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Vulnerability and adaptative capacity to climate change in five localities riparating the wetlands of the Oti Plain in the north du of Togo

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Abstract— *In the National Development Plan (PND) 2018-2022, particularly in point 1.5, in connection with environmental management, taking into account the fight against climate change has been clearly defined as crucial for the development of Togo based on the National Climate Change Adaptation Plan (PNACC). With this in mind, we have assessed the vulnerability and adaptive capacities to climate variability and change in five localities bordering the wetlands of the Oti Plain. The work consisted of conducting surveys in a participatory manner with the target groups. These surveys focused on the perception of populations and producers of climate change, the shocks experienced, and adaptation measures. Risk indices were calculated. Then we proceeded to calculate the vulnerability or severity indices. The results highlight the irregularity of rains, poverty in general, the poverty of agricultural soils, pockets of drought, the drop in agricultural yields, diseases, and deforestation as the main shocks emanating from climate change. The observation of the populations indicates a clear increase in temperatures and an irregularity in rainfall. The adaptive capacities developed by producers to cope with these multifaceted shocks have been identified and depend on the production sector. Given these results, future investigations should make it possible to deepen the understanding of climate change in all vulnerable sectors. This information will be used to better establish adaptation strategies to climate change, particularly in vulnerable areas.*

Keywords— ***Adaptation, climate change, perception, Togo, wetland.***

I. INTRODUCTION

Climate change has already caused widespread damage to nature and humans, beyond natural climate variability. It is responsible for a widespread deterioration of the functions and structures of ecosystems (terrestrial, freshwater, marine). The increase in the frequency and intensity of several types of extreme weather events (heat waves, heavy rainfall, droughts, etc.) cause irreversible impacts by pushing natural and human systems beyond their adaptation limit. They also cause increasing population displacements. These events expose millions of humans to food insecurity and lack of water, to which children, the elderly, and pregnant women are particularly susceptible (IPCC, 2022).

Aware that the fight against the adverse effects of climate change must be collective, Togo joined the dynamics of the international community in this area, by ratifying the United Nations Framework Convention on Climate Change (UNFCCC) on March 8, 1995 and the Kyoto Protocol on July 2, 2004. Among the actions, and in the direction of the fight against this scourge, in 2009, Togo proposed a National Action Plan for Adaptation responding to questions relating to natural disasters, agriculture, flooding, and coastal erosion (MANATIONTOGO, 2015).

Despite the government's efforts, the vulnerability of populations to climate change has increased in recent years due to the security context coupled with the health context of the Covid-19 pandemic.

Throughout the country and especially in the savanna region, the effects of climate change are more noticeable. Chronic drought resulting from climate variability and change plays an accelerating role in deforestation, poverty, famine, and the cruel lack of drinking water for the population, especially in rural areas. Rainfall variability is therefore the main handicap to the development of survival and income-generating activities (agriculture, livestock, fishing, trade, etc.).

Togo has experienced drought events (1972, 1980, 2000-2004, 2008, and 2016) and flood episodes (2009-2011), which affected a large number of people, particularly in the savannah region, the most vulnerable and most exposed to the effects of climate change. Farmers face great threats and struggle to maintain their livelihoods (Fiankan-Bokongo, 2009). The vulnerability of the agricultural sector is measured in terms of impacts on the profitability or viability of farming systems exposed to hydro-meteorological hazards and water control problems. Other sectors of activity such as livestock and fishing are also affected by this scourge. Rising temperatures accentuate the mortality of livestock, the transmission of diseases via food and water, the lack of pasture, and the drying up of fishing grounds.

There is a general consensus that climate change threatens food security, mainly due to the increase in extreme events and spatiotemporal lags. The continent is already experiencing a major deficit in food production in many regions and the potential decline in soil moisture and energy will be an additional pressure (Diop et al., 1999; Louvel and Gromard, 2006). Countries that lack food are more vulnerable to the adverse effects of climate change according to IPCC (2001). This vulnerability of ecosystems and human societies varies greatly depending on the region. It strongly depends on the level of development, the unsustainable use of oceans and soils, the level of inequity and marginalization, contemporary and past unjust societal models (such as colonialism), as well as governance (IPCC, 2022).

The mostly rural local populations of northern Togo have their own way of appreciating the effects and manifestations of climate change. The surveys carried out in five localities bordering the wetlands of the Oti Plain as part of our study made it possible to determine the shocks, impacts, and severity of climate change in the area.

II. MATERIALS AND METHODS

2.1 Study area

This study is carried out in North-Togo between latitudes N 9°30' and N 11°00' and longitudes E 0°15' and E 0°55' corresponding to the northern plains covered mainly with dry savannas with Leguminoseae and Combretaceae, home to significant biological diversity (Koumantiga et al., 2018; Badabaté et al., 2012) and a hydrographic network drained by the Oti River and its tributaries. This area straddles the savanna region and the Kara region. It includes five (05) localities, three of which are in the Oti prefecture: Poporkou, Tchanaga, and Sadori, and two in the Kéran prefecture: Atalotè and Pessidè (Fig 1). The, dry savanna enjoys a Sudanian-type climate with a dry season and a rainy season. The annual rainfall is 1,201.69 mm and the average annual temperature is 27.7°C (Badjaré, 2012). Extreme temperatures vary between 39°C and 17°C in the dry season and between 34°C and 22°C in the rainy season (Agboh & Badjaré, 2007). The population, which is largely rural, was 30,476 in 2010 (INSEED, 2011). The localities in this area have experienced strong urbanization and demographic pressure in recent years in connection with the intense pressure on wetlands accentuated by the effects of climate change.

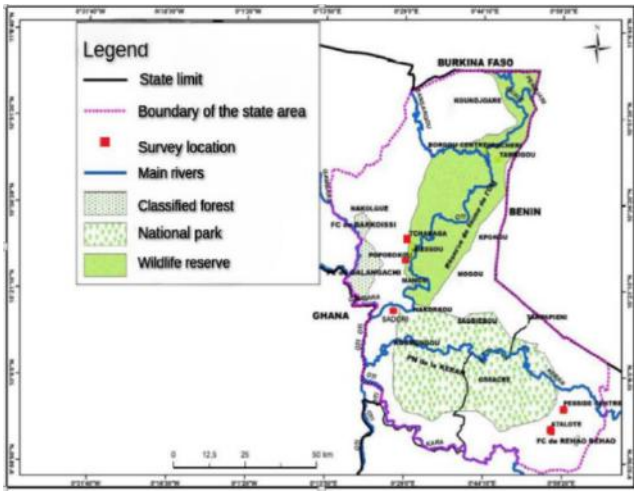

Fig.1. Map of the study area

Source: DGSCN, 2010, Authors: Lamboni L.

