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Climate Change Perceptions and Adaptations among Smallholder Farmers in the Mountains of Eastern Democratic Republic of Congo

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Citation: Amani, R.K.; Riera, B.; Imani, G.; Batumike, R.; Zafra-Calvo, N.; Cuni-Sanchez, A. Climate Change Perceptions and Adaptations among Smallholder Farmers in the Mountains of Eastern Democratic Republic of Congo. *Land* **2022**, *11*, 628. <https://doi.org/10.3390/land11050628>

Academic Editors: Le Yu and Elisa Marraccini

Received: 17 December 2021

Accepted: 18 April 2022

Published: 24 April 2022

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Abstract: The warming rates in many mountain areas are higher than the global average, negatively impacting crop systems. Little is known about the climatic changes which are already being observed in eastern Democratic Republic (DR) of Congo, due to the lack of long-term meteorological data. Local perceptions could help us to understand not only the climatic changes and impacts but also which adaptation strategies are already being used by local smallholder farmers. Semi-structured questionnaires were administered to 300 smallholder Bafuliru ($n = 150$) and Lega ($n = 150$) farmers living in the Itombwe Mountains. The respondents reported climatic changes and impacts, with the Bafuliru—living on the eastern drier slopes—reporting more changes and impacts. While the Bafuliru were implementing several adaptation strategies (e.g., increased irrigation and use of inputs, more soil conservation, more income diversification), the Lega were implementing very few, due to soft limits (access to inputs, markets, and information) and culture (less interest in farming, less capacity to organize into groups). The results highlight important differences in sociocultural contexts, even for one 'remote' mountain, calling for a more collaborative approach to adaptation planning and action.

Keywords: adaptation strategies; ethnicity; farmers; Itombwe Mountains; local knowledge; perceptions; wealth group

1. Introduction

It is increasingly recognised that in order to better understand the climatic changes observed and their impacts on the biophysical domain at local scales, local communities'

perceptions of climatic changes can be used to complement meteorological data scarce areas [1,2]. Research on local knowledge can also help us to understand smallholder farmers concerns and priorities, offering new opportunities to better target climate change adaptation policies and development interventions that are more fitted to the local context(s) [1,3].

Smallholder farmers have addressed (or tried to address) the effects of climate change, including food shortages and reduced health and income, e.g., [4], by implementing different measures, often classified as ‘coping strategies’—when addressing the post-disaster damages—or as ‘adaptation of strategies’, when they are carried out before a hazardous climate event occurs [5]. Sometimes, though, approaches which start as coping strategies in exceptional years can become ‘true’ adaptation strategies for households or whole communities over time [5]. In general, smallholder farmers’ adaptation strategies can be clustered into two groups: on-farm and off-farm strategies. The most common on-farm strategies are the maintenance of high agrobiodiversity—to spread the risk of crop failure among species which are susceptible to different climatic stresses—and soil or water conservation practices [6]. Two of the most prominent off-farm strategies are off-farm labour and membership in farmers’ organisations (which can facilitate technical help or access to improved seeds, inputs, credit and subsidies; see [7]). A recent review of the adaptation strategies used by smallholder farmers in Tanzanian mountains reported over 20 adaptation strategies, and showed that wealthier households generally had more options for adaptation [8]. This is because wealthier households have greater access to land, greater resources to invest in irrigation or inputs such as improved seeds or pesticides, and even better access to information and technologies (e.g., [8]).

There is an increasing interest in understanding the limits of adaptation [9] or adaptation deficits [10], with recent work on mountain systems being focused on adaptation gaps [11]. The latter authors highlighted three components of adaptation gaps: exposure, realisation and coherence. While the first component refers to the gap between the magnitude of climatic exposure and the sum of all adaptation options, the second component refers to the gap between all of the adaptation options and actual adaptation action, and the third refers to the gap between actual adaptation action and the proportion of adaptations that are in alignment with established national or international goals, such as the Paris Agreement’s Global Goal on Adaptation [11]. Adaptation gaps are context specific, and the realization gap can be particularly large in areas where social conditions (e.g., poor access to education, information or financial capital) inhibit adaptation, but other social conditions such as high social capital might foster a high adaptive capacity [11]. The Itombwe Mountains of DR Congo offer a unique opportunity for the investigation of adaptation gaps. Apart from high physical isolation and the distance to decision-making centers (urban cities), which contribute to socioeconomic and political isolation and marginalization [12], they are culturally complex systems. Cultural differences, related to ethnic differences, are known to affect adaptation, e.g., the adaptation gap might be smaller amongst cultures in which high levels of social capital foster adaptive capacity, while strong food preferences might constrain crop diversification (or staple crop change), and therefore adaptive capacity, as shown in Tanzania [8].

