Scientific Research Publishing

Agricultural Sciences, 2024, 15, 1353-1370
https://www.scirp.org/journal/as
ISSN Online: 2156-8561
ISSN Print: 2156-8553

Living Conditions Vulnerabilities of Farm Households in Cotton-Growing Areas of Northern Benin

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How to cite this paper: Issaka, K., Yaï, E., Agani, F.O. and Yabi, J.A. (2024) Living Conditions Vulnerabilities of Farm Households in Cotton-Growing Areas of Northern Benin. *Agricultural Sciences*, **15**, 1353-1370.
https://doi.org/10.4236/as.2024.1512074

Received: October 18, 2024
Accepted: November 26, 2024
Published: November 29, 2024

Abstract

The vulnerability of farms to the effects of climate change weighs heavily and indirectly on the living conditions of farming households in northern Benin. This article analyses the vulnerability of cotton-growing households to the effects of climate change. Using a simple random sample of 240 households, the study identified the hardships suffered by cotton-growing farm households in the communes of Boukoumbé and Kérou in northern Benin. The theoretical framework is based on sustainable living conditions, according to which poverty is no longer understood solely in monetary or pecuniary terms, but rather is based on a multidimensional approach. The normalization method is used to calculate the index level for each sub-component. The results show that the level of vulnerability to living conditions per household is 0.3120. Households headed by women are less vulnerable to the effects of climate change (-0.0042) than those headed by men (0.0258). The effects of climate change on household living conditions are estimated at 0.0209.

Keywords

Vulnerability, Farm Households, Living Conditions, Climate Change

1. Introduction

In Benin, the cotton sector is the main source of growth for the national economy, accounting for 40% of export earnings, employing 45% of farm households and providing a substantial income for a third of the population in the Ministry of Agriculture, Livestock and Fisheries report (MALF, 2011). It remains the best-organized of the country's many existing sectors [1] [2].

For 325,000 farmers, it is a direct source of cash income, according to statistics from the Association Interprofessionnelle du Coton (AIC). Paradoxically, producers do not benefit from this and stagnate in poverty, despite the fact that they receive cash receipts from the sale of seed cotton once the product has been marketed.

Benin's cotton-growing areas consist mainly of the center, the north and a few communes in the south. The center of the country is wetter, receiving around 1,000 to 1,200 mm of water per year. It is more densely populated and agriculture is well diversified, with crops such as maize, cassava, cowpeas, groundnuts and cotton (INSAE, 2013). The north is semi-arid, with a single rainy season running from May to September, and annual rainfall of around 800 to 1,000 mm. The rural economy is based on maize, sorghum, millet, yams, cotton and livestock.

The performance of Benin's agriculture is not helping to improve the living conditions of producers in the country's cotton-growing areas [3]. Faced with this situation, the Beninese government, in its Growth and Poverty Reduction Strategy Paper (GPRSP, 2011-2015), opted for a diversified agriculture that would be enhanced by the promotion of new value chains. This option has been confirmed in subsequent documents (PSDSA 2017-2021, PSDSA 2021-2025, PAG1 2017-2021 and PAG2 2021-2025. Nor are these diversification strategies without risk, either because maize itself is subject to variations in supply and price, or because producers divert too many cotton inputs to maize, to the point where the income from cotton is no longer sufficient to repay the loan taken out.

Despite all the efforts made in the agricultural sector, the problem persists, and producers in Benin's cotton-growing areas are mired in poverty. In the Atacora department, 8 out of 10 households suffer from food insecurity, and at least 70% of households live in extreme poverty, according to statistics from the Institut Nationale de la Statistique et de l'Analyse Economique (INSAE, 2016). According to the same sources, 61.8% of producers have suffered shocks of all types. Economic shocks affect 41.7% of households. These are followed by biophysical shocks, which affect 31.9% of households. Social shocks affected 4.3% of producers. The most significant shocks in 2009 were linked to rainfall and price fluctuations. In addition, the extent of the shocks suffered by producers over the years varies considerably, reflecting the discontinuous and unpredictable nature of these shocks. [4] examined the effects of climate change on the health of the population of 45 countries south of the Sahara over a period from 1960 to 2019. They found that temperature variation is associated with long-term health losses. Producers (81%) are very vulnerable because of the cost of living, and 91% have no means of combating climate risks [5]. Ideally, farm households in cotton-growing areas should be able to feed themselves adequately. Studies on the agricultural production value chain pay little attention to the vulnerability of farming households and the effects of climate change on their living conditions. It is important to take a look at farm households in cotton-growing areas and identify the deprivations they suffer as a

result of impoverishment.

