



## Environmental Dynamic in the West-African Sudanese Area: Analysis of Changes and Evaluation of the Damages to the Sota Protected Forest in the North of Benin Republic.

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**ABSTRACT:** *Unceasing abasement of natural resources in general and forestry resources in particular has been the current major concerns of developing. The aim of the present research work is to review the causes of abasement of the Sota protected forest on Kandi network, in order to find strategies for its sustainable conservation. The methodological approach adopted for this research is the one of research – action. SIG has allowed making the soil occupation maps of the Sota forest, which have been used for collecting the various vegetation facies data and anthropic actions. Analysis and processing of the different collected data have indicated that anthropic actions which are the main causes of damages to that forest are, following a decreasing importance: agriculture (27%), forestry exploitation (25%), and poaching (15%). For a sustainable management of that forest resources, sensitizing and including the nearby population, has stood out as an efficient strategy for protecting and managing sustainably the Sota protected forest.*

**Keywords:** *Kandi, Sota, protected forest, damages, factors.*

### I. PROBLEMATIC

The African forestry ecosystems are among the most important and the richest in term of abundance and species diversity. Uncontrolled destruction of natural resources, the multiple air, water and soil pollutions, and the demographic explosion are basic causes of the damages to the ecosystems [1]. Natural resources and especially forests hold an important place in the life of Benin populations in general and the nearby people of the Sota protected forest in particular. Forests provide people with woody and non-woody, food and medicinal products. They contribute to improving and maintaining the soils fertility and agriculture sustainability. Globally, forests play an essential part in regularizing hydrologic cycles and contributing in halting or lessening desertification and climate changes. On the socioeconomic ground, the forestry sector contributes to reducing poverty through the increase of revenues and the provision of job to people in cities and in the countryside as well [2].

In Benin, forty-four (44) protected forests covering a 1, 292, 543ha land, which represents 11.5% of the country land, have been recorded throughout the whole country. All those forest masses had been classified by the colonial governments in the 1940s and 1950s, generally to protect the upper part of the main water streams, or to preserve in the form of a sanctuary some natural patterns of fauna and others resources, or likely to stand for a reforestation perimeter. Despite their being protected areas, those forests have for a long time benefitted from no conservation plan with adequate means, and as such they have been a 'No Man's Land' marked with abusive and illegal exploitation of the land. Since the late 1980s, some protected forests have benefitted from a participative conservation plan (Lama, Toui-Kilibo, upper Ouémé, Bassila, Goungoun, Sota, Wari Maro, Kouffé Mounts, Agoua, Penessoulou, etc.), but the impact of those plans over sustainable conservation of those forests is not effective. Nowadays, those forests are under threat of bush-fire, agriculture, extensive grazing by bovines, illegal and abusive timber extraction, pollution, etc. It urges, however, to dispose of useful information about the whole country's forests masses, which could help contribute to their better conservation [3]. Although the consequences of anthropic activities are observable on the land, the environmental issue in developing African countries appears in terms of maladjustment between natural resources and populations' acute needs for improving their living and working conditions [4].

Generally, this maladjustment is worsened by a number of factors including agriculture, over-grazing and bush-fire which, together with climate and pedological factors, represent the causes of the delicate disturbance

of the phytocenosis [5]. In Benin, destruction of the ecosystems with the advent of cotton growing for example, has hastened the increase of farming lands, the abundant use of pesticides, and exploitation of marginal lands [6]. Destroying plants largely contributes to global changes, since plants are important elements of the environmental system [7]. The speedy population growth has increased pressure on the use of the genetic patrimony and other resources from the biosphere [8].

Unceasing destruction of natural resources in general and forest resources in particular are today a central major concern for developing countries including Benin. In the global context of environment and natural resources degradation, the protected areas are the only hope for safeguarding a representative sample of the biodiversity [7]. Apart from those protected areas, conserving the biodiversity will particularly be difficult and truly improbable since they represent the only places where forestry services still have a minimum protection contrivance [9]. Due to the 1980s' economic crisis followed by restrictive budgets, governments deprived from their protectionist policy means, have made do with theoretical control, and no effective police action on the field.

The protected areas in general and forests have become 'No Man's Lands' where people freely do what they want. Due to the acute deterioration of those forests, the Benin government has adopted a new forestry policy followed with priority action plans. One of the major innovations from this reform has been the implication of local communities in the sustainable management of natural resources in general and forests in particular following a consensual method which is the participative approach. This approach aims at ensuring the sustainability of forests conservation, by including local communities that take profit from those resources, in a decision making process, so that they could have an eye on the usage and the benefits coming from the forests exploitation [10]. Fighting deforestation is then a major concern in our country, and national authorities have decided on measures aiming at protecting those forests. Despite all those measures, why do protected areas remain threatened? Who are the main actors of deforestation and who are to fight it? The present research will help answer the above questions.

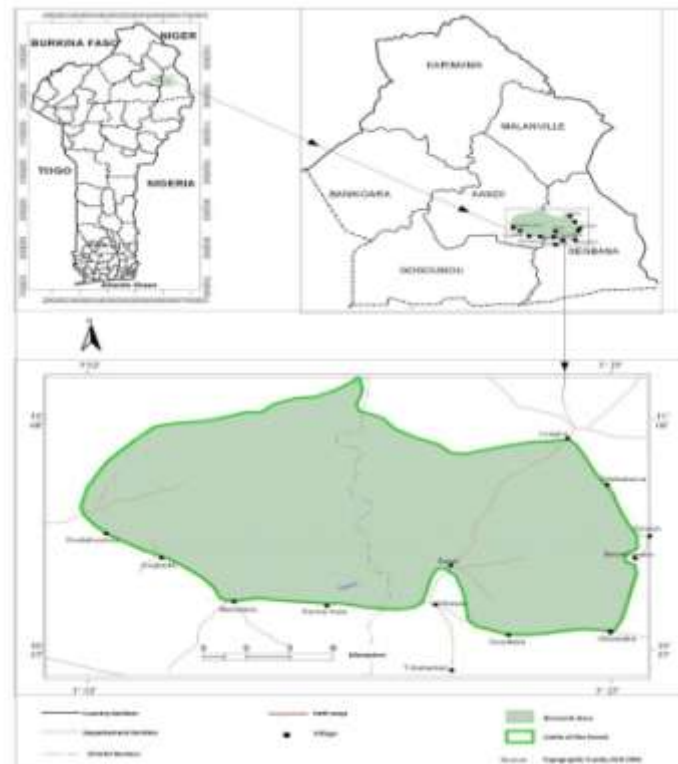
The Kandi district is not free from abusive forest destruction. Actors of this abusive and illegal forest destruction are not only Beninese but also Togolese, Nigerians, and Burkinabe, sometimes with unsuspected other people. The Sota protected forest is then not free from that destruction which causes degradation of that forest, with enormous consequences on the climate, on the vegetation, on the fauna and on human beings as well. Indeed, despite the fact that the protected Sota forest disposes of a participative conservation plan, its ecosystems have unceasingly been highly damaged [4]. Facing such a situation, the following questions are worth considering: what is the present degradation state of the protected Sota forest, on the Kandi network? What are the causes of the degradation of that forest? What has to be done so as to ensure a sustainable conservation of that forest?

