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Social factors explaining poor fishing practices on Buyo Lake in N'zo Partial Wildlife Reserve, Côte d'Ivoire

Kouadio Juslin Hervé KOIGNY[1*], Abdoulaye DIARRASSOUBA[2], Martin YELKOUNI[1], Djeyao Roy Hartman ASSIE[2] and Velmah Wambui WAIRIMU[3]

[1]Environment Department, Senghor University, Alexandria, Egypt; 1, Place Ahmed Orabi, Al Mancheya; BP: 415, 21111 Alexandria-Egypt.
[2]Direction Zone Sud-Ouest de l'Office Ivoirien des Parcs et Réserves, Soubré, BP: 1342 Soubré, Côte d'Ivoire.
[3]Departement of environmental sciences and education, Kenyatta University, Nairobi, Kenya.
[*]Corresponding author; E-mail: kouadio.koigny.2019@alumni-usenghor.org

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ABSTRACT

The Buyo lake, which is the result of Buyo hydroelectric dam, is exploited by the local population for fishing. However, fishermen use non-regulatory fishing gear and techniques that destroy fish stock, leading to a depletion of the lake's fisheries resource. This study aimed at understanding the social factors that explain the use of non-regulatory fishing tools and techniques by fishermen. Social data and data relating to fishing practices were collected from 109 fishermen of Buyo lake in 3 fishermen camps, namely PK15, PK28, and Derra. Statistical analysis of the data showed that young fishermen are the most numerous and represent a proportion of 58.75% of this population. The years of experience of the fishermen vary from 2 years to 40 years with an average of 19.3 years. The majority of fishermen are illiterate, that is 86.24%. Fishing was the main economic activity for 96.33% of the fishermen. The fishermen visited Buyo lake daily for fishing. The majority of fishermen (92.66%) acknowledged a decline in the fishery resource in Buyo lake. The results also showed that the poor fishing practices adopted by the fishermen can be explained by the age of the fishermen and their years of experience of the fishermen.

Keywords: Côte d'Ivoire, fisheries resources, bad practices, explanatory factors, Buyo Lake, N'zo Faunal Reserve,

INTRODUCTION

Wetlands such as lakes are home to a high level of animal biodiversity and are sources of many ecosystem services (Ostendorp et al., 2004). This biodiversity can vary from one area to another depending on ecological and climatic conditions. Wetlands are places where various human activities take place. They directly support the needs of millions of people by providing goods and

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services to the regions outside the wetlands, such as livestock farming, fishing, hunting, and various recreational activities (Aoubid and Gaubert, 2010). Lake wetlands play an important role in the socio-economic development of riparian communities. Fishing is now an economic issue for many lake communities (Fabio et al., 2002). In Côte d'Ivoire, Buyo lake in the N'zo Wildlife Reserve is exploited by the lakeside communities for fishing activities. This lake occupies 8,400 hectares of the Reserve, north of the Taï National Park. The development of fishing on Buyo lake has been accompanied by the installation of fishing camps on the banks of the lake, particularly within the N'zo Partial Wildlife Reserve (OIPR, 2006). The study by Berger et al. (2015) showed that the part of the N'zo Partial Wildlife Reserve occupied by Buyo lake is home to fish breeding grounds and thus contributes to the renewal of the lake's fish stock. Around 74 tonnes of fish are caught and marketed each year in this part of Buyo lake (Berger et al., 2015). However, these fishing activities are practiced in disregard of the legal provisions in force and the norms of sustainable management of fishery resources. Goli et al. (2019) reveal that the fish species most caught by fishermen are *Oreochromis niloticus*, *Malapterurus electricus*, *Chrysichthys nigrodigitatus*, *Distichodus rostratus*, and *Lates niloticus* with a stock reduced to more than 50%. The populations are undoubtedly in sharp decline due to poor fishing practices on the lake. Fishermen use non-regulatory mesh nets and prohibited techniques resulting in the destruction of stocks and the disappearance of some fish species (Grell et al., 2013; Berger et al., 2015; N'dri et al., 2020). Despite awareness-raising and monitoring activities carried out by agents of the Ivorian Office of Parks and Reserves (OIPR) to ensure sustainable management of fishing on the lake, these bad practices persist on Buyo lake. Several factors can explain the use of non-regulatory fishing gear and practices by fishermen, including social factors. The objective of this study was therefore to identify the social factors that explain the bad fishing practices of the fishermen of Buyo lake in the N'zo Partial Wildlife Reserve.

