Original Research Article

External interventions and community innovativeness to cope with changes in Ecosystem Services of the Okpara dam in the district of Tchaourou, in Northen Benin

ABSTRACT

The Okpara dam in the Northern Benin offers multiple ecosystem services (ESS) to the riparian populations. It is an important drinking water source for the populations of the largest nearby metropolis Parakou. Many development activities have been undertaken to increase its capacity to supply drinking water by the national water company of Benin (SONEB: Société National des Eaux du Bénin). These activities combined with climate change are drastically affecting the sustainability of ESS supply. This paper aims to analyse the determinants of changes in the provision of ESS and to assess the local innovations developed by local communities to adapt to these changes. Data collection consisted in interviewing 111 individuals in the nearby villages of the Okpara dam. It included farmers, fishermen, religious dignitaries, SONEB officials, and traditional leaders. The results show that the modernization work undertaken by SONEB has increased the capacity of the dam to supply drinking water to the Parakou's population. On the other hand, they have deprived the local communities of many ESS such as cultural and religious spaces, entertainment and agricultural production areas. In addition to these development works, climate change and other anthropic actions are also cited as factors explaining the depletion of certain ESS around the dam. To limit the damage and safeguard agricultural production, local population have developed agricultural areas downstream of the dam with the creation of autonomous water points for market gardening. Fish farming areas have also been created for small-scale fishing. These innovations have helped not only to improve the availability of drinking water but also increase the income of farmers and fishermen and improve the social cohesion among the communities.

Keywords:External interventions, Ecosystem services, Innovativeness, Water resources management, North-Benin

1. INTRODUCTION

Ecosystem services (ESS) are provided by a large number of physical and ecological functions [1].For Johan, *et al.*(2014), ecosystem services do not only depend on the interactions between soil and atmosphere, soil and vegetation cover, biodiversity and its

interactions with other components of the environment but also on the conditions of land use and occupation or climatic dynamics. This multifunctional system shows the needs, desires, competing practices, uses and representations [2].

Despite the fact that water is considered as an indispensable element, both for humans and the rest of the living species, the current state of the earth's drinking water sources has to be questioned. Water sources and aquatic environments are constantly disturbed by human activities. These disruptions take well-known forms such as various chemical pollutions and those due to waste discharged directly into rivers or water bodies [3]. In addition, there are other problems that are less mentioned, such as thermal pollution and ecosystem disruption of rivers due to construction and dams, whose impact is by no means negligible [3]. Moreover, forecasts predicted a decline in per capita water availability in the coming decades [4].

Furthermore, under the pressure of population growth combined with increasing impoverishment, protected areas are highly affected. So, thepopulation growth is forcing farmers to seek new agricultural land no matter the consequence on the environment. [5;6]. Consequently, the balance of the ecosystem of water bodies and rivers and the health of population around is affected [3].

On the other hand, Africa is particularly affected by climate change and becomes very vulnerable[7]. Manyscholars also demonstrated that climate change could worsen the pressure on water resources and food security [8;9;10]. The situation requires adequate strategies in managing water resources [11]. Studies carried out on these aspects showed the importance of taking into account external and internal actors in the governance of water and climate change [12].

The Okpara Dam case is an excellent illustration of how external interventions affectESSof water resources supply. Many stakeholders interact around the Okpara dam. It is essential to investigate on the changes caused by the various actions at the dam site –development activities undertaken by SONEB, climate change and anthropogenic actions. This may impact the socio-economic and institutional situation of the riparian communities.

This research therefore aims at i) understanding the dynamic of ecosystem services of the Okpara dam; ii) the factors that influence them and iii) the innovativeness of the riparian communities in coping with these changes.

