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Scientific Research and Essays

*Full Length Research Paper*

# Assessment of ecosystem services in the Wildlife Reserve of Togodo (South East of Togo, West Africa) and vulnerability-adaptation of surrounding communities to climate variability and change effects

**Jérémie Kokou Fontodji[1*], Kossi Adjonou[1], Kossi Novinyo Segla[1], Kodjo Napo[1], Komla Elikplim Abotsi[1], Adzo Dzifa Kokutse[1], Regina Sagoe[2] and Kouami Kokou[1]**

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**This study aims at contributing to the vulnerability and adaptation to climate changes (CC) analysis of bordering communities of Togodo Reserve, in order to enhance their resilience. Specifically, the present study attempted to (i) identify the climatic hazards of the WRT; (ii) determine the impacts of climate variability and change on their livelihoods; (iii) assess the socio-economic vulnerability of these communities to food insecurity in relation to CC; and (iv) identify indigenous adaptation strategies to control the effects of CC. The methodological approach used is based on a factual research and a field investigation. The investigation is conducted in two villages around the reserve, namely Dévé and Gbohoulé. The results showed that climate variability and change were appreciated in different indicators by the local communities living around the WRT: Droughts, flooding, high winds and temperature increase with severe consequences on the communities (famine, destruction of tangible and intangible properties, loss of human life, populations' migration). The communities are aware that humans are responsible for these events that have become recurrent from 2007 and occur almost every year. According to them, the causes of climate changes are deforestation (due to overexploitation of timber, fuelwood and shifting agriculture), bush fires, rapid increase in population, anger of gods due to irregularities of sacrifices and violations of customs. The communities are vulnerable to main climatic hazards and suffered from food insecurity. The factorial correspondence analysis (FCA)) carried out shows that the perception of the degree of exposure of households to risks depends on their standard of livelihood. Facing these climate events, the populations develop many adaptive strategies of which most are consistent with the national orientations and strategies. These adaptive strategies must be reinforced and supported in order to reduce the vulnerability of these populations to climate changes.**

**Key words:** Climate variability and change, communities, livelihood, vulnerability and adaptation, Wildlife Reserve of Togodo.

## INTRODUCTION

Climate change (CC) is the current major threat for the environment and socio-economic development in most countries in the world, especially in developing countries (König et al., 2013; Seaman et al., 2014). Indeed, developing countries, particularly those in Africa are the most vulnerable to climate change and variability because of the limited adaptive capacities of these population and their great dependence on natural resources (Mwale et al., 2015; Ezra, 2016; Vogt et al., 2016; Dumenu and Obeng, 2016).

In Sub Saharan Africa (SSA), more than 90% of the population depends on rain-fed crop production and pastoralism to meet their basic food supplies (Patt and Winkler, 2007; Calzadilla et al., 2013). Thus, the gross domestic product of this sub-region, across food production, depends directly on climate and in particular on rainfall (Verdin et al., 2005, Ziervogel et al., 2008). Moreover, Africa is a continent with varied agro-ecological and geographical characteristics. Therefore, the impacts of climate change are considerably different from a country to another across the continent, and even from a point to another within the same country (Liu et al., 2008). Some scenarios indicate that Africa may lose about 50% of its revenues related to agricultural production due to climate changes (Mendelsohn et al., 2000), with extreme weather events (like drought, heat waves and flooding) which are expected to be more frequent and severe, and with increasing risk to health and life (Few et al. 2004; McMichael et al., 2004). So, the natural ecosystems will be increasingly affected, reducing their effectiveness to provide services to local populations in West Africa.

In Togo, the third national communication on climate change (TNC) reported that between 1961 and 2012, temperatures increased from 0.69 to 1.2°C and the rainfalls decreased overall with amplitude ranging from 3.29 to 81 mm (MERF, 2015). These changes are bringing up floods, temperature rise and/or rainfall deficit with severe impacts on the economic livelihood of the local communities. According to Togo's second national communication on climate change (SNC), agricultural losses caused by floods were estimated at 633,994.48 dollars in 2008 (MERF, 2010). Scenarios indicate that the CC may lead to agricultural losses (MERF, 2010) and could impact forest goods and services availability with long term socio-economic consequences for local populations (UIFRO, 2010).

For instance, communities around protected areas are more vulnerable because forests are the mainstay of their livelihoods through ecosystem services and cultural values. This is the case of the Wildlife Reserve of Togodo (WRT) in southeastern Togo. Located in a very populated area, the WRT contributes to the local economy by creating jobs, processing and marketing of forest products for a large part of the surrounding populations in Togo and Benin. It is about forest wood products (FWP) and non-wood forest products (NWFP). Among the WFP, there are fuelwood (firewood and charcoal) and timber. But the NWFP harvested from the forest are bush meat (reptile, hare, francolin, greater cane rat, snail, cobe, insects, etc.), liana, straw, medicinal plants (leaves, roots, bark), honey, fruits, mushrooms, etc (LBEV, 2013). Timber, fuelwood, lianas, and straw are collected most of the time for local use (timber, lianas, and straw for construction and firewood as source of energy of the household). On the other hand, medicinal plants and hunting products are partly used locally and partly sold on the neighboring markets. It should be noted that local communities mostly women, live partly on medicinal plants trade. However, the proper functioning of this ecosystem remains intimately linked to both climatic and meteorological events and to the dynamics of all these surrounding populations. Thus, the conservation of the WRT forest is currently a huge issue due to the heterogeneity of anthropogenic and natural pressures (Adjonou et al., 2016). Global warming and anthropogenic activities (crop intensification, illegal logging, charcoal production and intensive firewood exploitation) are the threats of this protected area.

In order to understand the real impacts of climate variability and change on the livelihood of communities living around the WRT, as well as the indigenous adaptation strategies developed by these communities, this study is conducted to evaluate the vulnerability and adaptation to CC of the surrounding communities of Togodo Reserve. Specifically, it attempted to (i) identify the climatic hazards of the WRT; (ii) determine the impacts of climate variability and change on their livelihoods; (iii) assess the socio-economic vulnerability of these communities to food insecurity in relation to CC; and (iv) identify indigenous adaptation options to control the effects of CC.

## MATERIALS AND METHODS

### Description of the study area

The Wildlife Reserve of Togodo (WRT) is located between 6°23’ and 7° Northern latitude, and between 1°23' and 1°34 Western longitude (Figure 1). The area is a large rolling plain (maximum altitude 90 m above sea level). The only noticeable land form is a hill which rises to 228 m. The river system is part of the sedimentary basin of the Mono River, including the tributaries of the right bank. It is composed of two entities including the classified forest of South Togodo (18000 ha, classified by the Act n° 354/EF of 07/04/1952) and the classified forest of North Togodo (13000 ha, classified by the Act n° 174/EF of February 26, 1954), that is, a total area of 31000 ha. According to the Act n° 003 MERF/CAB of May 3, 2005, a part of the protected area of about 6000 ha was reassigned to the population. By the same Act, the southern part (classified forest of South Togodo) became the National Park with 15000 ha and will be assigned the following functions:

(i) Protection of the relict forests for spiritual, scientific, educational,

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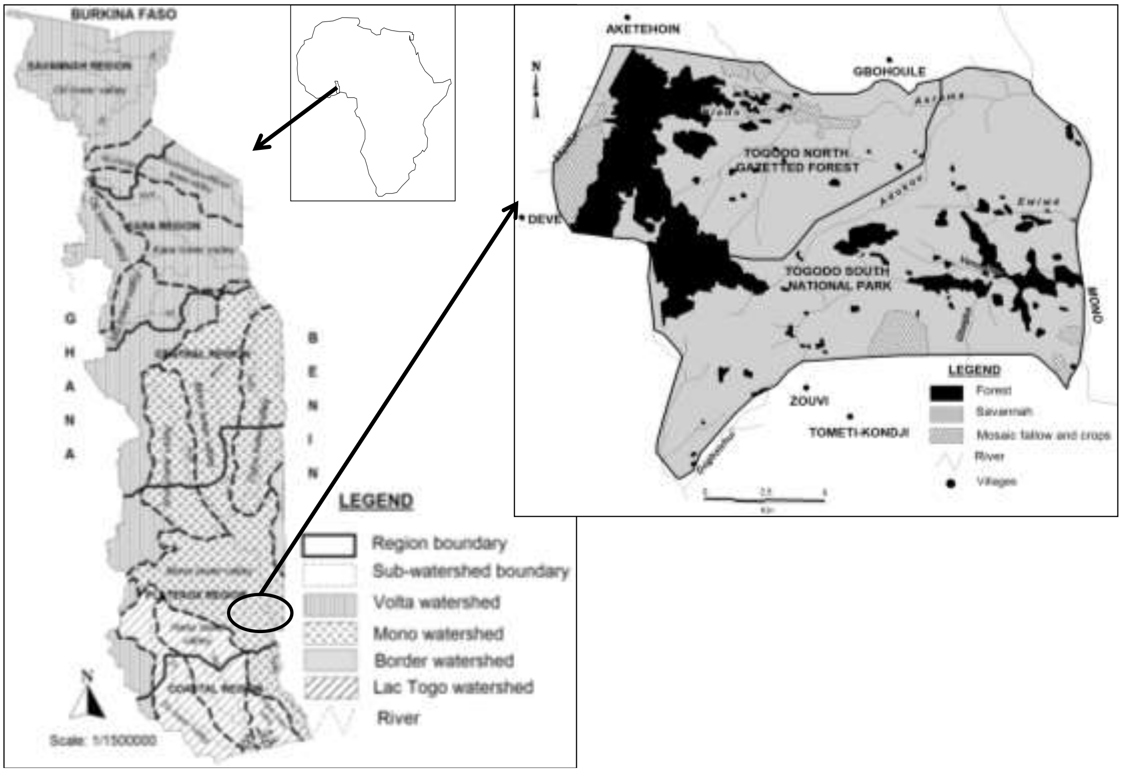


