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Livestock farmers' vulnerability to climate change in the extreme northern region of Benin Republic

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Vulnérabilité des éleveurs au changement climatique dans l'extrême nord de la République du Bénin

Résumé : Les données du Groupe d'experts intergouvernemental sur l'évolution du climat convainquent massivement que le changement climatique est réel et que ses effets négatifs sont plus sévèrement ressentis par les populations pauvres des pays en développement qui dépendent fortement des ressources naturelles pour leurs moyens de subsistance. L'élevage est une activité majeure parmi les secteurs économiques les plus sensibles au climat, mais on sait très peu de choses sur le niveau de vulnérabilité des éleveurs face aux changements climatiques dans l'extrême nord de la République du Bénin. Ceci a motivé ce travail d'évaluation de l'effet du changement climatique sur la production animale dans les localités de Karimama et Malanville en développant un indice de vulnérabilité. Un total de 221 ménages de ruminants a été enquêté entre avril et mai 2017. L'approche d'évaluation intégrée a été utilisée pour quantifier la vulnérabilité à travers un indice composite composé de sous-indices liés à l'exposition, la sensibilité et la capacité d'adaptation des communautés pastorales. Les résultats de ce travail de recherche ont montré que la commune de Malanville est plus vulnérable au changement climatique que Karimama malgré le fait qu'ils aient été exposés au même niveau. Les résultats montrent également que l'exposition, la sensibilité et la capacité d'adaptation influent différemment sur la vulnérabilité des éleveurs. De plus, les caractéristiques socioéconomiques ont influencé le niveau de vulnérabilité. Concrètement, l'étude a montré que les efforts de réduction de la vulnérabilité doivent être intégrés pour agir simultanément sur l'exposition, la sensibilité et la capacité d'adaptation. En outre, il aidera les communautés pastorales à diversifier leurs moyens de subsistance. Enfin, une attention particulière devrait être accordée aux systèmes de collecte et de fourniture de données et d'informations pour la recherche.

Mots clés: Bovins, changement climatique, éleveurs, indice de vulnérabilité.

Abstract: Evidence from the Intergovernmental Panel on Climate Change is now overwhelmingly convincing that climate change is real and its negative impacts are more severely felt by poor people in developing countries who rely heavily on the natural resource base for their livelihoods. Animal husbandry is a major activity among the most climate-sensitive economic sectors, but very little is known about the vulnerability level of livestock farmers to climate change in the extreme northern region of Benin Republic. This motivated this work which aimed to assess the effect of climate change on livestock production in the localities of Karimama and Malanville by developing a vulnerability index. A total of 221 ruminant households were surveyed between April and May 2017. The integrated assessment approach was used to quantify the vulnerability through a composite index comprised of sub-indices related to exposure, sensitivity and adaptive capacity of pastoral communities. The findings from this research work showed that the commune of Malanville is more vulnerable to climate change than Karimama despite the fact that they were exposed at the same level. Results also show that exposure, sensitivity and adaptive capacity differently influenced the vulnerability of livestock farmers. Also, socioeconomic features influenced the level of vulnerability. In practical terms, the study showed that efforts to reduce vulnerability must be integrated to act simultaneously on exposure, sensitivity and adaptive capacity. In addition, it will support pastoralist communities to diversify their livelihoods. Finally, special attention should be given to systems of collection and provision of data and information for research.

Keywords: Cattle, climate change, livestock farmers, vulnerability index.

1. Introduction

Climate change is disrupting national economies and affecting lives, costing people, communities and countries dearly today and even more tomorrow (PNUD, 2016). While climate change is a global phenomenon, its negative impacts are more severely felt by poor people in developing countries who rely heavily on the natural resource base for their livelihoods (Hertel and Lobell, 2014). Indeed, rural poor communities rely greatly for their survival on crop production and livestock husbandry, which are among the most climate-sensitive economic sectors (IFAD, 2010). Most African countries are vulnerable to the effects of climate change particularly because of high dependence on rain fed agriculture, widespread poverty, lack of access to technology and improved cultural practices (Mohammed et al., 2014). Agriculture which includes crop production, animal husbandry, forestry, fisheries, is the backbone of West African economies (Hussein et al., 2008), providing employment and income to about 70% of the population.

