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Indigenous Knowledge and Farmer Perceptions of Climate and Ecological Changes in the Bamenda Highlands of Cameroon: Insights from the Bui Plateau

Suiven John Paul Tume [1], Jude Ndzifon Kimengsi [2,3,*] and Zephania Nji Fogwe [1]

[1] Department of Geography and Planning, The University of Bamenda, P.O. Box 39 Bambili, Cameroon; wantume@gmail.com (S.J.P.T.); nfogwez@yahoo.co.uk (Z.N.F.)
[2] Department of Geography & Environmental Studies, Catholic University of Cameroon (CATUC), Bamenda P. O. Box 782 Bamenda, Cameroon
[3] Faculty of Environmental Sciences, Technische Universitat Dresden, 01737 Tharandt, Germany
* Correspondence: jude_ndzifon.kimengsi@tu-dresden.de

Received: 24 October 2019; Accepted: 6 December 2019; Published: 8 December 2019

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Abstract: Anticipating seasonal and shorter time scale dynamics to farming practices is primordial for indigenous farmers' resilience under extreme environmental conditions, where climate change is a menace to agro-hydro-ecological systems. This paper assesses the effectiveness of indigenous farmers' knowledge and aptitude to read weather signs for informed decisions on their daily and seasonal activities. Such climate-proof development is anchored on indigenous people's knowledge and perceptions in circumstances where the dearth of scientific evidence or information exists as in Cameroon. The study is based on eight focus group discussions and a survey of 597 farming households in seven agro-ecological basins on the Bui Plateau of the Bamenda Highlands. The results indicate that indigenous smallholder farmers value their ability to accurately observe and anticipate local conditions in various ways to serve their local realities more aptly than outside forecasts. Such local knowledge should thus exercise a complementary role weave in a local climate information understanding system that replicates ecological variability.

Keywords: ethno-meteorology; farmers; indigenous knowledge

1. Introduction

Climate variability and change affects the ability of rural communities to satisfy those needs that are inherent to the environment [1–3]. Even though changes have been occurring over generations, rural farmers have been adapting to these changes throughout their life using local environmental knowledge [4,5]. The knowledge is relatively cheap, readily available to rural farmers, and it is a climatically smart tool for sustainable development and the management of climate variability [6,7]. Environmental problems vary spatio-temporarily, but rural farmers, through continued experimentation, trial and error, and sustained interactions with their local environment, have developed a vast local knowledge about nature in their locale that they use in coping with and solving their problems, amongst which are climate-related problems [8].

UNESCO has a well-established program on preserving traditional knowledge, called Local and Indigenous Knowledge Systems, LINKS. This program was one of the key pillars that contributed to the framing of the Millennium Development Goals (MDGs) of poverty eradication and of environmental sustainability. The same program has been expanded and incorporated in the Post-2015 Development Agenda (Sustainable Development Goals-SDGs) to empower local and indigenous peoples in various aspects of environmental management by advocating and mobilizing their unique knowledge and practices in climate change adaptation [9]. LINKS also contribute to safeguarding traditional knowledge within indigenous communities by reinforcing intergenerational continuity through the development of educational resources, based on local knowledge [10].

Indigenous knowledge is a cumulative and complex body of knowledge, practices, and representations that are maintained and developed by peoples with extended histories of interactions with the natural environment [11–14]. These systems are part of a complex that includes language, attachment to place, spirituality, and perception of worldview [15]. Notwithstanding a variety of terminology used to refer to local environmental knowledge (LEK), traditional ecological knowledge (TEK), indigenous knowledge (IK), indigenous traditional knowledge (ITK), [16–21], all the terminology has similar meanings and is used interchangeably to refer to the local environmental or traditional knowledge and skills held by indigenous people, developed outside the formal scientific domain, embedded in culture and steeped in tradition through oral tradition [22].

Climate change is any change in climate over time, whether due to natural variability or because of human activity. According to a study by [23], climate change is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. Indigenous farmers' knowledge and perception of climate and ecological change is a function of traditions and customs, handed to them from one generation to another. In the Bui Plateau of the Bamenda Highlands of Cameroon, indigenous climate and ecological change perception are grounded on traditions and culture, community priorities, needs, knowledge, and capacities, which enable local people to plan and cope with the impact of environmental change in agriculture and other sectors. Perceptions of these changes by rural communities are concentrated on observations of variations in temperature, rainfall, and vegetation patterns, which are often backed by blending such perceptions with scientific evidence [24]. Indigenous stakeholders of Bui Plateau in climate and environmental knowledge systems include farmers, community elders, weather seers, and other gifted persons. They can study and interpret weather signs to advise farmers to make informed choices on their agrarian practices. Indigenous communities rely on their immediate environment for sustenance. Their environmental knowledge systems are built through generations of living in close contact with nature [17]. Local people often have knowledge of climatic conditions and extreme events going back generations and have developed effective strategies for adaptation and resilience [25]. Such knowledge systems are critical in informing local and national adaptation responses because conventional adaptation strategies most often use top-bottom approaches which do not reflect grassroots realities. Not building on local knowledge brings the risk of maladaptation and inappropriate responses [16]. Traditional ecological knowledge must also be used in assessments, such as the Intergovernmental Panel on Climate Change (IPCC), which remains a key influence on government policymaking [26–28]. This paper, therefore, seeks to assess indigenous knowledge and farmers' perception of climate and ecological changes as a means to build on local sustainable environmental practice in the Bamenda Highlands of Cameroon.

2. Materials and Methods

The Bui Plateau of the Bamenda Highlands of Cameroon is segmented into seven micro agro-ecological zones that stretch between latitudes 6°00′–6°20′ N and longitudes 10°30′–10°60′ E. Bui is an extension of the Western High Lava Plateau that diagonally cuts Cameroon from the Gulf of Guinea along the tectonic axis called the Cameroon Volcanic Line (CVL). The study area offers subsistent farmers with widely contrasting landscapes in the like of Mount Oku (3011 masl) and Mbaw in the Tikar Plains (≈710 masl) that sustain diverse crops with varied agricultural calendars. This hydro-morphological citadel is the watershed for Cameroons Western drainage basins for the River Niger and Sanaga systems. It spans on an area of 2795 km^2 (Figure 1), made up of six administrative sub-divisions of Bui Division, namely, Kumbo (630 km^2), Jakiri (675 km^2), Nkum (375.3 km^2), Nkor–Noni (307.7 km^2), Mbiame (575 km^2), and Oku (232 km^2).

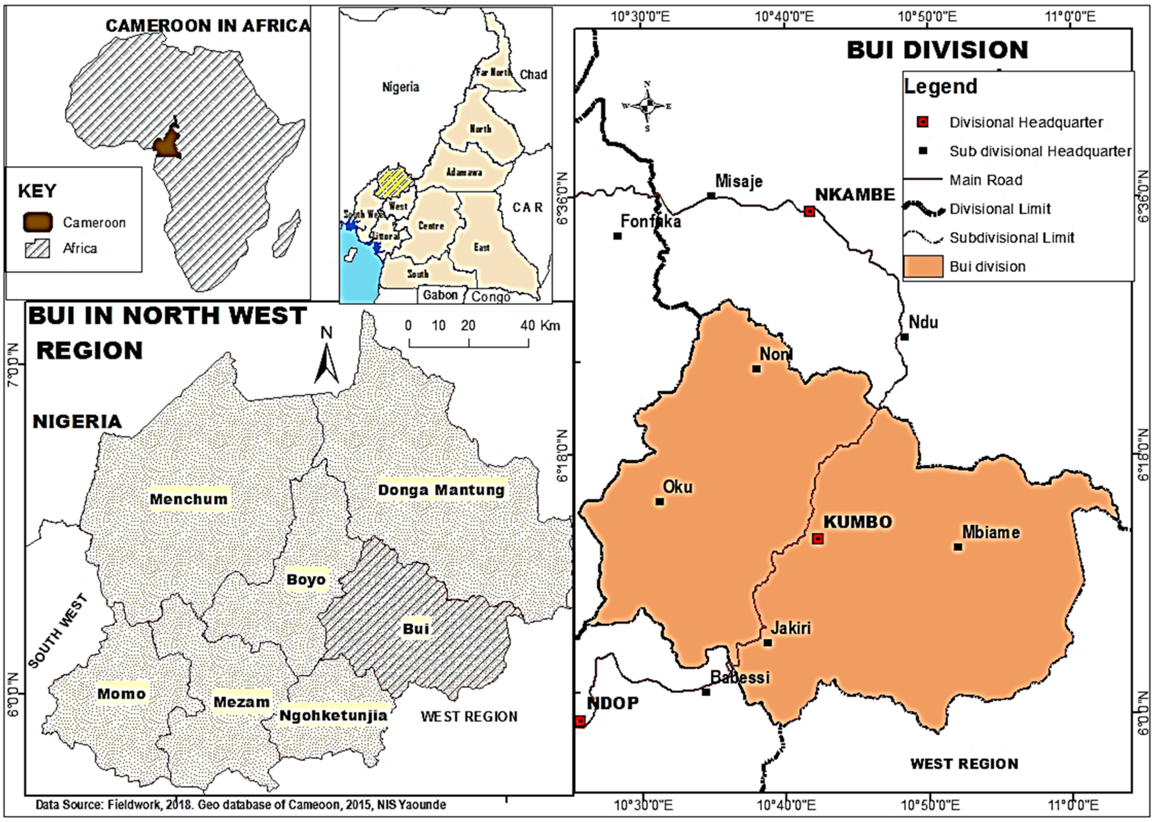

Figure 1. Location of the Bui Plateau.

