (Bénié et al., 2005, Arouna et al., 2010) and also with inadequacies especially in the field of modelling and spatial management models. The studies of modelling the dynamics of the occupation of plant formations in general and the changes in the spatio-temporal dynamics of sacred woods in particular were made with enough complexity that the generalization and comparison of the results became (Rindfuss et al., 2008).

This first study on the sacred woodlands of the northwest of the Atacora department in Benin should help to highlight the special and remarkable character of these sacred woods

Materials and methods

Presentation of the study environment

This study was carried out in the northwest of the Atacora department in Benin. It is situated between 0 ° 55 'and 1 ° 58' east longitude and between 10 ° and 11 ° 30 'north latitude. It covers

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an area of 11,137 km2 and includes the Communes of Boukombé, Natitingou, Toukountouna and Tanguiéta, (Figure 1).

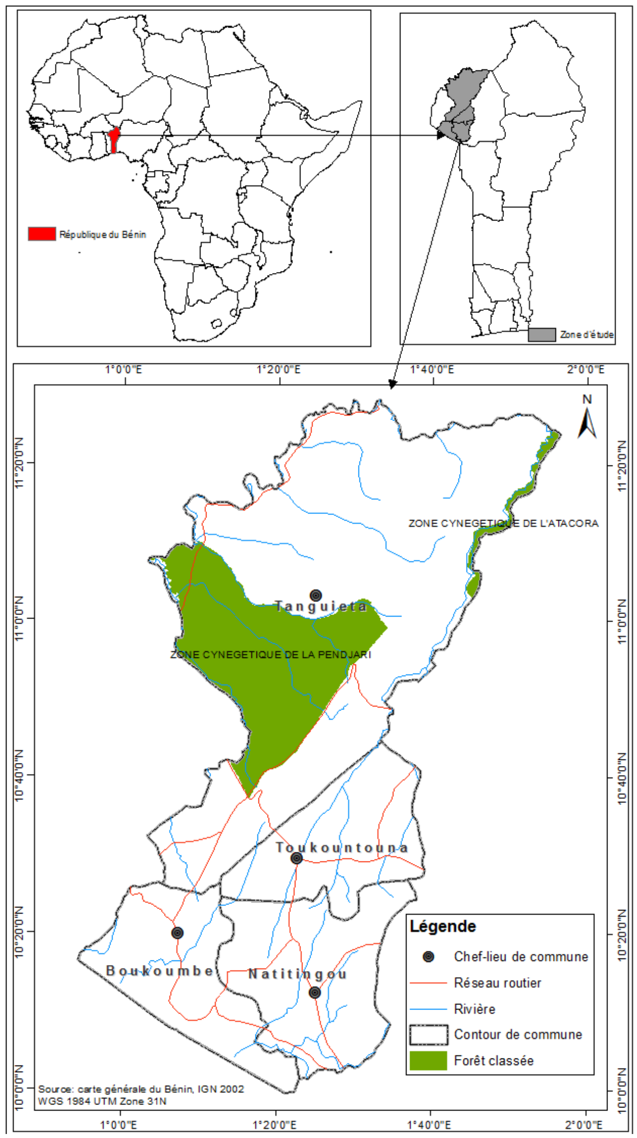

Figure 1: Location of Study Area

The type of climate that dominates the study area is determined through geographic foundations. It is termed the Sudanian (tropical) climate, with two great seasons: a rainy season and a dry season that punctuate life and human activities. The rainy season from May to October sees the predominance of monsoon flows from west to southwest, but those linked to grain lines generate heavy showers in the region with an average annual rainfall ranging from 900 to 1200 mm and Number of rainy days ranging from 60 to 70 days. (Ouorou Barrè, 2014). The dry season covers two periods, the harmattan period (November-February) and the heat season (March-April) relatively warm during the day, drying up and accelerating the vegetation decline. The succession of seasons is due to the climatic mechanisms observed in West Africa. The different meteorological data and their variations result from several general mechanisms that determine the climate.