2. Theoretical and Analytical Framework on Vulnerability to the Living Conditions of Agricultural Households

Figure 1 below shows the analytical framework for sustainable living. Sustainable living conditions came to the fore in the 1990s as a response to growing dissatisfaction with development theories [6] [7]. This was fostered by a consensus to move to macroeconomic adjustment policies, taking into account factors and processes that limit or enhance a household's ability to earn a living [8] [9]. The United Nations Brundtland report (1987) and a critique of the [8] report led to new concepts of poverty, later called "sustainable living conditions" [7]. This conceptual advance encompassed an inclusive approach to decision-making, based on the idea that poverty is not simply a low level of income but represents a multitude of dimensions, such as health and access to education [10].

Sustainable living conditions is a concept, aimed at improving our understanding of the living conditions of the farm household. It takes into account the complexities inherent in existential poverty by assessing the different factors, constraints and opportunities that shape the livelihood strategies of the farm household (DfID, 2000). The framework is composed of assets (**Figure 1**) grouped into seven main types of capital. The vulnerability context can be understood as the external influences on livelihoods that affect the asset base of the farm household [11], which are: i) shocks, such as a flood or a death in the family; ii) trends, such as population pressure, deforestation; and iii) seasonality. An individual's ability to earn a living depends on the diversity, quantity and balance of livelihood assets that a farm household can accumulate [12] and use to implement various livelihood strategies [13].

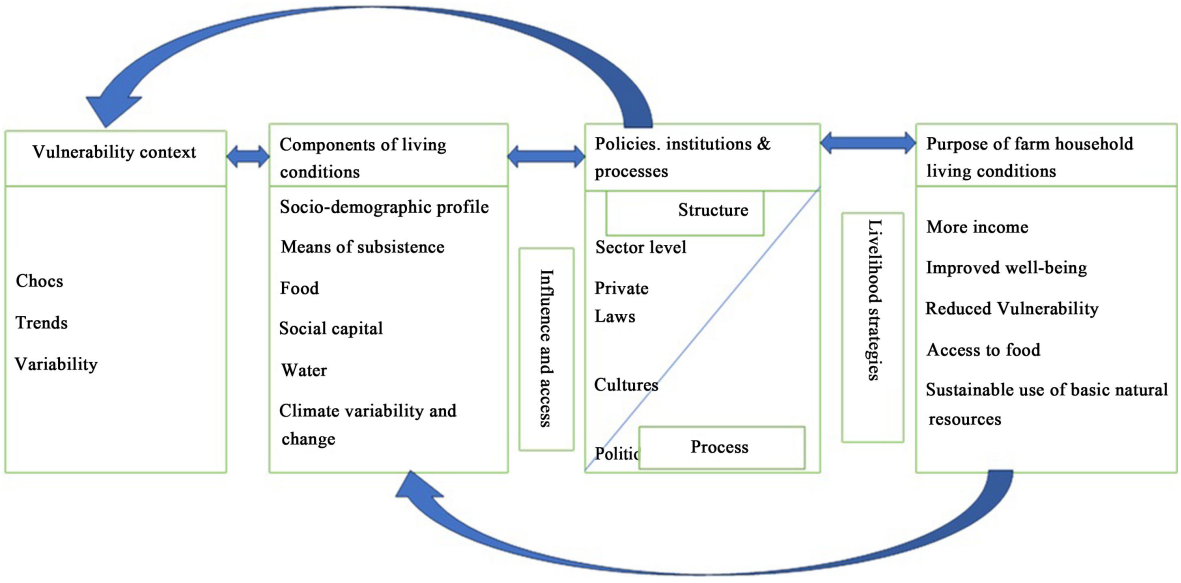


Figure 1. Analytical framework for sustainable living [9] (Adapted from DFID, 2000).

