



Research Paper

## Community Resilience to Climate Variability in the Municipality Of ATHIEME/BENIN

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### Résumé

La récurrence de risques climatiques ainsi que leurs interactions ne peuvent plus être ignorées aujourd'hui des décideurs publics ou privés et des citoyens. La capacité de réponse et de protection face à ces risques, reste très inégale entre les pays, de même que la distribution des dommages mais aussi des bénéfices éventuels de ces changements globaux. L'objectif de cette étude est de contribuer à une meilleure connaissance des risques climatiques et des stratégies d'adaptation développées par les communautés de la commune d'Athiémè pour y faire face.

La démarche méthodologique utilisée a consisté en la collecte des données (pluie et température de 1989 à 2019 à Athiémè), le traitement desdites données et la méthode d'analyse des résultats. La technique de collecte des données prend en compte la recherche documentaire et les enquêtes de terrain. Pour ce faire, des enquêtes de terrain ont été menées auprès de 175 ménages (hommes et femmes) ruraux de la commune d'Athiémè, suivies des enquêtes semi-structurées orientées vers des autorités locales (15 enquêtées) pour recueillir des informations relatives aux risques climatiques (à travers leurs impacts et effets), à la vulnérabilité socio-économique et aux stratégies d'adaptation développées par les groupes socioculturels présents.

Les données de terrains, associées à l'analyse des données météorologiques de 1989 à 2019 ont permis d'identifier les inondations (plus récurrentes et catastrophiques dans la Commune), les sécheresses, les vagues de chaleur et la perturbation des régimes pluviométriques comme risques affectant les ménages ruraux dans la commune d'Athiémè. Ces risques impactent les moyens et les modes d'existence des femmes de la zone d'étude, en particulier l'agriculture qui constitue la principale source de revenu de ces ménages. De l'analyse des moyens d'existences durables et des impacts climatiques sont assortis les facteurs qui influencent la vulnérabilité. Parmi ces facteurs, on peut citer : le caractère pluvial de l'agriculture, la non-accessibilité des femmes aux ressources de base et l'analphabétisation. Face aux impacts directs des changements climatiques, ces ménages ont recours aux options d'alerte précoces, d'adoption des variétés à cycle court, des semis précoces et échelonnés dans le temps selon 91 % des personnes enquêtées. Ces ménages ont aussi recommandé pour une adaptation durable que les aménagements hydroagricoles présents et fortement utilisés par les populations, soient aménagés afin de réduire leur dépendance vis-à-vis du climat.

**Mots Clés :** Athiémè, climat, risque, vulnérabilité, stratégie d'adaptation, Production agricoles.

### Abstract

The recurrence of climate risks and their interactions can no longer be ignored by public or private decision-makers and citizens. The capacity to respond and protect against these risks remains very unequal between countries, as does the distribution of damages but also of the possible benefits of these global changes. The objective of this study is to contribute to a better knowledge of climate risks and the adaptation strategies developed by the communities of the municipality of Athiémè to deal with them.

The methodological approach used consisted of the collection of data (rain and temperature from 1989 to 2019 in Athiémè), the processing of said data and the method of analyzing the results. The data collection technique takes into account documentary research and field surveys. To do this, field surveys were conducted among 175 rural households (men and women) in the municipality of Athiémè, followed by semi-structured surveys directed towards local authorities (15 respondents) to collect information relating to the risks (through their impacts and effects), socio-economic vulnerability and adaptation strategies developed by the socio-cultural groups present.

*Field data, combined with the analysis of meteorological data from 1989 to 2019, made it possible to identify floods (more recurrent and catastrophic in the Commune), droughts, heat waves and disruption of rainfall patterns as risks affecting rural households in the commune of Athiémè. These risks impact the means and livelihoods of women in the study area, particularly agriculture, which is the main source of income for these households. The analysis of sustainable livelihoods and climate impacts are accompanied by the factors that influence vulnerability. These factors include: the rain-fed nature of agriculture, women's lack of access to basic resources and illiteracy. Faced with the direct impacts of climate change, these households resort to early warning options, adoption of short-cycle varieties, early and staggered sowing over time, according to 91% of those surveyed. These households also recommended, for sustainable adaptation, that the hydro-agricultural facilities present and heavily used by the populations be developed in order to reduce their dependence on the climate.*

**Keywords:** Athiémè, climate, risk, vulnerability, adaptation strategy, agricultural production.

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## I. Introduction

Climate change is the concerns of both scientific actors and policy makers at the global level because it is one of the various obstacles to human development (Boko et al., 2007, p. 439; Niang, 2009, p.15; Ali, 2010, p. 16). Indeed, according to the IPCC (Boko, 1988, p. 65; IPCC, 2001, p. 16 and 2007, p. 36; Houndénou, 2005, p. 38; IUCN, 2011, p. 9), poor communities will be the most vulnerable due to their limited adaptive capacities and their high dependence on climate-sensitive resources such as water resources and agricultural production systems. Thus, agricultural production conditions are made increasingly difficult by climate hazards (Enete et al., 2011, p. 245; Chanzy et al., 2015, p. 3). Climate variability has a direct impact on agricultural production, as farming systems depend in part on the nature of the climate (Boko et al., 2007). This impact is quite important in developing countries where agriculture is 100% rainfed with no irrigation alternatives and is the main source of employment and income for the majority of the population (FAO, 2011, p. 9; FAO, IFAD, WFP, 2004, p. 5; Agossou et al.)

With a growing world population, increasing demand for food, water and energy, and depleting natural resources, climate change will act as a 'threat multiplier' (Le Barbé et al., 1993, p. 89; Ana et al., 2011, p. 26), exacerbating resource scarcity and imposing additional stress on socio-ecological systems. Climate variability and its socio-environmental consequences are even more noticeable at the local scale. The effects and impacts of climate variations mostly affect the rural environment, which derives most of its income from speculation that highly depends on the climate; but their intensity and importance vary according to the vulnerability of the different actors confronted with climate disturbances (Sall et al., 2014, p. 254).