The global objective of the present research work is to study the degradation causes of the protected Sota forest on the Kandi network in order to propose some approaches of solution. This specifically means : i) to show the importance of the protected Sota forest and describe the dynamic of its vegetation ; ii) to identify its degradation factors and iii) find strategies with the implication of the nearby community for protecting that forest.

## **II. METHODOLOGICAL APPROACH**

### **2.1. Global Presentation Of The Study Setting**

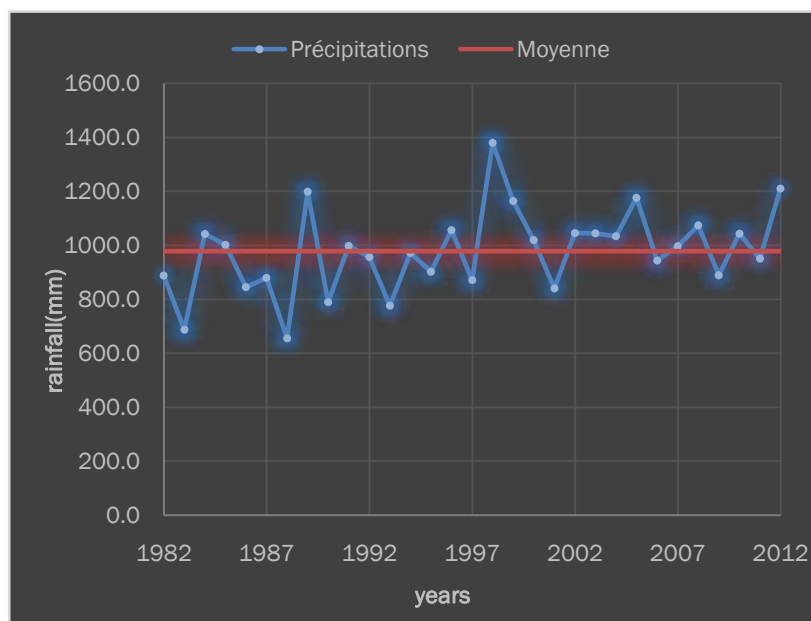
The Sota protected forest is in the North-East of Benin. This forest is situated between parallels 10°58' and 11°11' North Latitude in the one hand, and the meridians 3°03' and 3°25' East longitude in the other hand (figure 1). The Sota protected forest stretches over the district of Kandi and that of Ségbana, and over the Goungoun protected forest to the North and that of the Three Rivers to the South. It is bounded to the North by the Irané Lake, to the South by the Kandi – Ségbana inter-road, to the East by the Lougou – Sinwan path, and to the West by the Irané River. There eleven (11) villages in the surrounding, namely: Koutakroukou, Gougbedè, Bensèkou (in the district of Kandi) and Gbassè, Zonzi, Gbessaka, Boumoussou, Sinwan, Gbékarou, Niambara and Lougou (in the district of Ségbana). Following the Order of Council N°1862/SE of May 16th, 1947, the Sota protected forest has become a protected land forest stretching over an area of 53, 000 hectares.



**Figure 1:** Geographic Situation of the Sota protected forest  
**Source:**LABEE, 2011

### The climate

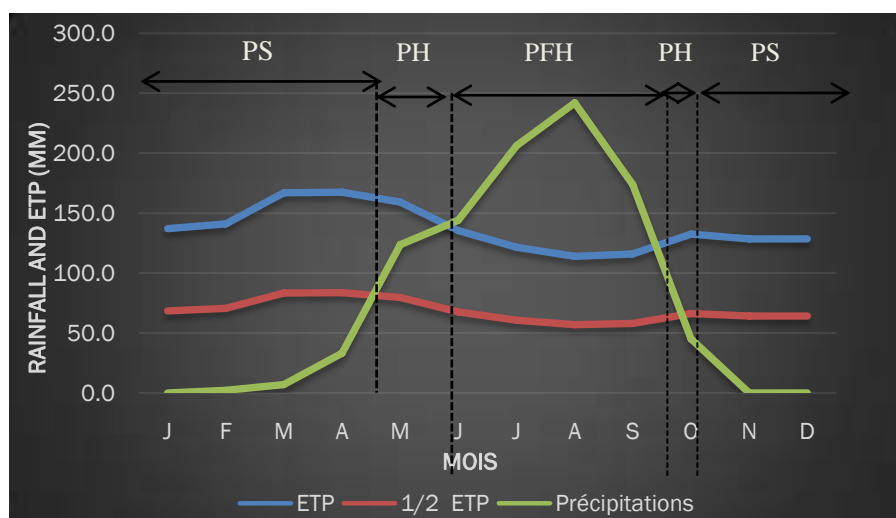
The host area of the forest has a Sudanese climate, and it comprises a dry season and a rainy season which lasts between five and six months. The climate data of the research are obtained from the synoptic station of Kandi, which is the nearest meteorological. Figure 2 presents the inter-annual variations of precipitations between 1982 and 2012.