The average annual temperature is 26.5 ° C and varies between 15 ° C and 35 ° C during the harmattan between November and March. The relief has an altitude varying between 400 to 640 meters, or even more. It is very rugged and characterized by the different links of the Atacorian massif. This type of relief constitutes a brake on agriculture and this causes local populations to resort to plant formations. Several types of soils characterize the study area. These are: rough mineral soils (less than 10 cm deep), poorly developed soils (10 to 30 cm depth), tropical ferruginous soils, and hydro orphic soils.

Agriculture is the main source of income for the majority of the study population, which has grown from 211,733 in 2002 to 300,877 in 2013 (INSAE 2014). The dominant socio-cultural groups in the area are the Waaba, the Btamaribè, the Natimba, the Gourmantché.

Data used and methods of analysis of the dynamics of occupation of Sacred Woods

Satellite and auxiliary data

The remote sensing data used in this research are:

- a TM image of LANDSAT 5 in Géotiff format, of 13/01/1990, scene 192-054, with a spatial resolution of 30 m, obtained on the GLCF / USA website;

- an ETM + image of LANDSAT 7 in Géotiff format, scene 192-054 dated 31/01/2006, with a spatial resolution of 30 m, obtained on the GLCF / USA website;

- an OLI-TIRS image of LANDSAT 8 in Géotiff format, scene 192-054 dated 09/11/2014, with a spatial resolution of 30 m, obtained on the website of EarthExplorer-USGS.GOV/USA.

The auxiliary data include:

- Google Earth Pro image for 2014

- Land use and land use map of Benin (IMPETUS, 2000)

- Map of vegetation of Benin (CENATEL, 1990).

Equipment

The material used for this study is the Erdas Imagine 9.1 software for the digital processing of satellite images and the GIS (Arc GIS 10.1), ESRI (Environmental Systems Research Institute) software for spatial mapping and analysis.

Landsat image processing

The processing of each of the Landsat images in the study area was a set of application processes that transformed the images for information retrieval. This treatment has undergone several essential steps.

pre-treatment

There are a number of operations including retrieval, correction, combination and contrast enhancement of the study environment.

Extraction of the study area

The extraction of the study area was possible thanks to the subset command of the Erdas Imagine software, after having projected the limit of it on the image concerned.

Geometric correction of 2000 image

Geometric correction or correction is the process of projecting the data onto a flat surface and matching it to a given projection system.

The accuracy of this correction affects the accuracy of the change detection.

Thus the image of 2000 whose datum is WGS 1886 has been corrected with respect to the image of 1990 which has for datum the WGS 1884 by a polynomial of degree 1 with a quadratic mean error of the order of 0, 31 pixel, using 5 docking points. This correction is necessary because the two images being of different datums could not be superimposed. The pre-sampling of the images was carried out using the nearest neighbour method because it does not alter the radiometric value of the pixels (Gbaguidi, 2016)

In this case, the projection system is UTM Zone 31N, Spheroid WGS 84, and datum WGS 84. The procedure took place in ERDAS Imagine, thanks to the rectification function which is Geometric correction from the Raster window.

Colourful composition

It is the combination of three spectral bands and their respective assignment to one of the three basic or primary colours available: blue, green and red. It is possible to make several types of colored compositions with the different channels of a Landsat image, but only a few are relevant. The human eye is much more sensitive to shades of red than green, which explains why the composition 453, 432 or 345 is used to study vegetation because there is a strong reflection of vegetation in channel 4 (PIR).

In the present study, the colored composition that has been favored for the determination of soil occupation units is that of standard false colors. It combines the bands of the near infrared, red and green sensor respectively with the red, green and blue display plane of the screen. This composition, which is very effective for the analysis of vegetation, has the advantage for the interpreter of having practically the same properties as the infrared photographs in color, used for a long time by photo-interpreters (Kerle and Van Wyk de Vries , 2001).

In ERDAS IMAGINE, the colored composition was made after grouping the different bands or creating an image in ".img" format by the Layer Stackvia Interpreter / Utility function. The latter displays by default the composition 432. However, depending on the needs of the study, this combination can be changed. Thus, the choice was made for the false-colored colored composition 345. The latter means that the band 3 corresponding to the Red color was placed in the Red channel; Near-Infrared band 4, in the Green channel and the Middle Infrared band 5 in the Blue channel of the software.

