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Perceptions of Fish Hole Operators on Climate Change and Adaptation Measures in the Wetlands of Southern Benin

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Résumé

Dans les zones humides du sud du Bénin, la pêcherie occupant près de 75 % de la population est tributaire du caractère aléatoire du climat ; ce qui rend la majorité vulnérable au changement climatique. Cette étude analyse la perception paysanne des changements climatiques et vise à appuyer les exploitants des trous traditionnels à poissons pour la mise en œuvre de mesures d'adaptation afin de faire face aux changements climatiques. A cet effet, nous avons enquêté 366 exploitantset 23 personnes ressources, politico-administratives et cadres techniques dans la basse vallée de l'Ouémé. Es les analyses des données d'enquêtes sur la perception des producteurs du changement climatique ont montré trois manifestations des changements climatiques en rapport avec la pluviométrie (diminution du nombre de jours de pluie (36,9 %), pluies tardives et violentes (23,8 %) et diminution de la quantité de pluie (39,3 %) et ont indiqué quatre manifestations des changements climatiques en rapport avec la température. Il s'agit de l'augmentation de la température (31,7 %), de la chaleur excessive (26,2 %), de l'augmentation de la durée d'insolation (6,3 %) et de la réduction de la fraîcheur nocturne (35,8 %). Ces enquêtes réalisées auprès des exploitants ont permis de ressortir quatre principaux risques climatiques à savoir : la péjoration pluviométrique (sécheresse), la chaleur excessive, les pluies tardives et violentes et les inondations.Différentes mesures ont été mises en oeuvre par les exploitants pour y faire face, la plantation d'arbres spécifiques, l'utilisation de bouse de vache et la pisciculture dans les cages flotantes. L'absence de systèmes d'alertes précoces constitue un handicap pour le développement de l'exploitation.

Mots clés : Trous à poissons, risques, changement climatique, vallée de l'Ouémé.

ABSTRACT

In the wetlands of the south of Benin, the fishery occupying nearly 75% of the population depends on the random nature of the climate; Making the majority vulnerable to climate change.

This study analyzes the peasant perception of climate change and aims to support operators of traditional fish holes for the implementation of adaptation strategies in order to cope with climate change. To this end, we investigated 366 producers and 23 resource persons, political and administrative staff and technical staff in the lower Ouémé valley.

The major climatic risks identified are drought, floods, late and violent rains and excessive heat. The most impacted ecosystem resources are soil and water resources. Different strategies have been put in place by producers to address them, but their low adaptive capacity means that they remain vulnerable to climate change. Prioritizing adaptation options suggests that semi-intensive or intensive fish farming should be associated with production before the flood period, then develop hydro-agricultural facilities, and build infrastructure (roads and trails) Improve the standard of living of the population. It should also be noted that the absence of early warning systems constitutes a brake on the development of production.

Key words: Fish holes, risks, climate change, Ouémé valley.

Introduction:

Climate change is a major component of global change that affects ecosystems and makes them vulnerable (FAO, 2012). Vulnerability in the context of climate change is a function of 3 main parameters: sensitivity to present climate variability, risk of adverse climate change and adaptive capacity (IPCC, 2001). In the context of global environmental change events, aquatic ecosystems are particularly vulnerable (IPCC, 2015) to human activities and climate change (Dudgeon et al., 2006; Root et al., 2003). In recent years, the decline in natural fish stocks, caused by excessive and uncontrolled fishing, and the potential impacts of climate change on water resources justify the focused attention on fisheries and in turn on aquatic ecosystems (Naylor et al., 2000; Pauly et al., 2002; Baptist et al., 2014).

