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Characterization of Fisheries Systems In The Oueme Valley South of Benin

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ABSTRACT

The objective of this article is to characterize the different existing fish farming systems and to identify the factors that could influence their choice by fish farmers. For doing this, 300 fish farmers were surveyed in four towns of Ouémé valley. Factorial Analysis of Multiple Correspondences (FAMC) and Logit regression have been used as methods of analysis. The results showed three categories of fish systems. It's about fish farmers who raise only Clarias fish holes (PICLAT), fish farmers who raise tilapia alone in drainable ponds (PITEV) and fish farmers raising both Clarias and tilapia at the pond level not drainable (PICLATEN). The area planted for the palm grove, the mode of access to the land, the age, the experiment and the different types of training farming, the level of education, the part of the agricultural credit that he dedicates to the fish farming, the total number of mutual aid labour he uses, the socio-cultural group, the perception of the arrival of the flood, the place taken by livestock and fish farming in its activities were the factors influencing the choice of a fish farming system. These results suggest that policies have to focus on fish farming and access to finance to gradually facilitate the transition from traditional fish farming to modern fish farming.

KEY WORDS: Fish hole, drainable ponds, non drainable ponds, AFCM, Logit, Benin.

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INTRODUCTION

Aquaculture is one of the fastest growing sectors of food production in the world. Fish production and the number of cultivated species have increased in developing countries.[1]Fish farming, activity of fish production in aquatic environment, has been booming since the 1980s and now supplies more than half of the world's fish.[2]It is an important source of animal protein in West Africa.[3,4]In Benin, globally, national fish production can cover only 35% of estimated needs of 113 000 tonnes per year.[5]

The deficit is being filled by ever-increasing imports of frozen fish.[6]The quantities of fish imported increased from around 20 000 tonnes in 2000 to 153 328 tonnes in 2016.[7]The national supply of fish products cannot meet the needs. This inability of supply to cover demand can be explained by a number of constraints that actors are facing.[5]

The poor quality and high cost of food, the genetic degeneration of Oreochromisniloticus stump, the lack of strains adapted to the different aquatic environments (brackish and freshwater), the limited number of species raised in aquaculture (Clarias, tilapia), the high cost of infrastructure and equipment for fish production, the lack of control of fish farming production parameters including fish farming protocols (pond management, breeding of breeding stock, appropriate feeding, prophylaxis and veterinary care), difficulties dry up non drainable ponds that make the majority of ponds, insufficient research and adapted supervision in fish farming and land insecurity are the constraints that faced by the farmers of Benin.

Among these constraints, the feeding of fish represents one of the major constraints to the emergence of tropical fish farming not yet sufficiently taken into account in most empirical studies.[4]Indeed, the value chain is held back by the high costs of producing inputs, which reduce the incomes of small producers.[8]

According to the literature, there are several systems of fish farming production. It's all about extensive systems on the fish holes, or production of semi-intensive systems practiced in the undrainable and drainable ponds.[9]Acadjas, whedos, enclosures, floating cages, ponds, above-ground tanks, tanks (concrete, plastic, fiberglass) are the most popular fish farming systems.[5] Depending on the intensive or extensive character of the systems, the power modes are different. It becomes important to understand the functioning of these different fish farming systems in order to control the various constraints including their feeding system. The scientific information gap is the fact that most studies on fish systems have not focused on the diversity of fish infrastructure as an important factor of characterization of fish farming systems.[10]

The information generated by this study will enable to policymakers to formulate policies for promoting the development of fish culture by addressing the challenges faced by fish farmers in the sector. They will also use the results generated by this study to improve the management of their fish enterprises.

