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SOCIO-ECONOMIC IMPACTS OF MORPHOLOGICAL DYNAMICS INDICATORS AND ECOLOGICAL CHANGE IN THE FISHERIES OF LAKE NOKOUÉ (SOUTH BENIN)

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ABSTRACT

Lake Nokoué is experiencing serious environmental problems which threaten its existence and contribute to the reduction of goods and services for the beneficiary population. The objective of this study is to understand the dynamics of ecological factors and their impacts on the biocenosis. This study is based on bathymetric data collected in 11 stations on the lake following seasonal sampling from February 2017 to January 2018 and from March 2019 to February 2020. Documentary research, field surveys, interview guides, a camera digital and labeled sachets are the tools and materials used for data collection from 120 households. In addition, images from aerial and satellite photographs of the LANDSAT type (TM and ETM) were used to assess the dynamics of the acadjas of Lake Nokoué. The results were analyzed with the FPEIR model.

The results show that from 2000 to 2020 Lake Nokoué experienced an increase in the number of acadja which went from 667 to 1417 or 47.07% followed by a decrease in its depth from West to East of the order of 0.5m. The factors favorable to the filling of Lake Nokoué are according to 70% of the population surveyed: the flood and its solid inputs, the proliferation of water hyacinth in the rainy season and its degeneration in the dry season, the erosion of the banks, the intrusion of marine water and stations with high human and economic densities (implantation and decomposition of acadja, agricultural activities, etc.). These internal and external factors contribute to the morphological dynamics of Lake Nokoué, thus hindering the socio-economic development of populations dependent on Lake Nokoué. Faced with this situation, measures have been proposed for better management of this ecosystem, which is essential to the survival of its population.

Keywords: Lake Nokoué, Socio-economic Impacts, Morphological Dynamics, Ecological Changes.

1. INTRODUCTION

Estuaries and coastal areas are areas of high strategic stake for economies and the environment (Amara, 2011) cited by H.B.P. Capo-Chichi et *al*., (2022, p. 17753). Lake Nokoué, classified as a Ramsar site 1018, is the most important body of water in Benin in terms of surface area, productivity and exploitation by almost the entire riverside population. Indeed, lakes play a crucial role in the functioning of biodiversity and are an economic power due to their high potential for the production of fish species (F. Ruiz et *al*., 2006, p. 216). Generally, in these lakes, the diversity of species, their abundance, their ecological production and their spatial

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distribution show large seasonal variations in response to hydrological variations (Zabi and Le Loeuf, 1993) cited by P. M. Gnohossou (2006, p.52). However, massive nutrient inputs to Lake Nokoué linked to multiple anthropogenic activities have caused its eutrophication (D. Mama et *al*., (2011, p. 2077). Also, the increasing intensification of the exploitation of fish species stands by the constantly increasing local populations and the alarming acceleration of all the processes of degradation of the natural environment pose a major risk of scarcity of stocks (Lalèyè, 1995) cited by P.M. Gnohossou (2006, p. 16). The high use of "Acadja" fish traps and sediment inputs related to the hydrodynamics of the lake are the main causes of this tendency to fill the lake (D. Mama et *al*., 2011, p. 518). Natural and anthropogenic constraints (human settlements, construction of structures, development of Acadja parks) have weakened and made the economy of Lake Nokoué vulnerable over the past two decades. This situation is affecting the living conditions of the population, both economically and health-wise.

2. PRESENTATION OF THE STUDY AREA

Lake Nokoué is located in the south-east of the country and is located between the parallels 6°20' and 6°30' North and the meridians 2°20' and 2°35' East and is partially fed by theRivers Ouéméandsô, which drain sediments from the area to the lake (Figure 1).

