International Journal of Multidisciplinary Research and Publications
ISSN (Online): 2581-6187

Analysis of the Economic Profitability of Fish Hole Production in the Lower Oueme Valley in Benin

AISSI Jean-Roitinos[1]
[1]Department of Geography and Land Management (DGAT), University of Abomey-Calavi (UAC), Benin, 00229 97 46 80 99
*Correspondance : aissirockfeller@gmail.com

Abstract— *Socio-economic data were collected from 366 producers in four communes: Adjohoun, Aguégués, Bonou and Dangbo in southern Benin. The Gordon static model and the COBB-DOUGLAS model were used to evaluate the profitability of fish hole exploitation. The analyses show that in the first year of production, the profitability of the fish holes presents a deficit between 0 and 750.000 FCFA. This deficit is attributable to the cost of the labor which significantly influences the reduction of the incomes of the producers. However, the variables area, yield and unit selling price have a positive and significant impact on income. From the second year of production, the activity becomes beneficial with gains varying between 30,000 and 120,000 FCFA depending on the hole due to the decrease in labor costs and its insignificance in the variation of producers' income. Variables such as area, yield and the selling price of a kilogram of fish explain 98% of the variation in producers' income. The 2% of variation in annual profit not explained by the variables introduced in the model would be attributable to factors that are difficult to measure such as the level of water production, climatic conditions and the various changes that can be recorded from one season to another.*

Keywords— *Benin, fish holes, economic profitability, Ouémé valley.*

I. INTRODUCTION

In the lake environment in Benin, fishing remains the income generating activity for the riparian populations. However, it must be noted that the increase in these populations and the use of destructive fishing techniques (acadja, xha, etc.) have harmful consequences on the fauna of these waters as a result of their filling and overexploitation (PANA-Benin, 2008).

The situation of fishing has never been as difficult as it is today and one can reasonably wonder about the threats to the future of fishing and fishermen (Denhez, 2008). Most fishermen are turning to fish farming (fish holes).

According to Floquet et al,(2013), fish holes are initially installed either in natural depressions or ponds or ditches made in floodplains to trap fish during flooding. They are located in marshes where water can still be retained during the dry season. For Nonfon (1988), the plains of the Ouémé valley are regularly flooded for about 5 months each year. These plains dry up when the water level falls, leaving in some places waterlogged holes dug naturally by runoff water, providing refuges for fish abandoned by the ebb current. The fishermen with simple baskets simply arrive to collect. Subsequently, the survival strategies developed by the riparian populations of the lake areas in the face of socio-economic changes, led them to enlarge these holes in order to increase production and thus their income, gradually the system received the support of several fishermen and was developed (Lévèque et al., 2006). This is to reduce the depletion of the natural stock to curb the decline in the yields of fishing efforts and to improve this practice, which contributes to a responsible and sustainable fishing and participates in the preservation of the environment. It is therefore important to reflect on the production of these fish holes.

II. MATERIALS AND METHODS

Study areas

The present study was conducted in the lower Ouémé valley in Benin, which includes the communes of Adjohoun, Aguégués, Bonou and Dangbo. Indeed, these four communes are in the department of Ouémé and are crossed by the Ouémé River, the Nokoué Lake, the Porto-Novo Lagoon and the Sô River. The Ouémé River enters the coastal sedimentary basin from the northeast of the Zangnanado Plateau, receives its main tributary Zou at the latitude of Pobè and then flows along the Pobè-Porto-Novo Plateau before emptying into the Porto-Novo Lagoon (Dissou, 1986). The area thus crossed constitutes the lower valley of the Ouémé. The large number of water bodies in the valley is a fundamental element for production.