**Figure 1.** Location of the Wildlife Reserve of Togodo.

recreational and tourism purposes;
ii) Sustainability of the ecological, geomorphologic, sacred and aesthetic components under the natural conditions;
iii) Provision of stability and local economic diversity.

The area has a sub-equatorial climate, with a long rainy season from March to July (maximum in June) and a short rainy season from September to October (maximum in October). These two rainy seasons are interrupted by a long dry season and a short dry season, giving therefore a bimodal rainfall pattern including two maxima and two minima which are unequally high (Figure 2). According to Köppen classification, this climate corresponds to the AW type of tropical forest or savanna without winter with 5 to 3 ecologically dry months (Demangeot, 1999). The average annual rainfall ranges from 1000 to 1200 mm and is distributed over 70-80 days. The relative humidity is about 75% in average whereas the annual average temperature is around 27°C.

Human occupation of this area is quite old, and includes various ethnic groups settled in the region for more than three centuries (Abotchi, 1997):

(i) Adja-Tado ethnic group: represented in the North of Togodo area in the villages of Gbohoulé and Akétéhuin and in the South East at Tométi-Kondji (Figure 1);
(ii) Ewe ethnic group: settled in the Western part of the reserve, Notsé being the original centre of this ethnic group. They founded the village of Dévé;
(iii) Ouatchi ethnic group which occupies the South West quarter of the area, at the level of Kouvé and Zouvi.

Other ethnic groups, qualified as non-native, have been recently established:

(i) Adja-Ehoué ethnic group: their immigration from Benin began in the nineteenth century but mostly increased from 1920 and considerably increased from the 60s. In some cases, like in Gbohoulé, they are considered the largest community (Abotchi, 1997);
(ii) Kabie-Losso ethnic group: these emanate from the northern part of Togo whose migration in the area is very recent.

These successive waves of settlement resulted in an increase in the local population. According to the fourth General Census of Population and Housing (RGPH4) of 2010, the population density ranges between 100 and 150 inhabitants/km$^2$ (INSEED, 2011). This population, composed of a mosaic of ethnic groups, has another important feature which is a high population growth around 3%. This population with rapidly demographic change is mainly agricultural (22,318 urban dwellers against 135,108 rural dwellers). This population practices prescribed burning extensive agriculture crops, relying mainly on family labour. The main crops are corn in the first season, from April to July and cotton in the second season, from June to December. The area is often referred to as "granary of Togo" and supplies the large coastal cities with foodstuff. It is also the largest producer of cotton (MAEH, 1999). In addition, the palm oil planting is particularly developed in the area.

### Data collection

#### *Choice and characteristics of the sample*

The large agglomerations around the WRT are Aketehoin, Dévé, Gbohoulé, Kouvé, Tométi Kondji, and Zouvi with a total population of 245 600 inhabitants (INSEED, 2011). In addition, about 25% more of the populace living in the Beninese territory depends on the WRT.

The survey focused on two villages selected based on their close

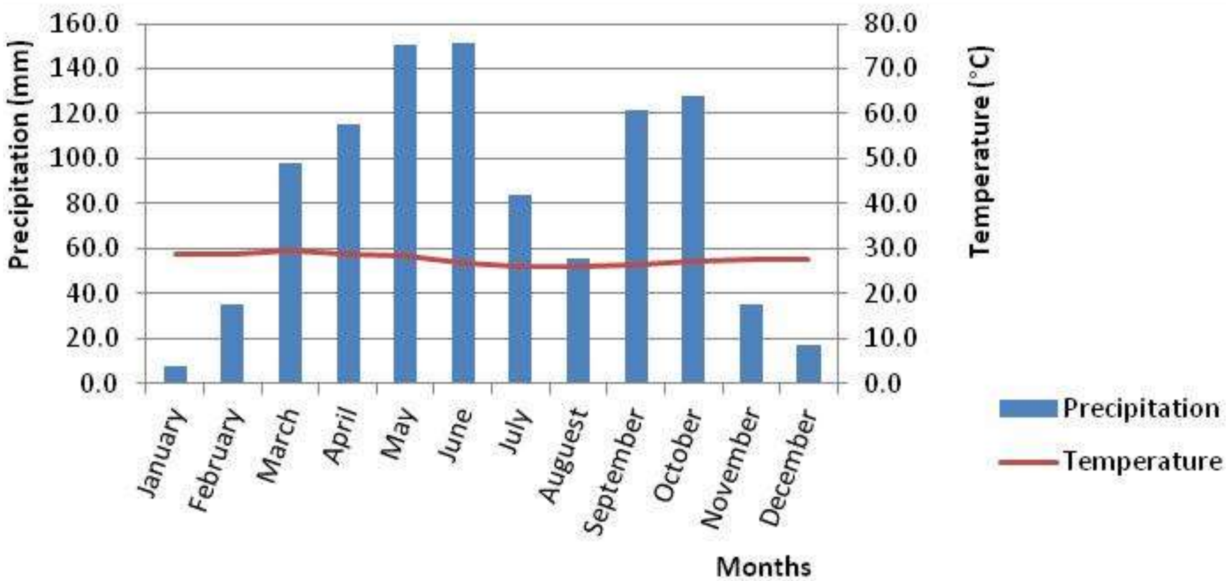


**Figure 2.** Temperature and precipitation of the station of Tabligbo (1971-2000). Data sources: Direction Générale de la Météorologie Nationale.

proximity to the Togodo Reserve, the diversity of the natural environment that includes both forests and savannah and that represent the two main ethnic groups of the area. It is located in Deve forest area and 90% occupied by the Ewe and Gbohoulé located in the savannah zone and 99% occupied by the Adja (Table 1). The average size of household is higher in Gbohoulé (13.00±7.09) than in Dévé (5.72 ±2.57). Almost the totality of these populations lives permanently in the areas. Whatever their standard of living, the main source of households' income is agricultural activity that employs more than 80% of the active population of Gbohoulé and of Dévé.

***Data collection tools***

A survey guide and questionnaire are used to collect survey data. Data collected during the investigation are:

(i) WRT ecosystem services to communities;
(ii) The historical climatic events of the study area and their chronology;
(iii) Population perceptions of climate variability and climate change;
(iv) The main resources available to communities;
(v) The impacts of weather hazards on resources;
(vi) Household vulnerability to food insecurity due to climate variability and climate change;
(vii) The adaptation strategies developed by the communities.

***Data collection methods***

Focus groups discussion and individual interview are used to collect survey data according to the sections of the interview guide and questionnaire.

**Focus groups discussion (FGD)**

These were done with 10 opinion leaders per each village giving a total of 20 persons for the two villages. These FGD form the basis for the development of the historical profile of climate events of the villages selected (Figure 3). It helped to establish the chronology of the major climatic events of the study area, mapping of resources, and identifying the main community climate exposure units. The same FGD were used to identify the causes and consequences of climate changes.

**Individual interviews**

Individual interviews were conducted using semi-structured questionnaires with the heads of households to collect data on the use of forest resources (ecosystem services), the farmer's perception of climate variability and change, impacts of climate change on resources and adaptations strategies. The choice of households was made in a random manner after having classified the households in three class of standard of living (high, average and low) (Tschakert and Sagoe, 2009). This classification is done with the support of opinion leaders on the basis of the following indicators:

i) a household is considered as having a high standard of living if it possesses properties such as corn mill or car or motor cycle, more than 10 ha of palm tree plantations, house built with cement, and a large family [more than 10 persons];
ii) a household is considered as having an average standard of living if it possesses properties such as a motor cycle, a house built with cement, less than 10 ha of palm tree plantations and whose family is of an average size [between 5 and 10 persons];
iii) a household which is considered as having a low standard of living has no oil palm plantations, no motor cycle, no house built with cement and whose family size is small [less than 5 persons].