The lower Ouémé valley, which is the subject of this study, abounds in important biological resources, particularly fisheries resources (Lougbégnon, 2016). It is observed there the hydroclimatic disruption, which is perceptible through early and particularly long floods, floods (Boko et al., 2007; Aho et al., 2006; IPCC, 2007a; PANA-Benin, 2008; Yabi and Afouda, 2011; Houéssou, 2014), a tendency to increase the frequency of extreme events such as drought (PANA-Benin, 2008) and the transformation of the bimodal regime into unimodal in southern Benin (WMO, 2011; Boko et al., 2007; Vissin, 2013). The impacts on fisheries are already visible with the sustained downward trend in fishing yields (Lalèyè et al., 2004; 2007; Chikou, 2006; Imorou Toko et al., 2007). Catches fell by more than 15% from 2003 to 2008 while the population's need for fish increased (MAEP, 2009; Sohou et al., 2009). To make up for this deficit, the country has resorted to importing frozen fish, the volume of which has exceeded national production since 2005. It is therefore essential to promote the development of aquaculture in order not only to ensure greater availability of fishery products, but also to reduce the exploitation of natural fishery resources (Imourou Toko, 2007). Indeed, many fishermen practice "whédos" or fish holes, another form of traditional fish farming devised by continental fishermen to take advantage of the succession of floods and ebbs in the flood plains. These holes dug in the flood plains trap fish that migrate laterally during the flood.

This study aims to analyze the perceptions of climate change as felt by the operators of fish holes, from the causes experienced, then their adaptation measures developed for a good productivity of holes.

Materials and Methods:

Study setting:

Located in the department of Ouémé, the Ouémé valley is a good site to analyze the perception of fish hole farmers on climate change. The present study was conducted in the agroecological zone favorable to the exploitation of fish holes in Benin. Indeed, the climatic, geomorphological and anthropic characteristics of the valley (which intervene in the phenomenon of flood) show two quite distinct facets of the valley.

It is thus observed certain districts exempt from flooding, which are found on the plateau and certain periodically flooded entirely or partially. These are the districts located in the wetlands. It is in these zones that this activity develops. According to the division of agro-ecological zones of the Institut National des Recherches Agricoles du Bénin (INRAB, 1995), this is agro-ecological zone 8 in Benin. The geographic setting of the study area is between 6° 23' 28" and 6° 57' 48" north latitude, and between 2° 23' 28" and 2° 36' east longitude (Figure 1), which corresponds to the Guinean or subequatorial region of Benin. The lower Ouémé valley is located in the department of Ouémé.