The Bui Plateau has two seasons (dry and wet). The dry season lasts for four to five months (November–March) while the wet season lasts for eight months (March/April–October). There is a general decrease in rainfall during the dry season, during which water resources shrink due to the drying out of intermittent springs and a drop in the water table. This results to water scarcity. The dry season is characterized by dry harmattan winds, which lack moisture and rather facilitate the drying out of the environment.

This is an analytical study that employed the cluster sample survey procedure to data collection. The choice of this design is because the research problem is multi–disciplinary with several stakeholders involved and disciplines affected by climate vulnerability and adaptation. The aspect of indigenous adaptation to climate variability in the agrarian sector falls within the scope of cultural anthropology. This design is based on a mixed approach that combines quantitative and qualitative methods to improve on the robustness of the results. The study is exploratory in nature since it assesses indigenous adaptations to climate variability vis-à-vis conventional adaptations. Qualitatively, information from farmers pertaining to adaptations of rain-fed agricultural systems was obtained using a closed-ended questionnaire, focus group discussions, expert interviews in key sectors involved in climate and agriculture, as some key informants of community-based organizations involved in climate change management for sustainable rural livelihoods. The questionnaire used a five-point Likert scale to assess farmers' indigenous climate knowledge (very high, high, very low, low, and unknown). Other questionnaire items contained close-ended questions on local sources of weather knowledge, farmer's knowledge of weather forecasting, perception about the nature of local and scientific weather knowledge, and perception of agro-ecological evolution in the Bui Plateau. Eight focus group discussions (FDGs) were conducted to substantiate the responses acquired using questionnaires. The following groups: Bongsiysi (Kishong), Kongadzem (Kishong), Bongatati (Shisong), Mbokam Mixed Farmers Common Initiative Group (CIG), Loweh Rice Farmers CIG (Ber), Bongba Mixed Farming CIG (Manchock-Oku), Men of Vision CIG (Shisong), and Momeyen Mixed Farming CIG (Nkor) participated (Table 1).

Table 1. Focus group discussions participants.

Groups	Location	Gender Type	Number	Activity Domain
Bongsiysi	Kishong	Women	10	Agriculture, weekly thrifts, and loans
Kongadzem	Kishong	Women	9	Agriculture, weekly thrifts, and loans
Bongatati	Shisong	Mixed	8	Soybean processing, monthly thrifts, and loans
Men of Vision CIG	Shisong	Men	8	Livestock and Fisheries
Mbokam Mixed Farmers CIG	Mbokam	Mixed	10	Cassava processing, weekly thrifts, and loans
Loweh Rice Farmers CIG	Ber	Mixed	9	Rice farming
Bongba Mixed Farming CIG	Manckock	Mixed	8	Solanum potato production
Momeyen Mixed Farming CIG	Nkor	Mixed	10	Maize production
Total	8		72	

Source: Fieldwork, August 2018.

The criteria of the selection of the groups was based on activities of rural farmers who rely solely on indigenous knowledge systems to make informed choices on their activities. These included farmers' groups, associations, and cooperatives. Other group of discussions were with community leaders and elders to explore local knowledge practices and applications throughout the agricultural calendar. Women-only groups help develop women's management capabilities more than joint groups and having their groups enable women to act and gain self-esteem. Women-only groups are stricter about resource regulation and enforcement than men-only or mixed-gender groups. Mixed groups may inadvertently strengthen gender inequality by ignoring uneven power relations that translate into a low social status and heavier workloads for women. Social inequalities found in mixed-gender groups in which wealthier members usurp the benefits could be reproduced in women-only groups. Women-only groups may also do less well in resource governance than mixed or men-only groups because of laboor constraints faced by women, gender biases in technology access and dissemination, and possible limits in women's sanctioning authority. Evidence suggests that women-only groups may have ecological benefits from stricter enforcement and in the short term may help in giving women self-confidence, but in the long run, there is a risk that they may also reinforce existing gender inequalities. These gender differentials greatly influence resilience to climate variability and change.

Community leaders who participated on discussions about indigenous environmental knowledge systems were staff of Green Care Association, a local NGO based in Shisong, Fon (traditional chief) of Taabah, Kingomen and Shufai Taansam, Takui. Guided interviews were conducted with some traditional leaders to explore ways in which cultural and traditional practices enhance adaptation to climate change. Other expert interviews were administered to the Divisional Delegation of Agriculture and Rural Development (top-down approach). Questions were directed to rural farmers' adaption to climate variability and problems they face in the process. Some of the questions were on the number of the agricultural basins and the specific activities and crops cultivated therein as well the agricultural support programs that have directly supported rural farmers' adaptation to climate variability and poverty alleviation. The Bui Plateau is diverse and segmented into seven agrarian basins. Given that the research problem revolves on the agrarian system, which is the life wire of the inhabitants of Bui, the questionnaires (597, Table 2) were administered in clusters.

Table 2. Population of Bui Division and administration of questionnaires.

Sub-Divisions	Population	Agrarian Basins	Questionnaires		Crops
			Frequency	%	
Kumbo	127,919	Nkar-Kumbo-Kikaikom	94	15.7	Maize, cassava, beans, yams, market gardening, solanum potato
Jakiri	59,951	Mbokam-Ngomrin-Mbaw Nso	68	11.4	Rice, maize, soya beans, groundnuts, oil palm, cassava
Nkum	127,538	Dzeng-Tatum-Banten	91	15.2	Maize, beans, solanum potato
Nkor	63,487	Djottin-Nkor-Lassin	81	13.6	Groundnuts, maize, beans
Elak-Oku	144,800	Oku-Vekovi-Tadu	105	17.6	Solanum potato, maize, beans
Mbiame	48,684	Mbiame	85	14.2	Maize, cassava, beans, yams, cow pea, groundnuts, solanum potato, plantains
		Nkuv-Ndzeen	73	12.2	Maize, cassava, beans, yams, cow pea, groundnuts
Total	572,379	Total	597	100	

Source: Fieldwork, August 2018.

The principle of cluster sampling solves the problem of data collection in a culturally and physically diverse area. A convenient way in which a sample can be taken is to divide the area into smaller overlapping areas and then to randomly select a number of these smaller areas (households located in the agricultural basins), with the ultimate samples that are representative of the entire Bui Plateau. In cluster sampling over the Bui Plateau, the target population were farmers in rural areas. These were sub-divided into relatively smaller units relating to crops which are grown in specific areas. In cases where more than one crop dominates in an agro-basin, double or multiple levels of clustering were applied (multi-stage cluster sampling). The questionnaire was analyzed quantitatively in the Statistical Package for Social Sciences (SPSS) Version 20 and Microsoft Excel 2013. Qualitative analysis entailed recording of perceived agro-ecological changes during FDGs.

3. Results

3.1. Indigenous Knowledge Levels and Sources

Perception is the way of processing raw data that a person receives through his/her daily and long-term interaction with immediate environment into meaningful pattern. Indigenous perception depends not only on individual personality but also on community, environment, and interaction among these components [29]. Before taking any further analysis of indigenous knowledge and farmer perceptions of climate and ecological changes in the Bamenda Highlands of Cameroon, it was necessary to assess the peoples' knowledge levels about climate change (Figure 2).