In total, 54 households of which 25 in Dévé and 29 in Gbohoulé were investigated. In assessing household vulnerability to food security in relation to climate change, the main reasons of food shortage were first discussed with the Households' head. They listed the 8 main problems they face or think to make their


**Figure 3.** Design of the historical profile of climate events at Gbohoule.

**Table 1.** Distribution of the population according to ethnic group.

| Characteristics | Modality | Number of people (%) | |
|---|---|---|---|
| | | **Dévé** | **Gbohoulé** |
| Ethnic group | Ewe | 90.91 | 0.26 |
| | Adja | 4.90 | 99.74 |
| | Ana | 4.20 | 0 |

household more vulnerable to food shortage. Factors like health status, educational level, income, unstable employment, ecosystem services, the role of women and survival strategies were considered.

To conceive the map, a big paper is folded in 8 parts to obtain 8 axes that cross in the middle and the edges of the axes are joined in the form of a spider web by a pen. The 8 main stress factors are written one by one on the axes. Each axis represents therefore a stress factor. Each of the axes is subdivided in 5 equal parts graduated from 0 to 5 (0 = is not a problem, 1 = almost negligible, 5 = fatal). The respondents were asked to score for each of the 8 main problems their degree of vulnerability on the scale of 0 to 5. The scores are made using cereal grains or pebbles for better visibility and understanding because of the low level of education of most respondents. The map is made separately with the man and the woman. Then, the two sexes came together to discuss the future of their children.

Field observations also made it possible to triangulate survey data. The meteorological data (daily rains, monthly average wind speeds) of the Tabligbo station are also collected at the General Direction of National Meteorology (DGMN) in Lomé to check the farmer's perception on climate variability and change. The data collected are over the period from 1961 to 2014 (55 years); also, the data from 2015 to 2017 are not yet available.

## Data analysis

### *Risk analysis*

The impact matrix was used to identify the consequences of climate hazards on the main resources available to communities (exposure units) through mental representations. It consists in a cross between climate hazards and possible consequences they would have on the exposure units.

#### *Meteorological data analysis*

The calculation of the indices and parameters characterizing the variability and the climate change was done using the software INSTAT + 3.36. It allows the validation of farmers' perception on climate variability and change.

**Lamb's index:** The standardized Lamb index (Vcr) was used to characterize variability and climate change. It highlights the major trends in the time series and allows for better observation of the deficit and surplus periods on a year-to-year basis. Applied to precipitation, the positive values of this index correspond to the wet years, while the negative values correspond to the dry years (Dao et al., 2010). It is calculated from the formula (Equation 1):

$$Vcr = \frac{x_i - x}{\sigma} \quad (1)$$

Where,
$x$i = data i of the annual data series;
$x$ = average of the annual data series over the reference period;
σ = standard deviation of the series of annual data on the reference period.

The reference period (1961-1990) is of choice because it has been marked by different climatic events.

**Duration of the longest dry sequence:** The duration of the longest dry sequence during the rainiest months of the year makes it possible to highlight the pockets of drought during this period. The longest drought duration is found more in the dry month (Sarr and Lona, 2009).

**Frequency of extreme rainfall:** This characterizes the probability of rainfall that can cause flooding. Under the soil and topographic conditions of the plateau region, a daily rainfall is said to be extreme and is likely to cause flooding when the rainfall collected is greater than 55 mm (Issaou, 2015). This frequency (Fr) was determined by the formula (Equation 2):

$$Fr = \frac{100n}{N} \quad (2)$$

Where,
n = Number of rainy days over 55 mm in height;
N = Number of days of rain in the year.

**Average wind speed:** In West Africa and especially in coastal countries, climatic conditions indicate that high winds occur during the wettest months of the year. Thus, the determination of the mean monthly wind velocity during this period allows the detection of violent winds characterized by a speed greater than 4 m/s (Sarr and Lona, 2009).

### Statistical analysis

Pearson's "chi-square" independence test is conducted to assess whether or not a dependency relationship exists between the food insecurity stresses evoked by the respondents, their locality and their standard of living. Thereafter, a factorial correspondence analysis (CFA) is carried out in the R software to know the correlations that exist between the standard of living of households and their degree of exposure to stresses related to food insecurity.
To do this, each stress is coupled with the degree of exposure or vulnerability expressed by each respondent according to his standard of living.

## RESULTS

### Climatic hazards of the study area

#### *Farmers' perception of climate variability and change*

According to the opinion leader, the main disasters linked to climate variability and change in the area of WRT are drought, high winds and floodings. At Dévé, droughts occurred in 1982 and 2007 and caused famine, deaths, damages and migration of populations. The high winds occurred in the years 1974 and 2011 with damages. Floodings occurred in 2003 and 2005 with damages as well (Table 2). Among these disasters, the most memorable and catastrophic are the flooding of 2005, the drought of 2007 and the high wind of 2011 because of the severe damages.

At Gbohoulé, droughts that occurred in years 1977, 1982 – 1984 and 2005 were very severe, especially those of 1982-1984 because of the significant damages (Table 2). On the other hand, violent winds occurred in the years 1968 and 2003 and were very severe in 2003. Floodings occurred from 2007 to 2009 with very high severity in 2007. Of all these climatic events registered in Gbohoulé, the most devastating are the drought of 1977, the high wind of 1968 (loss of human life and wounded people) and the flooding of 2007.

In addition to these three climatic hazards (drought, flooding and high winds), the populations of the two localities recognize a rise in temperature in recent years.

#### *Indicators of climate variability and change based on the meteorological data versus farmers' perception*

From 1961 to 2014 in Tabligbo, the inter-annual variation of rainfall anomalies indicate that the years 1961, 1964, 1969-1977, 1981-1984, 1986, 1991-1994, 1997, 1998, 2000, 2001, 2003, 2005, 2007, 2009, 2012 and 2013 showed a rainfall deficit relative to the average over the reference period and are therefore dry years (Figure 4). In the same period (1961 to 2014), the inter-annual variation in the frequency of extreme rainfall shows that there is a probability that each year of extreme rainfall causes flooding. This probability is high for the years 1972, 1986, 1995, 1996, 2000, 2005, 2006 and 2011 (Figure 5). It should be noted that the floods remain linked to extreme rainfall as well as to the soil and topographic characteristics of the study area. On the other hand, there was an increase in maximum and minimum temperatures, indicating increasingly hot days and hot nights during this period. The 1969-1973, 1983-1998 and 2000-2014 periods correspond to the years of warmest days (Figure 6) and the periods 1968-1970, 1972-1973, 1979-1981, 1983-1984, 1987-1988 and 1990-2014 correspond to the warmest nights (Figure 7). These results are therefore in agreement with the farmers' perception of droughts, flooding, and rising

**Table 2.** Historical matrix of climatic events in the villages around WRT.

| Village | Climate Indicators | Period or year | Indicators description |
|---|---|---|---|
| Dévé | Drought | 1982 | Severe for 6 months |
| | | 2007 | Very severe |
| | High wind | 1974 | Severe |
| | | 2011 | Very severe |
| | Flooding | 2003 | Severe |
| | | 2005 | Severe |
| Gbohoulé | Drought | 1977 | Severe |
| | | 1982-1984 | Very severe |
| | | 2005 | Less severe |
| | High wind | 1968 | Severe |
| | | 2003 | Very severe |
| | Flooding | 2007 | Very severe |
| | | 2008-2009 | Severe |