EXPERIMENTAL SECTION

StudyArea

This research has been conducted in four towns in south Benin between 9° and 12° north latitude and 2° and 4° south longitude (Figure 1). The main criterion for choosing these towns is the constant availability of water throughout the year. Thus the town of Dangbo, Adjohoun, Bonou and Ouinhi had been chosen. These towns are crossed by the Ouémé River, which offers a favourable environment for the development of agro-fish farming activities carried out by the populations. This river is the largest river basin of Benin.[11] Its main course has a length of 510 about km; it has its source in the Tanéka Mountains and receives two main tributaries, Okpara (200 km) and Zou (150 km). Figure No 1 shows the search area.

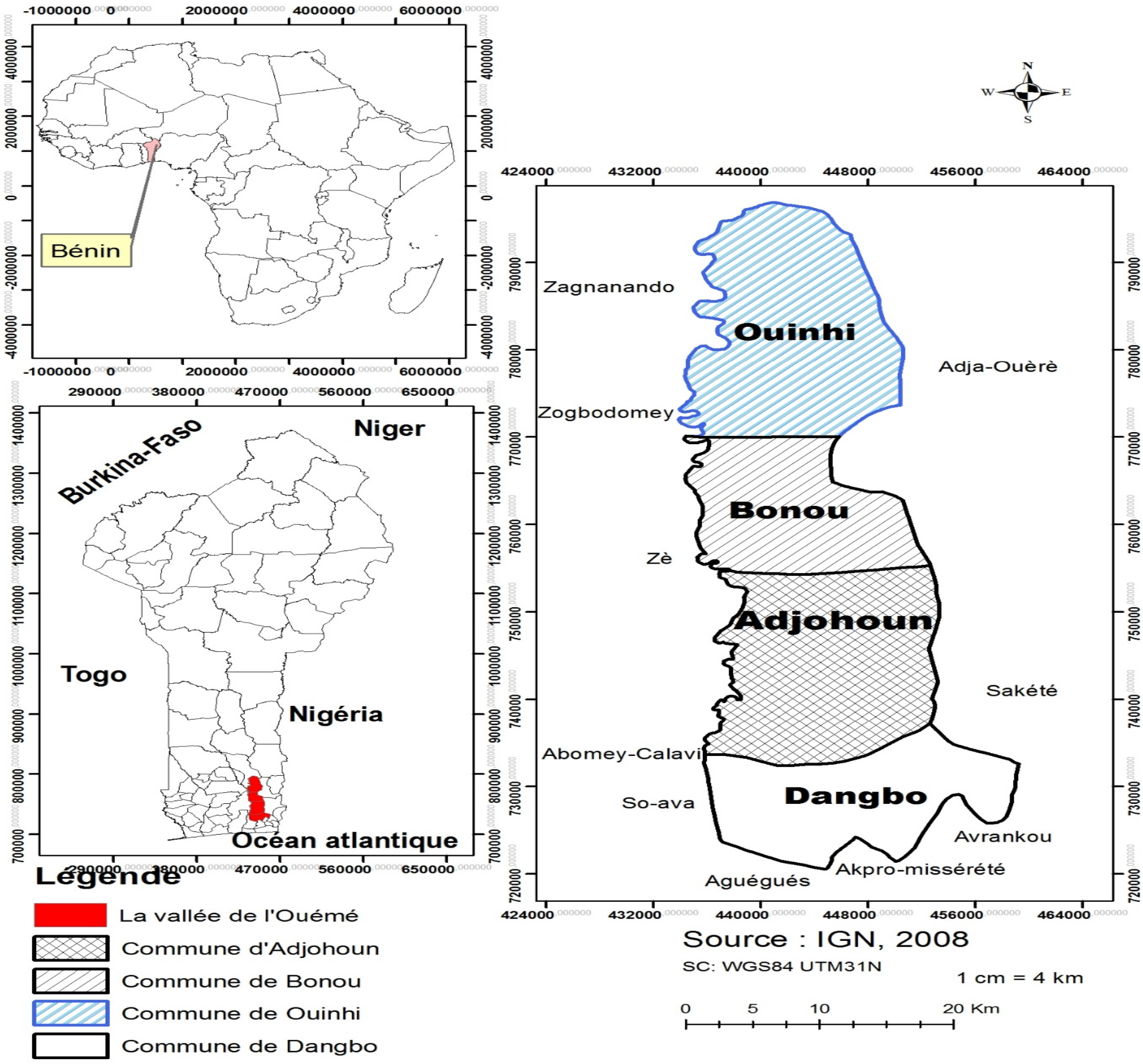

Figure No. 1: Study area

Sampling and data collected

The observation unit in this research was the head fish farmer. In each town, seventy-five (75) fish farmers have been surveyed, a total of 300 fish farmers in all four survey towns. In fact, at the town level, fish farmers were first surveyed. Then, the list of farmers at the town level has been submitted to the random number table for sampling. Finally, the village of each fish farmer has been identified. The data have been collected in two stages. The first one consisted to collect qualitative and general data in group interviews. The second step aimed to deepen these data thanks to a structured questionnaire with each sampled farmer.

Data have been collected on the farmer, head of household. The data collected on the farmer are related to its socio-economic characteristics and demographic (age, experience, gender, level of education, access to credit, ethnicity, and etc.), the training received in fish farming, the types of infrastructure (fish hole, draining ponds, not drainable ponds), the environment sheltering the fish farm (low background, trays), the type of fish produced (tilapia, Clarias), the mode of animal husbandry practiced (monocropping, mixed farming). The Kobo collect data collection tool on the smartphonehas been used to collect the data for this research.

Theoretical approach of functioning of fish farming systems

To render an account of functioning of the farms, we generally consider as a system, the whole constituted by the farm (the production system) and the family (the family group) designated by system-family- farm (SFF).[12] In this theoretical framework, references [13] and [14]have proposed elements of a model called the techno-economic adaptive behaviour of farmers. This model is based on the consideration of the system-family-farm, the situation and the family projects on the farm and on the postulate of coherence. The production system thus appears as the domain of coherence of the rationality of the farmer.