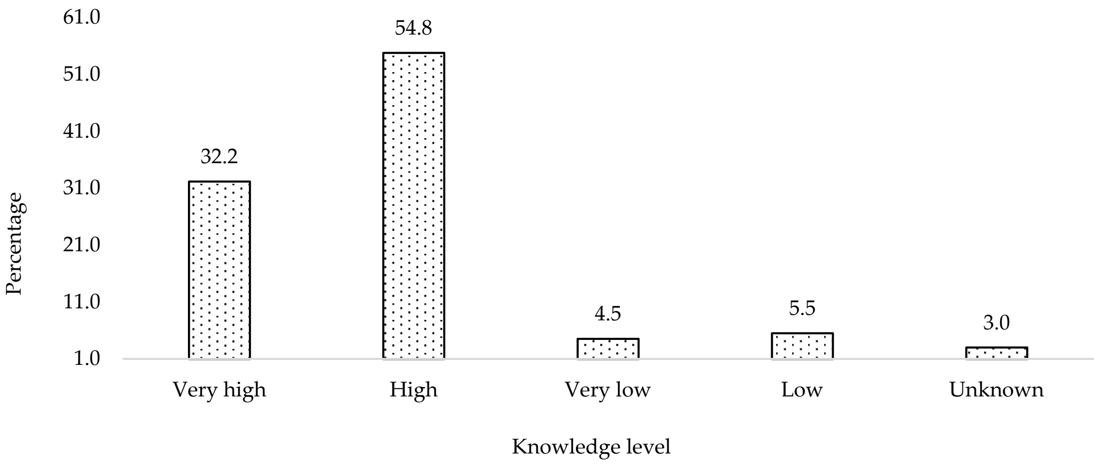

Figure 2. Levels of indigenous climate knowledge. Source: Fieldwork, August 2018.

One-third (32.2%) of farmers have very high knowledge of climate change, 54.8% have high knowledge, 4.5% have very low, 5.5% have low, and only 3% have no knowledge. Sources of indigenous weather activities on the Bui Plateau are through plant behavior (49.4%), personal intuitive perception (18.9%), animal behavior (12.2%), consultation of traditional weather seers (4.7%), stream behavior (6%), and consultation of community elders (3.7%) (Table 3).

Table 3. Sources of weather knowledge in the Bui Plateau.

Conventional Sources	Frequency	%	Traditional Sources	Frequency	%
Meteorological service	10	1.7	Animal behavior	73	12.2
TV	5	0.8	Plant behavior	298	49.9
Radio	9	1.5	Personal perception	113	18.9
			No weather information	3	0.5
			Weather seers	28	4.7
			Elders	22	3.7
			Stream behavior	36	6

Source: Fieldwork, August 2018.

A small proportion of inhabitants of the population of the Bui Plateau uses conventional sources such as television, (0.8%), meteorological services (1.7%), radio (1.5%), and those who do not have any weather information (0.5%). The dominance of indigenous sources of weather activities is because most farming communities do not have access to electricity, which deprives them of gadgets like televisions and other electronic devices. Typical farmers in frontier basins like Lassin, Mbaw Nso, Nkuv, Gwarkang, Mbokam, Njanawa use mainly simple phones (for those who can afford) that can be charged with a small solar panel. This partly accounts why such farmers resort more to indigenous sources of weather activities than scientific weather information. Furthermore, indigenous farmers reported at about 47% that the language of conventional weather forecasting is too complicated and hard for them to comprehend. They also asserted that the situation is made worse by the absence of local weather scientists (37%) to teach them weather changes for agricultural planning. The farmers also perceived that scientific weather reporting is faulty (9%), and hardly corresponds to the observed realities and communicates irregularly (7%). With these limitations of conventional weather sources, Bui farmers rely on community elders (45%), personal weather predictions (27%), local weather seers (24%), and friends and neighbors (3%).

Community elders and local weather seers often invoke the gods of the rain through periodical incantations and traditional sacrifices. In Nso land, such traditional sacrifices are performed at the beginning of the planting season, where the gods are invoked for a good agricultural season, before the start of first weeding, harvest, and at the start of the farming season. The first sacrifice to invoke the gods of the land is performed by His Royal Highness the Fon of Nso. This is done at five shrines located at the palace in Kumbo, Mantum in Jakiri, the Kinsaan plunge pool in Kitiwum, the Mairin plunge pool in Takui, and the palace in Kovifem. After the fon's performance, other traditional leaders do the same in their respective areas of jurisdiction. Such sacrifices entail pouring libation (palm wine), pronouncing incantations and slaughtering goats and chickens, where their blood is sprinkled as sacrifice. The slaughtered chickens or goats are not edible by the indigenes or any other person. The carcasses are allowed in the open air to be devoured by vultures. Indigenous and local practices (ILP) are the result of the application of culture, context and location-specific knowledge to solve local problems. The close relationship of indigenous peoples with their environment makes them vulnerable to the effects of global warming. Indigenous people tend to live in worst places hit by the impacts of environmental change and their poverty exacerbates vulnerability [5].

3.2. Community Knowledge for Agrarian Weather Forecasting

Community knowledge of weather forecasting is an important component of the concept of ethno-meteorology. It is based on traditional ecological knowledge handed down from generation to generation [16]. Several variables were chosen in this study to express indigenous community knowledge for planning in the agro-hydrological systems of the Bui Plateau (Table 4).

Table 4. Farmers' knowledge of weather forecasting.

Variables	Freq	%
Personal experience	431	72.2
Mere smells	307	51.4
Sounds of birds and insects	440	73.7
Make necessary decisions to overcome any weather problem as required and deemed fit	306	51.3
Through certain plants	296	49.6
Forefathers from whom farming experience was acquired	422	70.7
Through the gathering of clouds	570	95.5
Pattern of first rains in a farming year	332	55.6
Through certain signs, discern whether there will be excess or scarce rains in a given farming year	250	41.9
Through star constellation, predict whether it will rain or not	217	60
From personal experience, predict the extreme of temperatures in a given farming year	334	55.9
Using trend observation/ sequence of yearly weather events, determine what the climate would be in a farming season	256	42.9

Source: Fieldwork, August 2018.

The choice of this is because conventional weather information systems are absent, with only five functional stations on the Bui Plateau (Tatum, Takui, Kumbo, Jakiri, and Mbaw Nso). With increasing variability in climate and uncertainty of first rains, most decisions made by indigenous farmers on the Bui Plateau are based on personal experience and conviction (72.2%). As risky as such decisions at the beginning of the planting may be, farmers perceive that the behavior of rains at the onset of the wet season gives them a clue as to how the rest of the growing season will unfold. Erratic nature of rainfall can cause misinformation and mislead farmers to make wrong decisions, given that the dry season is already gradually prolonged. Some signs such are mere smells (51.4%) that indigenous communities rely on to predict whether it going to rain or not at a time is still en vogue.

Some people are gifted to predict the onset of first rains through weather smells, especially in the mornings of the months of February, March, and April. The sounds of some birds and insects is a common indigenous weather forecasting tool in many communities of the Bui Plateau (73.7%). One of such birds is the Senegalese Cowcow, which sings in the morning or anytime of the day to announce rains in about the next 10 to 60 min. On the other hand, the chattering of the Cameroon Mountain Francolin indicates good weather. Insects like crickets cackling at night is an indicator that there will be no rain. Another visible indicator of cessation of the wet season is swarms of dragon flies that fly eastwards from October to November. In the absence of conventional weather forecasting, farmers in the Bui Plateau are able to read weather signs through the behavior of some plants (49.6%). One of such plants is *Scadaxus multifluros*, which blossoms only once in a year in late February to early March. This plant has been used for generations in Kumbo-Jakiri-Wainamah, Nkum and Oku agrarian basins to read the weather about the onset of the first rains. Once it blooms, the rainy season will begin in about three weeks to one month. A farmer in Shisong affirmed that reading weather signs through the behavior of plants and animals was handed to him by his great grandfather. Indigenous knowledge handed down by forefathers from whom they acquired farming experience have had long standing and proven experience of weather forecast from which they have benefitted. From such experiences, farmers predict rainfall patterns through the farming season. During the dry season, indigenous communities of the Bui Plateau also study the yellowish-reddish atmospheric aerosol loading to make informed decisions about their farming activities.

