ENVIRONMENTAL DEGRADATION OF THE OKPARA UPPER POND AT NANON OUTFALL

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ABSTRACT

The environment of the upper field of Okpara River, which is concerned with this study has been facing a serious deterioration. The final goal is to determine the different elements of that deterioration and to evaluate the impact of the non-limited human-being actions on the environment. The technics of remote detection through satellite, especially interpretation and classification of pictures from Landsat 7 ETM+ of 2000 and Landsat 8 OLI of 2014 with simulation tools (Land Change Modeler of IDRISI Selva) have allowed analysis of the changes which happened and some projections on the horizon 2030. So the matrix of Léopold and model PEIR used for the study of impact environment.

Agriculture, forest exploitation, carbonization and, to a little level, breeding, and hunting, are the main elements determined by the resident populations as the great reasons for vegetation deterioration; those reasons are amplified by population growth and climate changes. This causes a regression of the forests galleries and the clear forests and wooded savannas and forests dense. On the horizon 2030, the physiognomy of the basin will dominate by mosaics of fields and fallows (46%). To become natural courses in these Common remains alarming then if the current tendency is maintained.

KEYWORDS: Slope Basin, Degradation, Outlet, Environment & Okpara

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INTRODUCTION

In intertropical Africa, the ecosystems undergo for several decades a strong degradation because of the pejoration of weather conditions and increasing anthropization (Bio Yèrè, 2014). The conjunction of these natural and anthropological phenomena has four consequences the deforestation, the degradation of grounds and desertification (Kadiri, 2012). The degradation of the plant place setting contributes widely to the global changes because the vegetation is one of the important elements of the environmental system (Arouna, 2012).

Benin arranges many potentialities in natural resources. The diverse anthropological pressures on the environment caused over the years an advanced degradation of these resources. So the causes of the degradation are connected directly or indirectly to the demography and to the human activities which influence the environment (Bamba, 2010). The main environmental problem identified in Benin is the management of lands (Samba, 2011). These lands are exploited for diverse activities among which the agriculture, the breeding, and the forestry development. The clearing, the deforestation and the over pasture are, among others, the threats which weigh on the environment. The anthropological actions influence negatively the normal functioning of this ecosystem the resources of which diminish over the years. With the increase in population, the waterside populations exploiting

the stream became more numerous while the halieutic resources decrease (Badahoui and al., 2010).

The present article, after presenting the upper pond of Okpara, described the implemented methodological approach to study its dynamics and management, then exposes the results obtained as well as the comments and the reflections which arouse the latter.

ZONE OF STUDY

Several communes are drained by the waters of the upper slope pond of Okpara. The upper slope pond of Okpara is situated between $9^{\circ}16'$ and $9^{\circ}58'$ the North on one hand and $2^{\circ}35'$ and $3^{\circ}04'$ is on the other hand. From the administrative point of view, it includes the municipalities of N' Dali, Parakou, Tchaourou and Pèrèrè.

The upper pond of Okpara is under the influence of the tropical climate of Sudanese type. It is marked by a Pluviometricunimodalregime going from April till October. Therefore, the flow of water of Okpara varies according to the quantity of water by the rainy season. The rainy heights are 38 mm in March and 208 mm in August and 218 mm in September, 99 mm in October to reach the minimum of 6 mm and 4 mm respectively in December and January.

The grounds of the pond have a vertical structure in compliance with that observed in the whole western Africa (Ogouwalé, 2013). The main types of grounds are ferruginous tropical and subjected to the washing. They are grounds having a more or less important depth, their permeability, and their porosity are generally good. On the other hand, they have mineral reserves and strong acidity a reduced saturation.

These grounds appear as the result of an intense and deep change. Almost everywhere, they show a big physical homogeneity. Lands usable correspond to relatively deep grounds of 1 in 4m generally very drained at least on 1m of depth.

The vegetation consists of clear forest and woody savanna, shrubby and raised savannas. We meet also the dense forests and the forest Gallery there. But the action of the man provoked numerous upheavals there, creating a "humanized" vegetation characterized by the disappearance of numerous ligneous and wildlife resources. The raised and shrubby saxicolouss savannas are formations which occupy essentially the rocky outcrops, on the least evolved, rocky and shallow grounds. We note the presence of shrubs in the thin trunks with cowardly foliage and some trees. figure 1 presents the upper pond of Okpara.

Figure 1: Geographical Situation of the Upper Pond of Okpara

Between 2002 and 2013, the upper pond knew a rate of increase of its population (5,49%). The socioeconomic activities led in the upper pond of Okpara are, among others: the agriculture, the breeding, the fishing, the hunting, the forestry development and the carbonization.

