



# Implications of Climatic Stressors on Agro-Pastoral Resources Among Mbororo Communities Along the Slopes of Kilum-Ijim Mountain, North West Region, Cameroon

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Mountains are rich in pastures and water for agro-pastoral resources and supports rain-fed farming that sustain the livelihoods of many indigenous communities. This work seeks to examine the implications of climatic variability on agro-pastoral resources (pasture land, water) and food security within the Mbororo communities. To ascertain this, 350 household questionnaires were randomly administered in four Mbororo Ardorates and in-depth interviews conducted with local authorities. Quantitative and qualitative analysis of data collected revealed that the link between climate, land and water is paramount in animal rearing and crop farming in mountains. Cattle rearing and crop farming have been the main source of livelihoods for about 90% of the Mbororos as they depend on it for food and income. Climatic perturbations characterized by frequent dry spells, rainfall anomalies and other environmental stressors predicted degrading pastoral resources and the independent variable explained the outcome variable at  $R = 0.787$ ;  $R^2 = 0.623$ ;  $\Delta R^2 = 0.622$ ;  $p < 0.01$ . This implies that 62.3% of degradation is accounted for by environmental stressors. As such, the carrying capacity of grazing have gone above the authorized number of two cattle per hectare, leading to overgrazing and degradation. Encroachments into grazing lands by crop farmers, invasion by unproductive grass species and farmer-grazer conflicts are aggravated by climatic stressors. The Fundong council and traditional authorities of the Kom Fondom have been working together to demarcate grazing land and provide water for cattle rearing. Mbororo communities are equally diversifying their activities to ensure food availability.

**Keywords:** climate variability, land, water, food security, Cameroon

## INTRODUCTION

Mountains are specific ecosystems rich in pastures and water for agro-pastoral activities. These resources, coupled with specific ecological conditions have made tropical mountains attractive to Mbororo pastoralists. However, mountains are very sensitive to climatic aberrations and agro-pastoralists have been considered as one of the most climate-change-vulnerable groups on the planet (Herrero et al., 2016). Food production and livelihoods of agro-pastoralist depend on the climate, land and water nexus. Land provides the basis for livelihoods as it supplies food, fresh water and multiple other ecosystem services and biodiversity (IPCC, 2019). Pastoralism is a critical asset for food security and it sustains livelihoods in and outside of pastoralism (Krätli et al., 2020).

Climate change has led to increase in rainfall intensity, floods frequency and severity and dry spells which have exacerbated land degradation as well as other agro-pastoral resources (IPCC, 2019). Climate variability and change is hitting hard on agro-pastoral systems and making the future uncertain for pastoralists in Sub-Saharan mountains (Herrero et al., 2016). This uncertainty warrants that adaptation systems be reviewed and upgraded to lessen the negative impacts of weather aberrations. Works by Nakashima et al. (2012) and Herrero et al. (2016); show that pastoralists communities in Sub-Saharan Africa are affected by climate change, with impacts ranging from rangelands, livestock, water and extended repercussions on income and food security. Agro-pastoral systems are highly vulnerable and adapting requires multiple and simultaneous responses. According to IPCC (2014), adaptation implies adjustment to actual or expected climate to lessen the negative effects or exploit the opportunities. This is crucial as pastoral resources are already highly vulnerable.

Climate change has become a major threat to food security especially in Sub-Saharan Africa that depends on rain-fed agro-pastoral systems (FAO, 2014). Livelihoods and food security of agro-pastoralists are already negatively affected by climate change. Ensuring food production and food security in the context of global climate change necessitates an understanding of the links between climate, water and land. According to FAO (2015), food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Climate change has compromised the ability of indigenous communities to satisfy their food needs because it has profoundly affected the conditions under which agro-pastoral activities are carried out.

As such, the achievement of Sustainable Development Goals is not possible without directly addressing the impacts of climate change. Eradicating poverty and hunger, ensuring food security, clean water and sanitation, ecosystems conservation and restoration can only be achieved by addressing climate change issues (Capitani et al., 2018; Lewis et al., 2018). Land, water, energy and climate are key inputs of the food production system. Rapid population growth, deforestation, overgrazing, over-cultivation and bush fires have exacerbated the impacts of climate change on mountain agro-pastoral systems.

In Cameroon, cattle rearing is an important economic activity. It is prominent in the Northern regions and in the North West Region where it is a source of livelihoods to more 5,041 households (Manu et al., 2014). According to Nyuyumenka (2015), traditional grazing dominated and still does, with more than 95% of Mbororo Fulani practicing extensive grazing that depends solely on natural pasture.

The state of the environment has been shown to play a great role on the sustainability of cattle rearing. According to Tamufor et al. (2017), sustainable cattle herding demands adaptation to the stressful environment, the conservation of ecosystems and biodiversity. Atanga (2013), noted that soils of the region are progressively degrading due to overgrazing, invasion of pastoral lands by noxious plants and others. Consequently, the environment is becoming unsuitable for pastoral nomadism

and herders are diversifying their livelihood sources. According to Pelican (2008), the Mbororo in the Cameroon Grassfields are agro-pastoralists. While most families complement cattle husbandry with subsistence agriculture, they first and foremost understand themselves as cattle pastoralists. As an adaptation to nomadic pastoral crisis, transhumance has been adopted as an alternative form of rearing by the Mbororos. They move with their cattle seasonally between uplands and lowlands in search of pasture and water. The transhumance zone was carved by Presidential Decree No. 76/420 of the 1976, regulating the movement and exploitation of livestock in the country.