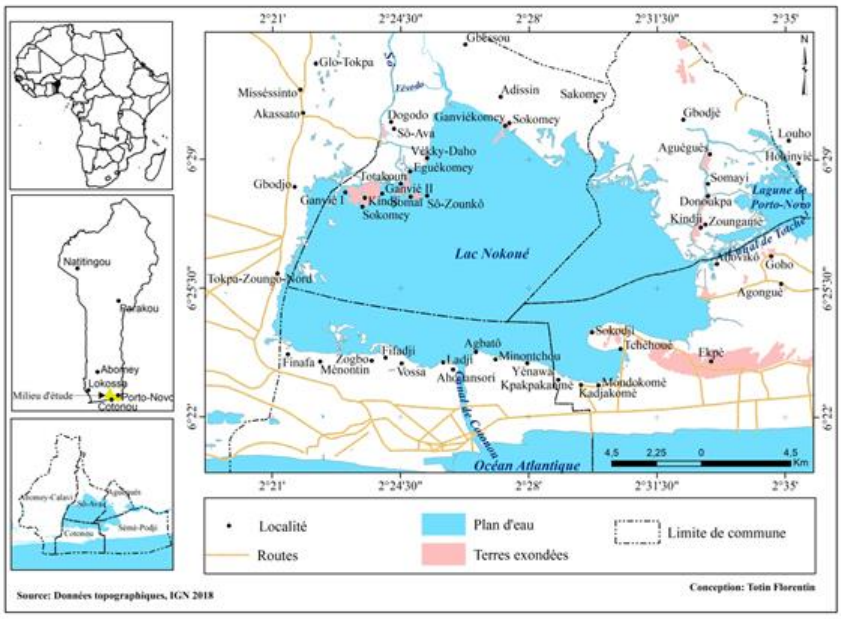

Figure 1:Geographical location of Lake Nokoué

With a depth of between 0.4 m and 3.4 m, it is directly connected to the ocean by the Cotonou channel over a length of 4.5 km with a width of about 300 m. This lake is shared between the municipalities of Sô-Ava, Sèmè-Kpodji, Aguégués, Abomey-Calavi and Cotonou.

II– Methodological approach

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This study on Lake Nokoué was carried out through the use of data collected in the libraries and documentation centers of the FAST, LACEEDE, LABEE, CENATEL, etc., and in a real environment. The equipment used for data collection consists of the Global Position System (GPS) for the georeferencing of each locality surveyed; topographic maps were used to define investigation routes in advance and to facilitate travel in the field using motorized boats; the lead and decameter used for water bathymetry at each of the selected sites; The observation guides helped to characterize in situ the eroded sectors, the activities of the environment, the distribution of acadjas in the lake and to identify the different factors that condition the morphological dynamics of the lake and their impacts on biodiversity; The interview guides were used to interview key stakeholders (fishermen, petrol sellers, local authorities, religious leaders, NGO representatives, and some state structures) involved in the management of Lake Nokoué. In addition, LANDSAT aerial and satellite photographs (TM and ETM) were used to assess the dynamics of fishing techniques (acadja) in Lake Nokoué through sites selected according to the intensification of activities; The erosive capacity of the lake was determined according to the equation:

$$F = {}^{p2}/_{p}$$

Where *p is the highest monthly rainfall, and p* is the average annual rainfall; for the BOD5 load, it is deduced by taking into account the following reaction: C+ O2 = CO2; BOD5/C is therefore 32/12

3. RESULTS

3.1 Distribution of eroded areas of Lake Nokoué

Investigations have shown that erosion is very pronounced in areas with a high concentration of people (Figure 2).

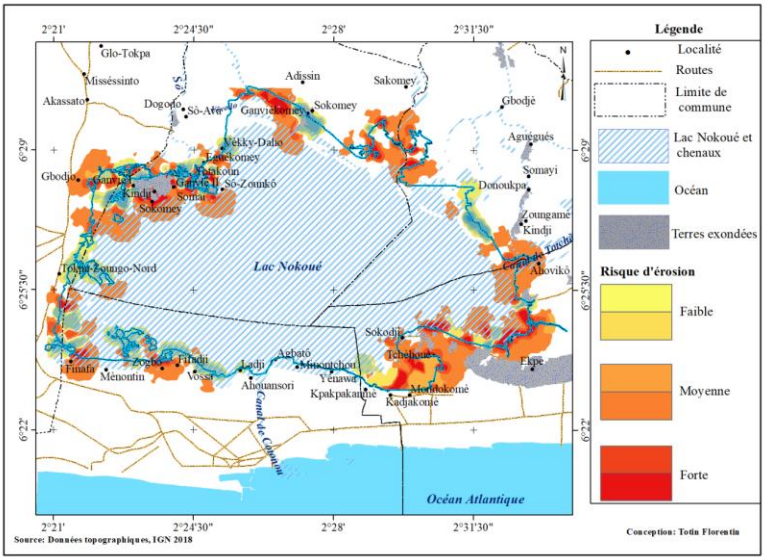

Figure 2: Map of eroded areas around Lake Nokoué
Source: Field surveys, February 2017 and January 2018