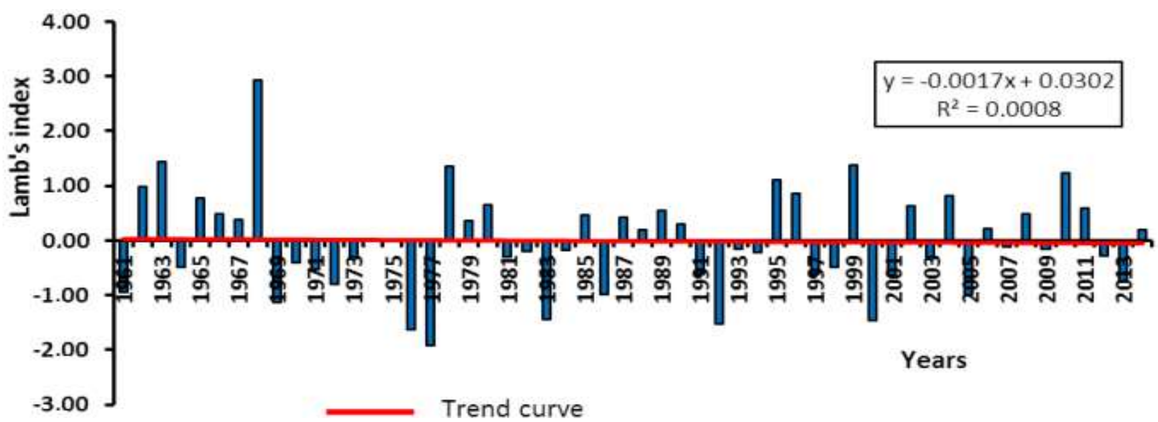


**Figure 4.** Interannual variation of rainfall anomalies from 1961 to 2014 in Tabligbo.

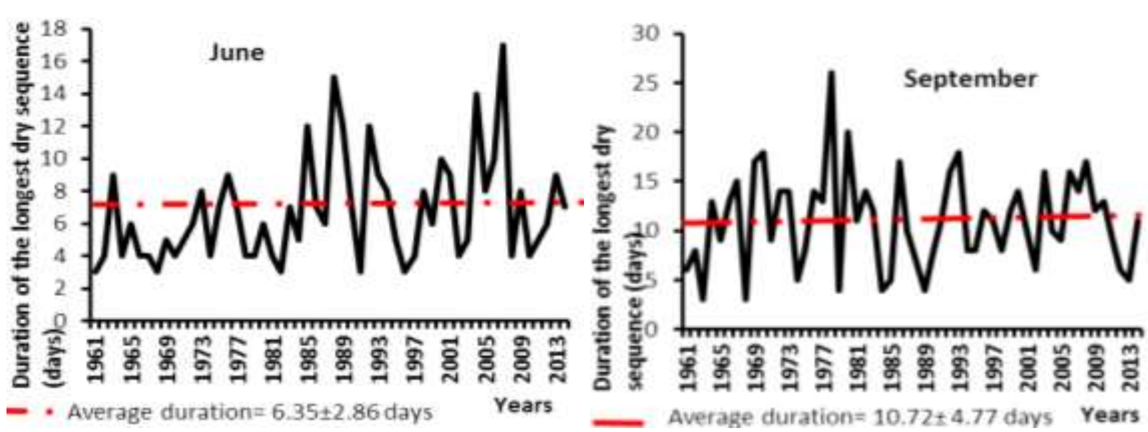


**Figure 5.** Interannual variation of the longest dry season of the rainiest months from 1961 to 2014 in Tabligbo. Data source: DGMN-Lomé.

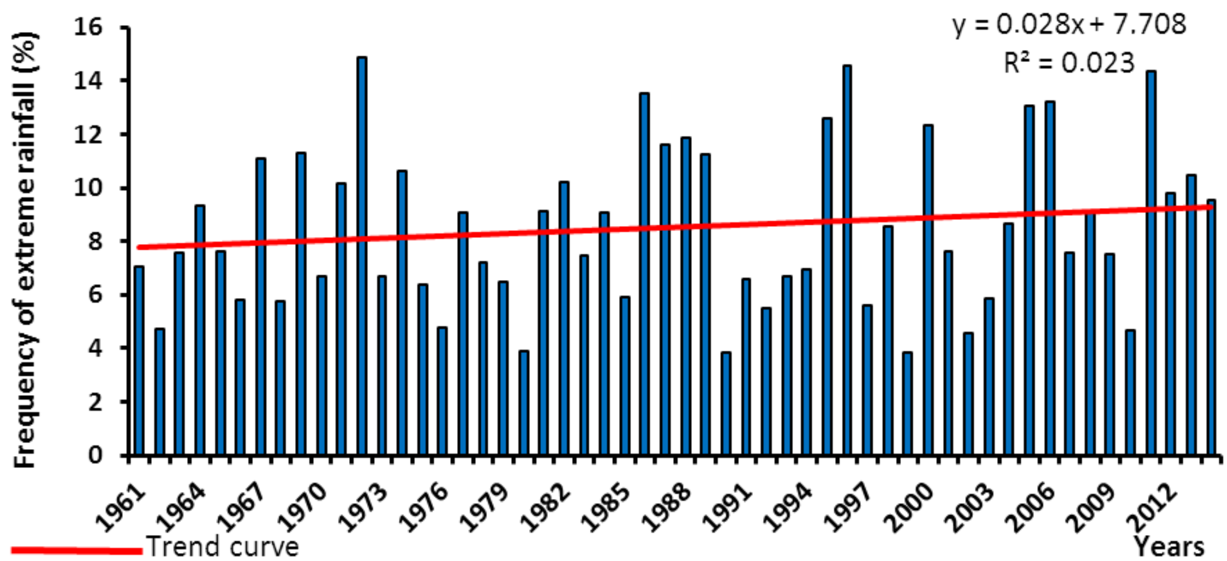


**Figure 6.** Interannual variation in the frequency of extreme rainfall from 1961 to 2014 in Tabligbo.
Data source: DGMN-Lomé.

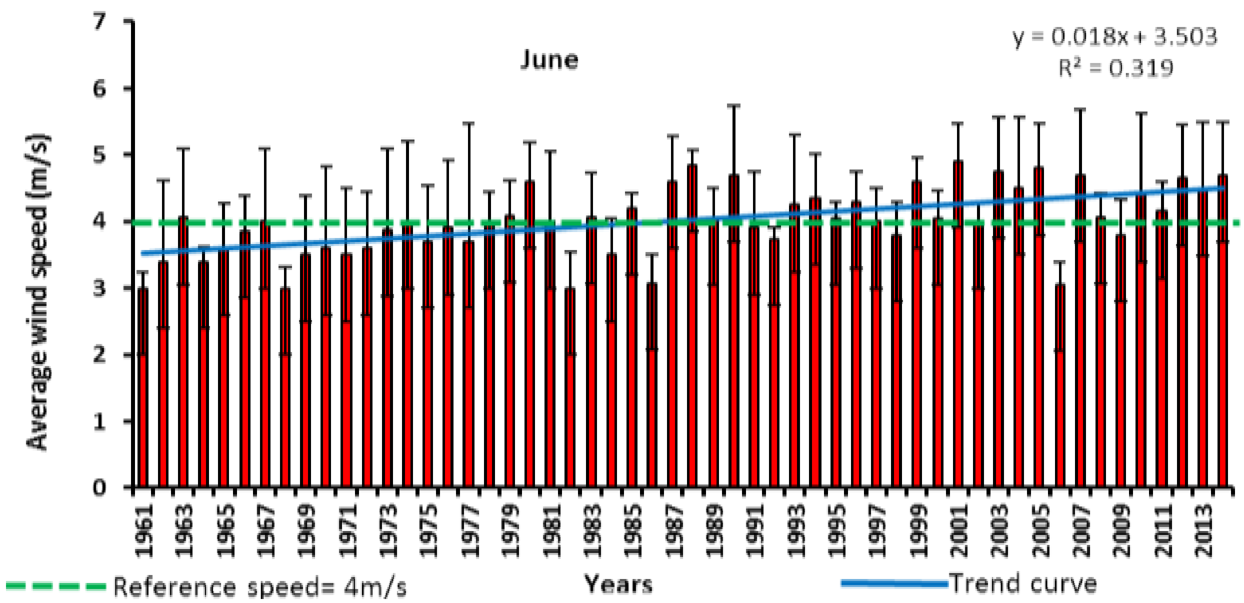


**Figure 7.** Interannual variation of the mean wind speed of the rainiest month from 1961 to 2014 in Tabligbo.
Data source: DGMN-Lomé.

temperatures especially in recent years.

## Impacts of climate variability and change on the resources of the study area

### *Farmers' perception of the causes and consequences of climate variability and change*

According to the communities, the causes of climate changes are deforestation (due to the exploitation of timber, energy wood and shifting agriculture), bush fires, rapid increase in population, anger of gods due to irregularities of sacrifices and violations of customs (Table 3). The opinion leaders are aware that human beings are the main cause of climate change. The resulted consequences are the floods, droughts, high winds, irregular rains that led to the famine, property damages and the losses of human lives which were attributed to gods' anger against humans.

**Table 3.** Matrix of causes and consequences of climate variability and change.

| Village | Causes | Consequence |
|---|---|---|
| Dévé | Deforestation (fuelwood and shifting agriculture) | Irregularity of rains<br>Flooding<br>High winds<br>Famine<br>Death<br>Property damages |
| Gbohoulé | Deforestation (fuelwood, shifting agriculture, timber)<br>Violation of customs (greed, murder, etc.)<br>Irregularity of sacrifices to gods<br>Bush fire<br>Rapid increase in population | Flooding<br>Drought<br>High winds<br>Death<br>Famine |

***Farmers' perceptions of the biophysical impacts of climate variability and change on household livelihoods***

The climate changes had important impacts on the economic livelihoods of households (crops production, animal production and forest resources) during the last 10 years.