This article presents a case study in the mountain region of the Albertine Rift, which is a climatically complex region comprising bimodal and unimodal rainfall regime zones, with important rain shadow effects due to the highly variable topography [13]. This region comprises the western branch of the East African Rift, covering parts of Uganda, DR Congo, Rwanda, Burundi and Tanzania. The climatic patterns of this region are poorly understood, due to (i) the unreliable rain gauge coverage over central equatorial Africa [14], and (ii) the disagreement among satellite rainfall products [13,15]. Satellite-based rainfall estimates have reported a drying trend for the Congo Basin (e.g., [16]), while research from western Uganda, which combined satellite and gauge-based rainfall estimates with farmers’ perceptions, reported changes in seasons’ lengths and wetting trends caused by increased rainfall during the rainy seasons [13]. Recent work from Mt. Kahuzi in eastern DR Congo,

which also combined gauge-based rainfall estimates with farmers' perceptions, showed changing season lengths but reduced overall rainfall [4].

In the mountains of DR Congo, both on-farm and off-farm adaptation options are likely to be more limited. Recent work from Mt. Kahuzi showed that smallholder farmers were implementing only four on-farm strategies (improved seeds, new crops, irrigation, and increased farm size) and only two off-farm strategies (diversification into animal rearing, diversification into selling charcoal/timber) [4], with labour and membership in farmers' organisations not being cited. Indeed, many mountain communities continue to face socioeconomic difficulties that constrain their ability to enact their own locally appropriate responses to climate change [11]. This leads to persistent vulnerabilities and greater reliance on external actors and outside intervention [11], if such external actors are present.

This paper, focused on two smallholder farmer ethnic groups living in the Itombwe Mountains in eastern DR Congo (Bafuliru and Lega), aims to: (1) identify the changes in climate and their impacts on the biophysical system, as perceived by these farmers; (2) determine which strategies they are using to adapt to these climatic changes and their impacts; and (3) investigate adaptation gaps. We address the following research questions: (1) Have climatic changes and/or impacts been perceived by farmers, and do these differ between ethnic groups? (2) Have farmers used strategies to adapt to these impacts, and if yes, do these differ between ethnic groups or wealth groups? (3) Which adaptation gaps can be observed, do these differ between ethnic groups? This study contributes to the field with three novel aspects: (i) it is the first study to investigate how culture affects adaptation gaps in the Albertine Rift, (ii) it is the first study to document how wealth affects (or it does not) the adaptation strategies used by smallholder farmers in DR Congo, and (iii) it documents that climate change impacts have already been perceived by smallholder farmers in the Itombwe Mountains—a region for which meteorological data is unavailable. Our study provides a basis for better understanding the concerns and priorities of smallholder farmers' adaptation in mountain regions, offering new opportunities to better target climate change adaptation policies and development interventions.

2. Materials and Methods

2.1. Study Sites

We selected two farmer communities living in the northern part of the Itombwe Mountains (Mts) (Mt. Mohi 3475 m) (Figure 1), which are more easily accessible from Bukavu and are slightly less prone to insecurity due to rebel groups. The annual rainfall ranges between 1200 (the northeastern slopes) and 3000 mm yr⁻¹ (the southeastern slopes) [17]. The Itombwe Mountains have a unimodal rainfall regime with a dry season between June and July (*Kipwa*), and a rainy season from mid-August to May (*Wakati ya vula*) [14]. Important climatic differences can be observed with increasing altitude (colder and wetter), with fog being a common feature at high altitudes (personal observation; see Figure S1 in the Supplementary Material). In Bafuliru villages, the soil is clay loam with very little fine, rounded quartz gravel, and is a very dark grey at a superficial depth (0–15 cm). This soil is haplic Cambisol (Eutric) [18]. In the middle altitudes in Mwenga, the soil is clayey-sandy and very fertile due to rocks of the Lukuga series [17].

