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RESEARCH ARTICLE

SOCIO-ECONOMIC ASPECTS OF THE FISHING IN THE SINGROBO-AHOUATY DAM PROJECT AREA (BANDAMA RIVER)

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Abstract

Dam's bulding can lead to the disturbance of the living environment of aquatic species, directly impacting the fishing sector and indirectly the lives of riparian populations. A new hydroelectric dam is currently under construction on the Bandama River. This development could cause risks of disruption of the habits of the riparian populations who live from activities related to fishing. This study was conducted to obtain baseline data on the lives of the local populations before the dam is actually put in place in order to understand the long-term impacts of this hydroelectric development. Informations were collected every day, except holidays, in the villages of the area impacted by the development, between November 2019 and October 2020. A questionnaire was used with the actors (fishermen and fishmongers) and interviews were held to characterize their activities, income and socio-demographic profile.

Most of the fishermen are natives who practice the activity on a part-time basis, with agriculture as a secondary activity; while the non-native fishermen are full-time. The majority of fishermen are educated, with a rate of 48%. The others are either illiterate (31%) or have attended Koranic school (21%). They are adults in the 30 to 45 age group. The fishing activity is successful with excellent profit margins, despite the lack of organization noted in some localities. The distribution circuit observed involves sale by rope or by heap, and processing by smoking, with the involvement of fishmongers. In the study area, fishing provides a good income for the actors and is practiced mainly by Ivorians. The results of the characteristics of the fishing activities constitute a basis for assessing the future impact of the dam, and also for the managers in the implementation of a sustainable management plan of the fishery resources in this area.

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Introduction:-

The dense hydrological network of Côte d'Ivoire offers the country enormous potential for fishing (Kien, 2016), particularly for artisanal fishing, which is a sector that provides and promotes employment (Manimaran and Suriyan, 2021). This constitutes an economic stake for the neighboring communities (Bédia *et al.*, 2009) and also for the whole country. In addition, this vast hydrological network allows the development of economic infrastructures such as hydroelectric dams. These dams produce the necessary and essential energy for industrialization and urbanization activities (Nguyen, 2015). However, these developments are a source of changes in the ecological conditions of aquatic ecosystems. These structures can directly lead to a change in the composition of fish stocks and indirectly impact the lives of local populations. Indeed, on the main bed of the Bandama River already comprising two hydroelectric dams, another hydroelectric development project is underway in the locality of Taabo. It is therefore obvious that the development work of such a structure could cause real risks of disruption of the habits of the local populations who live from fishing-related activities. The purpose of this study is to have reference data on the life of the local populations, before the effective impoundment of this dam lake in order to understand the long-term impacts of this hydroelectric development.

Material and Methods:-

Study area

This study was conducted in the area impacted by the hydroelectric development project. The dam construction site is located about 32 km downstream of the Taabo dam, about 3.5 km from the village of Singrobo and 2 km from that of Ahouaty, in the Agneby-Tiassa region. Specifically, the latitudes and longitudes of the dam construction site are respectively 06°06'11.3''N and 4°57'0.7''W (BNETD, 2017). Six village localities that are Singrobo, Ahouaty, Kotiessou, N'denou, Pacobo and Aheremou 2 in the department of Taabo were concerned (Figure 1).