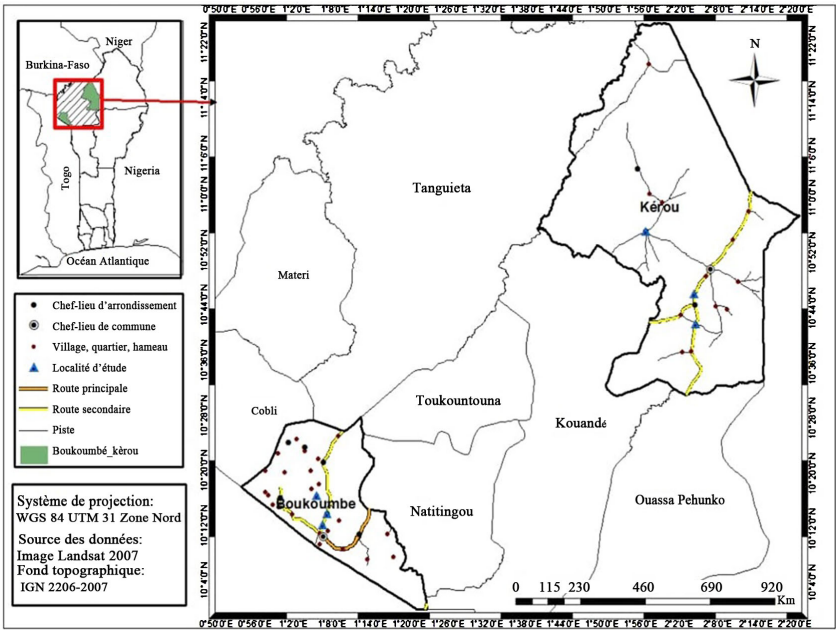
The sustainable living framework also examines how livelihoods interact in a feedback system with the structures of wider transformations [14], such as the influence of government policies or community-based organizations. Processes refer to everyday values, dictated by social norms and customs [9]. Livelihood strategies refer to the combination of activities that individuals undertake according to their available assets [15], based on the premise that individuals adopt strategies that best preserve and enhance their assets [11]. Livelihood strategies and decisions are also motivated by a variety of individual, household and community goals, as well as social goals that often override material factors [16]-[19]. This is achieved through the diversification of household activities and social support capabilities, and often involves reducing their dependence on natural capital assets [14].

3. Methodology

3.1. Study Area

The study took place in the communes of Boukombé and Kérou, located in the Atacora department in north-west Benin. The department covers an area of 20,499 km^2 in the National Institute of Statistics and Economic Analysis (NISEA, 2013). The department's economy is based on agriculture, livestock farming, fishing, gathering, crafts and trade. In addition to cotton production, maize and sorghum production are also being developed to exploit the after-effects of fertilizer use on cotton cultivation. These communes were chosen on the basis of their social experience, in addition, they are part of low-income areas affected by the effects of climate change.

Figure 2 below shows the study area.



Source: Produced by the authors

Figure 2. Geolocation map of surveyed households.

3.2. Sampling and Analysis of the Data Collected

The sample size was 240 households. The reasoned choice and simple random sampling technique were adopted. Three villages were selected per commune for the field survey. These were the villages of Dipoukomontri, Koupagou and Manta in the commune of Boukoumbé and the villages of Kangourou, Bérékossou and Firou in the commune of Kèrou. A total sample of 240 cotton-producing farm heads were interviewed, 120 from each commune. Data was collected using a monographic sheet and a modular questionnaire. Data from primary sources were supplemented by climate data for the period 2011-2017 from Météo Benin. These data were analysed using the following vulnerability indices and measures:

- **Index of the vulnerability of agricultural households to living conditions**

The Farm Household Livelihood Vulnerability Index has seven main components: i) socio-demographic profile; ii) social capital; iii) household health; iv) food; vi) livelihoods; and vii) water and natural disasters and climate variability. Each component is made up of indicators or sub-components (see **Table 1**). The Livelihood Vulnerability Index is based on Sen's capability approach, developed by [20] and further developed by [21] and [22]. Each sub-component is measured on different levels, requiring its normalization into an index. The normalization method used to calculate the index level lative to each sub-component is that developed by [23]; to calculate the quality-of-life index. The following formula is used to normalize the index for each sub-component.

$$Indice_{Sd} = \frac{S_d - S_{\min}}{S_{\max} - S_{\min}} \quad (1)$$

Where is one of the sub-components of the 7 components for each household; $S_{\min}$ and $S_{\max}$ are the respective minimum and maximum values for each sub-component for all households.

Having obtained the normalized index for each sub-component, it is easy to calculate the index for each component. It is defined by:

$$M_d = \frac{\sum_{i=1}^{n} Indice_{Sd}}{n} \quad (2)$$

Where M_d is the index of each component, n is the number of indicators or sub-components of the main component and $\sum_{i=1}^{n} Indice_{Sd}$ is the sum of each index obtained from each sub-component from equation (1).