Aerosol coloring of the atmosphere occurs mainly from December till the start of the wet season. This coloring indicates the appropriate time for farmers to start raising '*ankara*' on farms. In the Dzeng-Tatum-Banten basin, raising *ankara* (a form of slash and burn) is through the burying of maize stalks for burning. In Mbam valley, ankara is practiced in newly opened fields and in old fields. Bush burning for agricultural activities, pasture regeneration, dry season dust storms are the main sources of local aerosol loading into the atmosphere on the Bui Plateau during the dry season. As from the month of February rain clouds (cumulo-nimbus) start building. Through the gathering of clouds (95.5%) such as a small alto-cumulus and strato-cumulus, community elders, weather seers, and people with experience in reading weather signs can predict the approximate date that the wet season will begin. Other indicators of indigenous weather forecasting include star constellation (60%), extreme temperatures (55.9%) and sequence of yearly weather events to determine what the climate would be in a farming season (42.9%). Dark clouds, according to indigenes signify approaching heavy rain. Ethno-meteorology is a mystery and only some members of the community are gifted in reading and interpreting cloud patterns [30–32]. Some of the predictions of 'cloud watchers' often miss out and can be very misleading because of changing climatic and environmental conditions. In the Bui Plateau, weather seers are mostly old men of more than 50 years of age who have been practicing agriculture all their life.

3.3. Local and Scientific Weather Knowledge in Agrarian Practices

A local farmer's ability to make informed decisions is largely governed by personal experiences acquired over the years. In the absence of credible scientific weather information systems to farmers, they must resort to what is at their disposal. Even when scientific weather systems are broadcast on the media, it appears hard to be understood by rural farmers because of low levels of formal education (Table 5). Daily weather forecast broadcast by the Cameroon Radio Television (CRTV), Spectrum Television (STV), and Equinox TV are faulty. Local weather knowledge is simple to understand than conventional scientific knowledge. Both local and scientific knowledge in weather forecasting over the years are produced through observation, experimentation, and validation.

Scientific knowledge in weather reading follows certain procedures in its production process, but local knowledge is unregulated and haphazard or unorganized by oral tradition. Local knowledge in weather prediction does not require sophisticated tools. Formal education or training is not needed to acquire skills in local weather forecasting. Exercising local knowledge in weather prediction requires no financial investments. Despite yawning differences, scientific weather forecasting and local predictions are mutually exclusive. Local approaches to weather prediction is often accurate and as such are the best in making the right decisions in farming activities. Whereas scientific weather forecasting is purely secular, local knowledge in weather reading entails a great measure of spirituality. Indigenous peoples are among the first to face the direct consequences of climate change due to their dependence on and close relationship with the environment and its resources [33].

Traditional environmental knowledge has an advantage of being directly linked to household daily activities. It is concerned with the immediate necessities of people's daily livelihoods and can provide a short-term and immediate solution to a means of survival in the community, making it meaningful [4,34]. It may also be useful under transitory conditions, as opposed to contemporary science developed through research and principles for solving global problems without a local origin nor link to social, cultural, political, and physical environment of a specific local area and removed from the daily lives of the people [18]. Researchers have acknowledged the dynamism of local knowledge in providing solutions and coping with new environmental and economic hardships in society [20,35], with further acknowledgement that some local farmers have succeeded in their farming systems by combining local farming methods with scientific knowledge [36,37].

Table 5. Farmers' perception about the nature of local and scientific weather knowledge.

Variables	Local	Scientific	Undecided
	%	%	%
Scientific weather forecast cannot be relied upon as it does fail most of the time	56.6	23.8	19.6
Local knowledge, is simple to understand in weather prediction, the same cannot be said of scientific knowledge	72.5	17.8	9.7
Both local & scientific knowledge in weather forecasting are over the years produced through observation, experimentation & validation	81.4	9.2	9.4
Scientific knowledge in weather reading follows certain procedures in its production process, local knowledge is unregulated and haphazard or unorganized	74	15	11.7
Local knowledge in weather prediction does not require the use of sophisticated tools	75	13	11.2
Formal education or training is not needed to acquire skills in local weather forecasting	70	10	20.1
Wielding local knowledge in weather prediction requires no financial investments	65	17	17.1
Scientific weather forecasting and local predictions are mutually exclusive	58	29	12.9
Local approaches to weather prediction is always accurate & as such are the best in making the right decisions in farming activities	62	27	10.4
Local knowledge in weather reading entails a great measure of spirituality	52	35	12.7
Scientific approach to weather forecasting should only be supplementary to local approach in making farming decisions	53	27	19.9

Source: Fieldwork, August 2018.

Scientific approach to weather forecasting should only be supplementary to local approach in making farming decisions. Scientific analysis of climatic data and indigenous perceptions recorded in this study shows some convergences. There are problems that hinder the synergies of indigenous traditional local knowledge with contemporary science in the management of resources, such as differences in power relations between developed and developing countries. This is aggravated by limited integration techniques which are exacerbated by the lack of proper background in local knowledge, lack of realization that indigenous traditional knowledge has values attached to local content touching the life of the local people and could contribute to the development of sustainable climate change, mitigation, and adaptation strategies and lack of proper understanding on how local knowledge could be used in dealing with environmental issues hence solutions to developmental problems [37,38]. Despite the positive features of indigenous traditional knowledge, there are doubts that question the legitimacy of the knowledge in managing agriculture, while many farmers still suffer from food shortages and increased environmental degradation [13]. There are other factors that are embedded in food production that farmers encounter such as imported food, abrupt and prolonged occurrence of natural hazards such as floods, drought, and windstorms that most rural farmers are not able to cope with [20,39], as well as the misguided notion that all indigenous practices are unproblematic and would be a panacea to all small-scale farming and nature related environmental problems because they are local in origin [40].

3.4. Agro-Hydro-Ecological Indicators of Climate Variability in Bui

The relationship of humans with the Earth's environment has changed throughout the evolution of Homo sapiens and the development of societies [41,42]. Apart from climate change, the environment at the local scale of Bui Plateau has witnessed changes in weather conditions, the ebbing of streams and shrinking water resources, loss of rich tropical montane forests, land degradation from overgrazing, and accelerated erosion on arable land. These dramatic changes are within the framework of *'anthropisation'* given that man has become a robust geophysical agent during the Anthropocene Era [43,44]. The impact of human activity in the Bui Plateau has perturbed the delicate steady state of nature. This has greatly reduced the resilience of livelihood and life support systems. From 1970–1979, the agrarian system in the Nkar-Kumbo-Kikaikom basin was characterized by flat ridging, high coffee prices, massive deforestation to establish new farmlands, and planting of eucalyptus (Table 6).

Table 6. Farmers' perception of agro-ecological evolution in the Bui Plateau.

Period	Agro Activity	Weather Traits	Hydrological Responses	Remarks
1970–1979	Flat ridging, high yields, massive deforestation, high coffee prices, planting of eucalyptus, long fallow periods,	Regular onset of first rains in mid-March	Abundant water resources	Unperceived changes
1980–1989	Decline in coffee prices, massive deforestation, emergence of large-scale eucalyptus plantations, massive elimination of coffee farms in the mid-1980s due to slump of prices at world market	Regular onset of first rains in mid-March, severe droughts (extreme weather events)	Abundant water resources, stable water resources, but noticeable drops in some head springs & streams	Moderate changes
1990–1999	Fallow periods <3 years, advent of application of chemical fertilizers in the early 1990s	Irregular onset of first rains, high frequency of extreme weather events	Shrinking local springs and streams, enhancement of watersheds/springs and realization of community water projects	Moderate vulnerability
2000–2009	Intensive application of chemical fertilizers to boost production, emergence of farmer-grazier conflicts	Irregular onset of first rains, frequency of extreme weather events (floods and droughts), increasing temperatures	Visible drops in water levels in major streams, mounting water shortages	High vulnerability
2010–2018	Use of herbicides (spraying weeding), fast maturing of crops, intense application of chemical fertilizers, caterpillar attacks during early growing season	Uncertain weather patterns, irregular rainfall, swelling temperatures	Emerging water insecurity	Severe vulnerability

Source: Fieldwork, August 2018.

There was regular onset of first rain in mid-March. Water resources were abundant and there were hardly noticeable environmental changes. With the fall in coffee prices in the mid-1980s, farmers eliminated their coffee farms and transformed them into eucalyptus plantations and for food crop farms. Rainfall was regular with the onset rainy season occurring around mid-March. The drought of 1983–1984 raised caused much agitation in farming communities. With these, there were still no major changes in water resources. The drought of early and mid-1980 caused minor environmental changes like drops in crop production.