[15] The choice of a production system is therefore influenced by the activities satisfying the socio-economic objectives. In other words, by choosing a production system, the farmer takes into account the factors of production that he has or has the capacity to acquire in the market, as well as the utility that the choice of the system affords him under economic, technical, social and environmental constraints.[16] Land is one of the determinant factors of choosing some fish production system.[16,17]

In the literature, the main determinants of the choice of a production system are: -the social group of membership. Many groups live side by side and are characterized by particular know-how and statutes whose nature determines access to certain activities. The choice of a fish production system can therefore be cultural, that is to say in the social and economic organization of certain groups.[9]-the local economic poles, such as the proximity of a river where fish farming can be practiced, for example, the presence of a flood plain.[3]-the family unit, decision center of the activity system.

Land-based fish farmers are more likely to facilitate certain fish farming infrastructures without the fear of losing their investment, unlike non-native farmers who are entitled to only small acreage often obtained by pledge or by loans. This can influence the decision to choose the fish farming system.[9,18]

Contact with extension services and extension training were factors that may influence the choice of a fish system.[19] For reference [20], lack of access to financial capital and labour is a determining factor in the selection of an appropriate fish production system. The average ages obtained have important consequences on the future adoptionof fish farming asa commercial enterprisebecauseyoung people are more likely topractice longer than older farmers.[21] Similarly, the capacity to combine animal husbandry and agriculture with fish farming was an important factor in the adoption of fish farming systems. Also, the fact that fish farmers are educated can facilitate the dissemination of information and likely to produce positive results in terms of improving of the management and productivity of fish farming.[10]

Factorial Analysis of Multiple Matches (FAMM) of fish farmers

To characterize the fish farming systems, the Factorial Analysis of Multiple Matches (FAMM) was used. Nominal variables such as the types of infrastructure (hole fish, drainable ponds, undrainable ponds), the environment sheltering the fish farm (low background, trays), the type of fish produced (tilapia, Clarias), animal husbandry practices (monocropping, mixed farming) were used (Table No 1). The main feature of the FAMM is that it can put variables in reduced groups and homogeneous. This facilitates the interpretation of the results. Estimates were made by using software R- 3.5.1.