One challenge in constructing a composite index lies in the choice of weights. Weights determine the intensity with which a chosen component contributes to explaining vulnerability to household living conditions. The main weighting methods proposed in the literature include equal weights, frequency-based weights, and multivariate statistical weights, such as the principal component analysis developed by [23]-[25] or multiple correspondence analysis, regression-based weights and normative weights [26]. None of these methods has been proven to be better, and most approaches to measuring multidimensional phenomena do

not guarantee appropriate methods for solving the weighting problem.

Failing that, most of the various approaches take the liberty of assigning weights to each dimension in a normative manner [27]. Attention is also drawn to the trade-offs involved in using different weighting methods and the usefulness of using robustness tests to determine the impact of the specific weight value on composite indices [28]. The most commonly used approach in multidimensional poverty measurement is equal weighting [26]. Although practical, equal weighting Is far from uncontroversial [26] [29] [30].

The new approach to measuring vulnerability to living conditions developed by [22], contains on average at least three indicators per component. The appropriate weighting technique is frequency weighting [31] [32]. Thus, in this study, the weighting equal to the frequency weight is used (**Table 1**). Thus, the vulnerability index is calculated from the sum of the index of each component weighted at the frequency weight from the following equation 3:

$$IVME_d = \frac{\sum_{i=1}^{7} W_{Mi} M_{di}}{\sum_{i=1}^{7} W_{Mi}} \tag{3}$$

This index is between 0 and 0.66 when analyzing the household's vulnerability to living conditions. An index value close to 0 indicates that the household is less vulnerable to living conditions and an index value close to 0.66 means that the household is more vulnerable to living conditions.

- **Measuring vulnerability to the living conditions of agricultural households in the context of climate change**

A new classification of the 7 components of the index of vulnerability to living conditions has been made by [33] into the following three components: i) exposure (natural disasters and climate variability); ii) adaptive capacity (socio-demographic profile, livelihood strategy, social capital) and iii) sensitivity (food, water and health). This classification is used to assess the effects of climate change on household living conditions (IPCC, 2007).

The process for calculating the exposure (e_d), adaptive capacity (a_d) and sensitivity (s_d)) indices is identical to that for the other components defined above. Thus, the index for each component of the new classification can be defined as follows:

$$CF_d = \frac{\sum_{i=1}^{7} W_{Mi} M_{di}}{\sum_{i=1}^{7} W_{Mi}} \tag{4}$$

The following formula is used to estimate the effect of climate change on the livelihood of the household, or even the municipality.

$$IVME - IPCC_d = \left(e_d - a_d\right) * s_d \tag{5}$$

The value of the IVME-IPCCd index is between −1 and 1. For an index value close to −1, the household is less vulnerable to climate change and for an index value close to 1, the household is more vulnerable. **Table 1** presents the indicators, and the weighting thresholds for the living conditions vulnerability index.

Table 1. Indicators, weighting thresholds for the vulnerability to living conditions index.

main components	sub-components	thresholds	weighting
Socio-demographic profile	Dependency ratio per household	Ratio of the population aged under 18 and over 65 to the population aged between 18 and 64.	16.13%
	Female head of household	Female-headed households. If the male head of household is away for more than 6 months, the woman is considered to be the head of household.	
	Age of head of household	Inverse of age of head of household	
	Household where the head of household has not been to school	Household where the head of household is not educated	
	Households with orphans	Household with at least one orphan living in the household.	
	Households with a family member working in another village	Household who reported that at least one member of their family works outside their locality or village	
Means of subsistence	Households whose sole source of income is agricultural production	Households acknowledging that agricultural production is their sole source of income	9.68%
	Agricultural livelihood diversification index (ranked = 0.20 – 1)	The inverse of the number of primary activities used as a livelihood +1, declared by a household	
Health	Average time to get to a health facility	Average time in minutes taken by a member to reach a health facility attended	12.90%
	Household where a family member suffers from a frequent illness	Household responding that they had at least one family member suffering from a chronic illness or falling ill regularly	
	Household where a family member has missed work due to illness in the last two weeks	Household responding that at least one member of their household had missed work/school due to ill health in the two weeks prior to the survey	
	Average malaria exposure and prevention index (rank: 0 - 12)	Number of months exposed to malaria*at least one household member has a mosquito net (having a net = 0.5 and no net = 1)	
Share capital	Average ratio of aid received to aid given (rank: 0 - 15)	Ratio of the number of types of assistance received by the household to the number of assistances given by the household in the past month	9.68%
	Average borrowing to lending ratio (n + 1/n' + 1)	Ratio of a household that has borrowed money in the last month to a household loan in the last month	
Food	Household that has not consulted its local authority in the last 12 months for any assistance	Households who said they had not asked their local authority/leader for help in the last 12 months.	16.13%
	Average number of months the household has difficulty finding food (range: 0 - 12)	Average number of months that the household reduced the quantity of the meal due to lack of food	
	Household dependent on a family farm for food	Households where their food comes mainly from their family farm	
	Average crop diversity index (rank: 0 - 1)	The reverse of crop plus 1 per household	