2.2 Data collection methods

2.2.1 Choice of survey localities and constitution of the sample

The choice of the localities prospected during the study is guided by three criteria: the proximity of the localities in relation to the wetlands, the geographical accessibility of the localities, and the production sectors (activities) which can directly or indirectly influence the important wetlands of the Oti basin. The target population concerned by the survey is made up of people who are direct users of wetlands, mainly farmers, fishermen, breeders, and hunters.

2.2.2 Investigations

The socio-anthropological surveys aim, on the one hand, to understand the perceptions of the populations on the

wetlands, the anthropic activities carried out around these zones, and the socioeconomic importance of these ecosystems in their well-being and development. On the other hand, to also understand their perceptions of climate change and their capacities to adapt to current and future adverse effects of climate change and variability. These surveys should make it possible to highlight the vulnerable populations in each locality, prioritize the main shocks due to climate change and variability, and take stock of the technological, organizational, and/or socioeconomic adaptation capacities.

This method ultimately enabled us to measure the severity of the change in the production sectors and the lives of the populations, taking gender into account. To achieve this, the method adopted consisted of questioning, in a semi-structured way, target groups according to the production sectors on their perception of climate change, the manifestations, the effects, the shocks feelings, and coping strategies. Questionnaires and interview guides have been designed for this purpose.

In this approach, the Q method and the method for calculating the risk of climate change in the production sectors were used.

2.3 Data management

2.3.1 The Severity of climate change

After listing the shocks in each group, the producers themselves ranked them. The village survey data made it possible to analyze the severity of climate change in each village according to the production sectors. Once the shocks were listed, the terms were harmonized. For example, “lack of rain” has been harmonized with “irregular rain”. The data were then used to calculate the incidence I, the severity S and the risk index. From the incidence and the severity, the severity map of the villages or of a target group such as men and women was established. In the analysis of the map, a high value indicates a high impact. However, high severity is associated with low value.

2.3.2 Impact, vulnerability risk indices

The risk indices were calculated according to the method of Smith et al. (2000) and Quinn et al. (2003). We first proceeded to the calculation of the impact **I** of climate change in each locality, then to the calculation of the Severity index, and finally we ended up with the calculation of the climate risk index.

The severity indices allowed us to produce graphs of shocks for each locality or vulnerability indices from the following equations:

(1) Severity index Sj = 1 + (r-1) / (n-1)

With: r = threat rank (in order of importance according to the participant);

n = total number of threats listed by the participant;

We then calculate the average for all participants who listed a certain threat

$$(2)\text{Incidence(Ij)} = \frac{\textbf{Type of threat X number of times listed}}{\textbf{Number of participants}}$$

(3) **Indice de risque (0-1) : Rj = Ij/Sj**

2.4. Data processing and analysis

Climate data and data from field surveys and interviews were processed using Excel 2013 and Kobocollete software.

III. RESULTS

3.1 People's Perception of climate change

3.1.1 Parameters and Indicators of climate change

In the five localities surveyed, climatic parameters such as rainfall, temperature, wind, and insolation were cited as the most determining climatic variables. The indicators of changes in climatic parameters that are perceived by the peasant populations are 8 in number for rainfall, 3 for temperature, 2 for wind, and 2 also for insolation (Table 1).

Table 1: Climate parameters and change indicators cited by the populations

Climatic parameters	Indicators of change
Rainfall	- Irregularity of rains; - Decline in rainfall; - Shortening of the duration of the rainy season; - Existence of pockets of drought; - Early agricultural season; - Early cessation of the rains; - Delay of rains; - Frequent flooding
Temperature	- Increasingly high temperatures; - Decrease in freshness during harmattan periods; -Increased minimum temperatures
Wind	- Increasingly violent winds; - Increased whirlwinds
Insolation	- Increase in the number of sunny days; - Decrease in the number of cloudy days

3.1.2 Perceptions by the local populations of the wetlands of the Oti Plain of climate parameters and indicators of change

The climatic phenomena are perceived by the rural populations in a sensory way starting from the variation of the factors of the climate such as the temperature, the pluviometry, the winds and the insolation; but also psychically under the influence of functional factors. The declarations of the mostly peasant populations are inspired by local knowledge, and which reveal their perception of the phenomenon of climate change.

- **Rainfall**

The populations, regardless of their sectors of activity, have noticed an upheaval with regard to the normal course, as known in the past, of the rainy events. The elderly situates these climate changes in the 70s and 80s following the drop in rainfall and the droughts that hit the populations hard at that time (Fig 1). The youngest, given their short existence in time, perceive climate change less well but remember recent climatic manifestations, in particular, the famines of 2005 and 2007 and recent flood episodes (2009 and 2010). The main upheavals perceived by the population's concern: the late start and/or poor distribution of the rains during the rainy season, the shortening of the duration of the rainy season, the reduction in rainfall heights, the reduction in the number of rainy days, the existence of pockets of drought, the occurrence of very heavy rains.

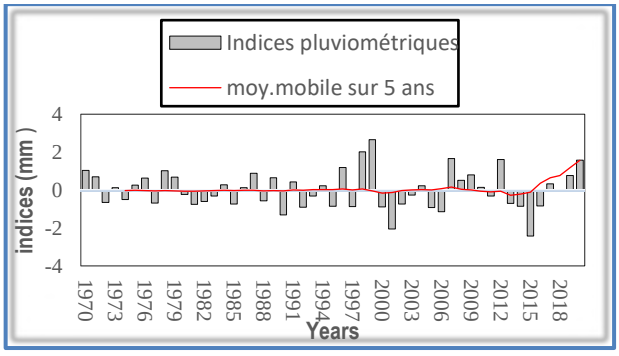

Fig.1: Rainfall index of the Mango synoptic station from 1970-2020

- **Temperature**

More than 80% of respondents found that it is getting hotter and hotter. The two other indicators of temperature changes such as "decrease in coolness during the harmattan period and increase in minimum temperatures" were reported by less than 20% of those surveyed (Fig 2).

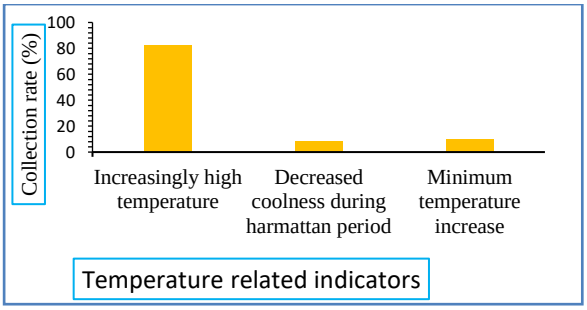

Fig.2. Perception of temperature changes

- **Wind**

More than 70% of the populations questioned perceived the indicator "increasingly violent winds" in our survey localities. 27% reported "increased eddies" especially during the harmattan (Fig 3).

