Research article

Adaptation strategies of cattle farmers in the dry and sub-humid tropical zones of Benin in the context of climate change

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ABSTRACT

Cattle farming is directly impacted by climate change (CC), as it utilizes resources whose seasonality and productivity are strongly climate-dependent. Farmers respond to the negative influence of CC by implementing different adaptation strategies, where choices are informed by many factors. This study aims at analyzing the adaptation strategies of cattle farmers in the dry tropical zone (DTZ) and sub-humid tropical zone (STZ) of Benin with regard to climate change, as well as the determinants for the choice of these strategies. For that matter, 360 cattle farmers were surveyed. Data collected were related to the demographic and socio-economic characteristics of the cattle farmers, their perception and adaptation to CC. The data collected were subjected to frequency analysis and binary logistic regression. The results showed that livestock farmers were partly aware of climate related with CC, especially the increase of temperature. The most important adaptation strategies mentioned by cattle farmers were mobility, integration of livestock and crop husbandry, provision of concentrate feed, reduction of herd size, diversification of livestock, and forage cropping. Farming experience, cattle herd size, membership in an organization, number of farm assets, level of education, and climate zone were the major variables affecting farmers’ adaptation strategies. From this study, we recommend that any program promoting adoption of climate change resilience among farmers, especially cattle farmers, should take the identified factors into account.

1. Introduction

Climate change is a global phenomenon that causes warming of both the earth and sea surface, droughts, floods and exhaustion of natural resources (Naqvi and Sejian, 2011; Feleke et al., 2016). It has a direct impact on agricultural production, since agricultural systems depend on the nature of the climate (Boko et al., 2007; Bambara et al., 2013). This impact is most felt in developing countries (Emete and Onyekuru, 2011) where capital investment in farming activities is relatively low compared to developed countries. Benin, a developing country in West Africa, is not immune to the threats of climate change. Studies carried out in 2011 indicated that rainfall will remain more or less stable (+0.2%) in the southern part of the country but will be reduced by 13–15% in the North by 2100 (MEHU, 2011). According to the same study, the temperature is expected to increase between +2.6 °C and +3.2 °C by 2100. Under these scenarios, cattle farms located in these climatic zones of the northern part of Benin, the country’s favorite cattle production zone (Tijenontin, 2010), will suffer more from the effects of climatic variations, with expected decreases in productivity.

Adaptation therefore remains one of the policies for addressing the climate challenges that prevail in the livestock sector (Deressa et al., 2009; Di Falco et al., 2012), especially cattle. This is of great importance for developing countries such as Benin, where livestock production contribute significantly to food and nutrient security plans (Di Falco et al., 2012; Tubiello, 2012). Socio-economic and environmental factors influence the choice of adoption of an adaptation strategy by farmers (Taruvinga et al., 2013). According to Feleke et al. (2016), the most vulnerable farmers to the negative impacts of CC are those with low adaptive capacity. Understanding their adaptive response behavior is therefore critical in developing programs that would be yield optimum output in building their resilience.

Several research projects have been conducted in Benin to assess the perception of cattle farmers of climate change, as well as the adaptation strategies put in place (Tijenontin et al., 2009; Zakari et al., 2015; Dossa...
et al., 2017; Idrissou et al., 2020). The results from these studies revealed that farmers are aware of CC and adapt through various strategies. Although a wide diversity of adaptation strategies for cattle farmers with climate change has been reported, the analysis of the factors that affect the choice of these strategies is still neglected. However, identification and understanding of these factors are essential to improving the effectiveness of support of cattle farmers confronted to climate change (Mabe et al., 2014; Folefack and Tenikue, 2015). The present study thus seeks to fill this gap, by first identifying the adaptation strategies implemented by the farmers, and then analyzing the determining factors.