Table No.1:"List of qualitative variables, modalities and meanings used to carry out the Factorial Analysis of Multiple Correspondences (FAMC)"

Qualitative variables	Modalities	Meaning
Drainable pond	ETV + and ETV - ,	AND ETV + = Have a drainable pond ETV- = Do not have a drainable pond
Non-draining pond	ENV + and ENV - ,	ENV + = Have a non- drainable pond ENV- = Do not have a non drainable pond
Fish hole	trou + ; trou -	trou + = Have hole to fish, trou- = Do not have a hole fish
Low background	basfond + basfond-	basfond+ = Have fish infrastructures in a shallow bottom, basfond- = Do not have the fish infrastructures in a shallow
Clarias	Clarias + Clarias-	Clarias + = Raise the Clarias only , Clarias- = Do not raise only the Clarias
tilapia	tilapia - tilapia +	tilapia + = Elevate tilapia only , tilapia- = Do not raise only tilapia
Monocropping	Mono + Mono	Mono + = Monoculture only Mono- = Do not just monoculture
Mixed farming	Poly + Poly-	Poly + = Make polyculture only Poly- = Do not only do polyculture
Clarias-Tilapia	Clatila + Clatila -	Clatila + = Raising both Clarias and tilipia Clatila- = Do not raise both Clarias and tilipia

Modeling of the determinants of the grouping of fish farmers according to different fish farming systems

As part of this research, logistic regression, specifically the multinomial Logit model, has been used to determine the factors affecting the choice of alternative fish farming systems by fish farmers. The stata software made it possible to turn the model. In the Multinomial Logit model, it is assumed that fish farmers make adoption decisions based on a goal of maximizing their utility. The Logit function introduced by [22]is written as follows :

$$\sum(Yi) = P(Yi) = \frac{(e\alpha + \beta Xi)}{(1 + \mathrm{e}\alpha + \beta Xi)} \quad (1)$$

The Logit model is used to estimate the determinants of adoption of fish systems. Thus, for a fish farmer i, the probability of adopting a fish farming system according to the logit model is given by the following formula :

P (adoption of the fish farming system) = $\frac{exp(\beta Zi)}{1+\exp(\beta Zi)}$ (2) and

P (non adoption of the fish farming system) = $\frac{1}{1+\exp(\beta Zi)}$ (3)

Where: $\beta$is an unknown coefficient vector. Zi is a vector of explanatory variables used to predict the adoption behavior of the 1^{st} to the 2^{nd}fish farmer.

The Logit model assumes that, to produce fish, the fish farmer must deal with several disjunctive and exhaustive alternatives represented by the dependent variable Yi which is the choice of fish farming systems. So here three disjointed and exhaustive alternatives offered to a fish farmer, Yi takes the values i = 1, 2 and 3 such that :

- Y = 1 if the farmer chooses to produce exclusively in fish holes

- Y = 2 if the farmer chooses to produce exclusively in drainable ponds
- Y = 3 if the farmer chooses to produce exclusively in non-drainable ponds

According to the theoretical considerations, the fact that fish farmers choose or not a fish farming system could be explained by a set of socio-economic characteristics (number of years of schooling, number of years of experience in fish farming, Training in fish farming, palm grove area, allochthonous, fish farming as a secondary activity).[23]

After estimating the correlation matrix between these independent variables, the variables with multi-collinearity with other variables are eliminated. Robust estimation methods have been used to correct possible heteroscedasticities.

RESULTS

Characterization of fish systems in the Ouémé valley

The results of Factor Analysis Multiple Correspondence (FAMC) have indicated that the first two dimensions factorialwere allowing to explain 52, 67% of the inertness (Table No2). They were therefore retained.