From 1990, there were already remarkable drops in food production, which initiated the advent of chemical fertilizers application. The onset of first rains became irregular and extreme weather events like dry spells, stormy weather, and floods increased. In July 1998, hail stones destroyed crops and over the Bui Plateau. Water levels dropped remarkably in local streams. The inhabitants could already perceive that their livelihoods were vulnerable to changing environmental conditions. The Strategic Humanitarian Services (SHUMAS) initiated the eucalyptus replacement project to save watersheds from the overwhelming effects of eucalyptus plantations. From 2000, reasonable food crop production for maize could only be boosted by application of chemical fertilizers. Temperatures plunged and the onset of first rains became very irregular. Mounting water scarcity became a daily reality, leading to the emergence of water scarcity problems. [45,46] affirmed that rapid urbanization and poor water governance are threats to water security in Kumbo town. From 2010, an innovation in the agricultural sector was the increased use of herbicides (spray weeding). Pests like caterpillar invasions also became regular during the early growing seasons. The 1970s, in the Nkum basin, were characterized by long fallow periods, low population growth, and thick natural forest from Nkum Kov to Banten.

Other pockets of natural forest cover are at Kov Mven, Kovifem and Takui. Rainfall was regular with onset of first rains in mid-March. Like Nkar-Kumbo-Kikaikom basin, water resources were abundant, and people could hardly perceive any environmental changes. The 1980s were characterized by massive deforestation and the emergence of large-scale eucalyptus plantation all over the landscape (watersheds, fertile lowland plains). With the slumping of coffee prices at the world market and the closure of the West Cameroon Marketing Board, farmers, transformed coffee farms into cultivable land and eucalyptus plantations. The emergence of eucalyptus plantations at head waters caused noticeable drops in spring yields in the late 1980s, thereby leading to vulnerability of water resources to environmental change. With increasing population, fallow periods dropped significantly, necessitating the use of chemical fertilizers to boost crop output. The onset of first rains became irregular, characterized by frequent dry spells and stormy weather, leading to a drop in water levels in streams. To address degradation of watersheds, SHUMAS embarked on the eucalyptus replacement project, through cutting down of eucalyptus and replacing with eco-friendly species like *maesopsis*, *pronus*, *polysia*, *vitex,* and *cordia*. Between 1996 and 2005, over six million environmentally friendly trees have been planted in Bui and Donga Mantung Divisions through SHUMAS' eucalyptus replacement project. Recent weather patterns and a changing climate have led to severe water scarcity and vulnerability of livelihoods system to environmental changes. Tatum, the headquarters of Nkum Sub-Division is reputed for water shortages all since 1980s.

The Nkuv-Ndzeen agrarian basin is one of the areas of drastic *anthropisation* in the Bui Plateau. In the 1970s, this frontier zone was characterized by thick cover of tropical savannah transition forest, with a normal seasonal hollow frontier and transhumance phenomenon. Like in the other basins, rainfall was regular with the onset of first rains in mid-March. There were relatively clean natural streams. The environment was relatively stable. In the 1980s, the basin was transformed into a sedentary frontier (a new permanent farming area). Rainfall was still regular with the onset of first rain in mid-March; though there were signs of extreme weather events such as the droughts of 1983–1984. With increasing *anthropisation*, there was massive deforestation, accelerated erosion in agricultural land, which led to sedimentation of water bodies. In the 1990s, intensive agriculture and grazing caused massive forest loss, leading to a decline of water resources indicating high vulnerability of human and environmental systems. From 2000–2009, this area became a sedentary basin for agro-pastoral activities, characterized by frequent cultivator-grazier conflicts, which have been persisting. The persistence of cultivator-grazier conflicts is because these activities are not compatible in the same area. Severe land degradation has transformed the landscape into desert-like conditions leading to complete loss of surface vegetation and the development of bad lands. Between 2010 and 2018, frontier settlements like Nkuv, Bamkov, Ndzeen, and Gwarkang suffered from fuel-wood crisis, water scarcity and highly susceptible to landslides, prolonged dry seasons, and a host of other environmental stressors.

The Mbokam-Ngomrin-Mbaw Nso area was traditionally a hollow frontier like the Nkuv-Ndzeen basin. In the 1970s, regular onset of first rains and stable environmental conditions were the norms. In the 1980s, the area was transformed into a sedentary basin in the same vein as Nkuv-Ndzeen. The drought of the early to mid-1980s led to disturbances of the natural state of the environment with shrinking of water resources. With the low-lying nature of this area, rice culture was experimented in the 1990s, which became an additional agrarian practice. Irregular onset of the first rains continued, leading to frequent cultivator-grazier conflicts. Water resources continued to shrink, leading to vulnerability of agrarian systems to climate variability and change. From 2000, there has been decreasing drop in maize and beans cultivation. Cultivator-grazier conflicts have also intensified. Flooding and other environmental stressors have increased leading to high vulnerability of agro-hydrological systems to changing environmental conditions.

The Djottin-Nkor-Lasin plain located north-west of the Bui Plateau is an eastern extension of the Donga-Plain. In the 1970s, there was abundant crop output, lush tropical highland forest cover, regular onset of first rains in March, and overflowing springs and springs. Like the Nkum area, there was massive elimination of coffee farms in the 1980s due to slumping of the coffee prices at the world market. The drought of the early to mid-1980s caused people to know that environmental changes were occurring. When food crop started dwindling in the 1990s, farmers resorted to the use of chemical fertilizers. The Bamti area also attracted graziers. As a result, Bamti has become one of the hotspots for cultivator-grazier conflicts. From 2010, uncertainty of weather patterns became regular. The inhabitants also faced water shortages as an indicator of climatic and environmental stressors.

The Oku-Vekovi-Tadu basin is a highland agrarian basin. In the 1970s, the area was covered by thick montane forest of the Kilum Ijim. Agricultural output was abundant. There was regular onset of first rains at mid-March, with high yielding springs and a relatively stable environment. In the 1980s, there was massive deforestation of the Kilum-Ijim forest due to population increase and the need for increased food production; the destruction of springs and disturbance of the natural state of the environment. In the late 1980s, conservation measures were put in place and enforced by legislation. A few community forests were created around the Kilum-Ijim like Ijim, Upper Shinga, Mawes, Kedjin, Emfeh-Mii, Nchiy, Mbai, and Bihkov (Vekovi). There is also a plant life sanctuary in Elak-Oku. Despite these measures, water crisis has become the order of the day in Oku because of population growth, ailing infrastructure, climate and other environmental changes. Population increase has been progressive in Oku against a backdrop of declining resource base.

The Mbiame agro-ecological basin has witnessed its own share of agro-hydrological changes since the 1970s. The 1970s were characterized by stable conditions through abundant overflowing streams, regular onset of first rains in mid-March, abundant crops output, longer fallow periods, shifting cultivation, and large expanses of tropical highland forest like the Mbiame forest. Changing environmental conditions in the early to the mid-1980s like droughts and the slumping of coffee prices pushed farmers into the Mbiame forest to open new farmlands. Despite this, there were no discernible changes in water resources. By the 1990s, agricultural output was already dropping, and farmers embraced the application of chemical fertilizers to boost production. The Mbiame forest continued to vanish, while farmers were experiencing high temperature and irregular onset of the first rains. With increasing threats of climate change and environmental degradation, some NGOs like the Centre for Nursery Development and Eru Propagation (CENDEP) and Green Care Association (GCA) stepped in to restore the Mbiame forest through soil and water conservation.