2. Material and methods

2.1. Research area

This study was conducted in two climatic zones of Benin; these are the dry tropical zone (DTZ) and sub-humid tropical zone (STZ). The choice of these zones was based on the fact that climate forecasts indicate that they are the most vulnerable in the country (Gnangl/C18e et al., 2011; MEHU, 2011), and yet the cattle herd is more than 85% concentrated (Alkoiret et al., 2011) in these two zones. In each zone, two (2) municipality were chosen on the basis of their importance in cattle breeding and preliminary interviews with the technicians of the “Agence Territoriale pour le Développement Agricole” (ATDA). Thus, the municipality of Tchaourou and Nikki were retained in the STZ and those of Gogounou and Banikoara in the DTZ. Within each municipality, three (3) villages were selected based on their importance in cattle breeding and accessibility (Figure 1, Table 1). In the DTZ, which includes the municipality of Gogounou and Banikoara, the soils are ferruginous and the vegetation is dominated by savannah and dry woodland. The STZ, which consists of the municipality of Tchaourou and Nikki, is characterized by ferruginous soils, savannah and dry woodland.

2.2. Data collection

Data collection was carried out from November 2018 to April 2019 in two stages that include: the exploratory phase and the in-depth research phase.

2.3. Exploratory investigation

During this phase, the villages and cattle farmers to be surveyed were defined. Interview sessions were conducted with technicians of the ATDA to identify the villages to be investigated. The criteria for choosing villages were the accessibility and importance of cattle breeding among the activities of the population. On the basis of these criteria, the villages of Koubou, Papan/C18e and Agbassa were chosen in the municipality of Tchaourou; the villages of Tebo, Biro and Sakabansi in Nikki municipality; the villages of Bagou, Fana and Lougou in the municipality of

![Figure 1. Location of the villages surveyed in the dry tropical zone (DTZ) and sub-humid tropical zone (STZ) in Benin.](image-url)
Table 1. General characteristics of the Tchaourou, Nikki, Gogounou, Banikoara municipalities in Benin where the study was based.

| Municipalities           | Villages          | Vegetation zones | Climatic zones | Annual rainfall (mm) | Daily temperature (°C) | Estimates of total cattle (n) |
|--------------------------|-------------------|------------------|----------------|----------------------|-------------------------|-----------------------------|
| Tchaourou                | Koupou Papapane   | SGZ              | STZ            | 1100–1200            | 23–32                   | 47,000                      |
|                          | Agbassa           |                  |                |                      |                         |                             |
| Nikki                    | Tebo Biro         | SGZ              | STZ            | 1100–1300            | 28–35                   | 125,000                     |
|                          | Sakabansi         |                  |                |                      |                         |                             |
| Gogounou                 | Bagou Fana Lougou | SZ               | DTZ            | 1051                 | 28.2                    | 139,000                     |
| Banikoara                | Founougo Goumori  | SZ               | DTZ            | 850                  | 27.5                    | 218,800                     |

SGZ: Sudano-Guinean Zone; SZ: Sudanian Zone; STZ: Sub-humid Tropical Zone; DTZ: Dry Tropical Zone.

FAOSTAT (2019).

Gogounou and finally the villages of Founougo, Goumori and Soroko in the municipality of Banikoara.

After the villages were identified, focus groups of 6–15 people were formed, with one focus group per village. This stage helped to test and corrects the questionnaire that was used during the in-depth phase. The interviews conducted during this exploratory survey allowed us to randomly select 30 breeders per village to whom questionnaires were sent individually for the rest of the study. Thus, a total of 360 cattle farmers were surveyed during this study. Breeders’ choice criteria were: to have cattle farming as the main activity; be at least 50 years old; have at least 10 heads of cattle. The choice of livestock as the main activity to discriminate against the respondents is justified by the fact that several studies nowadays focus on agro-pastoralists and generalize the results obtained both to agro-pastoralists and pastoralists. These socio-professional categories face different socio-economic problems (Zampaligré et al., 2014). The age barrier (50 years) is explained by the fact that we would like to go back 40 years to analyze the facts related to climate change. The choice of cattle size as a criterion is justified by the fact that the size of the herd reflects the economic power of the farmer and gives him a certain social rank in society and then influences his behavior to adopt an adaptation strategy (Agossou et al., 2012; Houngbo, 2013).

2.4. In-depth investigation

The in-depth investigation phase consisted of collecting data through semi-structured interviews based on questionnaires tested and corrected during the exploratory phase. No ethical approvals were required for the study, but the consent of participants was taken and they remained anonymous. Data collected from cattle producers were related to their demographic and socio-economic characteristics (sex, age, ethnicity, household size, secondary activity, level of education, farming experience, contact with agricultural extension services, workforce employed and organization membership), livestock structure (breed and herd size), their perception of the change of precipitation and temperature and adaptation strategies developed to cope with climate change. In addition, temperature and precipitation data covering the period 1976–2015 were collected on two synoptic stations (Kandi station for the DTZ and Parakou station for the STZ).

