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Climate change vulnerability and smallholder farmers' adaptive responses in the semi-arid Far North Region of Cameroon

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Abstract
Climate change and variability contribute to exacerbating poverty and social unrest in poor countries. Therefore, it becomes important to assess vulnerability and adaptation measures to raise awareness and monitoring of climate change adaptation policy for better decision-making. This research examines how farmers perceive their vulnerability and how they respond to climate change in the semi-arid Far North Region of Cameroon. Using both quantitative and qualitative approaches, data on perceptions with regards to vulnerability and adaptation responses to climate change related hazards were collected based on expert opinions, individual farmers' interviews, and focus group discussion. The qualitative data were triangulated with direct observations in the field. The results reveal that farmers are mostly concerned about drought and decrease in rainfall. Thus, they have mainly implemented behavioral and locally-made options such as short-cycle varieties, terrace farming, half-moon, and bunds, among others, to overcome water shortages. Nevertheless, these measures were not solely driven by vulnerability; the socioeconomic context might play a role. Moreover, farmers perceive a limited capacity to adapt to climate change, which suggests that the government and policy-makers should focus, not only on implementing planned adaptation strategies, but also on the improvement and promotion of farmers' autonomous adaptation strategies.

Keywords Water shortage · Livelihoods · Agriculture · Resilience · Social vulnerability · Adaptation · Climate change

1 Introduction

Worldwide, extreme weather and climate events have been occurring with more intensity and frequency as a result of climate change [1]. Moreover, evidence suggests a decrease in precipitation and expansion of drylands in the global semi-arid regions [2]. This has disproportionately affected the world's poorest population [3, 4], especially in Africa where the population expansion is expected to place more people in exceptionally vulnerable locations [5]. Therefore, vulnerability and adaptation assessments become important tools to raise awareness and monitoring climate change adaptation policy for a better decision-making [6, 7]. Nevertheless, while adaptation to climate change is an imperative to reduce vulnerability and enhance resilience [8], the evidence of vulnerability reduction due to adaptation is rather scant [6].

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In Cameroon, as in most Sub-Saharan African countries, adaptation to climate change is particularly important due to high proportion of people relying on rain-fed agriculture [9, 10], which is highly sensitive to temperature and precipitation variability, as well as to light and extreme events [11]. Small-scale farmers are, in many cases, capable of developing highly complex farming systems that are well suited to the specific ecological setting and natural resources upon which they depend [12]. However, variations in precipitation and temperatures have also resulted in variation in crop yields, thus aggravating food insecurity [13, 14]. In fact, warming temperatures are projected to decrease crop yields and outdoor physical working capacity in world most vulnerable regions [15, 16].

Moreover, the expected population growth [17] is likely to exacerbate the negative effects of climate change on vulnerable populations. These populations include small-scale farmers of the Far North semiarid region of Cameroon, who present high poverty rates compared to other regions of the country [18] and must often deal with numerous external factors that put pressure on the natural resources that sustain their livelihoods, including government resettlement programmes and land laws. This calls for more urgent preventative efforts towards increasing the adaptive capacity of smallholder farmer to external chocks. The government of Cameroon, through the different ministries, have developed policies, programs and strategies with various activities that directly or indirectly address climate change. These include capacity building, research, climate change dialogue platforms and conferences [19]. Nevertheless, the climate change policy and related activities in Cameroon have been mostly directed toward mitigation, with limited concern about adaptation issues [20]. Local governmental institutions are limited in their knowledge of how to help communities respond to climate change [21]. Hence, studies have been conducted to assess vulnerability and adaptation in Cameroon, focusing on specific sectors, e.g. forest-related sectors [22, 23], coastal areas and mangroves [24, 25], agriculture [26, 27] or in legislative framework and institutional performance [28, 29].

This study, however, despite its focus on farming communities, attempts to holistically understand how humans perceive their vulnerability and how they respond to climate change. It draws information from farmers and experts in the semi-arid Far North Region of Cameroon. The study also identifies the enabling and constraining factors for farmers' ability to respond, recover and adapt to climate change. The findings will help to inform more effective decision-making, planning and management in the study area.

2 Methodology

2.1 Description of the study area

This study was conducted in two areas, namely, Mayo-Moskota and Logone Birni sub-divisions, in the Far North semi-arid region of Cameroon (Fig. 1). Mayo Moskota sub-division is a mountainous region whereas Logone Birini Sub-Division is mainly a flatland. Farming systems at these sites are diverse, ranging from pastoral-dominated systems through strongly interacting crop-livestock enterprises to crop-dominated systems. This diversity offers an opportunity to identify different types of "best fit" adaptation strategies, each matching the specific agro-ecological niches named above. The Mayo-Moskota sub-division comprises seven councils classified as "mountainous", while the Logone Birini sub-division has 10 councils classified as "floodplains". The majority of the population in the region lives far below the official poverty line [18]. The study took place in one "Mandara" mountainous council (Mayo-Moskota) and one floodplain council (Logone Birni), with two villages (Tilde and Zeleved) identified for study. The villages were selected based on differences in institutional arrangements with regards to natural resource management, mainly determined by traditional, informal institutions and land use policies. Farming systems in the villages were similar in composition and crop production forms, a major part of livelihoods in both villages, thus facilitating inter-village comparisons.