Table No.2: "Powerof Factorial Analysis of Multiple Correspondences (FAMC)"

Parameters	dim1	dim2	dim3	DIM4	DIM5	DIM6	dim7	Dim8
Variance	0.321	0.206	0.145	0.119	0.107	0.062	0.022	0.017
% of variance	32.117	20.550	14.543	11.911	10.740	6.185	2.221	1.734
% cumulative variance	32.117	52.667	67.210	79.121	89.860	96.045	98.266	100

Dim = Dimension

Distribution of fish farmers in the ouémé valley in more or less homogeneous groups

Figures No 2 and No 3 respectively showed the grouping of the characteristic variables of fish farming systems and the grouping of individuals according to the characteristic variables of fish farming systems. By superimposing these two figures, we observe three groupings. First, the first grouping (PICLAT) was characterized by fish farmers raising Clarias (Clarias) in fish holes (trou) in monocropping (mono). Secondly, the second grouping (PITEV) was characterized by fish farmingwho raise the fish tilapia alone (tilapia) in drainable ponds (ETV) built in the shallows (basfond). Finally the third grouping (PICLATEN), takes into account the fish farmers who raise both of Clarias and tilapia in non-drainable ponds (ENV) in mixed agriculture (mixed).

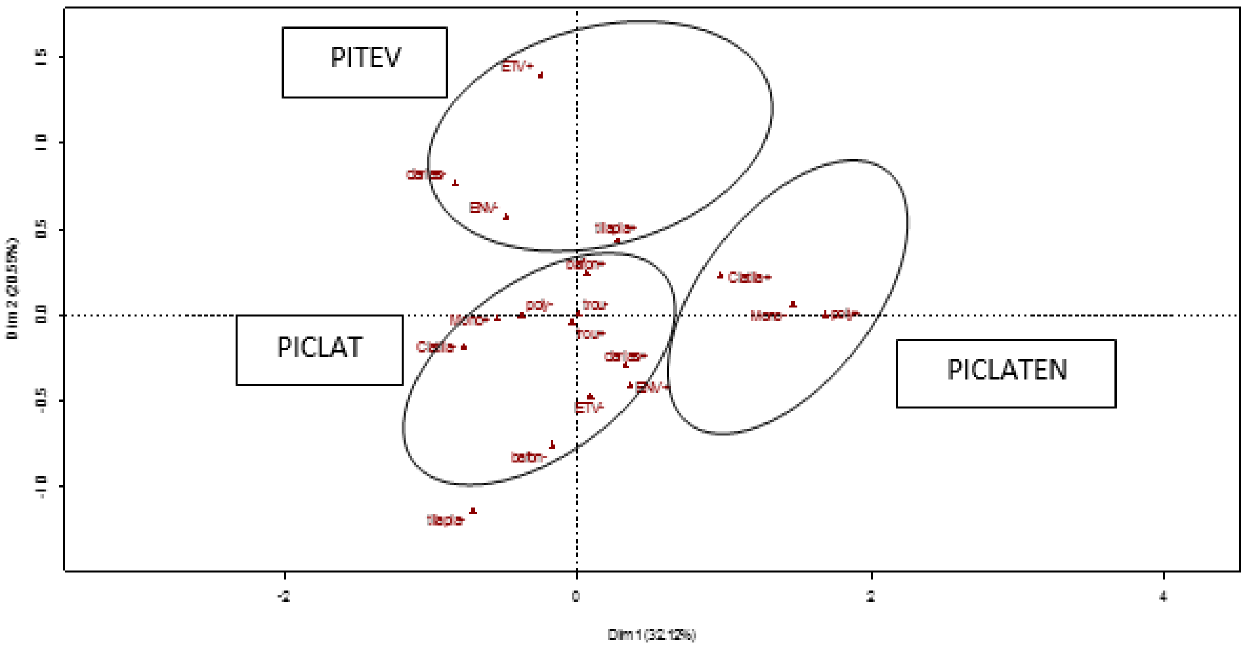

Figure No 2:"Graphical representation of the groupings of the characteristic variables of the fish-farming systems on the first two dimensions"