Benin's agriculture is mainly rain-fed, and the agro-climatic parameters present constraining characteristics for agriculture and forestry, especially in the South and Far North, which sometimes experience severe droughts (MEPN, 2008, p. 22). To reduce the direct or indirect adverse effects of climate variability and change on livelihoods, several adaptation strategies are developed by rural communities in the municipality of Athiémè to cope with them. It is therefore necessary to determine factors that influence the vulnerability of these communities and to analyze their capacity to adapt to climate change in order to better support them in their contribution to the country's development (Baudouin, 2012, p. 18).

This study aims to contribute to a better understanding of climate risks and the adaptation strategies developed by the communities of the municipality of Athiémè to cope with them. This municipality is located in the southwest of the Republic of Benin, between 6°28' and 6°40' of North latitude and 1°35' and 1°47' of East longitude.

Figure 1 shows the geographical location of the municipality of Athiémè.

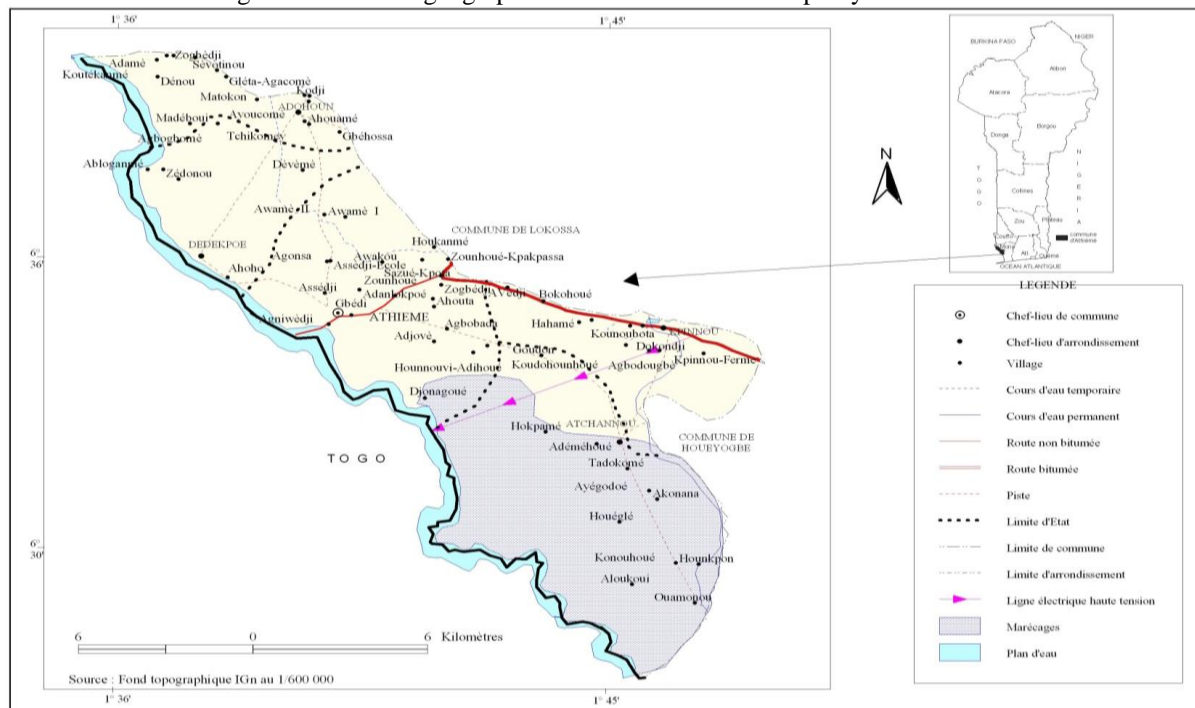


Figure 1 : geographical location of the municipality of Athiémè.

Figure 1 shows that the municipality covers an area of 238 km<sup>2</sup>, i.e. 14.83% of Mono department. It is bordered to the North by the Commune of Lokossa, to the South by the Commune of Grand-Popo, to the East by the Commune of Houéyogbé and to the West by the Republic of Togo, with which it shares a natural border, Mono River. The municipality of Athiémé has five (05) districts: Adohoun, Atchannou, Athiémé, Dédékpòè, Kpinnou (Adam and Boko, 1993, p.39; PDC3, 2017, p. 57). These districts are subdivided into 61 villages and city districts. The climate of the commune is sub-equatorial and is marked by relatively high humidity and rainfall, varying between 900 and 1100 mm/year. The relief is flat monotonous, eroded in places. It is marked by numerous depressions and banks (cordons) of sand and sandstone. These depressions are watersheds or river valleys. They are sheltered by pools, swamps and shallows. The soils are clayey, black hydromorphic clay, sandy-clay or sandy-clay and very suitable for multi-cropping. They are waterlogged during the season and are mostly flooded by flood waters. They are very rich and favorable to off-season and flood-recession crops. Mono River is the main watercourse with a wide valley and catchment areas that irrigate almost all the villages of the Commune. It is completed by Sazué river and Toho, Godogba and Djèto lakes. The latter also have catchment areas. The original dense vegetation has almost disappeared and is replaced by plantations of oil palms and shrubs. However, there are some relics of teak, caïcedrat and eucalyptus forests in places (Djèssounou, 2013, p. 39). Due to its pivotal position between Benin and Togo, the city is of the major poles of trade and economic transaction in southern Benin-Togo. Over time, Athiémé has lost its economic and administrative dynamism, which made it a benchmark in Mono department and on the national scene, as the ruins of its administrative and colonial buildings testify (PDC3, 2017, p. 57).

## II. Methodological Approach

The methodological approach is around data collection, data processing method and the analysis of the results. The data collection technique consisted of documentary research and field surveys. These consisted of direct observations, surveys, interviews and were conducted using questionnaires, interview guides and observation grid.

The data collected concerns climatological data (rainfall and temperature in the Commune of Athiémè from 1989 to 2019), and socio-anthropological data collected in the field from households and institutional actors. They made it possible to gain a better understanding of climate risks, their consequences on livelihoods, and the adaptation strategies developed by the communities to cope with them in the municipality of Athiémè.