2.5. Data analysis

The data collected were coded, entered and processed using the Excel spreadsheets and SPSS (Statistical Package for Social Sciences) software version 17. The average response rate, which constitutes percentage of respondents who perceived a particular event and having adopted a particular adaptation strategy was calculated, compared by the Chi-square test ($X^2$) and presented in tabular and graphical form. The comparison was made according to the climatic zone.

Subsequently, a binary logistic regression with a stepwise backward elimination of predictors was performed to identify the most determinant variables affecting cattle farmers’ choice of adaptation strategies. The equation of the binary model is as follows:

$$Y_i = \beta_0 + \beta_i X_i$$

where: Yi is the dependent variable which takes the value 1 if the farmer adopts the adaptation strategy and 0 if he does not adopt it; Xi are the explanatory variables; βi is the regression coefficient of the explanatory variables and β0 is the constant term. The explanatory variables of the regression are shown in Table 2. Well-fitted models show significance (p ≤ 0.05) on the Chi-square test ($X^2$) and non-significance (p > 0.05) on the Hosmer and Lemeshow fit test (Archer and Lemeshow, 2006). Climatic data (annual precipitation and maximum temperature) for the last 40 years (1976–2015) was subjected to a simple linear regression.

3. Results

3.1. Socio-demographic characteristics of cattle farmers surveyed

The socio-demographic characteristics of the cattle farmers surveyed are summarized in Table 3. Almost all the farmers surveyed are men (92.5%), from mainly the Fulani socio-cultural group (80.83%). Their ages ranged from 50 to 76 (average age 56) and 95% were unschooled. The average household size was 11 people and the cattle herd averaged 64 heads. The experience in cattle rearing averaged 30 years. Majority of the farmers surveyed were members of herders’ organization (90.92%) and were also in contact with the extension service (66.21%).

3.2. Farmers’ perception of changes in rainfall and temperature

In both climate zones, majority of cattle farmers reported noticing changes in rainfall and temperature regimes (Figure 2). In the STZ, 77% of farmers perceived a decrease in rainfall, against 15% of farmers who perceived an increase. The same trend has been observed in the DTZ. These perception rates were significantly different (p < 0.05) within the same zone. With regard to temperature changes, majority of cattle farmers in the two climatic zones (75% and 85% respectively in the STZ and in the DTZ) perceived an increase against a minority having perceived a decrease. This perception difference was significant at the 5% level.

The evolution of rainfall and temperature in the two research areas has been on an upward trend since 1976 (Figure 3) as noted by some
breeders. This increase in rainfall and temperature is greater in the DTZ where the correlation curves have higher coefficients of variation.

3.3. Cattle farmers’ perception of impact of climate change

Cattle farmers in both climatic zones reported that changes in precipitation and temperature had negatively affected on their herd, natural resources and the farmer community (Table 4). According to the surveyed farmers, the impacts of CC on animals are felt on reproduction, health and productivity. In terms of reproduction, farmers reported a decrease in fertility, an increase in age at the first calving and in the number of abortions. All of these perception significantly differed ($p < 0.001$) between climatic zones except “age at first calving” (Table 4). On the health front, cattle farmers in both climate zones reported to have seen an increase in disease frequencies, occurrence of new diseases and mortality. Only the perception of the increase in mortality varied

### Table 2. Explanatory variables introduced in the regression model.

| Variables                      | Types of variables | Description                                                                 | Expected signs |
|--------------------------------|--------------------|------------------------------------------------------------------------------|----------------|
| Climatic zone                  | Qualitative        | 1 if farmer is located in the dry tropical zone, 0 otherwise                | ±              |
| Age                            | Quantitative       | Number of years of the farmer                                              | ±              |
| Sex                            | Qualitative        | 1 if farmer is male, 0 female                                               | ±              |
| Farming experience             | Quantitative       | Experience in livestock rearing (in year)                                  | ±              |
| Agricultural assets            | Quantitative       | Number of agricultural asset employed                                      | ±              |
| Ethnic group                   | Qualitative        | 1 if farmer is Fulani, 0 otherwise                                          | ±              |
| Education level                | Qualitative        | 1 if farmer is schooled, 0 otherwise                                        | ±              |
| Household size                 | Quantitative       | Number of family members living in the household                           | ±              |
| Membership in an organization  | Qualitative        | 1 if farmer belongs to a herder organization, 0 otherwise                  | ±              |
| Contact with agricultural extension service | Qualitative | 1 if farmer is in contact with an agricultural extension service, 0 otherwise | ±              |
| Cattle herd size               | Quantitative       | Number of cattle owned by farmer                                           | ±              |