2.2 Data types and sources

In this study, we collected data between August 2020 and February 2021 using three different approaches, namely, individual in-depth face-to-face interviews with farmers (28 individuals) and experts (22 individuals) and focus group discussions (8 sessions with 15 participants each). Although there is not a magic number of focus groups sessions for the successful completion of data collection, the literature suggests a minimum of 3–5 focus groups [30]. Therefore, we conducted 4 sessions of focus group discussions (FGD) in each study area. To select participants, lists of smallholder farmers provided by local extension services, government authorities and non-governmental organizations (NGOs) were combined and duplicates removed. This resulted in a total of 1223 farmers in Mayo-Moskota and 1465 farmers in Logone

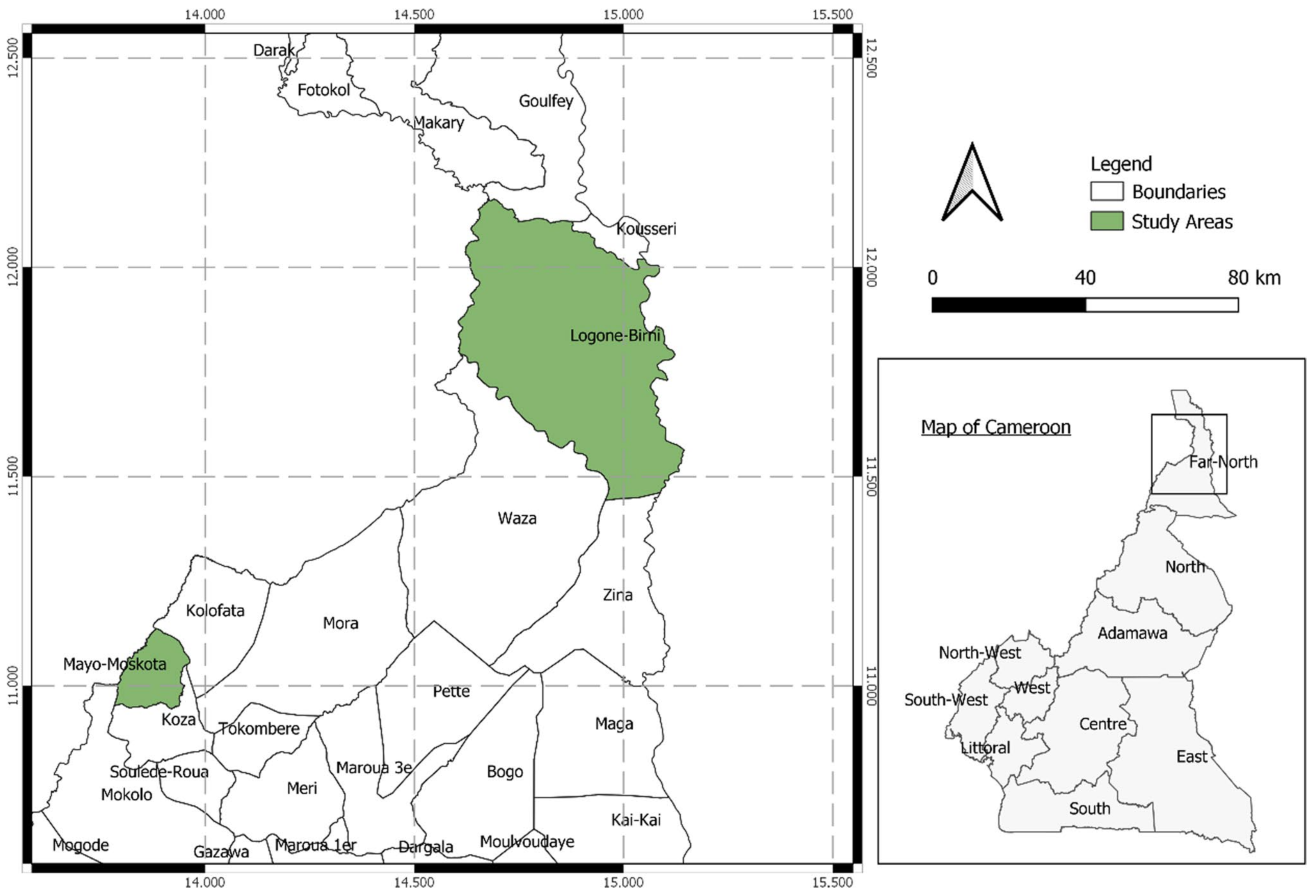

Fig. 1 Geographical Location of the Study Areas. (Source: Forestry Atlas 2018)

Birni. The potential participants were firstly stratified by gender and within the two gender groups, farmers were further stratified based on their age. We targeted farmers over 18 years old, therefore, we created three age categories, namely, early working age (18–24 years), prime working age (25–54 years), mature working age (55–64 years) and elderly (65 years and over) (cf. Edzie, Gorleku [31]). Two participants were randomly selected for each age group, except for the elderly, in which only 1 person was selected. As such, each gender group consisted of 7 participants per FGD session. An additional participant with a leadership position was recruited to the FGD. The literature suggest a maximum of 12 participants per FGD to avoid group fragmentation [30, 32]. Nevertheless, in this study the number of participants was limited to 15 since we aimed to have a heterogeneous group that was large enough to gain a variety of opinions and perspectives. Each session of FGD was guided by a semi-structured interview and lasted 1.5–2 h. All sessions were audio-recorded. Additionally, individual farmers' interviews were conducted to complement the FGD. A total of 28 farmers, half of whom were female – also composed of people of different ages – were randomly selected from the aforementioned list, excluding the FGD participants. This sample size was due to financial constraints and each interview lasted approximately 1 h.