Animal husbandry is a major component of the agricultural economy of developing countries (40% of GDP) and goes well beyond direct food production (FAO, 2009). Herrero et al. (2013) present its multiple roles which include provision of employment, wealth accumulation, economic insurance and insurance, gender equity through generation of opportunities for women, recycling waste products and residues from cropping or agro-industries, improvement of the structure and fertility of soil, and control of insects and weeds. Livestock residues can also serve as an energy source for cooking (Tucho and Nonhebel, 2015), contributing to food security. Livestock also serve various social and cultural functions (Weiler et al., 2014). Hence, livestock systems directly support the livelihoods of at least 600 million smallholder farmers, mostly in sub-Saharan Africa and South Asia (Thornton, 2010). While the demand for all livestock products is expected to nearly double in sub-Saharan Africa by 2050, the livestock systems face multiple stressors that can interact with climate change and variability to amplify the vulnerability of livestock-keeping communities (Niang et al, 2014). In Benin Republic, the livestock sector contributes to about 15% of the agricultural GDP besides crop farming (MAEP, 2016). The extreme northern region of the country, which holds more than 50% of the national herd (FAOSTAT, 2016) is among the most exposed to the change in climate due to the extreme weather events (PNUD, 2016).

Yet, worldwide, relatively little research has been conducted on the impacts of climate change on livestock production (IPCC, 2014). Consequently, little is known about the extent to which livestock and their owners are vulnerable to climate change and how they do cope with its negative effects. In Benin, there have been no previous quantitative index-based assessment of livestock vulnerability to climate change. This study therefore seeks to fill this information gap by measuring vulnerability index of livestock farmers in extreme northern region of the country.

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2. Materials and Methods

2.1. Study area and data collection

The study was carried out in the communes of Malanville and Karimama located in the Alibori department, in the extreme north of Benin. Livestock is the predominant livelihood activity in this region which is exposed to hydro-climatic variability (PANA, 2008). The communes are divided into 5 districts each with 18 and 31 villages respectively for Karimama and Malanville (INSAE, 2017). The target population for this study was all cattle farmers in the two communes. Thirty-five percent of the villages in each commune was used for this study. This resulted in six and eleven villages for Karimama and Malanville respectively (Table 1). Thirteen households were chosen and interviewed per village. A total of seventy-eight farmers were conveniently selected and interviewed in May 2017 using a semi-structured questionnaire.

Table 1: Districts and villages surveyed in Malanville and Karimama

Communes	Districts	Villages
Malanville	Guene	Boifo, Issene, Torozougou
	Tombouctou	Degue-Degue, Mola
	Malanville	Golobanda, Wolo
	Garou	Garou-Tedji, Garou-Zienon
	Madecali	Madecali, Sende
Karimama	Birni-Lafia	Tondikoiria, Birni-Lafia
	Karimama	Mamassi, Karimama
	Bogo-Bogo	Banikanin
	Kompa	Kompanti

Due to lack of climate and weather recording in the two communes, the climatic information (temperature, sunshine, humidity and rainfall) for the nearest and most similar climate station of Kandi was obtained from the Agency for Air Safety and Navigation in Africa and Madagascar (ASECNA). Information on cattle populations was collected from past publications and grey literature.

2.2. Data analysis

The collected data were analysed using descriptive analysis, Likert-type scale. The principal Component Analysis techniques were used for the computation of vulnerability index. All statistical analyses were performed using The R-software version 3.0.2.