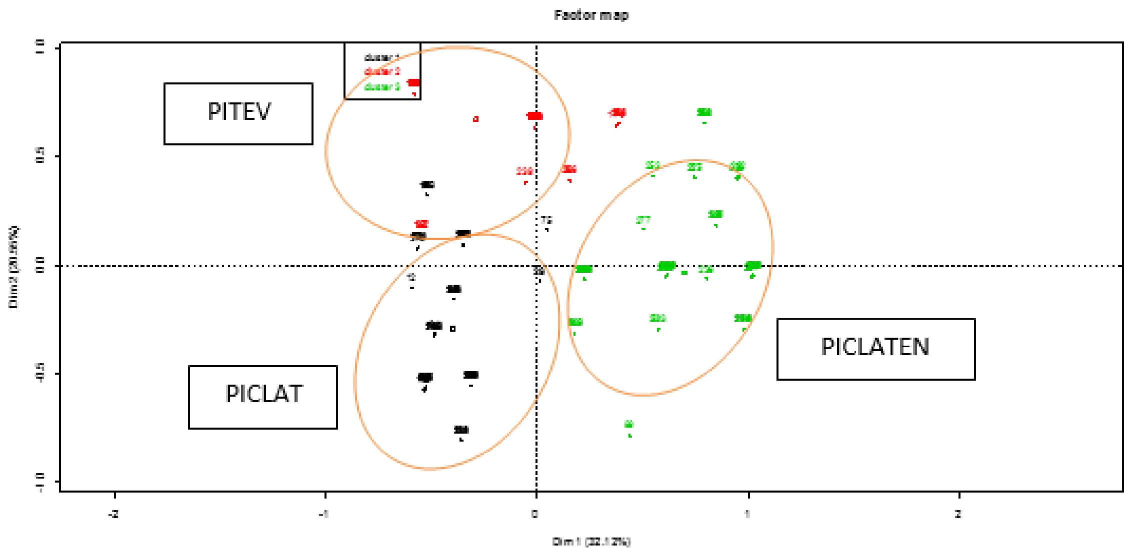

Figure No 3:"Graphical representation of groups of fish farmers on the first two dimensions"

Distribution of fish farmers in the Ouémé valley as belonging to a fish's system and their town

The Pearson Independence Khi2 test performed had a Khi^2 value of 269.43 (degree of freedom 6) significant at the 1% threshold. Thus, the distribution of fish farmers according to their belonging to a fish-farming system varied with the town of origin of the fish farmers.

Figure 4 shows the distribution of fish farmers in the Ouémé Valley according to their fish farming systems and their towns. We see that the fish farmers (PICLAT) were more represented with a frequency of 44.34%, then the fish farmers are (PICLATEN) with a proportion of 34.33% and finally the fish farmers (PITEV) represented at 21.33%.

Indeed, fish farmers (PICLAT) were most represented in the towns of Adjohoun and Dangbo than in other towns while fish farmers (PITEV) and (PICLATEN) were respectively represented in the towns of Ouinhi and Bonou. It can therefore be concluded that fish farming systems change from one town to another.