To select excerpts, we targeted individuals with in-depth knowledge about the research topic and employed in universities, research institutes, government and NGOs. Potential experts were identified based on authors personal knowledge, institutional reports (including other published grey literature) and peer review articles. Table 1 provides an overview of the major field of respondents' specialization and affiliation.

Our aim was to explore farmers' thoughts, feelings and behaviors regarding their vulnerability to food security related hazards (Table 2). Thus, we firstly, asked experts to list the most important hazards related to food security in the study area. Secondly, we asked smallholder farmers during the individual interviews and the FGD to rank the degree of vulnerability and adaptive capacity to those hazards, using a 4-point scale (Table 3). This mixed-methods approach was used to capture personal experiences, opinions and beliefs about the vulnerability (cf. Molzahn, Starzomski [33]). Thirdly, farmers were asked to name the adaptation responses used to adjust to actual or expected climate hazards and their effects. Contrary to the hazards, we did not assume to know a priori the adaptation measures adopted by farmers. Rather,

Table 1 Respondents' field of specialization and affiliation

No.	Institution	Respondent's education/major field
1	Ministry of Environment, Nature Protection and Sustainable Development, Division of Monitoring, Conservation and Promotion of Natural Resources MINEPDED/DSCPR, Yaounde	Master in Natural resources management
2	Ministry of Environment, Nature Protection and Sustainable Development (MINEPDED) - Climate Change Unit	Forestry and wildlife Engineer
3	Regional Delegation of MINEPDED in the Far North Region, P.O.Box 68 Maroua	Forestry and wildlife Engineer
4	Regional Delegation of the Ministry of Agriculture and Rural Development (MINADER) in the Far North region, Maroua	Agricultural Engineer
5	Regional Delegation of MINADER in the Far North region, Maroua	Agricultural Engineer
6	Department of National Meteorological Service	Master in geography
7	Regional meteorological service, Regional Delegation of the Far North Region	Civil engineer
8	Regional Delegation of the Ministry of Forestry and wildlife	Forestry and wildlife Engineer
9	Regional Delegation of the Ministry of Livestock, Fisheries and animal husbandries	Veterinarian
10	Regional Delegation of the Ministry of water and energy in the Far North region,	Hydraulic engineer
11	Regional Delegation of the Ministry of Public Health in the Far North region, Maroua	Regional delegate
12	Centre of Environmental and Development Study in Cameroon (CEDC)	Head of Centre, Agronomist
13	National Polytechnic School of Maroua, State University of Maroua	Head of the department of social sciences for development
14	Agricultural Research Institute for Development (IRAD), Maroua	Agricultural Engineer
15	International Union for Conservation of Nature **(IUCN)** Cameroon Maroua	Natural resources management
16	Rural Development Programme for the Far North Region " PDR-EN " Operational Structure	Civil engineer
17	FAO-WFP Regional committee, Far North Region of Cameroon	Executive Secretary
18	PRODEBALT "Sustainable Development Programme of Lake Chad Basin"	National coordinator PRODEBALT
19	Support Service for Local Development Initiatives (SAILD)	Agricultural economist
20	Action against Hunger (ACF)	Agricultural economist
21	French Red Cross	Agricultural economist
22	Integrated participatory local development support unit. CADEPI	Rural engineer

Table 2 List of hazards identified during the interviews with experts

No.	Hazard
1	Extreme precipitation
2	Precipitation variability
3	Decrease in precipitation
4	Flooding
5	Increasing frequency and intensity of extreme heat
6	Drought
7	Wind
8	Pests
9	Human disease
10	Animal disease
11	Food prices

these were identified over the course of the fieldwork based primarily on data provided by farmers during the individual interviews and FGD. Both farmers and experts were explained the definitions of hazard, vulnerability, adaptive responses, based on IPCC [34] (see Box 1).

Box 1: Definition of terms

Hazard: the potential occurrence of a climate-relatedevent or trend or physical impact that may cause loss ofyields, health impacts, as well as damage and loss toproperty, crop field, infrastructure, livelihoods, serviceprovision, and environmental resources.

Vulnerability: the propensity or predisposition to beadversely affected. It encompasses the susceptibility to harmand lack of capacity to cope and adapt.

Adaptive responses: initiated or assisted by humanshuman with aim of moderating or avoiding harm or exploit.