Contrast enhancement

Contrast enhancement is a radiometric correction that consists in rendering an image (colored composition) more interpretable / readable with respect to a given thematic image. There are several techniques for contrasting an image. The contrast enhancement method used for this study is the histogram equalization. With this method, radiometric (DN) values are assigned to large brightness’s based on their frequency of occurrence, so that the highest brightness levels are assigned to the frequently occurring image values.

Digital processing proper

Digital processing per se highlights multispectral classification and evaluation of data classification.

Multi-spectral classification by maximum likelihood

Pixel classification is a process of grouping the pixels of an image into a limited number of classes. If the pixel meets a set of criteria, it is assigned to the class that meets these criteria. There are two types of classifications: supervised classification and unsupervised classification. For this study the choice is made on the classification supervised because of the knowledge of the sector of study. The latter consists in first selecting training plots (AOI) which are homogeneous groupings of pixels characteristic of a given land occupation (samples). On the training plots, the software classified each image according to the parametric algorithm that is the Maximum likelihood. It is an algorithm very commonly used because, generally the most powerful. Its use assumes that distributions of the reflectance values of the training plots are normal (Wolff, 2006). This classification algorithm computes a multidimensional probability function which makes it possible to determine the probability of each pixel belonging to one of the categories corresponding to the spectral signatures (Collet, 1992). It has the advantage of providing a certainty index related to this choice for each pixel, in addition to the class to which it has been assigned. For classification with less confusion, it is recommended to take as many training areas per class as possible. In this study, the number of samples selected was limited to 10 for each class. Overall, the classes defined are 9 (forest gallery, dry dense forest, clear forest, wooded savanna, wooded savanna, shrub savannah, fallow fields, bare soil and burned area).

Evaluation of classification

A classification is not complete without an evaluation of its accuracy (Lillesand and Kiefer, 1994). Indeed, we cannot use data obtained by remote sensing with certainty if we do not know what is statistically the level of the error associated with it. It is not enough to present a percentage of correctly classified pixels, as is often the case in many studies, because this statistic ignores the local accuracy, only the total quantity of a class is considered irrespective of its location (Jensen, 1996). The results of a classification are evaluated by comparing the classified image with reference data (aerial photographs, maps or field surveys). These assessment areas will be surveyed with the same care as the training areas. The values of the classified image will be compared with those of the field in a double entry table commonly called a contingency matrix or a confusion matrix. The number of zones according to their belonging to the different classes in the classified image (in rows) and in the field (in columns) are shown in the boxes of the table. The well classified areas are located on the diagonal of the matrix and the errors outside. There are two types of errors: errors of omission and confusion (or "commission"). An error of omission is an observation that should have been categorized as B but has been "forgotten" and placed in another class. An error of confusion is an observation that is classified as B when it should have been classified in another class, there is confusion (Wolff, 2006).

In this study, it was field surveys that enabled this validation. Thus, the confusion matrices of the 1990, 2000 and 2014 classification were calculated from the spectral signatures in ERDAS IMAGINE according to the functions: Signature Editor / Evaluate / Contingency. These confusion matrices have been used to calculate errors of omission, commission errors, class purity indices and cartographic validity indices. The omission errors (in column) were obtained by making the ratio (of the number of pixels well classified in each unit of occupation of the ground) and the total number of pixels of the unit. Commission errors, on the other hand, were also obtained by the same procedure, but here at line level. The cartographic validity indices were obtained by subtracting 100% errors of omission. Class purity indices are obtained by subtracting 100% commission errors. The index of accuracy of the classification of the images of these three periods was calculated from the values of each confusion matrix, using the following formula (Mugisha et al., 2010, Arouna, 2012):

$$I = \sum_{i=1}^{k} \frac{x_i}{X}$$

With xi: Number of observations of the diagonal for class i; X: Total number of observations for all classes.

If I ≥ 0.9 (90%), then interpretation is correct (Mugisha et al., 2010).

For this study, the results obtained are respectively 86,09% for 1990; 84.13% for 2000 and 94, 26% for 2014. These validated each of the three classifications because the first two are "close" to the 90%.