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Figure 2 shows that the risk of erosion is medium in areas with a high population density in the sphere of Ganvié, Abomey-Calavi, Zogbo (Cotonou), commune of Sèmè-Kpodji, Canal de Totché and towards Dékanmey. The erosive zones mentioned above are linked to the activities of the riverside populations (areas exploited for agricultural purposes, cleared and developed or under construction, etc.) which lead to the cutting of protective vegetation exposing the lake's soils. According to 70% of the population surveyed, this phenomenon has significant consequences on the quality of the lake's waters, resulting in a low yield of fish catches and a drop in income. Also, the consequences of climate change (increase in total precipitation, rainfall intensity, extreme events) are responsible for the risk of erosion of the lake with an increase in the concentrations of suspended solids and the problems of sedimentation and siltation.

3.2. Characteristics of the bathymetry of Lake Nokoué

Figures 3 and 4 show the different monthly variations in depth and those of the measuring stations for the years 2017 and 2018.

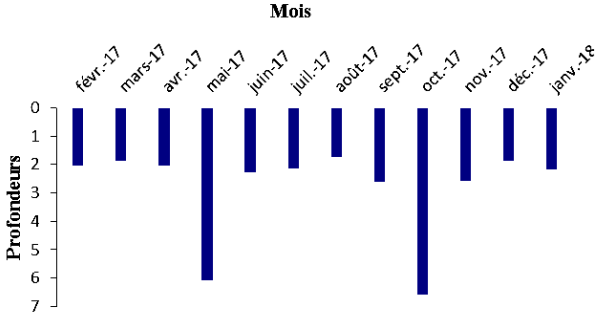

Figure 3: Monthly Average Depth Measurement of Lake Nokoué

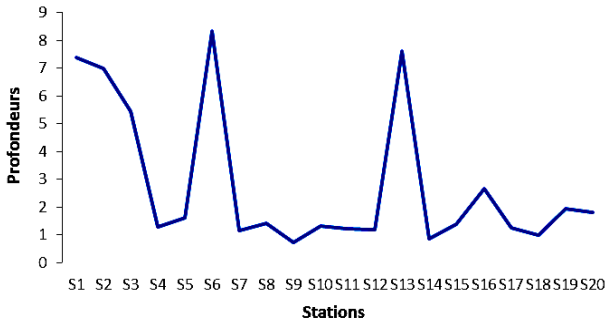

Figure 4: Depth variation by station 2017-2018

The considerable variations observed in Godomey and Ouédogbadji can be explained by the increased density of sand dredging observed according to 100% of the respondents. But those of the first stations close to the sea can be explained by the permanent current of water at these places. The variations in this factor make it possible to assess the evolution of other factors such as pH, dissolved oxygen (where its low concentration at depth can be explained by its consumption by bacteria that decompose dead organic matter), and temperature. There is also a relationship between the transparency observed in an environment and the depth of the water

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where the trophic level of the different stations depends on it. Since the depth does not exceed the limit value at most other measuring stations, it is rather difficult to observe such a considerable variation in the physico-chemical parameters.

3.3. Dynamics of acadja occupation in Lake Nokoué

The occupancy status of acadjas in 2000, 2010, and 2020 represented by Figures 5, 6 and 7 shows an increase in acadja area each decade by the riparian population in the lake in order to increase their fish income.