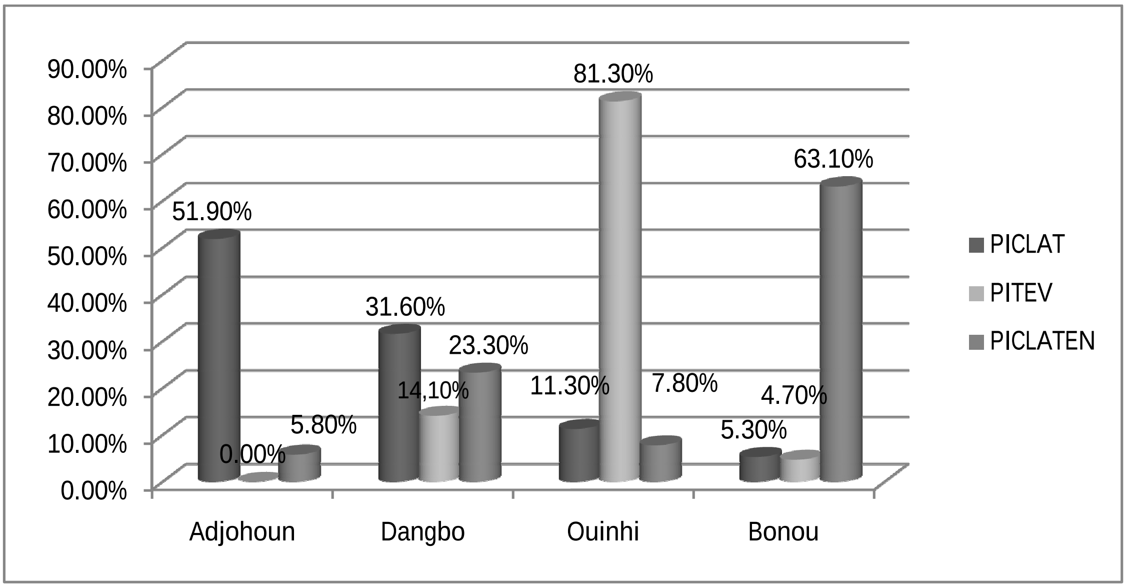

Figure No 4:"Distribution of fish farmers in south Benin, following their system of taxation and their town"

Determinants of the belonging of fish farmers to different fish farming systems

Table No 3 provides information on model estimation results. The estimated model was globally significant at the 1% level. The explicative variables introduced in the model are explaining at 28.35 % ofthe variations ofthe probability of adopting PITEV systems and the PICLATEN systems are explained by the variations of the variables introduced in the Multinomial Logit.

The membership of a farmer in one or other of fish farming systems were determined e significantly by variables such as the level of primary education, the training received by the farmer on feed stuffs production, the training received by the farmer on fry production, training received by the farmer on the monitoring and quality of the water, training received by the farmer on the maintenance of infrastructures, the area of palm grove, fish farming as a secondary activity of the fish farmer . However, the sign and marginal effects of these variables are varying by group. Note that the signs of marginal effects are not necessarily the same as the estimated coefficients (Croissant, 2009).

The level of primary education of fish farmers decreased significantly with the probability of belonging to PITEV farmers. Specifically, the membership rate decreased at 22 % points. With the agricultural advice and extension system policy put in place, fish farmers are able to better assimilate techniques even with a low level of education. On the contrary, the most educated think they have enough knowledge and do not update their knowledge. The PITEV system being a semi modern system, despite their level of education, their chances of belonging to this system decreased. This result is opposite to those of [19], which showed that educated producers have better abilities to apply and disseminate instructions from extension services.

Farmers trained in feed stuffs production were less likely to belong to the PITEV system when they were more likely to belong to the PICLATEN system. These fish farmers who received this training consider it of great importance. They are more inclined to go to a more intensive production from where their chance to belong to the PICLATEN system increases of 9% points when they are trained on feed stuffs production. In addition, this system requires the control of feeding by provender for its success compared to the PITEV system. These results confirm those of [21] who have shown that the ability of agriculture to associate with fish farming is an important factor in the adoption of fish farming systems.

Fish farmers trained in fry production are less likely to belong to the PICLATEN system and the chance of belonging decreases of 25% points. The PICLATEN system is a modern, fish farmers have realized that its success requires a great attention. These fish farmers prefer to concentrate on market production.

Fish farmers trained in water quality monitoring tend to belong to the PITEV system and the PICLATEN system and their chances increased by 17% points and 8% points, respectively.

For successful fish farming in the PITEV and PICLATEN systems, water control is required. This mastery requires regular monitoring with special emphasis on water quality. When the quality of the water is not good, it could lead to the death of the fish and thus negatively influence the performance of the breeding.