Continued

	Household that has shifted that it does not do storage	Households that do not stock food products	
	A household that spares no seeds	Household not saving seeds from one year to the next.	
	Ménage déclarant des conflits liés à l'eau	Household who said they had heard of water-related conflicts in their community	
	Household using a natural water source	Households reporting a stream, river, lake, swimming pool or well as their main source of water.	
Water	Average time to water source	Average time taken for households to reach their main water source	16.13%
	Households without a constant water supply	Household reporting that water is not available from their primary water supply every day	
	nverse of the average number of litres of water stored per household (range:> 0 - 1)	The inverse of the average number of litres of water stored by each household + 1.	
	Number of floods or droughts in the last 6 years (extremes: 0 - 7)	Total number of floods or droughts reported by the household in the last six years.	
	Household that has not received an alert concerning pending natural disasters	Household that has not received an alert for the most severe floods or droughts in the last six years.	
	Household or member injured or killed as a result of the natural disaster	Households reporting that one of their family members was injured or killed as a result of the most severe floods/droughts in the last six years.	
Natural disasters and climate variability	Average standard deviation of mean daily maximum temperature per month	The standard deviation of the maximum temperature per month between 2011-2017 has been calculated for each district.	19.35%
	Average standard deviation of mean daily minimum temperature per month	Standard deviation of mean daily minimum temperature per month between 2011-2017 calculated by district	
	Average standard deviation of mean precipitation per month	Standard deviation of average monthly precipitation between 2011-2017 calculated by district	

Source: Author based on literature review summary.

4. Results

4.1. Contribution of Components to Vulnerability to Living Conditions by Gender

The results in Table 2 show that the socio-demographic profile component has the highest contribution at 0.4392. It is followed by the climate change component with 0.4159, and the health component with 0.3255. The food component has the lowest contribution at 0.1820. The livelihood vulnerability index for each farm household in the sample is 0.320. This implies that the socio-demographic profile, climate change and household health should be a policy target for reducing vulnerability to the living conditions of farm households in Benin.

Table 2. Contribution of components to vulnerability to household living conditions.

variable	observation	average	standard deviation	minimum	maximum
Socio-demographic profile	240	0.4392	0.1853	0.0125	0.8750
Means of subsistence	240	0.2479	0.1691	0.0000	0.5555
Share capital	240	0.2283	0.1873	0.0000	0.7315
Health	240	0.3255	0.2003	0.0042	0.7954
Food	240	0.1820	0.1615	0.0025	0.6333
Water	240	0.2681	0.1619	0.0135	0.7567
Climate change	240	0.4159	0.0532	0.2868	0.5719
IVCVM	240	0.3120	0.0647	0.1373	0.4869

Source: field survey data.

Looking at the socio-demographic profile component, female-headed households have a significantly different contribution to vulnerability to living conditions than male-headed households, at a critical threshold of 1%. This discrimination is also observed for the food component. The female-headed household is vulnerable to the socio-demographic profile, livelihoods, food, water and climate change, while the male-headed household is vulnerable to social capital and health (Table 3).

Table 3. Contribution of components to vulnerability to living conditions by gender.

variable	observation	average	standard error	standard deviation	t	probability	dl
Socio-demographic profile							
Woman	25	0.6687	0.0242	0.1212	7.1988***	0.0000	238
Man	215	0.4126	0.0117	0.1728			
Means of subsistence							
Woman	25	0.2992	0.0391	0.1957	1.6087	0.1090	238
Man	215	0.2420	0.0112	0.1650			
Share capital							
Woman	25	0.1638	0.0378	0.1894	−1.8254*	0.0692	238
Man	215	0.2358	0.0127	0.1860			
Health							
Woman	25	0.2938	0.0434	0.2172	−0.8378	0.4030	238
Man	215	0.3292	0.0135	0.1984			
Food							
Woman	25	0.2797	0.0358	0.1788	3.2601***	0.0013	238
Man	215	0.1706	0.0106	0.1558			
Water							
Woman	25	0.2752	0.0392	0.1963	0.2330	0.8159	238
Man	215	0.2673	0.0108	0.1579			
Climate variability and change							
Woman	25	0.4244	0.0103	0.0517	0.8387	0.4019	238
Man	215	0.4149	0.0036	0.0534			

Legend: ***p < 0.01, **p < 0.05, *p < 0.1; Source: field survey data.