METHODOLOGY

The methodological approach adopted is based on a diachronic and cartographic analysis based on the use of the remote detection completed by fieldworks. She contains three phases which are: the quantitative and qualitative data collection, the treatment and the data analysis.

The planimetric data used in this study are:

- Topographic maps, IGN in 1/200 000;
- Embellish with images Landsat7 ETM + of 2000, Path: 192 and Row: 053 on November 25th, 2000;
- Embellish with images Landsat8 OLI of 2014, Path: 192 and Row: 053 on February 12th, 2014.

These data allowed to realize the maps of land use of the upper pond of Okpara of 2000 and 2014.

Statistical Analysis of the Changes of State of the Vegetation

Annual Average Rate of Spatial Exploitation (T)

The annual average rate of spatial exploitation expresses the proportion of every landscaped unity which changes annually. It is calculated from the formula drawn from Bernier (1992) and adopted by Oloukoï and al. (2006), Arouna and al. (2009).

$$T = \frac{\ln S_2 - \ln S_1}{(t_2 - t_1) \times \ln e} \times 100$$

S_1 and S_2 : a surface of a landscaped unity in the date t_1 and t_2 respectively;

$t_2 - t_1$: number of years of evolution;

$\ln$: natural logarithm;

e : base of natural logarithms ($e = 2,71828$)

Rate of Conversion

The rate of conversion of a class of landscaped unity corresponds to the degree of transformation undergone by this class being converted towards other classes (Arouna, 2012). It is then the number of changes observed at the level of a landscaped unity between dates t_1 and t_2 . He so allowed to measure the degree of conversion of a unity given in other landscaped units. It is obtained from the matrix of transition following the formula:

$$T_c = \frac{S_{it} - S_{is}}{S_{it}} \times 100$$

S_{it} : surface of the landscaped unity i in the initial date t ;

S_{is} : surface of the same stable half-witted unity in the date t_1 .

Rate of regression

This rate expresses the reduction of a surface by a type of training given between two dates. He is calculated by the following formula:

$$TR = S_2 - S_1 / S_1 \times 100$$

With TR the rate of regression, S_1 the surface of a unity of vegetation in the date t_1 ; S_2 the surface of the same unity of vegetation in the date t_2 .

Data Processing

The ENVI 5.1 software was of use to the interpretation of satellite pictures.

The ArcGIS 10.3 software allowed the realization of the maps of land use of the sector of study.

The used valuation methods of the impacts are, among others the matrix of Léopold (1971) and the PEIR model.

RESULTS

The upper pond of Okpara is under the constant influence of the anthropological pressure. The investigations show that the agricultural practices, the transhumant breeding, the fires of vegetation, the fraudulent wooden exploitation are the main factors of degradation of the environment. The analysis of the maps of an occupation of the ground of 2000 and 2014 shows the disappearance or the regression of certain vegetable formations because of this anthropological pressure.

Dynamic of the Land Use from 2000 Till 2014

The evolution of the land use of 2000 and 2014 is represented according to two maps made on the basis of the images Landsat 7 ETM+, 2000 and Embellishes with images Landsat 8 OLI, 2014.

State of the Surfaces of the Units of Occupation in 2000

The face of the vegetation of the upper pond of Okpara was widely dominated by the clearance forests, the woody savannas, the dense forests, the raised and shrubby savannas which represented about 90 % of the surface (Figure 2, Table). We also met there, forests galleries, fields and fallows, plantations and conglomerations.

Table 1: Plant Formations and Other Land Use Units in 2000

Land Cover Unit	2000 Areas (Km ²)	Proportion (%)
Forest gallery	76,19	1,49
Dense forest	1411,62	27,58
Clear forest and wooded savannah	2375,94	46,42
Savannah with trees and shrubs	801,20	15,65
Plantation	18,50	0,36
Field mosaic and fallow land	377,80	7,38
Plan of water	38,43	0,75
Agglomeration	18,79	0,37
Total	5118,47	100

Source: Interpretation of Landsat 7 ETM+ 2000 Images

This state of degradation of plant formations is represented in figure 2 which follows. This figure shows the physiognomy of the different plant formations in 2000.

Figure 2: Land Cover Units in the Upper Pond of Okpara in 2000

State of the Surfaces of the Units of Land Use in 2014

In 2014, the face of the vegetation of the upper pond of Okpara is dominated by the mosaics of fields and fallows (47,26 %) followed by the raised and shrubby savannas (29,36 %). The clear forests, the woody savannas represent only 18,87 % of the surface (Figure 3, Table 2). We meet also the dense forests, the forests galleries, plantations and the urban areas but of small proportions there.

