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## **Social perception of climate change and forms of use impact on the forests of Dogo-Kétou and Pobè in Benin**

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### **ABSTRACT**

This study examined the local perception on the climate changes and how these changes combined with anthropogenic pressures generated by the forms of use of the forest resources, impact the sustainability of the forests of Pobè and Dogo-Kétou in southeast Benin. The data were collected through an investigation of 148 and 139 local populations sampled respectively in the municipalities of Pobè and Kétou in the studied area. An interview guide and a structured research questionnaire were used to collect the data which were analyzed using the software R<sub>i386 3.5.1</sub>. The main results revealed that more than 98% of the local population living around these forests perceive the effects of climate change and anthropogenic activities are the main causes. The consequences of climate change from the social perception are diversified, such as the violent winds and the scarcity of rains. The prolonged droughts are also confirmed by 61% of local population in Kétou and 81% in Pobè. In these conditions, trees have a harder time of reproduction with a poor capacity of regeneration. The analysis of the vulnerability of these forests in relation to the use values (UV) revealed that the populations living near to Dogo-Kétou forest use so much the forest resources (UV>2.5) than those of Pobè (UV<2.5). So, moderate pressure was notified on Pobè forest. The forest of Dogo-Kétou is therefore more vulnerable than the forest of Pobè from the view of the pressures linked to the categories of uses relative to food, energy wood, service wood, non-timber forest products and medicinal use. For adaptation strategies, the local population revealed the enrichment of the forests by indigenous forest species (32% in Kétou and 19% in Pobè), the reforestation (76% in Kétou and 84% in Pobè) and the creation of private plantations (39% in Kétou and 57% in Pobè). However, the establishment of ethnobotanical family gardens, the reduction of wood consumption for energy to the detriment of domestic gas, sensitization, prayer (church and vodoun) are ways to better adapt a good resilience to climate change.

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**Keywords:** Climate change, adaptation strategies, reforestation, resilience, forests, Benin.

### **INTRODUCTION**

Climate change around the world is characterized by the phenomenon of climate variability over the last 30 years (Gnanglè et al., 2012). This climatic variability manifests itself mainly by the increase of the temperature and the decrease of the amount of precipitation.

Benin, a developing country in West Africa, is a country that is not immune against the threats of climate change (Yegbemey et al., 2014). Scientists believe that climate change will have negative effects on agriculture, the economy and the overall well-being of people in developing countries (Kandji et al., 2006).

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According to the Ministry of the Environment for the Protection of Nature (MEPN, 2008), constraining peculiarities for agriculture and forestry appear at the level of agro-climatic parameters especially in the South-West and the far North which are sometimes submitted to severe droughts.

The evolution of climatic factors between 1960 and 2008 in the three climatic zones (Guinean, Soudano-guinean and Soudanian) of Benin, Gnganglè et al. (2011) revealed a significant increase in the average temperature (over 1 °C), a noticeable decrease in rainfall (-5.5 mm / year on average) and in the average annual number of rainy days. Thus, these climate change trends will impact on species and their ecosystems and lead to a decrease in ecosystem services in forests (Leemans and Eickhout, 2004). This loss of the ecosystem services will also reduce human well-being at all scales (Locatelli et al., 2008). According to the fourth assessment report of the Intergovernmental Group of Experts on Climate Change (IPCC, 2007), poor communities will be the most vulnerable due to their limited adaptive capacities and their high dependence on high-energy resources. Resources in water and the agricultural systems of the production are more sensitive to the climatic change. Adaptation would be the combined result of the reading-perception that populations make of climate change and their demographic and socio-economic characteristics (Maddison, 2007; Gbetibouo, 2009).

Faced with climate change, the two fundamental response options provided for this purpose are respectively mitigation and adaptation. Mitigation that refers to the control of the global climate change by reducing greenhouse gas emissions and improving carbon pits, while adaptation mainly focuses on moderation of the climate change's impacts through a broad range of actions targeted on the vulnerability system (Chitale et al., 2014). Thus, to better understand the vulnerability and resilience of the natural dense forests of Benin belonging to the subequatorial climate in the context of climate change and on which no information is yet available to date, it is urgent

to provide answers to these worrying questions. Is climate change perceived as a threat to the dense natural forests of Benin? How vulnerable the forests of Pobè and Dogo-Ketou are, according to the perception of local populations? What adaptation practices are known and implemented?

In order to improve the sustainable management of forest resources, this research was undertaken to evaluate the perception of local population on the vulnerability state of the last remnants dense forests in Benin in the context of climate changes.

## MATERIALS AND METHODS

### Study area

The municipalities of Kétou and Pobè are located in the southeast Benin in Plateau division (Figure 1). The both forests are in the Guinean climatic zone of Benin. The municipality of Kétou has 157,352 inhabitants and that of Pobè has 123,677 inhabitants (INSAE, 2013). The municipality of Kétou has two classified forests, that of Dogo (29,703 ha) and that of Kétou (12,255 ha), all located in the district of Adakplame and Idigny. In addition to these classified, there are also islands of sacred forest in the state protected domain. As for the commune of Pobè, it has two forest areas made up of the Itchede-Toffo classified forest (191 ha) and the dense semi-deciduous forest of Agricultural Research Center on Perennial Plants (CRAPP) (117 ha).