**Crop production:** The excess of rains lead to the destruction of crops expressed as crop growth delay, stripping, death of plants for 84% of households in Dévé and for 93% of households in Gbohoulé (Table 4). This is a source of unproductivity and therefore reduction of crops output. In addition, 20% of the populations of Dévé believe excess rains hasten the deterioration of crops. But for the populace of Gbohoulé, 7% of households of this village of which 11% of households had high standard of living and 10% with average standard of living affirm that the excess of rain did not have negative impacts on their crops. The reasons mentioned are related to the crop grown on the slope. Deficit of rain and increase of temperature also have a destructive impact on the crops of 92% of households in Dévé and 89% of households in Gbohoulé (Table 4). However, 8% of households in Dévé and 11% of households in Gbohoulé affirm that their crops did not have any impact linked to temperature increase or to deficit of rain. The reasons mentioned are related to farming in either lowlands or high slopes; where those farming in low lying areas may have good yields during rainfall deficits and high slope farmers may experience good yields in excessive rainfall regimes.

**Animal production:** Too much of rains have impacts on the farmyard animals. The main impacts are the plague and death of animal due to cold for 56% of households in Dévé and for 55% of households in Gbohoulé (Table 5). The deficit of rain and the temperature increase led also to the sickness and death of animals in the proportions of 40% in Dévé and 45% in Gbohoulé. In addition to these impacts, excess of rains or high temperature increases leads to reduced or non-hatchability of eggs.

**Forest ecosystem services:** According to the study population, CC has important impacts on the goods and services harvested in the forest (Table 6). The excess rain brings about flooding that makes forest ecosystem services unavailable as presented by 59% of Gbohoulé and 4% of Dévé households; causing drowning of some animals and scaring others out of their habitats to non flooded areas. Thus, the game became rare handicapping the activity of hunters and resulting in unavailability of the privileged source of protein of the populations (according to 16% of households in Dévé and 28% in Gbohoulé). These flooding cause also the death of some trees (according to 36% of households in Dévé and 21% in Gbohoulé) increasing thus the unavailability of such trees as wood fuel in the long term.

The collection of medicinal plants (roots, barks, leaves) becomes almost difficult (according to 4% of households in Dévé and 17% of those of Gbohoulé). Communities report that during these periods of flooding, access to medicinal plants become less efficient. This constitutes a threat for communities that use mainly plants to cure diseases. Moreover, it is a threat to the economy notably for women living on the trade of medicinal plants. Excess rain also makes lianas very fragile, according to 20% of households in Dévé and only 3% in Gbohoulé. Timber and straw (used to build the homes in the community) become inaccessible and about 10% of households in Gbohoulé believe the forests become inaccessible for ceremonies.

Low rainfall and high temperature increases lead to the scarcity of medicinal plants as a result of leaves dropping and/or the death of species (according to 44% of households in Dévé and 86% in Gbohoulé). Drought leads also to the death of wild animals because of thirst

**Table 4.** Impacts of climatic risks on the crops during the last 10 years in Dévé and Gbohoulé.

| Standard of living of households | Village | Impacts of excess of rain: Destruction of crops (growth delay, death of plants, flower shatter) | Impacts of excess of rain: Deterioration of crops | Impacts of excess of rain: No impact | Impacts of deficit of rain and temperature increase: Destruction crops and low output (flower shatter, death of plant, growth delay, non-germination of seeds) | Impacts of deficit of rain and temperature increase: No impact |
|---|---|---|---|---|---|---|
| Number of Households with high standard of living affected (%) | Dévé | 60 | 40 | 0 | 100 | 0 |
| | Gbohoulé | 88.9 | 0 | 11.1 | 100 | 0 |
| Number of Households with average standard of living affected (%) | Dévé | 80 | 20 | 0 | 80 | 20 |
| | Gbohoulé | 90 | 0 | 10 | 66.7 | 33.3 |
| Number of Households with low standard of living affected | Dévé | 100 | 10 | 0 | 100 | 0 |
| | Gbohoulé | 100 | 0 | 0 | 88.9 | 11.1 |
| General number of Households affected (%) | Dévé | 84 | 20 | 0 | 92 | 8 |
| | Gbohoulé | 93 | 0 | 7 | 89 | 11 |

**Table 5.** Impacts of climatic risks on the animal production during the last 10 years in Dévé and Gbohoulé.

| Standard of living of Households | Village | Impacts of excess of rain: Sickness and death of animal by cold | Impacts of excess of rain: Attack by ants magans | Impacts of excess of rain: Non-hatching and deterioration of eggs | Impacts of excess of rain: No impact | Impacts of deficit of rain and temperature increase: Sickness and death | Impacts of deficit of rain and temperature increase: Non-hatching and deterioration of eggs because of heat | Impacts of deficit of rain and temperature increase: Attack of mange | Impacts of deficit of rain and temperature increase: No impact |
|---|---|---|---|---|---|---|---|---|---|
| Number of Households with high standard of living affected (%) | Dévé | 80 | 0 | 0 | 20 | 60 | 0 | 0 | 40 |
| | Gbohoulé | 40 | 10 | 10 | 40 | 50 | 10 | 10 | 30 |
| Number of Households with average standard of living affected (%) | Dévé | 50 | 0 | 10 | 40 | 40 | 10 | 0 | 50 |
| | Gbohoulé | 70 | 0 | 0 | 30 | 40 | 10 | 0 | 50 |
| Number of Households with low standard of living affected | Dévé | 50 | 0 | 10 | 40 | 30 | 10 | 0 | 60 |
| | Gbohoulé | 55.6 | 0 | 0 | 44.4 | 44.4 | 11.1 | 0 | 44.4 |
| General number of Households affected (%) | Dévé | 56 | 0 | 8 | 36 | 40 | 8 | 0 | 52 |
| | Gbohoulé | 55.2 | 3.5 | 3.5 | 37.9 | 44.8 | 10.3 | 3.5 | 41.4 |

**Table 6.** Impacts of climatic risks on the goods and services drawn from the forest during the last 10 years.

| Climatic risks | Impact on the goods and services drawn from the forest | Frequency (%) | |
|---|---|---|---|
| | | Dévé | Gbohoulé |
| Excess of rain | Goods abundant but difficult to access | 4 | 59 |
| | Scarcity of game | 16 | 28 |
| | Death of trees | 36 | 21 |
| | Inefficiency of medicinal plants | 4 | 17 |
| | Inaccessibility for the ceremonies | 0 | 10 |
| | Fragility of lianas | 20 | 4 |
| Deficit of rain and temperature increase | Fall of leave and death of medicinal plant | 44 | 86 |
| | Death of animals and shortage of game | 12 | 35 |
| | Death of lianas | 20 | 14 |

and therefore the shortage of game (12% of households in Dévé for 34% in Gbohoulé) and the death of lianas (Table 6).

### *Potential impacts of climate variability and change on resources*

As a result of the analysis, the main units exposed to climatic hazards in the study area are: flora, fauna, crops, livestock, populations and dwellings. Both in Dévé and Gbohoulé, the impacts of the main climatic hazards identified on these units are variable. Droughts have caused famine, death, material damage and migration (Table 7). Rising temperature is a factor that causes damage such as non-hatching and rot of egg, seed rot, crop death, and plant diseases. Similarly, violent winds caused damage such as the destruction of crops and houses, the uprooting of trees and even traffic accidents. Furthermore, floods cause significant damage, especially loss of life, collapse of houses and destruction of crops (Table 7).

## Household vulnerability to food insecurity in relation to climate change

### *Identification of risks related to food insecurity*

Households surveyed in the 2 study communities identified the problems listed in Table 8 as possible risk or stressors that may influence food insecurity in their locality. The main problems mentioned by most households are health issues (38.68%), followed by marital conflict (18.16%), social conflict (13.92%), theft (10.38%), dropping out of school (8.02%) and financial issues (7.78%) (Table 8). Few households feel that food insecurity could expose them to stressors related to migration (1.89%), alcoholism (0.71%) and prostitution (0.47%).

### *Exposure of households to risks related to food insecurity*

The $\chi^2$ test carried out on the perception of the exposure of the respondents to the various stressors identified shows an independence concerning the locality (p-value = 0.7855) and the standard of livelihoods of the households (p-value = 0.4781). This can be explained by the fact that in rural areas, the expression of the risks linked to food insecurity does not depend on whether one lives in a forest area (such as the village of Dévé) or in a savanna zone (such as the village of Gbohoulé), nor the household income.

Also, the factorial correspondence analysis (FCA) carried out on the perception of the degree of exposure of households to risks makes it possible to discriminate the exposure of households according to their standard of livelihoods. Most of the information useful for interpreting the perception of these risks related to food insecurity is carried by 2 axes (axis 1 and axis 2) which cumulate a percentage of inertia evaluated at 57.35% for the axis 1 and 42.65% for axis 2 (Figure 8).