### Table 3. Socio-demographic characteristics of cattle farmers in the sub-humid topical zone (STZ) and dry tropical zone (DTZ) of Benin.

| Characteristics                   | Climatic zones | Total |
|----------------------------------|----------------|-------|
|                                  | STZ           | DTZ   |
| Percentage (%)                   |               |       |
| Sex                              |               |       |
| Male                             | 95.00         | 90.00  | 92.50 |
| Female                           | 5.00          | 10.00  | 7.50  |
| Ethnic group                     |               |       |
| Fulani                           | 80.00         | 81.67  | 80.83 |
| Bariba                           | 20.00         | 18.33  | 19.17 |
| Level of education               |               |       |
| Educated                         | 6.67          | 3.33   | 5.00  |
| Non-educated                     | 93.33         | 96.67  | 95.00 |
| Membership in an organization    | 88.33         | 93.50  | 90.92 |
| Contact with the extension       | 60.67         | 71.75  | 66.21 |
| Mean ± Standard deviation        |               |       |
| Age                              | 57.95 ± 6.52  | 54.91 ± 4.7 | 56.43 ± 5.88 |
| Farming experience               | 34.37 ± 10.95 | 25.75 ± 8.4 | 30.05 ± 10.63 |
| Number of agricultural assets    | 8.55 ± 3.64   | 7.16 ± 3.25 | 7.85 ± 3.50 |
| Household size                   | 11.70 ± 4.64  | 11.71 ± 4.81 | 11.70 ± 4.71 |
| Cattle herd size                 | 61.28 ± 41.59 | 67.72 ± 35.46 | 64.50 ± 38.62 |

![Figure 2](image_url)  
Figure 2. Perceptions of changes in rainfall (a) and temperature (b) of cattle farmers in the dry tropical zone (white) and the sub-humid tropical zone (black) of Benin.
significantly (p < 0.001) between zones with more farmers on DTZ (85%) reporting this than farmers in STZ (28%). The increase in the occurrence of new diseases has been observed by almost all farmers in both climatic zones. With regard to animal productivity, the majority of farmers observed a decrease in milk production, lactation length and growth of animals. The latter perception was higher (p < 0.05) among cattle farmers in the DTZ (93%) than those in the STZ (77%).

In both zones, at least 80% of cattle farmers perceived negative changes in natural resources related CC. These changes are related to the increment of drying of watercourse, increased in the disappearance of existing plant species, increased growth of invasive plant species, decreased availability of forage, increasing of unknown insects and aridity soil. These perception rates however was not significant (p > 0.05) from one climatic zone to another, except the “increase of aridity soil”.

Almost all the farmers surveyed (at least 90%), perceived harmful effects of CC on the farming community. The main harmful effects enumerated were the decline in income, food insecurity, the land

Table 4. Perception of the harmful effects of climate change by cattle farmers in the dry tropical zone (DTZ) and sub-humid tropical zone (STZ) of Benin.