2.2.3 Mapping of Image Classification Results in ArcGIS

Once the different treatments are done, the mapping of the results of the classification of the images in ArcGIS is necessary.

Vectorization in ArcMap

After filtering the classified image, the raster file has been vectorized under ArcMap. This conversion resulted in segmentation of the image. The units are individualized and each one can

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be modified without involving the others. It is only after the vectorization that the cartographic operations have really begun.

Diachronic analysis of land occupation

After the 1990 land-use maps (T1), 2000 (T2) and 2014 (T3), a comparative analysis of the three T1, T2 and T3 states was made. Land use change and land-use change rates between 1990-2000 (T1-T2), 2000-14 (T2-T3) and The dates 1990 - 2014 (T1 - T3) were determined. The assessment of the changes is quantified using the formula proposed by FAO (1996) and is very commonly used. It is as follows:

$$T = \frac{1}{t_2 - t_1} \times \ln(\frac{S_2}{S_1})$$

With S1 and S2, corresponding respectively to the area of a category of land occupancy in year t1 and year t2;

T the number of years of evolution;

Ln the natural logarithm.

The positive values of the balance sheet represent a progression of the surface of the class during the period analyzed and the negative values indicate the loss of area (regression) of a class between the two dates. Values close to zero indicate that the class remains relatively stable between the two dates.

Determining changes since 1990

The 1990 land use map consists of six classes. Those of 2000 and 2014 contain 5 classes. In order to be able to map the evolution of land use in the study area between 1990 and 2014, the 2000 and 2014 nomenclature headings were therefore aggregated into six classes. A crossing of the land use maps (1990-2000, 2000-2014 and 1990-2014) with a tolerance of 5 meters then allowed to identify the changes that occurred between 1990 and 2014 in spite of the different scales of the two maps.

Determining factors of change

Factors affecting land use and soil fertility have been identified and identified. The factors were determined not only on the basis of the trends identified by the comparison of 1990, 2000 and 2014 land use maps but also from interviews with farmers in the study area.

Once identified, the factors of change have been specialized with a GIS. Accessibility is derived from the slope. This was calculated from the SRTM DTM. The type of agricultural production was estimated at the communal level using the ratio of bare soil to useful agricultural area. The distance to roads and agricultural roads was calculated from the topo of the IGN (topographic map). Pedology was defined from a map of soil fertility in southern Benin (Igue et al., 2013).

Sacred Wood Simulation Scenarios

The probable evolution of the vegetation was estimated from the matrix of transition probabilities following the Markov chains integrated into the Land Change Modeler program. The Markov chain studies the process of evolution of a set of states evolving in the spatio-temporal domain from the transition probabilities. A process is called Markovian if the probability of observing the state depends on a finite number of its neighbours, whether spatial or temporal (Ben Arfa, 2006). The Markov chain integrated in the Land Change Modeler program is therefore well adapted to the predictive modelling of vegetation.

Two contrasting normative scenarios have been developed. The first is a trend-type scenario.

The second scenario is an environmental scenario. The assumptions in this scenario take into account the constraints of wood and wetland management established in the Prospective Forestry Sector Study documents in Africa (Benin, 2025).

Rationale for choosing the simulation time horizon

The year 2050 is the time horizon for which the scenarios are constructed in this study. This choice is made because FAO (2006) foresees a stabilization of fertility in developing countries by this time (Ogouwalé, 2006). Similarly, with regard to the available literature, 2050 is indicated as the simulation year if we do not want to get away from reality.

3. Results

The dynamics of land use in the research environment and its implications for sacred woodland have been analyzed. Then, a predictive exploration of the state of land occupation by 2050, was made with particular emphasis on the sacred woods.

3.1 Dynamics of land-use units and evolution of sacred trees.

The dynamics of land use were assessed by the analysis of three-date land cover conditions (1990, 2000 and 2014). Figure 2 shows the state of land use and sacred woodlands in 1990.