### Perception data Collection

Survey data on social perception of climate change and forms of use impact on the forests of Dogo-Kétou and Pobè were collected from interviews with agricultural populations. The respondents are chosen at random from the populations concerned. To determine the sample size (n), we used Dagnelie's formula (Dagnelie, 2013):

$$n = \mu^2_{(1-\frac{\alpha}{2})} \frac{p(1-p)}{\delta^2}$$

n is the sample size of the population of the Municipality of Kétou and Pobè

$\mu_{(1-\alpha / 2)}$  is the value of the reduced centered normal distribution for a confidence degree of 95 %, and corresponds to 1.96

$P$  = estimated proportion of the agricultural population in the Municipality

$$P_{(Pobè)} (p = 70\ 297/123\ 677 = 0.56)$$

$$P_{(Kétou)} (p = 100.062 / 157.352 = 0.63)$$

$\delta$  is the margin of error of the estimate of any parameter that could be calculated in the study and the value of 8 % is considered formula (Assogbadjo et al., 2011).

$$n_{Pobè} = (1,96^2) * (0,56(1-0,56)) / 0,08^2 \quad n_{Pobè} = 148 \text{ surveyed in Pobè}$$

$$n_{Kétou} = (1,96^2) * (0,63(1-0,63)) / 0,08^2 \quad n_{Kétou} = 139 \text{ surveyed in Kétou}$$

The structured survey questionnaire was used with the 148 and 139 local populations respectively in the municipalities of Pobè and Kétou. The structured interview consisted in predefined questions. These questions related to (1) the socio-demographic characteristics of the respondents; (2) their perception of climate change; (3) the perceived impacts of climate change by the populations (deforestation, strong winds, flooding, scarcity of rains, prolonged drought, etc.); (4) the different uses made of the biological resources of these forests (fuelwood, service wood, fodder, medicinal use, food, etc.); (6) the dynamics of forests and the threats weighing on them according to the populations; (7) the endogenous strategies currently used for forest restoration and, (8) the conservation of these forest ecosystems.

The ethnic groups met in this study for the two municipalities are 4 in number, namely: the Nago (Na), the Hollis (Ho), the Fons and the like including the Mahi (Fm) and the minority groups (Gm) constitute by the other ethnics as Goun, Adja, Idatcha and Ditammari. The members of each ethnic group are grouped according to gender, male (Mi) and female (Fi), age group (1) young ( $i \leq 30$  years); (2) adults ( $30 \text{ years} < i \leq 60 \text{ years}$ ); and (3) elderly ( $i \geq 60 \text{ years}$ ) (Teka and Vogt, 2010).

### Statistical analysis

The relative frequencies of perception of each risk were determined for each socio-ethnic subgroup. A socio-ethnic subgroup corresponds to an ethnic group of a given

gender and age as defined above, for example, young Fon men and the like aged under 30 (FmM1) or Holli men aged between 30 and 60 years old (HoM2). Thus 24 socio-ethnic subgroups were identified within the framework of this study. The relative frequency is defined as the proportion of interviewees who belong to the subgroup that identifies the different risks (Teka and Vogt, 2010). The collected and coded data were used to calculate the relative frequency using the R software.

During the survey, the value of each category of importance was spontaneously given by each respondent among three modalities (low use, moderate use, heavy use) of the resources of each forest. Each importance of use corresponds to a score from 1 to 3 where the lack of score for a category of use will correspond to 0. The correspondence of the scores and their modality will give (1 = low importance of the use, 2 = moderate importance of use, 3 = high importance of use) (Teka et al., 2018). Scores very close to 1 imply low exploitation of the resource and therefore its non-vulnerability to use; scores very close to 2 imply heavy exploitation of the resource and therefore its vulnerability to use; scores close to 3 imply a very strong exploitation of the resource and therefore its high vulnerability to use. The use values (UVs) relating to each forest was analyzed for each ethnic group, age class and gender according to Phillips and Gentry (1993):

$$VU_p = \frac{1}{n_c} \sum_1^{n_c} S_i$$

Where  $S_i$  represents the score given by a respondent for a specific category of use ( $p$ ) for the biological resources of each forest;  $n_c$  is the number of respondents in each ethnic group, age group and gender type.

The overall value of use (VGU) of each forest was calculated by:

$$VGU_p = \sum_1^j VU_p$$

Where  $j$  represents the number of use categories for the biological resources for the forests of Pobè and Dogo-Kétou. When the use values do not satisfy a normal distribution, the

Mann-Whitney and Kruskal-Wallis nonparametric tests to statistically were used to test the difference between the values of each category of uses between the ethnic groups, the classes of 'ages and the types of genres. These analyzes were carried out using  $R_{i386\ 3.5.1}$ .

The data matrix relating to the frequencies of each type of endogenous strategy according to the 24 socio-ethnic subgroups was subjected to a principal

component analysis using version 9 of software  $R_{i386\ 3.5.1}$ . This statistical method based on the relative frequency also made it possible to minimize the effects of differentiating values between subgroups. The main component analysis done, highlighted the possible link between endogenous strategies with the different socio-demographic characteristics of the respondents.