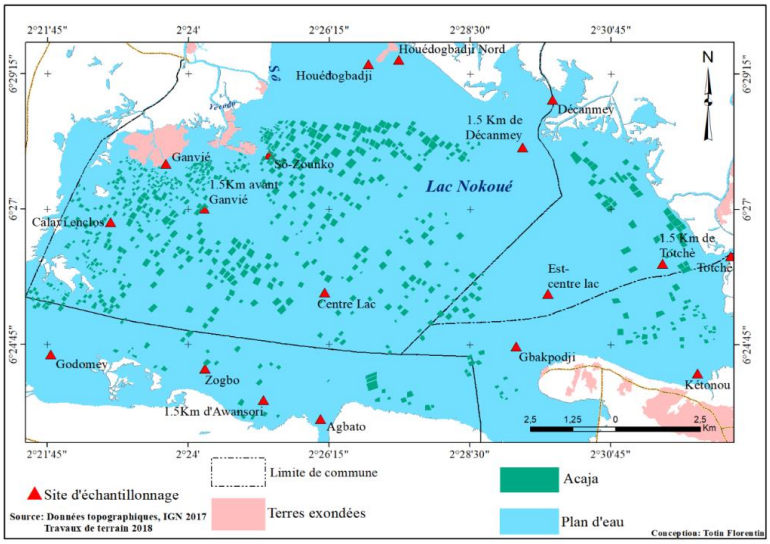

Figure 5: Map of the distribution of acadjas in 2000
Source: Field Surveys, February 200

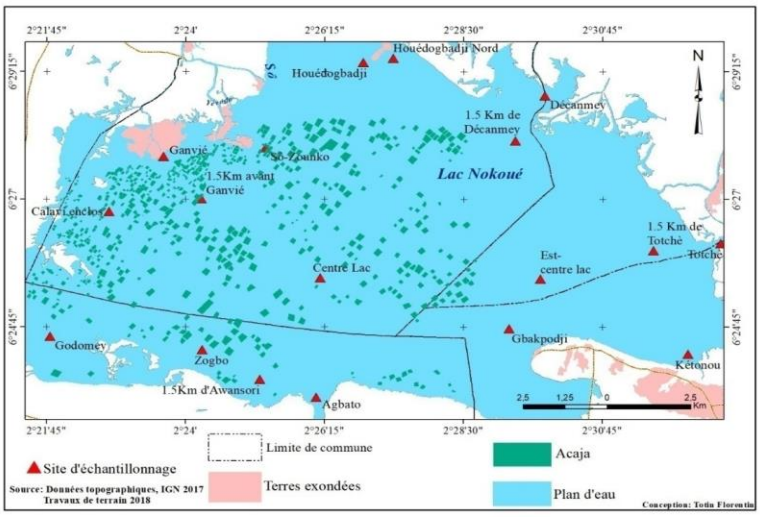

Figure 6: 2010 Map of Distribution of Acadjas

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Source: Field Surveys, April 2010

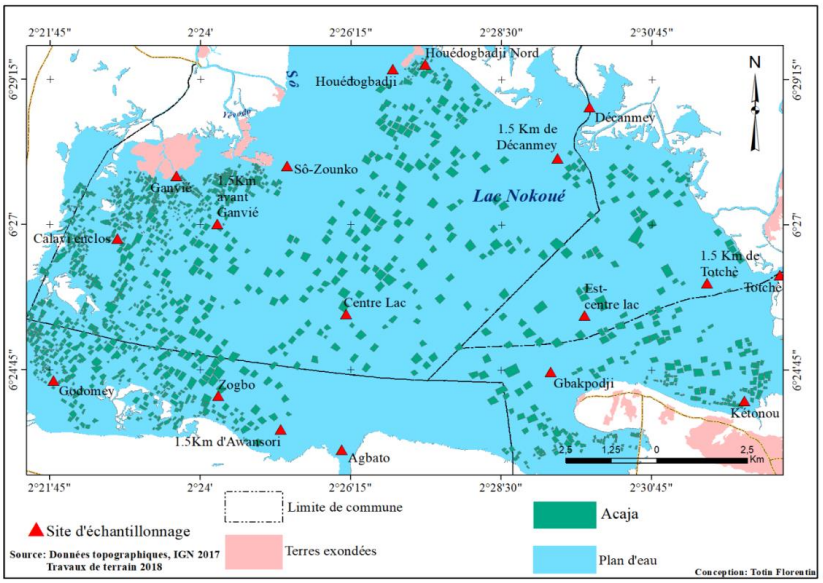

Figure 7: Distribution map of acadjas in 2020
Source: Field surveys, March 2020

This is due to the decline in fish species, the filling and sedimentation of the lake by human waste, and the rapid increase in the population. In addition, tables I and II on the right indicate respectively the areas of acadjas on Lake Nokoué over two decades on the one hand and on the other hand the loads brought by acadjas into the lake in 2020.