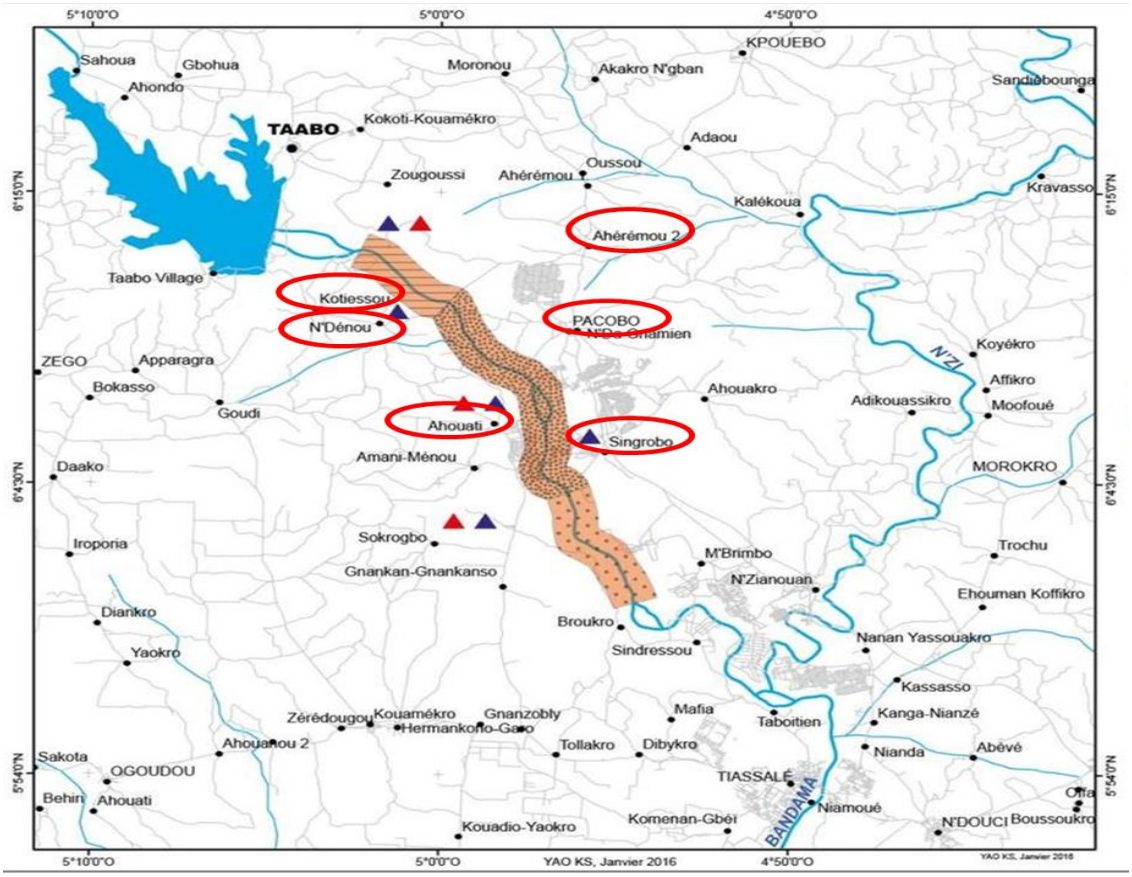

Figure 1:- Presentation of the study area
(Source: BNETD, 2017 modified).

= area surveyed

Data collection

The localities chosen take into account the fishermen working in the area of the Singrobo-Ahouaty hydroelectric dam construction project. Informations were collected every day, except holidays in the villages of the impacted area (Kotiessou, N'denou, Ahouaty, Pacobo, Singrobo and Aheremou 2) by the hydroelectric development between November 2019 and October 2020. A questionnaire was used with fishing actors (fishermen and fishmongers) and interviews were held to characterize their activities, income and socio-demographic profile.

Data analysis

Fishing effort and catches

The fishing effort was considered as the daily fishing trip and expressed in number of fishermen landing day. The CPUE was estimated every month per landing area, as follows (Tah *et al.*, 2009):

$CPUE_i = W_i / T_i$; where $CPUE_i$ is the weight of fish caught (kg) per fishing trip in the month i, W_i is the total weight (kg) of daily catches landed by fishermen in the month i; T_i is to the number of daily fishing trip in the month i.

The monthly total catches per station i was estimated following Tah *et al.* (2009):
$C(t)_i = CPUE_i \times F_i \times D$; where $C(t)_i$ is the monthly total catches in the station i; $CPUE_i$ is the weight of fish caught (kg) per fishing trip in the month i; F_i is the monthly average number of fishermen landing catches in station i; D correspond to the number of fishing days during the month i.

Economic and financial performance

Profitability analysis is inspired by Agbeja and Falaye (2007) and Boguhé *et al.* (2014).

- The net income (NI) expresses the absolute income of the fisher. It was computed as the difference between revenue and the cost of production using the expression:

$NI_t = TR_t - TC_t$ Where, TR_t denotes total revenue, TC_t is the sum of fixed and variable costs which represent total costs of a fisher at time t.

- Average income per fisher per monthly (MNI) was obtained from net income.
$MNI = NI_t / n$; where, Ni_t is net income per fisher per annum and n is the number of months in one year.