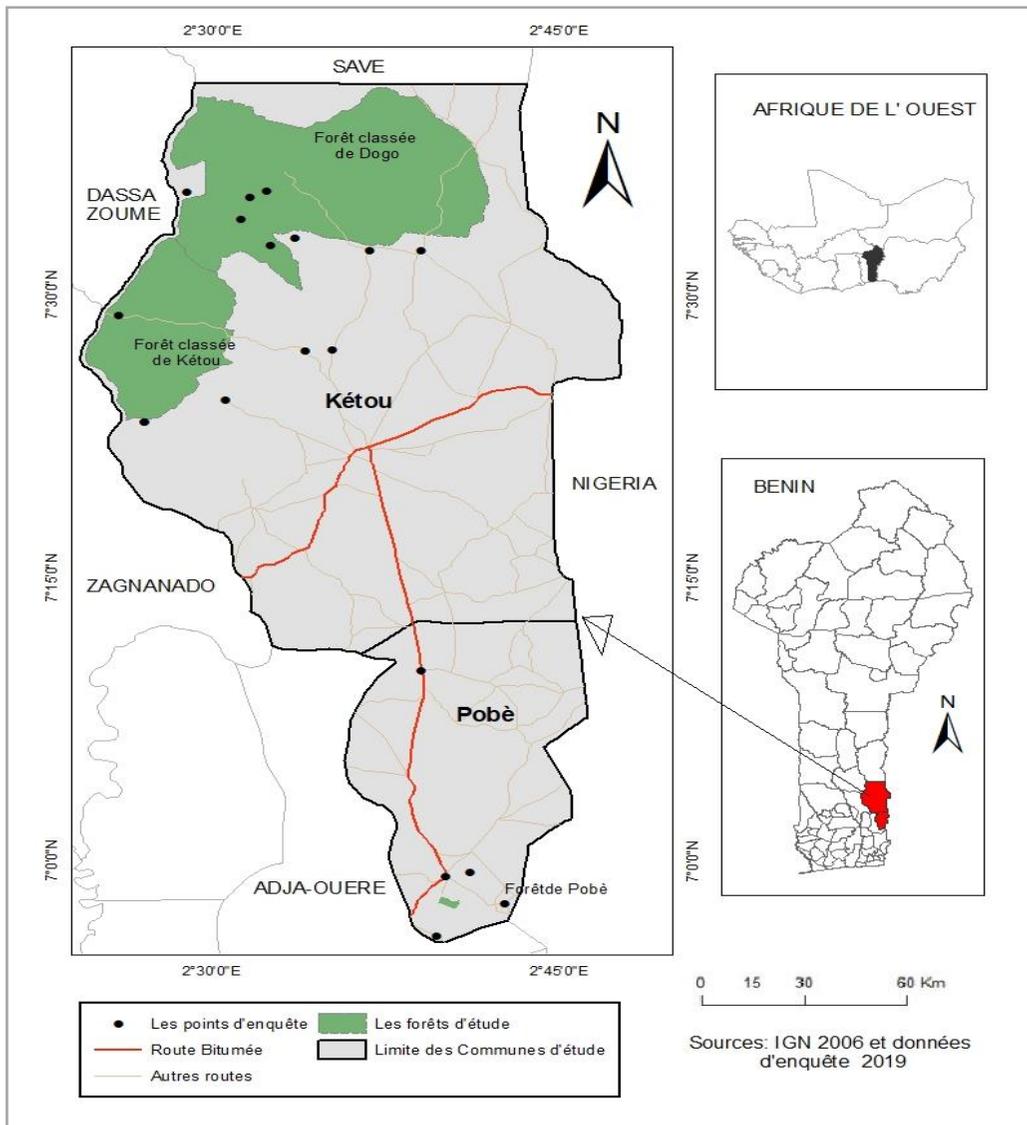


Figure 1: Map of the study area.

## RESULTS

### Perception of the local populations on climate change

More than 98% of the local populations perceived the climate change in the municipalities of Pobè and Kétou in overall, but they are 100% confirmed by the women surveyed as shown on Figure 2. Thus, all the respondents derive at least one resource from one of the forests of these two municipalities, which means that they are the users of the forests of the areas covered by the study.

For the causes of climate change, local populations have been able to enumerate them to varying degrees, as shown in Figure 3 below. These are mainly human activities ( $F > 80\%$ ), deforestation ( $F > 70\%$ ), non-compliance with traditional and religious prohibitions ( $F > 50\%$ ) and vegetation fires ( $F > 40\%$ ). The consequences of climate change from the perspective of local populations have been listed as shown in Figure 4. These are high winds that have become more frequent causing windfall in forests. These winds have been recorded in recent decades. The prolonged droughts have also become frequent and this observation is confirmed by 61% of local populations in Kétou and 81% in Pobè. The prolonged droughts thus confirm the scarcity of rains. Trees also have more difficulty. Reproducing and regenerating ( $F > 65\%$ ) are less frequent.

The survey revealed a clear decline in forest cover in both Pobè and Dogo-Kétou and the disappearance of some trees (Figure 5). The reduction in tree density within each forest was revealed with very little response from respondents who believe the forests are doing well in every way.

