Chapter 6

Climate Change and Food Security in the Bamenda Highlands of Cameroon

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Introduction

Climate variability and change is a socio-ecological system which cannot be understood and evaluated by relying on physical sciences alone because its effects trickle down to the lowest level of society, particularly in rural communities (Tume and Tanyanyiwa 2018). This stems from the fact that rural communities rely on climate-sensitive sectors that include agriculture and other primary activities for their livelihoods. Climate variability and change has exacerbated food supply issues by impacting adversely on crop production, food security, and availability as well as crop distribution (Ericksen et al. 2010). With the shifting precipitation patterns and the rise of land and ocean surface temperatures by 0.65–1.06 °C between 1880 and 2012 (IPCC 2013), there has been a decrease in crop yields exacerbated by the shifting precipitation patterns and decreased crop yields that are expected with climate change which has pushed many developing countries to become increasingly dependent on food imports. At the same time, pressure to cultivate marginal land or use unsustainable cultivation practices may lead to increased land degradation (Biermann et al. 2016). Food and resource scarcity is particularly problematic in the developing world, which is heavily reliant upon local resources for day-to-day survival (Newbold 2010; Weeks 2008). Climate change could further jeopardize food crops and security as precipitation patterns shift and temperatures increase (Collier et al. 2008). On its own, climate change is estimated to increase the number of malnourished between 40 and 170 million globally. Even slight increases in temperature are expected to reduce crop yields, particularly in tropical latitudes, including sub-Saharan Africa (SSA) (Hasan et al. 2017).

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Extreme weather events such as droughts in some of the agroecological domain and floods in others are the main triggers of agrarian vulnerability in the sub-Saharan Africa (Mathews et al. 2014; Kinuthia et al. 2018). Unlike flooding, drought is a recurrent phenomenon in all the microclimatic environments though its onset is slow and imperceptible. There is an established consensus that climate is changing and impacting more negatively than positively on agricultural livelihood systems (Tume and Fogwe 2018). Frequent irregular onset of the rains complicates practices and the sustainability of such rain-fed agriculture in the Bamenda Highlands. Since the full implications of climate change for development are currently not clearly understood, the poor often cannot adopt diversification as an adaptive strategy because they have limited diversification options.

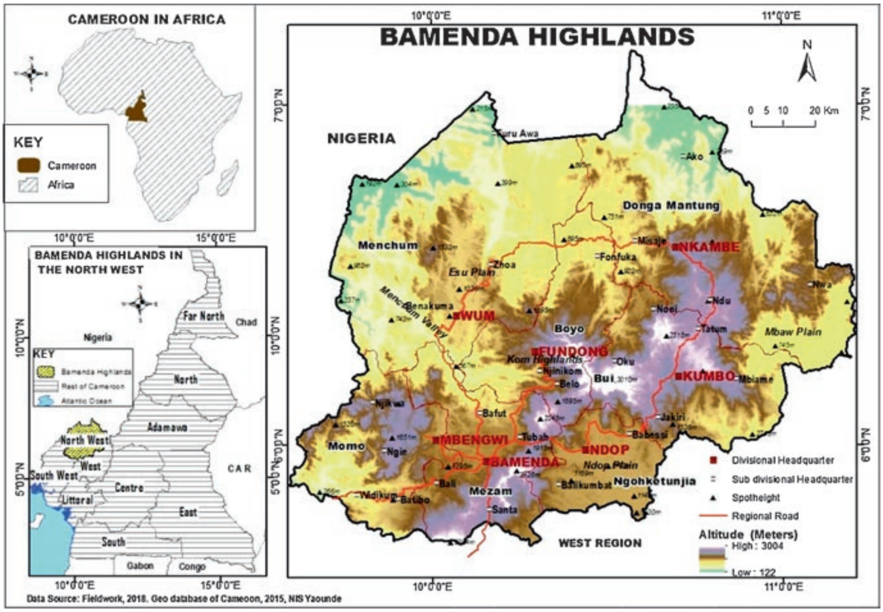
Agriculture contributes about 70% of the GDP of some sub-Saharan African (SSA) economies (Campbell et al. 2011). Climate variability is projected to reduce yields from rain-fed agriculture by up to 50% by 2020 in Africa (Campbell et al. 2011). Rain-fed lands account for more than 80% of global crop area and 60% of global food output but are especially susceptible to the impacts of climate change. In Cameroon, agriculture directly employs about 80% of the work force and more than 90% on some rural areas of the Bamenda Highlands of Cameroon (Tume and Fogwe 2018).

Study Area and Methods

The Bamenda Highlands is part of the Cameroon volcanic line (CVL) that is a mountainous landscape rising as high as Mount Oku (3011masl) cut across by a series of plains and extensive valleys (Fig. 6.1).

The geology of this highland is volcanic which acts as aquifers that directly determine the water supply to one of three agrarian production basins (Tume et al. 2018). The area has two seasons being the wet season from mid-March/April to October and the dry season from November to mid-March. This highland has microclimatic zones: cold, cloudy, and misty zone; cool misty zone; dominantly warm and wet climatic conditions; and variable conditions dominated by hot, wet, and sunny conditions. This microclimatic zonation aligns with the topography to constitute a blend of micro agroecological basins where climate change (long term) and variability (inter-annual, intra-annual) are major environmental challenges confronting crop production systems. These systems are part of the larger three agrodomains of the Bamenda Highlands which are:

- The low-altitude agroecological domain of less than 800 masl that extends on parts of Mezam, Donga Mantung, Bui, Boyo, Menchum, and Momo. The specific farming localities are Bafut, Ako, Nwa, Nvem, Belo, Njinikom, Menchum Valley, Fundong, Ngie, Njikwa, Widikum, and Batibo. The dominant fruits in these localities that are remarkably affected by climate change and vulnerabilities yet are fundamental to farmers' livelihoods are citrus, avocado, mango, pineapple, plum, guava, pawpaw, banana, and oil palm.