To familiarize the respondents and adjust the concepts to local language or locally known climate variability and change terms, before the interviews and FGD, local experts and community members were asked to indicate the appropriate meaning in local terminology of some of the key concepts used in the field of climate change. Table 4 provides an overview of some of the climate change concept equivalence in the Arabe Choa and Mafa dialects.

2.3 Data analysis

To analyze the data, we followed several steps as suggested by the literature on how to perform focus group analysis [35, 36]. Firstly, we produced a verbatim transcript of the audio-recorded discussion, which were compared with the handwritten notes taken by the moderator and subsequently translated into English. Secondly, the interview transcripts were manually coded into pre-determined categories of adaptation responses. Since we aimed at understanding farmers' autonomous response to the hazards, three main categories were created, namely, behavioral, ecosystem-based, and technical or infrastructural responses (cf. Berrang-Ford, Siders [6]). The coded responses were used as the organizing frame in which to report the information generated by the interviews (see Lederman [37] and Lederman [38]). Thirdly, the qualitative data, obtained during the collection phase, were triangulated with direct observations in the field. This was made possible by the first author's stay in the study area. The forth step involved the descriptive presentation and interpretation of the data in the context of the discussion. To support the findings, we used direct quotes (reported anonymously) to illustrate participants' understanding and explanations of their experience at the time of the FGD [39]. Moreover, quantitative data was also produced in the course of the data collection. Therefore, descriptive statistics (average and percentages) were computed in Microsoft Excel 2013. We calculated the percentages of farmers who have adopted each type of adaptation strategy and created an overall rank for the vulnerability to hazards by calculating the average rate based on individual response from both FGD and individual interviews. Moreover, we conducted a Principal Component Analysis (PCA) of the correlations between the perceived vulnerability and the adaptation responses adopted. This is a multivariate statistical and analytical technique applied to data to reduce the dimensionality of a

Table 3 Vulnerability and adaptive capacity self-assessment scale

Point	Description of vulnerability	Description of adaptive capacity
0	No vulnerability (hazard does not affect any resources of community members)	No capacity (We do not have any capacity to cope with the consequences of the hazards)
1	Low vulnerability (hazard slightly affect resources)	Low capacity (We do have some capacity to cope with the consequences of the hazards)
2	Medium vulnerability (hazard affect considerably the resources, but only in specific areas)	Medium capacity (We do have capacity to cope with the hazards, but only some of them)
3	Significant/high vulnerability (hazard significantly affect the community's resources and is widespread)	Significant/high capacity (we have capacity to cope with the consequences of all hazards)

Table 4 Equivalence to some of the key concepts of climate change adaption in Arabe Choa and Mafa dialects

Key concepts	Dialect of Arabe Choa	Mafa dialect
Vulnerability	da if	Ndi te dalali
adaptation	walafa	skwi nwoudi tepa a va
Social vulnerability	pauvreté	Ndji te dalali a ndohi télé
Climate variability and change	khayirine al djao	sem Mana ngodeva anvi anvi
Indigenous climate forecasting	min al djahi guiddam	nhirgued a skwi Man a vama Man ka guia a Mana sem ngode va an vi
Soothsayer or 'rainmakers'	Kharif	ndohi n'guiyam
Coping strategy:	wassifa kef walafa	maya Man ka guia a nchinde skwi nwoudi tepa
Adaptive capacity	tandar tiwalif	woudi gui skwi Man ka de tepa

dataset with multiple variables to a smaller set of underlying independent variables based on patterns of correlation among the original variables [40].

3 Results

3.1 Vulnerability to hazards and adaptive capacity

All study participants reported experiencing climate related hazards. Drought and precipitation decrease are viewed as the major threats to food security by farmers in the study region, whereas food prices, animal and human diseases received a rank of 0 (zero), which implies that farmers do not see this as threat to food security (Table 5). Furthermore, the results in Table 5 indicate low vulnerability to variable and extreme precipitation. During both FGD and individual interviews, farmers expressed their concern about food insecurity, largely attributed to lower agricultural yield due to rain and water shortage. Nevertheless, respondents also pointed out the occurrence of unpredictable and out-of-season rain. For example, one respondent noted:

"*The rain has been disappointing me lately, sometimes it reduces, sometimes in starts soon and other times it starts very late and it is complicated for us because we don't have agro-meteorological services in this region*" [Respondent 327,671, September 15th, 2020].

The lack of access to weather forecasts services was confirmed during our expert interview in which one expert stated that the meteorological stations in the region are inoperative. Consequently, seasonal climate forecast information is inaccessible, with data reflecting climate variables (mostly temperature) scarce:

"*We have a complicated situation due to the lack of an agro-meteorological service in the Far North Region of Cameroon. Although the region is well known for its fragile ecosystem, none of the meteorological stations in the region are operating.*

Table 5 Farmers perception with regards to the degree of vulnerability to food security related hazards and adaptation responses

Hazard	Degree of vulnerability	Adaptive capacity
Extreme precipitation	1	0
Precipitation variability	1	0
Decrease in precipitation	3	1
Flooding	1	1
Increasing frequency and intensity of extreme heat	2	0
Drought	3	1
Wind	2	2
Pests	2	0
Human disease	0	0
Animal disease	0	0
Food prices	0	0