The contributions of the socio-demographic profile, water and climate change components to vulnerability to living conditions for the Boukombé commune

farm household are 0.4607, 0.2902 and 0.4371 respectively, and statistically different from zero for the Kérou farm household (0.4179, 0.2459 and 0.3948 respectively). The fact of being a farm household in the commune of Boukombé, all other things being equal, explains the difference in the relative contribution of the socio-demographic profile, water and climate change components between the study zones. In addition, the agricultural household in the commune of Kérou is only vulnerable to livelihoods (Table 4).

Table 4. Contribution of components to vulnerability to living conditions by zone.

variable	observation	average	standard error	standard deviation	t	probability	dl
Socio-demographic profile							
Boukombé	120	0.4607	0.0165	0.1814	1.7966*	0.0737	238
Kérou	120	0.4179	0.0171	0.1875			
Means of subsistence							
Boukombé	120	0.2379	0.0151	0.1659	−0.9197	0.3587	238
Kérou	120	0.2580	0.0157	0.1719			
Share capital							
Boukombé	120	0.2315	0.0177	0.1943	0.2638	0.7921	238
Kérou	120	0.2251	0.0165	0.1873			
Food							
Boukombé	120	0.1866	0.0147	0.1609	0.4448	0.6569	238
Kérou	120	0.1774	0.0148	0.1625			
Health							
Boukombé	120	0.3290	0.0189	0.2081	0.2683	0.7887	238
Kérou	120	0.3221	0.0176	0.1929			
Water							
Boukombé	120	0.2902	0.0155	0.1699	2.1338**	0.0339	238
Kérou	120	0.2459	0.0138	0.1508			
Climate variability and change							
Boukombé	120	0.4371	0.0045	0.0497	6.6926***	0.0000	238
Kéeou	120	0.3948	0.0044	0.0481			

Legend: ***p < 0.01, **p < 0.05, *p < 0, Source: field survey data.

4.2. Breakdown of the Index of Vulnerability to Living Conditions by Gender

Table 5 shows that households headed by women are more vulnerable to living conditions than those headed by men. This breakdown by zone shows that the agricultural household in the commune of Boukombé is more vulnerable to living conditions than its counterpart in the commune of Kérou. This indicates that being the female head of household and belonging to the commune of Boukombé explain the differences in vulnerability observed.

Table 5. Breakdown of the index of vulnerability to living conditions by gender and zone.

variable	observation	average	standard error	standard deviation	t	probability	dl
Index of vulnerability to household living conditions by sex of head of household (IVCV)							
Femme	25	0.3622	0.0111	0.0557	4.2361***	0.0000	238
Homme	215	0.3062	0.0043	0.0633			
Index of vulnerability to household living conditions by study area							
Boukombé	120	0.3237	0.0055	0.0604	2.8273***	0.0051	238
Kéeou	120	0.3004	0.0061	0.0671			
Indice_vcvm	240	0.3120	0.0042	0.0647			

Legend: ***p < 0.01, **p < 0.05, *p < 0.1, Source: field survey data.

4.3. Contribution of Components to the Effects of Climate Change on Living Conditions by Gender

The contribution of the sensitivity, adaptive capacity and exposure components to the index of the effects of climate change on living conditions increases with respective values of 0.2538, 0.3296 and 0.4159 (Table 6). The average effect of climate change on the living conditions of each agricultural household is estimated at 0.0209, far from −1. The farm household is vulnerable to the effects of climate change.

Table 6. Index components of the effects of climate change on living conditions.

variables	observation	average	standard deviation	minimum	maximum
Exposure	240	0.4159	0.0532	0.2868	0.5718
Sensitivity	240	0.2538	0.1066	0.0356	0.5600
Ability to adapt	240	0.3296	0.1081	0.0904	0.5921
IVCVM-IPCC	240	0.0209	0.0356	−0.0889	0.1912

Source: field survey data.

Households headed by women have a high contribution to the effects of climate change on living conditions when considering the adaptive capacity component (Table 7), and are significantly different from zero at the critical threshold of 1%. This means that the household's adaptive capacity differs depending on whether the household is headed by a woman or a man.