Data Source: Fieldwork, 2018. Geo database of Cameroon, 2015, NIS Yaounde

Fig. 6.1 Location of the Bamenda Highlands

- The mid-altitude agroecological domain lies between 800 and 1400 masl and extends on parts of Mezam, Ngoketunjia, Donga Mantung, Bui, Boyo, Menchum, and Momo. The specific farming localities are Tubah, Bafut, Bali, Bamenda Central, Babessi, Ndop, Balikumbat, Mbengwi, Batibo, Njikwa, Wum, Fungom, Fundong, Belo, Njinikom, Bum, Noni, Mbiame, Kumbo, Jakiri, Mesaje, and Nwa.
- The high-altitude agroecological domain above 1400 masl that extends on parts of Mezam, Donga Mantung, Bui, Boyo, and Momo. The specific farming localities are Santa, Batibo, Fundong, Belo, Njinikom, Oku, Noni, Kumbo, Nkambe, and Ndu.

In order to assess the effects of climate variability and change on food security, the rainfall parameter was considered for investigating climate variability and change. Rainfall data was collected from ten stations spread all over the Bamenda Highlands, namely, Ndu (62 years), Jakiri (58 years), Tubah (18 years), MbawNso (43 years), Takui (20 years), Santa (38 years), Bamenda (55 years), Ndop (29 years), Oku (33 years), and Belo (30 years). Rainfall data was treated using rainfall anomaly index (RAI). RAI, designed by van Rooy (1965), considers the rank of the precipitation values to calculate positive and negative precipitation anomalies. RAI positive and negative were calculated using the following equations:

$$RAI = +3\frac{RF - M_{RF}}{MH_{10} - M_{RF}} \text{(Positive anomalies)}$$

$$RAI = -3\frac{RF - M_{RF}}{ML_{10} - M_{RF}}\text{(Negative anomalies)}$$

where:

RAI = the rainfall anomaly index
RF = the rainfall for the year in question
M_{RF} = the mean actual annual rainfall for the total length of the period
MH_{10} and ML_{10} = the mean of ten highest and lowest values of rainfall (RF), respectively, of the period

RAI-normalized precipitation values are based on weather history at a particular location. The only input parameter is precipitation. It reflects droughts that impact agriculture, water resources, and other sectors. RAI is flexible in that it can be analyzed at various time scales (World Meteorological Organization-WMO 2016). It is easy to calculate, with a single input (precipitation) that can be analyzed on a monthly, seasonal, and annual time scales. For this study, the annual time scale is used. RAI classification ranges from ≥3.0 (extremely wet) to ≤ -3.00 (extremely dry) (Table 6.1). RAI is dimensionless.

These extreme conditions are not favorable for rain-fed tropical crop production because extreme wetness is associated with flooding that destroys agricultural land while extreme dry conditions are associated with severe water deficits that cannot support agricultural production. Positive anomalies have their values above the average, and negative anomalies have their values below the average. Trend lines were fitted on the anomaly graphs to show changes in climate.

Food crop data were collected for maize, solanum potato, and beans for Oku (1982–2018) and Ndu (2000–2018). Rice production data were collected for Obang (1983–2018) and Ndop (1977–2018). These datasets were treated in anomaly form to show positive and negative changes with respect to variable climatic conditions. Food crop data was complemented by 597 household questionnaires administered throughout the three agroecological zones that make up the Bamenda Highlands to capture farmers' perceptions of changes in crop output with respect to climate variability and change.

Table 6.1 RAI classification

RAI range	Class description
≥3.0	Extremely wet
2.00 to 2.99	Very wet
1.00 to 1.99	Moderately wet
0.50 to 0.99	Slightly wet
0.49 to –49	Near normal
–0.50 to -0.99	Slightly dry
-1.00 to -1.99	Moderately dry
-2.00 to -2.99	Very dry
≤ -3.00	Extremely dry

Source: van Rooy 1965

Results and Discussions

Climate Variability and Change in the Bamenda Highlands

Climate variability and change is a global challenge facing socioeconomic systems, health, livelihoods, and food and water security. Climate variability has significant impacts on agrarian systems, especially in developing countries, which are dominantly rain-fed production systems (Tume and Fogwe 2018). Several indices are used to assess climate variability, especially in the tropical agrarian systems, such that the increasing trend of RAI implies a decreasing rainfall. This index was analyzed for ten stations across the Bamenda Highlands. Eight of the stations (Ndu, Tubah, MbawNso, Santa, Bamenda, Ndop, Oku, and Belo) have an increasing RAI (Figs. 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8 and 6.9), while Jakiri has a relative constant RAI (Fig. 6.10), and that of Takui is decreasing (Fig. 6.11). A decreasing trend in RAI shows that rainfall is still reliable at this highland area.

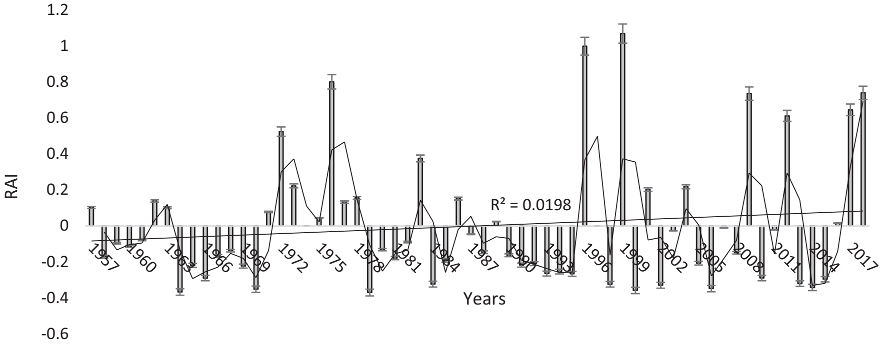


Fig. 6.2 Rainfall anomaly index for Ndu (1957–2018)