The geographic setting of the study area is between 6°23'28"and 6°57'48"N latitude, and between 2°23'28" and 2°36'00"E longitude (Figure 2), which corresponds to the Guinean or subequatorial region of Benin. Located in the southeastern region of Benin, the Ouémé Valley is characterized by a floodplain in the shape of an elongated triangle measuring 90 km from north to south. The floodplain is bounded to the south by Lake Nokoué and the Porto-Novo lagoon; to the north by the department of Zou, to the east by the Commune of Akpro-Missérété and the department of Plateau, and to the west by the department of Atlantique (Figure 1). Its surface area can therefore vary from 1000 to 9000 km² depending on when the observations were made (Lalèyè, 1995). Thus, the area is a good site to study the economic profitability of fish hole production.

Figure 1 below shows the geographical location of the study area.

Sampling

The probabilistic method was adopted. Thus, the sample size (n) of respondents was determined by the formula of the binomial sampling law of Dagnelie (1998) which is expressed as follows:

AISSI Jean-Roitinos, "Analysis of the Economic Profitability of Fish Hole Production in the Lower Oueme Valley in Benin," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 5, Issue 12, pp. 113-118, 2023.

$$n = \frac{U^2{}_{1-\alpha/2} \times P(1-P)}{d^2}$$

With n: sample size considered; U_(1-∝/2): value of the normal distribution at the probability value; 1-∝/2 with ∝ = 5% is 1.96; d: margin of error of the estimate set at a value of 5% ;
P: proportion of people to be surveyed in the ten districts selected with the technical agents for their greater production in the communes of the lower Ouémé valley for this study.

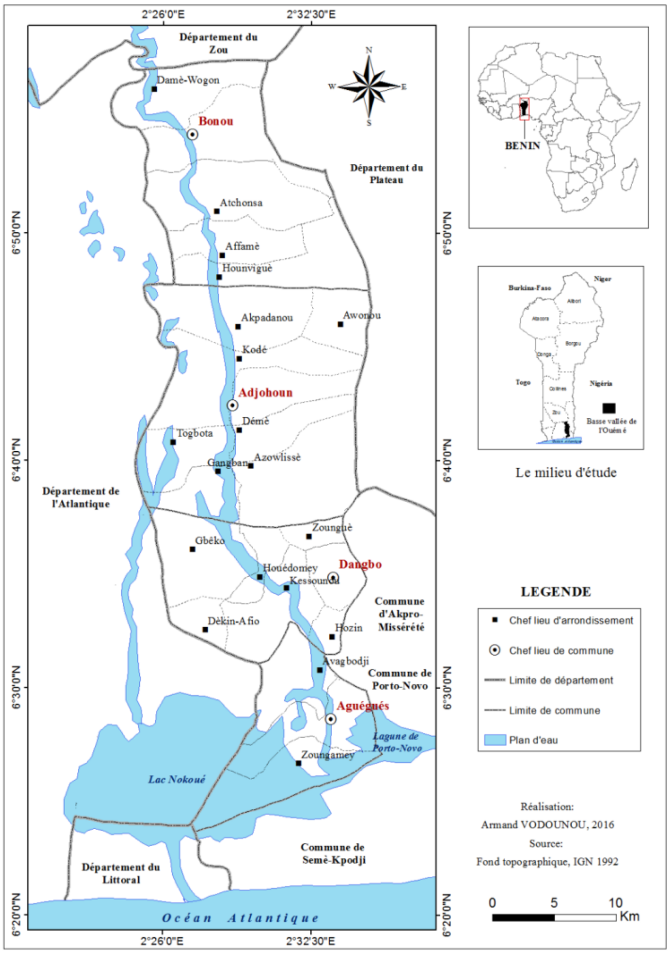

Figure 1: Location map of the study area

Table 1 below shows the numbers of respondents by district.