The sample takes into account two (02) of the five (05) districts in the municipality of Athiémè. The choice of these two districts is explained by the fact that the districts of Athiémè and Dédékpœ are the most at risk in the Commune. Indeed, these two districts (Athiémè and Dédékpœ) are located close to Mono River and are therefore more affected by climatic risks (especially flooding) than the other three districts (Adohoun, Atchannou and Kpinnou). Thus, in these two districts, the villages of Koudohounhoué, Adjovè, Adjassinhoun-Codji, and Ahofo are the most vulnerable to the effects of climatic hazards because their production is more vulnerable to these effects.

Thus, based on the hypothesis that members of the same group do not necessarily have the same capacity to cope with shocks, an individual questionnaire was separately sent to men and women. In sum, one hundred and eighty (180) people were surveyed in the municipality of Athiémè (90 in Athiémè and 90 in Dédékpœ). A purposive sample was drawn from resource persons and groups of people actively involved in crisis and disaster management in this municipality, including ATDA agents, NGOs and local authorities (15 in total) for the semi-structured interviews. A total of 195 people were interviewed in the municipality

Both quantitative and qualitative data were processed automatically, summarized in tables and graphs and analyzed with SPSS software. The interview guide and survey forms were manually analyzed and then processed with the computer tool Word and Excel to identify trends using descriptive statistics.

The matrix approach (Table I) was the root for the analysis of environmental impacts through the identification of impact sources and environmental components and the analysis of direct and potential impacts as well as their evaluation.

Table I: Sensitivity matrix for risks related to the exploitation of the populations of the municipality of Athiémè

	Risks related to the exploitation of Mono River				Exposure indicators (%)
	Depletion of fisheries stocks	Filling / siltation	Water quality	Social changes	
<i>Services provided by Ouémé River</i>					
Ecological habitats					
Fishery resources					
Water resources					
<i>Livelihoods</i>					
Fishery products					
Agriculture					
Trade					
Fish farming					
<i>Ways of life</i>					
Fishermen					
Farmer					
Traders					
Fish farmer					
Impact indicators (%)					

*Source: Flint et al., 2007/Fall, 2007 and adapted according to fieldwork data, November 2022*

The scale of assessment of the extent of the risks affecting the populations of the municipality of Athiémè is presented in Table II.

Table II: Scale of assessment of climatic risks in the municipality of Athiémè

Ampleur du risque	Seuil d'impacts ou d'exposition
Faible	1
Assez faible	2
Moyen	3
Assez fort	4
Fort	5

*Source: Flint et al., 2007/Fall, 2007 and adapted according to fieldwork data, November 2022*

The threshold is high according to the extent of the risk related to the environmental exploitation. This threshold scale is used to determine the degree of impact of lake exploitation on natural, socio-economic and livelihood systems. The indicators are calculated in terms of proportion (percentage) according to the total number of points gathered by the elements of the headings: services rendered by the commune, livelihoods and ways of life. Thus, the adaptive capacity index is obtained by averaging the scores of the indicators. For this

purpose, three classes of adaptive capacity have been distinguished according to the value of the score (Table III).

Table III: Example of adaptive capacity classes

Score	10 ;11	11 ;21	12 ;31
Adaptability	Low	Average	High

Source : Flint et al., 2007/Fall, 2007 et adapté en fonction des données de travaux de terrain, novembre 2022  
 These scores are then represented in the spider web curve (Figure 2) to show the adaptive capacity of actors, which varies from low to high.

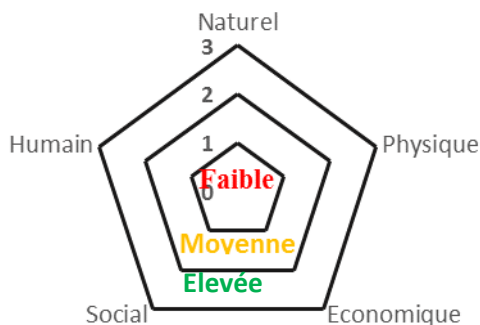


Figure 2 : Illustrative diagram of the adaptive capacity of communities

The coping strategies were also analyzed. They essentially took into account the endogenous strategies implemented by the communities themselves and the strategies that were suggested to them.

### III. Results

#### 3.1. Activities and livelihoods of women in the municipality of Athiémè

According to 95% of respondents, agriculture is the main activity carried out by communities in the two districts located near Mono River. Figure 3 presents the proportions of activities carried out by communities in this municipality.

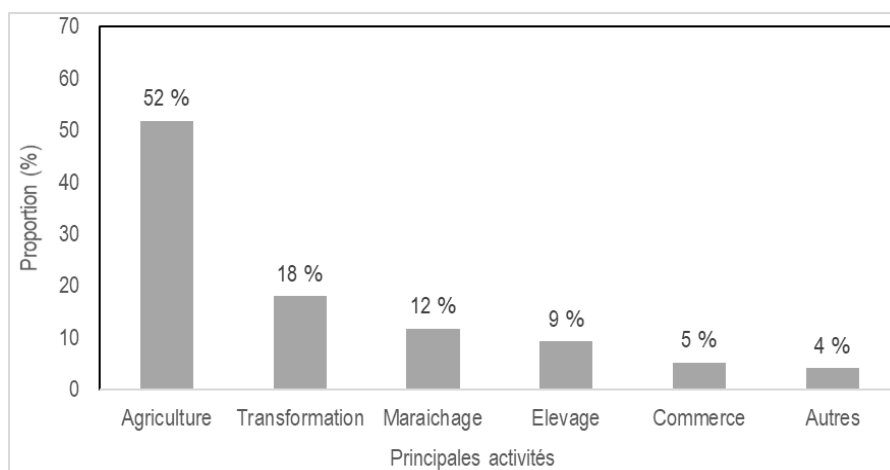


Figure 3 : Activities carried out by women in the municipality of Athiémè

Figure 3 shows that more than half of the surveyed population is engaged in rural activities. The remaining 44% develop activities related to palm oil processing (18%), market gardening (12%), poultry farming (09%), small businesses (5%) and others (4%). Thus, the main activity of the population remains agriculture, followed by market gardening and other activities that are qualified as secondary activities. The agricultural equipment used is still rudimentary. The initial activities practised by these populations are of several types depending on the natural resources exploited.

#### 3.2. Main livelihoods, livelihoods and access to land

The communities use several types of resources to meet their livelihood needs. These resources are used for the survival of these communities and mainly concern natural resources and physical resources.