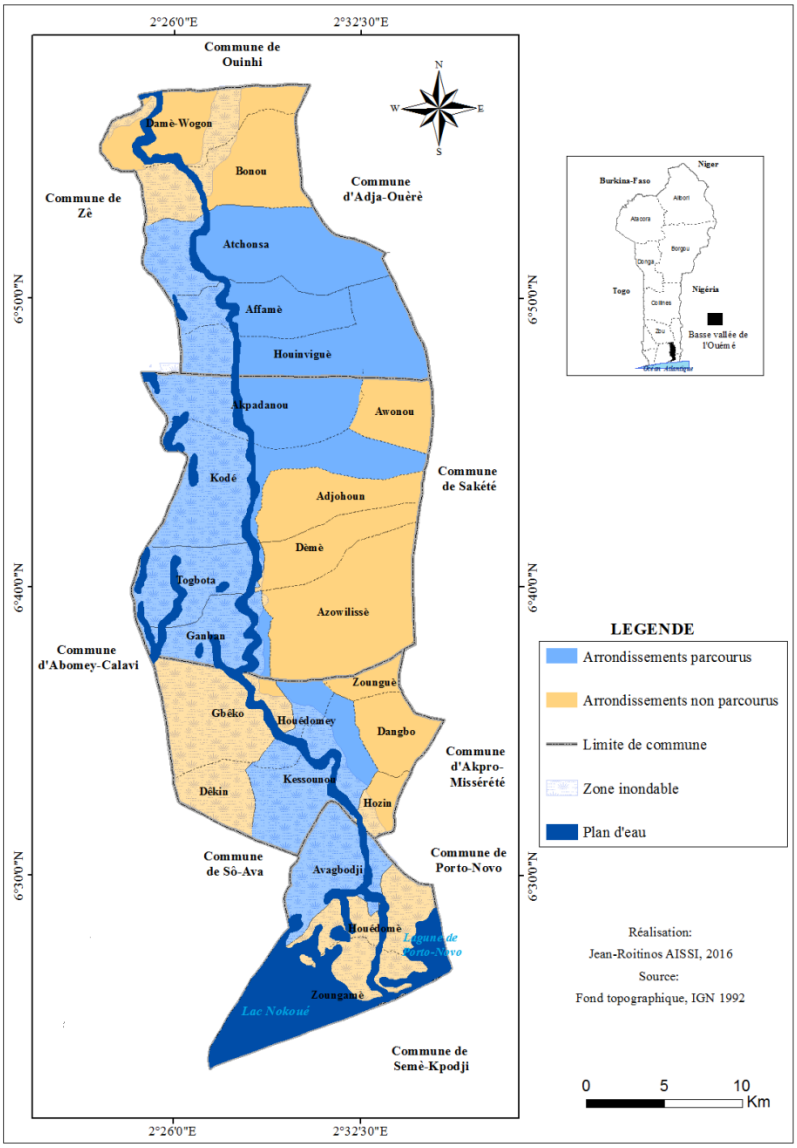


Figure 1: Map of the geographic location of the districts surveyed in the lower Ouémé valley.

Sampling and collection techniques:

The probabilistic method, which amounts to a selection of the sample by simple random drawing from the parent population, was adopted. The parent population in this study was all fish hole operators. Thus, the sample size (n) of the fishhole operators surveyed was determined by the binomial sampling formula of Dagnelie (1998), which is expressed as follows:

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

With n: sample size considered; $U_{1-\propto/2}$: value of the normal distribution at 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.
The sample size is then :

$$n = \frac{(1,96)^2 \times 0,39(1-0,39)}{(0,05)^2} = 365,57$$ i.e. 366 farmers to be surveyed

This size was distributed proportionally within the selected districts.

Data collected:

The realization of this study required the collection of data in real environment and by documentary research. The information collected was qualitative and focused on environmental benchmarks and farmers' perceptions of climate risks and vulnerability of the fishery.

Data analysis method:

The surveys conducted among the producers allowed us to bring out information on the socio-professional characteristics of the producers (Age, marital status, gender, membership in a group, socio-cultural categories, experience in the activity and their origin), their perceptions of climate change as well as local adaptation measures to minimize their impacts on fisheries production in the lower Ouémé valley. And by referring to the literature (PANA-BENIN, 2008), drought, excessive heat, late and violent rains and floods are the major plausible climatic risks that can affect the production of fish holes in the Ouémé valley that were identified and then analyzed.

Thus, descriptive statistics (frequency, percentage, etc.) were used to analyze data related to farmers' perceptions. To study the geographical profile of farmers' perceptions of climate change, a Correspondence Factorial Analysis (CFA) was used. This analysis made it possible to link the different perceptions to the geographical areas studied. All the statistics were done with the SPSS (Statistical Package for the Social Sciences) version 21.0 software.

Results and discussion:

Socio-professional characteristics of producers:

Table I presents the socio-professional characteristics of producers according to the Communes of the lower Ouémé valley.