Assessment of vulnerability index

The term vulnerability has been defined in many different ways by various scholarly communities. This work is based on the most widely used definition provided by the Fourth Assessment Report of the IPCC (AR4, 2007). It refers to vulnerability as: '(…) the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity' (Parry et al. 2007). Based on this definition, the Vulnerability Sourcebook (GIZ, 2014) distinguishes between four key components that determine whether, and to what extent, a system is susceptible to climate change: exposure, sensitivity, potential impact and adaptive capacity. Using Fellmann's (2012) categorization as a basis for this grouping, we distinguished vulnerability methodologies based on stakeholder, on model and geographic information system (GIS) and on indicator. Assessments often use a combination of approaches when measuring vulnerability. But for the present study, we used an indicator-based methodology which produces measurable outputs and was applied at village/district scale. However, the major limitation of this methodology is its inability to capture the complex temporal and social dynamics of the various systems measured. Despite these challenges, indicators still provide one of the most dominant ways for measuring vulnerability and they continue to evolve and develop complexity. The steps to the index construction are i) selection of indicators per vulnerability components; ii) normalization of Value and iii) weights assignment and aggregation of indicators (GIZ, 2014). Principal Component Analysis (PCA) was used to avoid influence of subjective opinion in the assessment process by aggregating recorded values into components of vulnerability (exposure, sensitivity or adaptive capacity according to the case.

The aggregation of indicators into specific components was done according to GIZ (2014) as follows:

$$\mathrm{CI} = \frac{(I1 * w1 + I2 * w2 + \ldots In * wn)}{\sum_1^n w} \qquad \text{(Eq. 1)}$$

Where CI is the composite indicator, $I_{1\text{-}n}$ an individual indicator of a vulnerability component and w the weight assigned to the corresponding indicator.

Aggregation of Exposure and Sensitivity into Potential Impacts

Exposure and sensitivity components were then assigned weights and aggregated into potential impacts according to GIZ (2014) using following formula (equation 2):

$$\mathrm{PI} = \frac{EX \times wEX + SE \times wSE}{wEX + wSE} \qquad \text{(Eq. 2)}$$

Where PI is the potential impact composite indicator, **EX** the vulnerability component exposure, **SE** the vulnerability component sensitivity and **w** the weight assigned to the vulnerability components.

Aggregation of Vulnerability Components to Vulnerability

In the last step, exposure and sensitivity components were all aggregated with adaptive capacity in order to generate a composite vulnerability index. This was done according to GIZ (2014) using following formula (equation 3):

$$\mathrm{V} = \frac{EX \times wEX + SE \times wSE - AC * wAC}{wEX + wSE + wAC} \qquad \text{(Eq. 3)}$$

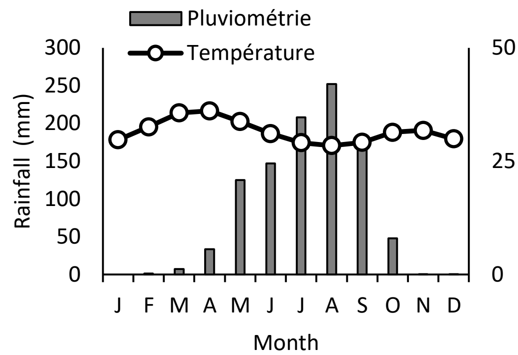
Where V is the Vulnerability index, **EX** the vulnerability component exposure, **SE** the vulnerability component sensitivity, AC the vulnerability component adaptive capacity, and **w** the weight assigned to the vulnerability components.

3. Results

3.1. Climatic trend

Figure 1 shows that the dry period lasts at least 7 months in our study area. The dry season is defined as all months where the monthly rainfall expressed in mm is less than twice the mean monthly temperature expressed in ° C. Rainfall data covering the last thirty (30) years (1984 to 2013) have established an average rainfall regime of 998.88 mm for Kandi.

Figure 1: Rainfall and temperature at Kandi station (1984- 2013), ASECNA, 2017



The temperatures are seasonal. As shown in Figure 2, the maximum temperatures were recorded in the months of March and April with a maximum of 39.81 in April. The lowest average temperatures were recorded in December and January (Harmattan Period) with a minimum of 19.67° C in January.