Table I: Comparison of acadja occupancy areas on Lake Nokoué from 2000 to 2020

Characteristics / Year	Number D'acadja	Surface Total (ha)	Area Minimum (ha)	Area Maximum (ha)
2000	667	987	0,02	11
2010	773	1101	0,05	7,5
2020	1417	1844	0,01	9

Source: Field surveys, February 2000, April 2010 and March 2020

From the observation of the table, it appears that from 2000 to 2020 Lake Nokoué has seen an increase in the number of acadja which has increased from 667 to 1417 or 47.07%. Considering the area of 1844 hectares occupied in March 2020, the mass of a lot is around 25kg and a quantity of lots of around 2500 are arranged per hectare, the annual load of acadja is then about 115250 tons. Also, during this same year, the mass of degraded acadja is about 2300 to 2900 tons per year. On the basis of this information, estimates of the pollution loads brought into Lake Nokoué are given in Table II.

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Table II : Loads brought by acadjas into Lake Nokoué March 2020

Nutrients	Annual load in tonne(s) or kg	Daily load in tonne(s) or kg
Carbon (C)	1150 to 1425	3.1 to 3.9
BOD5 (C*32/12)	3066 to 3800	8.4 to 10.41
Nitrogen N = C/200	5.75 to 7.125	15 to 19 kg
Phosphorus P = 0.08N	0.46 to 0.58	1.2 to 1.5 kg

Source: Field surveys, March 2020

From the observation of Table II, the loads brought by the acadjas annually in tonnes of carbon and BOD5 are much higher than those brought in daily. On the other hand, the daily load in tonnes or kg of nitrogen and phosphorus in Lake Nokoué is double or even triple the annual load. It can be deduced that acadjas bring a significant daily load of nitrogen and phosphorus to this lake ecosystem on the one hand. On the other hand, carbon and BOD5 are higher annually than daily.

In addition, estimates of particulate loads in Lake Nokoué can be explained by the aggressiveness index as shown in Figure 8.