2. THEORETICAL AND ANALYTICAL FRAMEWORK: FROM SOCIAL REPRESENTATION THEORY TO ANTHROPO- ECOLOGY

According to the theory of social representations [13], knowledge emerges from common thought, which is shaped during interactions where the processes of transmission and construction are intertwined [14]. In this theory, a central role is given to the social as a place of co-construction and sharing of knowledge between individuals [15]. Social representations are conceived as dynamic sets that make possible to interpret and intervene on reality [13]. They are formed through relationship between individuals. They are whether convergent, or conflicting [14]. Indeed, several socio-economic factors such as age, gender and migration influence the knowledge of ecosystem services related to water resources[16;17]Furthermore, where the relationship between humans and their natures will preoccupy the ethnologist, the ecologist will focus on the relationship between nature and their societies, thus reversing the order of epistemological priorities. The anthropo-ecologist, on the other hand, will be in search of the anthropological and ecological invariants of the dialectical relationship maintained by Man and Nature[18]. The combination of these two theories is interesting in order to better understand the link between populations and their physical, social, economic and political environments. It helped us understand possible interactions in order to effectively address the effects of changes in ecosystem services on the nearby communities of Okpara dam.

3. METHODOLOGY

The study is carried out in the district of Tchaourou in Northern Benin where the Okpara dam is located. Okpara is a river located in the Department of Borgou and has its source at Darou Kparou, district of Pèrèrè. It is a tributary of Oueme river, with an irregular flow varying between 0.0001 and 150 m^3/s. It is about 362 km long with a total area of 10,000 km^2 [19]. Its watershed has an area of 2,070 km^2 andcovers in large part the districts of Bembèrèkè in the North, Parakou and Tchaourou in the South, Pèrèrè in the East and N'Dali in the West of Benin. Three nearby villages were randomly selected, Kpassa, Kika and Kassouala (Fig 1). Quantitative and qualitative data were collected from 111 people including 37 women and 74 men from different socio-professional groups: farmers (49), breeders (12), fishermen (30), religious and traditional leaders (15) and head of SONEB (5). The data collected were related to their socio-demographic characteristics, socio-economic activities, perceptions of the ESS provided, changes in the provision of ESS, adaptation strategies of riparian communities and innovations for better management.

The qualitative analysis methods used consists in examining various dimensions of the discourse of the people interviewed. The relationship between discourse and context or syntactic structure was also examined as suggested by Krippendorff(2004). In terms of quantitative data analysis frequencies and means were calculated.