Indeed, axis 1 (57.35% of the inertia percentage) contrasts households with average standard of livelihood (Households of Level 2) with those with high standard of livelihood (Households of Level 1) and low standard of livelihood (Households of Level 3) (Figure 8). According to this axis, households with an average standard of livelihood (Level 2) feel very little exposed to social and marital conflict as well as to alcoholism and are moderately exposed to depraved customs, particularly prostitution. On the other hand, households with low and high standards of living feel extremely vulnerable to theft and weakly to prostitution. Some of them feel very vulnerable to social conflict when others think that their exposure to this risk is negligible. For Axis 2 (42.65 % of the inertia percentage), it contrasts households with low standard of livelihood (Households of Level 3) to those with high standard of livelihood (Households of Level 1) (Figure 8). Households with low standard of livelihood

**Table 7.** Matrix of impacts of climate variability and change on resources.

| Unit / Climatic hazards | Flora | Fauna | Crop production | Habitations | Animal production | Population |
|---|---|---|---|---|---|---|
| Drought | Poor regeneration (death of young shoots) | Death of animals | (i) Destruction of crops<br>(ii) Decreasing yield | - | (i) Death of animals<br>(ii) Pathologies | (i) Loss of human lives<br>(ii) Migration of part of the population<br>(iii) Famine;<br>(iv) Diseases |
| Floodings | Uprooting of trees | Death of animals | (i) Destruction of crops<br>(ii) Decreasing yield | Collapse of houses | (i) Death of animals | (i) Loss of human lives ;<br>(ii) Famine |
| Violent wind | Uprooting of trees | Death of animals | (i) Destruction of crops<br>(ii) Decreasing yield | Destruction of houses roofs | (i) Destruction of enclosures<br>(ii) Death of animals | (i) Loss of human lives<br>(ii) Traffic accidents |
| Temperature increase | (i) Fall of Flowers and Leaves<br>(ii) Death of young plants | Death of animals | (i) New phytopathologies<br>(ii) Destruction of crop;<br>(iii) Seed rot | - | (i) Non-hatching and rot of egg ;<br>(ii) Death of animals | (i) Diseases<br>(ii) Production cost increase |

**Table 8.** Stressors related to food insecurity identified by households

| Stressors | Proportion of households (%) | | |
|---|---|---|---|
| | **Dévé** | **Gbohoulé** | **Total** |
| Alcoholism | 1.00 | 0.45 | 0.71 |
| Dropping out | 9.00 | 7.14 | 8.02 |
| Financial issues | 8.50 | 7.14 | 7.78 |
| Health issues | 38.00 | 39.29 | 38.68 |
| Marital conflict | 14.00 | 21.88 | 18.16 |
| Migration | 2.00 | 1.79 | 1.89 |
| Prostitution | 0.00 | 0.89 | 0.47 |
| Social conflict | 16.50 | 11.61 | 13.92 |
| Theft | 11.00 | 9.82 | 10.38 |
| **Total** | **100.00** | **100.00** | **100.00** |

feel very little or lowly exposed to risk of dropping out of school, prostitution and financial issues, moderately exposed to marital conflict and extremely exposed to theft. Households of high standard of live, on the other hand, feel lowly to moderately exposed to alcoholism and migration and highly exposed to financial issues, theft and social conflict.

From the analysis of the FCA, it appears that households of low standard of livelihood and those with high standard of livelihood have differentiated perceptions or even contrary according to their exposure to risk linked to food insecurity. When the poor feels slightly vulnerable to marital conflict and financial problems the rich feels very exposed to these risks plus alcoholism and migration. This can be explained by the fact that, in general and particularly in rural areas, the poor seem to live with a lifestyle with few vital resources, which is not the case for the rich who are used to relatively important vital resources. Thus, it appears that the lack of vital resources does not significantly change the way of life of households with low standard of livelihood, contrary to the households of high standard of livelihood who are forced to face a new way of life that will be very difficult for them to accommodate. This situation could also be explained by the fact that in rural areas, the size of households increases with standard of livelihood, that is

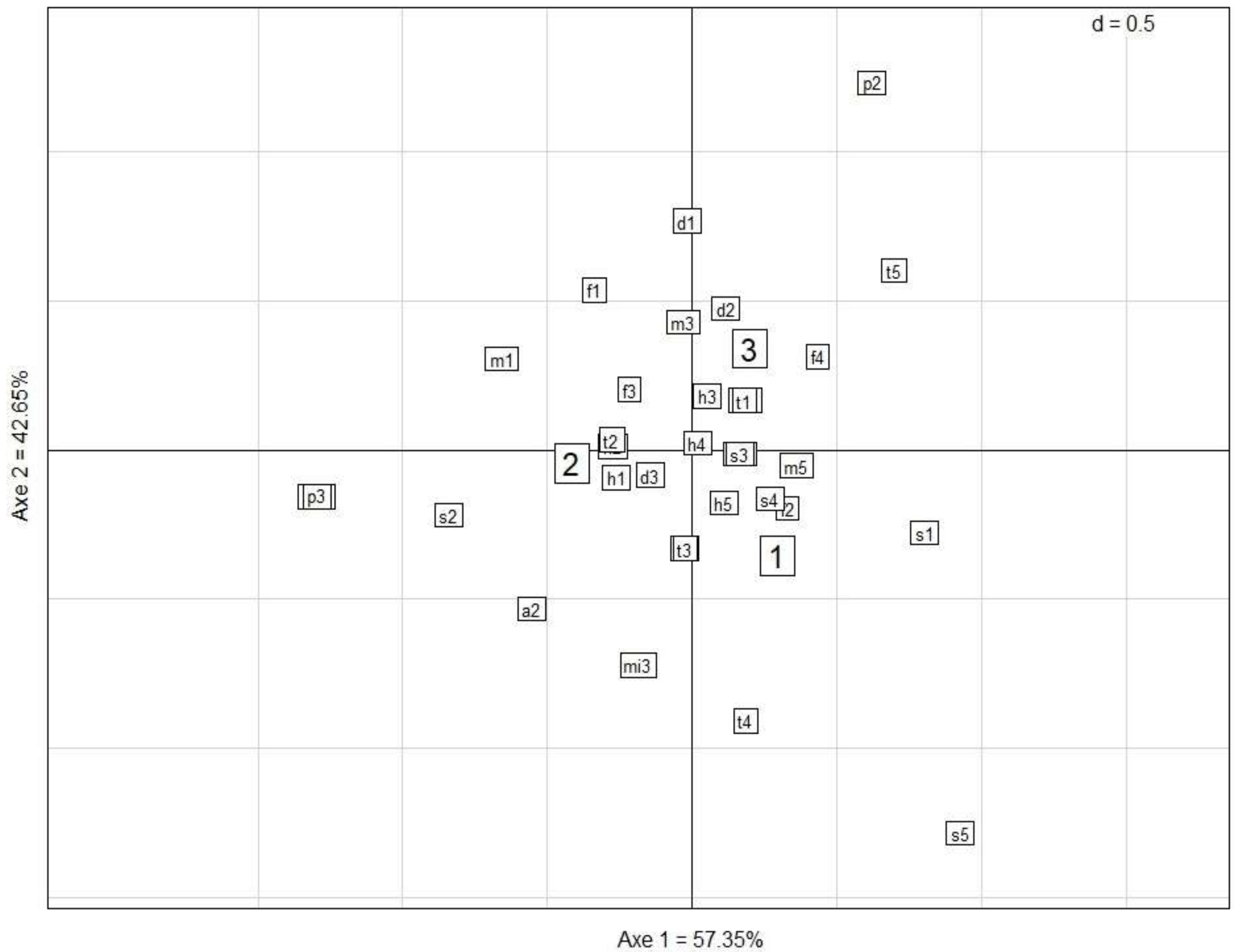


**Figure 8.** Correlations between the standard of livelihood of households and their degree of exposure to stresses related to food insecurity.**Note 1:** Household of high standard of livelihood; 2: Household of average standard of livelihood; 3: Household of low standard of livelihood a: alcoholism; d: dropping out; f: financial issues; h: health issues; m: marital conflict; mi: migration; p: prostitution; s: social conflict; t: theft.

to say that the rich have more dependent persons than the poor. In the situation of a reduction or lack of vital resources, it seems more difficult for the rich to provide for the needs of all those who depend on them (especially since the main source of rural income remains agriculture), hence their perception of their greater vulnerability to the risks of food insecurity.

To control the impacts of climate change and reduce their vulnerability to food insecurity risks, populations develop several adaptation strategies.

## Adaptation strategies developed by the communities

To adapt to the extreme climatic events, the communities developed strategies or adaptive strategies. These adaptive strategies vary from a community to another with different frequencies.