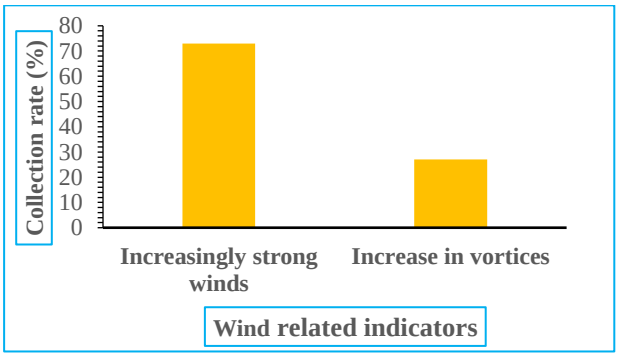

Fig.3. Perception of wind changes

- **Sunstroke**

According to the histogram (Fig 4), more than 90% of farmers claim "an increase in the number of sunny days" compared to the 1980s. This change resulted in "a decrease in the number of cloudy days"; a finding corroborated by more than 60% of respondents.

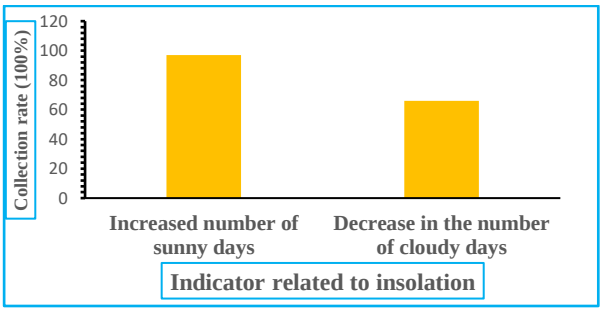

Fig.4: Perception of changes in insolation

3.2 Vulnerability of populations living near wetlands in the Oti Plain to climate change

3.2.1. The incidence and severity in all the localities

bordering the wetlands of the plain of the Oti

Table 2 shows 30 shocks listed by all populations. These shocks were identified taking into account gender and sector of activity. Among these shocks, the irregularity of rains, deforestation, poor agricultural soils, and low agricultural yield are the most important with an incidence of 1, followed by the invasion and resistance of weeds and the lack of firewood. heats 0.8. Medium-impact shocks include difficult access to land, an increase in temperature, a drop in income, the existence of pockets of drought, short agricultural season, distance from health centers, drought, insufficient drinking water points and poverty with a value of 0.6. Low-impact shocks include pastoralist/farmer conflicts, the disappearance of certain fish species, the reduction of fodder species, soil erosion, flooding of agricultural fields, famine, diseases, poultry diseases, lack of grazing, livestock mortality, scarcity of fish in rivers, a parasite of crops and strong winds with a value of 0.4. Two shocks with very low incidence were given: the drying up of watering points and conflicts between fishermen 0.2.

In terms of severity, poverty; irregular rainfall, poor agricultural soils, deforestation, and low agricultural yield are the most severe with respectively 1 and 1.1. Five shocks have a fairly high severity and range from 1.2 to 1.3: the existence of pockets of drought and the invasion and resistance of weeds (1.2); difficult access to land, a decline in income, and flooding of agricultural fields (1.3). Six medium-severity shocks (1.4 and 1.5) respectively disease, short agricultural sea, son and strong winds (1.4); distance from health centers insufficient drinking water points, and soil erosion (1.5). The low-severity shocks include respectively conflicts between fishermen and the drying up of watering points (2), the disappearance of certain fish species, famine and reduction of fodder species (1.9), three shocks with severe =1.8: lack of pasture, livestock mortality and scarcity of fish in the rivers; two shocks with severity = 1.7: poultry disease, breeder/farmer conflicts and crop parasite; three shocks with severity =1.6: increase in temperature, drought and lack of firewood. Of all this, it is the irregularity of the rains and the existence of pockets of drought which seem to be the shocks most indicative of climate change.

Table 2: Incidence and severity values in all five study localities bordering the wetlands of the Oti Plain

Order number	Shocks of all men and women according to the sector of activity (agriculture, livestock, and fishing)	Impact	Severity
1	Difficult access to land	0.6	1.3
2	Drying up of drinking water points	0.2	2.0
3	Temperature increase	0.6	1.6
4	Income drop	0.6	1.3
5	Breeder/farmer conflicts	0.4	1.7
6	Fisherman conflicts	0.2	2.0
7	Deforestation	1	1.1
8	The disappearance of certain species of fish	0.4	1.9
9	Decrease in forage species	0.4	1.9
10	Distance from a health center	0.6	1.5
11	Weed invasion and resistance	0.8	1.2
12	Existence of pockets of drought	0.6	1.2
13	Soil erosion	0.4	1.5
14	Low agricultural yield	1	1.1
15	Famine	0.4	1.9
16	Flooding of agricultural fields	0.4	1.3
17	Irregularity of rains	1	1.0
18	Lack of water points	0.6	1.5
19	Disease	0.4	1.4
20	poultry disease	0.4	1.7
21	Lack of firewood	0.8	1.6
22	Lack of pasture	0.4	1.8
23	Livestock mortality	0.4	1.8
24	Scarcity of fish in rivers	0.4	1.8
25	Short agricultural season	0.6	1.4
26	Drought	0.6	1.6
27	Agricultural soil poverty	1	1.1
28	Poverty	0.6	1.0
29	crop pest	0.4	1.7
30	strong winds	0.4	1.4

3.2.2 Incidence and severity in all localities of riparian studies of the wetlands of the Oti Plain according to gender

- **According to women**

The data in Table 3 shows that 14 shocks were identified by women. The strongest incidences (1) are given by poverty, the irregularity of rains, the drop in agricultural yields, poor soils, and deforestation. Five shocks have a fairly high incidence (0.8): difficult access to land, insufficient drinking water points, illnesses, drop in income, and lack of firewood. Three shocks have an incidence = 0.6: distance from health centers, pockets of drought and crop pests, and a single shock with low incidence (0.4): famine.