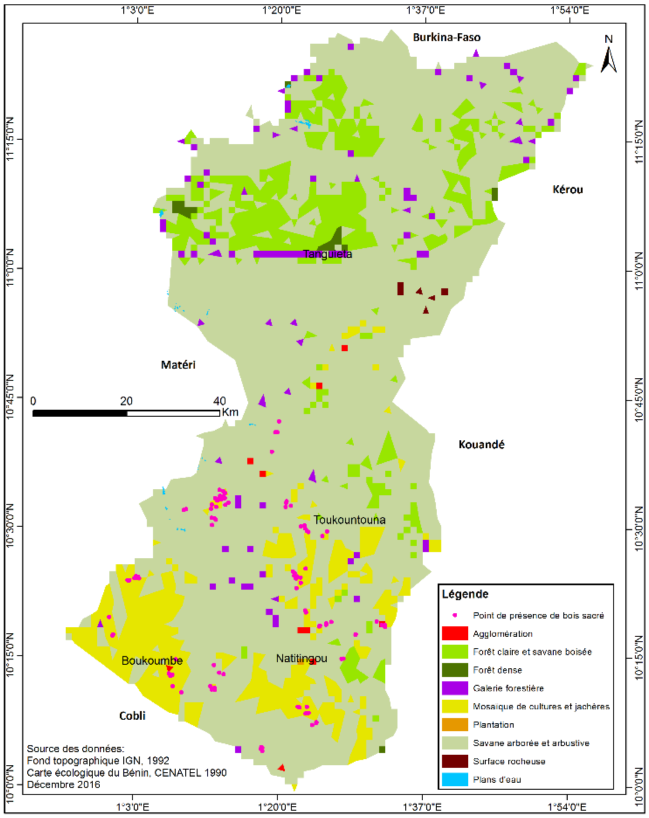

Figure 2: State of the sacred months in 1990

Figure 2 shows that the sacred woodlands of the research environment are found much more in crop mosaics, tree and shrub savannahs, wooded savannahs and forest galleries. It should be noted that the lack of data on the area of sacred wood in 1990 means that the condition of these sacred woods could not be analyzed. However, the presence of these sacred woods in crop mosaics suggests that they are already stormed by farmers in this period.

The analysis of the state of the land use in 2000 makes it possible to better appreciate the dynamics of the sacred woods (figure 3).