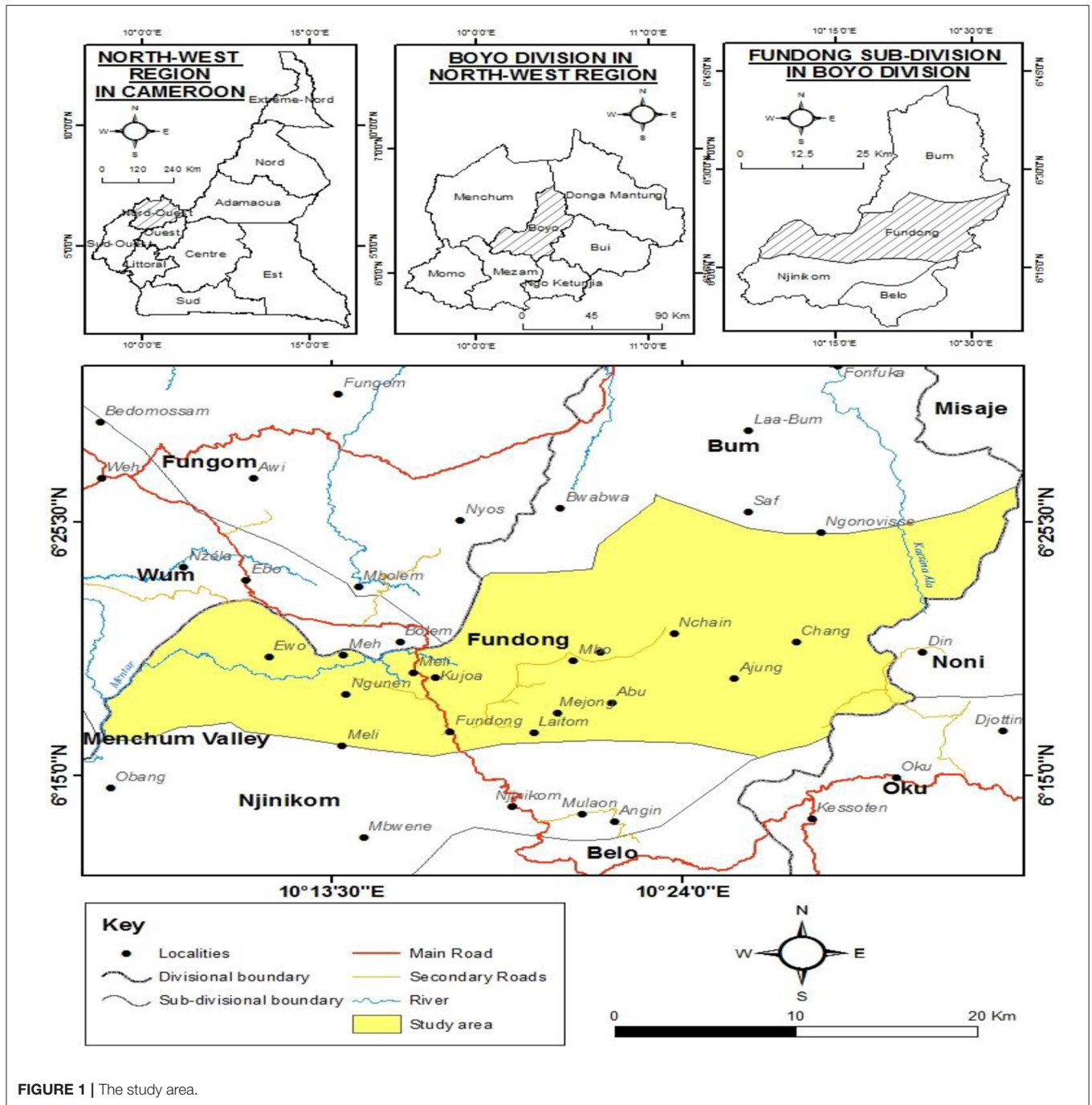
The Mbororo communities of the Kilum-Ijim mountain range have adopted a sedentary lifestyle. They have structured communities called Ardorates. However, they still have many challenges. The question of access to land resources by recently sedentarized pastoralists is a difficult one because their settlement is not only facilitated by available space; but most importantly by the attitude of native people (Ngalim, 2015). Climate variability and change have equally contributed in degrading their already fragile systems and increasing food insecurity. Many studies have singled out climate change as a crucial factor affecting agro-pastoral systems without establishing the nexus existing between climate and pastoral resources of land and water. This work thus makes a useful contribution in the understanding of the relationship that exists between land, water and food security in the context of global climate change.

## MATERIALS AND METHODS

### The Study Area

This study is carried out along the western flanks of the Kilum-Ijim Mountain range where pastoral activities are prominent. It falls precisely in the Fundong Subdivision, located between latitude 6°7' and 6°24' North of the Equator and between latitude 10°41' and 10°31' East of the Greenwich Meridian. It is bounded in the East by the Chiefdoms of Oku, Babanki and Babungo to the South, Bafemen to the North, Beba-Befang to the North-West and Bafut in the West. Prominent here is Mount Oku (3,011 m) which is the highest point along the Kilum Ijim range (**Figure 1**). The land covers total surface area of 1,592 km<sup>2</sup> comprising the Kom, the Bums and Mbororo or Fulani community with a population estimated at 45,831 inhabitants (BUCREP, 2005). The settlement of Mbororos amongst these native communities have been received with mixed feelings. They occupied hilly slopes and other marginal lands whose agricultural productivity was low. This exposes them to risks of environmental degradation, including climate change.

On the temporal scale, this work covers the period from 1960 till present. The year 1960 marked the beginning of actual sedentarization of a majority of the Nomadic Mbororo pastoralist in this area. The sedentarization was accompanied by a diversification of activities and a change from pastoral to agro-pastoral activities. They contributed significantly in supplying food to their communities and to the native communities. Nevertheless, this change in activities reduced their chances of using traditional knowledge systems to produce food and cope with the changing climate. Limited access to resources such



as land and water and discrimination suffered by Mbororos from the native populations have given rise to what was termed “the Mbororo problem” in the North West region of Cameroon. Given that climate change adaptation demands equitable distribution of natural resources, it was thus interesting to study food production systems within these resource-poor communities, the impacts of climate variability on the already stressed resources and the coping options implemented across households and institutions.

### Methods of Data Collection and Analysis

This study adopted a cross sectional approach in data collection. Qualitative and quantitative data was collected from primary and secondary sources. Primary data was collected using questionnaires and interviews. Using a simple random sampling technique, the sample was computed at 95% confidence level, with a 0.05% error margin using the formula;

$$n = N * [Z^{2*}p*(1 - p)/e^2] / [N - 1 + (Z^{2*}p*(1 - p)/e^2)] \quad (1)$$

**TABLE 1** | Distribution of questionnaires in villages.

Villages	Number Households	Number of Questionnaires	Percentages
Mentang 2 Ardorate	800	35	10%
Meli	500	20	5.7%
Mbam 1	300	15	4.2%
Mbam 2	350	20	5.7%
Mentang 1 Ardorate	900	35	10%
Bolam	450	26	7.4%
Aduck	420	25	7.1%
Ijim 1	500	20	5.7%
Ijim 2	350	15	4.2%
Achian	850	34	9.7%
Fundong Center	730	30	8.6%
Fujua	400	30	8.6%
Ngwah	300	15	4.2%
Anchangne	650	30	8.6%
Total	7500	350	100%

Source: Fieldwork (2019).

where;  $N$  = Population size,  $Z$  = Critical value of the normal distribution at the required confidence level,  $p$  = Sample proportion,  $e$  = Margin of error.

This computation gave an adjusted sample size of 350 households. Questionnaires were administered randomly in 14 villages (Table 1). The number administered in each village varied proportionally with the number of households. The use of a household questionnaire permitted to get data from pastoralist since there is no official data base and equally appreciate practices carried out at individual levels.