Table 2: Plant Formations and Other Land Use Units in 2014

Land Cover Units	2014 Areas (Km ²)	Proportion (%)
Forest gallery	11,69	0,23
Dense forest	128,76	2,52
Clear forest and wooded savannah	966,11	18,87
Savannah with trees and shrubs	1502,94	29,36
Plantation	25,41	0,50
Field mosaic and fallow land	2418,96	47,26
Plan of water	20,01	0,39
Agglomeration	44,59	0,87
Total	5118,47	100

Source: Interpretation of Landsat 8 OLI Images 2014

This state of degradation of plant formations is represented in the figure. 3 which follows. This figure shows what became the different plant formations in 2014.

Figure 3: Okpara Upper Basin Land Cover Units in 2014

Evolution of the Vegetable Formations and the Units of Occupation of Ground from 2000 till 2014

The dynamics of the various units of land use from 2000 till 2014 is synthesized by the matrix of transition (Table 3). In the units of lines and columns are respectively the vegetable formations and the other units of land use of 2000 and 2014. The conversions are made lines towards columns. The units of the diagonal correspond to the surfaces of the units which remained stable from 2000 till 2014. The units which are except the diagonal represent the changes of vegetation and the other units of land use.

Table 3: Transition Matrix of Units of Occupation 2000 to 2014

Units of 2000	Units of 2014								Total surface 2000 (Km ²)
	FG	FD	FCSB	SAA	PL	MCJ	P_E	AG	
FG	11,69	0	4,02	37,02	0,37	22,72	0	0,37	76,19
FD	0	128,76	137,80	518,96	0,37	623,95	0	1,78	1411,62
FCSB	0	0	824,29	509,24	4,86	1030,44	0	7,11	2375,94
SAA	0	0	0	437,72	0,09	361,43	0	1,96	801,20
PL	0	0	0	0	16,26	2,15	0	0,09	18,50
MCJ	0	0	0	0	3,46	360,13	0	14,21	377,80
P_E	0	0	0	0	0	18,14	20,01	0,28	38,43
AG	0	0	0	0	0	0	0	18,79	18,79
Total surface 2014 (Km²)	11,69	128,76	966,11	1502,94	25,41	2418,96	20,01	44,59	5118,47

Source: Interpretation of Landsat 7 ETM + 2000 and Landsat 8 OLI Images 2014

Legend

FG: Forest Gallery; FD: Dense Forest; FCSB: Clear Forest and Wooded Savannah; SAA: Savannahs, Trees, and shrubs; PL: Plantations; MCJ: Field Mosaic and Fallow Fields; P_E: Plan of Water; AG: Agglomeration.

11.69: Area remained stable between 2000 and 2014

Examination of the table shows that 8 classes of land use were observed between 2000 and 2014. It should be noted that all classes remained identical between these two years. Analysis of the evolution of plant formations from the transition matrix allows to better understand the different transformations undergone by the vegetation from 2000 to 2014.

Impacts of the Anthropological Pressures on the Environment

A significant part of the arable land was degraded by the human activities such as the stumping, the application of the hitched culture and the use of the tractors which favor the upheaval of the superior horizons and the process of the erosion. So the destruction of horizons decreases the stability of the ground. The colloidal elements are thus drawn in depth by washing or laterally on a surface by agents of transport (erosive, river). Mounds practice, especially for the culture of the yam cause ,even more, the detachment of the particles of the ground. From this moment, the action of the erosion becomes easy and fast. Over time, the superficial aggregates are destroyed and the fine particles are pulled from runoff water.

Figure 1: Erosion of the Banks of the Okparariver at Gbégourou

Coordinates: X = 9 ° 26'38 " and Y = 2 ° 45'52 "

Shooting: Bassè, December 2015

The impacts of socioeconomic activities on the components of the environment are analyzed thanks to Leopold's matrix model (1971)

Activities	Environmental Components of Impacts				Fauna	Social Health	Economy	Landscape
	Water	Air	Soil	Flora				
1. Agriculture								
1.1 Slash and burn	Pollution	Pollution	Degradation of soils	Destruction of covered because of archaic cultural practices	Decrease of the productivity of animals due to the destruction of their ecosystems that serve as habitat	Loss of some Medicinal species		Significant decrease in vegetation cover due to anthropogenic pressures
1.2 Use of agricultural input	Pollution	Pollution	Compaction, erosion leaching		Intoxication and disappearance of certain animal species	Respiratory disease, skin irritation, food poisoning	Better yield of agricultural production increase in people's income sources	Vulnerability of Vegetation cover
2. Breeding								
2.1 Pasture	Water pollution		Soil clogging and erosion	Destruction of flora		Conflict between breeders and farmers	Existence of high income source	Destruction of soil and vegetation
3. Hunting								
3.1 Poaching			Spraying and compaction of surface soils following trampling of animals during their escape	Destruction of flora	Escape and disappearance of certain animal Species		Riparian populations income source	Soil degradation and vegetation cover destruction due to animal and anthropical pressure
4. Fishing								
4.1 Fishing Technics	Pollution and filling of the stream		Banks degradation		Decrease of fish species		Increase of people's income sources and satisfaction of food needs	Degradation of the stream and fish species
5. Gardening								
Use of inputs	Pollution	Pollution	Compaction, erosion, leaching			Food poisoning	Better yield and increase of income sources	

Source: Field Survey, December 2015

This table allowed to raise the various impacts of the socioeconomic activities on the environmental components. It appears that all the led activities are without consequences on the environment. The PEIR model also allowed to analyze the environmental components in all their aspects and the size (figure 4).