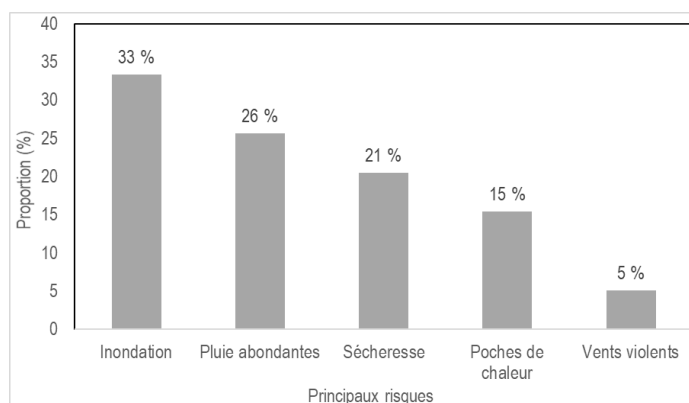
Natural resources include arable land: they allow the production of different crops (market gardening, food crops, cash crops), Mono River (which allows people to practice agriculture and fishing), forest resources (composed of palm plantations, banana plantations, several fruit trees), animals composed of sheep, goats, poultry and the transformation and exploitation of timber for trade and cooking (which are activities that are developed around the said resources in the municipality).

The physical resources are made up of temples of deities (these temples are a meeting place for the followers of endogenous cults), churches, houses, roads, bridges (which limit the flow of water and the deterioration of roads), schools and colleges, pumps and wells (where women and girls gather to collect water), markets, processing units (these units are mainly operated by women), entertainment areas and various services (district, health centers, police station).

The different modes of access to land are inheritance, loan, purchase and rental. Women do not inherit land in this municipality despite the existing laws. The reason given by the men is that women are called upon to leave the family home and join other families. It is unbelievable for the men that the land of one family becomes the property of another family. It is also explained that women have the right to receive plots of land from their husbands (gift) or from a relative (loan) with the obligation to return it when needs be, which creates a form of insecurity for the woman. All these provisions are silent rules that these societies have built and operate on.

### **3.3. Main risks identified in the municipality of Athiémè**

Several risks have a negative impact on the commune's resources. They are reflected in increasingly long pockets of drought, which cause scarcity of grazing, increasingly pronounced soil degradation, late and violent rains that cause disruption in the various activities carried out, excessive heat that causes the appearance of epizootic and hydric diseases, the rise in sea level causing strong coastal erosion, drought, flooding, floods, heavy rains, excessive heat and the early end of the seasons. The major hazards are flooding, heavy rainfall, drought and high winds (Figure 4).



**Figure 4 :** Main risks identified in the municipality of Athiémè

Figure 4 shows that several risks impact the activities of the communities in the municipality of Athiémè and concern floods, heavy rains, droughts, heat pockets and violent winds.

#### **3.3.1. Floods**

Flooding is the main risk in the municipality of Athiémè. There are two types: fluvial and pluvial. Fluvial flooding is caused by the overflow of Mono River; and the pluvial type is caused by the abundance of rainfall. Photos 1, 2 and 3 show some of the consequences of climatic risks on agricultural production in this municipality.



**Photo 1** : Rice cultivation



**Photo 2** : Cultivation of crincrin



**Photo 3** : Maize growing

*Shooting: Blalogoé, september 2021*

Most of the villages in Athiémè undergo flooding every year or two, with varying intensities. The populations are vulnerable to this risk and often have no choice but to move away while the water recedes or suffer the scourge. The consequences of this risk are the destruction of houses and arable land. Several resources become inaccessible (wells, processing units, some pumps). School is suspended during this period and families support themselves with their savings or by taking out a loan from Village Savings and Credit Association (AVEC). Floods occur in all localities of Athiémè, but more in the districts of Athiémè and Dédékpòè, which are near Mono River. The years of major floods are: 1980, 1985, 1990, 1995, 2000, 2010 and 2019. The greatness of floods creates damage year after year.

### 3.3.2. Drought

Crops suffer from lack of water during drought. There is a proliferation of pests, which leads to the overuse of chemical inputs. The better-off producers build boreholes for market gardening while reducing the area under cultivation. The less well-off become laborers for the others. During drought, Peulhs, in search of better pastures, arrive in the various localities. This leads to conflicts between them and farmers, forcing the indigenous people, mainly men, to flee their localities for their safety. This has a negative impact on the men as they have no choice but to take refuge far from their families, leaving the family responsibilities to women who then look after the household. Droughts occur throughout the municipality but those who have their fields near Mono River manage to water their crops more easily. The great drought years in the municipality are: 1977, 1983, 1985, 1991, 2001, 2005, 2009, and 2020.

### 3.3.3. Heavy rains

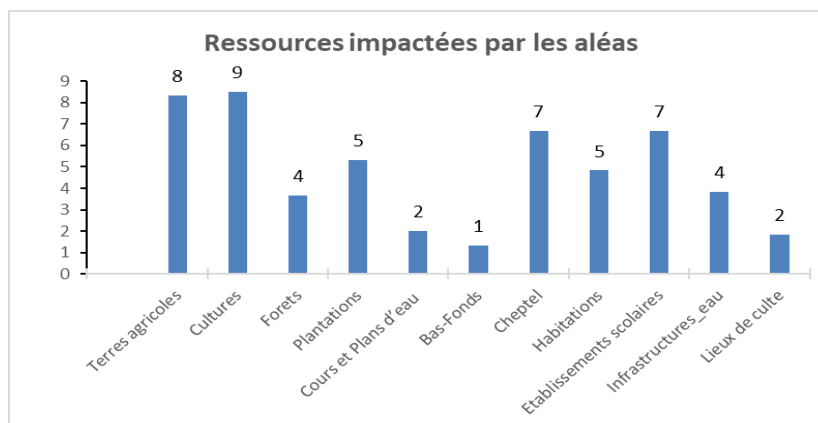
Heavy rains lead to the rise of water levels, sometimes flooding fields and destroying crops. During heavy rains, the increased coolness leads to the loss of domestic animals due to the lack of adequate infrastructure. Also, heavy rains cause degradation of roads, which makes it difficult to transport agricultural products to markets and inhibits the movement of women who carry out small-scale activities (food trading, door-to-door sales) to meet their needs and their households. Heavy rains are felt throughout the town.