| Parameters                          | Level of perception (%) | p-value |
|-------------------------------------|-------------------------|---------|
| **Reproduction**                    |                         |         |
| Increasing age at first calving     | 88                      | 95      | 0.186   |
| Decreased fertility                | 65                      | 98      | 0.000   |
| Increase in the number of abortions | 33                      | 75      | 0.000   |
| **Animal health**                   |                         |         |
| Increased frequency of diseases     | 43                      | 47      | 0.713   |
| Increased occurrence of new diseases | 97                    | 100     | 0.153   |
| Increase in mortality               | 28                      | 85      | 0.000   |
| **Productivity of animals**         |                         |         |
| Decrease in milk production         | 97                      | 100     | 0.153   |
| Decrease in lactation length        | 95                      | 97      | 0.647   |
| Decrease in growth                  | 77                      | 93      | 0.01    |
| **Natural resources**               |                         |         |
| Increased drying of watercourses    | 97                      | 88      | 0.083   |
| Increase in the disappearance of existing plant species | 98 | 100 | 0.315 |
| Increased occurrence of invasive plant species | 95 | 93 | 0.696 |
| Decrease of the available forage    | 98                      | 93      | 0.17    |
| Increased appearance of unknown insects | 95                    | 92      | 0.464   |
| Increased soil aridity              | 92                      | 100     | 0.022   |
| **Pastoral community**              |                         |         |
| Decrease in income                  | 92                      | 92      | 1       |
| Food insecurity                     | 98                      | 98      | 1       |
| Land problem                        | 95                      | 93      | 0.696   |
| Conflicts between communities over the use of resources | 90 | 95 | 0.298 |

Figure 3. Trend of the annual rainfall (left) and maximum temperature (right) of the dry and sub-humid tropical zones of Benin from 1976 to 2015.
3.4. Adaptation strategies of cattle farmers to climate change

To cope with the negative effects of climate change, cattle farmers in both study areas have developed a variety of adaptation strategies to continue to draw from their environment their essentials livelihood. Seven (7) major adaptation strategies were identified that have been developed by cattle farmers (Figure 4). Thought a great similarity was observed among these strategies, it must be emphasized that they do not have the same frequencies in the two climatic zones. In the STZ the most relevant strategies put in place by cattle farmers to cope to climate change are integration livestock and crop husbandry (95%), transhumance (92%), use of concentrated feed (68%), reduction in herd size (62%), and forage cropping (52%). As for farmers in the DTZ, they focused on transhumance (100%), livestock diversification (93%), reduction in herd size (78%), usage of concentrate feed (78%) and integration of livestock and crop husbandry (73%). Adaptation strategies such as integration of livestock and crop husbandry, the forage cropping and the practice of off-farm activity were significantly different (p < 0.05) between the two climatic zones.

3.5. Determinants of cattle farmers’ adaptation strategies in the face of climate change

The factors influencing the adoption of adaptation strategies by cattle farmers in the face of CC are summarized in Table 5 (See Appendix for details). It was observed that cattle farming experience and size of cattle herd influenced the concentrate feeding to animals as an adaptation strategy in the two zones. Cattle herd size and the memberships of herders’ organization were the factors that seem to determine the forage cropping. The cattle herd size was the only factor determining the reduction in herd size. Cattle production experience and number of agricultural assets influenced (p < 0.05) to integrate livestock and crop husbandry. The climatic zone was the only factor influencing farmers to diversify the herd and to practice off-farm activities. Transhumance as an adaptation strategy was influenced by the level of education and cattle herd size.

4. Discussion

4.1. Perception of changes in temperature and rainfall and of their impacts

The study suggests that cattle farmers in the STZ and DTZ of Benin were aware of CC. This observation is supported by earlier studies in Burkina (Zampaligré et al., 2014; Sanfo et al., 2015; Kima et al., 2015; Bambara et al., 2016; Sanou et al., 2018), Ghana (Fagariba et al., 2018), and in even in Benin (Zakari et al., 2015; Dossa et al., 2017). It should be noted that the perception of changes in the rainfall patterns by cattle farmers in the two study areas does not correspond well with the weather data of the last 40 years. Their perceptions could probably have been affected by poor rainy seasons. Indeed, Yabi and Afouda (2012) noted that the decade 1970 and 1980 presented years with significantly low rainfall (1973, 1977, 1982, 1983 and 1984) throughout the country (Benin) than expected average. These events could therefore still be engraved in the memory of the farmers and hence informed their responses.

According to the surveyed cattle farmers, CC has negative impacts on animals (reproduction, health and production), natural resources and the cattle rearing community that could be associated with increasing aridity affecting feed availability and quality. This result is not surprising given that agricultural activities are climate dependent (Ayanlaïde et al., 2010). The decline in fertility, milk production and meat reported by farmers as impact of CC on animals in this study, corroborate the results of several authors (Nardone et al., 2010; Kima et al., 2015; Sanou et al., 2018). The same is true for increased morbidity and mortality in livestock due to an increase in some vector-borne diseases (Courtin et al., 2010; Sanfo et al., 2015). Oyekale (2014) in his study in Mali and Burkina Faso reported that farmers have reported new diseases and pests in cattle. Climate change will affect positively or negatively the development of pathogens according to their sensitivity to heat or humidity, but also their dispersion according to changes in intensity of rain or wind (Bazin et al., 2013).