Table 1 shows that the number of questionnaires per village was proportionate to the number of Mbororo households in each village. The highest numbers were administered in Fundong Center (8.6%), the Ardorates of Mentang 1 and 2 (10%), Fujua and Anchange (8.6%). Interviews were conducted with the Ardos of Mentang 1 and 2, Ardos of Ijim 1 and 2 and that of Achian. The Divisional Delegate of Livestock for Fundong, the Mayor for Fundong Council and some quarters heads. These provided information that could not be gotten through questionnaires. Field visits were carried out during periods marking important activities that affect pastoral life such as transhumance period, beginning of rainy season, beginning of crop farming. These periodic visits permitted us to take photographs of some activities, see state of infrastructures and appreciate the difficulties encountered by pastoralists. Archives of the Fundong Council and MOSCUDA Archives were consulted. *In-situ* climatic data was collected from Divisional Delegation of Agriculture and rural Development.

Data collected was treated and analyzed quantitatively and qualitatively. Questionnaires were treated in SPSS while interviews were treated using thematic and content analysis. Climate data set was smoothened using five-year moving averages in order to correct extremes and

reduce observation errors. Variability was computed using coefficient of variations (CV) while climatic variability trends were established using rainfall anomaly index. Interviews were transcribed and analyzed using thematic and content analysis. The relationship between environmental factors and pastoral resources was established using a linear regression function and coefficient of determinations to get the proportion of other variables (human factors). Environmental factors were entered as a predictor of degrading pastoral resources and the independent variable used to explain the outcome variable.

## PRESENTATION OF RESULTS AND ANALYSIS

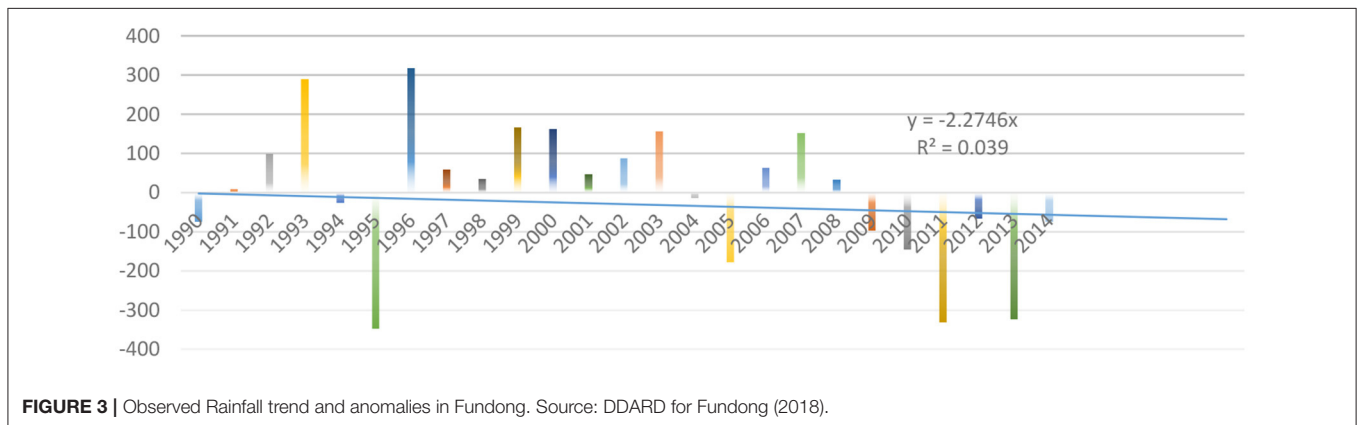
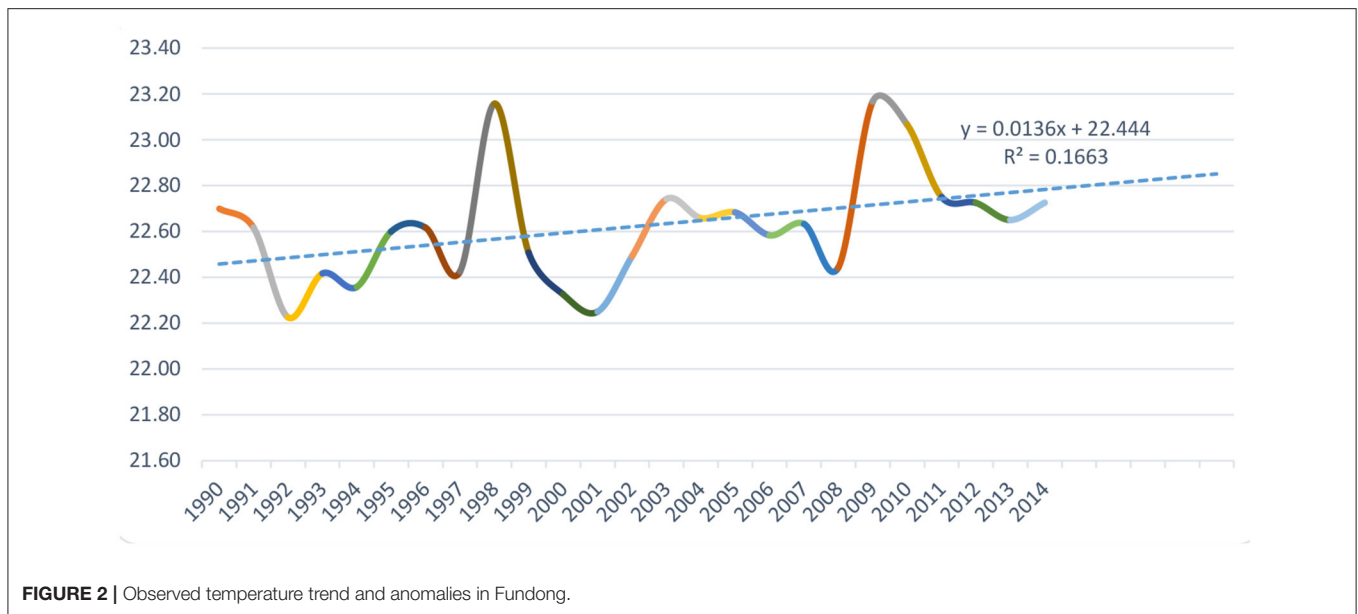
### Identification of Climatic and Non-climatic Stressors on the Agro-Pastoral System

Fundong Subdivision is located in the Western Highlands of Cameroon with a humid tropical climate. It has two main seasons, a long rainy season (8 months, from mid-march to mid-November and short dry season that lasts for 4 months). Seasons are regulated by the shifting of the Inter-Tropical Convergence Zone (ITCZ) due to trade winds. Generally, the region receives heavy rainfall ranging from 2,000 to 2,500 mm per annum. The great variations in slope has put in place a mountain climate conducive for pasture growth and for the cultivation of market garden crops.

Daily temperatures range from 15°C to 38°C with an annual average temperature of about 20°C. The mountain slopes are generally cold, windy and wet. The presence of the Kilum-Ijim mountain range has equally led to temperature modifications as there is a systematic reduction in temperatures as we ascend the mountain slopes. This cool climatic conditions have made the area free from tse-tse flies, thus favoring cattle breeding. However, climate variability and change are compromising this comparative advantage.