Variables	Modalites	Perrcent of respondents			
		Adjohoun (n = 124)	**Aguégués (n = 44)**	**Bonou (n = 88)**	**Dangbo (n = 110)**
Age	< 30 years old	10	3	5	8
	Between 30 and 60 years old	73	32	57	69
	> 60 years old	41	9	26	33
Sex	Femal	15	7	17	15
	Male	109	37	71	95
Matrimonial status	Married	107	41	80	94
	single	13	3	6	11
	Widowed	4	0	2	5
Socio-cultural group	Ouémé	107	12	77	87
	Toffin	7	29	5	10
	Fon	5	1	2	7
	others	5	2	4	6
Origin	Aboriginal	107	41	77	97
	Non-native	17	3	11	13
Experience	< 10 years old	9	4	3	7
	Between 10 and 20 years old	78	25	56	52
	>20years old	37	15	29	51
Membership in a group	Yes	77	23	56	47
	No	47	21	32	63

Table 1 presents the socio-professional characteristics of fish hole operators in the study area.Generally speaking, men are more likely to own fish holes compared to women (85.25% men versus 14.75% women). These results confirm those of Imorou Toko et al (2011), who stipulate that production is male dominated which is also confirmed by the work of Sogansa (2014) who showed that men are more involved in the exploitation of fish holes than women. According to the latter the percentage of female hole owners is 11.66%. For Hirigoyen et al (1997), in the forest zone of Cameroon, only 5% of fish farmers are women. According to them, the few women who practice this activity do so either as a result of inheritance upon the death of the husband, or as a result of the division of property following divorce in matrilocal residence. The same result was obtained by FAO (1993) in certain localities of Madagascar. Similarly, Dossou (2008) reported that in Malanville in northeastern Benin, only 27% of the groups operating fish farms contain women. The author explains this low percentage of women's representation by the great physical effort that the activity requires. Thus, they regularly use the services of men for tasks requiring physical effort. According to Imorou Toko et al (2011), the presence of women in these fish farming groups is due to their role as traders of harvested products, i.e. fish. This could be explained by the fact that the activity requires great physical effort (especially for the construction and cleaning of holes) which is not easily done by women. It is also this constraint that very often pushes producers to form groups. However, it is important to note the presence of women in some associations. These women are mainly involved in the sale of fishing products.

The age of 63.33% of the producers surveyed is between 30 and 60 years. The young (< 30 years) constitute 6.71% of the producers and the old (> 60 years) constitute 29.96% as shown in Table I. But for Sogansa (2014), the owners of fish holes in the upper Ouémé delta are people over 40 years old. Despite the difference between the age groups used in these studies the observation made is that these owners are adults, generally managers and heads of households.

According to Hirigoyen et al (1997), this age group was favored in relation to awareness of fish farming techniques (between 40 and 50 years old). Thus, these owners are eligible targets for sensitization in order to show them the added value that they can derive from the transformation of their fish holes into modern fish farming sites during the dry period when these holes experience a great decline in fish production.

Moreover 88 % of the producers are married and 57,65 % of them have between 10 to 20 years of seniority in the field. Also, the majority of fish holes are owned by natives (87.98%). The dominance of indigenous people can be explained mainly by their easy access to land (Dossou, 2008). Indeed, because they are indigenous, they are therefore the landowners who can more easily build fish holes on their land. The dominant socio-cultural groups among the actors of this fishing technique are the "Ouéménous" who constitute 77% of the sample followed by the "toffins" who represent only 14%. They consider this fishing technique to be an income generating activity. Thus, it appears that the fish hole operators in the lower Ouémé valley have very varied socio-economic characteristics.

Producers' perception of climate change:

Producers indicated three manifestations of climate change in relation to rainfall. These were: a decrease in the number of rainy days (36.9%), late and heavy rains (23.8%), and a decrease in the amount of rain (39.3%). Figure 2 presents producers' perceptions related to rainfall variability.