A common trait in all the basins is that the local agro-hydrological system has changed over time, though the indigenes of the Bui Plateau perceive mostly negative changes. Farmers perceived that the 1970s were characterized by flat ridging, regular onset of first rains in mid-March, massive deforestation, high coffee prices, planting of eucalyptus, severe droughts (extreme weather events) and abundant water resources. Agricultural intensification has brought major environmental changes on the Bui Plateau. Kishong village, for example is known to have been carpeted with natural forest up till the 1970's. With increasing population and the need to feed and accommodate the additional mouths, these forested areas were transformed into farmlands. In Kumbo central, there has been rapid population growth. Within the Kumbo urban space, there is land use competition for functions such as residential, commercial, and agricultural. This often leads to conflicting interests, thereby creating environmental problems within the urban space [47]. Some fallowed pieces of land are now occupied by eucalyptus. Along the Kuvlu-Banten range, there has been rapid deforestation, thereby turning natural forests into savannahs. These changes increase the vulnerability of agro-hydrological systems and weaken adaptive capacities. These systems interact with each other, so there is need to maintain them all to underpin human well-being. Global impacts and associated risks to humans are already evident for climate change, biosphere integrity, biogeochemical flows and land-system change. By 2012, the equivalent of 1.6 Earths was needed to provide the natural resources and services humanity consumed in one year [48]. Rapid and unsustainable cultivation has also intruded into natural forest patches around the Kovifem Fon's Palace, Kifem, Takui, Mount Oku, Mbiame, Nkuv, Kov Ndzeen, and montane forest communities of Nkum-Kov. Another agricultural practice is human intrusion in wetlands along stream flood plains. Along the Mairin valley, stretching from Mbimtsen are artificial levees constructed about 1 m high and 1 m in width to contain floodwaters from destroying crops during the rainy season. In some places like Takui, Kaiy, Kishong, some stream channels have been straightened and even diverted to cultivate vegetables and solanum potato during the dry season. These practices are also feasible in the Mbim valley at Ngondzen and Nseh.

4. Discussion

Indigenous environmental knowledge on the Bui Plateau is plagued by several factors. Some of these include the lack of government assistance, gender sensitivity, unreliability, changing environmental conditions, and inapplicable nature of indigenous knowledge in all aspects of daily life. Indigenous environmental knowledge is also threatened its reliance on local beliefs and taboos and difficulties to apply when some critical decisions must be made in the agrarian cycle [49,50]. Of these factors plaguing indigenous environmental knowledge practices on the Bui Plateau, the lack of government assistance appears most outstanding. The farmers perceive that the government does not promote indigenous environmental practices. It is also perceived that traditional ecological knowledge is known only by a few community members (elders, weather seers, and gifted persons). Changing environmental conditions are also threatening local farmers' knowledge because they are no longer accurate in predicting weather condition as in the past. Climate change exacerbates the difficulties already faced by vulnerable indigenous communities, such as political and economic marginalization, loss of land and resources, discrimination, and unemployment [33]. Climate change disrupts seasonal cycles of activities like agriculture, prolongs the dry season, reduces precipitation, and dries up water sources [51,52]. These changes impact on indigenous activities due to loss of seeds, bad harvests, livestock mortality, emergence of new insect pests, thereby threatening local food, and water security.

According to [53], the major threats of changing climate are erratic rainfall and rising air temperature. The intensity of rainfall has reduced, and the number of rainy days has declined leading to a decline in crop production and offsets in other ecological systems. In rural areas, farmers must sow seeds in advance. Since the crops' growth period is shortened and growing speed is accelerated, indigenes can no longer follow their tradition to plant and harvest crops like before [54,55]. The onset of the wet season in 2018, for instance, 'confused' the weather seers. While some advised farmers to sow their crops, others were reticent and convinced that the rains had really started. Those who, however, sowed early enough had abundant harvests, while those who sowed late had very poor harvests. Despite the successful and the widely recognized role of local environmental knowledge in managing natural resources and agricultural production under climate variability and change over generations [56], the knowledge faces challenges as a panacea to some climatic and other environmental related problems [57]. The knowledge is blamed being vague and unsatisfactory by failing to boost food production and economic transformation in Africa [58]. This may result in the knowledge being pushed to the margin of development practices in a very near future [59]. To some extent rural farmers are responsible in making local environmental knowledge unsuccessful. [18] argued that local knowledge lacks support from development practitioners and even households themselves may have little confidence in their own knowledge that might provide a solution to their environmental problems, even though it has done so for over generations. This makes local knowledge gradually disappear in most African countries without any tangible efforts to recognize or manage it [60].

Local knowledge is preserved in the memories of elders which means it gradually disappears due to memory lapses and deaths due to the fact that most of the indigenous practices are handed down orally or by demonstration from generation to generation and when those owning the knowledge die, or refuse to pass it to another generation, the knowledge undergoes extinction [61]. This is because most of the knowledge has not been captured, documented, recorded, and stored in a systematic way [62]. This is reflected in the African adage that 'when a knowledgeable old person dies, it is a whole library that disappears'. [9] pointed out resolutions to preserve indigenous knowledge as foot prints that may provide paths to future analysis and appreciation of the knowledge and wisdom that sustained local African cultures over time. It is being rapidly eroded by the absence of independent, codified records of the orally transmitted past by traditional community chroniclers, as opposed to formal knowledge which is successful due to its open systems with formal structures and rules to which members of organizations adhere [63]. Similarly, the way the local knowledge is transmitted, accessed, and shared in the society is not smooth but rather fragmented due to various factors such as age, gender, status, wealth, and political influence, as well as attitude, perceptions, norms, values, and belief systems inherited by the communities [64]. The knowledge is also threatened by the processes of urbanization and growth of towns into cities, which attract more migrants from African rural areas into cities and towns, hence limiting constant refreshment, transmission and or appropriate modification of indigenous knowledge [65].

Much traditional knowledge is no longer transmitted to the youth as the society becomes more involved in the market economy replacing locally used crops and plants by cultivated or market-based consumer goods [66]. Most societies owning local knowledge in Africa were once colonized [67], hence the influence of colonialism and colonial economy, which devalued all belief systems and local ways of knowing through the attribution of such descriptors as 'pagan, savage, and ungodly'. Rationalization of various processes for 'civilizing the conquered natives', contributed to the loss of important traditional values that cannot be restored. Indigenous knowledge systems have become a field of interest since communities are generally under threat from the new economic systems that continue to undermine their livelihoods, belief systems, value and interests.

5. Conclusions

The trend of weaknesses of indigenous climate and environmental knowledge on the Bui Plateau is decreasing as the government does not promote indigenous environmental practices. Traditional ecological knowledge is in the hands of a few community members (elders, weather seers, and gifted persons). Climate change would thus continue to disrupt seasonal cycles of activities like agriculture, prolongs the dry season, reduces precipitation, and dries up water sources. Local knowledge that is preserved in the memories of elders is gradually disappearing due to memory lapses and deaths creating indigenous knowledge extinction. The knowledge is also threatened by the processes of urbanization and growth of towns which attract more migrants from rural areas hence limiting constant refreshment, transmission, and/or appropriate modification of indigenous knowledge. Through indigenous environmental knowledge, Bui farmers have been able to identify changes occurring in their environment and plan their social and communal activities, such as planting, harvesting, and hunting, in response to changes in weather and climate in different seasons of the year, making informed environmental decisions for their survival through exploiting their natural resource base over generations, in spite of the variations occurring due to climate change. Current climatic conditions appear to be changing more rapidly than they were in the past, limiting the application of local environmental knowledge as adaptation strategies. It is thus, recommended that there is a need for a blend of traditional and conventional knowledge in order to ensure local sustainable development in the Bui Plateau as indigenous traditional knowledge cannot be used as a substitute for modern scientific knowledge. Both knowledge systems can be used concurrently in solving environmental problems towards attaining sustainable environmental practices. There is need for a cluster the environment-related sustainable development goals (SDGs) with the sustainable agriculture component of SDG 2 and the sustainable management of freshwater systems component of SDG 6. This overarching emphasizes the need for greater links across environmental local institutions within the goals, paired with links to the processes that impact on the long-term functioning of the Earth system.

Author Contributions: Conceptualization, design of research instruments, data collection, writing—original draft preparation, S.J.P.T.; conceptualization, writing—review and editing, J.N.K.; review of draft manuscript, supervision, Z.N.F.

Funding: Open access funding for this research was provided by the Technische Universitaet Dresden (TU Dresden).