The perception of farmers regarding the negative effects of CC on natural resources has been reported by Zampaligré et al. (2014). According to the authors, CC has an impact on forage availability, soil fertility, desertification and the specific composition of pastures. To these climatic causes of degradation of the environment, it is necessary to add the anthropic causes of degradation which was outside the scope of the present study. According to Diallo et al. (2011) environmental change is influenced by factors such as human activities and CC. Farming practices such as repeated bush fires, deforestation, slash and burn, overgrazing and the reduction of fallow duration result in the degradation of vegetation and soil, favoring the release of greenhouse gases e.g. CO2 into the atmosphere (Diallo et al., 2011; Enete and Onyekuru, 2011).

The social consequences of CC were perceived by farmers in both study areas in the same way. Food insecurity was the indicator with a high rate of perception. This result corroborates those reported by Bambara et al. (2013) in Burkina.

4.2. Determinants of cattle farmers’ adaptation strategies

To cope with the harmful effects of climate change, farmers in the two climatic zones of northern Benin surveyed, diversified their livestock species, integrated livestock and crop husbandry, destocked their herds, practiced forage cropping, fed concentrates to their animals, practiced transhumance and off-farm activities. These strategies adopted by cattle farmers in the DTZ and STZ of Benin are consistent with those found by several authors in Africa (Naès et al., 2010; Zampaligré et al., 2014; Getachew et al., 2014; Zakari et al., 2015; Kima et al., 2015; Dossa et al., 2017; Sanou et al., 2018). The adoption of one of these strategies by the farmers is influenced by at least one factor. Cattle herd size has positively influenced adaptation strategies such as bring concentrated feed to animals, growing of forages, decrease of herd size and transhumance. Indeed, insufficient forage resources due to the precariousness of rains push farmers, especially those with large numbers of cattle to buy concentrate feeds (Kanao, 2012) and also to grow forage fodder to feed their animals. In a context of uncertain pastoral resources, the purchase of livestock feed appears as a means to reduce mortality (Thiam, 2008; Jouve, 2010) associated with feed scarcity. Otherwise, farmers with large numbers of cattle and lacking the financial resources to maintain them are forced to reduce their herd size. This same observation was made by other authors (Oyekale, 2014; Kima et al., 2015) who reported farmers reducing their herd sizes in the face of feed scarcity. The precarious state of animal feed pushes farmers with a large herd size to move (transhumance) to reduce the risk of mortality. Cattle rearing experience had positive influenced in buying and feeding concentrate feed to animals.
and integration of livestock and crop husbandry as adaptation strategies. Cattle farmers with many years of experience in livestock rearing were more aware of CC and its consequences, and they are developing adaptation strategies. In addition, experienced farmers observe changes over time and compared them to current climatic conditions, allowing them to respond by developing strategies to mitigate effects of CC. Moreover, the number of years spent in the activity could have allowed the farmer to have some control over the entire production process and the factors that influence the various stages of this process. This result confirmed the observations of Mabe et al. (2014); Obayelu et al. (2014); Yegbemey et al. (2014) and Feleke et al. (2016). Nevertheless, other studies have revealed that the most experienced farmers are elderly and therefore generally lack interest and incentive to adapt (Uddin et al., 2014; Ndamani and Watanabe, 2016). The results of this study revealed that membership of herders’ organization have a positive influence on the establishing of forage cropping as a strategy for adapting to climate change. Livestock associations’ members benefit from training from development partners through non-governmental organizations (NGOs), agricultural development projects and programs. These different structures make farmers aware of the current climate variability and the present and future consequences on their livelihoods. In addition, the relationships that farmers maintain with each other serve as channels for sharing experiences that could have led to common adaptation initiative. Membership in an organization thus facilitates access to information and practices, such as the installation of forage cropping observed in this study.