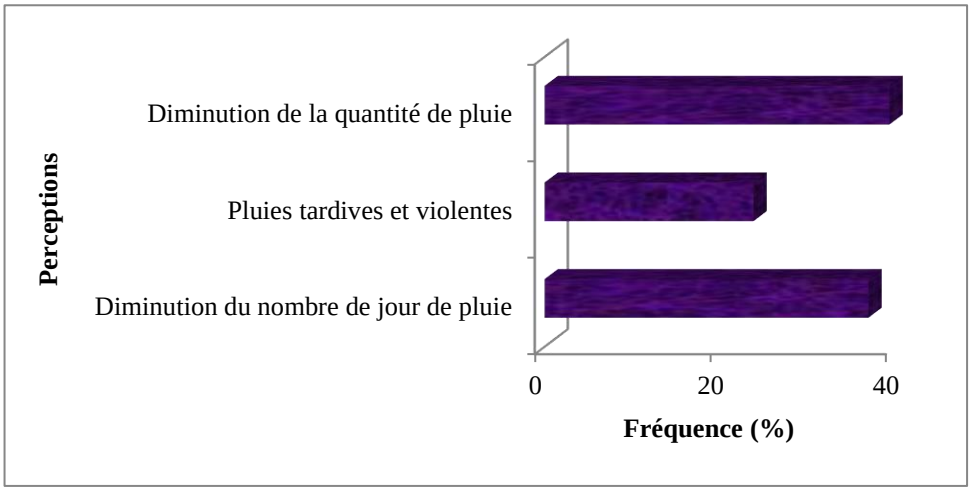
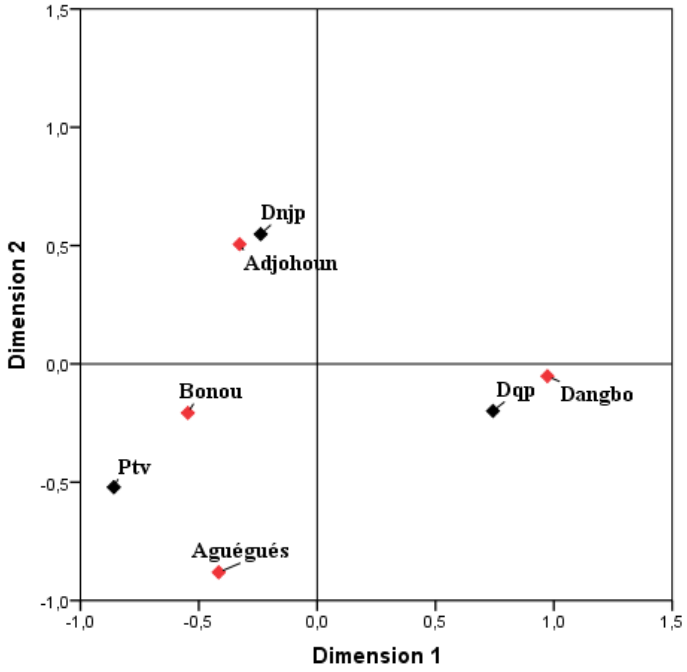


Figure 2 Producers' Perceptions of Rainfall-Related Climate Change

The factorial correspondence analysis (FCA) conducted to analyze the relationships between Communes and fishers' opinions on climate change in relation to rainfall revealed two factual axes that explain 100% of fish hole producers' perceptions of rainfall variability. Thus, producers in Adjohoun believe that climate change is manifested by a decrease in the number of rainy days. In Dangbo, producers believe that these changes are reflected in a decrease in the amount of rainfall, while in Bonou, late and violent rainfall is mentioned. Figure 3 presents the factorial map of producers' perceptions of rainfall variability according to the four communes in the lower Ouémé valley.



Dqp: Decrease in the amount of rainfal ; **Ptv** : Late and heavy rains ; **Dnjp:** Decrease in the number of days of rain.

Figure 3: Perceptions of rainfall variability according to fishermen in the 4 communes of the lower Ouémé valley.

Producers' perception of climate change in relation to temperature:

Producers identified four manifestations of climate change in relation to temperature. These were increased temperature (31.7%), excessive heat (26.2%), increased sunshine duration (6.3%), and reduced nighttime coolness (35.8%).