**In case of drought:** re-seeding, construction of water tanks for storing rain water and sacrifices to the ancestors were identified by communities (Table 9). In addition to that, water supply in inexhaustible rivers is mentioned (Yoto), construction of a borehole for the community of Dévé, storage of food (that is, avoid selling the little food that they possess) and tobacco farming (intended for commercialization) which is easily adaptive to drought for the community of Gbohoulé.

**In case of high winds:** the fixing of the base of roofs in sheets against the wall with iron rods and the roofs in straw with pegs were some of the strategies done in Dévé (Table 9). In this community, the opinion leaders informed about the setting up of a green belt around the village.

**In case of flooding:** Raised seedbed technique, digging

**Table 9.** Indigenous adaptive strategies and their frequencies.

| Climatic events | Adaptive strategies | Frequence (%) | |
|---|---|---|---|
| | | Dévé | Gbohoulé |
| Drought | Construction of tanks to store rain water | 38 | 50 |
| | Re-seeding | 16 | 6.9 |
| | Prayer to God/ sacrifices to ancestors | 12 | 6.9 |
| | Go on long distance in search of water | 4 | * |
| | Food storage | * | 6.9 |
| | Farm tobacco | * | 3.5 |
| High winds | Fixing of the base of roofs in sheet against the wall with iron rods and roofs in straw with pegs | 16 | * |
| Flooding | Prayer to God /Sacrifices to ancestors | 12 | 6.9 |
| | Exploit the slope tops/ upland farming | 8 | * |
| | Heating of granaries to avoid the rotting of crops | 8 | * |
| | Build channels in the fields to drain the excess of water | 4 | 6.9 |
| | Do early seedings / early planting | 4 | * |
| | Raised seedbed technique | 4 | * |
| | Roughcasting of huts | * | 3.5 |
| | Farm in second season | * | 3.5 |
| Climatic events and famine | Purchase of food stuff | 16 | 24.1 |
| | Sale of goods (palm oil, breeding products, real estate business) | 8 | 24.1 |
| | Production of palm wine | * | 6.9 |
| | Maneuvering | * | 6.9 |
| | Processing cassava into gari | * | 6.9 |
| | Petty trading | * | 6.9 |
| | Motor taxi | * | 3.5 |
| | Harvestof wild yam | * | 3.5 |
| | Hunting for the sale of bush meat | * | 3.5 |
| | Take loans | * | 3.5 |

*:Option not mentioned in community.

of channels to evacuate the excess of water, early seeding, exploitation of the top of the slope, heating of the granary to avoid the rotting of crops and sacrifices to ancestors in the community of Dévé, practice of hunting, digging of channels in the fields to evacuate the excess of water, sacrifices to ancestors and farming in the second season at Gbohoulé are practiced (Table 9).

When the extreme climatic events occur and cause important damages on the crops with the famine as consequence, the populations sell their goods (palm oil, palm nuts, farm animals and livestock, and land) to buy food. In addition to this, in the community of Gbohoulé, some people resort to the production of palm wine (for their own consumption and for sale), maneuvering, petty trading, driving motor taxi, processing cassava into gari, and hunting as alternate livelihoods to earn income (Table 9).

Adaption strategies' efficiency scores were evaluated in communities and presented in Table 10. The best adaptive strategies (Table 11) are those with scores equal to 2.5 or more on a scale of 1 to 5. In Dévé, the best strategies were as follows: fixing of the base of the roof in sheet against the wall with iron rods and the roofs in straw with pegs, the exploitation of slope tops or planting on slopes, the practice of raised seedbed technique, the heating of granaries to avoid the rotting of crops, the sale of farm goods and properties (palm oil, farm animal and livestock and real estate) for the purchase of food stuff, early re-seeding and prayers to God/sacrifices to ancestors (Table 11).

In Gbohoulé, the best strategies from the point of view of the community members are the processing cassava into gari, the roughcasting of huts, food stuff storage and sell when in high demand (to avoid cheap pricing at harvest), the maneuvering, small trade, the exploitation of planting on high slopes, the sale of goods (palm oil, farm

**Table 10.** Efficiency scores affected by the communities to the adaptive strategies.

| Climatic events | Adaptive strategies | Efficiency score (1-5) | |
|---|---|---|---|
| | | Dévé | Gbohoulé |
| Drought | Prayer to God/ sacrifices to ancestors | 2.7±0.1 | 1±0 |
| | Re-seeding | 2±2 | 2±1.4 |
| | Construction of tank to store rain water | 1.6±0.7 | 2.73±0.6 |
| | Go on long distance to fetch water | 1±0 | * |
| | Storage of food stuff | * | 4.5±0.7 |
| | Tobacco farming | * | 1±0 |
| High winds | Fixing of the base of roofs in sheet against the wall with iron rods and roofs in straw with pegs | 4.3±1 | * |
| Flooding | Prayer to God/Consult fetishes | 2.7±2.1 | 1±0 |
| | Exploit the hill slope top farming | 4±0.1 | 4 |
| | Heating of granaries to avoid the rotting of crops | 3.8±1 | * |
| | Dig channels in the fields to drain excess of water | 1±0 | 3.5±2.1 |
| | Do early seeding | 3±0 | * |
| | Raised Seedbed technique | 4±0 | * |
| | Roughcasting of huts | * | 5±0 |
| | Farming in the second season | * | 2±0 |
| Climatic events and famine | Purchase of food stuff | 3.8±1 | 2.3±1.7 |
| | Sale of goods (palm oil, farm animal and livestock, real estates) | 2.5±0.7 | 3.9±1.6 |
| | Production of palm wine | * | 3±2.8 |
| | Maneuvering | * | 4.5±0.7 |
| | Processing cassava into gari | * | 5±1.4 |
| | Small scale trade /petty trading | * | 4.5±0.7 |
| | Motor taxi | * | 1±0 |
| | Harvest of wild yam | * | 1±0 |
| | Hunting | * | 5±0 |

*:Option not mentioned in community.

animal and livestock, real estate) for the purchase of food stuff, the digging of channels in the fields to evacuate the excess of water, the production of palm wine and the construction of water tanks to store rain water (Table 11).

## DISCUSSION

This study showed how local communities around a protected area in southern Togo perceive climate events. The events mentioned by the local communities in the two villages studied are floods, drought, high winds, rising temperatures. It should be noted that these climate events have become recurring from 2007 and occur almost every year. In other African countries such as Benin, Burkina Faso, Nigeria, Tanzania, farmers reported recurrent flooding, seasonal variability, dry spells, and temperature rise as major threats to their livelihoods (Mongi et al., 2010; Callo-Concha, 2018, Mohammad-Lawal et al., 2012). In addition to those events, Nielsen and Reenberg (2010) and Ouaba (2013) mentioned that in the northern Burkina Faso, farmers reported high winds. Mertz et al*.* *(*2009) and Aberra (2012) also reported the same events in the dry zones of the Sahelian belt notably in Senegal and Niger.

Moreover, the study showed that climate events do not occur in the same way in the villages around the WRT and illustrate the paradox of climate change. Indeed, it appears that when the communities of Gbohoulé, in savannah at the north of the WRT, mentioned the flooding with great damage in 2007, those of Dévé in the forest zone in the west of the WRT reported the drought that occurred in the same year. This phenomenon can be related to the rains in the north and the releases of water from the dam of Nangbéto flooding. Gbohoulé is located between two important rivers (Mono and Asrama) while Dévé is spared. Household perceptions of climate change and variability (floods, drought, high winds, rising

**Table 11.** Best adaptive strategies scores in Dévé and Gbohoulé.

| Village | Adaptive strategies | Efficiency score | Rank |
|---|---|---|---|
| Dévé | Fixing of the base of roofs in sheet against the wall with iron rods and roofs in straw with pegs | 4.3±1 | 1 |
| | Exploit the top of hill slope for farming | 4±0.1 | 2 |
| | Raised seedbedding technique | 4±0 | 3 |
| | Heating of granaries to avoid the rotting of crops | 3.8±1 | 4 |
| | Purchase of food stuff | 3.8±1 | 5 |
| | Do early seedings | 3±0 | 6 |
| | Prayer to God/ sacrifices to ancestors | 2.7±0.1 | 7 |
| | Sale of goods (palm oil, farm animal and livestock, real estates) | 2.5±0.7 | 8 |
| Gbohoulé | Processing cassava into gari | 5±1.4 | 1 |
| | Roughcasting of huts | 5±0 | 1 |
| | Storage of food stuff | 4.5±0.7 | 3 |
| | Maneuvering | 4.5±0.7 | 3 |
| | Petty trading | 4.5±0.7 | 3 |
| | Exploit the tops of hillslope for farming | 4 | 6 |
| | Sale of goods (palm oil, farm animal and livestock, real estates) | 3.9±1.6 | 7 |
| | Dig channels in the fields to drain out excess of water | 3.5±2.1 | 8 |
| | Production of palm wine | 3±2.8 | 9 |
| | Construction of tank to store rain water | 2.7±0.6 | 10 |

temperatures) as mentioned in this study were supported by the observed scientific meteorological data. This correlation between population perception and observed scientific meteorological data is also observed in Burkina Faso, Niger, Tanzania, Bangladesh (Slegers, 2008; Ouaba, 2013; Alam et al., 2017).