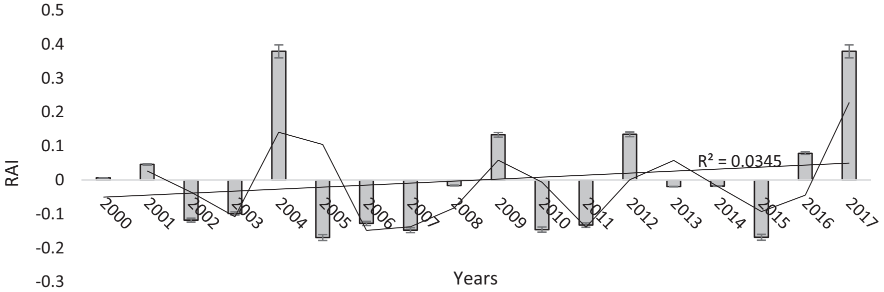


Fig. 6.3 Rainfall anomaly index for Tubah (2000–2017)

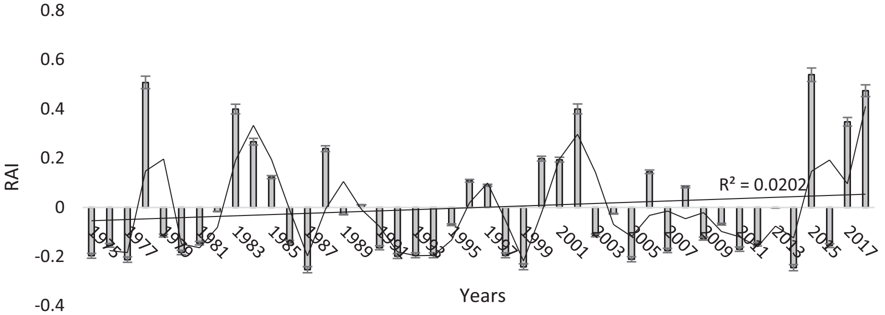


Fig. 6.4 Rainfall anomaly index for MbawNso (1975–2018)

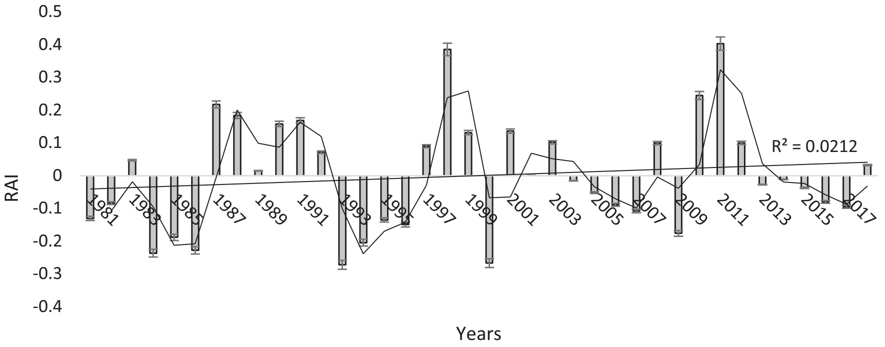


Fig. 6.5 Rainfall anomaly index for Santa (1981–2018)

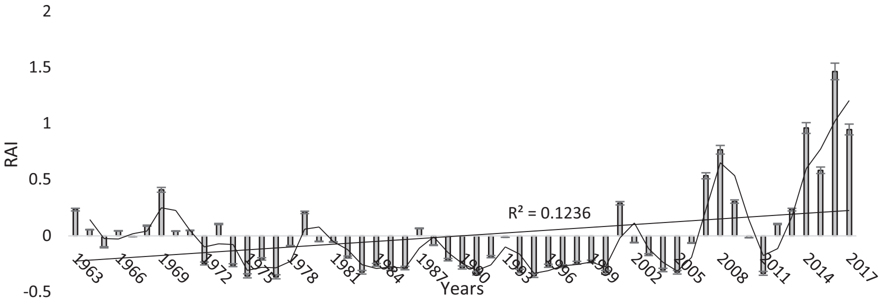


Fig. 6.6 Rainfall anomaly index for Bamenda (1963–2017)

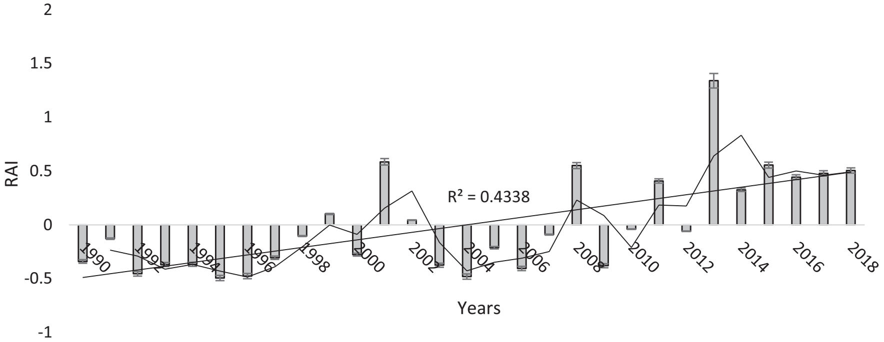


Fig. 6.7 Rainfall anomaly index for Ndop (1990–2018)