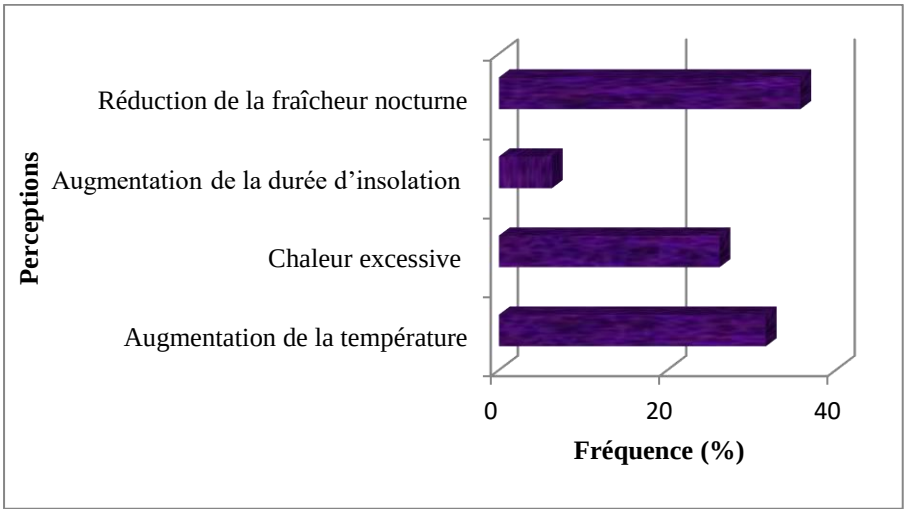
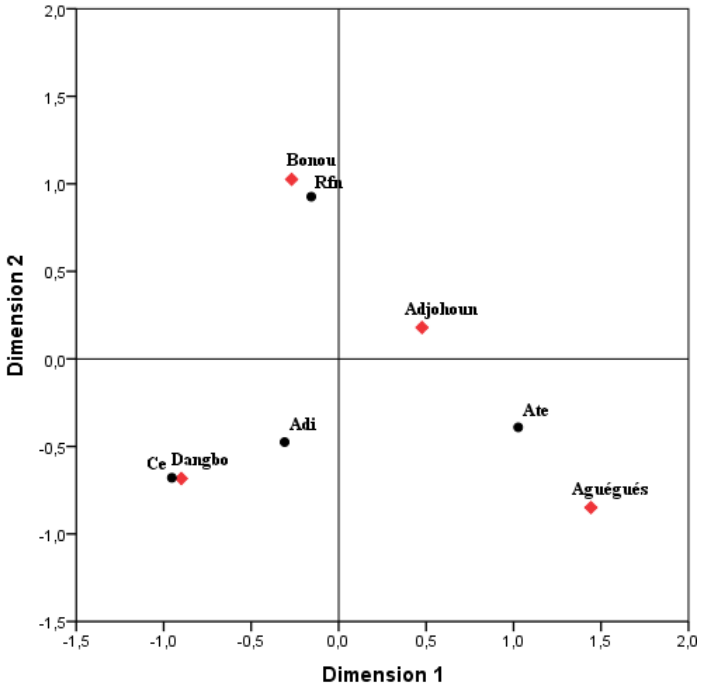


Figure 4: Producers' perceptions of temperature-related climate change

The factorial correspondence analysis (FCA) conducted to analyze the relationships between communes and fishers' opinions on temperature-related climate change revealed two factual axes explaining 95.5% of fish hole producers' perceptions. Figure 5 presents the factorial map of producers' perceptions of temperature according to the four communes of the lower Ouémé valley. Analysis of this figure reveals that for producers in Bonou, climate change is manifested by a reduction in nighttime coolness. In Dangbo, producers believe that climate change is manifested by excessive heat, while in Aguégués, there is an increase in water temperature.



Rfn: Reduction in night-time coolness, **Adi**: Increase in sunshine duration, **Ce**: Excessive heat, **Ate:** Increase in water temperature.

Figure 5: Producers' perceptions of temperature variability in the four communes of the lower Ouémé valley.