The surveys carried out made it possible to identify the threats that continue to weigh on the forest resources of the communes of Kétou and Pobè as shown in Figure 6. To this end, the populations have listed the uncontrolled exploitation and overexploitation of forests by the populations and users of these forests then, the scarcity of the rains which are major threats

to the sustainability of the forests on which they depend ( $F > 80\%$ ). However, they also did not fail to cite climate change, which according to them is difficult to control by humans, and vegetation fires as other obvious threats on the sustainability of these forests ( $F > 50\%$ ).

### Comparative analysis of the vulnerability of forests to harvesting

Table 1 shows the resume of the comparative analysis results of the vulnerability among the forests of Pobè and Dogo-Kétou in order to highlight the impact of forest resources samplings for five uses. The results of the comparison between the overall use values of the two forests indicate that there is no statistically significant difference at the 5% threshold between all the uses made of forest resources when one leaves one forest to another. On the other hand, for each of the categories of use, there is statistically a significant difference between the values of use compared to the categories of use "Wood energy and Medicinal use" of the resources of the forests of Pobè and Dogo-Kétou at the threshold of 5%. The highest values for these two categories of use are more observed in Kétou than in Pobè, we conclude that these categories of uses are very strongly carried out in the forest of Dogo-Kétou ( $UV > 2.5$ ) than in that of Pobè where the population is more moderate in the pressure on the forest because this forest is closely monitored by the administration of the National institute of Agricultural Research of Benin (INRAB). The forest of Dogo-Kétou is then more vulnerable than that of Pobè in terms of the importance given to use values (UV).

### Perception on climate change adaptation strategies

Figure 7 summarizes the endogenous strategies applied by the populations and the adaptation strategies that they think relevant to promote in order to better adapt to climate change. According to this figure, the local populations are used to creating ethnobotanical

gardens where plants that are very useful in their daily lives are often kept. The survey shows that there is a small fringe of the population in Kétou who use the prayers do at the church and the vodoun monasteries, which they believe, help them to make rain fall for example. Sensitization is widely practiced at the level of the populations, especially in Kétou 73% and in Pobè 47%.

As for the adaptation strategies presented by the populations surveyed, the reforestation of forest species is the idea best shared from one municipality to another with the creation of private plantations of native species.

#### **Adaptive strategies by the populations surrounding the forests**

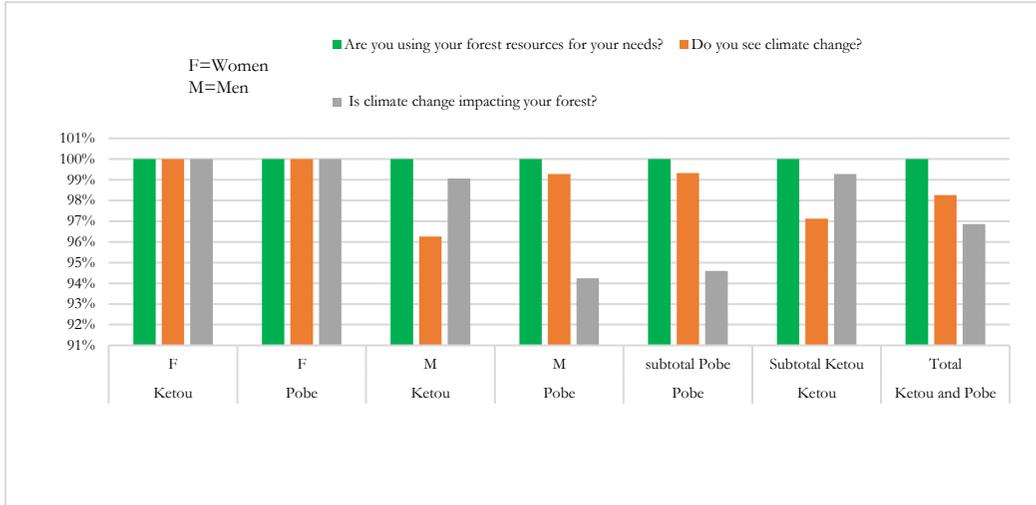
The analysis in Figure 8 shows that Fons and Mina men and women whose ages are between 30 and 60 (FmM2, FmF2) believe very strongly that the reforestation of tree species from the Dogo-Kétou forest, the production of indigenous Dogo-Kétou species in nurseries, the establishment of family ethnobotanical gardens based on species from this forest, the creation of private plantations based on the species of this forest, reducing the consumption of wood from this forest and raising sensitization will allow the surrounding population of the Dogo-Kétou forest to better adapt to climate changes which disrupt climate regularities with which all natural resources were accustomed. Young Fon men and the like under 30 (FmM1) and Holli men between 30 and 60 (HoM2) believe that the strategies listed above may also help men adapt better to changing climate. Although not correlated, some populations still believe that ritual sacrifices and prayers are a means that will allow humans to better adapt to the variations generated by climate change.