Acknowledgments: "Open Access Funding by the Publication Fund of the TU Dresden". We deeply acknowledge the household representatives who took out time to provide the relevant data by responding to the questionnaire. Many thanks to the research assistants who supported the data collection process. We equally thank the anonymous reviewers whose comments enriched the paper.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Nakashima, D.J.; Galloway McLean, K.; Thulstrup, H.D.; Ramos Castillo, A.; Rubis, J.T. *Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation*; UNESCO & Darwin, UNU: Paris, France, 2012; p. 120.
2. Kimengsi, J.N.; Amawa, S.G.; Fondufe, S.L. Building a Strategy to Overcome the Psychological Barriers to Climate Change Management in Rural Communities of Fako Division, Cameroon. *J. Sustain. Dev.* **2016**, *9*, 14–22. [CrossRef]
3. Bate, G.B.; Kimengsi, J.N.; Amawa, S.G. Determinants and Policy Implications of Farmers' Climate Adaptation Choices in Rural Cameroon. *Sustainability* **2019**, *11*, 1921. [CrossRef]
4. Gyampoh, B.A.; Amisah, S.; Idinoba, M.; Nkem, J. Using Traditional Knowledge to Cope with Climate Change in Rural Ghana. *Unasylva (Engl. Ed.)* **2009**, *60*, 70–74.
5. Mafongoya, P.L.; Ajayi, O.C. (Eds.) *Indigenous Knowledge Systems and Climate Change Management in Africa*; CTA: Wageningen, The Netherlands, 2017; pp. 17–28.
6. Abeysinghe, A.C. *Addressing Climate Adaptation through Equity Concepts. International Institute for Environment and Development (IIED)*; Briefing: London, UK, 2013; pp. 1–4.
7. Nchu, I.N.; Kimengsi, J.N.; Kapp, G. Diagnosing climate adaptation constraints in rural subsistence farming systems in Cameroon. Gender and institutional perspectives. *Sustainability* **2019**, *11*, 3767. [CrossRef]
8. Boansi, D.; Tambo, J.A.; Muller, M. Analysis of farmers' Adaptation to Weather extremes in West African Sudan Savanna. *Weather Clim. Extrem.* **2017**, *16*, 1–13. [CrossRef]
9. UNESCO. Local and Indigenous Knowledge Systems (LINKS). 2015. Available online: http://portal.unesco.prg/science/en/ev.phpURL_ID=2031&URL_DO=DO_TOPIC&URL_SECTION=20html (accessed on 27 September 2019).
10. Swiderska, K.; Malmer, P. *Climate Change and Biocultural Adaptation in Mountain Communities: Second International Learning Exchange of the International Network of Mountain Indigenous People (INMIP)*; International Institute for Environment and Development: London, UK, 2016; p. 46.
11. Hiwasaki, L.; Luna, E.; Syamsidik Shaw, R. *Local and Indigenous Knowledge for Community Resilience: Hydro-meteorological Disaster Risk Reduction and Climate Change Adaptation in Coastal and Small Island Communities*; UNESCO: Jakarta, Indonesia, 2014; p. 60.
12. Egan, A. *Knowledge Management Strategy on Climate Change Adaptation for Cameroon*; Ministry of the Environment, Protection of Nature and Sustainable Development: Yaoundé, Cameroon, 2013; pp. 17–19.

13. Kolawole, D.O.; Motsholapheko, M.R.; Ngwenya, B.N.; Thakadu, O. Climate Variability and Rural Livelihoods: How Households Perceive and Adapt to Climatic Shocks in the Okavango Delta, Botswana. *Am. Meteorol. Soc.* **2016**, *8*, 131–145. [CrossRef]
14. Rhodes, E.R.; Jalloh, A.; Diouf, A. *Review of Research and Policies for Climate Change Adaptation in the Agriculture Sector in West Africa*; Future Agricultures, Working Paper Number 090; University of Sussex: Brighton, UK, 2014; pp. 12–18.
15. Macchi, M.; Boedhihartono, A.; Wolfangel, C.; Howell, M.; Oviedo, G.; Gotheil, S.; Cross, K. *Indigenous and Traditional Peoples and Climate Change*; International Union for Conservation of Nature: Gland, Switzerland, 2008; pp. 9–22.
16. Fernández-Llamazares, Á.; Díaz-Reviriego, I.; Luz, A.C.; Cabeza, M.; Pyhälä, A.; Reyes-Garcia, V. Rapid Ecosystem Change Challenges the Adaptive Capacity of Local Environmental Knowledge. *Glob. Environ. Chang.* **2015**, *31*, 272–284. [CrossRef]
17. Mwaura, P. *Indigenous Knowledge in Disaster Management in Africa*; UNEP: Nairobi, Kenya, 2008; pp. 21–33.
18. Briggs, J. The Use of Indigenous Knowledge in Development: Problems and Challenges. *Prog. Dev. Stud.* **2005**, *5*, 99–114. [CrossRef]
19. Senanayake, S. Indigenous Knowledge as a Key to Sustainable Development. *J. Agric. Sci.* **2006**, *2*, 87–94. [CrossRef]
20. Beckford, C.; Barker, D. The Role and Value of Local Knowledge in Jamaican Agriculture: Adaptation and Change in Small-scale Farming. *Geogr. J.* **2007**, *173*, 118–128. [CrossRef]
21. Odero, K. The Role of Indigenous Knowledge in Responding to Climate Change: Local-global Perspectives. Panel 10: Roles of Local and Indigenous Knowledge in Addressing Climate Change. In Proceedings of the African Adapt, Climate Change Symposium, Addis Ababa, Ethiopia, 9–11 March 2011.
22. Mafongoya, P.L.; Jiri, O.; Mubaya, C.P.; Mafongoya, O. Using indigenous knowledge for seasonal quality prediction in managing climate risk in Sub-Saharan Africa. In *Indigenous Knowledge Systems and Climate Change Management in Africa*; Mafongoya, P.L., Ajayi, O.C., Eds.; CTA: Wageningen, The Netherlands, 2017; pp. 43–66.
23. United Nations Convention on Climate Change-UNFCCC. *UNFCCC Handbook*; UNFCCC Secretariat: Bonn, Germany, 2006; p. 26.
24. Baird, R. The Impact of Climate Change on Minorities and Indigenous Peoples. In *Minority Rights Group International*; Briefing: London, UK, 2008; p. 12.
25. Bolden, I.W.; Seroy, S.K.; Roberts, E.A.; Schmeisser, L.; Koehn, J.Z.; Rilometo, C.H.; Odango, E.L.; Barros, C.; Sachs, J.P.; Klinger, T. Climate-related community knowledge networks as a tool to increase learning in the context of environmental change. *Clim. Risk Manag.* **2018**, *21*, 1–6.
26. International Institute for Environment and Development-IIED. *Vulnerable Communities: Getting their Needs and Knowledge into Climate Policy*; IIED Briefing: London, UK, 2015; pp. 1–4.
27. International Institute for Environment and Development-IIED. *Vulnerable Communities: Climate Adaptation that Works for the Poor*; IIED Briefing: London, UK, 2015; pp. 1–4.
28. International Institute for Environment and Development-IIED. *Biocultural Innovation: The Key to Global Food Security?* IIED: London, UK, 2018; pp. 1–4.
29. Jamshidi, O.; Asadi, A.; Kalantari, K.; Azadi, H. Perception, Knowledge and Behaviour towards Climate Change: A survey among Agricultural Professionals in Hamadan Province, Iran. *J. Agric. Sci. Technol.* **2018**, *20*, 1369–1382.
30. Fabayi, O.O.; Oloukoi, J. Indigenous Knowledge System and Local Adaptation Strategies for Flooding in Coastal Rural Communities of Nigeria. *J. Indig. Soc. Dev.* **2013**, *2*, 1–19.
31. Okonya, J.S.; Ajayi, O.C.; Mafongoya, P.L. The role of indigenous knowledge in seasonal weather forecasting and planning of farm activities by rural crop farmers in Uganda. In *Indigenous Knowledge Systems and Climate Change Management in Africa*; Mafongoya, P.L., Ajayi, O.C., Eds.; CTA: Wageningen, The Netherlands, 2017; pp. 239–254.
32. Nanja, D.H. Indigenous knowledge in weather and seasonal rainfall prediction in Zambia. In *Indigenous Knowledge Systems and Climate Change Management in Africa*; Mafongoya, P.L., Ajayi, O.C., Eds.; CTA: Wageningen, The Netherlands, 2017; pp. 295–308.
33. United Nations Permanent Forum on Indigenous Issues-UNPFII. *Climate Change and Indigenous Peoples*; Indigenous Peoples, Indigenous Voices: New York, NY, USA, 2008; p. 3.