Climate variability in this area is characterized by a coefficient of variation (CV) of 14% for mean annual temperatures and 21% for annual rainfall amounts. These CV values are below the threshold of 30% for tropical regions and shows that rainfall and temperature are reliable for agro-pastoral activities. However, corresponding trends indicate that global temperatures are rising while rainfall has been reducing over the last few decades. Significant anomalous scenarios have been established over the time series and data sets (Figures 2, 3).

Temperatures have been rising with positive and negative anomalies ranging from +0.5°C and -0.4°C, around the annual mean of 26.24°C. In the same light, rainfall have been fluctuating significantly around the mean annual amount of 1969.226 mm. Positive anomalies go up to +300 mm while negative anomalies go beyond -320 mm. Positive anomalies signify periods of more water supply while negative anomalies are periods of water shortages. The frequency and intensity of extreme events, especially dry spells have been exacerbated. These climatic aberrations have compromised the reliability nature of rainfall with implications on water and pastures.



### Reduction in Grazing Land and Overgrazing

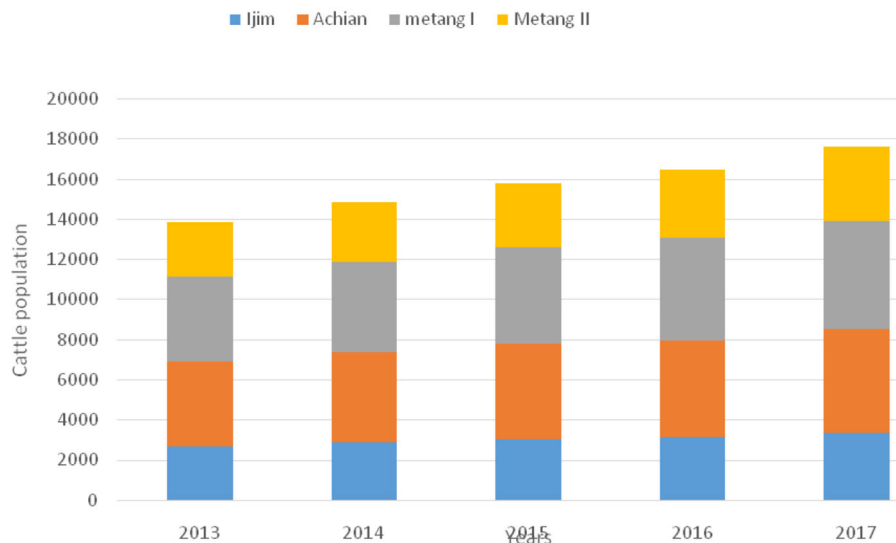
A greater proportion of rearers in this area use the traditional method of cattle grazing which is characterized by overgrazing and pasture degradation. The natural pasture lands are rapidly reducing in quality and quantity while the cattle population is on the rise. This has resulted to over concentration of cattle over the reducing grassland, which is already affected by climate change and other anthropogenic factors. The first cause of this overgrazing is attributed to an increase in cattle population without a corresponding increase in grazing land (Figure 4).

Figure 4 shows that the cattle population have been increasing steadily from 2013 to 2017 in the main grazing zones or Ardorates of Ijim, Achian, Metang I and Metang II. The implications of such an increase on pastoral resources are seen when we evaluate the carrying capacity of each grazing zone. The computation of the carrying capacity shows that with the present scenario, the carrying capacity of grazing lands have been superseded, leading to pasture degradation, both in quality and quantity.

Considering, the relationship between cattle numbers and grazing zones, the cattle density have been determined for each grazing zone (Table 2).

Table 1 shows that cattle densities or carrying capacities varies from one zone to the other. The differences are obvious because the surface areas and the cattle populations are not the same. According to the Divisional Delegation of Livestocks, Fisheries and Animal Husbandry, the normal carrying capacity for Fundong area is two cattle per hectare of grazing land. However, statistics from the table above shows that some grazing zones had more than their carrying capacity (Figure 5).

Figure 5 depicts that two zones, Ijim and Metang II have carrying capacities above the authorized number of two cattle per hectare. The implications of this is that the pasture lands are degrading rapidly as well as other resources such as water. Equally, as the number of cattle population increases, there is a corresponding increase pressure on land and resources resulting to overgrazing and the acceleration of conflict between the



**FIGURE 4** | Evolution in cattle population in the main grazing zones. Source: Generated from Field Data (2020).

pastoralists themselves and the agriculturalist on the other hand because of the reduction in surface land and infertility of the soil.

### Pasture Degradation and Shrinking Water Courses

Mbororo pastoralists along the Kilum Ijim slopes depend on natural pasture to feed their cattle. The growth of pasture on the dry and hilly slopes is conditioned by the onset and duration of the rainy season. However, field surveys demonstrated that the sporadic and unreliable rainfall pattern, with increasing frequency of dry spells have negatively affected the growth of pasture. The quantity and quality of pastures have been reducing over the years, forcing herders to move over long distances in search of fresh pasture or go on transhumance. **Figure 6** shows the poor pasture quality in the grazing zones and a shrinking river course.

In **Figure 6A** shows a completely dry landscape with poor pastures. Cattle cannot feed properly on such grazing lands and given that their carrying capacities have been exceeded, the landscape is gradually being transformed into a bare and unproductive area. **Figure 6B** on the other hand shows a shrinking river course. Cattle have to go into the river bed to be able to drink water. Amongst the factors responsible for such rapid degradation is climate change as ascertain by Mr Ali in the following excerpt.

“...some years back, we use to have fresh grass all over and enough water to feed our animals. We do not understand what is happening any more, the sun has become too intense and rainfall has reduced. The grazing lands have become drier because there is no rain water to make pastures grow normally. Some fields in Achian have completely dried off and grass do not grow on it any longer. Cattle drink a lot of water on daily basis, now that rivers are drying due to too much sun too, our activity will be affected badly...”

This excerpt captured from a discussion with a herder in Fundong testifies the perceptions of the Mbororos on the effects of climate change on pasture lands. The degradation of pastures which is attributed equally to overgrazing has been exacerbated by rainfall irregularities and dry spells. The consequences of this have been the drying up of pasture lands and a reduction in grazing zones. The dependence of Mbororo pastoralists on natural pastures have limited their coping options as transhumance corridors are equally affected. The conquest for new grazing zones have resulted to encroachment into farming zones, causing agro-pastoral conflicts. The outcome has been a fall in cattle and milk production and food insecurity.

### Encroachments Into Grazing Zones and Farmer-Herder Conflicts

The native Kom population are mostly crop farmers with only a few involved in cattle rearing. The fast growing native population and the desire to increase food production have led to the expansion of farms into mountain slopes and into grazing lands. The cold mountain climate favors the cultivation of market gardening crops such as Irish potatoes and vegetables. As such areas that were meant for cattle rearing have entered into competition with crop farming (**Figure 6D**).