The analysis of Figure 9 of adaptation measures in relation to socio-ethnic groups in the case of the Pobè forest shows that Nago and

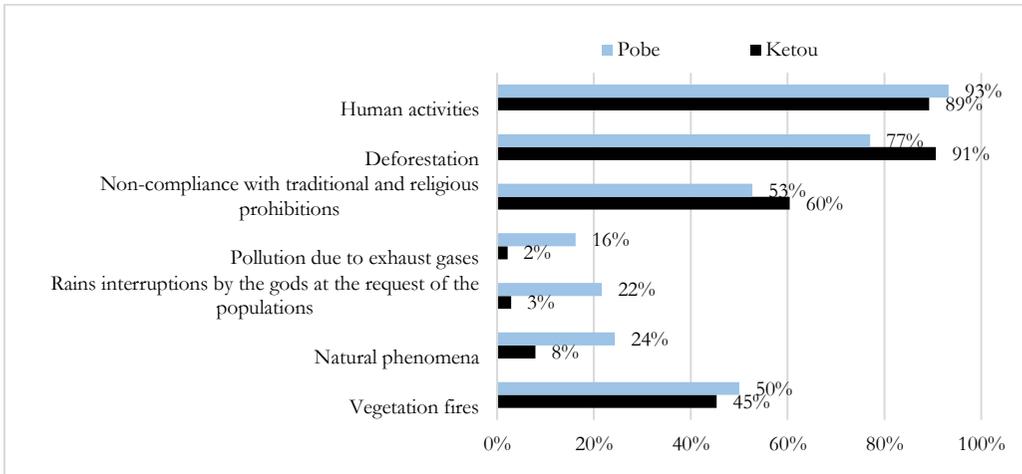
Holli men whose age is between 30 and 60 (NaM2, HoM2) strongly believe that the reforestation of tree species from the Pobè forest, the production of indigenous Pobè species in the nursery, the establishment of family ethnobotanical gardens based on species from this forest, the creation of private plantations based on the species of this forest, reducing the consumption of wood from this forest and raising sensitization, will allow the surrounding population of the Pobè forest to better adapt to climate change which disrupts the climatic regularities with which all natural resources were used to.

In one or other of the municipalities with regard to adaptation strategies, we retain that for better adaptation according to the local perception, these measures must be applied in lifestyle; this involves the reforestation of native tree species from both forests in order to develop in-situ conservation of the species. The production of indigenous Pobè species in the nursery which will facilitate the reforestation of indigenous species, which implies controlling the silviculture of species which will be of priority from the point of view of conservation. The establishment of family ethnobotanical gardens based on species from this forest where populations can reproduce valuable species for their various uses; which requires popularization of reproduction techniques for these species. The creation of private plantations based on the species of this forest which can be done in the fields or areas identified for this purpose.

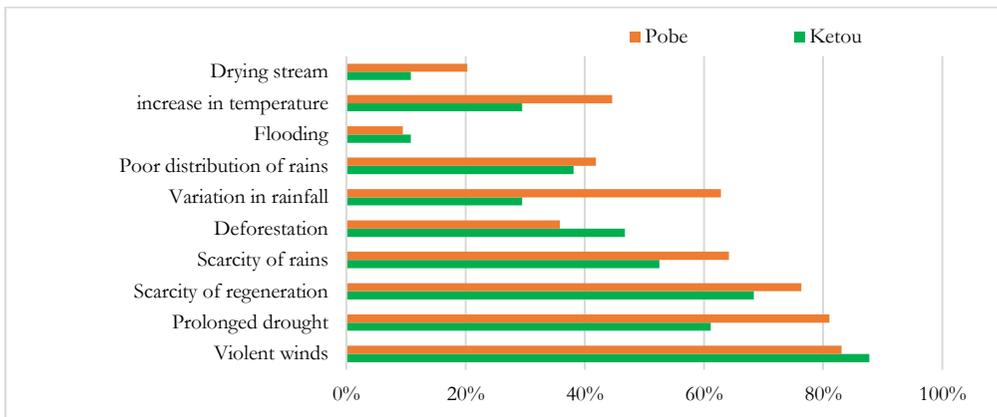
Sensitization campaigns should be organized to reduce the consumption of wood from this forest and the dangers that the population faces in the face of the disappearance of certain species and that it would be better to find alternatives to reduce the rate of 'use of wood from these two natural forests such as domestic gas and techniques for upgrading agricultural biomass waste for the manufacture of fuel briquettes.



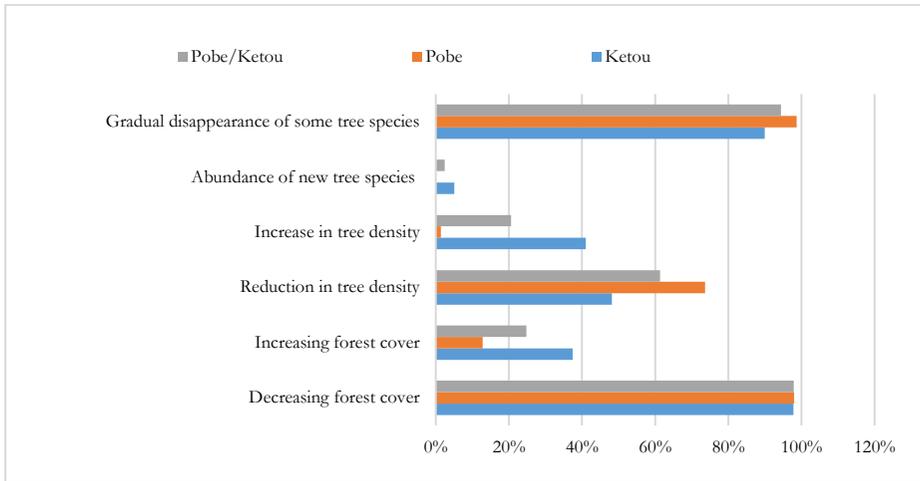
**Figure 2 :** Perceptions of climate change.