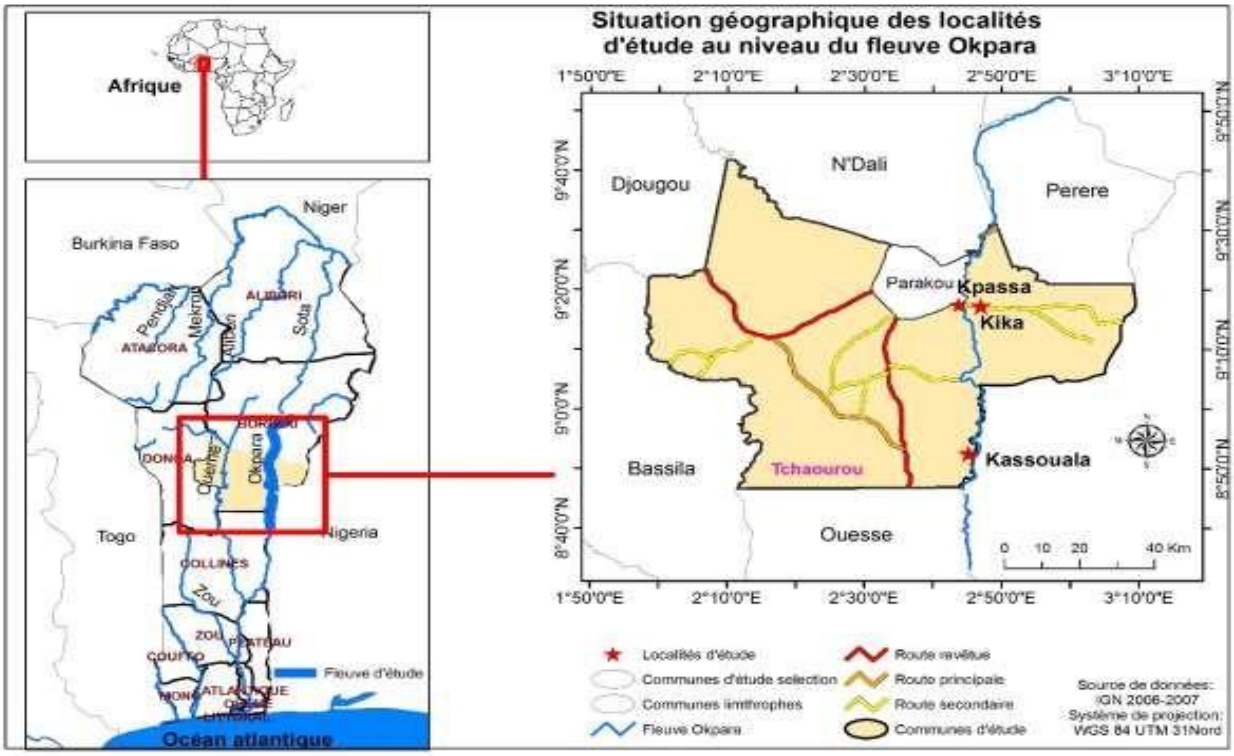

Fig1: Geographic location of the research area

4. RESULTS

4.1. Dynamics of Ecosystem Services generated around the Okpara Dam

Several ESS are generated around the Okpara Dam ecosystem. Fig 2 below shows the services identified taking into account their importance of usage.

4.1.1. Okpara dam as a recreational swimming place

The main ESS offered by the dam and recognized by more than 93% of the respondents is its emblematic landscape that offers bathing and entertainment spaces to the riparian populations. In fact, this landscape represents for the riparian populations what the beach is for the populations located in the coastal areas. The place is a right place for youth even couples for picnic or entertainment. The nearby villagers take advantage of the place by taking bath after a long day of hard work in their farms when returning home. It is also a place where women fetch water for domestic use or for other various activities because of water scarcity in the region. During the field survey, one respondent declare this:
"*Every evening, we take advantage of this dam. When we return from the fields we take bath before going home. It is a strategy to limit the waste of water in the household especially in the dry season*." Interview with T.R., Kika, 23/07/2020.
This testimony demonstrates the crucial role of the dam in helping the population to cope with water scarcity especially during dry season

4.1.2. Main source of drinking water for households and domestic use

The second main service mentioned by 78 % of respondents is the supply in water. For more than forty years, the Okpara dam has been used to supply Parakou (Third biggest city of Benin) and surrounding areas with drinking water. In order to strengthen the function of the dam in the distribution of drinking water to the taps, massive investments have been made and structural reforms carried out by SONEB and the Government. It allowed to improve the quality of the service offered to the people who subscribe to the National Water Company of Benin (SONEB). It has solved the shortage of drinking water for the users.
Apart from drinking water, the dam provides the community with water for various domestic uses including washing, cooking, drinking and other economic activities. Indeed, several laundry camps are set up around the dam in order to punctually solve the problems of water deficit which arises especially during the dry season. Apart from a few exceptions, notably households that have boreholes or wells in their homes, the river facilitates access to water for more than two thirds of the population. On average, each household uses four to six basins (25 litres per basin) of water per day for various domestic uses. One respondent told us:
"*The existence of this resource relieves the pain of the people of our villages. We take at least four basins of water every day for our needs*" said T.R., Kika village, 23/07/2020.
These words show how dependent the populations are on this resource and the need to preserve it against all possible destruction.

4.1.3. Place for fishing and agricultural production

Artisanal fishing is one of the activities developed in the Okpara dam ecosystem. It offers the local populations various fish products to meet their needs in animal protein. The market of Kpassa in Kika District offers a framework for the populations especially from Parakou who come there every morning to buy freshwater fish from women sellers or fishermen.