A clear observation emerged from these analyses; from a pluvio-hydrological point of view, the effects of climate change are strongly felt by rural populations, regardless of their geographic location and the rainfall zone considered. A majority suffer from a decrease in the length of the rainy season due to a delay in its onset and early termination, an increase in extreme rainfall events (which can lead to flooding), and an increase in dry periods within the rainy seasons (which can compromise production). Long ignored, the perception of climate change has become a much explored field of research in recent years (Akponikpè et al., 2010; Nielsen and Reenberg, 2010; Baudoin, 2010; Mertz et al., 2009, 2012; Ofuoku, 2011; Ajibefun and Fatuase, 2012; Fosu-Mensah et al, 2012; Ozer et al., 2013). Analysis of farmers' perceptions of climate variability in the lower Ouémé valley reveals that almost all of the population believes that there is a climatic pejoration and that the duration or length of rainy seasons is getting shorter and it is much hotter, which is in line with the work of Donou (2009). Numerous studies in Africa and elsewhere in the world have reached similar results (Adamou et al., 2015; Vissin, 2013; Macharia et al., 2012; Mustapha et al., 2012). The major climate changes reported by fishermen are delayed rainfall and increased water temperature. Traoré et al. (2002), Hassan and Nhemechena (2008) noted that in the West African sub-region, farmers perceived climate change through long-term temperature increases and decreases in rainfall, pronounced changes in rainfall timing, recurrent droughts, and the drying up of formerly perennial water bodies during the dry season.

Adaptation strategies of producers in the lower Ouémé valley:

The modification of climatic parameters has consequences on the production of fish holes. Surveys conducted among fish hole farmers in the lower Ouémé valley revealed four main climatic risks/factors, namely: rainfall deterioration (drought), excessive heat, late and violent rains and floods. This is in line with the results of PANA, on the climatic risks of agro-ecological zone 8, which is the fisheries production zone. Faced with these risks, some producers have been able to adopt measures to minimize the effects of climate change. These measures implemented by farming communities to adapt to climate change, vary according to the Communes studied and are strongly dependent on cultural factors (Nielsen and Reenberg, 2010; Mertz et al., 2012). These include the use of cow dung, fish farming in floating cages, planting of bamboo (Phyllostachys spp.) and papyrus (Cyperus spp.), and the use of local and imported fish feed. Figure 6 shows the adaptation measures of fish hole producers in the lower Ouémé valley.

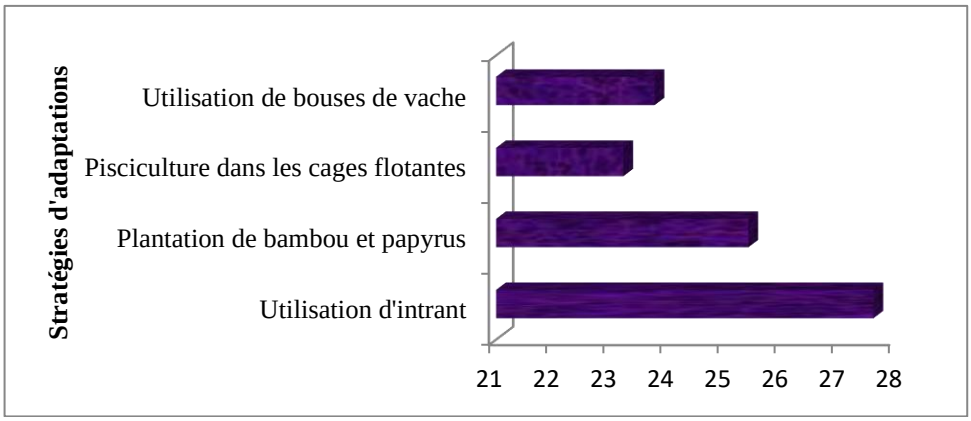
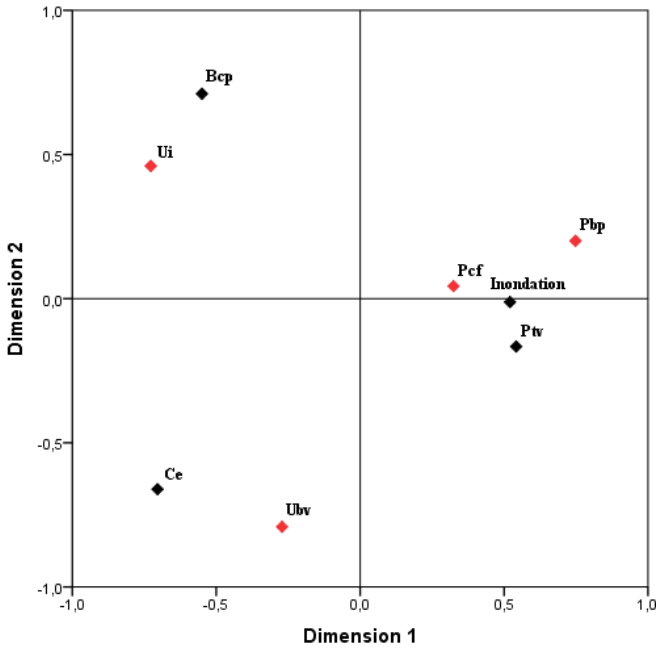