MATERIALS AND METHODS

Technical equipment

The technical equipment for data collection consists of a digital tablet, a digital camera, a questionnaire, interview guides, a notepad, and a motorized dugout canoe.

The digital tablet was used to collect data during the interviews using the KoBotoolbox mobile application, instead of the collection sheets. The questionnaire and the interview guides were imported into the digital tablet using this application. The advantage of KoBotoolbox is that it allows you to create a survey form from an online server. KoBotoolbox allows you to obtain the database directly in an Excel file. This mobile application also offers descriptive statistics of the survey conducted in the field.

The dugout canoe was used as a means of moving from one camp to another on the water.

Study area and sampling

The study was conducted on Buyo lake in the N'zo Partial Wildlife Reserve, part of the buffer zone of the Taï Biosphere Reserve. In the study area, three (3) fishermen's camps were chosen for data collection. These were PK15, PK28, and Derra. Camps PK15 and PK28 are located inside the N'zo Reserve, while Derra is outside the protected area (Figure 1). These three camps have 40, 60, and 36 fishermen respectively as shown in Table 1. Fishermen from Derra also fished in the water body of the N'zo Partial Wildlife Reserve. Our study sample size for all three sites was 109 fishers, corresponding to a sampling rate of 80% presented by Table 1 (MIRAH, 2021).

Data collection

Data collection from the fishermen was carried out through directive and semi-directive interviews, following a qualitative approach using a questionnaire. The convenience sampling technique was used for data collection in each of the three fishermen's camps. The data collected during the interviews relate to the perception of the evolution of fishery resources, the type of

fishing tools, the number of fishing days, the age of the fisherman, the level of education of the fisherman, the year of experience of the fisherman in the fishing activity (Table 2).

Data analysis

The data were analysed in two stages: a descriptive analysis and an inferential analysis. The descriptive statistics made it possible to show, in the form of a table, the evolution, and dispersion of the quantitative data of the study sample thanks to statistical parameters (mean, median, standard deviation, minimum and maximum). The "age of the fisherman" variable was structured in age classes and adapted according to the Statistics Canada (2021) classification in order to know the age categories of the lake fishermen. This classification is defined as follows:

[15 to 24 years] = Adolescents
[25 to 44 years] = Young people
[45-60 years] = Adults
[61 to 75 years] = Elderly

As for the qualitative data, the descriptive analysis made it possible to present these data through graphical representations (pie charts and bar charts). For each of these qualitative variables, the description of the data made it possible to present the relative frequency of the different modalities.

The inferential statistics consisted of studying the relationship between the variable "Type of fishing tools" and the variables (level of education, perception of the evolution of the fishery resource, the number of days fishing per week, the age of the fisherman and the year of experience of the fisherman). A binomial logistic regression model was therefore used to identify the factors explaining the use of non-regulatory tools by fishermen. This method was also used by Codjo et al. (2020) to explain poor fishing practices on Lake Toho in Benin.

With this model, the dependent variable or variable to be explained has two modalities: either the fisherman uses an illegal fishing tool or he does not. The equation of the binary logistic model according to Agresti et al. (2009) and Rakotomalala (2015), is as follows:

$$ln(\pi 1 - \pi) = \alpha + \beta X \quad (1)$$

Linearisation of equation (1) gives the following equation (2):

$$\pi = P(Y) = \frac{e^{\alpha+\beta Xi}}{1+e^{\alpha+\beta Xi}} \quad (2)$$

Where π is the probability that the fisherman uses at least one illegal fishing tool (Y =1), X_i = vector of explanatory variables, α is the constant of the equation, β represents the regression coefficients of the explanatory variables to be estimated.