These women supply the restaurants and hotels of the city of Parakou with fish every day. As soon as they return from fishing, there are buyers waiting to collect the fish. A woman reseller we met in the village of Kpassa said:

"I have my customers who order in advance and are the first to be served when my husband arrives from fishing. The rest is sold to the first arrived among the other customers". (A. I, 22/07/2020).

Okpara Dam ecosystem offers a multitude of opportunities for agricultural development too. Different agricultural activities are carried out such as soybeans, maize, bananas production and market gardening. The crops produced particularly maize, millet and beans are the main staple food for a large proportion of the population. Each household produces an average of 7 to 10 bags (100 kg per bag) of maize per year.75% of the crops produced is for consumption and the rest to supply local markets and the next season's seed.

4.1.4. Place of worship and cultural uses

The ecosystem around the dam is used for cultural and religious purposes as well. There are endogenous practices which consist in venerating the divinity that resides in the watercourse upstream and downstream of the dam. There are also external actors, notably religious believers (especially Islam and Christianity) who go to the place for prayers or exorcism sessions. Rituals of head washing, immersion or baptisms were often practiced there. Some objects and remains of immolated animals are easily noticeable in the site. These spaces offer emblematic landscapes favourable to communion with the spirits of water and forests. One respondent testified:

"We come here to get rid of our impurities and be born again. We have satisfaction when we come here to pray". (Z.A., Kika, 23/07/2020).

Another said:

"In the river, there is a great power that we have been worshipping for years. Every year, we make sacrifices to benefit from its protection and avoid cases of drowning of people. Reported T.R., Kika, 23/07/2020*".*

These testimonies show the degree of spiritual practices in this ecosystem and their importance in the eyes of the dignitaries and followers various religions encountered in the field.

4.1.5. Ecological reserve

According to people interviewed, the Okpara dam ecosystem is made up of forest where several species of plants and animals cohabit. These totemic animals often alert the populations of disasters or drought that are coming to the village.As result, people prepare themselves to minimize the damage. As for certain species of trees found there, they are used in the pharmacopoeia to cure certain illnesses and ward off bad luck.

As an illustration, one respondent said:

*"With a little attention, we receive from nature (birds) signals of bad luck that are about to come in the village. Also, several cases of illnesses are cured with our plants without necessarily going to hospital."*Said, G.P. in Kika, August 29, 2019.

According to most of the religious dignitaries we met in the field, the scarcity of certain medicinal plants and the disappearance of certain totemic animals –snakes, crocodiles, lizards are contributing to natural imbalance. Thataffects people well-being. During the interviews, one respondent confided:

"Even some of our totemic animals namely, the monitor lizards, the herald birds, the giant termites, are gradually disappearing. Before, when a disaster was about to strike the village, they would appear to give the alert so that people could prepare for it. Nowadays, this is no longer the case."(G.P., Kika, August 29, 2019).

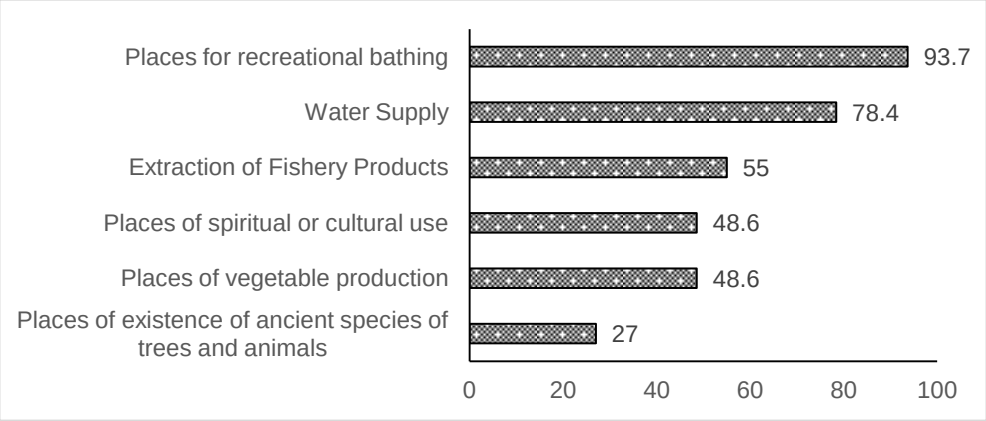

Fig 2: ESSprovided by Okpara dam (source: data collected, 2020)