**Figure 2:** Inter-annual precipitation variations in Kandi from 1982 to 2012  
**Source:**ASECNA Kandi, 2013

Analysis of figure 2 shows an uneven progress of rainfall. It can then be deduced a succession of shortage and exceeding rainfall compared with the average, an exceptional year 1983, followed with the year

1988, which represent the most deficient years from the chronological series. Figure 3 presents the climate balance-sheet from the Kandi station. The climate balance-sheet helps share the year into two successive bio-climate events periods using the rainfall and potential and evapotranspiration data (ETP).



**Figure 3:Kandi station climate diagram (1982-2012)**  
 Source:ASECNA Kandi, 2013

Figure 3 shows the dry periods (PS), the humid periods (PH) and the highly humid periods (PFH). According to the Kandi meteorological station, the dry period goes from October to mid-April. During that period, rains are rare and we have  $P < \frac{1}{2} ETP$ . Herbaceous vegetation exists and is straw-like, if it is not destroyed through fire. One talks about pre-humid period when we have the following:  $\frac{1}{2} ETP < P < ETP$ . This period goes from mid-April to June and from mid-September to October (with  $P > \frac{1}{2} ETP$ ). This corresponds to the vegetation active period where soil water store is superior to plants' needs. Then gramineous plants produce inflorescences and herbaceous plants become important. Most of the therophyts start drying up as soon as the withering stage comes at the end of this period. When we have:  $P > ETP$ , this is called a highly humid period. This period goes from June to mid-September and vegetation is not limited in finding hydric and mineral food. This is the rainiest period, reaching a peak rainfall in August.

Yearly average temperature which is around  $27^{\circ}C$  could come down below  $20^{\circ}C$  during the harmattan (December to January) and frequently go up above  $40^{\circ}C$  from March to April. As for soils in the Sota protected forest, there are washed out tropical ferruginous soils with concretion on sedimentary rocks, often with buckler over a gritty underground. They are non-deep and chemically poor soils. We also have less developed soils and raw mineral soils over leveled rocks and cuirass. The Sota protected forest is crossed from North to South by the Sota River with its affluents Irané and Taii longing the forest respectively to the West and to the East. The observed vegetation units in the Sota protected forest are: i) the gallery *Diospyros mespiliformis* forest (2 694.56 ha and 4.90%) ; ii) the *Vitellaria paradoxa* clear and afforested Savannah (16 455.67 ha and 29.85%) ; iii) the *Crossopteryx febrifuga* afforested and shrub savannah (30 709.73 ha and 55.89%) ; iv) plantations (172.42 ha with 0.78%) and v) the agricultural, grazing and fallowing mosaics (4 637.91 ha and 8.44%). The main recorded plants in that forest are: *Terminalia avicennioides*, *Vitex doniana*, *Combretum glutinosum*, *Prosopis africana*, *Erythrina senegalensis*, *Daniellia oliveri*, *Tamarindu sindica*, *Lanea acida*, *Isobertinia tomento*, *Sakhya senegalensis*, *Detarium microcarpum*, *Parkia biglobosa*, *Pteleopsis suberosa*. [11].

▪ **The human and economic framework**

According to the 2003 global population and habitat census (RGPH 4), there are about 13,898 people living around the forest in 2013, distributed in 1824 households. The most representative ethnic groups are:Boo; the Fulani; the Mokolé; the Dendi, and the Djerma from Niger looking for farming lands (17%). There are three religious groups around the forest: Islam 68%; Christianity 21 %; and Animism (11%). Those religious groups are living in a perfect collaboration. The economic activities people practice in the area are: agriculture and stock-farm, with a weak transformation of local produces and a tertiary sector handicapped by the non-practicability of paths. The formal sector is not developed and unmarketable goods are dominant. In the opposite, the informal sector is the most dominant and includes handicraft activities, commerce, transport and services. Nigeria being close to the area, this favors the smuggling of essential living products. Local officials lack control over such transaction [12].

## 2.2. Material and Method

### 2.2.1. Material

The used material includes a GPS for the geographic location; a photographic devise for taking photographs; a recorder for recording audio information; some thematic administrative maps of the Sota protected forest for identifying the different study zones; some questionnaires and guiding paper for interview with the sample population.

Four types of people are concerned by the questionnaire. They are members of the joint-management committee, who belong to socio-professional groups; there are also local members of the forest administration, and local authorities including mayors, heads of district divisions and villages, at last traditional leaders like kings and the elderly.

### 2.2.2. Method

The methods used in the present research work are the Participative Research Accelerated Method (MARP), the Collective Inquiry on Conflicts and Strategic Group Identification Conflicts (ECRIS), and Mapping.

- The Participative Research Accelerated Method (MARP) is one of the main methods that are a learning process based on good apprehension of the rural area. It includes the local population in the quest of sustainable practices for managing natural resources.
- The Collective Inquiry on Conflicts and Strategic Group Identification Conflicts (ECRIS) (ECRIS) method is a classical field complementary work method, which remains essential and which requires a group investigation, relatively intense, then prolonged. It is framed to determine, to impulse and to coordinate future classical enquiries by individual researchers in the framework of a comparative research carried out on many fields.
- The soil occupation cartography based on the SIG has consisted in: the visual interpreting of Landsat ETM+ of 1998, of 2006 and of February 2010 images; the 'supervised' classification, the 'field control' through the classified picture, the classification exportation into ArcView GIS 3.3 followed with the digitalization of the different vegetation classes. The 'supervised' classification is shaped through the blurred logic and the objects are classified using the 'closest neighbors' techniques, as well as the associate statistics [13], [14]. The floristic inventory points are those whose arborescent covering is a minimum of 70%, that is, the facies of the typical humid thick forest. The phytosociological readings are done in 30 x 30 meter tubes following the classical method of [15]. The geographic coordinates of the placets are taken using a GPS (Global Positioning System). Species are identified using the Benin Analytic Flora [16] and the field Guide of ligneous of humid thick forests in West Africa [17]. A rapid ethnobotanical inquiry has allowed appreciating the importance of the forest for the local population, and to collect the kinds of action they exercise on that forest. The ascendant hierarchical classification using "cluster analysis" (the Ward method) has allowed making the vegetal groups' typology.

#### ▪ Data Collection Techniques

The direct and individual interviews are used for this research. Those informal exchanges have allowed gathering information of various types. These mainly include description of the current exploitation of natural resources, current major problems on the fields, their views about the on-going changes in the Sota protected forest. The necessity to complete and verify bibliographical data through observation facts as well as interviewing the main concerned actors has required going onto the land for a shaped representative sampling.