### 3.3.4. Strong winds

Strong winds destroy market garden crops, creating a loss of yield for the majority of men. Those who can afford it resort to staking their crops to save them. Strong winds are often followed by a drop in temperature, making children more vulnerable to bacteria and microbes, and leading women to take extra care of their offspring. This leads to an increased workload for women. These winds occur throughout the town. The years of high winds in the town are 2005, 2006, 2017, 2018, 2019.

### 3.4. Impact of risks on the communities' resources in the municipality of Athiémè

Several important resources have been identified for the communities of the districts in the municipality of Athiémè. These resources provide people with income to achieve the desired and targeted state of well-being. During hazards such as heavy rains, drought, violent winds and floods, several of the resources are impacted. Figure 5 presents the important resources identified in the municipality.



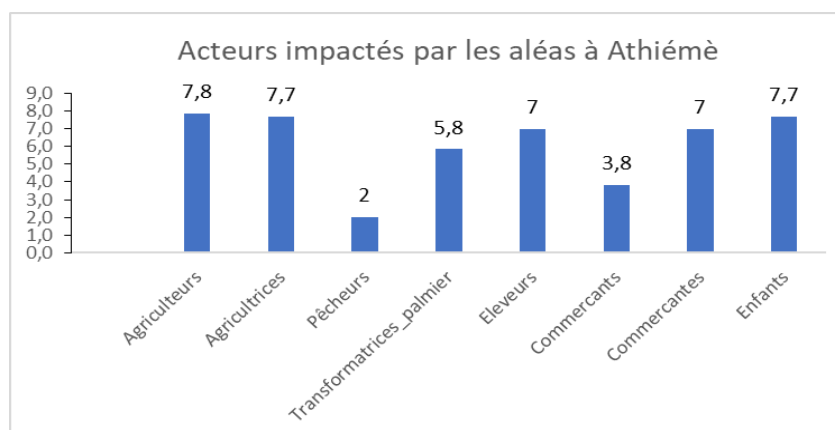
**Figure 5 :** Resources impacted by hazards in the municipality of Athiémè

Figure 5 shows that the impacted resources are agricultural land (on which market gardens, maize, cassava and rice are grown), forests (which provide non-timber forest resources and firewood), banana and palm plantations and livestock (cattle, sheep, goats and poultry). These resources provide financial income for men and women of the various communities. In addition, housing, schools, water facilities and places of worship are important resources in the municipality because they provide social well-being, health and security for the population.

Agricultural land and crops are most impacted by hazards with exposure indicators of 8 and 9 in the municipality of Athiémè. This difference is noted due to violent winds which only impact crops and not agricultural land. Livestock and schools are also affected by hazards. Schools are closed in times of floods, creating a drop in the success rate of the various exams. Communities suffer losses in their livestock due to the rising water. Homes and plantations are also impacted by climatic hazards. All this creates a disruption in the communities' daily life.

### 3.5. Stakeholders most affected by hazards in the municipality of Athiémè

The existing resources in the municipality of Athiémè (Athiémè and Dédékpœ) are exploited by men and women. Each resource is used to develop specific sectors. When impacted by hazards, the different actors suffer different shocks. Figure 6 shows the different actors impacted by hazards in the municipality.



**Figure 6 :** Stakeholders impacted by the various hazards in the municipality of Athiémè

Farmers are most impacted by climate hazards. Rising water levels lead to flooding of fields. Much of the products from agricultural production are destroyed during climatic hazards. Farmers with the largest areas are the most affected, but this loss does not exclude women farmers who also have small plots of land that they cultivate in order to contribute to household needs. During drought, the lack of water leads to the destruction of crops (market gardening, maize, cassava, etc.), creating a drop in income for the stakeholders. Herders are also affected by climatic hazards. Both men and women are affected. During floods, women suffer more losses due to the vulnerability of their livestock, but men suffer losses in their livestock due to the lack of grazing and the drying up of water points during drought.



Women processors and traders suffer a drop in income during heavy rains and floods. Palm oil processing is reduced or non-existent and women traders restrict their movement due to the degradation of roads and water levels.

### 3.6. Impacts identified in the municipality of Athiémè

Tables IV and V show the direct and indirect impacts of the different climate risks on the communities on one hand, and on the production resources of the communities on the other.

Table IV: Impacts of climate change on the communities of Athiémè

Hazards	Direct effects	Indirect effects (Categorization of indirect effects)	More affected socio-economic groups	How? Women-Men-Girls-Boys, Gr vulnerable?
<b>Flood</b>	Flooding of fields and crops	Slowing down of agricultural activities Decline in yield Decrease in income	Men Women Disabled people	Difficulty in transporting crops to homes Loss of large part of the production
	House destruction	Insecurity Theft	Men Women Children Disabled people	Households suffer from house destruction
	Increased freshness	Loss of animals	Men Women Disabled people	Both men and women are affected. Women are involved in poultry rearing and men in sheep and goat rearing
		Diseases of children and elderly people (colds, coughs)	Children Elderly people	Children and elderly people are the most vulnerable
	Insect proliferation	Diseases (malaria, cholera, diarrhoea)	Children Elderly people	Children and elderly people are the most vulnerable
	Interruption of school	Decline in success rate	Children Woman	The flood creates schools to close, leading the local authorities to suspend schooling during this period. Women are obliged to care for children during this period
	Interruption des activités	Decline in income	Men Women	During flooding, agricultural and processing activities are suspended until the water recedes. Both women and men experience a decrease in the intensity of their activities due to rising water that blocks mobility.
	Difficulty in accessing drinking water	Waterborne diseases (cholera, diarrhoea) Increase in women's workload	Children Women	Children with more vulnerable bodies are prone to illness and women are the ones who take care of them. Women are the most affected as water collection becomes more difficult
<b>Strong winds</b>	Destruction of crops (tomato, chilli, maize)	Yield reduction	Men Women Disabled people	Several stems twist inhibit fruiting, leading to a drop in yield during strong winds
	Diseases (Freshness)	woman's workload increase Decreased income	Children Elderly people Women	Children and elderly people are the most vulnerable. Taking care of them puts a strain on the household budget and increases women's workload
	Houses' destruction	Insecurity Theft	Men Women Children	Households suffer from the destruction of houses