- Profit Margin (%) = NI/TR. Closely related indicator of economic performance, which expresses the net profit as a percentage of the total revenue. A ratio of more than 10% can be considered as good (Tietze *et al.*, 2005).

- Profitability (N) = NI/TC. The financial performance was measured by profitability. A level of 10% is generally considered to be a good result. The net profit expressed as a percentage of the invested capital, indicates the profitability of the investment in relation to other alternative investments (Tietze *et al.*, 2005).

- Benefit Cost Ratio (BCR) = TR/TC If the benefit cost ratio is greater than 1 (> 1) the project is profitable and if it is 1(=1), it means a project that breaks even. When the ratio is less than 1 (< 1), the project is operating at a loss.

Results:-

Fishing actors

Fishermen

A total of 274 fishermen were counted in the six zones visited (Table 1). The locality of N'denou has the largest number of fishermen with 70 fishermen recorded. It is followed by Singrobo, Kotiessou and Ahouaty with 59, 57 and 54 fishers respectively. The villages of Pacobo and Aheremou 2 have the lowest number of fishermen with 29 and 5 fishermen respectively. The majority of fishermen in the study area are of Ivorian nationality with a rate of 52%. Then come the Malian fishermen with 46% of the number of fishermen. The other nationalities, namely Ghanaians, Nigeriens, Togolese and Burkinabe, represent 2% (Figure 2).

According to the time allocated to the fishing activity, there are three categories of fishers, namely, part-time fishers who are the most numerous (54.47%, of which 44.68% are Ivorians), full-time fishers who represent only 37.87%, and occasional fishers (7.66%) (Table 1). The part-time fishermen carry out activities that are ancillary to fishing (agriculture, trade, sewing, etc.). These people fish just to have financial resources to solve specific problems. As for full-time fishermen, they are mostly non-Ivorians (37.02%). These are individuals who have only fishing as an

activity and practice it all year round. They are more numerous in Kotiessou (36 out of 87). The occasional fishermen are all Ivorians.

Table 1:- Distribution of fishermen according to locality and time spent fishing.

		Localities							
		Ahouaty	Kotiessou	N'denou	Aheremou 2	Pacobo	Singrobo	Total	Percentage
Fishermen		54	57	70	5	29	59	274	
Full-Time	Ivorians	0	0	1	0	1	0	2	0,85
	Others	6	36	16	2	3	24	87	37,02
Part-Time	Ivorians	40	0	38	0	21	6	105	44,68
	Others	1	0	4	0	4	14	23	9,79
Occasional	Ivorians	0	0	11	0	0	7	18	7,66

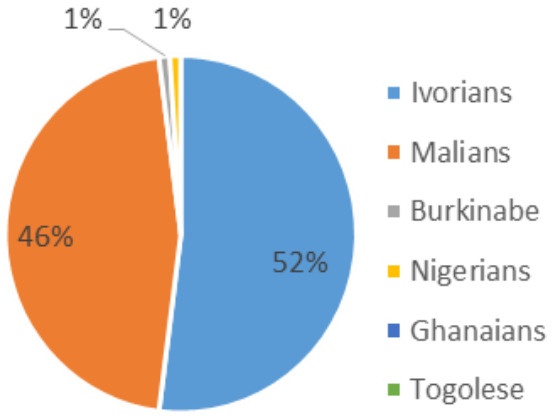

Figure 2:- Distribution of fishermen according to nationality.

As for alternative activities to fishing, we observe the cultivation of cocoa, oil palm, banana, corn and manioc. Others are involved in dugout canoe building, sheep or ox breeding, store management or are laborers.

Regarding the level of education of the fishermen, it was noted that they are mostly educated with a rate of 48% of the fishermen population. Fishermen who have not attended school and those who have attended Koranic school have the lowest proportions, 31% and 21% respectively (Figure 3).

The age of the fishermen interviewed ranges from 15 to 68 years (Figure 4). The relative proportions of the fishing communities make it possible to classify them into three age groups. Adults between 30 and 45 years of age are the most numerous with a proportion of 48.90%, those over 45 years of age are second with 30.66% and those under 30 years of age have the lowest proportion at 20.44%. Most of the fishermen surveyed in the different zones are married, with a rate of 87.59%, while singles represent a small proportion of 12.41%. Most of the married people are adults, and the unmarried are distributed more in the youth category.