TABLE I: Number of people surveyed by district

Municipalities	Districts surveyed	Population or household size	Number of persons surveyed	Rate en %
Adjohoun	Akpadanou	8571	30	7.39
	Gangban	15602	56	19.26
	Kodé	7178	26	7.10
	Togbota	3374	12	13.72
Aguégués	Avagbodji	12335	44	10.82
Bonou	Affamè	7733	27	6.86
	Atchonsa	8322	30	7.39
	Hounviguè	8576	31	7.39
Dangbo	Houédomè	17507	62	15.30
	Kessounou	13609	48	11.87
Total	10	102807	366	100

Source : field survey, September 2015 to June 2016

The examination of Table I shows that ten districts were visited, 366 producers were selected in the study area according to the number of holes. The selection of respondents in each district took into account their seniority (at least 10 years) in the exploitation of fish holes. The reason for taking seniority into account is that the respondent must be able to provide information on production costs and revenues.

Data collection

A survey was conducted from March 2015 to April 2016 with all 366 producers. It collected data on socio-economic characteristics.

The data collected concerned:

- fish measurement units;
- land acquisition;
- the cost of labor (sinking holes, maintenance, fishing equipment ...);
- the variation of the selling price of the fish from the exploitation of the fish holes according to the periods;
- the revenue generated by the exploitation of the fish holes.

Data analysis method

Profit π is the difference between revenues and costs:

$$\pi = RT - CT,$$

The effort in an open access fishery (fish hole) tends to reach an equilibrium called bioeconomic equilibrium characterized by the level $E = E^*$.

➢ *The COBB-DOUGLASS model of economic profitability*

Based on the theoretical considerations, in view of the efforts in a fishing production (fish holes) in open access or the production is profitable; it is then possible to write the model of the profitability of production in the form of the equation of COBB-DOUGLAS defined as follows:

$$RB_i = e^{\alpha_0} SUP_i^{k_1} MOS_i^{k_2} PRIX_i^{k_3} RDT_i^{k_4})(1)$$

This is equivalent to :

$$\ln(RB_i) = \alpha_0 + k_1 \ln(SUP_i) + k_2 \ln(MOS_i) + k_3 \ln(PRIX_i) + k_4 \ln(RDT_i) + \varepsilon_i(2)$$

The variables SUPi, MOS_i, PRIX_and RDT_i represent, respectively, for producer i, the area sown (in hectares) for fish hole production, the total cost of hired labor (in FCFA), the selling price of one kilogram of fish or depending on the measure used (in FCFA), and the fish yield (in kg/ha). The coefficients α and k are the parameters to be estimated and ε_are the error terms.

III. Results

Evaluation of the expenses related to the production and profitability of the activity

Cost of the production

The production of fish holes as any other production requires main cost items. The biggest expense of this activity remains inevitably the installation of the infrastructures (fish holes). Generally speaking, the expenses related to the production of fish holes would be: the initial investment for the setting up of the infrastructures, the acquisition of the fry and the feeding of the fish. However, for the production of traditional fish pits, the main cost is the construction of the fish pits. In addition, there are the costs of casual labor, local expertise and others, but these are not very expensive.

Evaluation of the expenses related to the installation of the holes

The cost of digging varies from one area to another (from one thousand to three thousand CFA francs) for a volume of 1 m3or 1 m (length) x 1 m (width) x 1 m (depth). The labor force used for the development has not received special training but must have some experience in the field.

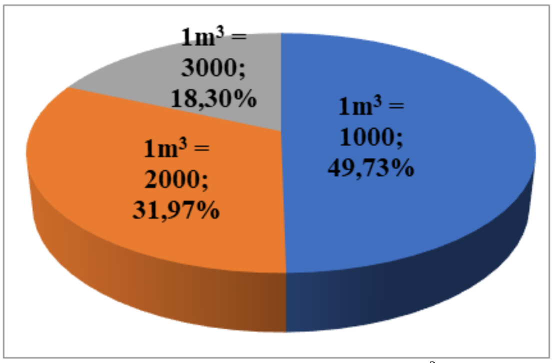

Figure 2 : Cost of completion per1m^3
Source : Field survey, 2016

Of the fish hole operators, 18.30 % affirm that the development of one m3 of fish hole costs them 3.000F, 31.97 % estimate that it costs them 2.000F and 49.73 % affirm that the m3 costs them 1.000F.