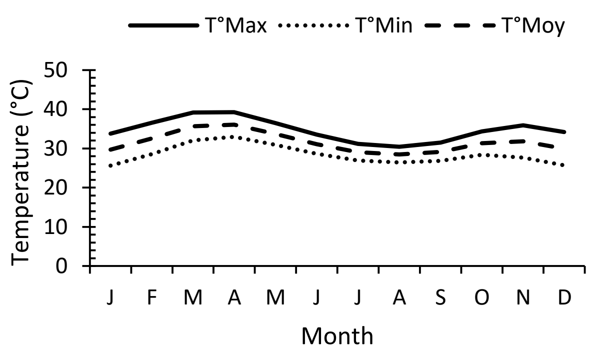


Figure 2: Change in Temperature (Maxima, Minima and Average) between 1984 and 2012 (ASECNA, 2017)

In the two communes the air becomes very hot and the heat unbearable between the beginning of March and the end of April, especially when rain fall twice around the period of mid-April and then followed by a long dry period. (Figure 3).

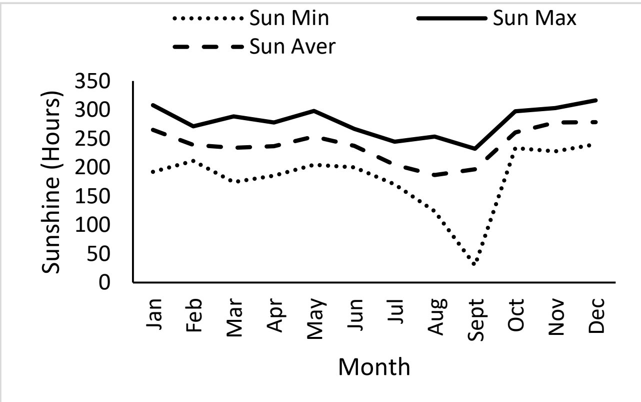


Figure 3: Relative Sunshine between 1984 and 2012 (ASECNA, 2017)

The relative humidity was high between May and mid-October and reached its peak of 96.67% in August which corresponds to the period of the rainy season. It was low in the months between November and April and reached its minimum (11%) in December.

3.2. Level of exposure to climate change

Table 2 shows the values and weights of the exposure indicators in the study area, based on the data obtained from the station of Kandi. It shows equal information for both communes contrasting with the perceptions of interviewed farmers. According to the latter, climatic conditions are much harsher in Karimama than in Malanville. Further, respondents reported scarcity of pasture and dryness of all water sources in both locations. All respondents admitted that excessive heat make their animals more vulnerable to different epizootic diseases and negatively affect their growth and milk performances.

Table 2: Values and weights of the exposure indicators in Malanville and Karimama

Indicators	Values	Weights
Minima temperature	0.573	0.222
Maxima temperature	0.603	0.469
Change in rainfall pattern	0.437	0.222
Minima humidity	0.492	0.469
Maxima humidity	0.538	0.469
Sunshine	0.527	0.147
Composite Index	**0.53432**	

3.3. Level of sensitivity to climate change

Table 3 presents the values and weights of sensitivity indicators in the study area. Farmers in Malanville were significantly (p <0.001) more sensitive to variability and climate change than those of Karimama. The latter spent relatively more time than the former on livestock activity.

Table 3: Level of sensitivity to climate change in Malanville and Karimama

Indicators	Malanville		Karimama	
	Values	Weights	Values	Weights
Time spent in activity per month	0.717	0.396	0.674	0.438
Number of person depending on livestock	0.256	0.293	0.127	0.361
Part of livestock activity in the revenue	**0.969**	0.312	0.642	0.438
Composite index	**0.220290921**		**0.207497764**	

3.4. Adaptive capacity

Table 4 presents the values and weights of adaptive capacity indicators in the study area. Farmers in Karimama showed significantly (p <0.001) higher adaptability than those in Malanville. Farmers in Karimama showed significantly (p <0.001) higher adaptability than those in Malanville. Older and experienced farmers were less vulnerable than younger ones. The results also revealed the use of extension and veterinary services as important factors that strengthen farmers' adaptive capacity.

Table 4: Values and weights of adaptive capacity indicators in Malanville and Karimama.