In terms of the severity of each of these fourteen shocks, the difficult access to land is of maximum severity (1). Then come successively poverty (1.1), the irregularity of the rains (1.2); deforestation, and insufficient drinking water points (1.3). Two shocks have an average severity (1.4; 1.5) respectively: diseases, the drop in agricultural yields, and soil poverty. The least severe shocks are represented by the drop in income (1.6); starvation (1.7); remoteness from health centers, pockets of drought (1.8); lack of firewood (1.9); and culture pests (2.0).

Table 3: Incidence and severity values in all five study localities bordering the wetlands of the Oti Plain according to women.

Order number	Women shocks	Impact	Severity
1	Difficult access to land	0.8	1.0
2	Falling agricultural yields	1	1.5
3	Income drop	0.8	1.6
4	Deforestation	1	1.3
5	Famine	0.4	1.7
6	Insufficient drinking water points	0.8	1.2
7	Irregularity of rains	1	1.2
8	Distance from a health center	0.6	1.8
9	Lack of firewood	0.8	1.9
10	Diseases	0.8	1.4
11	Poverty	1	1.1
12	Soil poverty	1	1.5
13	pocket of drought	0.6	1.8
14	Culture parasite	0.6	2.0

- **According to men**

Out of a total of 26 given shocks (Table 4), deforestation, erratic rainfall and low agricultural yield and poor agricultural soils emerge as the high-impact shocks (1.0). These shocks are followed by weed invasion and resistance and poverty (0.8). Six shocks have an impact of (0.6): increase in temperature, drop in income, existence of pockets of drought, short agricultural season, crop pests, and drought. Low incidence shocks are represented by: livestock breeder/farmer conflicts, the disappearance of certain fish species, the reduction of fodder species, soil erosion, starvation, disease, poultry disease, lack of pasture, livestock disease, scarcity of fish in rivers, and strong winds (0.4); the drying up of watering points and conflicts between fishermen (0.2).

With regard to the severities of the shocks, the irregularity of the rains, the increase in temperature, the deforestation is the shocks with maximum severity (1); followed by the low yield and poverty of agricultural soils (1.1), the existence of pockets of drought (1.2); invasion and resistance of weeds, short agricultural season and drought (1.3); flooding of agricultural fields, poverty and crop pests (1.4); declining income, starvation and strong winds, soil erosion and disease (1.6), poultry disease and lack of pasture (1.7); the decrease in fodder species, livestock mortality and the scarcity of fish in rivers (1.8); the drying up of drinking water points (1.9); the disappearance of certain species of fish (2).

Table 4: Incidence and severity values in all of the five study localities bordering the wetlands of the Oti Plain according to men.

Order number	men shocks	Impact	Severity
1	Drying up of drinking water points	0.2	1.9
2	Temperature increase	0.6	1.0
3	Income drop	0.6	1.5
4	Breeder/farmer conflicts	0.4	1.9
5	Fisherman conflicts	0.2	2.0
6	Deforestation	1.0	1.0
7	The disappearance of certain species of fish	0.4	2.0
8	Decrease in forage species	0.4	1.8
9	Weed invasion and resistance	0.8	1.3

10	Existence of pockets of drought	0.6	1.2
11	Soil erosion	0.4	1.6
12	Low agricultural yield	1.0	1.1
13	Famine	0.4	1.5
14	Flooding of agricultural fields	0.4	1.4
15	Irregularity of rains	1.0	1.0
16	Disease	0.4	1.6
17	poultry disease	0.4	1.7
18	Lack of pasture	0.4	1.7
19	Livestock mortality	0.4	1.8
20	Scarcity of fish in rivers	0.4	1.8
21	Short agricultural season	0.6	1.3
22	Drought	0.6	1.3
23	Agricultural soil poverty	1.0	1.1
24	Poverty	0.8	1.4
25	crop pest	0.6	1.4
26	strong winds	0.4	1.5

3.2.3. **The incidence and severity of each locality of riparian studies of the wetlands of the Oti Plain according to the sectors of activity and gender**

3.2.3.1 Incidence and severity according to Farmers

❖ **Locality of Poporkou**

- **Shocks given by women**

The analysis of the severity map S of the women of Poporkou (Fig 5) shows that poverty, disease, difficult access to land, and irregular rainfall stand out as high-impact shocks. In terms of severity, disease, and poverty are the most severe shocks, followed by difficult access to land, deforestation, and remoteness from health centers. These shocks are medium even if their impact is low.

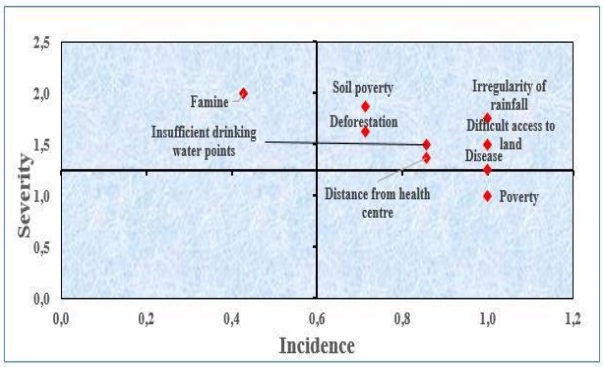

Fig.5: Severity S map of Poporkou women

- **Shocks given by the male farmers of Poporkou**

For male farmers, the trend that emerges at the level of the severity map is that the irregularity of rains and the low agricultural yield are of high incidence and of respectively high and medium severity, while the poverty of agricultural soils, crop pests, and the short agricultural season are of medium incidence and severity (Fig 6).

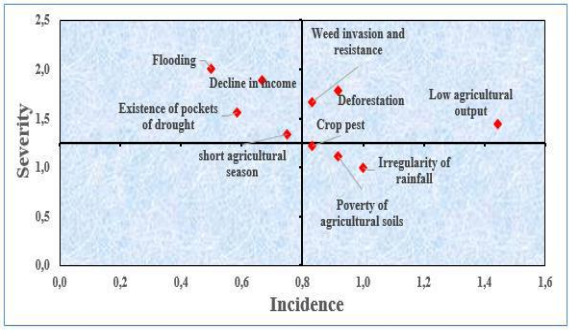

Fig.6: Severity S map of Poporkou Farmers

❖ **Locality of Tchanaga: a group of farmers**

- **Shocks given by women**

The analysis of the severity map of the women of Tchanaga shows that poverty, the irregularity of rains, and the decline in agricultural yields are shocks with high incidence and high severity in terms of poverty and the irregularity of rains. Soil poverty also emerges as a shock with high severity but medium incidence (Fig7).