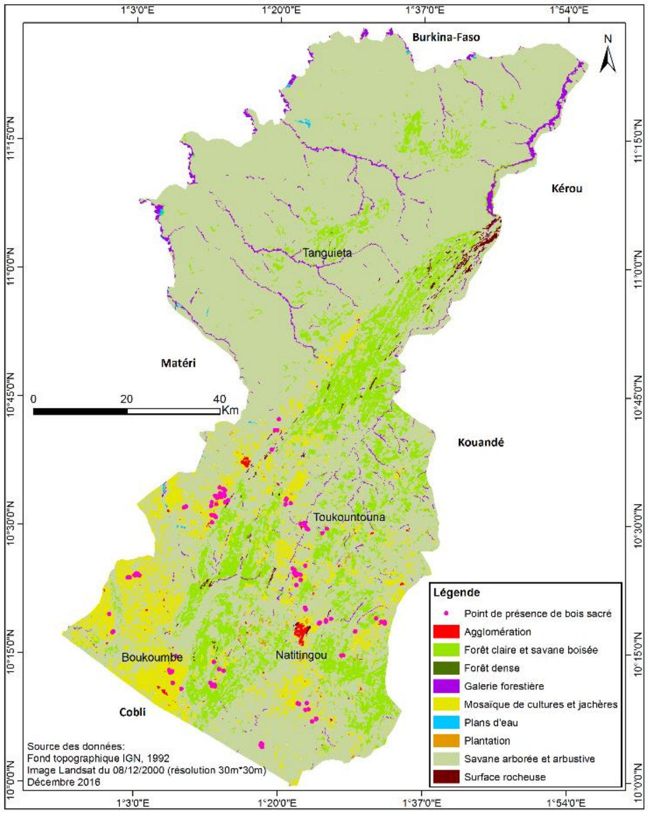

Figure 3: State of the sacred months in 2000

The analysis of Figure 3 shows an appearance of sacred woods in the research environment. These sacred woods are found in wooded savannas and shrubs, wooded savannahs and clear forests in the Natitingou Commune. Whereas in Boukombé the sacred groves are found more in the mosaics of crops and fallow and in the agglomerations. On the other hand, in Toukountouna, they are more present in clear forests, wooded savannahs and along some rivers. In Tanguiéta, the sacred groves are present in a few mosaics of crops and fallows, and a little in the savanna trees and shrubs. However, it is important to mention the presence of nine (9) sacred woods within the Pendjari Park enclosure according to the Local populations to whom access has prohibited them for ceremonies. This situation tells the people that these sacred woods have an uncertain future because they no longer know the state of these sacred woods.Overall, the sacred woods in the study area represent 99.1 ha or 0.88% Of the total area. Figure 4 shows the state of the sacred groves in 2014. In sum, it should be noted that in terms of area between 1990 and 2000, the sacred woods of the Commune of Tanguiéta remained almost identical, those of the Communes of Boukombé Are found more in the fields and fallow, while those of Natitingou and to a lesser extent those of Tanguiéta and Toukountouna are in the natural formations.

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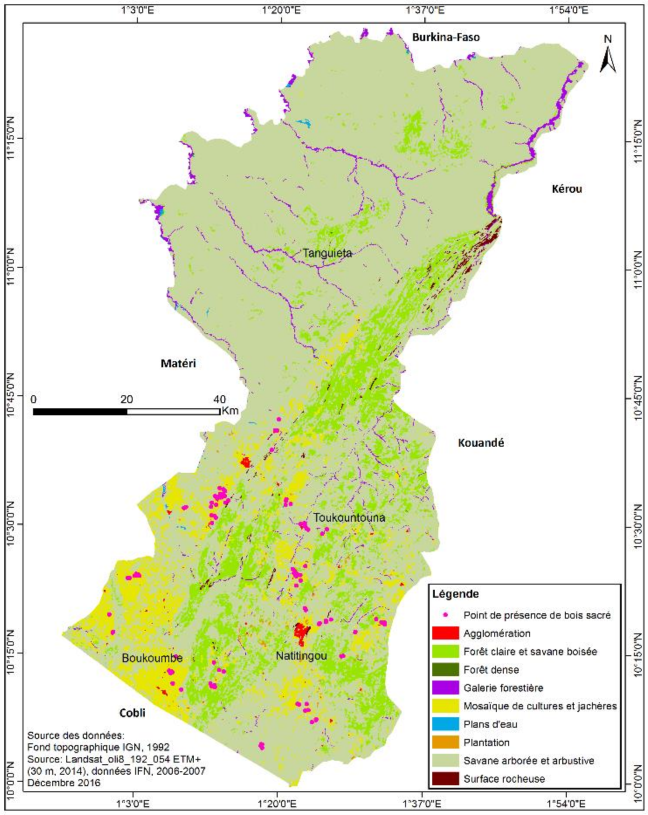

Figure 4: State of the sacred woods in 2014

The analysis of Figure 4 reveals that the sacred woodlands as a whole have seen a decrease in their area compared to 2000 (ie a variation of 3.84%) in favor of crop and fallow mosaics, much more agglomerations To the south of the study area. Dense forests have almost disappeared with a remaining area of 42.14 ha or 0.005% of the study area. Table II gives details on the development of areas occupied by sacred woods between 2000 and 2014.

Table II. Evolution of areas and trends of sacred wood between 2000 and 2014

town	Area BS 2000	Area BS 2014	Variation (%)
Boukoumbé	21,35	16,44	-1,87
Natitingou	15,31	14,15	-0,56
Tanguiéta	56,8	55,72	-0,14

Toukountouna	5,64	4,72	-1,27
Total	**99,1**	**91,03**	**-3,84**

The analysis of Table II shows that all the sacred woods of the research environment have experienced a regression of their surface area. The commune of Boukombé has the highest rate of degradation with a variation of -1.87 followed by the commune of Toukountouna with -1.27 and Natitingou -0.56. The commune of Tanguiéta appears to be the least degraded. This situation could be linked to the presence of the Pendjari Park in the commune of Tanguiéta, which leads to a greater surveillance of plant formations.