#### ▪ Echantillonnage

Four villages on the border of the Sota protected forests are used for the sampling. They are Koutakroukou, Bensèkou (in the district of Kandi) and Gbèssè, Zondji (in Ségbana). Those villages have been chosen following people's daily activities and their closeness with the forest (Table I).

Table I: Synthesis of the sampled target population

Elements	Number of people	Number of targeted people	Number of people effectively reached	Coefficient of inquiry (%)	Method
Local officials	5	5	5	100	Exhaustive
Heads of village and district divisions	10	10	10	100	Exhaustive
Households	1744	40	25	62,5	Hazardous

Populations living close to the forest	13288	100	74	74	Hazardous
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Source : field inquiry, August, 2015

### Data procession

After collecting modeling the data, they have been computerized in order to make easy their selection and the link among them. This has been done in two steps:

- ✓ Creating a data base with Microsoft Access for descriptive ;
- ✓ Digitalizing maps and creating cartographic data base with Arc Info.

## III. RESULTS

The results of the present research have dealt with the importance and the dynamic of the forest, the forest degradation causes, and the description of integrated strategies for its protection. The discussion is developed basing on the results from the present research as well as results from similar researches by other authors.

### 3.1. Importance and dynamic of the Sota protected forest

#### 3.1.1. Importance of the Sota protected forest

The quasi-whole of the inquired people have acknowledged that the forest is an enormous reservoir of natural resources, and that as such, it could help develop their area. They explain this by the fact that they take good advantages from the Sota protect forest, and then they have deduced the forest's sustainable advantages if only it were well managed. Table II shows the importance of the Sota protected forest as viewed by the populations.

Table II: Importance of the Sota protected forest for the nearby population

Given Reasons	Percentage of respondents (%)
Creating job opportunity	31.68
Causing Abundant rain	40.19
Achieving projects for developing the area	28.65
Setting up infrastructures	8.37

Source: Research on the Field, August, 2015

#### From the analysis of Table 2, it appears that:

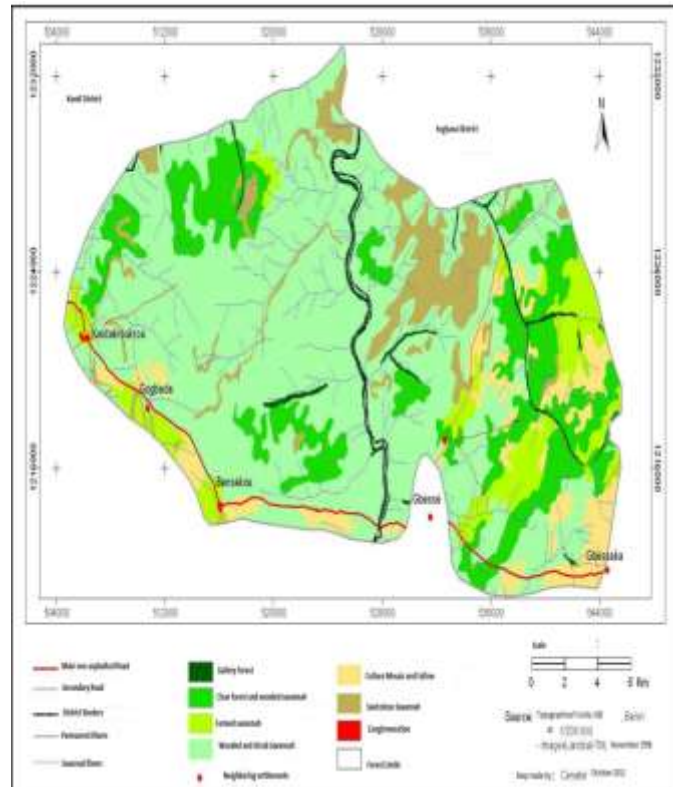
- 31.68% of respondents are convinced that the Sota protected forest is a source for job opportunity;
- 40.19% of them that the forest provokes abundant rain which is beneficial for their farming activities ;
- 28.65% of them the presence of that forest favors the setting up of development projects around the area; and 8.37% of the respondents think that the surrounding villages have benefitted from socio-communitarian infrastructures, thanks to the Sota protected forest.

Globally, 60% of inquired people have said that the Sota protected forest is source of job opportunity and the attraction of socio-communitarian projects, the nit urges that adequate measures be decided upon to stop the salient degradation of that forest.

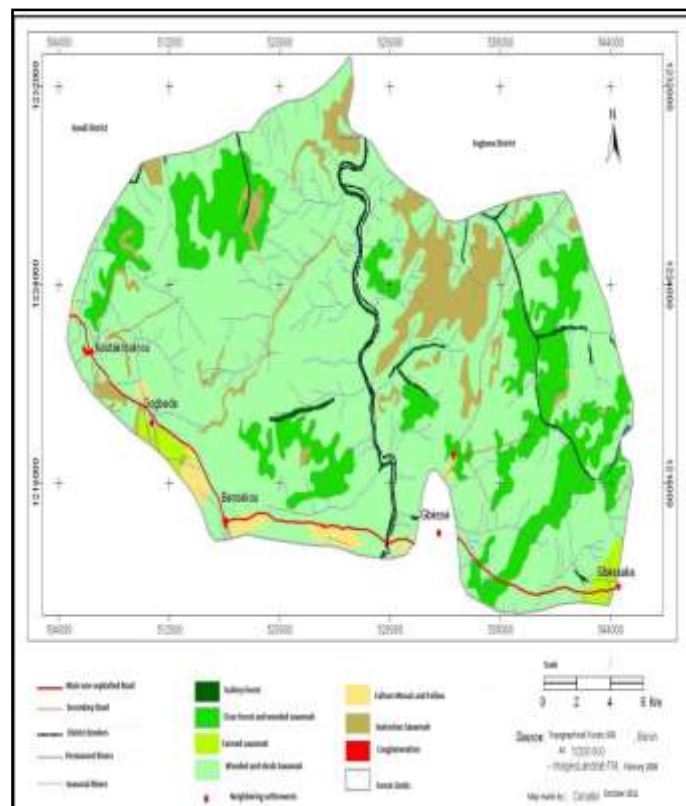
#### 3.1.2. Progress of vegetation in the Sota protected forest

The Sota protected forest soil in 1998, 2006 and 2012, is shown through figures 4, 5 et 6. The current vegetation characterized by a mosaic of forest strata, including: the *Diospyros mespiliformis* gallery forest; the *Isoblerlinia doka* and *Pterocarpus erinaceus* clear forest; the *Vitellaria paradoxa* woody savannah; the *Crossopteryx febrifuga* woody and shrub savannah, and farms as well as fallow grounds [12].