Figure 6: Adaptation strategies of fish hole producers in the lower Ouémé valley

The factorial correspondence analysis (FCA) carried out to analyze the proximities between adaptation measures and climate change risks revealed two factorial axes with a total inertia of 100%, thus explaining variations in adaptation measures according to climate risks. The strategies "input use", "fish farming in floating cages", "bamboo and papyrus plantation" and the climatic risks "excessive heat", "late and violent rains", "flood" have a good contribution and quality of representation on the first axis. Considering the second axis, the strategy "Use of cow dung" and "decrease in cumulative rainfall" have a good contribution and quality of representation on the second axis. Figure 7 presents the adaptation measures taken by producers in response to the effects of climate change.



Ubv: Use of cow dung, **Pcf**: fish farming in floating cages, **Pbp:** bamboo and papyrus planting, **Ui**: use of inputs.

Figures 7: Producers' adaptation measures to the effects of climate variability

The analysis of this figure shows that fish hole farmers adapt to flood risks by practicing fish farming in floating cages and by planting bamboo and papyrus.

In addition, it appears that producers do not use irrigation or water harvesting and soil conservation techniques, as these require expensive equipment and investments. In fact, the only change observed is to postpone the dates of planting (Akponikpè et al., 2010; Fosu-Mensah et al., 2012). The development of the aquaculture sector seems to be an effective option for national self-sufficiency in fishery products and adequate to the country's resources. Indeed, according to Lalèyè et al. (2004), Benin has a significant fisheries potential that has been exploited for centuries by populations mainly concentrated in the South. It is also characterized by countless valleys and vast flood plains that are favorable to extensive, semi-intensive and integrated fish farming. According to Imorou Toko (2007), in the valleys, the construction of conventional drainable ponds and their supply of water by gravity or pumping could favor the development of semi-intensive fish production systems. On the other hand, in the flood plains of the rivers and lakes of southern Benin, a particular form of fish farming in manually or mechanically dug holes called "whedos" is developing.

Conclusion:

The fish hole operators of the lower Ouémé valley have a good knowledge of climate change and its effects on fisheries production. Their perceptions of the variability of climatic parameters vary according to the environment and their repertoire of endogenous knowledge. Consequently, they develop adaptation measures to mitigate the effects of climate change in order to improve their yields in a sustainable manner. However, these adaptation measures, although relevant to flood risks, are inadequate for certain climatic risks such as the decrease in cumulative rainfall and excessive heat. It is therefore proposed that fish farming be carried out in floating cages with the use of adapted fry.

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