The dependent variable Yi = **1**, *if* the fisherman uses illegal fishing tools.
0, if *no*

Taking the log from equation (2), we obtain the following Logit model with the coefficients to be estimated:

$$Log\left(\frac{P(Y=1)}{1-P(Y=1)}\right) = \alpha+\beta_1 X_1 + \beta_2 X_2 + \cdots \beta_i X_i + e_i \quad (3)$$

e are the error terms and i = 1, 2, 3, 4, ... are the observations.

Next, equation (3) is estimated by determining the coefficients α, β_1 , β_2 ...β_i and finally interpreting the model results. The equation of our binomial logistic model in this study is therefore of the form:

$$Log\left(\frac{P(Top)}{1-P(Top)}\right) = \alpha+\beta_1 \text{ Study} + \beta_2 \text{ Percep} + \beta_3 \text{ Nbrj} + \beta_4 \text{ Age} + \beta_5 \text{ Anex} + e \quad (4)$$

Where:

Top: Type of fishing tools
Study: Level of education of the fisherman
Percep: Perception of the evolution of the fisheries resource
Nbrj: Number of fishing days per week
Age: Age of the fisherman
Anex: Year of experience

A likelihood ratio test (Chi-square test) was performed at the 5% threshold for model validation. Nagelkerke pseudo-R^2 gives the percentage variation of the dependent variable in relation to the explanatory variables introduced into the binomial logit model. The variables retained for this purpose in the model are those that were significant at the 5% threshold (Codjo et al., 2020) provided by the result of the Wald test.

Data analysis was carried out with the statistical software R 4.0.3 (for inferential statistics) and SPSS version 25 (for descriptive statistics).