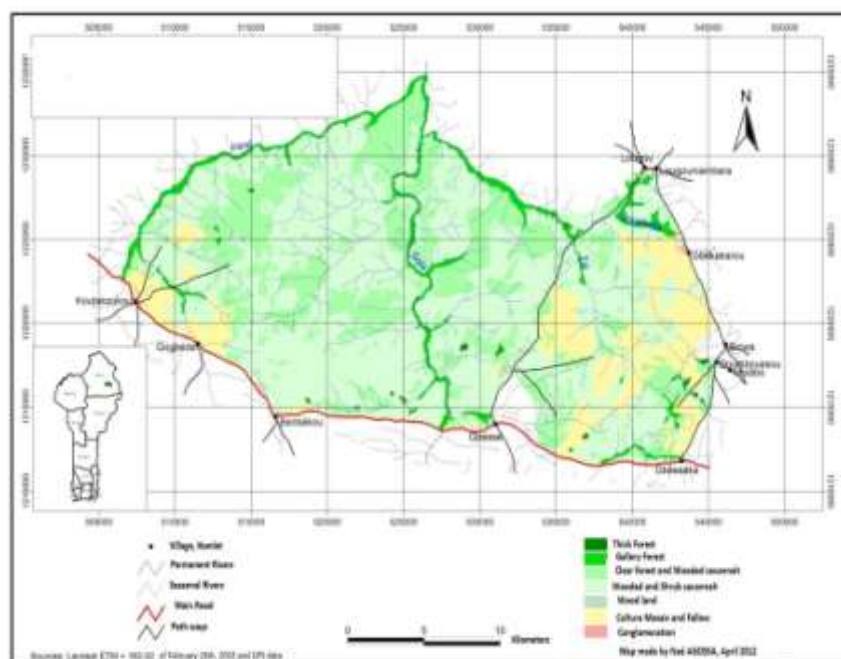




**Figure 4:** Land occupation in the Sota protected forest in 1998  
Source : CENATEL, 2011



**Figure 5:** Land occupation in the Sota protected forest in 2006  
Source: CENATEL, 2011



**Figure 6:** Land occupation in the Sota protected forest in 2012  
**Source:** PAPP-SGG 2013-2022

A parallel analysis of land occupation maps of 1998, 2006, and that of 2012 (figures 4, 5 and 6) shows a progressive development of fallow farms in the Sota protected forest. The Sota protected forest has then been under pressure through agricultural and pastoral occupation, forestry exploitation, poaching, and fishing. This has a huge impact on the biodiversity in the area. Figures 4, 5 and 6 show that the lands occupied by forestry, clear forests, wooded savannah, and wooded and shrub savannah have regressed over the fourteen (14) passed years. Observations from the field have shown that those different occupation entities are today subjected to hard pressure. The area occupied by saxicolous savannah has not changed significantly during that period. The area occupied by farms and fallows have progressed significantly from 1998 and 2012. The area concerned with conglomerations has evenly progressed over the whole period, as shown through table 3.

**Table III:** Occupation unit in the Sota protected forest

Occupation unit	1998		2006		2012	
	Superficies (ha)	(%)	Superficies (ha)	(%)	Superficies (ha)	(%)
Gallery forest	962	1.97	962	1.97	756	1.55
Clear Forest – wooded Savannah	8,682	17.75	8,582	17.54	6,348	12.98
Wooded and shrub Savannah	30,401	62.14	38,176	78.03	36,113	73.81
Saxicolous Savannah	4,249	8.68	4350	8.89	4,385	8.96
Farms and fallows	4,590	9.38	875	1.79	1,230	2.51
Conglomerations	40	0.08	65	0.13	92	0.19
<b>Total land</b>	<b>48,924</b>	<b>100</b>	<b>48,924</b>	<b>100</b>	<b>48,924</b>	<b>100</b>

**Source:** Inquiry on the field, 2015

The variations of superficieses for the different land occupation units as seen through table III could explain the Sota protected forest degradation rate. Indeed, the vegetal surface degradation represents the first indicator of natural resources degradation. The current occupation mode in the forests is disrespectful of technical prescriptions. Presently, occupations are marked with anarchy and characterized with camping, permanent infrastructures, and farming zones. According to the second, third and fourth Global Population and Habitat Census (RGPH 2, 3 and 4), population has grown from 9.595 inhabitants in 1992 to 11.370 inhabitants in 2002, and to 13,323 in 2013. Such current demographic dynamic is supported by the natural progress of strong migrations by the Fulani in particular. Other causes are:

the advent and progress of cotton farming has increased the populations' revenues, and also has encouraged the building of houses inside the forest. Indeed, the mass settlements of farmers in the Sota protected forest comes from the no more availability of farming lands in the cotton-growing basin of Banikoara



and Kandi, which has led people to migrate in large number into the Sota protected forest where many of them have set up their farms;

-the growing of scattered Fulani habitat in the area due to illegal intrusion of breeders into that forest. The farming surface has progressively shortened due to the demographic growth, the uncontrolled development of farms, the internal and inter-regional movements of peoples for agricultural needs, whose consequences are the growing of land-owning conflicts. The forests are then being depleted to allow lands for farms and fallows.

### **3.2. Causes of degradation of the Sota protected forest**

The observations made inside the Sota protected forest have permitted to notice the effectivity of humans' activity (grazing, farms, timber extraction, poaching, etc.). Photos 1 to 4 better illustrate this fact.