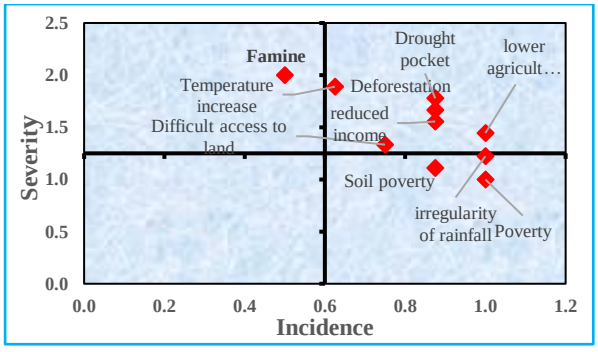

Fig.7: Severity S map of Tchanaga women

- **Shocks given by male farmers**

The men's severity map shown in Figure 8 reveals 5 groups of shocks: the group of shocks with high incidence and severity (poverty of agricultural soils and irregular rainfall), the group of shocks with medium incidence and high severity (low agricultural yield), the group of shocks with medium incidence and medium severity (invasion and resistance of weeds and diseases), the group of shocks with medium incidence and low severity (deforestation and poverty) and the group of shocks with low incidence and severity (drop in income, existence of pockets of drought, crop pests, short agricultural season, farmer/herder conflicts and increase in temperature).

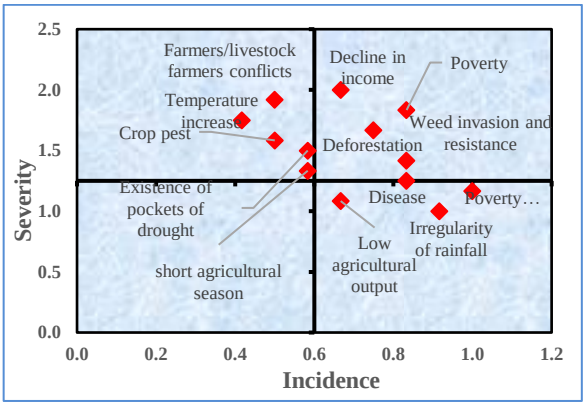

Fig.8: Severity S map of male farmers in Tchanaga

❖ **Locality of Sadori**

- **Shocks given by women**

The severity map of the shocks listed by the women of Sadori shows that groups of shocks emerge as follows (Fig 9): shock with high incidence and severity (poverty, irregular rainfall, and deforestation), shock with high incidence and severity medium (soil poverty and drop in agricultural yields), shock with high incidence and low severity (diseases, drop in income and lack of firewood), shock with low incidence and fairly high severity (invasion and resistance of weeds), low incidence and moderate severity (difficult access to land and pockets of drought). The rest of the shocks are divided into groups of shocks with low incidence and severity (flooding of agricultural fields and crop pests).

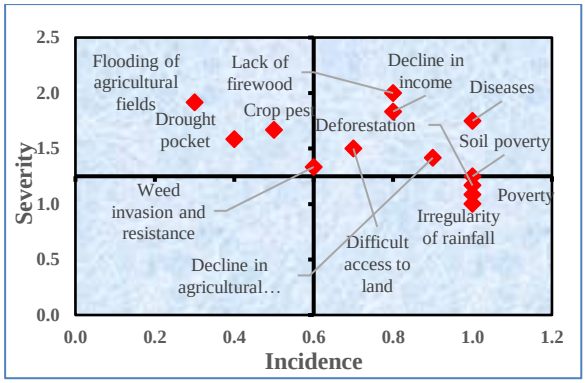

Fig.9: Severity S map of women in Sadori

- **Shocks given by men**

The severity map of the men of Sadori presents 7 groups of shocks (Fig 10): shock with maximum incidence and high severity (diseases and poor agricultural soils), shock with high incidence and high severity (invasion and resistance of weeds, low agricultural yield, and erratic rains), shock with medium incidence and medium severity (short agricultural season and flooding of agricultural fields), shock with medium incidence and low severity (deforestation), shock with low incidence and high severity (existence of pockets of drought), shock with low incidence and medium severity (crop pests and poverty). The rest is made up of low-impact and low-severity shocks (low income, farmer/herder conflicts, and temperature rise).

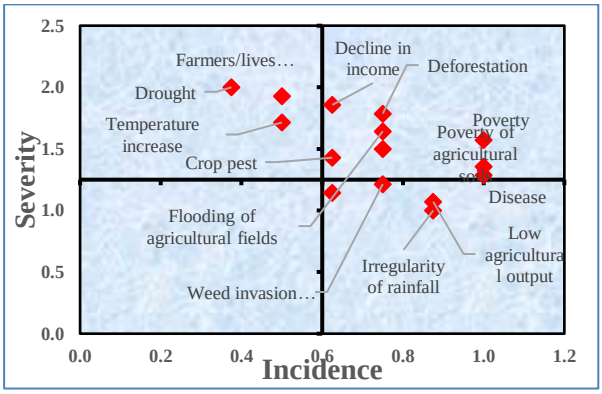

Fig.10: Severity map of male farmers in Sadori

❖ **Locality of Pessidè**

- **Shocks given by women**

According to Figure 11, the various shocks listed by the women of Péssidè could be divided into 9 groups: the group of shocks with high incidence and severity (poverty), the group of shocks with high incidence and medium severity (deforestation and soil poverty), the group of shocks with medium incidence and fairly high severity (lower agricultural yields, distance from water points, irregular rainfall), the group of shocks with medium incidence and

low severity (lower income), the medium incidence and severity shock group (high winds and diseases), high incidence and low severity shock group (weed invasion and resistance), low incidence and high severity shock group (pests crop), the group of shocks with low incidence and medium severity (pocket of drought) and the group of shocks with low incidence and severity (rise in temperature and lack of firewood).

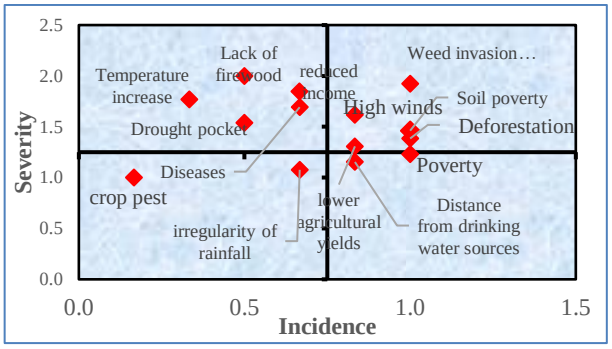

Fig.11: Severity map of the women of Péssidè

- **Shocks given by men**

Analysis of the map of the severity of the shocks listed by the men of Péssidè makes it possible to identify the following groups of shocks (Fig 12): shocks with high incidence and severity (poverty and irregular rainfall), shocks with high incidence and medium severity (invasion and resistance of weeds, poor agricultural soils, and low agricultural yield), shock with high incidence and low severity (strong winds and soil erosion), shock with medium incidence and high severity (diseases), shock with medium incidence and severity (crop pests), low incidence and medium severity shock (short agricultural season). The rest of the shocks are divided into groups of shocks with low incidence and severity (reduction of income, deforestation, existence of pockets of drought, farmer/herder conflicts, and temperature increase).