Indicators	Malanville		Karimama	
	Values	Weights	Values	Weights
Age	0.292	0.151	0.528	0.132
Instruction level	0.687	0.151	0.351	0.114
Formal or Informal education	0.439	0.151	0.684	0.132
Years of experience	0.607	0.175	0.397	0.132
Diversification	0.262	0.175	0.636	0.146
Veterinary services	0.339	0.175	0.245	0.146
Extensions services	0.719	0.175	0.319	0.146
Access to credit	0.656	0.151	0.716	0.132
Alternative source of revenue	0.572	0.118	0.568	0.146
Membership to association	0.255	0.175	0.524	0.115
Availability of pasture	0.298	0.175	1.22	0.146
Availability of water	0.598	0.118	1.365	0.115
Awareness of climate change	0.598	0.118	0.359	0.132
Composite index	**0.07**		**0.086**	

3.5. Vulnerability index

Table 5 presents the potential impact and the vulnerability index of each commune. Malanville had a relatively higher vulnerability index than Karimama. Furthermore, at the same level of exposition, the most vulnerable farmers were the most sensitive and the least able to cope.

Table 5: Potential impact of climate change and vulnerability index in Malanville and Karimama in Northern Benin

	Malanville	Karimama
Potential Impact	0.3986	0.356
Vulnerability index	0.31795	0.31553

4. Discussion

One important limitation of this study is the use of climatic information from the neighbouring commune of Kandi. Information and data availability is a real challenge for community vulnerability analysis. Unfortunately, data collection systems have serious problems in African countries (Lynam, 2006). It could have been recommendable to use those of Gaya (Niger) and Diapaga (Burkina-Faso) which are closer to the study area than Kandi.

Farmers in Malanville are significantly more sensitive to the change in climate than those in Karimama. This is probably due to the larger share of livestock in farmers' annual income in Malanville. Hence, they keep larger herd sizes and devote more time to livestock activities than their counterparts from Karimama.

The adaptive capacity depends on farmer's socio-economics characteristics and some other exogenous factors. The higher adaptability of farmers in Karimama to the climate change effects compared with their counterparts in Malanville may be explained by their greater age, the diversification in species or of their activities, the use of veterinary care, and access to extensions services. Diversification in activities or species and the use of veterinary care are two important factors that enhance livestock farmers' ability to adapt to changes in climatic conditions (IFAD, 2010). Vaccination is, for example, an effective solution in the early stages of drought to combat diseases caused by heat stress. But a lack in financial capital can make farmers unable to diversify their species or even to have another source of revenue. Therefore the most vulnerable are sometimes the poorest one (Deressa et al., 2011)

The results also show that the highest vulnerability coincides with the highest exposure, the highest sensitivity and the lowest capacity for adaptation. Thus, at the same level of exposure, the highest vulnerability is obtained with the highest sensitivity and the least capacity for adaptation. These findings are in line with those by Eakin and Bojorquez-Tapia (2008) and point out how socioeconomic inequalities can influence vulnerability to climate variability and change (Dyson 2006, Laska and Morrow 2006). These differences in vulnerability found between farmers from the two communes will help develop effective adaptation strategies to support them in strategies development (Smit and Wandel, 2006)..

5. Conclusion and recommendations

Climate change is northern Benin is real. Farmers are experiencing it, and its effects are visible, especially in animal husbandry. Based on the findings of this research, it can be concluded that livestock farmers in the extreme northern part of Benin Republic are vulnerable to climate change. It urges to implement strategies in order to enable the farmers to cope with that change. But the main challenge, particularly in developing countries, is that farmers have the low adaptive capacity, as most of them are small and marginal farmers. It follows that autonomous adaptation cannot be expected; even if adaptation were autonomous, it would not be sufficient to offset losses from climate change. Hence, policy-driven incentivized adaptation is required. Therefore, it could be recommended that researchers and policy-makers promote new research for improved characterization of livestock vulnerability taking into account spatio-temporal dynamics. They should study modern and endogenous adaptation measures and strategies adopted and developed by pastoralist communities to better guide policy. Finally, systems that allow an easy collection and provision of accurate climatic data and information should be implemented.

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CONFLICT OF INTEREST

The authors did not declare any conflict of interest.

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