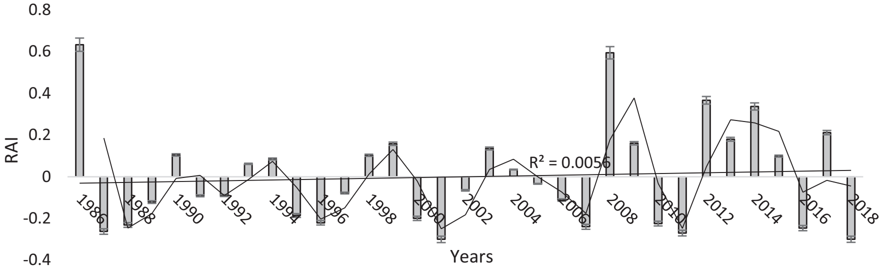


Fig. 6.8 Rainfall anomaly index for Oku (1986–2018)

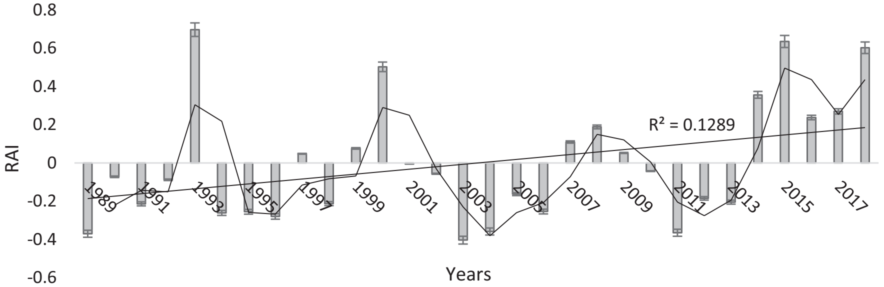


Fig. 6.9 Rainfall anomaly index for Belo (1989–2018)

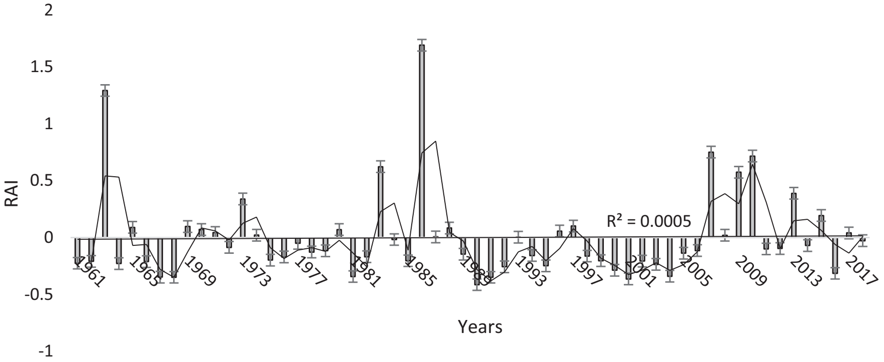


Fig. 6.10 Rainfall anomaly index for Jakiri (1961–2018)

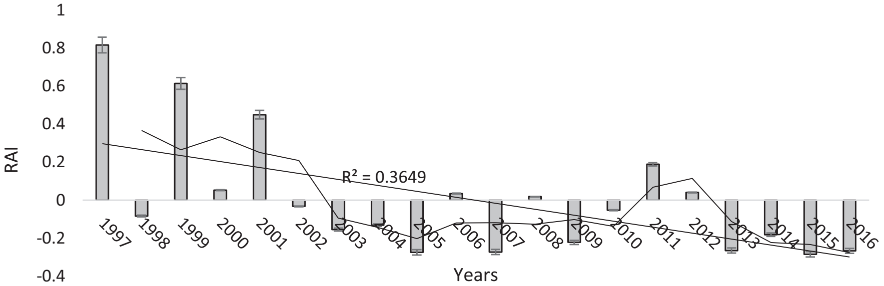


Fig. 6.11 Rainfall anomaly index for Takui (1997–2016)

In Ndu, which is located in the highland agroecological zone, the RAI ranges from -0.37 (near normal) to 1.07 (moderately wet conditions). The trend has been increasing.

In Tubah, located in the mid-latitude agroecological zone, RAI ranges from -0.17 to 0.38. These are near-normal conditions. Despite near-normal conditions, the trend has been increasing.

MbawNso, located in a lowland agroecological belt, has RAI values of -0.25 (near normal) to 0.54 (slightly wet). The trend has been increasing.

The Santa agrarian basin is located in the highland ecological belt. It has RAI values ranging from -0.27 (slightly dry) to 0.40 (near normal). The trend has been increasing.

Bamenda, located in the mid-latitude ecological belt, has RAI value of -0.37 (slightly dry) to moderately wet conditions. The trend has been increasing.

The Ndop plain is located in the lowland ecological zone, with RAI values ranging from -0.49 (slightly dry) to 1.34 (moderately wet). The trend has been increasing.

The highest altitude in the Bamenda Highlands is located in the Mount Oku region (≈3011 masl). RAI values here range from -0.29 near normal) to 0.63 (slightly wet). The trend has been increasing.

Belo is a highland ecological zone with RAI values ranging from 0.40 (near normal) to 0.7 (slightly wet). The trend has been increasing.

Jakiri has varied topography with lowland, mid-altitude, and highland ecological conditions. The RAI values range from -0.41 (near normal) to 1.69 (moderately wet). The trend is near constant, with an increasing tendency.

Takui is one of the highland ecological zones of the Bamenda Highlands at an altitude of about 2800 masl. RAI values here range from -0.28 (near normal) to 0.82 (slightly wet). This is the only station with a decreasing trend.

All the stations located at high-altitude ecological zones have near-normal to slightly wet conditions, while mid-altitude zones have slightly dry to moderately wet condition. Lowland ecological zones on the other hand have slightly dry to moderately wet conditions. It is worth noting that extreme dryness and wetness are rare in the Bamenda Highlands. With the changing climatic conditions, RAI trends are increasing, suggesting that rainfall is gradually reducing across all the ecological zones.