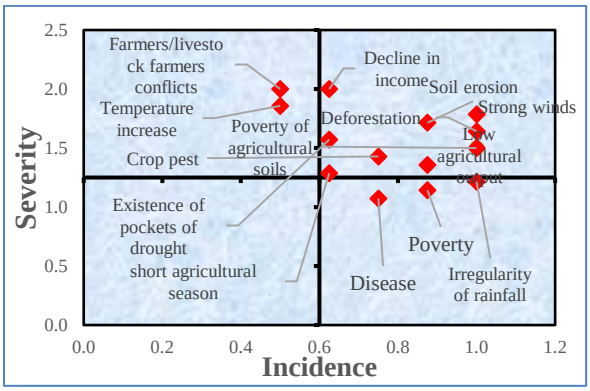

Fig.12: Map of severity S of the men of Péssidè

❖ **Locality Ataloté**

- **Shocks given by women**

The Atalotè women's severity map presents a breakdown of shocks into several sub-groups (Fig 13): shock with maximum incidence and severity (diseases), shock with high incidence and severity (poverty, irregular rainfall, and poor agricultural soils), shock with high incidence and low severity (deforestation, drop in income, soil erosion and strong winds), shocks with medium incidence and severity (difficult access to land, drop in agricultural yields and lack of firewood), shocks with low incidence and medium severity (invasion and resistance of weeds), shock with low incidence and severity (crop pests and pockets of drought).

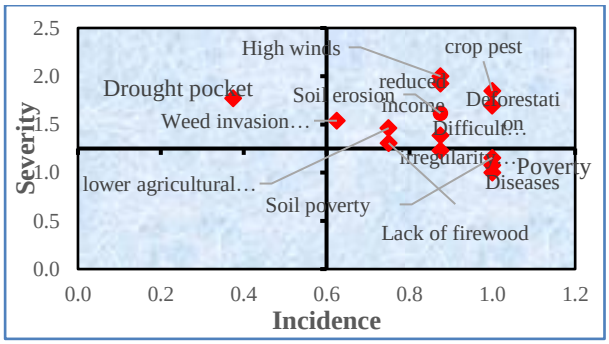

Fig.13: S Severity map of Atalote women

- **Shocks given by men**

Examination of the Atalote severity map (Fig 14) shows that the various shocks are distributed as follows: shocks with high incidence and severity (diseases, irregular rainfall, and poverty), shocks with high incidence and medium severity (invasion and resistance of weeds and poor agricultural soils), shocks with high incidence and low severity (strong winds, soil erosion and farmer/herder conflicts), shocks with medium incidence and severity (existence of pockets of drought , short agricultural season, crop parasite and low agricultural yield), and shocks with low incidence and severity (reduction of income, deforestation, increase in temperature and drought).

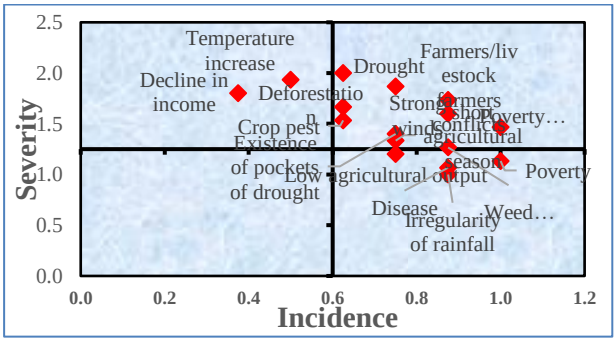

Fig.14: S severity map of Atalote men

3.2.3.2 Incidence and severity according to breeders

- **Shocks of breeders in the localities of Tchanaga, Sadori and Péssidè.**

Breeders in the localities of Tchanaga, Sadori, and Pessidè suffer the same shocks, with the only difference being the watering points for animals, which are lacking during the dry period in Péssidè. Thus, the shocks are divided into (Fig 15): shocks with high incidence, and severity (livestock mortality and poultry diseases), shocks with high incidence, and medium severity (breeder/farmer conflicts), shocks with high incidence and low severity (poverty and reduction of fodder species), shocks with medium incidence and high severity (drying up of watering points and irregular rainfall), shocks with medium incidence and severity (increase in temperature and lack of grazing), low incidence and medium severity shock (drought) and medium incidence to low severity shocks (low income, deforestation, disease , and insufficient drinking water points).

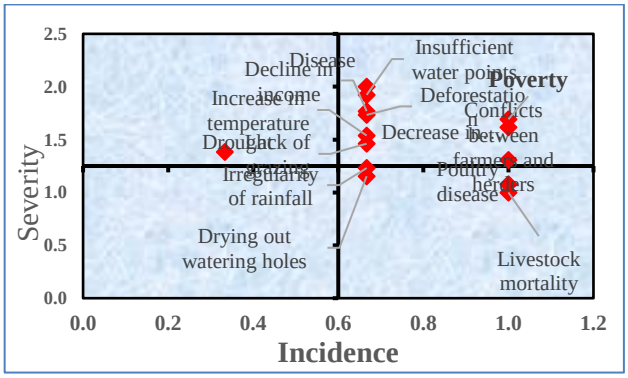

Fig.15: Severity map of breeders

3.2.3.3 Incidence and severity according to fishermen

- **Shocks of the fishermen of the localities of Poporkou, Tchanaga and Sadori**

Fishermen from the localities of Poporkou, Tchanaga and Sadori mentioned the same shocks. Analysis of the severity map shows a breakdown of shocks by group (Fig 16): shocks with high incidence, and severity (scarcity of fish and poverty), shocks with high incidence and high severity (silting of the river bed, bank erosion and water pollution), shocks with high incidences, and medium severity (disappearance of certain species of fish, drop in income and flooding), shock with high incidence, and low severity (low agricultural yield), shocks with low incidence and medium severity (conflicts between fishermen). The rest is made up of shocks with low incidence, and severity (irregular rains, poor agricultural soils and diseases).