The Itombwe Mts are part of the Albertine Afromontane Biodiversity Hotspot [19], and support globally important populations of Grauer's gorillas (*Gorilla beringei graueri*), eastern chimpanzees (*Pan troglodytes schweinfurthii*) and forest elephants (*Loxodonta cyclotis*) [20]. Most of the montane forest and alpine vegetation is now part of the Itombwe Nature Reserve, which was declared in 2006 but the boundaries of which were established in 2016 [21]. Insecurity (the presence of armed groups hiding in the forest) is high throughout the Itombwe Mts, and market access is limited in the eastern part due to poor road conditions and the greater distance to the Bukavu or Uvira urban centers (Figure 1).

Several ethnic groups live around the Itombwe Mts, with the Bafuliru and Lega being two important groups ones. The Bafuliru, of Bantu origin, are a small ethnic group of

250,000 people speaking Fuliiru, whose homeland is the Ruzizi plain in the northeast of the Itombwe Mts [22]. They are predominantly farmers, although they also own and raise cattle for milk and meat [22]. They are known for being the only highland Bantu people to be organized into a ‘single, relatively small state’, which is highly centralized [23].

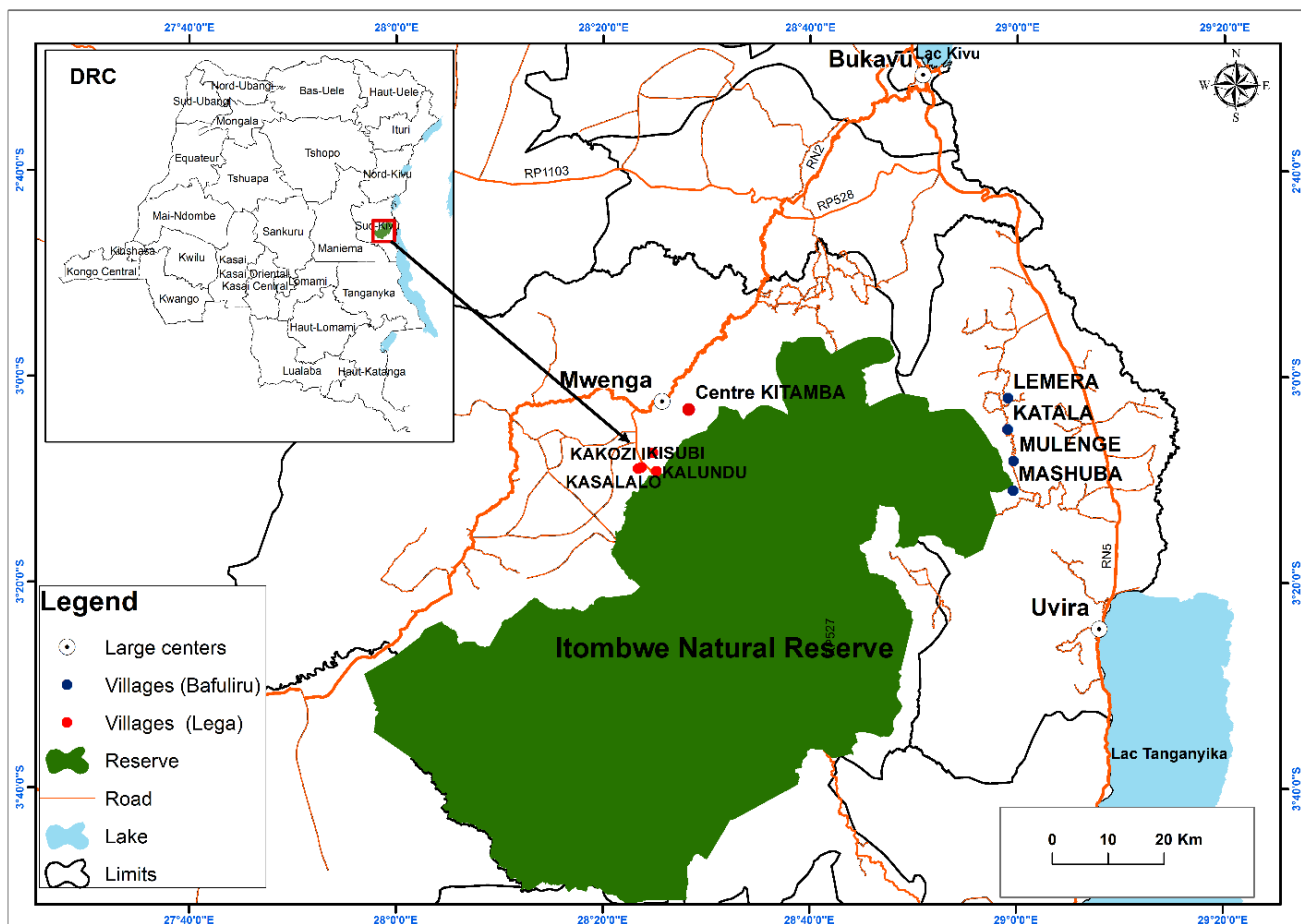


Figure 1. Study area with the location of the Lega and Bafuliru villages sampled.

The Lega (Rega or Barega), of Bantu origin, are a small ethnic group of 250,000 people speaking Kirega, whose homeland is the Mwenga territory, in the northwest of the Itombwe Mts [24]. The Lega traditionally lived by hunting and gathering, and were organised into small village groups, with no central authority. They were forced by the colonial administration to start farming in order to produce cassava and rice to feed the miners in the region [24]. In more recent years, the Lega have been increasingly engaged in panning for gold in the rivers and working in the iron ore mines of the region. The Lega are not engaged in cattle rearing, but they often engage in the pisciculture of *Tilapia nilotica*, e.g., fish ponds are often given as a bride price.