Predictive status of sacred trees by 2050

Taking into account the evolution of sacred wood from 2000 to 2014, a forecast of the transition states is established. Thus, the predictions of the sacred woods carried by the analysis of the starting data are observable (Figure 5).

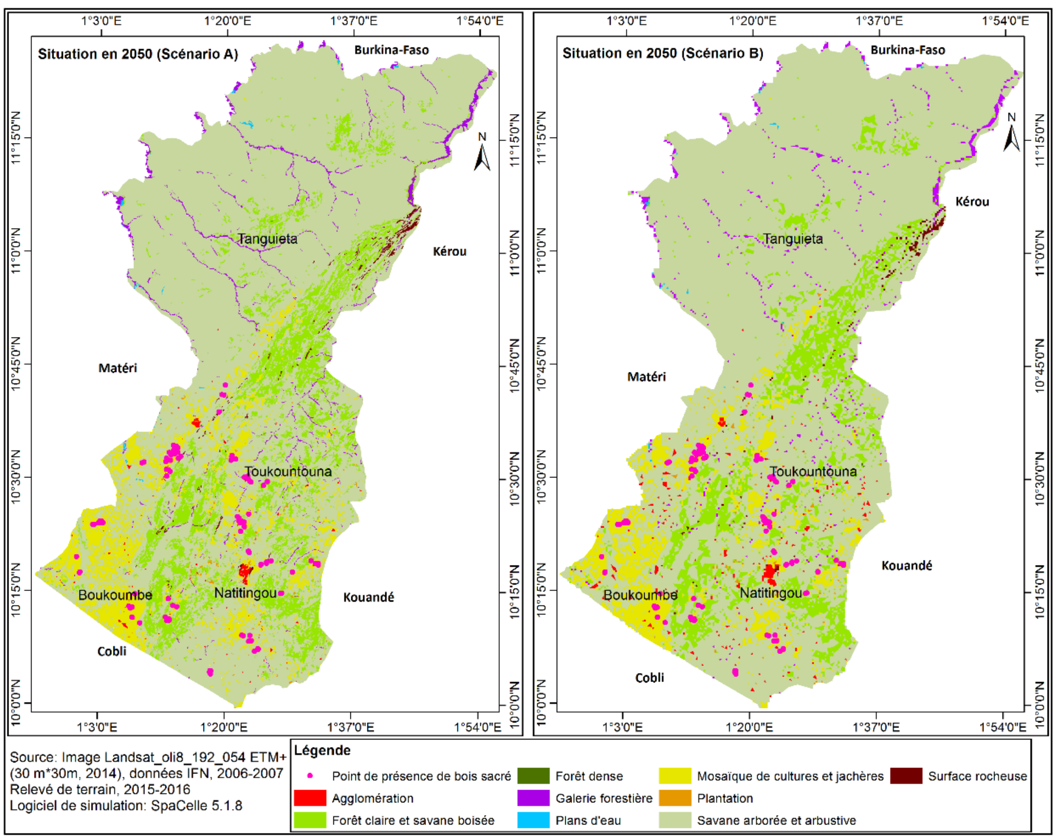

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Figure 5: State of the sacred woods for the scenarios of "environmental stability" and "disaster trend" by 2050

The starting trend seems to be respected. But this can not be long, as stability or restoration modalities can intervene and change the forecasting course of things. Assumptions relating to the scenario of "environmental stability" prioritize the preservation and controlled management of environmental resources, it is assumed That some sacred trees could see their lifespan double or triple.This scenario aims to reduce human pressures on plant resources. The scenario of "environmental stability" aims to reduce pressures on plant resources. In this scenario most land use units, especially sacred woods, will show a very low regression or progression. There will therefore be a conservation of sacred woods (91.03 ha) as their degree of degradation will not be as high. Their areas can then be conserved although they have experienced a regression between 2002 and 2014. They will be more so for the Sacred woods of Natitingou and Taguieta which are less degraded than those of Boukombé and Toukountouna. On the other hand, with the scenario of a disaster, it will be seen that the anthropization of the environment will be accentuated at the expense of the sacred woods in 2050. The latter will see their areas not only reduced considerably but most of the sacred woods will disappear from the Territory of research.