**Photo 1:** Cows grazing in the Sota protected forest  
**Photo by:** ABOUDOU, August, 2015

Extensive, transhumant and uncontrolled stock-farming is the second main cause for those natural resources degradation in the Sota, through severe pruning of trees as well as their cutting down. This goes along with vegetation fire which burns trees when it occurs late during the dry season. This analysis shows that tree destruction is the main cause of forest destruction, with a 59.45% frequency. Photo 2 shows another cause of forest degradation, which is anarchic occupation.



**Photo by:** ABOUDOU, August, 2015

Photo 2 shows people's settlements within the Sota protected forest. By so doing, those people exploit abusively the wood, either as timber or firewood, the production of charcoal, increase of farming surfaces, transhumance or poaching. All this use of the Sota protected forest is estimated to 0.19%. La photo 3 montre la troisième cause de dégradation par les activités champêtres.



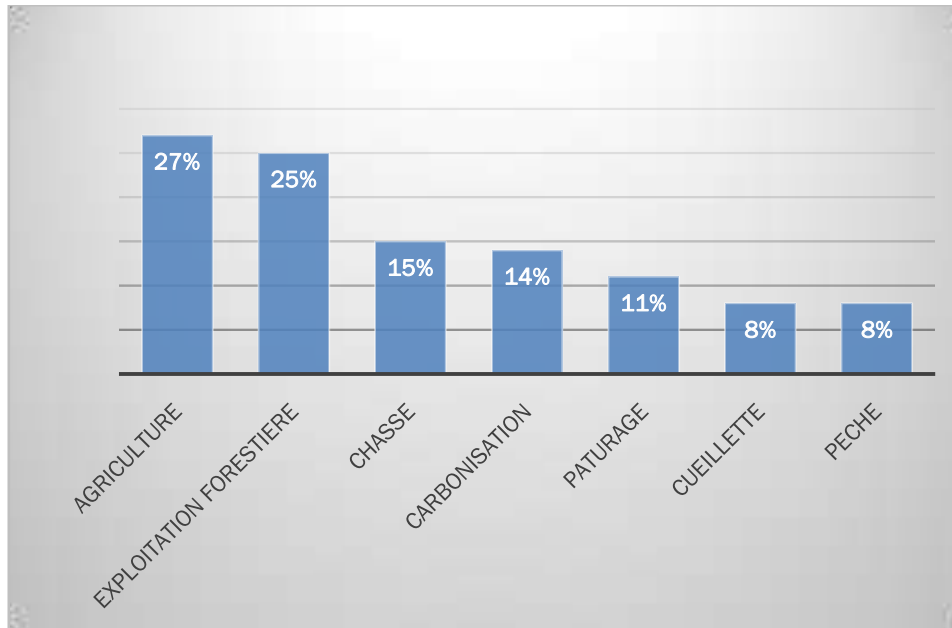
**Photo 3:** Clearing the land for yam farm in the Sota protected forest  
**Photo by:** ABOUDOU, 2015

Clearing the forest lands makes them become bare from all ligneous species. Clearing the land means, destroying trees and shrubs to allow the culture to profit in a maximum from the solar light; this provokes an acute disappearance of those species, then a salient degradation of the forest. Those agricultural practices destroy the forest for 60% of cases. Great road building infrastructures are also concerned with forest degradation (figure 4).



**Photo 4:** Deviation of the Kandi-Ségbana road through plain Sota forest  
**Photo by:** Aboudou, 2015

While asphaltting the Kandi-Ségbana road, SOROUBAT BJ Enterprise, has made a deviating way through the Sota forest. This way was possible after the mass cutting down of trees. It is then clear that the main causes of the Sota protected forest include humans' actions. The share for each kind of humans' activities can be found through figure 7.



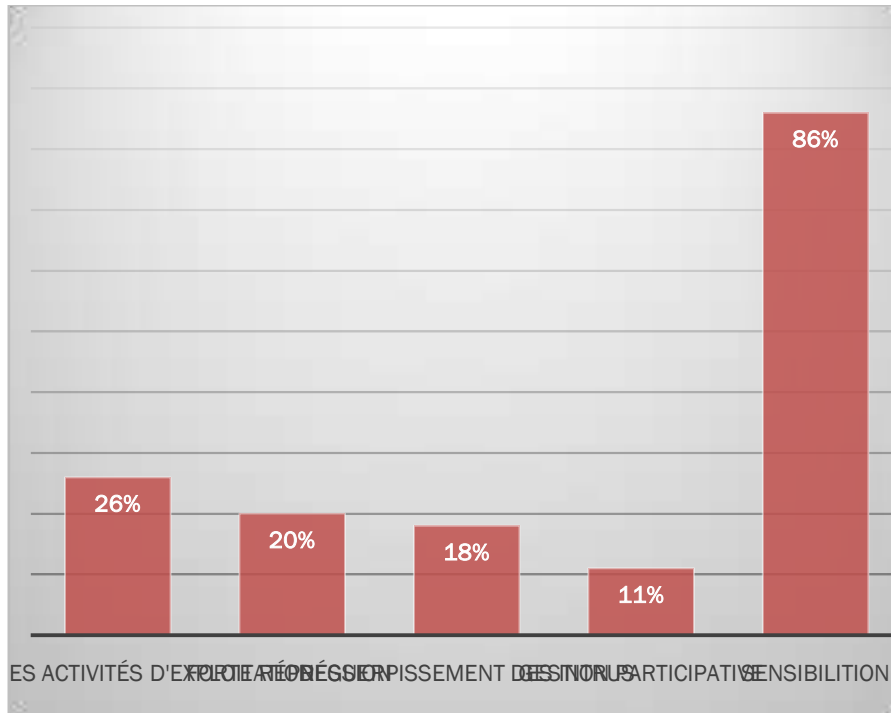
**Figure 7:** Percentage of activities practiced by people in the Sota protected forest