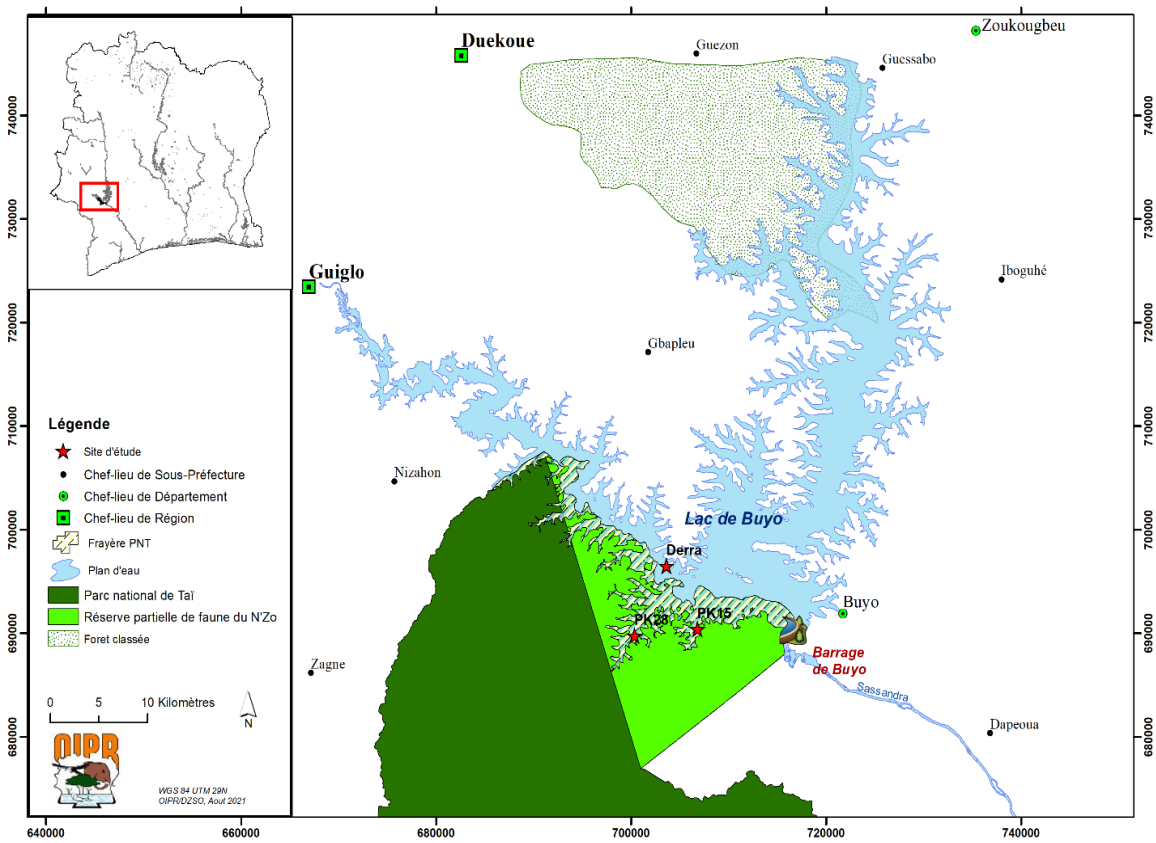

Figure 1: Location of sampling sites.
Source: OIPR/DZSO, August 2021.

Site étude = sampling sites
Chef-lieu de Sous-préfecture = Chief Town of sub-prefecture
Chef-lieu de department = Chief town of department
Chef-lieu de région = Chief of the region
Frayère PNT = Fish spawning area of Taï National Park
Plan d'eau = Water body
Parc national de Taï = Taï National Park
Réserve partielle de faune du N'zo = N'zo partial Faunal Reserve
Forêt classée = Classified forest
Lac de Buyo : Buyo Lake
Barrage de Buyo : Buyo dam

Table 1: Number of fishermen in the study area.

Collection site	Professional fishermen	Fishermen's aid	Total number of fishermen	Number of fishermen interviewed	Sampling rate
PK15	15	25	40	40	100%
PK28	18	42	60	25	75%
DERRA	5	31	36	24	66%
Total	38	98	136	109	80%

Source: MIRAH, 2021

Table 2: Data collected from fishermen.

Variables	Values	Nature of the variable
Perception of the evolution of fisheries resources	- Decreases - Increases - Constant	Qualitative nominal
Type of fishing tools	- Regulatory tools - Non-regulatory tools	Binary qualitative
Number of fishing days/week	- 1 day/week, - 2 days/ week, - 3 days/ week - More than 3 days/ week	Qualitative ordinal
Age of the fisherman	Fisherman's response	Discrete quantitative
Level of study	- Illiterate - Primary - Secondary	Qualitative ordinal
Year of experience	Fisherman's response	Discrete quantitative

RESULTS

Social characteristics of fishermen in Lake Buyo

The results of the descriptive analysis showed that the age of the fishermen in Buyo lake in the N'zo Partial Wildlife Reserve varied from 15 years to 73 years. The mean age was 39.51 ±12.74 years, while the median age was 36 years. The fishermen had years of experience ranging from 2 to 40 years with an average of 19.3 years. The median year of experience of the fishermen was 18 years (Table 3).

Young fishermen, who represent 58.75% of this population, were the most numerous on the lake. Adults, adolescents, and the elderly represent 23.85%, 9.17%, and 8.26% of fishermen respectively (Figure 2).

As for the level of education, 86.24% of the fishermen were illiterate, 9.17% had primary education and 4.59% had secondary education (Figure 3). Fishing was the main economic activity for 96.33% of the fishermen in the lake. Other activities such as agriculture (1.83%), trade (0.83%), and carpentry (0.83%) remained very little developed (Figure 4). The results also showed that 96.33% of the fishers had more than 3 days of fishing per week, while 3.67% had only 3 days maximum of fishing (Figure 5). The results also indicated that 92.66% of the interviewed fishermen acknowledge a decline in the fishery resource in Buyo lake. On the other hand, 1.83% of the fishermen reported an increase in the fishery resource and 5.50% stated that the resource has remained constant (Figure 6).