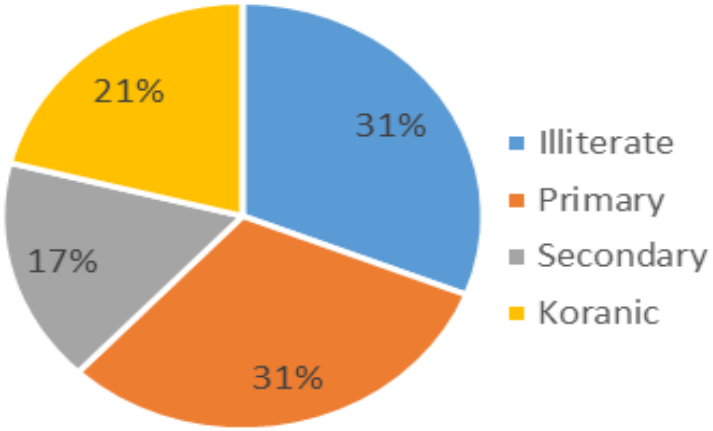

Figure 3:- Distribution of fishermen according to their level of education.

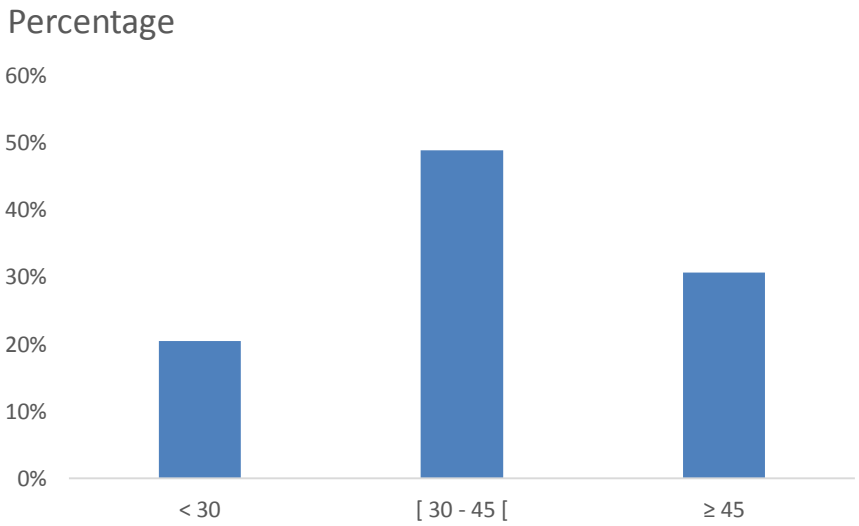

Figure 4:- Distribution of fishermen by age.

Fishmongers

In all the areas visited, a total of 45 fishmongers were recorded (Figure 5). The largest number of fishmongers was recorded in the locality of Singrobo, with 24 Singrobo fishmongers. The localities of N'denou and Ahouaty had 9 and 8 fishmongers respectively. A smaller number was noted in the village of Pacobo, with 4 fishmongers. In the localities of Kotiessou and Aheremou 2, no fishmongers were observed. Most of the registered fishmongers are of Ivorian nationality, i.e. 92% of the fish traders. Malian nationality accounts for 4% of the fish processor population and the other nationalities (Burkinabe and Guinean) represent 2% each (Figure 6). Fishmongers, those with schooling are the most numerous at 67%. Those not attending school account for 31% and those who attended Koranic school account for 2% in all the villages surveyed (Figure 6). Educated fishmongers are more likely to have a primary level of education (52% primary versus 13% secondary and 2% university). Figure 5 shows that the fish collectors surveyed are mostly individuals whose age is 45 years or older (42%). Only 20% of this population is made up of individuals under 30 years of age and 38% are between 30 and 45 years of age.