Thus, the cost of the development of fish holes of less than 100m² varies from 100,000 to 300,000F, the holes of 100 to 500m² cost between 100,000 to 1,500,000F and the holes of more than 500m² cost more than one million five hundred thousand.

This is the biggest burden of production. However, it is worth noting the duration of the holes. It is not up to the producers to make the holes every year but just to maintain them. Thus, the longevity of these holes depends on the maintenance that is done.

The producers believe that if these holes are well maintained, they can last more than 10 years, or even indefinitely, since a regularly maintained hole is always productive.

Given that the majority of farmers (96%) say that a hole that has been made can be used for as long as it is maintained, the fact remains that maintenance has a cost.

Maintenance often consists of weeding and scraping the holes, the cost of which varies between 2000 and 5000 FCFA. It should be noted that sometimes others use labor for harvesting. In the case of hired labor, the cost of the operation varies from one to two thousand CFA francs. The labor used for harvesting varies according to the size of the hole and can be composed of two to four people. The inherent cost of labor is 2000 CFA francs for a harvest.

Evaluation of outputs

Fish hole harvesting activities

Harvesting is done in the dry season, starting in January and ending in March. This period is favorable for harvesting since the flood water dries up in the flood plains; it is the recession. The drop in water level facilitates the fishing activity.

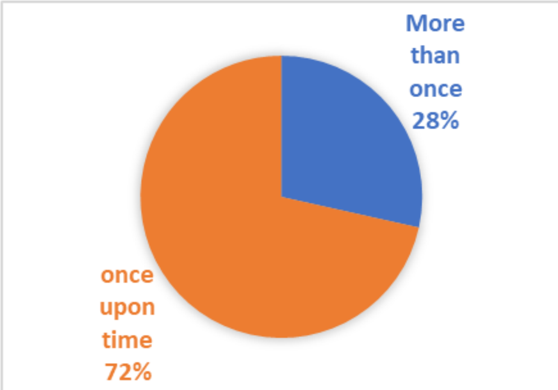

Figure 3 : Number of farms
Source : Field survey, 2016

It is shown from Figure 3 that harvesting can be done once, or more than once a year by. Also, it was revealed that the exploitation of fish holes is done only once a year, which is common among the majority of producers (71.51%). However, only 28.49% of the producers manage to harvest more than once. However, most of the latter category have holes with large areas. In this case, there are not enough human resources available for a single harvest; the fish hole is therefore subdivided into several compartments (for different harvests) with racks, nets or branches as a barrier. But before harvesting, the aquatic plants that populate the fish hole are carefully removed to facilitate the activity.

The sales units used to market the fish are: bowls and basins called "baffe". The bowl is sold at 4,000 F or even 5,000 F and the "baffe" from 60,000 to 75,000 F depending on the period. According to analyses, the full bowl weighs 3.5 kg and the "baffe" 50 kg. Thus, the cost per kilogram of fish varies between 1200 and 1500 F CFA.

According to our calculations, the holes in the study area produce 1.42 t/ha/year. 1.42 t/ha/year is the average production from the productivity of the holes, which varies from 0.54 to 2.17 t/ha/year.

Profitability of the activity

The profitability of the activity will be calculated according to two periods with the use of the Gordon model:

Profit π is the difference between revenues and costs:

$$\pi = RT - CT$$

First period

It is the year of the implementation of the production infrastructure (the digging of the fish holes). Since the construction of the fish holes is the biggest burden of production and applying Gordon's model, the result obtained is recorded in the table below.