**Figure 6D** depicts the encroachment of farms into grazing lands. These farms are mostly owned by the native population who usually discriminate against the minority Mbororos especially on land ownership. The portions of the grazing zones scrambled over by farmers are usually the lowlying zones with fertile soils that supports pasture growth. In such scenarios, the Mbororo herders are forced to carry their cattle to the hilly slopes with less pasture and a rugged terrain that makes cattle movement difficult. The agro-pastoral code is not respected in this area which is gradually becoming a mixed farming zone. The Mbororos themselves are getting sedentarized in Fundong

**TABLE 2** | Determining carrying capacity per grazing zones.

<b>Ijim ardorate</b>					
years	2013	2014	2015	2016	2017
cattle population	2668	2855	3014	3160	3340
grazing land	878.6	878.6	878.6	878.6	879.6
cattle density	3	3	3	4	4
average density	3.42 cattle/hactare				
<b>Achian ardorate</b>					
years	2013	2014	2015	2016	2017
cattle population	4241	4543	4771	4980	5172
grazing land	3953.9	3953.9	3953.9	3953.9	3953.9
cattle density	1	1	1	1	1
average density	1.2 cattle/hactare				
<b>Metang i ardorate</b>					
years	2013	2014	2015	2016	2017
cattle population	4237	4494	4810	5143	5434
grazing land	2635.7	2635.7	2635.7	2635.7	2635.7
cattle density	2	2	2	2	2
average density	1.83 cattle/hactare				
<b>Metang ii ardorate</b>					
years	2013	2014	2015	2016	2017
cattle population	2749	2976	3211	3434	3672
grazing land	1317.9	1317.9	1317.9	1317.9	1317.9
cattle density	2	2	2	3	3
average density	2.44 cattle/hactare				
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cattle density	2	2	2	3	3
average density	2.44 cattle/hactare				

Source: Computed from Field Data (2020).

with well-structured and organized traditional systems called the Ardorats. A good of them have equally adopted crop cultivation as a means of livelihoods.

The effects of encroachment into grazing lands have been a source of frequent conflicts between rearers and crop farmers. Cattle in search for pasture and water gets into farms and destroy crops and the reaction of farmers toward such destruction have been violent in some cases. Although there is an agro-pastoral commission in MBOSCUDA that work together to ensure a peaceful resolution of conflicts between farmers and herders, the situation on the field is still deplorable. Many attacks of the local population on cattle have been reported and many court cases are on-going. In an interview with Mr Aliyu, a Mbororo youth leader, he had the following to say;

“.....land acquisition and ownership is a serious problem with us. Our parents have been settled here for many years but they still consider us as strangers. The native population feel they have more rights over grazing land than us.....”

This excerpt raises the problem of land management and governance. The system of land acquisition and distribution in Fundong Subdivision reflects the land tenure system of the Western Highland which is an indicative of the customs of the people. The tenure system in the entire Kom Highlands gives

ownership of land to the Fon. The Fon’s titular ownership of land is recognized and expressed in a number of ways. The land could be donated to a stranger by the village or lineage head but with the approval of the Fon. Grazing land was to be demarcated and left at the disposal of the Fulani cattle graziers, under the control of the Ardos (the Mbororo traditional ruler) by the Fon and the administrative authorities. The Ardos could then distribute the land to other herders. However, many Mbororos still feel discriminated upon as far as this traditional tenure system is concerned.

## IMPLICATIONS OF ENVIRONMENTAL STRESSORS ON AGRO-PASTORAL RESOURCES AND FOOD PRODUCTION

### The Regression Model

The relationship between climatic stressors and agro-pastoral resources was determined using a regression function and the model summary has been presented on **Table 2**:

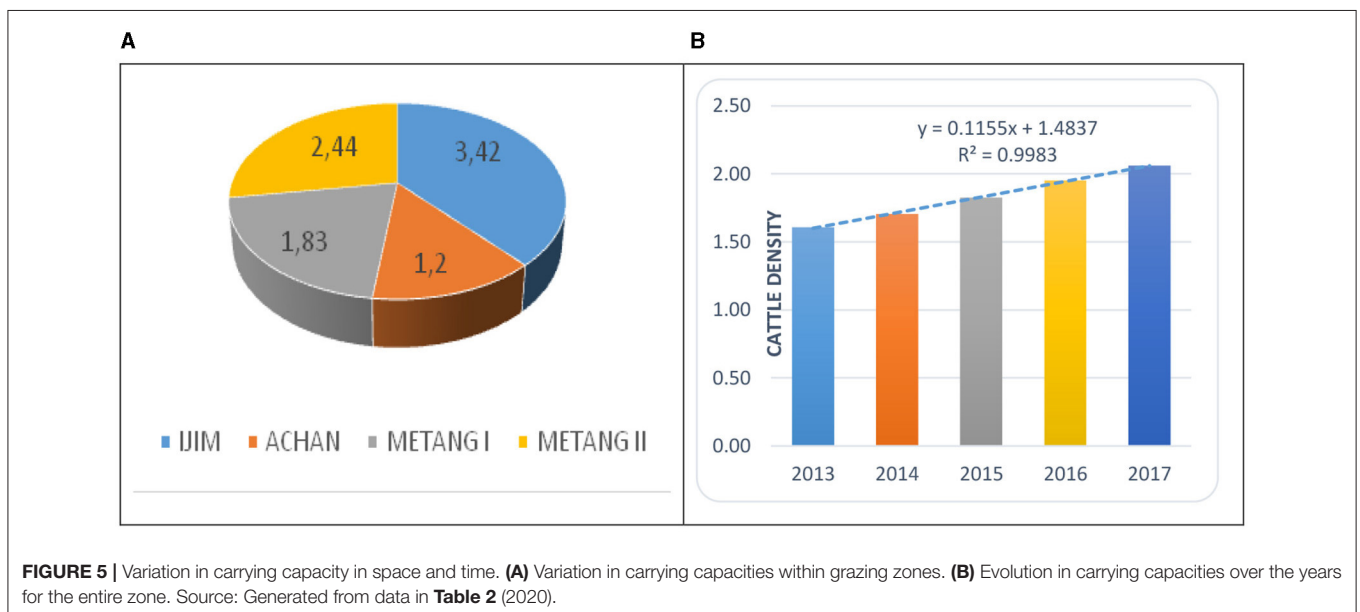
From **Table 3**, environmental factors were entered as a predictor of degrading pastoral resources and the independent variable explained the outcome variable at  $R = 0.787$ ;  $R^2 = 0.623$ ;  $\Delta R^2 = 0.622$ ;  $p < 0.01$ . From the analysis it is evident that