| Predictors                          | β         | SE β     | Wald X² | df | p       | Odd ratio (exp β) |
|-------------------------------------|-----------|----------|---------|----|---------|------------------|
| Concentrated livestock feed         |           |          |         |    |         |                  |
| Constant                            | 4.866     | 0.999    | 23.745  | 1  | 0.000   | 129.800          |
| Framing experience                  | 0.076     | 0.024    | 10.350  | 1  | 0.001   | 1.078            |
| Cattle herd size                    | 0.019     | 0.006    | 9.643   | 1  | 0.002   | 1.019            |
| Test                                |           |          |         |    |         |                  |
| Overall model evaluation            |           |          |         |    | 0.000   |                  |
| Goodness-of-fit                     | 11.855    | 8        |         |    | 0.000   |                  |
| Forage cropping                     |           |          |         |    |         |                  |
| Constant                            | 3.323     | 0.695    | 22.844  | 1  | 0.000   | 27.743           |
| Cattle herd size                    | 0.015     | 0.007    | 5.145   | 1  | 0.023   | 1.015            |
| Membership of herders’ organizations| 3.196     | 0.557    | 32.977  | 1  | 0.000   | 24.434           |
| Test                                |           |          |         |    | 0.000   |                  |
| Overall model evaluation            | 47.989    | 2        |         |    | 0.000   |                  |
| Goodness-of-fit                     | 5.845     | 8        |         |    | 0.000   | 0.665            |
| Herd destocking                     |           |          |         |    |         |                  |
| Constant                            | 2.048     | 0.449    | 20.838  | 1  | 0.000   | 7.752            |
| Cattle herd size                    | 0.017     | 0.006    | 10.063  | 1  | 0.002   | 1.017            |
| Test                                |           |          |         |    | 0.000   |                  |
| Overall model evaluation            | 11.028    | 1        |         |    | 0.001   |                  |
| Goodness-of-fit                     | 12.268    | 8        |         |    | 0.000   | 0.140            |
| Integration livestock and crop husbandry |         |          |         |    |         |                  |
| Constant                            | 1.971     | 1.054    | 3.497   | 1  | 0.061   | 7.180            |
| Farming experience                  | 0.078     | 0.031    | 6.210   | 1  | 0.013   | 1.081            |
| Agricultural asset                  | 0.190     | 0.067    | 8.049   | 1  | 0.005   | 1.209            |
| Test                                |           |          |         |    | 0.000   |                  |
| Overall model evaluation            | 14.711    | 2        |         |    | 0.000   |                  |
| Goodness-of-fit                     | 22.308    | 8        |         |    | 0.000   | 0.004            |
| Livestock diversification           |           |          |         |    |         |                  |
| Constant                            | 2.639     | 0.518    | 39.160  | 1  | 0.000   | 14.000           |
| Dry tropical zone                   | 3.738     | 0.597    | 26.001  | 1  | 0.000   | 42.013           |
| Test                                |           |          |         |    |         |                  |
| Overall model evaluation            | 65.427    | 1        |         |    | 0.000   |                  |
| Goodness-of-fit                     | 0.000     | 1        |         |    | 1.000   |                  |
| Off-farm activities                 |           |          |         |    |         |                  |
| Constant                            | 2.639     | 0.518    | 26.001  | 1  | 0.000   | 14.000           |
| Dry tropical zone                   | -3.258    | 0.584    | 31.118  | 1  | 0.000   | 0.038            |
| Test                                |           |          |         |    |         |                  |
| Overall model evaluation            | 49.504    | 1        |         |    | 0.000   |                  |
| Goodness-of-fit                     | 0.000     | 1        |         |    | 1.000   |                  |
| Transhumance                        |           |          |         |    |         |                  |
| Constant                            | -7.004    | 1.308    | 28.691  | 1  | 0.000   | 0.001            |
| Level of education                  | -5.802    | 1.856    | 9.773   | 1  | 0.002   | 0.003            |
| Cattle herd size                    | 0.124     | 0.023    | 28.515  | 1  | 0.000   | 1.132            |
| Test                                |           |          |         |    |         |                  |
| Overall model evaluation            | 114.165   | 2        |         |    | 0.000   |                  |
| Goodness-of-fit                     | 26.159    | 8        |         |    | 0.001   |                  |
The level of education (schooling) negatively influences the adoption of transhumance as an adaptation strategy. The educated farmers are often managers of the farmers associations and are mostly invited to attend training sessions with the development partners, which makes them less available for transhumance. Otherwise, education is likely to improve the ability of the farmer to receive, interpret and understand relevant information to make innovative decisions (Getachew et al., 2014). Thus, educated farmers prefer adopting other strategies such as concentrate feeding and the growing of forage fodder instead of transhumance. The results of this study revealed that the number of agricultural assets has a positive influence on the integration livestock and crop husbandry. Availability of manpower leads cattle farmers to get involved in crop farming. The integration of livestock and crop husbandry allows cattle farmers to have manure used in crop production, which gives them higher yields as compared to non-cattle keepers. Crop residues in return to cattle farmers to have manure used in crop production, which gives them higher yields as compared to non-cattle keepers. Crop residues in return fed to the animals. The DTZ positively influenced the diversification of livestock and negatively the practice of off-farm activities. Compared to the STZ, the DTZ had few fodder resources. As a result, farmers in the DTZ were faced with pasture scarcity and therefore had to diversify their herd with inclusion of small ruminants. A diversified herd is an adaptation to a broader ecology where vegetation can be very varied in space and time. According to IUCN (2010), the diversification of cattle herds through the introduction of small ruminants is a real benefit to the farmer because of their low feed requirements, their wider feed resource base and their higher reproduction rates. Off-farm activities are less practiced by cattle farmers in the DTZ and more practiced by those in the STZ. This could be explained by the fact that the STZ has more urban lifestyle than the dry zone, which could facilitate the practice of other non-agricultural activities. Thus, income from off-farm activities can be used by farmers to increase the level of investment in inputs such as manpower, concentrated feed and veterinary products. In addition, the practice of off-farm activity is a climate change adaptation strategy that reduces risks (Yegbemey et al., 2013; Piya et al., 2013). For this reason, farmers who practice an off-farm activity would have a higher probability of adapting to climate change.