Social factors explaining poor fishing practices on the lake

The result of the binomial logistic regression model to determine the explanatory factors of the use of bad fishing practices is presented in Table. The likelihood ratio was not significant at the 5% level (Chi-square= 14.402; p=0.072). The pseudo-R^2 of Nagelkerke (0.165) indicates that the explanatory variables of the model explained 16.5% of the use of non-regulatory practices by fishermen. Although the model is not significant and the value of the R^2 of Nagelkerke is low to attest to the good predictive quality of the model, the result of the Wald test provided by the model nevertheless maked it possible to identify two explanatory variables statistically associated with the dependent variable "Type of fishing tools". These two variables are the age of the fisherman and the year of experience.

The variable "age of the fisher" had a negative effect on the variable " Type of fishing tools " at the 5% threshold (β= -0, 06756; p=0.018), indicating that an increase in the age of the fisher decreased the probability of using non-regulation fishing tools. The variable "year of experience" had a positive effect on the variable "type of fishing tools" at the 5% threshold (β= 0, 08262; p=0.011), indicating that an increase in the year of experience increased the probability that the fisher uses illegal fishing tools.

As for the variables "level of education of the fisherman", "perception of the evolution of the fisheries resource" and "number of fishing days", they were not significant in the model. The p-values corresponding to each of these variables were above the 5% threshold (p> 0.05), which showed that they did not affect the dependent variable.

Table 3: Variation in age and year of experience of fishers.

Statistical parameters	Age of the fishermen	Year of experience
Total number of observations	109	109
Average	39.51	19.3
Median	36	18
Standard deviation	12.74	10.6
Minimum	15	2
Maximum	73	40

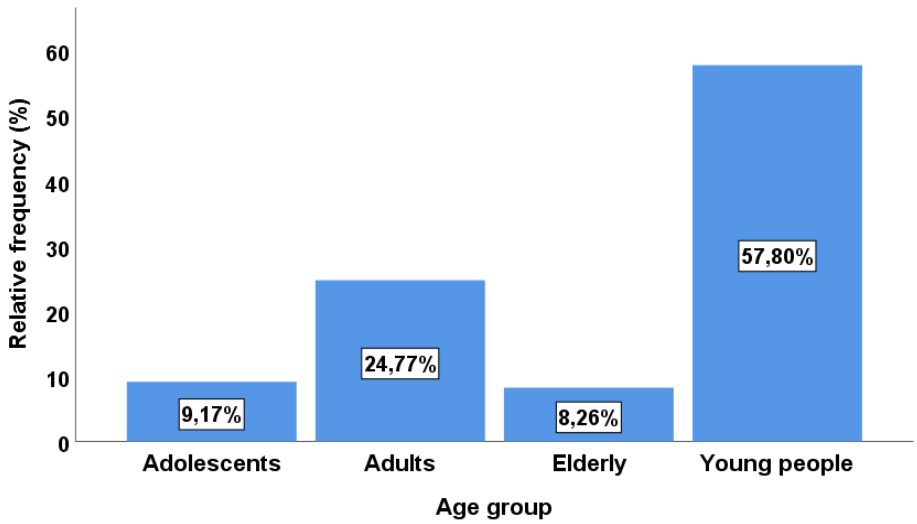

Figure 2: Age categories of fishermen in Lake Buyo.

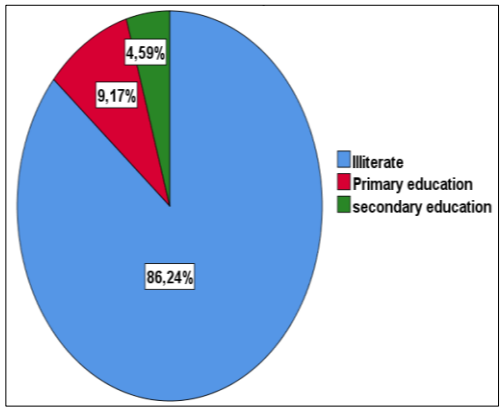

Figure 3: Level of study of fishermen in Lake Buyo.