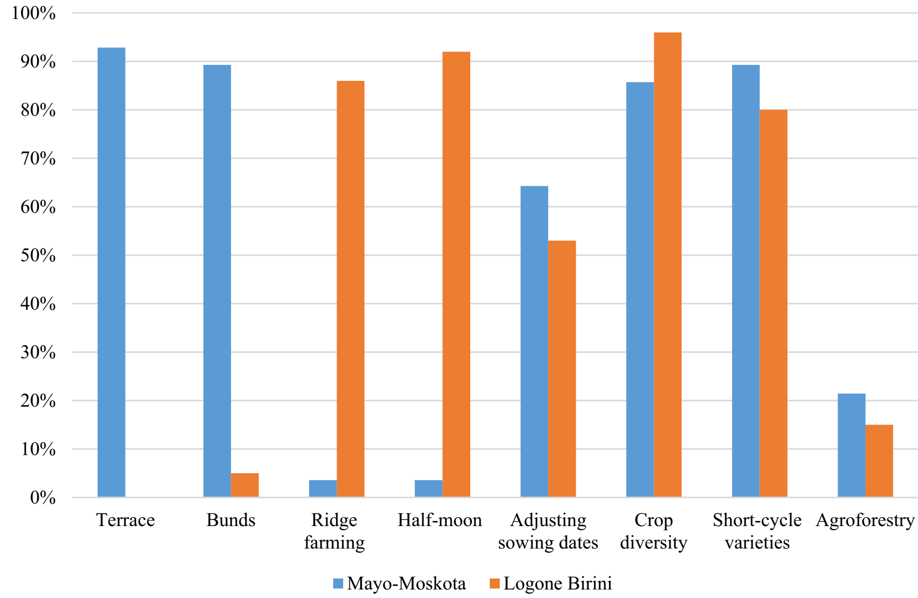

Fig. 2 Adaptation responses adopted by farmers in the study area

That is why seasonal climate forecast information is inaccessible. Data about temperature is scarce and agricultural users lack access to actionable weather forecasts" [Respondent 212,401, August 20th, 2020].

With regards to adaptive capacity, farmers have generally reported lack of capacity to adapt to climate hazards. The farmers believe they have medium capacity to deal with strong wind, while the capacity to adapt to drought, flooding, precipitation variability is low or inexistent. Nevertheless, the farmers have claimed to notice improvements in their yields after adopting the strategies described in the next section. For example: when asked to explain if they notice any change after they have adopted the adaptation strategies, Respondent 327,632 noted:

"*…basically, last year I used to harvest very little due to drought, but now that I am using this new variety, my situation has improved a little bit. I think it would be complicated if I continued to use the seeds I used to sow*" [October 14th, 2020].

3.2 Adaptation responses

The respondents further revealed that they have adopted some farming practices to cope with some of the appointed hazards. These techniques are mainly infrastructural. In Mayo-Moskota, which is mainly mountainous, farmers have adopted the terrace farming and the construction of bunds. The percentage of farmers using each of the adaptation practices is presented in Fig. 2. Terraces, adopted by 93% of the farmers, are built to prevent erosion and the loss of soil nutrients due to rains (Fig. 3). Bunds are constructed in flat areas to prevent water flow and retain the moisture on the field. These were adopted by 89% of the respondents.

In Logone Birini, the main techniques adopted are ridge farming (86%) and half-moon (92%). Nevertheless, some respondents indicated the use of stone bunds and zaï. These techniques are used to facilitate water filtration, reduce water runoff and are implemented depending on the crop (Fig. 4). Crops with developed roots, like beans and peanuts are cultivated under stone bunds, while crops with poorly developed roots, like maize, millet, and sorghum are cultivated under half moon.

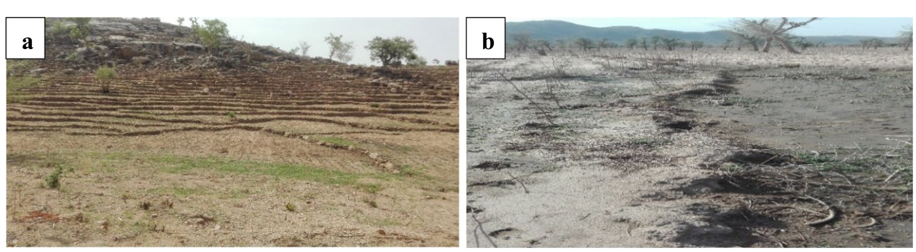

Fig. 3 Terrace (**a**) and bund (**b**) constructed by farmers in study area

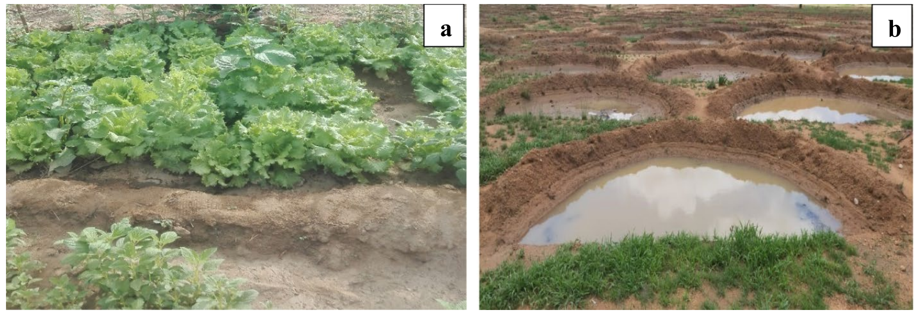

Fig. 4 Ridge farming (**a**) and half-moon (**b**)