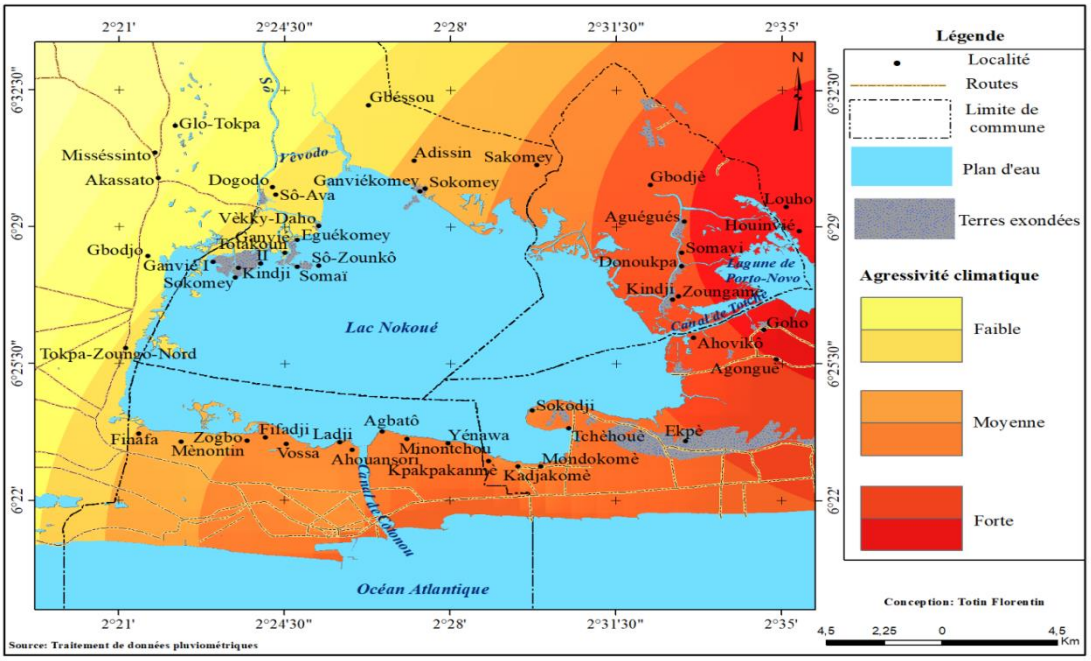

Figure 8: Aggressiveness index of Lake Nokoué

Figure 8 shows a variation in this aggressiveness index around Lake Nokoué, going from a low degree (in the stations surrounding Ganvié) to a high degree (in the stations near Totché), thus implying significant risks of soil degradation.

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The dynamics of the lake are not only the prerogative of the consequences of eroded areas or acadjas, but also of macrophytes such as the water hyacinth (*Eichhornia crassipes*). Plate I shows their different aspects in Lake Nokoué during the different seasons.

1

2

Plank 1: *Invasion of floating cages by water hyacinth during periods of high water (1) and degeneration of water hyacinth during periods of low water on Lake Nokoué Shooting: Totin, July and December 2019*

The proliferation of water hyacinth during the flood causes a very strong eutrophication of the environment, the asphyxiation of fish species, the proliferation of mosquitoes and a decrease in the income of the local population. According to 100% of the population surveyed, the parameters that promote this phenomenon of eutrophication in Lake Nokoué are, among others: wastewater discharged directly into the lake, leaching water following rainfall in the catchment area of the Ouémé and Sô rivers, as well as in the urbanized area near the lake, The decomposition of the plant biomass during low water that fills the lake bed under a water salinity threshold of around 27g/l (December – April) induces an increase in the quantity of organic matter which promotes anoxia and therefore the imbalance of the lake's ecological functions.

3.4. Socio-economic, ecological and environmental impacts of Dynamics of Lake Nokoué

Investigations on Lake Nokoué reveal a disturbance of its balance linked to the variation of physicochemical parameters and poorly planned and poorly coordinated management practices that have led to the upheaval of the fishery resources on which nearly 90% of the riverside population depends. This decline in primary and fisheries productivity has repercussions on the entire food web and therefore destroys their purchasing power.

In addition, periods of flooding and hygiene practices are major contributors to the outbreak, development, and multiplication of pathogenic germs. About 75% of local populations reported being aware that poor hygiene makes them vulnerable to pathogens. Similarly, the most exposed visitors being expatriates are more affected by flood weather (70%), hot weather (65%) than cool and sunny weather (35%).

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4. DISCUSSION

The present study has shown that Lake Nokoué is in perpetual degradation linked to the proliferation of acadjas, resulting in its increasingly increased sedimentation and siltation, and a decrease in fish stocks. This corroborates with the studies of P.M. Gnonhossou (2006, p.137). In fact, the bathymetric variation of the lake caused by garbage discharges, the degeneration of water hyacinth, shoreline erosion, the increase in the population, the decomposition of acadjas shows a decrease in its depth that varies from one station to another, as well as a decrease in the population's income. The work carried out by M. Daouda (2006, p. 36) has similarly addressed some problems specific to this lake ecosystem. The annual nutrient loads (carbon and BOD) provided by acadjas are higher (1150 to 1425 kg) than the daily loads (3.1 to 3.9). On the other hand, the daily loads of nutrients, nitrogen and phosphorus provided by the acadjas are double or even triple (15 to 19 kg) the annual loads (5.75 to 7.125 kg). These results are similar to those obtained by M. Daouda et *al*. (2011, p. 517). The nutrient loads of acadjas can be explained by the aggressiveness index ranging from a low degree (Ganvié) to a high degree (Totché). The rainfall dynamics and the physico-chemical pollution of the lake are the source of several diseases including malaria, schistosomiasis, etc.

5. CONCLUSION

At the end of this study, the increase in climatic instability, population growth, and the proliferation of acadjas are all factors that contribute to the degradation of Lake Nokoué and its tributaries. The changes that have occurred in the environment of Lake Nokoué affect the biocenosis and have a negative impact on the social, cultural, economic and environmental way of life of the populations of the five municipalities that share this ecosystem.

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