**TABLE 3** | Predicting sedentary tendency among Mbororo Nomads.

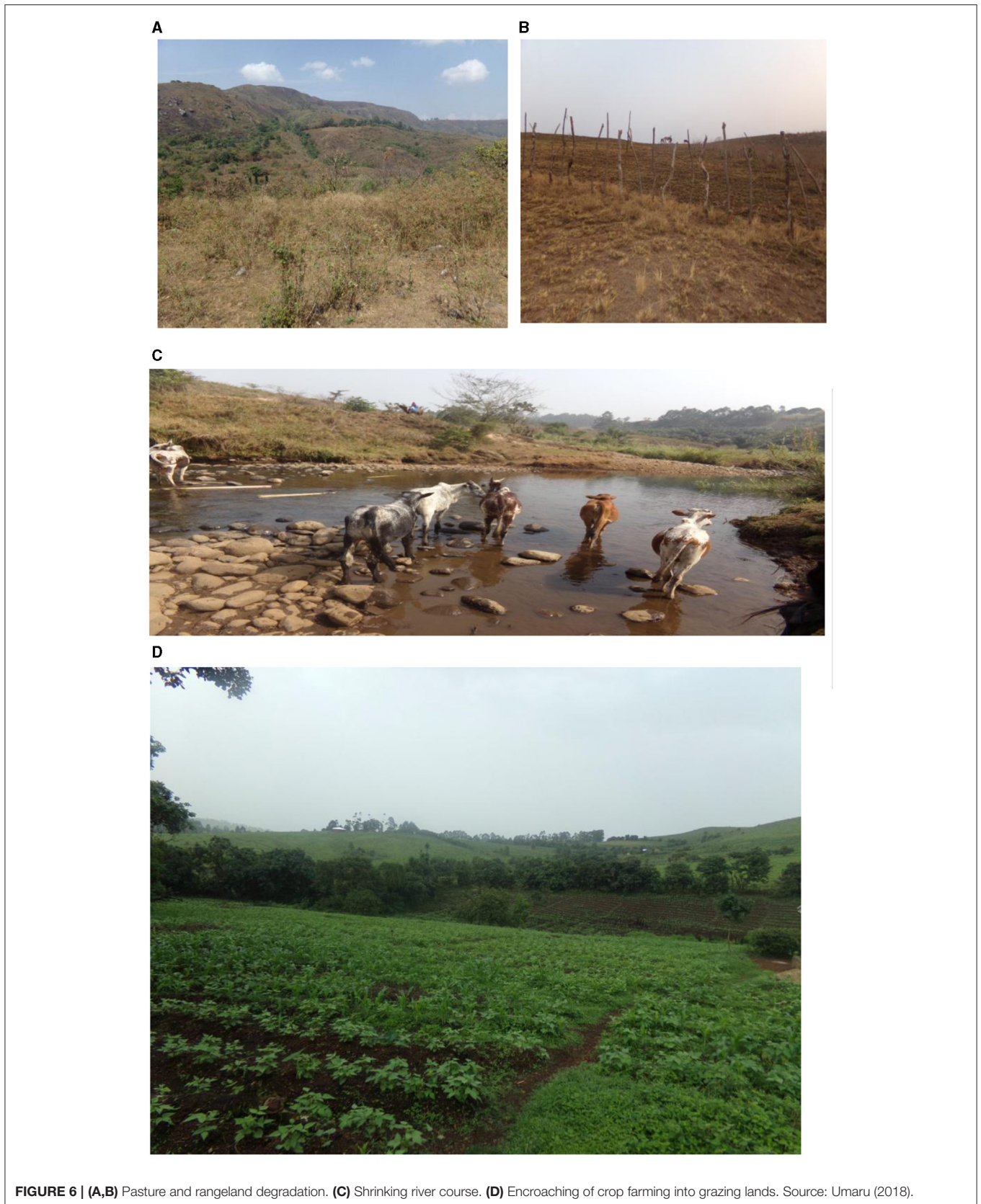
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					RSquare Change	F Change	df1	df2	Sig. F Change	
1	0.789 <sup>a</sup>	0.623	0.622	5.41092	0.623	359.05	1	217	0.000	1.720

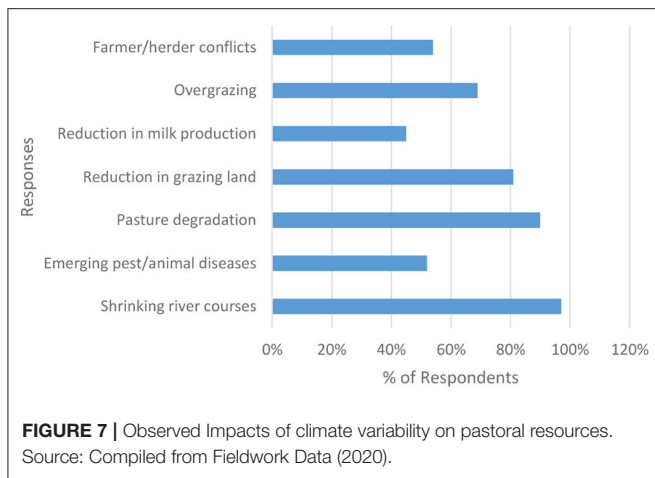
<sup>a</sup>Predictors: (Constant), Environmental stressors.

<sup>b</sup>Dependent Variable, agro-pastoral resources.









environmental stressors, including climate change were able to predict 62.3% of the variation in the independent variable.

This implies that climatic stressors, including climate variability and change could predict the changes in pastoral resources at 62.3%. This corroborates with herders observations as they identified a number of observable landmark consequences on the rangeland. Though at different degrees, the impacts are related to pasture degradation and water shortages with associated impacts (Figure 7).

From Figure 7, pastoralists were unanimous to the fact that river courses are shrinking and affecting water demands for cattle (97%) while pasture degradation to environmental and human stressors was acknowledged by 86% of the study population. The dependence of pastoralists on natural and shrinking water sources have led to congestion and conflicts amongst herders. The warming climatic conditions upslope have favored the emergence of animal pests and diseases. Despite possibilities to constantly vaccinate cattle and treat grazing lands, the costs are very high and the already resource-poor population cannot afford.

## Implications of Environmental Stressors on Livelihood Sources and Food Production

Climate change has been shown to have affected the natural resource base for the production of food and provision of income in the Mbororo communities. The performance of agro-pastoral systems is determined by the availability of land, water and energy, which are already hit hard by climatic aberrations. The following excerpt shows the weight of climate change on food production and social systems;

“.....we depend on cattle rearing to feed our families. For the past 5 years, my cattle have been reducing because grazing land is reducing too. It is difficult for me to feed my family and my two sons have gone to Bamenda town to look for jobs. I told them that cattle rearing alone could no longer satisfy our needs.....”