Farmers in both regions further revealed the use of behavioral adaptation strategies such as adjusting the sowing dates (64% in Mayo-Moskota and 53% Logone Birini), crop diversity (86% in Mayo-Moskota and 96% Logone Birini), adoption of short-cycle varieties (89% in Mayo-Moskota and 80% Logone Birini), and agroforestry (21% in Mayo-Moskota and 15% Logone Birini).

As farmers perceive a trend towards a changes in the onset of the rains, they indicated to have shifted the sawing dates. Nearly 90% of the respondents indicated to have shifted the sowing date from June to May. Nevertheless, farmers also think that this is a risky behavior due to ongoing uncertainty with regards to rain distribution. One of the respondents has stated:

"*We have been facing problems with false start of precipitation, especially in March. This make us sow too early while the rain hasn't really started and we end up losing everything*" [Respondent 327,551, November 4th, 2020].

As a result, the usual agricultural calendar is being abandoned due to the high spatio-temporal variability of rainfall. In general, the respondents cultivate maize, sorghum, beans, and ground nuts mostly in association. Although part of the respondents link this practice to a lack of land, more than half of them link it to a concern for preserving the food and nutritional security of the household. Indeed, these farmers see crop diversity as a way of increasing the chances to guarantee a minimum harvest at the end of the growing season, since "*…if one crop fails, the other can succeed*" [Respondent 327,431, January 11th, 2021]. Figure 5 illustrates a combination of maize and groundnuts in the Mayo-Moskota and in Logone Birini, respectively.

Faced with the usual drought events and poor rainfall distribution, farmers are increasingly expressing an interest in short-cycle varieties. They believe that these varieties could reduce the risk of crop failure. The emphasis was placed more on the case of maize and sorghum since they are the main staple crops in the study areas. Therefore, the sorghum variety S35 and the maize variety CMS 9015 have been adopted by the farmers.

"*…I grow maize in my farm but the droughts and lack of rainfall are very common in our region. The varieties of maize I use requires a lot of water. It used to have high yield, but now I prefer to use this new variety because it stays in the field for a short period* [Respondent 327511, February 5th, 2021].

The occurrence of strong winds has led farmers to plant trees in the fields. Tree species are planted around the perimeter of the crop plots and/or inside them. The farmers usually plant *Faidherbia albida* and *Acacia auriculiformis*. According to the respondents, the trees are used as windbreakers and are source of wood for construction and repair of houses.

The results from Principal Component Analysis (PCA) provided insights with regards to the relationship between the adaptation measure and climate change related hazards. Figure 6 shows that the adjustment of sawing date is and adaptation response mainly associated with drought, decreased precipitation and, to some extent, with increased frequency and intensity of extreme heat. Agroforestry was applied mainly by farmers who experience precipitation variability. Terrace, half moon, ridges and bunds were also related to increased frequency and intensity of extreme heat to some

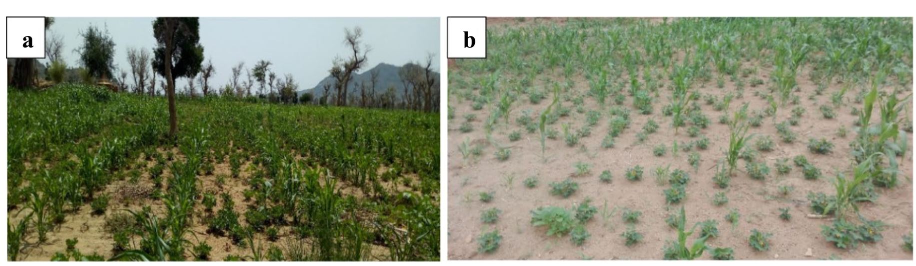

Fig. 5 Association between maize and groundnut in Mayo-Moskota (**a**) and Logone Birini (**b**)