Fish farmers trained in infrastructure maintenance are less likely to belong to the PITEV system. Their chance of belonging decreased by 25% points. The maintenance of the PITEV system, which is a drainable system, involves emptying the pond regularly. They therefore tend not to be trained on infrastructure maintenance. For references [9] and [18], land-based fish farmers are more likely to facilitate certain fish farming infrastructures without the fear of losing their investment, unlike non-native farmers who are entitled to only small acreage often obtained by pledge or by loans. This can influence the decision to choose the fish farming system.

As the area of palm groves of fish farmers increased, their probability of belonging to the PITEV system decreased while their likelihood of belonging to the PICLATEN system increased. Their luck decreased by 5% points for the PITEV system while their luck increased by 1% for the PICLATEN system.

Palm cultivation is a crop that provides a significant income for fish farmers. Farmers who own these palm trees are less likely to use semi-intensive fish farming (PITEV), which does not guarantee a significant income while they tend to invest more in the more modern fish farming (PICLATEN).

Indeed, the resources obtained from palm cultivation are invested in the PICLATEN system which is a system that requires a lot of investment.

When fish farming is a secondary activity, fish farmers are more likely to belong to the PITEV system. Their chance to belong increased by 21% points.

This research has focused much more on fish infrastructures that depend on the availability of land. It did not take sufficient account of other infrastructure such as above ground bins due to the low adoption in the research area. Future research could focus on characterization its increasingly modern infrastructures and meeting the challenge of long-term self-sufficiency in fisheries.

Table No 3:"Results of the estimation of the determinants of the membership of fish farmers to different fish" farming systems

variables	Breeders only of Clarias in fish holes (PICLAT) Variable of références			
	Breeders only of tilapia in the drainable ponds mainly in the lowlands (PITEV)		Breeders of both Clarias and tilapia in non-drainable ponds (PICLATEN)	
	Marginal effects	**P of meaning**	**Marginal effects**	**P of meaning**
Primlevel	-0.22 **	0.012	0.07	0.135
Secondarymorelevel	-0.02	0.825	-0.006	0.864
Feedstuffsproduction	-0.17 *	0.059	0.09 **	0.041
Fryproduction	0.015	0.854	-0.25 ***	0.000
Monitoringandwaterquality	0.17 **	0.035	0.08 ***	0.006
infrastructuremaintenance	-0.25 ***	0.009	-0.08	0.226
Palmgrovearea	-0.05	0.025	0.01 *	0.063
Acti_Seond_Fishfarming	0.21 ***	0.008	-0.04	0.171
constant	-	-		
Number of observations	300			
Kh^{i2}of Wald	80.58			
Pseudo R^2	28.35			

CONCLUSION

The objective of this study is to characterize the existing fish farming systems in the Ouémé Valley. The characterization has allowed retaining three fish farming systems. It's all about system (PICLAT) characterized by fish farmers raising Clarias alone (Clarias) in fish holes (trou) and doing Monocropping only (mono). Then, the system (PITEV) characterized by fish farmers who raise tilapia fish alone (tilapia) in the drainable ponds (ETV) in the Shallows (basfond) and finally the system (PICLATEN) which takes into account the fish farmers which breed both Clarias and tilapia in non-drainable ponds (ENV) and mixed farming (Mixed). Belonging to one or other of fish farming systems is determined significantly by the level of primary education, the training received by the farmer on feed stuffs production, the training received by the farmer on the production of fry, the training received by the fish farmer on the monitoring and quality of the water, the training received by the fish farmer on the maintenance of infrastructures, the area of palm grove, fish farming as a secondary activity of the fish farmer.

These results show that social, technical, economic and environmental realities significantly influence the choice of the fish farming system. The support institutions of fish farmers must put a particular emphasis on training and consider fish farming as a main activity to hope that fish farmers will gradually migrate from extensive fish farming to intensive fish farming with the aim of achieving in the long term, self- sufficiency in fishery products and, in turn, an increase in fish farmers' income.

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