This excerpt from an interview with Mr Ibrahim, a family head and a pastoralists clearly demonstrates the inability of pastoral

systems to ensure a steady food supply within the context of climate change. It is evident that the sustainability of their livelihoods entails a livelihood diversification as land is inelastic. Food security entails not only quantity but quality as well. The shrinking water sources get constantly polluted, the poor quality of pasture, the long distance movements to get pasture have reduced the quality of cattle products.

Findings equally revealed that thunder storms and lightning have increased in frequency with drastic consequence on the rearing of animals especially cattle. Each year especially during sudden and short-duration intensive rainfall accompanied by thunder and lightning, animals especially cattle and horses are killed. This have become frequent on the slopes of Kilum Ijim and herders attributes it to the changing rainfall pattern. It should be noted that the primary source of Mbororo income is the sale of animal and their products such as milk, butter and meat. The dependence on cattle for food and income has made the dependency ratio very high. The Mbororo culture does not allow women to take formal jobs and this has limited their ability to contribute in sustaining their families.

Women and children concentrate on animal milking and the sale of products such as butter. The reduction in grazing land and in cattle population has seriously led to a reduction in milk production which is an important sources of food for the Mbororos. It was revealed that the purchasing power of the Mbororo is reducing significantly but the numbers of persons to feed are increasing rapidly. The reduction in cattle heads due to fast rate of reduction on grazing land, climate change, and animal diseases are responsible for food insecurity within the Mbororo communities.

The adoption of an alliance system of farming introduced by MBOSCUDA has permitted Mbororo women to embark on crop cultivation. They cultivate maize, beans, Irish potatoes and vegetables for home consumption and for the market. Nevertheless, this activity have not yet yielded the required fruits as land ownership is a problem. Climate change especially rainfall variability has disrupted the cropping calendar and led to many crop failures in the area. The Mbororos equally lack entrepreneur skills to diversify their livelihood sources and this has led to food insecurity and poor diets.

## MEASURES TO CURB THE EFFECTS OF CLIMATE VARIABILITY ON PASTORAL RESOURCES AND IMPROVE FOOD PRODUCTION

Efforts have been by the local authorities and the Mbororo community in Fundong to improve on the management of agro-pastoral resources (water and land) in the context of climate change.

### Rangeland and Pasture Management

Adaptation to climate variability and change requires proper land management systems and good governance. Cattle rearing and rangeland management in Cameroon are regulated mainly by Decree No 76/420 of 14 September 1976, modified by Decree

No 86/755 24 of June 1986. According to Articles 1 and 2 of Decree No 76/420, animal grazing is free on all grazing land of the Country, but the Minister of livestock can limit grazing in some specified grazing land especially in case of a disease outbreak. There are also laws regulating pastoral resources with the primary issue in considering changes toward individualized tenure being equity, not efficiency. Questions such as how should “land” be divided among pastoralists (groups of pastoralists), or between pastoralists and non-pastoralists? are tackled.

Farming and grazing lands are managed by the land consultative board and the agro-pastoral commission. The agro-pastoral commission allocates and demarcates farmlands and grazing lands in rural areas according to the needs of the population as well as development needs, defines conditions for the use of a mixed farming zone, examines and settles farmer-herder conflicts. However, the functioning of this commission has problems. Mbororos are underrepresented and discriminated upon when critical decisions are being taken. This has kept them in a minority situation thereby limiting their efforts in climate change adaptation.

In the domain of pasture management, pastoralists have adopted alternative and environmentally friendly methods of rearing. Transhumant pastoralism which is widely practiced in the area has considerably reduced the rate of rangeland and pasture degradation. Modern methods of rearing such as ranching have been introduced in the area and adopted by herders. For instance, paddocking form of rearing and the planting of improved pasture species have been introduced in the Mentangl Ardorat (Figure 8).

Field investigations revealed that apart from climate change adaptation, the disadvantages of a nomadic lifestyle coupled with the important role played by NGOs and MBOSCUA in this area have encouraged many herders to adopt ranching as a method of rearing. Herders reported that this method has increased the rate of pasture degradation and improved on the quality of cattle and milk produced. The improved grazing land have a high carrying capacity as many animals can be fed over a small surface area of grazing land. The advantage of these grazing land is that they are used during periods of pasture shortages and also, during transhumance. The young cattle or the ones that are not able to move over long distances are grazed on these planted pasture fields. The animals can stay and feed here for a period of over two months. The effects of dry spells are less felt by such improved pasture species.

## Improved Water Management

Water is one of most important pastoral resources that is vulnerable to the vagaries of weather. The failure of rain-fed systems due to climate variability and change have negatively affected food production. Mbororo communities depended on shrinking streams and natural sources for potable water and for water to feed their animals. Recently, efforts have been made by MBOSCUA and the Fundong

council in order to provide these facilities to the people (Figure 9).

As established earlier, climate variability and change have led to a reduction in water resources. Improving water supply is an important element of climate change adaptation in nomadic communities all over the Fundong Subdivision. With water shortages, herders moved over long distances in search for water and pasture, especially in the dry season. Now, the availability of these water points have reduced movements and encouraged production during water stressed periods. Field surveys revealed that most of these water supply points are treated by the veterinary services, making them void of animal diseases.

## DISCUSSIONS

### Climate Change, Land, Water and Food Production Nexus

“.....climate change creates additional stresses on land, exacerbating existing risks to livelihoods, biodiversity, human and ecosystem health, infrastructure, and food systems (high confidence). Some regions will face higher risks, while some regions will face risks previously not anticipated (high confidence). Cascading risks with impacts on multiple systems and sectors also vary across regions (high confidence).”  
IPCC, 2019

This extraction from the IPCC (2019) special report on climate change, desertification, land degradation, sustainable land management, food security and greenhouse gas fluxes in terrestrial ecosystems stands tall to demonstrate the effects of climate change on land and food production systems. Land is an indispensable resource for food production by agro-pastoral systems and its inelastic nature has made it vulnerable to degradation with a lot of risks associated. The Mbororo pastoral communities along the Kilum Ijim mountain slopes live in a fragile ecosystems and climate variability and change have increased the stress on pastures and increased the risks on their food production systems and incomes.

Rangeland and pasture degradation in the grazing fields of Fundong are attributed to increasing population pressure and overgrazing. The carrying capacities of grazing zones are exceeded leading to greater risks. This work has pointed out the fact that the rapid degradation of pasture lands have led to a fall in cattle production. The land crisis among the Mbororo communities who already feel discriminated upon have exacerbated the impacts resulting from the vagaries of weather. Rainfall has become unreliable and the frequency and intensity of dry spells are increasing with marked repercussions on food production systems. These findings corroborates with the works of Lemma et al. (2013), Herrero et al. (2016) and Krätli et al. (2020).

According to FAO (2014), climate variability and change have reduced the productivity of farm lands thereby affecting small scale farmers negatively. The intensity of risks associated to land degradation to climate change have been aggravated by population pressure on already stressed resources as well



**FIGURE 8** | Ranching and improved pastures in Mentang 1 Ardorat. **(A)** Ranching in Mentang. **(B)** Cultivated improved pasture species. Source: Umaru (2018).