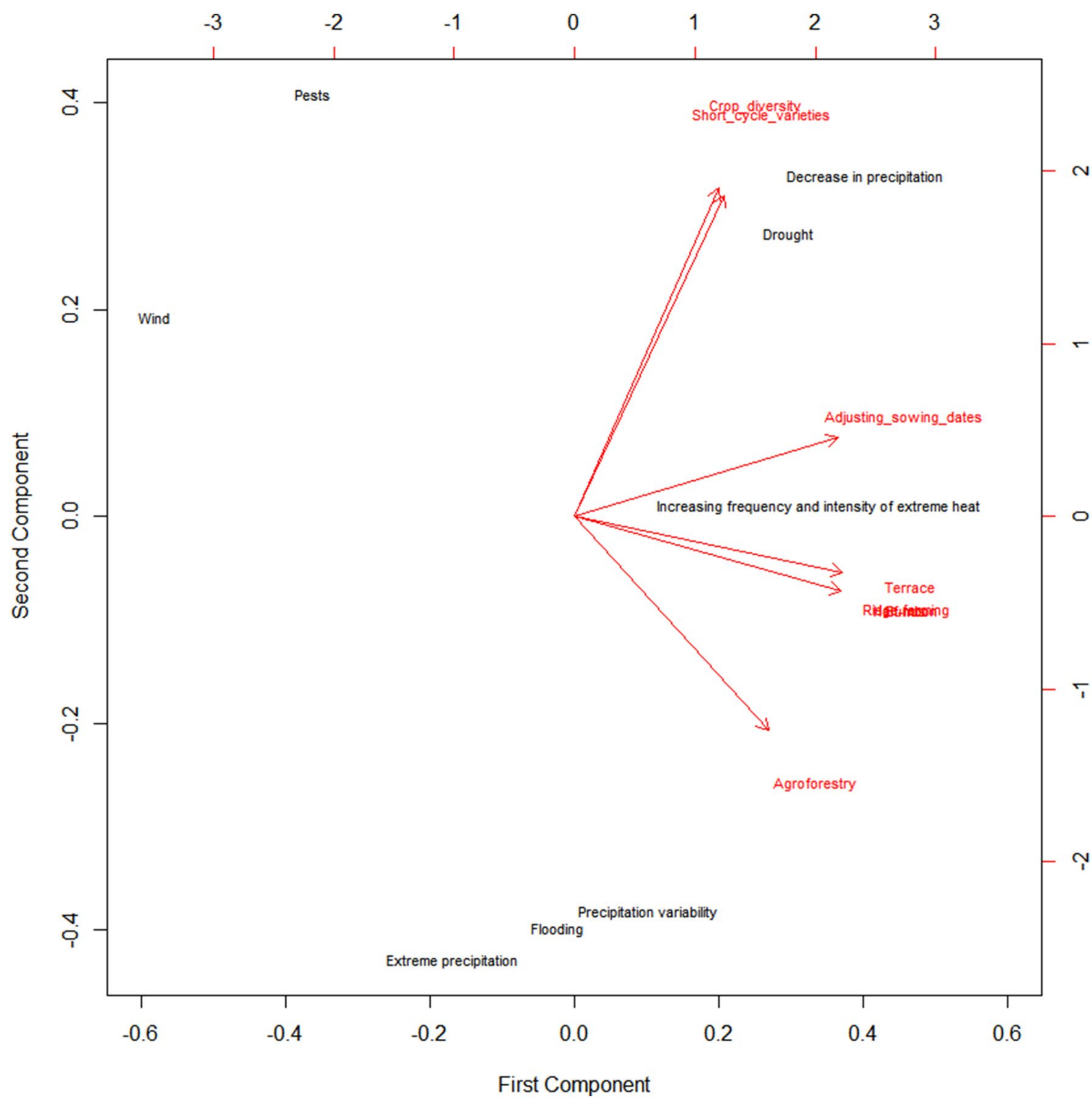

Fig. 6 Principal Component Analysis (PCA) for perceived vulnerability to hazards and adaptation responses

extent. Wind, pest, extreme precipitation and floods were not associated to the adaptation responses reported by our respondents. In addition, some of the adaptations strategies are not driven by climate factors.

4 Discussion

The documentation of climate change adaptation practices provides a valuable complement to efforts to track adaptation on the ground [6]. Thus, in this study we explored how farmers perceive their vulnerability to climate change related hazards and how they respond in the semiarid Far North Region of Cameroon. This analysis helps to document the hazards that affect the livelihoods and lives of farming communities in the study areas and the adopted coping mechanisms. Based on opinions of experts and farmers' perceived experiences the study found that there is a general concern with regard to the impacts of climate change in the study sites and farmers have started to adopt strategies to adjust to a changing climate.

4.1 Farmers' perceptions of their vulnerability and adaptive capacity

Drought and rainfall variability (both within and between seasons) are underlying risk factors, causing uncertainty to farm-level production. This findings are in line with those reported by Awazi, Tchamba [10] in which they found that farmers in the Western Highlands of Cameroon perceived extreme weather events and poverty as the major causes of their vulnerability to climatic variations and changes. Other studies conducted in other regions of Cameroon also provided evidence of increased vulnerability due to decreasing and irregular rainfall [41–45]. Variability of rainfall could have several implications. It results in increased stresses on crop production and food security. Kotir [11] states that increases in inter-annual variability, dry spells, as well as periods of flooding and infestation will affect crop productivity and could result in crop failure. Thus, we argue that more efficient dissemination of climate outlook information may have the potential to prevent crop losses. In fact, limited weather forecast is one of the causes of vulnerability [45]. Awazi, Tchamba [10] further note that "with high levels of fluctuation in temperature and rainfall in recent years, smallholder farmers increasingly find it difficult to plan the farming season". According to Cooper, Dimes [46], the consequence of the uncertainty to farm-level production is that farmers can be reluctant to invest in potentially more sustainable, productive, and economically rewarding practices when the returns to investment appear so unpredictable from season to season. Furthermore, in addition to knowledge about climate, fundamental livelihood and development problems need to be addresses to improve the social, economic, and environmental adaptive capacity [47].