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	Destruction of trees	Downturn in activities	Women	Women are the most affected because they carry out several activities from the resources produced by the trees (oil extraction)
<b>Drought</b>	Lack of water	Delay in agricultural activities and destruction of crops	Men Women	Men are the ones who have the largest areas but they acquire motor pumps and varieties more easily, unlike women who find it difficult to obtain them and see their yields drop
		Difficulté d'accès à l'eau potable Maladies hydriques (choléra, diarrhée) Augmentation de la charge de travail de la femme	Women Children	Women have difficulty in finding clean water during drought They also double the time spent in their field and their husband's time watering the plants The drying up of water leads to the problem of water quality and quantity, which creates diseases for children
	Loss of domestic animals (sheep, goats, poultry)	Low income	Men Women Disabled people	Men, women, disabled people are affected. Women are engaged in poultry rearing and men in sheep and goat rearing
	Loss of vegetation cover	Lack of grazing and watering points for sheep and cattle. Transhumance Destruction of crops (cassava, beans, market gardening) Pollution of water points	Men Women Disabled people	Sheep are raised by humans and during drought, they suffer from lack of grazing and accessibility to water points. Pastoralists leave the north and centre of the country in search of better pastures, creating conflicts with indigenous people during drought. Some herders go so far as to sexually assault the wives of indigenous people in order to demonstrate their power. Disabled people involved in livestock farming are also affected
	Bushfires	Fire	Men Women	Fire ravages houses, creating insecurity for households
	Heat output	Children's diseases (measles, cholera, sludge)	Children Women	Children suffer from the heat, which creates measles, cholera and boils due to the high temperatures. This creates an increased workload for women
	Dust propagation	Decline in fruit tree yields Decrease in women's activity Decrease in income	Women	Women are the most affected because they have several activities based on the resources produced by the trees (oil extraction, fruit trade) Palm trees do not provide enough nuts for oil extraction, which leads to a decrease in women's income in times of drought
<b>Heavy rainfall</b>	Rising water level	Flooding of fields (maize, beans, market gardening) Decrease in income	Men Women Disabled people	Difficulty in transporting crops to homes Loss of a large part of the production
		Moisture of wood bundles	Women	The bundles of wood are damp, which makes women's activities more difficult and reduce their income as they are forced to use charcoal to ease their cooking
	Increased freshness	Diseases of children and elderly people (Colds, coughs)	Children Elderly people Women	Children and elderly people are the most vulnerable.
	Deterioration of roads	Difficulty in transporting agricultural products Difficulty in accessing markets Difficulty in trading	Women	Women find it difficult to transport agricultural products to markets

*Source: Filed survey, september 2021*

Men and women see their income affected by the effects of the risks. Floods are recurrent phenomenon in the municipality of Athiémè and create impacts in all the localities of the municipality. They are fluvial and rain-fed. The risks lead to the destruction of market garden crops, introduce diseases in the most vulnerable groups (children, elderly) and destroy houses and trees. This leads to lower yields, income and increased workload for women. The difficulty in accessing drinking water leads to an increase in water-related diseases (cholera, diarrhoea, dysentery) and an increased workload for women. During late and violent rains, several roads deteriorate, making it more difficult to move around. As women are the ones who move along the most (market, wholesale and retail trade, door-to-door trade), they are forced to temporarily cease their activities, thus suffering a drop in income. The resources exploited by women are affected and their low economic power constitutes barriers to full development. The extra workload caused by the effects of climate change makes them more vulnerable. Table V presents the direct and indirect effects of the various climate risks on the communities' production resources.

**Table I :** Impacts of climate change on the production resources of Athiémè communities

Exhibition units	Climatic hazards			
	Drought	Flood	Drought	Heavy rains
Land Agricultural /shallows	Soil degradation and increased risk of erosion, reduced productivity	Flooding and water erosion of agricultural land	Risk of erosion Thermal ; Decrease in soil moisture, decrease in productivity	Loss of biodiversity (flora and fauna), decrease in productivity
Forests/ Vegetation	Degradation of the vegetation cover and disappearance of species, decrease in the yield of fruit trees	Death of trees by asphyxiation, decrease in wood production and forest products.	High evapotranspiration rate, slower growth - lower production of wood and non-wood forest products	Decline in timber and non-timber forest products
Culture	Decline in agricultural yields, contraction in the income of agricultural producers, Decline in purchasing power of farm women, Deterioration of living conditions	Stagnation of water in crop fields, Loss of crops through asphyxiation	Increased crop evapotranspiration, Crop wilting, Slower growth and lower yields	Mortality of first seedlings and young plants, delayed development, low yield
Water resources	Decrease in available water, Increased water requirements	Increased runoff	Drying up of watercourses, water scarcity for crops	Remoteness and low recharge of the water table, early drying up of surface water points

Source: Field survey, september 2021

### 3.7. Analysis of community coping strategies in the municipality of Athiémè

The current measures implemented by the communities have strengths but also weaknesses that limit the resilience of men and women to climate change. Table VI presents an inventory of current community strategies developed in the municipality of Athiémè.

**Table II :** Current community strategies developed by Athiémè communities

Hazards	Effects	Current measures
<b>Flood</b>	Field flooding	Early harvest
		Traditional drain systems
		Outflow to other cities
		Crops in non-flood areas
	House destruction	House reconstruction
		Relocation to the sites developed by the town hall
Loss of pets	Change in activities	

		Livestock reconstitution	
	Increase in waterborne and episodic diseases (children)	Child protection and curative care	
<b>Strong winds</b>	Crop destruction	Staking Early harvest	
	House destruction	House reconstruction	
	Trees' destruction	-	
<b>Drought</b>	Crop destruction	Hand watering Irrigation with motor pumps Construction of water reservoirs	
	Hard access to drinking water	The use of water disinfectants (aquatab, bleach) Use of Mono river water	
	Loss of animals	Livestock rebuilding	
	Transhumance	Exode rural Rural exodus	
	Decline in fruit tree yields	Business diversification	
	Household fires	House reconstruction	
	<b>Heavy rains</b>	Field flooding	Early harvest Rural exodus Crops in non-flood-prone areas Water draining system
		Increase in waterborne and episodic diseases (children)	Child protection and curative care
		Runway degradation	Development of rural tracks

*Source : Field survey, september 2021*

The different strategies used by rural communities to deal with different risks do not take men and women equally into account. During hazards, women's workload is increased. They are not entitled to any support from men and have no choice but to bear the risks and adapt to them as best they can. Their low purchasing power does not allow them to acquire adequate equipment and materials for production and processing during periods of drought or heavy rainfall.