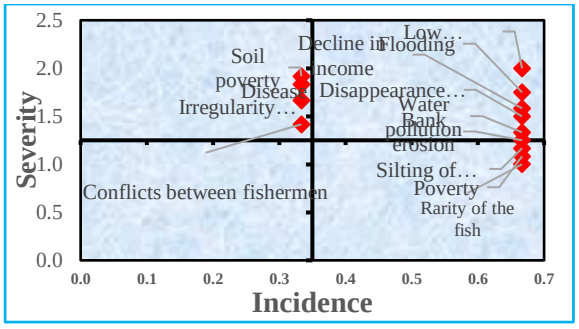

Fig.16: Severity S map of fishermen

3.3 Population adaptation to climate change

Aware of the various changes that occur in climatic rhythms and their perverse effects on life itself and on activities, local populations have initiated a set of readjustments or adaptations in farming systems. These identified local strategies for adaptation to climate change depend on the sectors of activity.

3.3.1 Farmers' adaptation strategies to climate change

The shocks with high incidence and severity that farmers experience are, among others, the irregularity of rains, the poverty of agricultural soils, the invasion and resistance of weeds, and pockets of drought. To mitigate the shocks due to the effects of climate change, the producers listed adaptation strategies. These new strategies, inspired by those implemented in the other regions of the country, are essentially based on the self-promotion and organizational capacities of local communities. The table below presents all the strategies encountered during our surveys.

Table 5: Farmers' coping strategies

Adaptation of the cropping calendar in relation to the climatic conditions of the year (modification of sowing dates)
Off-season cultivation to compensate for the poor agricultural campaign
Abandonment of certain crops such as cotton in favor of food and cash crops (soya, sesame).
Use of agricultural fertilizer (NPK fertilizer and manure) to improve soil fertility
Use of herbicides against weeds and insecticides against crop pests
Crop rotation for soil fertility management
Income-generating activities to cope with the high cost of living and declines in agricultural productivity
Use of short cycle seeds against the shortening of the rainy season

Increase in agricultural land to deal with low agricultural yields
Diversification of crops such as: soybeans, rice, yams, sesame, corn, sorghum, etc.
Youth investment in agribusiness: growing sesame and soybeans for sale
Exploitation of lowlands for market gardening and rice growing
Manufacture and trade of charcoal against monetary poverty
Trade
Breeding
Income Generating Activity
Exodus

Some strategies prove to be ineffective against certain shocks, in particular the exploitation of lowlands and the surroundings of watercourses for crops because of the richness of these soils. However, crop fields established on these soils are frequently victims of flooding. Also, the charcoal making activities encountered in all the localities of the study area, particularly in the Oti- kéran - Mandouri protected areas, contribute to the destruction of the vegetation cover. In addition, the use of herbicides are sources of degradation of plant cover, soil and water pollution and the destruction of soil fauna (earthworms and others, etc.). Moreover, after the harvest, it is market gardening activities that relieve the deficits of low harvest yields.

Illustration of some coping strategies

Photo1: Empty insecticide packaging at the edge of a sesame field

Photo 2: exploitation of the banks of watercourses for crops

Photo 3: onion cultivation near the backwaters of the Oti

Source: LAMBONI, August, 2022.

3.3.2 Livestock farmers' adaptation strategies to climate change

The coping strategies observed among breeders in the face of climate change are part of a logic that has existed for a long time in the study area and elsewhere. We can cite a bibliographic study by Boubacar Saïdou who put forward the notion of resilience to analyze the forms of adaptation of the Fulani to climate change in the Sahel (Saïdou, 2015, quoted by Bouju, 2016, p. 399-401). Other more recent studies in sub-Saharan Africa point in the same direction: we can cite Kabore et al. (2019) for Burkina Faso or Tidjani et al. (2016) for Niger, who showed how, historically, rural societies had to take into consideration the natural risks that prevailed in their territory. To respond immediately to problems, each breeder opts for management and operation that allows him to achieve his production objectives without departing from the characteristics of his traditional system. The table below summarizes the choices made by farmers to deal with the effects of climate change:

Table 6: Adaptation strategies of farmers

Use of veterinary care against poultry epidemics and livestock diseases
Construction of watering points for animals
Limitation of animal straying
Collection and storage of fodder in times of abundance for future use
Departure for transhumance for large breeders and grazing on the outskirts within a radius of 5km for small and medium breeders
Agriculture (grain farming) to cope with drought and food deficit
Storage of stubble transformed into bales for livestock feed
Diversification of activities
Sale of animals to avoid losses by disease
Exploitation of lowlands, source of green fodder
Exploitation of wetlands source of green fodder and water for watering

Illustration of some coping strategies of breeders

Photo 4: Animal watering well

Photo 5: exploitation of lowland fodder

Photo 6: exploitation of wetlands

Source: LAMBONI, August, 2022.

3.3.3 Fishermen's adaptation strategies to climate change

The shocks suffered by fishermen are, among others, the scarcity of fish, poverty, the silting up of riverbeds, the drying up of fishing water points (ponds, ponds, etc.), the pollution of water, disappearance of certain species of fish, erosion of the banks of waterways, etc. Strategies for adapting to climate change are based on seasonal subsistence agriculture (rice, maize, millet, sorghum, etc.), market gardening (onions, tomatoes, cabbage, etc.), trade. The adaptation strategies adopted by the fishermen are based on a capital of traditional knowledge, given the still rudimentary nature of this sector. The inventory of traditional knowledge available for the adaptation of fishers to climate change are:

- **Depositing bait in the water (nets, traps, etc.**): fishermen operate mainly in ponds, backwaters and the Oti River and its tributaries. These baits are used to attract fish.

Photo 7: fishing net

Photo 8: making traps in Poporkou

Photo 9: depositing nets as bait on the Oti River around Tchanaga**.**

Source: LAMBONI, September, 2022.

Depending on the climatic conditions, the weather may or may not be favorable for fishing. And fishermen generally use their traditional knowledge in case the climatic conditions are unfavorable to fishing.

- **The construction of micro-dams**

Fishermen build small dams in the water using branches, clods of earth or wood to prevent fish from moving away from their fishing area. Also during floods, shallower ravines and pits near watercourses fill up. During the floods the fish are trapped in these ravines and pits, a godsend for the fishermen who exploit them thoroughly.

- **Night fishing**

According to the opinion of a fisherman in Sadori, the night is one of the best times to fish because of the calm, because no noise will scare the fish away. In addition, it is during the night that we make big catches because the fish resume the course of their lives at this moment.

- **Decrease in collective fishing campaigns**

Once developed in the past, the decline in fishing yield has led to a decrease in the frequency of collective fishing.