Table 7. Index component of effects of climate change on living conditions, by gender.

variable	observation	average	standard error	standard deviation	T	probability	dl
Exhibition							
Women	25	0.4244	0.0103	0.0517	0.8397	0.4019	238
Men	215	0.4149	0.0036	0.0534			
Sensitivity							
Women	25	0.2821	0.0250	0.1250	1.4083	0.1603	238
Men	215	0.2505	0.0071	0.1066			
Ability to adapt							

Continued

Women	25	0.4302	0.0174	0.0872	5.1779***	0.0000	238
Men	215	0.3178	0.0071	0.1043			

Legend: ***p < 0.01, **p < 0.05, *p < 0.1, Source: field survey data.

The results in table 8 show a significant difference in the exposure of agricultural households in the commune of Boukombé to climatic shocks and hazards, compared to those in the commune of Kérou. Agricultural households in the commune of Boukombé are more exposed to climatic shocks and hazards than their counterparts in the commune of Kérou.

Table 8. Contribution of components to the effects of climate change on living conditions by zone.

variable	observation	average	standard error	standard deviation	t	probability	dl
Exhibition							
Boukombé	120	0.4371	0.0045	0.0497	6.692***	0.0000	238
Kérou	120	0.3948	0.0044	0.0481			
Sensitivity							
Boukombé	120	0.2643	0.0096	0.1059	1.5381	0.1253	238
Kérou	120	0.2432	0.0097	0.1067			
Ability to adapt							
Boukombé	120	0.3374	0.0097	0.1064	1.1271	0.2608	238
Kérou	120	0.3217	0.0100	0.1097			

Legend: ***p < 0.01, **p < 0.05, *p < 0.1, Source: field survey data.

4.4. Effects of Climate Change on Living Conditions by Gender

The average value of the index of the effects of climate change on the living conditions of each household is 0.0209 (Table 9). Households headed by women (−0.0042) are less vulnerable to the effects of climate change on their living conditions than their male counterparts (0.0254). At the municipal level, agricultural households in the commune of Boukombé are more vulnerable (0.0254) to the effects of climate change than those in the commune of Kérou (0.0164). These results are validated by the difference-in-means tests, which are significant at the 1% and 5% critical thresholds (Table 9).

Table 9. Effects of climate change on living conditions by gender and zone.

variable	observation	average	standard error	standard deviation	T	probability	dl
Index of the effect of climate change on vulnerability to household living conditions by gender of the CM							
Women	25	−0.0042	0.0061	0.0309	−3.8337***	0.0002	238
Men	215	0.0238	0.0024	0.0397			
Index of the effect of climate change on vulnerability to household living conditions. by zone							
Boukoumbé	120	0.0254	0.0033	0.0361	1.9819**	0.0486	238
Kérou	120	0.0164	0.0031	0.0346			
IVCVM-IPCC	240	0.0209	0.0023	0.0356			

Legend: ***p < 0.01, **p < 0.05, *p < 0.1, Source: field survey data.

4.5. Discussion

The aim of this study was to analyses vulnerability to living conditions in agricultural households in the cotton-growing areas of Benin. The results show that female heads of household are less vulnerable to social capital than their male counterparts. Indeed, the interviews showed that "women belong to self-help groups more than men". They receive support from the various groups for certain activities such as ploughing, sowing, weeding and harvesting. This "club" effect reduces individual working time and improves the productive efficiency of both the woman and the group. The "club" effect has been an essential component of human capital since the pioneering work of Becker, and of the social organization of work since the pioneering work of Smith. This dynamism of the group would be the cause of the low vulnerability of women in terms of the contribution of social capital to the index of vulnerability to living conditions. But despite this grouping effect, the female-headed household is more vulnerable to living conditions than the male-headed household. Studies by [34] on analyzing the vulnerability of populations to climate change in northern Benin have shown that young people and women are more vulnerable to climate change. According to the Analyse globale de la vulnérabilité et de la sécurité alimentaire (AGVSA), more female-headed households (12%) are food insecure than male-headed households (9%) (Institut national de la statistique appliquée et de l'économie (INSAE) and (WFP, 2017). Most female-headed households are poor households (26%). Thus, women are fragile and respond very poorly to the negative effects of climate change [34]. According to [35], the greater vulnerability of women than men lead to marital conflicts within families.

Female-headed households are more vulnerable to food and living conditions. The female head of household represents 25%, or approximately 10.42% of the heads of household in the sample. The female head of household has "access to marginal land" and is more involved in "market gardening" and "processing sorghum into local beverages" or "shea butter", according to the results of the interviews. Few female heads of household grow maize or sorghum, the staple foods in the study area. Consequently, vulnerability to food and living conditions could be partly explained by access to marginal land and crop choices. Despite the crucial role played by women, 70% of the world's undernourished people are women (FAO 2008). Women are disproportionately affected by hunger because they suffer multiple discrimination in access to food, productive resources and a decent wage [36].