The study confirmed human beings as the first responsible for climate change. But respondents argued that the resulting consequences are only due to gods' anger against human. This showed that the populations in rural area are little aware of the role human activity play in climate events thus increasing their vulnerability. The same results were obtained in northern Burkina Faso, where the surveyed populations mainly attributed the causes of climate events to divine anger and natural phenomena (Ouaba, 2013). They argued divine anger to be linked to the non-respect of religious values, lack of prayer and conflicts over access to natural resources. In China, some farmers still did not believe in climate change even though they had perceived an increase in average temperatures, a decrease in average precipitation, or an increase in the frequency of extreme weather events. They expressed that drought and flooding events were normal phenomenon, not caused by climate change and some of them even thought that all of this is God's arrangement (Zhai et al., 2017).

The study found that CC have important impacts on the forest ecosystem services on communities living around the WRT. These findings confirm the work of UIFRO (2010), which shows that African populations depend heavily on forest goods and services and are therefore particularly vulnerable to CC impacts. The communities around the WRT are aware of the negative effects of climate change and their impacts on the reduction of forest ecoystem services. They are also aware that the causes of the decline in forest resources are linked to their activities (agriculture and population pressure). They feel this decrease through several climate events but also through the distance increasingly longer to have access to these ecosystem services. These results confirm those of Mohammad-Lawal et al. (2012), which showed that 90% of the populations in Ekiti State in Nigeria are aware of the CC problem and its effects. They also confirm those of UIFRO (2010), which indicates that CC have already affected many aspects of forest ecosystems in Africa, including tree growth and decline, species distribution, seasonal trends in ecosystem processes, and dynamics of forest species. In some cases, CC has been implicated in the extinction of forest species. UIFRO (2010) adds that in Burkina Faso, for example, local extinction of several species exploited for their non-timber forest products such as *Adansonia digitata, Diospyros mespiliformis* and *Anogeissus leiocarpus* has been attributed to a combination of recurrent droughts and unsustainable exploitation of these species.

As other impacts of these climate events, the populations noted the loss of crops or the decrease of the net yield that exposes them to food insecurity. Other authors have found similar results in others countries. Ouaba (2013) indicated that climate events in Burkina

Faso affected agricultural productivity through physical damage to plants (poor growth and death of plants, rot of seedlings and crop), insect attack and appearance of diseases. In Nigeria, Mohammad-Lawal et al. (2012) have shown that agricultural yields before climate change are better than those obtained after climate change. Similarly, Madu and Ayogu (2009) have shown that the rainfall variability arising from CCs has resulted in decreased agricultural yields in the same country. In Tanzania, increased temperatures coupled with droughts increased the incidence of crop attack by pests (Mongi et al. 2010). The poor distribution of rainfall coupled with periods of drought has amplified the problems of water stress and exposed 20 to 30% of the population of semi-arid zones to risk (Mongi et al. 2010). Atedhor (2015) reports that unreliability of rainfall, desertification, temperature increase, grazing, and inaccessibility to credit have a significant relationship to farmers' vulnerability to CC, and therefore constitute the main factors of agricultural vulnerability to CC. The consequence of all the above is the reduction in the supply of foodstuffs, which is accompanied by a surge in prices. This implies that thousands of people who rely on rain-fed agriculture as their main livelihoods are at risk of food insecurity (Mongi et al. 2010). The international community agrees that CC will induce a significant reduction in agricultural productivity in developing countries (Parry et al., 2007). Tropical areas where rainfed agriculture provides 60% of the world's food supply will be most vulnerable to CC (Singh et al., 2011). The increase in temperature will have significant effects (8-30%) on reducing crop yields in dry soils. Consequently, dryland farmers will need to adapt their farming practices to address future environmental and socio-economic constraints (Singh et al., 2011).

In order to control the negative effects of the CCs, communities along the WRT develop a number of adaptation strategies. These results confirm those of Mohammad-Lawal et al. (2012), where the majority of the agricultural population seeks alternative sources of income when climate variability appears unpredictable and others adopt crop late sowing, or change crop varieties to adapt to them. In Burkina Faso and Nigeria, adaptation strategies developed by farmers included changes in the agricultural calendar, the adoption of new or improved varieties, the practice of soil and water conservation techniques, the use of organic manure, the use of fallow, and phytosanitary care (Barbier et al., 2009; Ayanwuyi et al., 2010; Ouaba, 2013). In Tanzania, to adapt to the effects of CC, the majority of farmers have developed mechanisms such as logging and seeding at different times of the season (Mongi, 2010). Elsewhere, farmers' response to the negative effects of CCs is reflected in the expansion of cropped areas to compensate for losses in yield caused by flooding (resulting in reduced fallows), the use of more resistant crops to flooding such as sorghum and cassava, and diversification of sources of income, including charcoal production, casual employment (Gbetibouo, 2009). It should be noted that adaptive capacity is influenced by many factors such as knowledge of and perceptions about climate change, and access to appropriate technology, institutions and policies (Adger et al., 2003; Sivakumar et al., 2005; Mertz et al., 2009; Hisali, 2011; Brulle et al., 2012; Adebo and Sekumade, 2013; Zampaligré et al., 2014; Alam et al., 2016). In Togo, as in other countries of sub-Saharan Africa, many non-climatic factors such as poverty, inadequate resources and lack of preparedness of populations, the lack or insufficiency of warning system and rainfall forecasts, the low level of education expose people to the impacts of climate variability and change and limit their adaptive capacity (Reid and Vogel, 2006; Ozor, 2010; Speranza et al., 2010; Roudier et al., 2012).

It should also be noted that some farmers believe that prayer and sacrifices to gods are part of the adaptation strategies to combat the impacts of CC. The same observations are made in Burkina Faso and Kenya (Benoît, 2008; Mertz et al., 2010; Speranza et al., 2010; Ouaba, 2013). Most of the adaptive strategies evoked by the populations living around the WRT are in line with the strategic and planification orientations of the Togolese government as stipulated in the planification documents (MERF, 2010; MERF, 2015).

These orientations emphasize farmers' awareness of the necessity of re-seeding after the first rains; the promotion of early and resistant varieties to droughts and to new parasites; the promotion of raised seedbed and mound techniques to drain wet lands; the increase of the soil fertility with the nutritive elements and maintain more moisture during the dry season; and the promotion of the diversification of revenue generating activities like the transformation of farm products, small scale animal production and beekeeping.

In addition to these orientations in line with the indigenous adaptive strategies identified, other planification documents notably the Agricultural Policy Document (MAEH, 2015) and the formulation of the national priorities to be submitted to FEM 5 (MERF, 2011), contain other strategic orientations that can be promoted in all the communities in order to reduce their vulnerability to climate changes. It is about:

(i) Reinforcement of the capacities of actors on climate change;
(ii) Setting up of health infrastructures having necessary materials and equipments for the medical care of populations in rural areas;
(iii) Creation of alternative and revenue generating activities for the charcoal producers in order to drive them from this activity;
(iv) Reforestation and participatory forest management;
(v) The study of the seeding dates per species and in relation to crop cycle and agroecological zones and the setting up of an adapted farming schedules;
(vi) The promotion of deep plowing techniques;

(vii) Follow up support for the application appropriate cropping techniques (legume, cereal, and others, etc.);
(viii) The promotion of the setting up of deep radicular systems of crops;
(ix) The promotion of appropriate varieties to new climatic conditions and to new characteristics of soils;
(x) And the management and the valorization of deep lands and the promotion of small scale irrigation.

## Conclusion

Climate events such as drought, high winds and floodings were observed to occur in the bordering communities of Togodo Reserve and these have led to enormous damages such as material and sociocultural damages and loss of human life. These events are becoming very recurrent from 2007 and will continue in the years to come according to the community members of the study area. These populations are aware that humans are the main cause of these events that constitute a punishment from the gods. They acknowledge being very vulnerable to climatic changes and to food insecurity. To reduce their vulnerability, they developed indigenous adaptive strategies. Most of these adaptive strategies are consistent with the strategic orientations of the Togolese government. These adaptive strategies deserve therefore to be reinforced and supported in order to reduce the vulnerability of the populations to climate changes. This can be done in the framework of the sustainable management of forests and should be supported by the new modes of governance that take into account the needs of the communities in general.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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