Discussion

The results of the dynamics of the sacred groves between 1990 and 2014 indicate that the areas of agglomerations, fields and fallow land have increased to the detriment of sacred woods. This could be explained by the demographic growth observed in the study area. Also, crop and fallow mosaics experienced an increase due to the conversion of plantations and dense forests into fields and also to deforestation. Dense forests have decreased in favor of gallery forests and savannas. These results are consistent with those of Orékan (2007), Bogaert et al. (2011), Diallo et al. (2011), which showed a steady decline of forests-savannahs in favor of fallow fields, bare soils and agglomerations in different regions of Benin. Agriculture, logging and other forms of deforestation are direct determinants of local vegetation degradation. This result is consistent with that of Sounon Bouko et al (2007), who sum up this state of affairs by pointing out that once a plot is cleared, the trees and shrubs there are destroyed to Cultures to make the most of sunlight. The conclusions of Hiernaux and Le Houérou (2006) went in the same direction, specifying that the cutting of most trees and shrubs that accompanies agricultural clearing and the burying of the soil surface by slash or not followed by plowing , Then by repeated weeding, have a major and lasting impact on vegetation and soils. Furthermore, Sodhi et al. (2009) placed particular emphasis on the impact of anthropogenic activities on plant formations, concluding that agriculture is the first activity which, beyond the degradation of vegetation, disrupts the entire ecological balance. The anthropogenic activities in the study area contribute to the reduction of the area of the sacred groves. These results are consistent with several studies conducted on the evolution of vegetation cover in different geographical zones of Benin. Oloukoi et al. (2006), by studying the dynamics of land use in the Department of Hills, concluded that natural plant formations regressed in favor of fields and fallow land. Sounon Bouko (2011), in analyzing the impact of agricultural colonization on the vegetation cover, has come to the conclusion that, in the Tchouou commune, and precisely in the localities of Igbomakro and Wari-Maro, Vegetal formations are regressing in favor of fields and fallows. In addition, Tenté (2005), in studying the factors of the floristic diversity of the slopes of the Atacora massif, also concluded that natural plant formations are in decline. The results of this study and similar studies in other geographical regions confirm the degradation of natural plant formations in favor of anthropogenic formations. The results of the last three general population and housing censuses (INSAE 1992, INSAE 2002, INSAE 2014) show that the population of the study area increased from 177,012 in 1992 to 221,061 in 2002 to 300 747 inhabitants in 2013. That is an increase of 69.90% in 21 years. This rapid population growth has led to an increase in cultivated areas and an increase in wood requirements. For this reason, population growth has been retained by most local actors as one of the most important factors of vegetation degradation in the communes of Boukombé, Natitingou, Toukountouna and Tanguiéta. This result is in perfect agreement with that of several authors, namely Vissin (2007), Vodounou (2010), Arouna (2012), who recognized demographic growth as the primary factor in the degradation of vegetation and natural resources. It was Barbault (1995) who warned that in the 1960s some environmentalists were already brandishing the "P-bomb" specter to draw attention to the key character of the explosion Demographic and threats to the balance and future of the planet. Ramade (1987) already considered demographic growth as the most serious environmental problem ever encountered by civilization apart from the consequences of nuclear war.

It is therefore important to mention the impact of climatic disturbances, which have been considered as a factor of vegetation degradation especially by farmers, the contribution of urbanization, land tenure and agricultural policies which are Also considered to be no less negligible, may be among the causes of the decline of vegetation cover. .

Conclusion

The study of the dynamics of the occupation of the sacred woods revealed the various forms of mutations that vegetation has undergone from cartography, remote sensing and Geographic Information Systems study. It is found that the sacred woods are gradually replaced in part by anthropic formations. Demographic pressure, agriculture and other forms of deforestation are the main causes of degradation of sacred woodlands in the study area.

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In total, in the chain of degradation of sacred woods several factors are directly and indirectly related. The interaction of these factors makes it difficult to determine the element responsible for the degradation of vegetation cover.

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