TABLE I: Annual revenues generated by each hole identified

SUPERFICIE (m²)	>0 – 100000	>100000 - 200000	>200000 - 300000	>300000 - 400000	>400000 - 500000	>500000 - 600000	>600000 - 700000	> 700000	Total
>0 – 100	91 (26,53%)	252 (73,47%)	0	0	0	0	0	0	343 (100%)
>100 – 500	1 (0,12%)	147 (17,44%)	33 (3,91%)	76 (9,02%)	268 (31,79%)	6 (0,71%)	312 (37,01%)	0 0	843 (100,00%)
>500	0	0	0	0	127 (52,26%)	102 (41,98%)	12 (4,94%)	2 (0,82%)	243 (100,00%)

The analysis of this table shows that for the first year of production, that all the holes are in deficit and that this loss, according to the surface of the hole is included between 0 and 700.000 FCFA.

In this case, the gross income is negative, so there is a loss for this first year of production, so the production is in deficit.

The linear regression model quantified the relationship between the independent variables area, yield, labor, unit price per kg and the dependent variable gross income. This model is significant at the 0.001 level with the variables area, yield, labor, unit price per kg explaining 95.2% of the variations in the producer's gross income (adjusted R-two = 0.952).

The analysis of the coefficient table made it possible to identify the variables with a significant influence on income variations. It appears that the variables area, yield and unit price have a positive and significant impact on income. In addition, an increase of one unit of labor significantly reduces income by 0.83 units.

Thus the equation for our linear regression model is as follows :

Income = 33.650 Sup + 158985.725 Yield - 0.830 Labor + 43.825 Price/kg - 93370.536.

Second period

These are the years following the year of construction of the production infrastructure.

It should be noted that the cost of production here consists of the cost of maintaining the holes and the labor used for harvesting.

The following table allows us to perceive the annual income generated by the production according to each fish hole. By gross revenues, we mean the total value of the production sold by the producers, taking into account the costs of maintenance and labor used for harvesting, etc. These annual revenues have been classified in the table below.

These annual revenues have been classified in the following table so that we can evaluate the profitability of this activity on them.

Coefficients[a]

Modèle	Coefficients non standardisés		Coefficients standardisés	t	Sig.
	A	Erreur standard	Bêta		
(Constante)	-93370,536	20430,653		-4,570	,000
Superficie	33,650	14,469	,032	2,326	,020
Prix/kg	43,825	15,005	,019	2,921	,004
Main d'œuvre	-,830	,012	-,988	-71,799	,000
Rendement	158985,725	29377,852	,032	5,412	,000

TABLE II: Annual income generated by each hole surveyed

AREA	>0 - 30000	>30000 - 60000	>60000 - 90000	>90000 - 100000	>100000	Total
>0 – 100	342	0	0	1	0	343
	(99,71%)	0,00%	0,00%	0,29%	0,00%	100,00%
>100 - 500	28	204	611	0	0	843
	3,32%	24,20%	72,48%	0,00%	0,00%	100,00%
>500	0	0	124	80	39	243
	0,00%	0,00%	51,03%	32,92%	16,05%	100,00%

The analysis of this table shows that all the fish holes produce profits. These profits vary from 30,000 to 120,000 FCFA depending on the hole.

The average and extreme trends of annual income per square meter per hole are reported in the following table.

TABLE III: Estimated annual revenue per square meter per producer

Observations	Minimum income (CFA)/ m²	Average Income (CFA)/ m²	Maximum income (CFA)/ m²	Standard deviation (CFA)
1429	23,93	1386,45	141,86	38,9

In this case, according to Gordon's model, the gross income is positive, so there is a profit, so the production of fish holes is profitable.

- *Empirical modeling of fish hole economics*

The results of the regression model estimated to identify the determinants of income generated by fish holes are presented in Table IV. Analysis of the results in Table IV shows that the regression model is highly significant ($P < 0.001$) and that 98% of the variations in the annual income of the producers surveyed are explained by variations in the variables introduced into the modeldes variables introduites dans le modèle.