4.2. Changes in ecosystem services provisionand their determinants

Fig 3 shows various factors that induce changesin ESS around the Okpara Dam. 98 % of people interviewed mentioned that the modernization and extension of the Okpara dam by SONEB have greatly contributed to the reduction or even disappearance of some ESS around the dam. A young man from the village of Kika told us:

"These people came to deprive us in the dry season of a precious heritage of our ancestors namely bathing and entertainment in the river. That is caused by the construction of the dam whose water largely benefits the people of Parakou, far from us." (S.A., kika, August 28, 2019).

This is a frustration noticed among some local residents who think that the dam's development work is less beneficial to them than to people in distant localities. Thus, for more than 95% of these residents, after the development work, certain farming practices are prohibited in a much wider area around the dam. This has had a negative impact on the production of some crops especially food crops, market garden produce and cotton which are no longer allowed to be produced in the vicinity of the dam. This has led to a drop in local agricultural production and a shortage of essential foodstuffs for the population's subsistence.

Several fishing practices are also prohibited in the place. Prohibited fishing practices include the use of chemical products and/or unsuitable traps. Indeed, the use of unauthorized small-mesh nets and chemical products is commonplace. They negatively impact the availability of fish products. These prohibited practices destroy all aquatic fauna and reduce their availability. Fishing that provides substantial income for nearby people is more and more restricted. Fish are also their main source of animal proteins.

The second main factor is the pressures on tourist and cultural site. The regulation around these sites excluded several people from farming. Consequently, farmers who do not know where to go are taken over these protected areas. Furthermore, they continue to use chemical fertilisers in agricultural production which affects water quality. Indeed, chemicals are drained to the dam that are made of pesticides and other prohibited products. These chemicals are sometimes difficult to remove despite the considerable means deployed by SONEB. As a result, the water collected and distributed by SONEB is depreciated by the population and deem to be the source of certain diseases that affect them. An agent of SONEB declared that

"It is not uncommon to hear on local radios that the typhoid fever widely spread in Parakou in the years 2015-2016 was from the consumption of water from SONEB. That was not true,

because the equipment in place limit considerably these risks." (A. T. of SONEB, 12 September 2020).

This situation has weakened certain endogenous practices of adoration of the local gods. One respondent stated:

"*Unlike the olden days, our ancestors are getting farther and farther away from us due to desecration of our places of worship by some people in the society who trample on the social norms. So, our prayers are no longer fulfilled like in the past."*Said T.R., Kika, 23/07/2020.

That shows the extent to which local people value the cultural events that bring them into communion with their ancestors.

Another important factor that causes changes in ESS is the increase in population.

It appears that the rapid increase of the population and its food needs have resulted in the overexploitation of the river and the degradation of the biodiversity. In the beginning the dam was built to serve at most 25,000 inhabitants but now estimated at more than 150,000 inhabitants.That reflects the pressure on the ecosystem through the reduction of cultivable land and the destruction of fauna and flora with the risk of food insecurity as mentioned by the respondents.

It is worth mentioning that climate change is highly influencing the provision of ESS. Climate changes are perceived by the local population through floods, the disappearance of certain fish species, the change in water temperatures, the variations in water wave currents, the abundance of predators of aquatic species, the decrease in water levels, the drying up of certain water points, the deterioration of water quality etc.