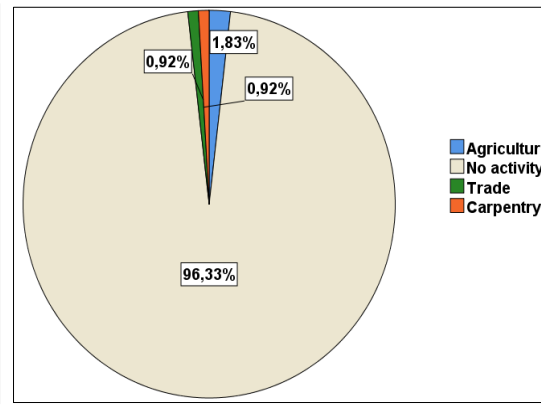

Figure 4: Other activities carried out by fishermen.

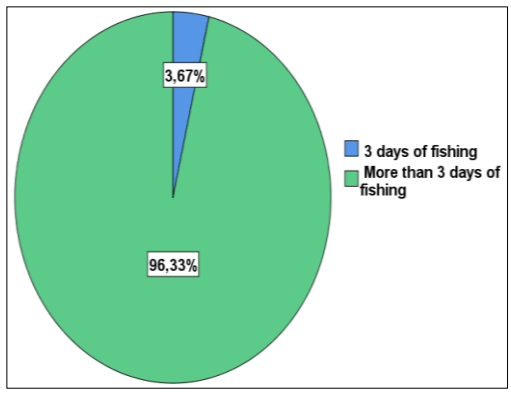

Figure 5: Number of fishing days per week of fishermen.

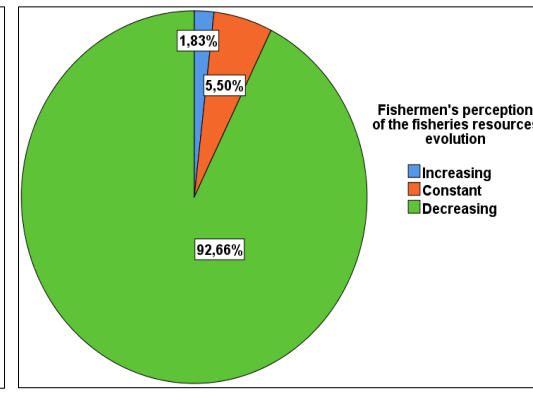

Figure 6: Fishermen's perception of the evolution of fishery resources in Lake Buyo.

Table 4: Result of the binomial logistic regression model.

Features	Coefficients	p-value
Study		
Illiterate	----	
Primary	-0.10176	0.8934
Secondary	-0.77470	0.5150
Percep		
Increases	----	
Constant	16.74194	0.9902
Decreases	16.73397	0.9902
Nbrej		
3 days	----	
More than 3 days	-1.22988	0.3083
Age	**-0.06756**	**0.0183 ***
Anex	**0.08262**	**0.0112 ***

Number of observations = 109
Model significance (Prob > chi2) = 0.072
Log-likelihood = 136.621
Chi-square (4) = 14.402
Pseudo R^2 of Nagelkerke = 0.165

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
***= significant at 1%, ** = significant at 5%; * = significant at 10%.

DISCUSSION

The poor fishing practices adopted by fishermen can be explained by the year of experience and the age of the fisherman as our results indicated. Indeed, an increase in the year of experience increased the probability that the fisherman uses illegal fishing tools. As the fisherman gains experience over the years, he adopts new fishing practices to adapt to the decrease in the fishery resource to increase his income. The older the fisherman gets, the greater the family burden. To do this, some fishermen engage in non-regulatory practices (51.38%), while those who respect the regulations in force (48.62%) increase their fishing effort. In all cases, these two groups of fishermen have an impact on the drastic reduction of fishery resources. This result does not agree with the work of Codjo et al. (2020) carried out on Toho lake in Benin. For these authors, the more the number of years of experience increases, the more the fisherman

becomes aware of the current state of the fishery resources and compares it to that of previous years intending to take measures that favor the conservation of these resources. These measures are, among others: the reduction of the use of destructive fishing practices, and the use of practices that conserve fishery resources such as nets with a mesh size greater than or equal to 50 millimeters (Montchowui et al., 2007; Ahouansou et al., 2016).