- **Diversification of income sources**

Because of the decline in fishing yields and to cope with the high cost of living, fishermen have diversified their source of income, particularly agriculture (cultivation of cotton, sesame, soy; food crops such as corn, millet, sorghum,

cowpea), trade (marketing of charcoal, wood, small shops, etc.) which represent some of the income-generating activities.

IV. DISCUSSION

People's perception of climate change

With regard to climatic parameters, rainfall, temperature, wind and insolation were cited as the most determining climatic variables. This perception of producers, whether they are farmers, breeders, or fishermen, is explained by the fact that these four climatic variables have a direct influence on the three sectors of activity.

These factors determine the good or bad agricultural season for the farmers, the availability of water and fodder for the animals (breeders), and a good yield of fishing activity for the fishermen. Indeed, the following facts are at the origin of these perceptions: (i) the irregularity of the rains has as a consequence, among other things, the poor development of crops, the lack of water for domestic needs and for livestock (ii); the increase in temperature causes the burning of crops, the early drying of fishing areas, agricultural land and watering points for animals, high livestock mortality (iii); the increase in the frequency and intensity of the winds cause the erosion of agricultural land, the lodging of crops, the uprooting of trees, the uncovering of the roofs of houses and public works (schools, market sheds), etc.

The work of Adjonou, 2009; Badjana, 2010; Badabate et al. 2012 noted similar perceptions in a study on the agricultural exploitation of the banks of the Oti Plain as a strategy for adapting to climate change. This work has shown that the progressive drying of the land and its degradation linked to climatic variability (reduction in rainfall and increase in temperature) cause the agricultural front to progress towards the edges of waterways in search of moist and fertile land. This adaptation strategy has led to the destruction of the gallery forests of the Oti Plain. Moreover, the results of our study are more or less consistent with those of Guibert et al. (2010) cited by Bambara et al. (2013) on peasant perceptions in responses to a survey conducted in the cotton-growing area of northern Benin.

The work of Ouédraogo et al. (2010), relating to a study on the perceptions and strategies of adaptation to changes in rainfall conducted in the Sahelian, Sudano-Sahelian, and Sudanian zones of Burkina Faso, noted indicators such as the drop in rainfall, the disruption of the season, erratic rainfall, pockets of drought, heavy rains and floods. Our results compared to those of Ouédraogo et al. (2010) point in the same direction.

Vulnerability of populations bordering the wetlands of the Oti Plain to climate change

The study of vulnerability to climate change, generally and particularly in Togo, cannot be dissociated from the effects linked to variability and climate change from those linked to anthropogenic factors. In fact, over the last few decades, extreme climatic phenomena (drought, decline in soil fertility, increase in animal diseases, floods, pockets of drought, violent winds, rise in temperature) have become more and more frequent with increasing intensity. increasing and therefore constitute real catalysts for the degradation of the biophysical environment (Belem et al. 2007, Vissoh et al., 2012). Several local concepts, adages and proverbs are used by rural communities to account for these observed shocks. The peasant world, in particular farmers, has a close link with its environment and its dependence on the climate (FAO, 2007). Recent Afrobarometer data (Afi and Ekoutiamé, 2019), show that Togolese believe that climatic conditions, with regard to agricultural production, especially drought, have deteriorated over the past ten years. This thought is more advanced among farmers in the Savannah region, the region where climate change is most severe.

With regard to the shocks of climate change, the work of Belem and Sanon (2006) carried out in the central plateau of Burkina Faso, identified famine and drought as the shocks having the greatest impact. In terms of severity, lack of plant species, drought, and famine represent the most severe shocks. In the southwestern area of Burkina Faso, Ouattara et *al* (2006) found that insufficient rainfall had the highest incidence. As for severity, these same authors identified poor seed quality and wandering animals as the most severe shocks. We also noted in our study, similar shocks which make vulnerable the populations and the various sectors of activity (agriculture, breeding and fishing). Indeed, through this study we have observed that climate change has a negative impact on vulnerable sectors (agriculture, livestock and fishing). So:

- at the agricultural level, the shocks with incidence and severity are poverty; the irregularity of the rains which affects the dates of the start of crops and, as a result, the shift in the agricultural seasons; the poverty of agricultural soils which leads to a drop in agricultural yields, the use of chemical fertilizers and the agricultural exploitation of the banks of watercourses; the existence of pockets of drought in the middle of the agricultural season which damage crops; invasiveness and weed resistance that encourage the use of chemical pesticides; the increase in temperature which explains the long dry seasons and the premature

drying up of water points; deforestation which leads to the degradation of plant cover, the erosion of biodiversity and soils, the degradation of gallery forests along watercourses; strong winds that destroy tall trees and homes.

- at the level of breeders, we noted shocks with high incidence and severity, degradation of pastures (decline in fodder species), poultry and livestock diseases, early drying up of water points, recurring conflicts with farmers;
- for fishermen, the shocks noted are the scarcity of fish, water pollution, the silting up of waterways, the disappearance of certain species of fish, the drying up of fishing areas.

This vulnerability is also felt differently at the gender level. For women, the shocks with the greatest incidence and severity are poverty, famine, difficult access to land, insufficient drinking water points, disease, and distance from health centres.

Even if our results do not allow us to conclude on the effects of climate change, it is clear that these various shocks negatively affect the populations, mostly rural, who see their living conditions deteriorate. And this vulnerability has increased lately due to covid, armed conflicts, terrorism affecting West African countries (Mali, Burkina-Faso, Niger, Benin, Togo, etc.).

To cope with these multifaceted shocks, the adaptive capacities developed by producers have been identified. The populations are disarmed in the face of water stress. For the other shocks, limited means are implemented and deserve to be improved by advisory support, better communication on the evolution of climatic parameters in rural areas, granting of credits to vulnerable groups, and awareness-raising on protections. natural ecosystems.

V. CONCLUSION

This study provided varied knowledge on the adaptive capacities developed by the populations bordering the wetlands of the Oti Plain and their vulnerabilities in the face of the adverse effects of climate change. The shocks suffered by the populations are, among other things, irregular rainfall, general poverty, poor agricultural soils, pockets of drought, declining agricultural yields, disease, and deforestation. Faced with the incidence and severity of these shocks, populations have had to develop multifaceted adaptation strategies that vary according to the production sectors. In addition, it also emerges from this study, on the one hand, that the most vulnerable production sector is the agricultural sector dependent on climatic parameters and, on the other hand, that the most vulnerable group among the rural poor is the group of women. In view of these results, future investigations should make it possible to deepen the understanding of climate change in all vulnerable sectors. This information will be used to better establish climate change adaptation strategies, particularly in vulnerable areas.

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