From the analysis of figure 7, it can be learnt that 27 % of the inquired people have acknowledged that agriculture is the main activity carried out inside the forest, and that this represents the first cause of degradation of that forest. That have also emphasized that other activities carried out inside the Sota protected forest are: forest exploitation (25% of them), hunting (15%), charcoal production (14%), grazing (11%), fruits and vegetable collection (8%), fishing (8%), and that those activities take part in the degradation of the forest. This degradation of the Sota protected forest is differently apprehended by people. Indeed, the degradation of the Sota protected forest is observed through the disappearance of some animal and vegetal species, the occurrence of farming activities and the settlement of people inside the forest. 28 % of those actors have asserted that value species such as , *Khaya senegalensis*, *Azelia africana*, *Pterocarpus erinaceus*, *Ceiba pentandra*, *Anogeissus leiocarpus*, *Isobertia spp.*, *Burkea africana*, *Diopyros mespiliformis*, *Antiaris toxicaria*, *Holoptela grandis*, *Pseudo cedrela kotschy*, etc. have disappeared. They acknowledge that presently in the Sota protected forest you'll hardly find neither timber from trees such as *azelia africana*, *Isobertia doka*, *Terminalia lasiflora*, etc., nor medicinal plants. At the same time, 25 % of people have said that the whole of those animal that in the past made the welfare of hunters and other surrounding people have now disappeared, whereas 23% of them think that it is rather the anarchical setting up of farms that have destroyed the forest. Lastly, 16 % of the enquired people attribute this degradation of the Sota protected forest to the building of houses and socio-communitarian infrastructures inside the forest. All these observations show the salient degradation of the Sota protected forest. Based on those various viewpoints, communities have developed integrated strategies for protection the forest.

(90%) of the enquired people have unanimously said that the Sota protected forest is saliently damaged, but also that this is not due to them solely; they affirm that visitors, strongly equipped also take active part in that fact. The latter would cut abusively species that are rare in that forest. When questioned about the presence houses, farms and grazing points inside the Sota protected forest, 80% of the enquired people have acknowledged that those are illegal; yet, 77% of them seem unconscious about the real impacts of those intrusions inside the forest. Forests and Water services' actions for protecting the Sota protected forest is not welcomed by the people living nearby. 75% of them think that those officials are the mains actors of the forest degradation, since they furnish some wood-workers with licenses, and that the latter freely abuse of that. As for the forest officials, they have all asserted that the degradation of the forest is solely due to people's presence and activities inside it.

### 3.3. Communitarian strategies for preserving the Sota protected forest

To sustainably safeguard those great natural riches, the here targeted people have made some suggestions (figure 6).



**Figure 8:** Viewpoint of the actors concerned with managing and exploiting the Sota protected forest

To ensure conservation of that biodiversity, 26% of the enquired people suggest putting an end to all exploitation activities. They think that by doing so, the Sota protected forest could naturally regenerate; 20 % of them would like stronger measures to be decided on so as to dissuade smugglers. They think that participative management without respect of regulations will not produce any good result. Then, strict application of penalties could be a solution. Also, for 18% of the respondents, getting those illegal occupants from the forest could be true solution for its better conservation. This would allow protecting the forest and valuing trees planting and planning actions. 11% of the actors have rather suggested a more inclusive management. For them, by better including local and traditional officials, the forest will be better preserved. Lastly, the whole of the questioned people think that the suggested solutions could be better and efficiently become effective if the nearby populations as well as the wood-workers were sensitized

## IV. DISCUSSION

### 4.1. Importance of the Sota protected forest

From the perception of the local populations, the Sota protected forest is not only a job provider source through development projects, but also it allows benefiting from socio-communitarian infrastructures in the one hand; in the other hand, it favors abundant rain. Researches led by [18] and [19], reveal that biodiversity globally and forests in particular are essentially important for Benin households, whether they in the urban or rural areas. Indeed, despite the absence of accurate data, the study about the contribution of the forestry sector to the national economy carried out in 2009 with the support of the Natural Resources Conservation and Management Programme (ProCGRN), has revealed that the forestry sector contributes up to 6.64% for the Raw Domestic Products (PIB), contrarily to the less 2.8% as often read through official or national documents. This estimation has not considered the energy wood and cashew channels. Indeed, the forestry sector contributes to about 6% to the PIB and the energy wood channel uses 200,000 people, with a yearly turnover of about seven billion francs cfa francs, in the one hand. The forestry resources for example are used as the first source of domestic combustible, as food, as medicinal plants, as hunting produces and other non-ligneous produces (fruits, resin, mushrooms, oleaginous grains, vegetables, etc.). They produce incomes and job opportunities for the population (farms, commerce, transport, ecotourism, transformation, private nurseries, etc.), and they are the base for training and consolidation of cultures, technological and endogenous knowledge. They provide, for the well-being of people, of the ecosystems services (fighting climate change, preserving the earth and fluvial ecosystems, the water cluster, etc.) and other goods and services. The firewood and charcoal sole, and the PFNL allow rural farmers to improve their revenue mainly during the dry season. All those produces are concerned with the small trade with nearby countries, mainly the non-ligneous forestry products used in the traditional medicine and in humans' food, and they bring about substantial revenues to households. For example, in



between the dry and the rain season when there is food shortage, households in the North of Benin refer to *Cochlospermum tinctorium* (a tree with semi-tuberose hardy roots) to redden the soup in replacing fresh tomatoes which then are rare.

#### **4.2. The Sota Protected Forest Degradation Factors**

Agriculture, forestry exploitation, charcoal production, and in a slight scale breeding and fishing have been viewed by the local population as determining activities in the degradation of the vegetation, impulse by the demographic growth, the arrival of migrants, the non-respect of forestry rules, and the inefficiency of agricultural policies, the land-owning mode, urbanization and the climate change. The increase of farms lands observed after the field study based on the 1998, 2006 and 2012 Landsat TM satellite picture is not surprising. According to [7], the predictive modelling of vegetation based on the hypothesis that current natural resources exploitation practices will be kept on, implies that the farm and fallow mosaics will occupy around 60% of the district land, followed by woody and shrub savannah and (30%) from now to the 2020s. Researches by the same author reveal that gallery forests, clear forest and woody savannah will be represented in the form small hills and will occupy less than 3% of the district land; they also clearly show that woody and shrub savannah are the principal components (more than 50% of the forest land) of the vegetation, whereas the forest galleries hardly represent 4%, and twice less than that for the thick forest. Yet, an analysis of the floristic diversity of the different vegetal formations existing in Benin reveals that despite their shortness in term of area, the forest galleries contain an important floristic diversity (more than one third of the total floristic diversity). Agriculture, the first type of economic activity which is dealt with by about 70% of the active population [20], is the primordial factor of the vegetal surface degradation. The new observed phenomenon is the one concerned with the extension of cotton and yam farm lands, which de facto leads to massive trees destruction followed by intensive charcoal production.