Emerging Food Insecurity in the Bamenda Highlands

Agricultural production in the Bamenda Highlands is rain-fed. The Bamenda Highlands is ecologically diverse with a variety of food and cash crops (Fig. 6.12).

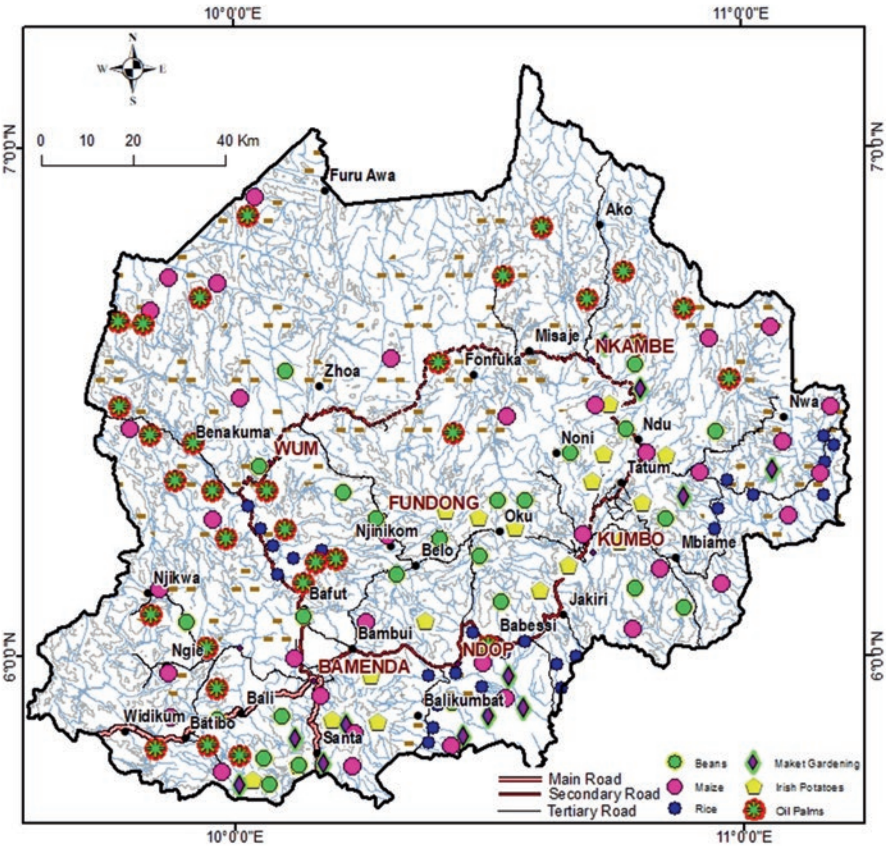


Fig. 6.12 Spatial distribution of crops in the Bamenda Highlands (Source: Fieldwork 2019)

The main food crops are solanum potato, beans, and maize, while cash crops are rice, groundnuts, palm oil, cassava, and market gardening crops. Maize, solanum potato, and beans have been reducing in Oku and Ndu, where considerable data was available (Figs. 6.13 and 6.14).

Maize yields dropped drastically during the 1982–1983 and the 1997–1998 droughts because rainfall was insufficient for successive growth during its vegetative growth period and the crops were bound to fail. This was the same with beans where during its pod formation period, there was not moisture sufficient to facilitate growth. Most of the bean plants were affected by the dwarf virus that is associated with high temperature. The potato plants all were wilted because of excessive evapotranspiration with no inadequate rains. Moreover, potatoes during their tuber enlargement need alternating sunshine and rainfall, but these years were characterized by less rainfall, so the tubers could not form properly. Again, 2002–2003 and 2007–2008 are all El Nino years. Besides, the heavy rains noticed during these years; they were accompanied by frequent wind storms and hail storms that destroyed bean flowers and leaves of crops during their pod formation season. The 2003, 2004, 2007, and

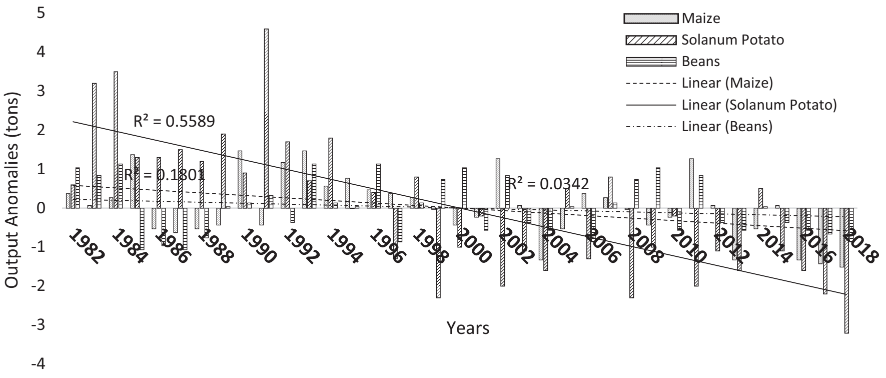


Fig. 6.13 Trends in crop output for Oku (1982–2018)

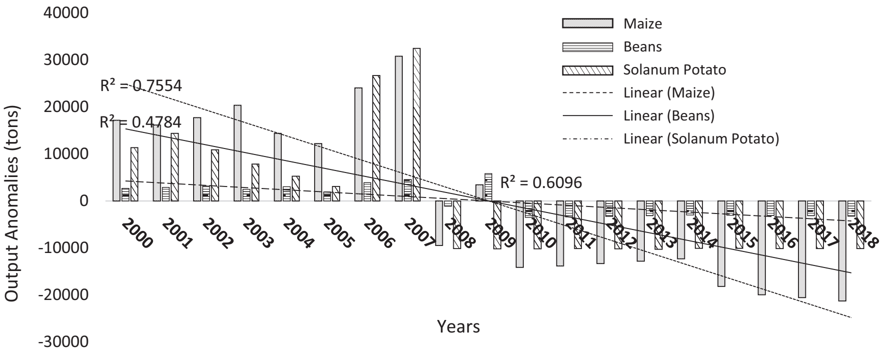


Fig. 6.14 Trends in crop output for Ndu (2000–2018)

2008 episodes are reflected in their harvest. These years corresponded with good yield from maize, but beans and potatoes, which are very sensitive to intense rainfall, experienced a reduction. A potato plant, for example, under high moisture content, is liable to late blight. Bean plants under such conditions are affected by aphids in the field. The 2007–2008 rains were so heavy up to periods of harvest that storage was difficult and most beans on the high-altitude areas rotted, thereby reducing yields.