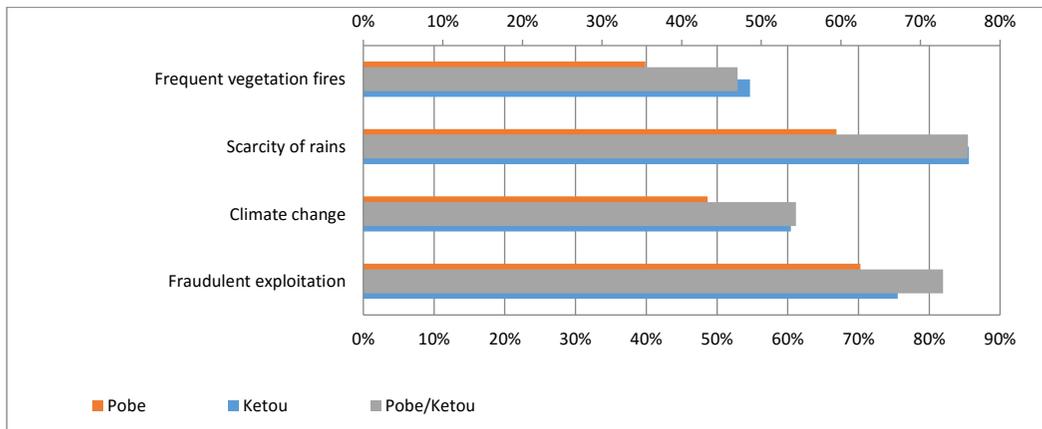
**Figure 3 :** Perception of the causes of climate change.



**Figure 4 :** Perception of the consequences of climate change.



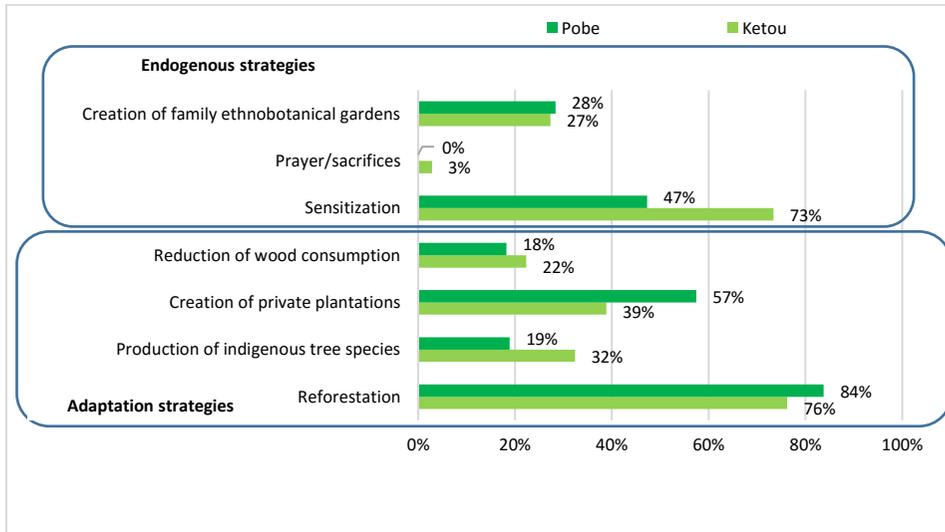
**Figure 5 :** Perception of forest dynamics in the context of climate change.



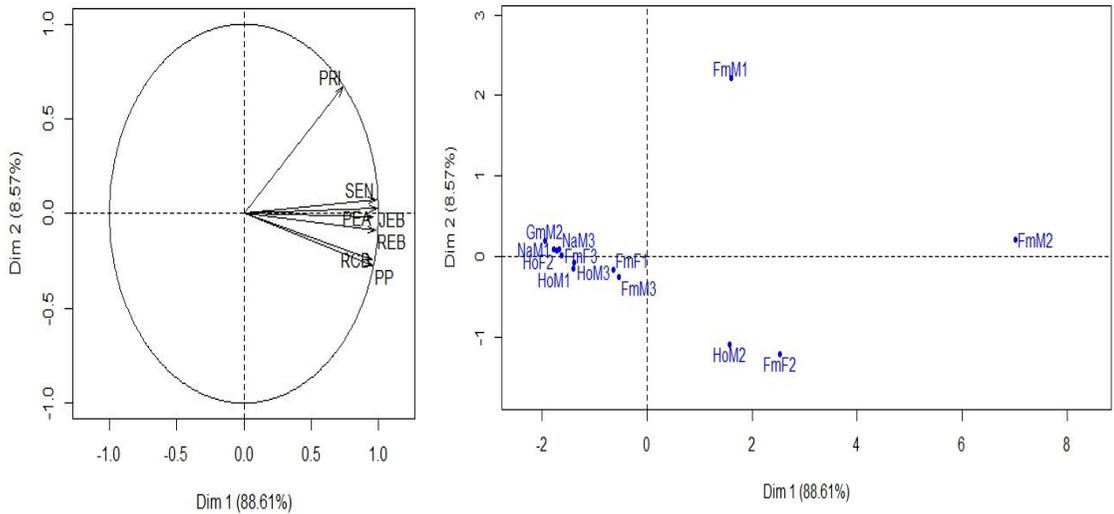
**Figure 6 :** Perception of threats to Pobe and Dogo-Kétou forests in the context of climate change.