Figure 4: Analysis of Environmental Impacts Linked Toanthopthical Activities in the Upper Pond of Okpara

Source: Field investigation, December 2015

Predictive Modeling of Evolution of Plant Formation

The prediction was made over a period of 16 years, i.e. by 2030, considering that current practice in the exploitation of natural resources will always be maintained. The transition probabilities established, derived from the 2000 and 2014 land cover maps constitute the base of this prediction (the input of the model). The land cover map of 2030 presents the probable evolution of the different units of occupation taking into account factors of change (Figure 5).

Figure 5: Projection of the Units of the Land Use of the Upper Pond of Okpara in 2030

From the examination of figure 5, we note in a general way that the face of the upper pond of Okpara, will be probably dominated by the raised and shrubby savannas. More specifically, the raised and shrubby savannas will be the most important units of this pond. Besides, the mosaics of fields and fallows will know an extension of their surfaces to the detriment of the vegetable formations. table 4 presents the likely surfaces of the various vegetable formations of the upper pond of Okpara in 2030.

Table 4: Assessment of the Area of the Upper Okapa Basin by 2030

Land cover units	2030 areas (Km ²)	Proportion (%)
Forest Gallery	7,75	0,15
Forêt dense	178,72	3,49
Clear Forest and Wooded Savannah	917,96	17,93
Savannah with trees and shrubs	1473,74	28,79
Plantations	29,64	0,58
Field mosaics and fallow land	2364,41	46,19
Water plan	0,28	0,01
Agglomeration	146,33	2,86
Total	5118,47	100

Source: Modeling of UOS from Landsat 7 ETM + 2000 and Landsat 8 ImagesOLI of 2014

Evolutionary Tendency of the Anthropological Formations to the Horizon 2030

The anthropological formations on the horizon 2030 would be in ascending order: the mosaics of fields and fallows, the plantations and the urban areas. The mosaics of fields and fallows are by far the units which will dominate probably the face of the upper pond of Okpara (46,19%). On the horizon 2030, the upper pond of Okpara can appear as an essentially agricultural zone.

Plantations would represent 0,58% of the surface of the various formations of the upper pond of Okpara to the horizon 2030. They are for the greater part the plantations of teak (*TectonaGrandis*), mahogany (*Anacardiumoccidentale*) and mango (*Maguiferasp*). The urban areas on the horizon 2030 will cover probably 2,86 % of the total surface of the upper pond of Okpara.

CONCLUSIONS AND DISCUSSIONS

At the end of this study, it appears that the dynamics of the soil occupation of the Okpara pond are characterized by the regression of natural plant formations profit fields and fallows. According to (Arouna, 2012), the conversion and modification of plant formations are the two phenomena that are at the basis of the evolution of the vegetation either towards a climax state or else towards a state of degradation. The basin Superior of Okpara is no exception to this claim. The current state of vegetation is characterized by the total degradation of the vegetal formations except for savannah trees and shrub that is increasing.

The diachronic analysis of land use has shown that plant formations,natural features made up of the forest gallery, dense forest, forest and wooded savannah regression between 2000 and 2014. These plant formation were converted to benefit of the savannah and shrub and mosaics of fields and fallow land. This trend regressive gallery forest and clear forests and wooded savannas in favor of savanna strees and shrubs and fields and follows is due to anthropogenic pressures. This point of view is shared by some authors in their research in particular (Hongbo, 2008;Ogouwalé, 2013; Toko, 2014). The direct effects recorded include filling in a stream and shoreline erosion or even pollution. Finally, the anarchic samples forest species with the riparian populations have contributed to the deforestation of banks and watersheds of Okpara.

Predictive modeling of land use in the Okpara Upper Basin on the horizon2030 revealed that the physiognomy of this basin will probably be dominated by savannas tree. The gallery forests and especially the clear forests and wooded savannas will experience a significant reduction in their area. This basin will also experience a virtual disappearance of its dense forests.

Today the protection of the environment must be a fundamental element in all economic policies (Bassè, 2014). To deal with the risks of degradation to which natural resources are exposed, it would be necessary to foresee a spatial development of these resources, this will lead to better land management.

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