### 3.8. Current Measures' Strengths and Weaknesses

The current adaptation measures enable rural communities to cope with climate risks but do not smooth greater resilience to climate change. One of the strategies developed in response to climate risks is early harvesting. Not all farmers manage to harvest all their production and suffer huge losses. Women see their crops destroyed because they select harvesting the crops from the head of household's field. Also in times of drought, hand watering is the first measure taken. One of the weaknesses of the current measures is that most men try to rebuild their lives elsewhere through periodic activities in other towns or a total reconversion to another activity. This leads women to cope with the daily routine of becoming heads of the household and providing security for women and the elderly, which increases their workload. Their low level of illiteracy also prevents them from being able to rebuild their lives easily. A lack of practical training for women to develop income-generating activities also prevents them from being able to really diversify when a disaster strikes. Adaptation strategies need to be strengthened to enable greater resilience of both men and women to climate change.

### 3.9. Adaptation measures identified by beneficiaries in the Municipality of Athiémè

Table VII presents the adaptation measures by beneficiary in the Municipality of Athiémè.

**Tableau III** : Adaptation measures by beneficiaries in the Commune of Athiémè

Adaptation measures	Measures to be implemented	Actors			
		Men	Women	Young/Children	Disabled people
<b>Option 1</b> : Establishment of a climate services access system	Establishment of a climate services access system	X	X	X	X
	Setting up alerts based on the tags	X	X	X	X
<b>Option 2</b> : Promotion of Income Generating Activities	Training in income-generating activities (livestock, market gardening, soap preparation)		X	X	X
	Support for equipment and materials for the processing of palm nuts, cassava and maize		X		
	Construction of palm nut processing and storage areas		X		
	Construction of a professional training centre for young people			X	
	Support in equipment for the craft industry				X
	Subsidy to women/disabled/youth for AGR, purchase and storage of palm oil		X	X	X
<b>Option 3</b> : Capacity building in several areas	Producers' capacity building on good agricultural practices	X	X	X	X
	Producers' capacity building on good practices for sustainable management of fisheries resources	X			
	Training on composting and bio-pesticides	X	X	X	
	Livestock training	X	X		X
	Training on rice production and processing	X	X		
	Support for the formalization of clusters	X	X	X	X
	Household Management Training		X		
	Training in nutrition for better child protection		X		
<b>Option 4</b> : Development of infrastructure for the marketing of agricultural and traditional fishing products	Development of rural access roads and tracks	X	X	X	X
	Creation of a market for the sale of products		X		
	Support in materials and equipment (boats, nets)	X			
	Construction of a warehouse for storing agricultural products	X	X		X
	Regulation of product prices in the market	X	X		X
<b>Option 5</b> : Easy access to adequate agricultural credit from Micro-Finance Institutions	Setting up agricultural credit institutions	X	X		X
	Easy access to adequate agricultural credit with lower interest rate from six months to a year later	X	X		X
	Financial management training	X	X	X	X
<b>Option 6</b> : Promotion and sustainable management of hydro-agricultural and water supply works	Support for the implementation of hydro-agricultural developments	X	X		X
	Construction of boreholes, tube wells and motor pumps to facilitate agricultural production	X	X		X
	Rehabilitation / construction of drinking water pumps		X	X	
	Construction of dykes - Lower Mono River Valley Hydro-agricultural Development Project (PAHV-MONO)	X	X	X	X
<b>Option 7</b> : Health care for rural communities during risks	Set up a fund to ensure producers' health (mosquito nets, medicines)	X	X	X	X
	Access to hospital care for the disabled at home				X
	Creating small drugstores in rural areas		X	X	X
	Advocacy for a disability fund				X
<b>Options 8</b> : Strengthening Clusters for Climate Smart Agriculture	Development of lowlands and wetlands for the development and diversification of off-season crops	X	X		X
	Support seed producers to make short-cycle seed, high-yielding varieties of maize, cassava and rice available	X			
	Development of drip irrigation	X	X		X
	Accessibility of adapted inputs for the benefit of market gardeners and other producers	X	X		X
	Easy access to veterinary care for poultry, sheep, goat farmers etc	X	X		X
	Advocacy for the implementation of transhumance corridors	X	X		X
	Availability of short-cycle, drought-resistant seeds	X	X		X
	Modern equipment for production (tractor, power tiller)	X	X		X
	Advocacy for a real follow-up of ATDA	X	X		X
	Teak reforestation	X	X		
	Construction of fish ponds	X			X
	Research/Creation of an elevated area to contain livestock in case of flooding	X	X		X

Source: Field survey, september 2021

### 3.10. Key adaptation measures identified by beneficiaries in the Municipality of Athiémè

The adaptation measures gathered from the rural communities of Athiémè were ranked. This took gender into account to enable greater resilience of the most vulnerable groups to climate change (Table VIII).

**Table IV** : Ranking of key adaptation measures in the municipality of Athiémè

RANK	KEY ADAPTATION MEASURES
First	<b>Option 3</b> : Capacity building in several areas
Second	<b>Option 2</b> : Promotion of Income Generating Activities
Third	<b>Option 8</b> : Strengthening Clusters for Climate Smart Agriculture
Fourth	<b>Option 1</b> : Establish a climate services access system
Fifth	<b>Option 5</b> : Easy access to adequate agricultural credit from Micro-Finance Institutions

<b>Sixth</b>	<b>Option 6</b> : Promotion and sustainable management of hydro-agricultural and water supply works
<b>Seventh</b>	<b>Option 7</b> : Health care for communities during risks
<b>Eighth</b>	<b>Option 4</b> : Development of infrastructure for the marketing of agricultural and traditional fishing products

*Source : Field survey, september 2021*

### 3.10. Limitations of farmers' adaptation strategies to climate variability in the Municipality of Athiémè

The analysis of the farmer adaptation strategies reveals that they have limits. These are not real solutions to climate variability. Table IX presents the limits of adaptation strategies to climate variability in the Municipality of Athiémè.