Local population believe that climate change has considerably influenced the balance around the ecosystem by acting on the volume of water in the dam (flooding or receding) and by drastically reducing the potential for agricultural and fishery. Also, the drying up of the dam limits the capacity to supply water for domestic use and consumption. This situation caused the water crisis in SONEB taps between 2005 and 2006.

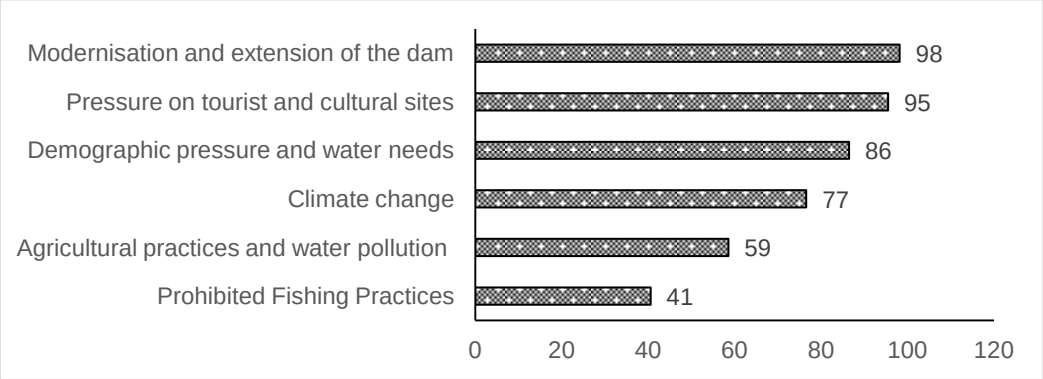

Fig 3: Explanatory factors of change in ESS around Okpara dam (source: data collected, 2020)

4.3. Innovativeness of riparian communities in dealing with the dynamics of ecosystem services around the dam

Innovativeness is the ability of a person, a company or a community to evolve, renew or innovate. This implies novelty, creativity and appropriation to impact the daily life of communities. The study showed that several local initiatives are undertaken to better adapt to the new environmental requirements.

The primary innovative action mentioned by more than 85% of the users interviewed is the one that led to the restoration of drinking water supply capacity carried out by the National

Water Company of Benin (SONEB). It has increased the production and storage capacity of water from 7,000 m^3 to 35,000 m^3 for about 16,305 subscribers. This has considerably reduced the distribution problems often encountered by the company during the dry season. In addition, Water Department and the Technical and Financial Partners have installed drinking water supply systems made up of boreholes for bordering villages that do not benefit from SONEB's water supply.In that sense,one respondent declared

"Even if it is true that we do not directly enjoy water from SONEB, we must have the honesty to recognize in return that the leaders of the country had the good idea to install inexhaustible water points for us for more than 15 years" (I.S. of Kpassa, August 2020).

Apart from that, there are some initiatives regarding the restoration of religious and cultural practices. In a participatory way –including all stakeholders the local population delimited areas of worship to venerate the gods of water and forest. There are also some places set for recreation or entertainment.According to them, this allows the restoration of local cultural values that have been lost and the development of tourism as explained by one resident from Kpassavillage in these terms:

"We think that these developed sites can attract tourists and bring us money as it happens in some localities of Atacora (in Benin). They receive hundreds of visitors every year and that bring income to the communities which are organized to welcome tourists who come to enjoy themselves every year. So, entertainment areas are developed in some places for local tourism in this perspective." (B.S. Kpassa, 22/08/2020).

The populations are aware of the need to develop tourism, which can be not only a source of employment for their offspring but also an opportunity of distraction for the youth.