The results also showed that the main components of vulnerability to living conditions are socio-demographic profile and climate change. These results are similar to those of [37] and Hien Luong in North-West Vietnam. However, the contribution of the "socio-demographic profile" component is stronger both at the level of the female household head as well as at the level of the Boukombé commune. The contribution of the "climate change" component is stronger and significantly different from zero for the commune of Boukombé than for that of

Kérou. This result was confirmed by the results of our interviews, in which 100% of the stakeholders interviewed stated that "apart from sorghum, fonio, small millet and voandzou, the Boukombé farming household can no longer produce without chemical inputs". The soil is very poor, and "a slight change in the agricultural calendar, either due to late or poorly distributed rainfall, has a negative impact on production", and in turn on their living conditions.

The commune of Boukombé has few watercourses and a few low-lying areas, concentrated in the arrondissement of Natta and Boukombé centre, which are used for market gardening and lowland rice. As a result, off-season crops, and even home gardens, are virtually non-existent, said the people in charge of the social promotion centre and the representative of the town hall during the direct interviews. Similarly, the high proportion of female heads of household from the commune of Boukombé in the sample, 95% of whom are uneducated compared with 70% in Kérou, would explain the vulnerability of female heads of household and those from Boukombé respectively. These results are similar to those of [38] and [31], according to whom the better educated the female head of household is, the more likely she is to adopt strategies in terms of crop selection in order to cushion the impact of climate change and survive.

On the other hand, the commune of Kérou has relatively fertile soil, crossed by the Mékrou river and the Pendjari. The commune of Kérou also benefits from the positive externalities of the state wildlife and forest reserves of "Alibori supérieur" and "Parc Pendjari", where most farmers in the arrondissements of Firou, Kaobagou and Brignamaro are allocated land for large-scale agricultural production. It is developing more export crops and those that require water, such as roots and tubers. The soil has a better water retention capacity than that of Boukombé. These geographical advantages could explain why the commune of Kérou is less vulnerable to climate change and food shortages. The commune of Boukombé is more vulnerable (0.0254) than that of Kérou (0.0164). This result is similar to the values of the index of the effects of climate change on the living conditions of households in southern Kombo and Nimuni in the Gambia, which gave 0.023 and 0.002 respectively in the work of [39].

The impact of climate change on household living conditions shows that the female head of household is less vulnerable (−0.0042) than the male head of household (0.0238). Although women are more vulnerable to exposure to shocks, they are less vulnerable to the impacts of climate change because their choice of crops is better adapted to the context.

The level of vulnerability can be linked to producers' behaviors that the index does not account for. Maize and sorghum are staple crops, mainly managed by household heads in the area. Female household heads producing these are often widows or divorced, potentially explaining their lower production. Observations show that non-widowed women cultivate rice, voandzou, and fonio as income-generating activities to support household expenses. Interviews indicate that local producers use an average of 5 bags of chemical fertilizer instead of the 3

recommended by the Interprofessional Cotton Agency (ICA) due to poor soil in Atacora, Benin. This leads to high production costs, as cotton profits absorb these expenses. Benin's lack of targeted agricultural inputs means farmers receive 6 bags from the ICA, with 3 intended for cotton and the rest for maize. However, compliance varies; some overuse while others sell portions.

Despite the presence of professional stakeholders in the agricultural sector, such as the AIC and the State through the Territorial Agricultural Development Agency hubs, there is no known database on non-agricultural households. Furthermore, this research did not include non-agricultural households due to the complexities involved in assessing the impact of climate change on them.

5. Conclusion

Indices of vulnerability to living conditions and of the effects of climate change on household living conditions have been constructed in agricultural areas of Benin. They could be used to assess the impact of a policy by replacing the value of the indicator that is expected to change and recalculating the index of vulnerability to living conditions. The limitations of the approach used in this paper include the subjectivity involved in selecting the indicators for each component and the link between these indicators and vulnerability, and also the possible selection bias to typical households not in the sample. Replicating this study at the level of the same households over time would provide a reliable information base on how household exposure, adaptive capacity and sensitivity change as adaptive practices are taught. This study suggests an accompaniment to the vulnerability to the living conditions of cotton-growing households by the zone most affected by the effects of climate change.

6. Author's Statement of Contribution

All the authors of this paper contributed to the research and writing.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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