The results obtained indicate that variables such as area, yield and selling price per kilogram of fish have positive and highly significant ($P < 0.01$) effects on the annual profit made by the producer. In contrast, total labor cost has non-significant ($P > 0.05$) negative effects on the producer's annual profit. The 2% variation in annual profit not explained by the variables introduced in the model would be attributable to factors that are difficult to measure, such as the level of water production, climatic conditions and the various changes that can be recorded from one season to another.

IV. Discussion

The production of fish holes is a form of artisanal fish farming representing a good part of the national production. It is an activity that provides income to producers. This activity is a little different from fish farming as in ponds or ponds, it is similar to the collection of fishery resources in water bodies. For (Sohou et al., 2009), the empirical and traditional knowledge of producers is important but little or not formalized and not yet assimilated by modern scientific approaches.

Table IIV: Determinants of income from fish sales

Independent variables	Variable descriptions	Coefficients	Standard errors	T de Student	Probability
Constant		-0,72	0,41	-1,75	,081
Unit price	Neperian logarithm of the unit price (FCFA)	0,65	0,05	12,18	< 0,001
Workforce	Neperian logarithm of labor (FCFA)	-0,01	0,02	-0,30	0,764
Performance	Logarithm of yield (kg/ha)	0,05	0,01	5,31	< 0,001
Area	Neperian logarithm of the area (ha)	1,20	0,01	184,63	< 0,001
Adjusted coefficient of determination R-two		0,98			
Fisher's statistics		17435,97(p < 0,001)			

The orientation of actions in this case is to the understanding and, if possible, the intensification of existing aquaculture systems. However, the production of fish holes participates in the improvement of the status of their owners and contributes to the supply of the populations in halieutic products although the exploitation of fish holes is generally done only once a year, which is common among the majority of the producers (71,51%). In addition, this production, like any other production, requires major cost items related in large part to the establishment of infrastructure (fish holes) during the first year of production. Thus, the regression model indicates that for this year of implementation of the production system, the annual profile of the producer is significantly influenced by the area, yield, unit price and labor. The latter has a significant negative impact on income, which explains the deficit that producers are experiencing during this first production season. Indeed, the total cost of labor during this year of production is highly dependent on the costs related to the development of fish holes. These costs vary between 100,000 and 1,500,000 and are estimated according to the area planted. Thus, the installation of the fish holes constitutes the greatest expense for the producers. However, in the years following the installation of the fish holes, this burden is reduced to weeding, scraping the holes and harvesting the fish. Although it has a cost, its impact on the variation of the producer's annual income is very small. Therefore, the income is positive with an average evaluated at 1386.45 ± 38.9 FCFA/m².

The result of the regression model estimated to identify the determinants of the variation in income generated by fish holes indicates the significant and positive effect of area, yield and selling price of a kilogram on producers' income. This reflects the fact that the combination of high values of these parameters, contributes to improve the income of producers. Total labor cost, on the other hand, has insignificant ($P > 0.05$) negative effects on the producer's annual profit, which confirms the benefit of higher income discussed above. Thus, moving towards a more profitable production system, producers could increase the production stock of fish holes. While the fish holes in our study do not benefit from any input from producers, this is not the case for the fish holes in the Niger Valley, which are used for intensive fish farming with the provision of feed and careful selection of fry. Moreover, the production of the fish holes of the Niger Valley is better than that of the "whedos" of the Ouémé delta which was estimated at about 1.5 t/ha according to Welcomme (1971); 3.16 t/ha according to Chikou (2006); and 22 t/ha after artificial stocking with African catfish fry (Imorou Toko et al., 2007). Therefore, increasing the productivity of whalefish is necessary to improve the living conditions of fishermen in the Ouémé Valley. Thus, for Toko (2011), the management mode of these holes, currently based on natural productivity, does not augur better yields given the increase in demand for fish and the fall in catches in the natural environment.