Climate variability and change has already impacted and will further impact the agriculture sector and food production. Sensitivity to climate as well as several to other driving forces, especially from the economic and societal domains, will determine the future evolution of the sector. But climate influence must be considered as a first-order factor in the context of the enormous challenge of providing food for about 8–9 billion people by 2100 compared to the current 7.2 billion today (Zilberman 2018). Assessments of climate influence on crop functionality should consider stimulation of photosynthesis by the elevation of CO_2 atmospheric concentration. The direct influence of climate variations on crop function evidently involves temperature, the effects of which may be quite variable. Higher temperatures are generally favorable for growth in cold climates (except in extreme events) and generally unfavorable for warm areas. Further warming has increasingly negative impacts in all regions.

On the other hand, rainfall variability seriously modulates the potential changes in plant growth resulting from the effects of increasing temperatures. Tendencies toward drier conditions in some areas such as the West and Southern Africa may cancel, at least partially, the positive potential impact due to higher CO_2 or milder temperatures. Such combined climate influence leads to a variety of contrasted effects on crop production, depending upon the type, the geographical zone, and the level of adaptation. Farmers' perceptions were recorded on changing crop patterns (Table 6.2), with decreasing trends in food and cash crops.

Table 6.2 Perception of changes in crops output

	Increase		Decrease		No change		
Crops	Freq.	%	Freq.	%	Freq.	%	% Change
Maize	351	58.8	218	36.5	28	4.7	22.3
Solanum potato	91	15.2	415	69.5	91	15.2	-21.3
Beans	311	52.1	235	39.4	51	8.5	15.6
Groundnuts	173	39	196	32.8	228	38.2	2.5
Cassava	138	23.1	256	42.9	203	34	-13.4
Cocoyams	163	27.3	312	52.3	122	20.4	-9.2
Yam	103	17.3	123	39.2	260	43.6	-19.2
Tomatoes	254	42.5	116	19.4	227	38	6
Onion	150	25.1	188	31.5	259	43.4	-11.4
Soybeans	103	17.3	320	53.6	174	29.1	-19.2
Rice	95	15.9	320	53.6	182	30.5	-20.6
Vegetables	323	54.1	148	24.8	126	21.1	17.6

Source: Fieldwork, February 2019

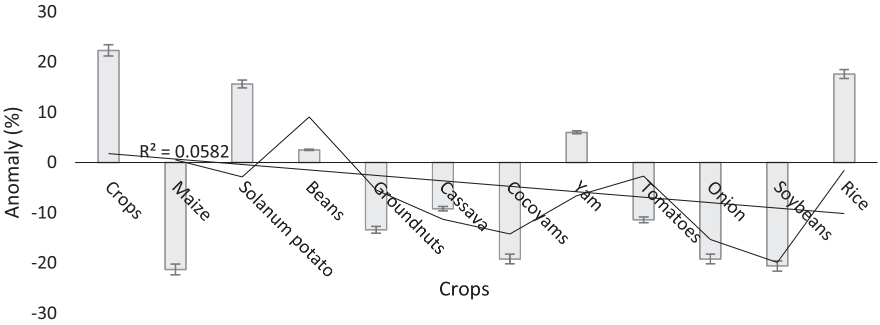


Fig. 6.15 Perceived crop variation anomalies

Solanum potato and coffee have the most perceived negative changes of -21.3% and -20.6%. Other crops with perceived negative changes are cassava (-13.4%), cocoyams (-9.2%), yam (-19.2%), onion (-11.4%), and soybeans (-19.2%) (Fig. 6.15).

These negative changes are attributed to changing climatic and environmental conditions. Crops are often attacked by blight and other pathogens during the tender growth stages, leading to plant mortality. Since the growing season of 2016, solanum potato has been devastated by blight. Irregular onset of rainfall has also negatively influenced coffee production. A strange disease has been devastating cocoyams since 2005. To have a clearer picture of perceived changes, crops have been grouped into food crops and cash crops. Farmers perceived that maize production is increasing. Solanum potato has been decreasing, while beans and vegetables have been increasing. Despite the increases in beans and vegetables, the cumulative trend of food crops is negative, with a coefficient of determination (R^2) of 0.0135 (1.35%). Cash crops on the other hand have been oscillating because of economic and environmental condition. Groundnuts have a positive change of +2.5%.

Cassava, cocoyam, rice, and soybeans have been decreasing because of their extreme susceptibility to climate variability and change. With no negative changes in vegetables, groundnuts, and onion, the cumulative perceived trend of cash crops has an insignificant positive R^2 of only 0.0002 (0.02%). These perceived variations in crop output have a direct link with temperature. The globally projected temperature increase by 1.4–5.8 °C, over the period 1990–2100 (Collier et al. 2008), will result in large changes in the frequency of extreme events which can have severe impacts on agriculture (Mathews et al. 2014). Increases in surface temperatures will increase soil temperatures which will in turn affect plant metabolism through the degradation of plant enzymes, limiting photosynthesis and affecting plant growth and yields (Campbell et al. 2011). Increases in soil temperature will increase potential evapotranspiration which causes damage especially to those crops with surface root systems which utilize mostly precipitation moisture (Collier et al. 2008). It increases leaf surface temperatures, hence affecting crop metabolism and yields making crops more sensitive to moisture stress conditions. Such crops include groundnuts, soybeans, maize, and fruit trees (Agba et al. 2017). Blanc (2012) revealed that crop yield changes in 2100 will be near zero for cassava, -19% to +6% for maize, -38% to -13% for millet, and -47% to -7% for sorghum under alternative climate change scenarios in sub-Saharan Africa.