34. Niles, M.T.; Mueller, N.D. Farmer Perceptions of Climate Change: Associations with Observed Temperature and Precipitation Trends, Irrigation, and Climate Beliefs. *Glob. Environ. Chang.* **2016**, *39*, 133–142. [CrossRef]
35. Krishna, V. Indigenous Communities and Climate Change Policy: An Inclusive Approach. In *The Economic, Social and Political Elements of Climate Change*; Springer: Cham, Switzerland, 2011; pp. 27–49.
36. International Labour Organisation-ILO. *Indigenous Peoples and Climate Change: From Victims to Change Agents through Decent Work*; ILO Office: Geneva, Switzerland, 2017; p. 45.
37. Government of Nepal. *Mainstreaming Climate Change Risk Management in Development*; Ministry of Science, Technology and Environment: Kathmandu, Nepal, 2017; p. 9.
38. Nyong, A.; Adesina, F.; Elasha, B.O. The Value of Indigenous Knowledge in Climate Change Mitigation and Adaptation Strategies in the African Sahel. *Mitig. Adapt. Strateg. Glob. Chang.* **2007**, *12*, 787–797. [CrossRef]
39. Intergovernmental Panel on Climate Change-IPCC. Climate Change 2007: Impacts, Adaptation and Vulnerability. In *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*; Cambridge University Press: Cambridge, UK, 2007; p. 976.
40. Orindi, V.A. Adapting to Climate Change in Africa: Climate Change and the Threat to African Food Security. *Int. Dev. Res. Cent. Nairobi* **2009**, *5*, 167–250.
41. Steffen, W.; Sanderson, A.; Tyson, P.; Jäger, J.; Matson, P.; Moore, B.; Oldfeld, F.; Richardson, K.; Schellnhuber, J.; Turner, B.L.; et al. *Global Change and the Earth System*; Springer: Cham, Switzerland, 2004; p. 336.
42. Häyhä, T.; Lucas, P.L.; van Vuuren, D.P.; Cornell, S.E.; Hoff, H. From Planetary Boundaries to national fair shares of the global safe operating space-How can the scales be bridged? *Glob. Environ. Chang.* **2016**, *40*, 60–72. [CrossRef]
43. Bai, X.; van der Leeuw, S.; O'Brien, K.; Berkhout, F.; Biermann, F.; Brondizio, E.S.; Cudennec, C.; Dearing, J.; Duraiappah, A.; Glaser, M.; et al. Plausible and desirable futures in the Anthropocene: A new research agenda. *Glob. Environ. Chang.* **2016**, *39*, 351–362.
44. Biermann, F.; Bai, X.; Bondre, N.; Broadgate, W.; Chen, C.-T.A.; Dube, O.P.; Jan Erisman, W.; Glaser, M.; van der Hel, S.; Lemos, M.C.; et al. Down to Earth: Contextualizing the Anthropocene. *Glob. Environ. Chang.* **2016**, *39*, 341–350. [CrossRef]
45. Ngah, R.F. *Management Annual Report for 2005*; Kumbo Water Authority: Kumbo, Cameroon, 2005; pp. 1–5.
46. Nformi, W. Kumbo Water Crisis: An Imminent Environmental Hazard. Focus on Kumbo. *Kumbo Urban Counc.* **2006**, *5*, 30–31.
47. Tume, S.J.P.; Nyuydine, A.R. Conflicting Land Uses within the Kumbo Urban Space, Northwest Region, Cameroon. *Afr. J. Soc. Sci.* **2011**, *2*, 39–53.
48. Tume, S.J.P.; Jumbam, M.S.; Nsoseka, N.A.; Nyarka, N.D.; Yenla, L.J.; Njodzeka, N.G. Role of Media in Climate Change Communication in the Northwest Region of Cameroon. In *Handbook of Climate Change Communication: Volume 2, Climate Change Management*; Leal Filho, W., Manola, E., Azul, A., Azeiteiro, U., McGhie, H., Eds.; Springer: Cham, Switzerland, 2018; pp. 47–60.
49. Kolawole, D.O.; Wolski, P.; Ngwenya, B.; Mmopelwa, G. Ethno-meteorology and Scientific Weather Forecasting: Small Farmers and Scientists' Perspectives on Climate Variability in the Okavango Delta, Botswana. *Clim. Risk Manag.* **2014**, *4–5*, 43–58. [CrossRef]
50. Mawal, E. The Baka of East Cameroon and the Challenges of Climate Change. In *Indigenous Peoples, Marginalised Populations and Climate Change: Vulnerability, Adaptation and Traditional Knowledge, Mexico City*; UNESCO: Paris, France, 2011; pp. 53–54.
51. Kimengsi, J.N.; Muluh, N.G. A Comparative Assessment of the Effect of Climatic Variations on the Crops of the Cameroon Development Corporation (CDC): Adaptation Options. *Environ. Nat. Res. Res.* **2013**, *3*, 144–156. [CrossRef]
52. Adjei, V.; Kyerematen, R. Impacts of Changing Climate on Maize Production in the Transitional Zone of Ghana. *Am. J. Clim. Chang.* **2018**, *7*, 463–476. [CrossRef]
53. Kimengsi, J.N.; Tosam, J.N. Climate Variability and Cocoa Production in Meme Division of Cameroon: Agricultural Development Policy Options. *Greener J. Agric. Sci.* **2013**, *3*, 606–617. [CrossRef]
54. Yin, L.; Zachary, M.M. Traditional Knowledge and Community-based Research in Climate Change Adaptation in East Himalayas. In *Climate Change Perception and Changing Agents in Africa & South Asia*; Tume, S.J.P., Tanyanyiwa, V.I., Eds.; Vernon Press: Wilmington, NC, USA, 2018; pp. 133–147.
55. Hart, T.G.B. Local Knowledge and Agricultural Applications: Lessons from a Ugandan Parish. *S. Afr. J. Agric. Ext.* **2007**, *36*, 229–248.

56. Jerie, S.; Matanga, E. The Effectiveness of ethno-Science Based Strategies in Drought Mitigation in Mberengwa District of Southern Zimbabwe. *J. Sustain. Dev. Afr.* **2011**, *13*, 395–409.
57. Toulmin, C.; Huq, S. *Sustainable Development: Africa and Climate Change*; International Institute for Environment and Development (IIED): London, UK, 2006; pp. 1–2.
58. Sillitoe, P.; Marzano, M. Future of Indigenous Knowledge Research in Development. *Futures* **2009**, *41*, 13–23. [CrossRef]
59. Lwoga, E.T.; Ngulube, P.; Stilwell, C. Managing Indigenous Knowledge for Sustainable Agricultural Development in Developing Countries: Knowledge Management Approaches in the Social Context. *Int. Inf. Libr. Rev.* **2010**, *42*, 174–185. [CrossRef]
60. Rankoana, S.A. Perception of Climate Change and the Potential for Adaptation in Rural Community of Limpopo, South Africa. *Sustainability* **2016**, *8*, 672. [CrossRef]
61. Mosia, L.N.; Ngulube, P. Managing the Collective Intelligence of Local Communities for the Sustainable Utilisation of Estuaries in the Eastern Cape, South Africa. *S. Afr. J. Libr. Inf. Sci.* **2005**, *71*, 175–186. [CrossRef]
62. Meyer, H.W. The Influence of Information Behaviour on Information Sharing Across Cultural Boundaries in Development Contexts. *Inf. Res. Int. Electron. J.* **2009**, *14*, 393.
63. Thomas, E. The Impact of Traditional Lifestyle, Provenance and Contact History on Plant Use Knowledge and Management: A Cross-Cultural Comparison of two Small-Scale Societies from the Bolivian Amazon. *Hum. Ecol.* **2012**, *40*, 355–368. [CrossRef]
64. Mudiwa, M. Global Commons: The Case of Indigenous Knowledge, Intellectual Property Rights and Biodiversity, Commons in an Age of Globalisation. In Proceedings of the Ninth Conference of the International Association for the Study of Common Property, Victoria Falls, Zimbabwe, 17–21 June 2002.
65. Easton, P.M.R. *Seeds of Life: Women and Agricultural Biodiversity in Africa. IK Notes 23*; World Bank: Washington, DC, USA, 2000; p. 4.
66. Kolawole, D.O.; Wolski, P.; Ngwenya, B.; Mmopelwa, G.; Thakadu, O. *Engaging Farmers and Climatologists in Adapting to Climate Variability and Change in the Okavango Delta of Botswana*; START New York and University of Botswana: New York, NY, USA, 2012; p. 105.
67. Mathews, T.; Mullan, D.; Wilby, R.L.; Broderick, C.; Murphy, C. The Household Economy Approach: Managing the Impact of Climate Change on Poverty and Food Security in Developing Countries. *Climate Risk Management* **2014**, *4–5*, 59–68.