Therefore, the artificial stocking of adapted species in these holes carried out by Toko (2011) presents interesting results that should be popularized to contribute to a better improvement of the living conditions of the fishermen. However, it must be remembered that the activity of producing fish holes presents risks that owners must face.

V. CONCLUSION

The present study shows that the production of fish holes offers economic benefits to the producers, except in the first year when it is loss-making. However, this activity becomes profitable from the following years because of the significant decrease in labor costs. However, it deserves a lot of attention since the yields of natural productivity are unsatisfactory and producers need to be trained in the artificial stocking of adapted fry and inputs in order to benefit more.

The consideration of traditional fish holes should be a priority since it avoids generating negative ecological, economic and social externalities that are detrimental to the survival of present and future generations on the one hand, and on the other hand, because of the possibilities it offers in the areas of employment and for its low capital intensity, its participation in the satisfaction of the nutritional needs of the population.

REFERENCE

[1]. Chikou A. (2006) : Etude de la démographie et de l’exploitation halieutique de six espèces de poissons-chats (Teleostei, siluriformes) dans le delta de l’Ouémé au Bénin, Liège, 482p.
[2]. Dagnelie P. (1998): Statistiques théoriques et appliquées. Brussels : De Boeck et Larcier.
[3]. Denhez F., (2008) : *Plus de poissons à la criée, menaces sur les réserves mondiales*, Paris Delachaux et Niestle, 224 p.
[4]. Floquet A., Vodouhe S., Mongbo R., Tossou R., Van Der Berg J., Bridier B., Sellamna N. E., (2013) : Assessing local innovations: experiences in Benin. Cross analysis of innovation cases - JOLISAA Benin report. Abomey-Calavi, Université d'Abomey-Calavi. 35 p.
[5]. Gordon H. S. (1954): « The economic theory of a common property ressource : the Fishery », Journal of political economy, 62, 124-142.

AISSI Jean-Roitinos, “Analysis of the Economic Profitability of Fish Hole Production in the Lower Oueme Valley in Benin,” *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 5, Issue 12, pp. 113-118, 2023.

[6]. Lévêque C. et Paugy D., 2006 ; Les poissons des eaux continentales africaines Diversité, écologie, utilisation par l'homme. IRD édition, paris, France. 564 p.
[7]. Nonfon M. (1988) : Données préliminaires sur l'écologie et la production halieutique des « trous à poissons » de la rive gauche de la basse vallée de l'Ouémé. Mémoire d'Ingénieur Agronome, FSA/UNB, 152p.
[8]. PANA- Bénin (2008) : Recueil des informations et des documents existants sur les effets néfastes des Changements Climatiques en République du Bénin, Rapport de consultation.
[9]. Sohou Z., Houedjissin R. C., Ahoyo N. R. A (2009) : La pisciculture au Bénin : de la tradition à la modernisation. Bulletin de la Recherche Agronomique du Bénin Numéro 66. Pp 48-59.
[10]. Toko I. (2007) : Amélioration de la production halieutique des trous Traditionnels à poissons(whedos) du delta de l'Ouémé (sud Bénin) par la promotion de l'élevage des poissons-chats *Clarias gariepinus* et *Heterobranchus longifilis*: Overview and socioeconomic valuation of the traditional fish ponds (whedos) in Oueme delta (West Africa, Benin), Thèse de Doctorat en Sciences Biologiques, Presse Universitaire de Namur, ISBN:978-2-87037-579-2 ; Dépôt légal:0/2007/1881/38, FUNDP, NAMUR, 214p.
[11]. Toko I., Attakpa E. Y., Baco M. N., Gouda A. (2011) : Analyse des systèmes piscicoles dans la vallée du Niger (Nord Bénin) Int. J. Biol. Chem. Sei. 5(5) 1993-2003, 12p
[12]. Welcomme R.L. (1971) : Evaluation de la pêche intérieure au Dahomey, son état actuel et ses possibilités. Rome, FAO AT 2938, 95 p.