The basic food stuffs on which people rely on daily have been declining in the Bamenda Highlands because food crop production systems are rain-fed. When there is hydrological, meteorological, or agricultural drought, threats to food security and crop failure will be evident. In Mbiame, the trend has taken a nose dive, and the climate continues to be very uncertain. This has to do with the timing of the onset of first rains and prevailing mild drought conditions throughout the growing season (Fig. 6.16).

The positive anomaly for solanum potato in Mbiame is because the dataset was documented prior to the great blight of 2016. Soybeans, groundnuts, rice, cocoyams, plantains, and onion have been decreasing in Mbiame. The general trend for crop production here has been negative, with a R^2 of 0.6654 (66.54%). This is an indicator of food insecurity. In the same vein, food crop production has been responding to climate variability, among other factors in Oku. Rice output has also been affected by variable climatic conditions. In Obang (Menchum Valley), the output is still slightly increasing (Fig. 6.17), while there has been a steep nose dive in the main production basin in Ndop (Fig. 6.18).

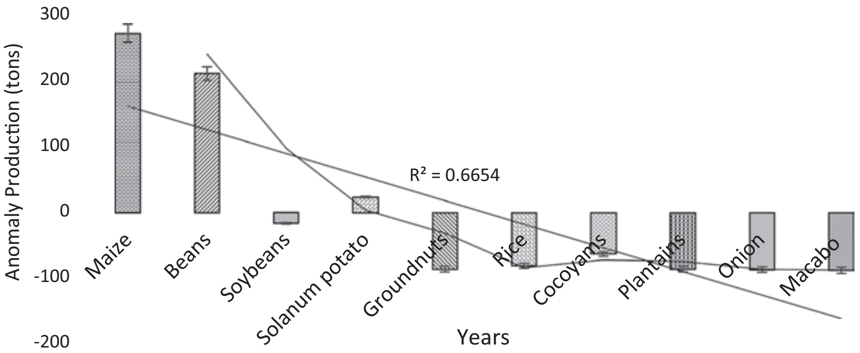


Fig. 6.16 Food crop production trend, Mbiame Sub-division (2006–2012). (Data source: Mbiame Council Development Plan, 2012)

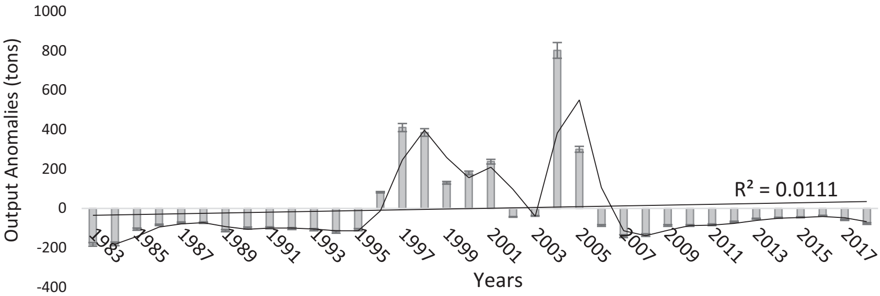


Fig. 6.17 Trend in rice output for Obang (1983–2018)

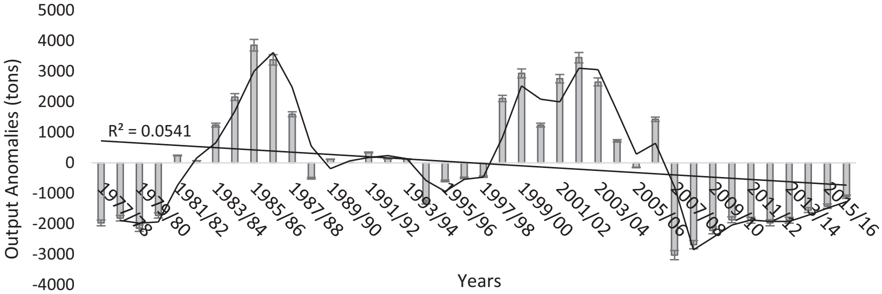


Fig. 6.18 Trend in rice output for Ndop (1977–2017)

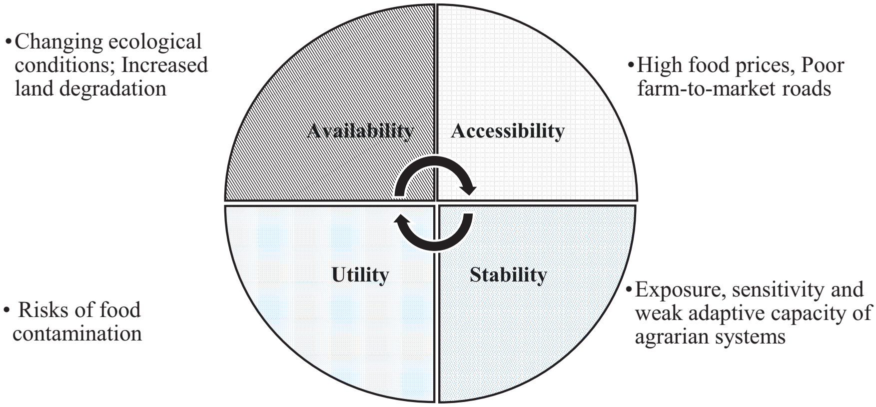


Fig. 6.19 The impact of climate change on food security dimensions in the Bamenda Highlands of Cameroon