**Table V : Limitations of farmers' strategies to climate variability**

Farmers' adaptation strategies	Limits of coping strategies
<b>Introduction of new varieties</b>	New varieties may not be adapted to the local soil types Growers are under-informed about the thermal and moisture requirements of new varieties Lack of training on the technical itinerary for the production of new varieties Non-resistance of new varieties to water stress Lack of information on the economic profitability of new varieties per hectare
<b>Change in the agricultural calendar</b>	Not suitable for the current climate rate Not effective if climate variability persists Most farmers do not have access to weather data
<b>Staggered sowing</b>	Most producers are aware of the technique but few practice it Impossible to harvest at once (multiple harvests) Requires great effort
<b>Early sowing in shallows</b>	There are floods that can occur and even wash away an entire field under the current conditions of climate change Difficult clearing Rapid weed growth
<b>Use of off-season crops</b>	Crops may wilt before ripening, especially if they are planted in areas that are not conducive to sustained moisture
<b>Backfilling of houses</b>	Requires a lot of strength and energy
<b>Agroforestry</b>	The competition between certain types of trees and the crops planted is undoubtedly one of the major disadvantages of agroforestry. There may be competition for space, and therefore for light, water and soil nutrients. The tree takes up space in small fields
<b>Construction of stilt houses</b>	A thorough study of the site is necessary because even though the pile structure is stronger than conventional ground foundations, the piles may be exposed to seismic risks, frost or regular flooding. Level access is difficult or restricted The space underneath the house tends to make it colder, as it lacks the natural geothermal insulation of traditional houses

*Source: Field survey, september 2021*

## IV. Discussion of the results

The results show that rural communities develop agriculture as their main activity and highly depend on natural resources such as forests/vegetation, water resources and agricultural land in the Municipality of Athiémè (Seydou, 2016, p. 49; Akponikpè et al., 2019, p. 68). This result is confirmed by the investigations of Mbaiguedem (2012, p. 49) and Mbaye et al. (2019, p. 36) who showed that agriculture remains the sector most influenced by climate and its variations. Moreover, the agriculture practised by the communities is still rainfed. The analysis of climate data shows that several changes occurred in the rainfall pattern and temperature evolution in the municipality. Rainfall disturbances (late rains and shorter seasons), floods, droughts and heat waves are the main climatic risks affecting rural communities in the municipality of Athiémè. These risks are among those identified in NAPA document (NAPA, 2008, p. 49). The rainfall regime is experiencing major disruptions in the town. Indeed, the strengthening of the trend towards climatic drying limits the efficiency of rainfall systems and to some extent leads to the choice of the most productive methods such as market gardening in the municipality. These same changes were identified in PANA (2008, p. 26). This situation is also confirmed by Ouédraogo (2019, p. 89) who states that 'the potential of water resources favors the development of market gardening and other irrigated crops'. This is the current study's case. According to 100% of farmers, flooding is the most catastrophic climate risk in recent decades. Floods and droughts showed themselves through the delayed onset of rains, insufficient rainfall due to recurrent breaks in rainfall during the rainy seasons and the

lengthening of the dry seasons. This situation makes farmers vulnerable as they can no longer meet their socio-economic needs (Boko, 1988, p. 318; FAO, 2003, p. 14; Akindélé, 2013, p. 3).

These identified risks contribute to the loss of natural resources in the form of disappearance of plant species, and to the disruption of socio-economic activities in form of agricultural calendars' disruption due to the increasingly lateness of the rainy seasons. To cope with climatic variability, some producers adopt short-cycle crops and modify the cropping calendar (sowing date) in order to reduce the vulnerability of agricultural production. These results are in line with those of Baudouin (2012, p. 108), Djessonou (2013, p. 46) and Allanéjé (2013, p. 42) who noted that farmers adopt short-cycle crops and modify the traditional agricultural calendar in order to reduce the vulnerability of their activities to climatic extremes such as flooding and the lengthening of dry seasons. The rice cultivation in swampy areas and the adoption of staggered sowing as coping strategies by 30% and 89% of farmers in Athiéme commune respectively confirm the findings of Ogouwalé (2006, p. 112), Houssou-Goé (2008, p. 41), Vodounou (2016, p. 87) and Yabi (2019, p. 203), according to which staggered sowing and lowland cultivation are farmers' strategies to agricultural disasters. The diversification of income is also an example of a strategy related to climate change. It responds to farmers' desires to reduce their vulnerability and dependence on the agricultural sector to climatic hazards. In his study on Lake Nokoué, Ogouwalé (2007, p. 59) found that fishermen working on this lake have converted to market gardening, exploitation of the lake's sand and other activities following the reduction in yields of the lake's fishery resources.

The adaptation techniques are not very effective. Indeed, the communities (mainly women) who have plots of land along the river, use them for off-season crops. However, this technique is unreliable as these communities often do not have the necessary means for irrigation. They also do not have access to climatic information on the area, mainly on the overflow/flooding of Mono River. The latter makes them lose all their crops through unexpected flooding when it leaves its banks.

## V. Conclusion

The vulnerability factors and adaptation strategies of the rural communities of the municipality of Athiéme in southern Benin were highlighted in this context of fighting against climate change in the world and especially in Benin,

Thus, the risks related to droughts, floods, disruption of rainfall patterns and heat waves are the major risks affecting the rural communities of the aforementioned municipality.

As main source of income for these communities, agriculture is dependent on the climate and is therefore strongly threatened by the climate risks identified in the municipality. Climate change worsens the agricultural land degradation and the plots close to flood-prone areas are the most affected. The factors that hinder the access to crucial resources for agricultural development by these communities not only tough their living conditions, but also increase the constraints on the agricultural sector and the economy. It is then crucial to act on the structural causes of the problems of these rural communities of the municipality of Athiéme so as to limit factors influencing the vulnerability of these communities.

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