**Table 1 :** Comparison of the average use values of the categories of use made of the resources of the Pobe and Dogo-Kétou forests.

Catégories of use	Use Values Kétou	Use Values Pobe	Shapiro-Wilk P-value<	Normality	Kruskal Wallis P-value=
<b>Alimentation</b>	<b>2,52</b>	<b>1,62</b>	2,2e-16	Non	0,0007
<b>Energy wood</b>	<b>2,81</b>	<b>2,24</b>	2,2e-16	Non	0,578
<b>Service wood</b>	<b>2,71</b>	<b>2,03</b>	2,2e-16	Non	0,008222
<b>Feed</b>	<b>2,6</b>	<b>1,95</b>	2,2e-16	Non	0,028
<b>NTFP (non-timber forest products)</b>	<b>2,7</b>	<b>2,32</b>	2,2e-16	Non	0,008696
<b>Medicinal use</b>	<b>2,82</b>	<b>2,72</b>	2,2e-16	Non	0,60
<b>Global use</b>	<b>2,69</b>	<b>2,14</b>	7,07e-12	Non	0,00002



**Figure 7 :** Endogenous strategies used and adaptation strategies to climate change.



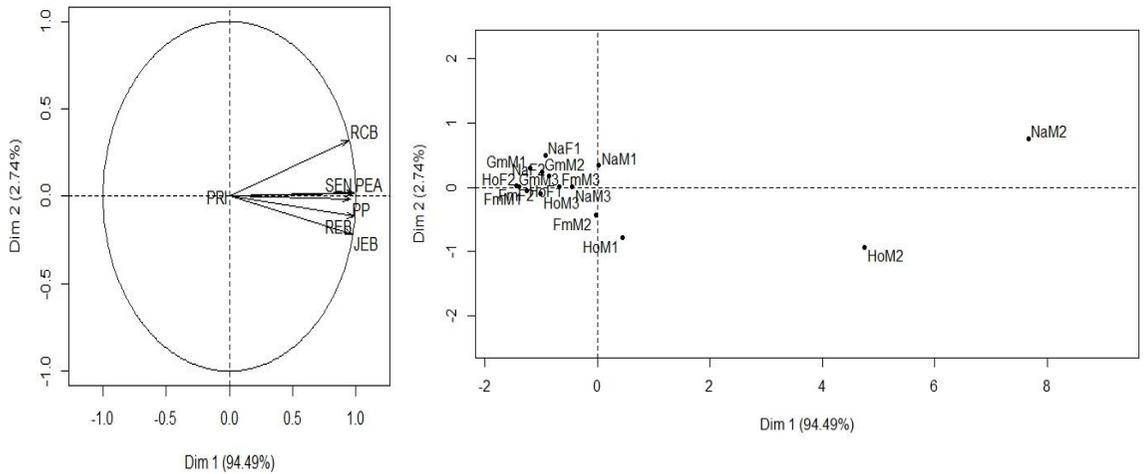
**Figure 8:** Projection of adaptation measures identified in Dogo-Kétou and socio-ethnic groups in the axis 1 and 2 system.

**REB** (Reforestation of tree species), **PEA** (Production of seedlings of indigenous species in nurseries), **JEB** (Establishment of family ethnobotanical gardens), **PP** (Creation of private plantations), **RCB** (Reduction of wood consumption), **SEN** (Sensitization), **PRI** (Prayer and Sacrifices).

Socio-ethnic group : Fm= Fon and assimilated; Ho=Hollidjè ; Na= Nago ; Gm= minority ethnic groups

Age : group (1) young ( $i \leq 30$  years); (2) adults ( $30 < i \leq 60$  years); (3) elderly ( $i \geq 60$  years)

Sex : M=Male ; F=Female.



**Figure 8 :** Projection of adaptation measures identified in Pobè and socio-ethnic groups in the axis 1 and 2 system.

**REB** (Reforestation of tree species), **PEA** (Production of seedlings of indigenous species in nurseries), **JEB** (Establishment of family ethnobotanical gardens), **PP** (Creation of private plantations), **RCB** (Reduction of wood consumption), **SEN** (Sensitization), **PRI** (Prayer and Sacrifices).

Socio-ethnic group : Fm= Fon and assimilated; Ho=Hollidjè ; Na= Nago ; Gm= minority ethnic groups.

Age : group (1) young ( $i \leq 30$  years); (2) adults ( $30 \text{ years} < i \leq 60$  years); (3) elderly ( $i \geq 60$  years).