Cotton farming (heliophile species), more and more encouraged by the government in order to increase the country's exportation incomes, has become the first speculating products, engaging farmers into clearing many hectare lands each year, mainly in the Northern part of the country. This practice does not favor a sustainable management of forest and biodiversity resources due to the high concentration of the forestry cover in the Sudan-Guinean and Sudanese parts of the country. Moreover, the use of high doses of pesticides in the growing of cotton has been a disturbing factor in the tropical channel through accumulation of pollutants along the food channel. Indeed, the used pesticides progress toward the phreatic sheet and / or washed-out towards water streams. The immediate consequence is intoxication of species living in those aquatic areas. Also, the entomo-fauna is strongly threatened by those pollutants, which also represents a risk of maladjustment of the ecosystems through the reduction of their services [21].

Since the early 1970s, a progressive disappearance of many « valued » tree species used by woodworkers has been noticed. From the start, for instance, woodworkers had preferred the wood from the Iroko-tree (*Milicia exelsa*) to any other types of wood. Later, getting that type of wood for their customers' needs had become difficult. Lacking a prompt reaction from the forestry services, woodworkers have made do with *Khaya senegalensis* (caïcedrat). After noticing once again through the 1980s that this new preference (*Khaya senegalensis*) was disappearing, they have now started using *Isoberlinia doka*, and then *Azelia africana* (lingué), *Pterocarpus erinaceus* (vène) and *Anogeissus leiocarpa* (African birch-tree). Some examples can also be given about the protected where free exploitation is allowed. These include the Guéné, the Dogo-Kétou, the Agoua, the upper Alibori, the Trois Rivières, the upper Ouémé, and the Nonsinansou protected forests which have been invaded by woodworkers, and which forests exist today just in name. The farm occupation rates of most of those protected forests are 25 to 40%. For example, in Bori (30 km away in the district of N'dali), the scene is amazing. [10].

As for the natural grazing ways, there are said to be concerned with more than 7 million hectares of land, mostly in the North and the Center of Benin. Those natural ways have subjected to many deepened research works, leading to the typology of pastoral groups, to the determining of the floristic diversity, as well as the pastoral value and the loading capacity. The great climate variabilities and the strong use of lands by humans are the main factors that influence the natural ways. Those two factors have made these ecosystems to become more exposed to degeneration [22]. The transhumance phenomenon is seen as one of the most striking threats to the protected areas. Two recent studies, one about the lion conservation strategy et the other concerning counting the fauna in the trans-border W forest [23], better illustrate that threat to our protected areas. Those degradation factors explain the position of Benin among the ten most tree-killer countries, in 2010 [24].

Urbanization progresses quickly in Benin, with a horizontal extension of cities. The urbanized lands have a yearly 4% progress, with an urban population evaluated at 42% of the whole population in 2010 [25]. This urbanization resulting from the demographic pressure is seen through anarchical occupation of lands followed by the destruction of ecologic habitats (diminution of fish resources in the rivers, degradation of river



banks...), and it reinforces the threats on the biodiversity whose destruction worsens the poor people's condition, maintaining them into an unprecedented vulnerability. [26].

#### **4.3. The Sota protected forest's sustainable conservation strategies**

Conscious of the degradation of the Sota protected forest, the different actors have made suggestions for its conservation. Going from the stopping of different exploitation activities, making more effective the penalties, to the sensitizing of the forest users through sending people out of the forest and the participative management of the Sota protected forest, it appears evident that for a sustainable management and an efficient protection, sensitizing the different actors would allow reaching more significant results.

Local populations' participation has more and more been acknowledged as one of the determining factors for the success of the sustainability of the protected areas' conservation plans all over the world [4]. It is then evident that sensitizing people for their being concerned with the management and protection of the Sota protected forest is of prior necessity

Much effort has been made by the Benin government to upset the degradation tendency, specifically in matter of reconstituting the forestry vegetation. Indeed, from 1985 to 2011, a yearly average of 3,980,201 trees was planted over a yearly average land area of 4,078ha. Based on this frequency, if efforts in following up and taking care of the plants are reinforced, about 50,000ha of land will be wooded within 12 years, corresponding to the forest land yearly destroyed during the period of time going from 2000 to 2010. The inselbergs contribute in a large scale into the floristic richness evaluated to 395 species (14 % of the flora). The yearly regression rate moving from -1.3% (1990-2000) to -1.0% (2000-2010) is an indicator of Benin government efforts in halting the degradation of forest lands. Yet, 3.77% (106) Benin Flora remains under threat [24].

## **V. CONCLUSION**

The biodiversity of the Sota protected forest is significantly damaged due to the different activities practiced by people inside that forest. The degradation causes of the forest land pointed out through the present research work are mainly agriculture, charcoal production, wood exploitation and cattle breeding. Those causes are supported by the demographic growth, the inefficiency of regulations and policies for the forest conservation, the misapprehension of the participative approach expressed through awkward application conservation plans. The striking degradation of that ecosystem has begun having negative impacts on people and the environment. It then urges to revisit implementation of the conservation plan so as to save the remaining. This action requires good apprehension of the participative approach which will allow the nearby population to better know the problems facing them as well appropriate remedies. The government and assisting organizations and institutions would just have to come with technical, logistical and financial means. This would permit to move from their passive participation to active participation. Then the population's consciousness will get all the actors to apprehend the challenges in the participative management, and determine accurate tools for facing the challenge of sustainable development. That's why actions of sensitizing, informing, educating, and training appear as necessary means for an effective sustainable management of natural resources and their conservation. The degradation of protected forests is a real issue for the society and the government should face it effectively. Implementing the here suggested measure could allow a better conservation and an efficient management of the Sota protected forest; these measures mainly include:

- ✓ making sure the procedures and prescriptions in the conservation plan are followed ;;
- ✓ make it effective collaboration between the nearby people and the forest services, the training of those nearby people for the implementation of the conservation plan;
- ✓ advise and help those people in the implementation of the conservation plan ;
- ✓ ensure collection of fees and taxes from the forest exploitation;
- ✓ help villagers' associations in implementing annual Management Plans (PAG).

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