In response to certain agricultural and fishing restrictions, the local population has developed adaptation strategies. Most of the population get converted into market gardening by installing boreholes equipped with motorized pumps to facilitate the irrigation of the plantations and fields during the dry season. In addition, dykes are built by these same farmers to facilitate the irrigation of the plantation. These measures have enabled the population to overcome water shortages and to carry out their activities in all seasons in complete safety. A market gardener met at the site in Kika said:

"We use our motorcycle pumps to draw water directly from the dam to the small dams we have dug or to boreholes. This allows us to continuously provide our plantations with water in dry season."(A.J., Kika, 30/01/2021)

This shows how creative people were in dealing with various changes.With regard to the development of fishing, the practitioners we met confided that they have organized themselves to develop areas along the river downstream where artisanal fishing is developed. This activity supplies the local markets with fish products. To control prohibited fishing techniques, village brigades are set up by the fishermen themselves. They are on duty to discourage bad fishing practices. Fines are imposed on offenders in case of non-compliance with established rules and standards. There are also other initiatives set up to protect some animals from hunting.A group of youth active in the field of ecology is mobilized to raise people awarenesson the regulation of hunting.

5. DISCUSSION

Ecosystem services are the benefits thatpeople get from ecosystems[21]. Thus, three types of ecosystem services contribute directly to human well-being: (i) harvesting services such as food and fuelwood (ii) regulating services such as water, climate or soil erosion regulation and iii) cultural services, such as recreational, spiritual or religious services. In addition to these three types, self-sustaining services represent a fourth type and include services that are necessary for the production of other services, such as primary production, nutrient cycling and soil formation.

Ecosystem services, while important in meeting the needs of local communities, are under severe threat from human interventions and climate change. [13]predict major upheavals in ecosystems as a result of the global changes mostly from human activities.
The modification of ecosystems by economic activities influences them positively or negatively [22;23].
As Cerceau (2013) noticed, the communities living along the Okpara dam recognize that the environment is an essential component of the territory and must therefore be included in the processes of exchange and management of anthropic activities.They are increasingly aware of the scarcity of water resources. Indeed, the results showed that each type of ecosystem service corresponds to different functions and services, which themselves depend on the state of the ecosystem –the pressures exerted on it [25].
It has been long admitted that human being has the right, and even the duty, to dominate nature and transform it [26]. That relationship between environment and human must be rethought when we observed the rapid modification of the ecosystem[27]. In this framework, ecosystem services, which constitute the interface between ecosystems and humans, allow a direct apprehension of anthropic impacts on ecosystems through the modification of the services rendered and thus the impacts on human well-being [28]. People harm themselves by their negative influence on the ecosystem.
Climate change strongly threatens many rural households in sub-Saharan Africa whose livelihood rely on natural resources [29]. The same observation was made in the case of Okpara dam where climate changes brought about changes in farming and fishing. It is worth mentioning that these changes are sometimes accompanied by various adaptation strategies to alleviate their pains. Thus, to adapt to changes and build resilience in coping with the degradation of ecosystem services, the traditional practices and knowledge of local people are indispensable[25]. In the case of Okpara dam an active water resources management by local population was set. The system was conducted in participatory way including all the stakeholders to make it successful. The local regulatory system played an important role in the managementof the dam in order to sustainably preserve the ESS provided. Because of the involvement of any stakeholder some major changes were accepted. They get to manage them through innovations.

6. CONCLUSION

The ecosystem service management difficulties that communities have to deal with are often highly territorial. They involve stakeholders with different interest. Moreover, water resource management is particularly demanding in terms of reconciling uses and preserving ecosystem services.
The various ecosystem services provided by the Okpara Dam justify the attention and pressure it receives from the stakeholders. For example, at the institutional level, the actions undertaken have made possible to increase the production capacity of drinking water to supply the commune of Parakou even if the populations surrounding the dam are confronted with shortage of this precious resource. Also, it should be noted that this dam, due to the multiple ecosystem services it offers, is strongly influenced by the riparian population'spractices.
Overall, the results show that the water resources of the Okpara Dam are increasingly subject to anthropogenic and environmental pressures. This situation explains why water resources management is particularly demanding and requires not only the involvement of all stakeholders but also their innovativeness. It is also clear that inclusive management is a mean of sustainable preservation of ecosystem. In other ways, it demonstrates the need to question the decision-making mechanisms set up in managing the ecosystem services provided by dams.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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