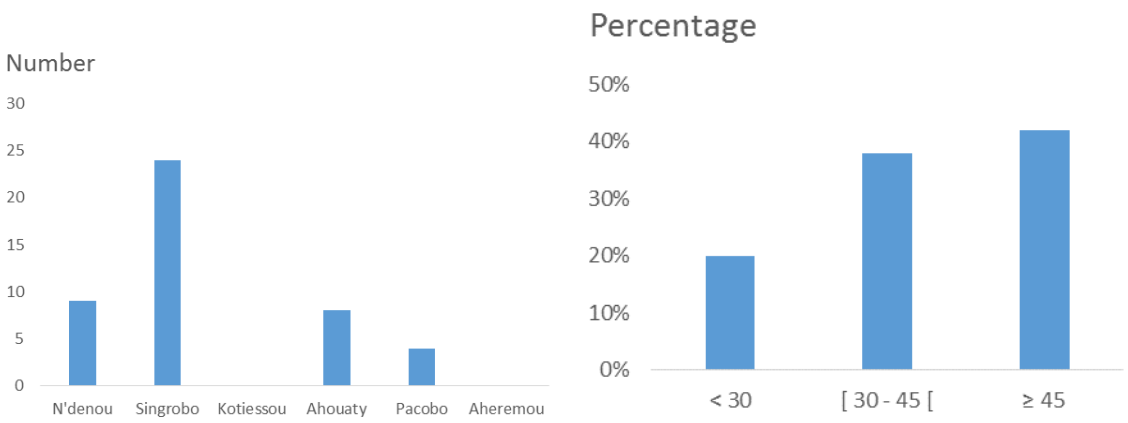

Figure 5:- Distribution of fishmongers by locality and age.

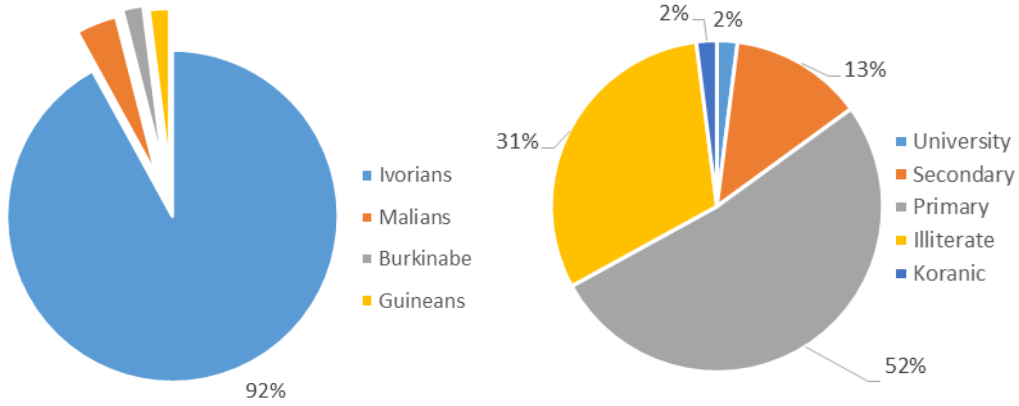

Figure 6:- Distribution of fishmongers according to nationality and level of education.

Fishing techniques

The fishermen use pirogues for their movement on the water and the transport of their fishing products. These pirogues are traditional and can be of different sizes from one fisherman to another. The gear used for the catches is multiple. Some fishermen use active gears such as hawks, shore seines and harpoons. Other fishermen use passive gears such as gillnets, longlines and pots. Fishermen use the various gears according to the species or families of fish targeted. These different gears must be maintained by the fishermen to keep their efficiency.

Fishing production

The daily catches of artisanal fisheries are variable and contain different families of fish. The main species encountered belong to the families Cichlidae, Clariidae, Mormyridae, Mochokidae and Claroteidae. The Claroteidae family, with the species *Chrysichthys nigrodigitatus*, dominates the catches in terms of quantity and weight. Other species, such as *Synodontis bastiani*, *S. punctifer*, *Schilbe intermedius*, *Oreochromis niloticus*, *Coptodon zillii*, *Hemichromis fasciatus*, as well as the genera *Sarotherodon*, *Labeo* and *Brycinus*, are frequently found in the fishery products.

A total of 274 fishermen have been counted in the two area (Taabo and Pacobo). Yields of 7971.43 kg performed by 2189 fishing trips were registered: 3932.43 kg for Taabo (1058.6 fishing trips and 181 fishers), then 4039 kg for Pacobo (1130 fishing trips and 93 fishers).