5. Conclusion

This study uses a rich set of data, collected in the DTZ and STZ, to analyze cattle farmers’ perception of climate change as well as the strategies they develop to adapt to this phenomenon. The results revealed that cattle farmers perceive climate change through decrease in rainfall and an increase in temperature. These climatic change have a negative impact on livestock, natural resources (water and fodder) and on the pastoral community. To adapt to climate change, cattle farmers in the two study zones mainly implemented seven (7) types of adaptation strategies, which included transhumance, integration livestock with crop production, use of feed concentrates, livestock diversification, herd reduction, forage cropping and off-farm activities. The adoption of one of these strategies by the farmer is influenced by at least one factor. Thus, farmers unschooled and who have a high number of cattle tend to practice transhumance. Farmers with long experience in cattle breeding and with an agricultural asset are likely to integrate farming with livestock as strategies to cope with climate change. The use of feed concentrates as an adaptation strategy is developed by experienced breeders with a high cattle herd size. Farmers located in the dry tropical zone are more inclined to resort to the livestock diversification and less inclined to resort to off-farms activities. Farmers belonging to a herder’s organization and with a large cattle herd size are installing fodder crops to mitigate the impact of climate change on livestock. Herd size reducing as an adaptation strategy is developed by farmers with high cattle herd size. These different factors must be taken into account in the implementation of livestock promotion policies in general, and cattle in particular, in a context of climate change.

As the adoption a strategy to reduce the impact of climate change on livestock leads to improved welfare for farmers, policies should focus on the implementation and capacity building of adaptation of cattle farmers to climate change. Also, regular sensitization, training, exchange and knowledge-sharing sessions on future climate conditions and sustainable adaptation strategies to CC could be potential intervention tools, geared towards farmers’ organization, through extension services. Future research may focus on assessing the effectiveness of these adaptation strategies in livestock productivity and on environment protection.

Declarations

Author contribution statement

Yaya Idrissou: Performed the experiments; Analyzed and interpreted the data; Wrote the paper.
Alasann Seidou Assani: Performed the experiments; Analyzed and interpreted the data.
Mohamed Nasser Baco: Conceived and designed the experiments.
Ayaadja Jacob Yabi: Contributed reagents, materials, analysis tools or data; Wrote the paper.
Ibrahim Alkoiret Traoré: Analyzed and interpreted the data; Wrote the paper.

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Competing interest statement

The authors declare no conflict of interest.

Additional information

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