The 1996 World Food Summit adopted the FAO definition of food security; thus, 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 (Jafari and Jafari this volume). The definition encompasses four dimensions:

- Availability of sufficient quantities of food of appropriate quality, supplied through domestic production
- Access by individuals to adequate resources for acquiring appropriate foods for a nutritious diet
- Utilization of food through adequate diet, clean water, sanitation, and health care to reach a state of nutritional well-being where all physiological needs are met
- Stability in the availability of and access to food, regardless of sudden shocks (an economic or climatic crisis) or cyclical events (seasonal food scarcity)

Climate variability and change is a threat to food availability, access, utilization, and stability. Ecological conditions in the Bamenda Highlands are favorable for diverse crops to be cultivated to meet the dietary needs of the population (Fig. 6.19).

Modification of agroecological conditions limits output and food availability, together with arable land degradation and a silent extinction of some food species like cocoyam which is a staple food in Ngemba land in Mezam.

Food is in abundant in interior villages and scarce in urban and semi-urban areas because of the poor state of farm-to-market roads to transport the produce. The poor transportation network, accentuated by heavy rains in the rainy season, limits physical accessibility. The transportation of food from areas of production to areas of consumption is interrupted. This leads to increase in food prices due to inadequate food supply in areas of high demand. Urban and semi-urban households with low income are the hardest hit because they cannot afford soaring prices. As such, food insecurity may eventually emerge in some areas because the excess food cannot be transported to areas of high demand. Again, extreme weather events such as recurrent floods and droughts increases food crop vulnerability to changing environmental conditions. Such physical shocks limit stability in crop output. This is not only in the Bamenda Highlands but in developing countries in general because they face a bleak future resulting from large-scale demographic, environmental, economic, and societal stresses. The links between food supply and demand are complex, with food supply affected by land and water, constraints, inadequate agrarian investments, trade, weather, and inadequate access to fertilizers and irrigation (FAO 2016). Food demand is affected by rising energy prices, population growth, globalization of food markets, changing diets, and the use of cropland for biofuel production.

Farmers' Adaptation Responses to Food Security Threats

The farmers most affected develop coping and adaptation strategies on crop production. These response strategies are perceived and applied in the three agroecological domains of the Bamenda Highlands. In the low-altitude domain, these are early planting, replanting, crop diversification, and the use of short season crops. In the mid-altitude domain, there is intensive use of organic manures, small-scale irrigation, water harvesting structures, chemical fertilizers, and early planting of crops. In the high-altitude domain, there is terracing, manure, fertilizer, agro-forestry, drought-tolerant crops, and crop diversification. Generally, early planting, crop diversification, increased use of manure and fertilizers, and the planting of crops with reduced growing degree days (GDD) were highly used by 70% of the farmers as crop production response strategies. The moderately adopted strategies here have been the practice of analogue forestry to curb adverse conditions of climate variability and change, the use of drought-tolerant crops, the implantation of water harvesting structures, irrigation, and terracing, among others. Based on the level of development and poor perception to climate change impact on food security, these adaptation responses are still far-fetched in some communities as most farmers have not fully adapted but are only resilient, a situation which has left behind footprints of food insecurity. Farmers are gradually embracing non-farm activities to supplement rural livelihoods such as petty trading and other climate smart activities like mushroom cultivation, apiculture, and aquaculture.

Farmers in the Bamenda Highlands are adapting to changing climatic conditions that play key roles in their decision-making, considering there are still a number of limitations to adaptation strategies. There is the urgency to mitigating greenhouse gas emissions from subsistence agriculture and other primary activities. This study has equally shown that there is a major improvement in knowledge and access to agricultural information among farmers with improved but inadequate access to media in the area through community radio stations (Tume et al. 2018). Households in some agro-zones observe positive changes in their farming practices largely because of the presence of some development NGOs such Green Care Association (GCA) in Shisong, Kumbo, Strategic Humanitarian Services (SHUMAS) with a climate-smart demonstration farm in Kumbo, and Rural Women Centre for Education and Development (RuWCED) in Ndop. Despite the presence of such development NGOs, agricultural productivity has continued to decline. There is, therefore, the need for a national climate change response strategy that will be put in place as a robust measure needed to address most, if not all, of the difficulties posed by climate variability and change to food and water security.

Conclusion

The current agricultural extension should target disaster risk preparedness and management to increase food security. Government must also look at the development of weather services for better and accurate weather information that farmers could use in their decision-making. The possible synergy between traditional and modern conception of climate change adaptation and mitigation could yield more benefit for better use of meteorological information. Encouraging farmers' education through extension services accessibility or adult education could help farmers in the adoption of new technologies and farming practices to deal with climate change effects to ensure food security. Farmers' adaptation response strategies should be improved by ameliorating the conditions affecting adaptation strategies like poor perception of changes in climatic patterns and receiving and documenting weather information, land tenure systems, and household characteristics. Global climate change has an adverse effect on agricultural production and will bring ever-increasing human population toward critical thresholds in many regions. Areas currently suffering from food insecurity are expected to experience disproportionately negative effects. To reduce the effect of climate change on food supplies, livelihoods, and economies, incentivizing greatly increased adaptive capacity in agriculture both to long-term climatic trends and to increasing variability in weather patterns is an urgent priority. This should be in line with Sustainable Goal 2 (SDG2) which aims to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture. The target is to ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, maintain ecosystems, strengthen capacity for adaptation to climate change, extreme weather, drought, flooding, and other disasters and that progressively improve land and soil quality by 2030.

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