The fishing effort, the catch per unit of effort and the annual catch per fisherman were estimated according to the time that the main actors allocate to the activity and the villages grouped in the 2 sub-prefectures (Taabo (Ahouaty, Kotiessou, N'denou) and Pacobo (Aheremou 2, Pacobo, Singrobo)). As regards fishing effort, between 255 and 300 trips were noted in the Taabo and Pacobo areas, respectively, among occasional fishers. Among part-time fishers, 322 and 380 trips were recorded in Taabo and Pacobo, respectively. Full-time fishermen obviously make the largest

number of trips with 481.62 trips in Taabo and 450 trips in Pacobo. For catches per trip in the Taabo area, a fish weight of 5.25 kg/trip was noted for full-time fishermen. The weight of fish per trip in the Taabo area was 5.25 kg/trip for full-time fishers, 4.36 kg/trip for part-time fishers and 2 kg/trip for occasional fishers. In contrast, in the Pacobo area, catch per trip is lower for both full-time and part-time fishermen (4.48 and 3.35 kg/trip respectively). The catch per trip is lower for full-time and part-time fishermen (4.48 and 3.35 kg/trip, respectively) and for occasional fishermen (2.5 kg/trip). As for the annual catch per fisherman, it is estimated for full-time fishermen at about 2,528 kg/year in Taabo compared to 2016 kg/year in Taabo. For part-time fishers, about 1403 kg/year in Taabo and 1273 kg/year in Pacobo are noted. They range from 510 to 750 kg/year for occasional fishermen.

Marketing of fish

Marketing of fresh fish

Once the fish reaches the wholesalers, it is preserved with pieces of ice in bowls or coolers. The amount of ice is based on the mass of fish to be preserved and the distance to be covered to the destination for sale. The fishmongers buy an average of 2,000 to 5,000 CFA francs of ice per day for a good conservation. Others use large refrigerated containers for transport to urban markets.

Marketing of fish after smoking

The smoking of fish is an alternative used by fish collectors to keep the fish edible as long as possible and to market them over a long period of time and/or a long distance. Smoking is done in a smoking house made of old metal barrels open at both ends and with a lower side opening to put firewood. The upper opening is covered with a circular or rectangular metal grill on which the fresh fish are placed, sometimes covered with sisal bags or cardboard.

Distribution circuit

In the sub-prefecture of Taabo, in N'denou, the fishermen are grouped into cooperatives, while in Pacobo, no form of professional organization was observed. In the case of Pacobo, no professional organization was observed. There is no landing stage and no place equipped to serve as a monitoring, registration and sales point for the production. Each fisherman delivers his production at home. The marketing of fish is marked by a growing trend towards fish trade. It should be noted that apart from the fishmongers, there are other players in the fish marketing circuit. These are the wholesalers, the semi-wholesalers and the retailers. The fishmongers are often the wives of the fishermen to whom their fishing products are given as soon as they arrive. Other may befish fishmongers or fishtraders who tend to strengthen their economic influence in the fishery by often granting loans to fishermen for the purchase of equipment, for the initial financing of fishing campaigns, or for one-off expenses. In return, they benefit from priority in the purchase of their debtor's catches and from the assurance of a regular supply of their means of transport. The fishmongers are also involved in processing by smoking so as not to risk losing unsold fish.

The selling prices by fish species in the different markets indicate that the most expensive fish are *Chrysichthys* sp. (Machoiron) with a price of 1,635 F CFA/kg and *Lates niloticus* (captain) costs 1,900 F CFA/kg. However, women generally sell the product by the rope. A rope is composed of several species and prices vary between 1,000 and 5,000 F CFA depending on the size of the individuals and species that make up the rope (Figure 7). The smallest fresh fish are sold in piles of 200 to 500 CFA francs. Smoked fish are sold by the heap and the price per heap varies from 2,000 to 5,000 FCFA (Figure 7). The income from the sale is mainly used by the actors for family needs, in this case household expenses, schooling for children, financing agricultural activities, etc.


Figure 7:- Ropes and piles of fresh and smoked fish for sale.