Other hazards, such as flooding, increasing frequency and intensity of extreme heat, wind and pests were also pointed out by farmers as a cause of vulnerability (cf. Table 5). Strong winds and flooding were also reported by farmers in the Bamenda Highlands of North Western Cameroon [48]. Plant diseases and pest infestations, as well as the supply of and demand for irrigation water, are also influenced by climate [49]. Contrary to the findings by Awazi, Tchamba [10], the prices of agricultural produce were not identified as a sources of vulnerability, probably due to the fact that majority of the study participants are subsistence farmers and, therefore, without much connection to the market. However, this result should be interpreted with caution, as this study was mainly based on qualitative data collection methods and more robust inferential statistical methods could not be applied. Therefore, the study results cannot be generalized to the entire population [36]. Despite these limitations, the use of FGD to collect qualitative data provide the study participants the opportunity to build upon one another's comments, stimulate thinking and discussion, thus generate ideas and breadth of discussion [50, 51]. Moreover, FGD can produce high quality data because the focus group moderator can respond to questions, probe for clarification and solicit more detailed responses [52].

4.2 Adaptation responses to climate change related hazards

Despite uncertainties with regards to climate change, farmers in the study area are responding to the adverse effects of weather events. This suggests that the government and policy-makers should focus, not only on implementing planned adaptation strategies, but also on the improvement, promotion and wider extension of farmers' autonomous adaptation strategies [53]. Farmers are mainly adopting behavioral and infrastructural strategies to deal with hazards that threaten their food security. This is in line with the results found in the academic literature by Berrang-Ford, Siders [6], who indicated that behavioral and technical and/or infrastructural responses are the most predominate. The use of measures such as bunds, half-moon, Zaï, improved seeds, agroforestry and crop diversification are also reported in other studies in Cameroon [54–58]. Other studies in SSA have also similar measures [59, 60]. The use of ridges is also documented in Ethiopia [61] and Tanzania [62]. Nevertheless, under the increasing unpredictability of future climate situation, the current adaptation strategies, despite being potentially good, may still be weak to allow an effective adaptation to climate change [58]. Moreover, we recognize that the adaptations strategies are not solely driven by climate factors, but also by the socio-economic context. For example the association of crops was in some instances driven by the need to manage the scare land and on-farm trees was practiced to also secure wood for construction and repair of houses. The PCA results indicate that some of the adaptation measures, such as crop diversity and the use of short-cycle varieties are not associated to the climate hazards. This might be due to the fact that this measures are mainly driven by government and NGO programs, rather than farmers' autonomous initiative. Thus, the results of this study should be interpreted with caution since they are solely based on personal opinions and experiences of the farmers and experts. Moreover, there is still a need to quantify the actual losses due to climate hazards using quantitative research methods.

More consideration must be given to the extent to which these hazards will affect the future productivity. This is where the importance of agro meteorological services and a national climate change observatory become obvious. With the help of these specialized units, the extent that small scale farmers in the semiarid Far North region of Cameroon will experience conditions under progressive climate variability and change that they are not already experiencing today can be explored. This can be done through analysis of longer time-scale relative to long-term daily weather data in order to provide more accurate information with regard to the length of growing period under temperature rise.

5 Conclusion

In this study, we show that that small-scale farmers in the semiarid Far North region of Cameroon are very aware of the increased climate variability. They indicated to have experienced within-season rainfall variability, strong winds, long dry spells within rainy seasons, and flooding. Therefore, they have already adopted some adaptation measures to adjust to a changing climate. These measures are mainly behavioral and infrastructural. The smallholder farmers perceive decrease in precipitation and drought as the major factors of vulnerability, thus, they have mostly adopted strategies to adapt to water scarcity. However, these strategies are not solely driven by climate change related hazards. Thus, there is still a need to further investigate the drivers of adaptation strategies and understand the socioeconomic context to better design strategies that are suitable to the specific local needs. The findings of this study suggest that autonomous adaptation by smallholder farmers should be taken into account during policy and decision making processes. The focus should be directed towards improvements of current adaptation strategies and development of strategies that are more adapted to the local context. Investments in weather forecast stations and provision of weather information should be integrated into agricultural extension services for a more informed decisions making process.

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Author contributions HMN and HANW designed the study, wrote the original draft, reviewed and edited the manuscript. CEM wrote the methodology section and Conceptualization and critically reviewed and edited the manuscript. KL and SS approved the study protocol and critically reviewed and edited the manuscript. All authors read and approved the final manuscript.

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Data availability The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics statement and consent to participate The research followed the ethical standards as laid down in the Declaration of Helsinki and the protocol was approved by the Faculty of Agronomy and Agricultural Sciences at the University of Dschang in Cameroon. A written consent was obtained from all study participants.

Consent for publication A verbal consent for publishing was obtained and no identifying details of the participants is published.

Competing interests The authors declare that they have no conflict of interest.

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