Sex : M=Male ; F=Female.

## DISCUSSION

### Perception on climate change

The public sensitization of the problem caused by climate change took place at the Earth Summit in June 1992 and on this occasion, more than one hundred and fifty governments signed the United Nations Framework Convention on Climate Change (Lescuyer and Locatelli, 1999). The perceptions recorded in this study such as the strong winds which are more frequent, the irregularity of rainfall the prolonged droughts which reduce the regeneration of trees corroborate the results found by Gnanglè et al. (2012) in Benin. The same indicators were found also by Bello et al. (2017), on the indicators listed by cashew producers to assess climate change in their production area in Benin. For decades, warming has been observed by most populations. This confirms the results of Lescuyer and Locatelli (1999) which show a recent increase in the global average temperature, which has increased by about  $0.8 \text{ }^\circ\text{C}$  in a hundred years. Half of the populations perceived climate change through

long-term temperature rise and decreased rainfall and the drying up of once perennial rivers during the dry season (Gnanglè et al., 2012). These disturbances of annual precipitation through their decrease and their poor space-time distribution are also observed in Côte d'Ivoire by Brou (2005) and in Benin center by Oloukoi et al. (2019). Drought and frequent winds have been perceived also by farmers who have developed adaptation strategies against agricultural land degradation, soil fertility management, water management techniques, crop diversification, in the case to the adoption of organic manure in the context of climate change in Kenya's Kibwezi region (Sale et al., 2014). The rural perceptions found in the study and the results of scientists on the evolution of climatic factors are in line in terms of temperature variation and rainfall (Gnanglè et al., 2012). These observations confirm the existence of a change in the Earth's climate and the reasons are multiple. This study generally indicates that local populations believe that the climate is changing for the worse. The same overall perception were done by Moyo et al.

2012 in Zimbabwe. It appears that climate change is caused by human activities primarily through urbanization, industrialization, construction of infrastructure (FAO, 2020). This is also due to deforestation, vegetation fires which reduce the number of trees available and which play a very close role with the climate (rain, temperatures etc.) because according to the populations, where there is less trees, it is hotter and it rains less, which prevents them from carrying out their rural activities. Other reasons although less known by the majority of respondents exist such as pollution from exhaust gases.

### **Perceptual strategy for the fight against climate change**

Approaches aimed at ecosystem resilience can be used for both climate change mitigation and adaptation. However, the population is implementing endogenous strategies for adapting to climate risk management through individual and collective prevention measures. Among these strategies, the religious prayer and rituals are endogenous strategies evoked which agree with the results of Traoré et al. (2002). The rituals practiced are reflected here by magico-religious practices through which the producers and *vodoun* priests of endogenous cults cause rain through practices inexplicable by science. The same results were found by Teka and Vogt (2010), in the management of natural risks in coastal areas of Benin where local populations have developed strategies based on ritual and cultural practices lacking in scientific rationality and which cannot be ignored for a modern and secular management of the coast. The creation of botanical gardens and reforestation are findings made in this study to the extent that some of these adaptation strategies are already applied collectively. The case of prayer unlike other strategies is applied individually. Traoré et al. (2002) and Gnganglè et al. (2012) made the same remark. In some regions in the south of Benin, the rituals practiced for gods within the forests have enabled some of them to be sacred, which has given birth to the sacred forests in Benin that the neighboring populations strictly respect.

This sacralization has made it possible to preserve these ecosystems thanks to the rituals that are continuously practiced there and the deities they shelter (Kokou and Sokpon, 2006). Sacralization through worship practices has had resilient action for forest conservation as part of sacred forests and this forest conservation mitigates global climate change and increases production of local ecosystem services to promote adaptation of societies (Locatelli, 2010). Adaptation is a process of climate risk management by implementing individual and collective prevention, response and recovery measures (FRB, 2015).

### **Conclusion**

The study of the social perception of climate change in Pobè and Kétou made it possible to understand that the riparian populations of the forests fully understand the changes that the land has been facing for several decades and for times to come. Human activities are highlighted mainly as the primary cause of these changes recorded in the climate with the impact on the forest, the low rate of regeneration of trees listed by 65 % of respondents. It is obvious that the forest of Dogo-Kétou presents a greater vulnerability than that of Pobè linked to uses for food, fuelwood, service wood, fodder, NTFPs and medicinal uses. The Pobè forest under the exclusive control of the National Institute of Agronomic Research of Benin presents less degradation than the Dogo-Kétou forest. The populations identified adaptation strategies through the reforestation of forest species, the creation of private plantations of indigenous species, the production of seedlings of indigenous species in nurseries, the establishment of family ethnobotanical gardens, the reduction of consumption. Wood for the benefit of domestic gas, sensitization raising and for a certain population prayer and sacrifices as means to better adapt and to present good resilience in the face of climate change.

### **COMPETING INTERESTS**

The authors declare that they have no competing interests related to this manuscript.

## AUTHORS' CONTRIBUTIONS

JCG, Faculty of Agricultural sciences of the University of Abomey-Calavi, is the supervisor who monitored and evaluated the data collection and this manuscript writing.

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