Fishing revenues

Fishing is one of the main economic activities in the study area. The actors do not have the same level of performance. The fishing activity is performing well with excellent profit margins (Table 2), despite the lack of organization noted in certain localities in the two sub-prefectures. They range from 75.29% to 88.70% for Taabo and from 92.45% to 89.6% for Pacobo. The highest profitability index value is 13.25 and the lowest is 4.05. All these values are well above 1 (threshold value). This shows that the fish harvesting industry is quite profitable in the study area. The margin reported by the fishmongers was difficult to estimate, as the women are not clear about their income and sometimes they do not know the cost of variable expenses.

Table 2:- Economic performance of fishermen in the Taabo and Pacobo areas.

	Taabo Zone			Pacobo Zone		
	Fulltime fisherman	Part-time fisherman	occasional fisherman	Fulltime fisherman	Part-time fisherman	occasional fisherman
Average net income per month	**186 905**	**97 870**	**32 000**	**155324.79**	**96981.54**	**56 000,00**
Profit margin (%) = BN/RT	**88.7**	**83.65**	**75.29**	**92.45**	**91.42**	**89.6**
Profitability = BN/DT	**7.85**	**5.12**	**3.05**	**12.25**	**10.65**	**8.65**
Profitability index (RI) = RT/DT	**8.85**	**6.12**	**4.05**	**13.25**	**11.65**	**9.61**

BN = Net profit; TR =Total revenue; DT = Total Expenses

Discussion:-

The number of fishermen is dominated by Ivorians at 52%. However, the latter are mainly engaged in other activities such as agriculture unlike their counterparts of another nationality. This is due to the fact that Ivorians tend to have a tradition of subsistence fishing (Koudou, 2012). This trend is also favored by the colonial legacy and a state development strategy that relies primarily on cash crops (Bédia et al., 2009). The presence of other nationalities in the fishing circuit can be explained by several reasons: (1) the existence of countries in the sub-region with a long tradition of fishing, such as Ghana and Mali; (2) ethnic characteristics that are sometimes very similar, which favor the movement of non-native fishermen to Côte d'Ivoire; (3) the high demand for fish, in the face of insufficient production, which is likely to guarantee an attractive price that is quite motivating for foreign fishermen (Kébé *et al.*, 1997; Vanga, 2001).

In addition, fishing is mostly practiced by adults. The low participation of young people could be justified by the rural exodus and the lack of adequate equipment.

With regard to the level of schooling, the surveys showed that more fishermen in the study area have schooling (48%) and the dominant level of education is primary school. This could be explained by the fact that the latter, having dropped out of school, have ended up in the village. The same is true for the fishmongers. Kamphorst and Teixeira (1995) made similar observations in Sao Tome and Principe.

There are more married fishermen than single ones. In fact, this observation could be justified by the fact that the dominant age group of the activity is composed of adults that find in the activity the necessary resources to satisfy the family needs.

In addition, women are more involved in the packaging and marketing of catches. In the case of fish trade, Ivorian nationals are in the majority (92%) and 67% of the women are educated. In addition, fish trade is not a matter for young girls but for adult women for the survival of their children. These results are similar to the data obtained on the Bandama River by Koudou (2012).

It is not easy to calculate the fixed costs of materials and the income of fish traders, because they do not keep rigorous and regular accounts, and also the losses due to unsold fish and the lack of ice for packaging. The purchase price of fish is the largest expense incurred by fish traders, as Ndiaye (1997) points out. The lack of organization noted in the distribution channel by Kien *et al.* (2018) on the Bandama River was observed in the present study.

With respect to the financial and economic performance of fishermen, the total revenue in the Taabo area is higher than in the Pacobo area. This could be justified by the high fishing effort in the Taabo area.

The profit margins obtained are satisfactory. The financial profitability index of the fishery in the different zones is higher than 1, hence fish exploitation is a profitable activity on the Bandama River as observed by Boguhé *et al.* (2011) on shrimp fishing.

Conclusion:-

The results of this work expose the characteristics of fishing activities and their influence on the standard of living of actors before the building of the Singrobo-Ahouaty dam. In the study area, fishing provides a good income to actors and is carried out mainly by Ivorians who practice the activity part-time, with agriculture as their main secondary activity. However, there are constraints related to the poor organization of the actors and the lack of means for the packaging of fishery products. The results on the characteristics of the fishing activities constitute a basis for assessing the impact of the future dam and for the managers in the implementation of a sustainable management plan of the fishery resources in this area.

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