**FIGURE 9** | Water supply for livestock production in Achain Ardorat. **(A)** Water reservoir(tank). **(B)** Cattle drinking point. Source: Umaru (2018).

as the low adaptive capacities of farmers (IPCC, 2019). Pastoralists of the Kilum Ijim Mountain have less adaptation options and limited access to land. Their over-dependence on cattle rearing have made them vulnerable to risks of foods shortages as their source of livelihood is threatened by the impacts of climate change. Land availability is necessary for proper adaptation and it is revealed that climate change driven land degradation has led to a fall in food crop production, meat, milk and butter which are the main stay of agro-pastoralists communities.

Agro-pastoral systems in the Western highlands of Cameroon in general are rain-fed. The productivity of land depends on the availability of water, either for plant (pasture) growth or for livestock. Water for crop production and pasture growth comes from rainfall while livestock drink water from rain-fed streams. It has been established that streams and natural water sources have been shrinking due to rainfall variability and dry spells. Recently, herders have been moving over long distances to get water for their animals with a lot of risk. Attacks by tse-tse flies, cattle

theft, conflicts between herders over water sources are some of the problems resulting from long distant search for water sources. The consequence has been a reduction in the quality of products and a general fall in food production. Many studies have reported food insecurity among pastoralists such as FAO (2014, 2015) and Capitani et al. (2018).

Climate driven land degradation and water scarcity have increased the risk of food insecurity.

“....Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.....” FAO (2018)

Climate variability and change have reduced the ability of communities to be food secured. It is established that the achievement of sustainable development goals and the fight against poverty and hunger cannot be effective without a proper climate change adaptation strategy. This work thus contributes in

revealing the state of exposure to the risk of poverty and hunger within a minority community with limited access to pastoral resources of land and water.

## Land and Water Management for Pastoral Resources

Pastoralists and stakeholders in the agro-pastoral sector of the Western Highlands of Cameroon have been making efforts to ensure the sustainable management of agro-pastoral resources (Azuhwi et al., 2017). The increasing population and rising pressure on diminishing resources have prompted autonomous and planned actions. Along the Kilum Ijim Mountain slopes, more the 70% of Mbororo communities have adopted transhumant pastoralism as means of cattle rearing so as to reduce pressure on pasture lands. Another lesser majority carry out ranching and planting of improved pasture species to supplement the natural pastures. These efforts have been carried out by other pastoralists' communities in Africa as reported by Eriksen et al. (2011) and Aida et al. (2018). For water resources, the Fundong council have provided potable water to Mbororo communities. Cattle water drinking points have been constructed in some Ardorats such as Achain and this has reduced pressure on natural sources. Intervention of NGOs such as HIEFER International and MBOSCUA have been accompanying the Mbororo communities in their efforts to improve on their livelihoods.

The Cameroon legislature is sound and clear on issues regarding the management of farming and grazing lands. The presidential Decree No 76/420 of 14 September 1976, modified by Decree No 86/755 24 June 1986 provides for the formation of a pastoral commission in each grazing area that ensures the allocation and management of land and the settlement of farmer-herder conflicts. Nevertheless, the Mbororos still suffer from discrimination and under-representation in such commissions (Pelican, 2012; Jabiru, 2017). In Fundong Subdivision, the traditional tenure system still dominates where the Fon of Kom has the full ownership of land. Land is given to the Mbororo communities through their Ardos who then redistribute to rearers. Despite efforts put in the domain of land management, Mbororo communities are not yet fully implicated in the management of pastoral resources and this has curbed their abilities to adapt and mitigate the efforts of climate change and environmental degradation. According to Nformi (2008), the capacity to adapt to new circumstances is very important to minority social groups if they must continue to survive. In the same light, Pelican (2008) opined that the patterns of interest within a particular social group continually evolve due to changing conditions, such as population pressure and the value of resources, so too would the customs and practices in relation to how the resources are managed have to evolve.

## Conclusions and Perspectives

This work set out to examine the link between climate change, land, water and food production within the Mbororo pastoralist communities in Fundong, situated along the slopes of the Kilum Ijim mountain range. The analysis of climatic data indicated that

rainfall has been fluctuating over time series but a decreasing trend while temperatures have been rising steadily over the last few decades. Pastoralists have reported an increased frequency of dry spells with greater negative anomalies in the rainy season. This climatic perturbations have exacerbated the degradation of land and pastures as well as the shrinking of water courses. Given that agro-pastoral systems in this area are rain-fed, production have been falling, affecting the livelihoods of the Mbororos negatively. Income sources and food supply systems are already compromised by climate change and environmental degradation because adaptation is limited. Faced with increasing food insecurity, efforts have been made the domain of land management and the provision of water to grazing zones. Nevertheless, this work has proven that more needs to be done. The Mbororos are still considered as strangers and discriminated upon by natives as far as land is concerned. It is common to hear natives say "...should a Mbororo own land in the same way they own cattle...?" Such statements portray the level of discrimination in a resource-degrading context which has prevented the Mbororos from adapting properly to the effects of climate change and ensuring a steady food supply system. The productivity of agro-pastoral systems requires an equitable distribution of pastoral resources and a good rangeland governance systems (Getachew et al., 2014). Cameroon has very good laws regulating the distribution and use of pastoral resources but their applicability needs to be improved upon. The bottom-top approach should be employed, the aspirations and capacities of Mbororos taken into consideration, climate change policies downscaled and incorporated into resource management systems and implementation and follow-up pastoral programs be upgraded.

Findings have shown that food security has a link with the production system in place. The agro-pastoral system includes the multiple environmental, socioeconomic and political elements that shape and are shaped by food production. Environmental stressors predicted degrading pastoral resources and the independent variable explained the outcome variable at  $R = 0.787$ ;  $R^2 = 0.623$ ;  $\Delta R^2 = 0.622$ ;  $p < 0.01$ . This implies that 62.3% of degradation is accounted for by environmental stressors. These elements, though with different intensity, work in interaction and understanding the impacts of climate change on pastoral resources require a collaborative approach. Local authorities in Fundong need to make provision for grazing land for the resource-poor Mbororo communities. Land tenure and ownership, including large land acquisitions (land grabbing) by Mbororo elites should be probe into and checked. Adaptation to climate change needs a well-structured resource base system and collaboration amongst actors. It is recommended that farmers, grazers, agricultural technology developers and climate scientists, local administrative and traditional authorities should work in a participatory way. This will help them to co-develop locally-appropriate climate-sensitive methods, build resilience and improve on food production. Further research should look at stakeholder participation, opportunities and constraints for effective management of resources within the context of climate change.

## DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary materials, further inquiries can be directed to the corresponding author/s.

## ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for

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## AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

**Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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