On the other hand, older people (61 to 75 years old) use regulatory tools more than adults (45 to 60 years old), adolescents (15 to 24 years old), and young people (25 to 44 years old). Except for the elderly, the other age groups tend to use non-regulatory fishing practices to improve their production and therefore their income. On Buyo lake, the age of the fisherman influences fishing practices; the younger the fisherman, the more he uses bad fishing practices. This observation was also made by André-Bigot (1997) in his work on the consideration of the dynamics of the practices of the fishermen of Sainte-Lucie Island in France. This author showed that age is a factor that determines the fishing techniques used by fishermen on Saint Lucia Island. He indicates that the arrival of new fishermen, including a large proportion of young people on this island, due to a lack of other professional opportunities, has contributed to the use of new fishing practices. Several other studies have also shown that age is a socioeconomic variable that negatively influences the use of destructive fishing techniques and practices (Allison and Ellis, 2001; Daw et al., 2012).

The result of the binary logistic model showed that the variables "level of education of the fisherman", "perception of the evolution of the fishery resource" and the "number of fishing days" are not significant. However, the work of Codjo et al. (2020) showed that the level of education of the fisherman and the number of fishing days are determining factors in the use of destructive fishing practices on Toho lake in Benin. On this lake, the fishermen who use destructive fishing practices more are those who frequent the lake much more and who have mostly a primary education level. Fishermen with no education and those with primary education are those who use and employ more destructive fishing gear and practices. Fishermen with a secondary level of education employ more practices that are conservative of fishery resources (Kpenavoun et al, 2017). The high frequentation of the lake leads to very high fishing pressure on fishery resources and therefore causes the decline in the productivity of these aquatic ecosystems (Lalèyè et al., 2005; Akonkwa et al., 2017). This is the case of Lake Buyo, where fishermen are present daily in the water body due to their dependence on fishing activity. Fishing is the only economic activity for 96, 33% of the fishermen in the lake. The results also showed that 96.33% of the fishermen have more than 3 fishing days in a week. Buyo lake is therefore in a state of overexploitation of the fishery resource confirming the work of Berger et al. (2015).

As for the perception of the evolution of the resource, the results indicated that the decrease in the fishery resource is perceived by the fishermen of Buyo lake as a decrease in the number of catches, the disappearance of certain fish species, and the reduction in the size of the catches. This result is also confirmed by the work of Codjo et al. (2018). These authors indicated that the majority of fishermen (91.47%) in Toho lake have a perception of the decline in fishery resources. The perceptions of the fishermen vary according to their socio-cultural background, age category, and education level. The decline in fishery resources is perceived in different forms: the disappearance of certain fish species, the decrease in the size of fish taken, and the decrease in the abundance of species suitable for processing by drying and smoking (Codjo et al., 2018).

Buyo lake is exploited by the local population for fish production. The part of the lake occupied by the N'zo Partial Wildlife Reserve serves as a breeding ground for fish. However, bad fishing practices on the lake have led to a degradation of the fishery resources. Fishermen use non-regulatory fishing gear and techniques for fishing. The use of these destructive fishing practices can be explained by several social factors, namely the

age of the fishermen, the year of experience of the fishermen, the perception of the evolution of the fishery resource, the level of education of the fisherman, and the number of fishing days. This study showed that the age and the year of experience of the fishermen are the explanatory factors of the use of non-regulatory fishing tools by the fishermen on the lake of Buyo in the partial reserve of Fauna of N'zo.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

KJHK: support for data collection in the field, data analysis and drafting of the first version of this paper; AD: correction and improvement of the French version of the paper; MY: correction and review on the methodology of the paper; DRHA: support and advice on data collection at the sampling sites; VWW: reading and correction of the English version of the document.

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