Both the Bafuliru and Lega practice small-scale rainfed subsistence agriculture, and cultivate cassava as a main staple food crop (both the roots and leaves are consumed). Farmers often intercrop cassava with maize, beans, amaranths and yam (especially the Bafuliru farmers). The use of tractors is limited due to the steep terrain and poor road infrastructure. Due to poor market access, there is no major cash crop. Examples of local farms can be seen in Figure S1 in the Supplementary Material. In the two local contexts, all of the local farmers are smallholders.

2.2. Data Collection

We administered a semi-structured questionnaire to 300 randomly selected household heads ($n = 150$ households per ethnic group) in four Bafuliru and four Lega villages (Figure 1), which represent a sample of 0.06% of the total population for each ethnic group (estimated at 250,000 people, see the previous section). In total, 150 households per ethnic group were considered an appropriate number, given the time and resources available for the research.

The questionnaires addressed household characteristics and assets, the climatic changes observed, the impacts in the bio-physical domain, and the adaptive strategies which were used to cope with or adapt to the observed changes (see the Supplementary Material). The methodological approach and the questionnaire used follow the guidelines of the project Local Indicator of Climate Change Impacts, a project focused on providing data on the contribution of local and indigenous knowledge to climate change research (see <https://licci.eu/>, accessed on 16 December 2021). The same approach (150 households per ethnic group, with a similar questionnaire) was used to survey smallholder farmers in Mt. Kilimanjaro in Tanzania [8].

The interviews were carried out in Swahili, and were facilitated by the first author between July and August 2021. All of the study participants were selected on a voluntary basis, and were first informed that the aim of the study was to better understand their everyday experiences and practices of climate change adaptation.

2.3. Data Analysis

The percentage of respondents was the main unit of analysis for each ethnic group ($n = 150$ per ethnic group). First, we explored the main patterns and differences between ethnic groups. Then, we explored the differences within the ethnic groups by pooling the respondents by wealth groups (poor, average, wealthy) based on a wealth index created from ten asset indicators [25,26]. The assets which varied most across households (over 25% of households did not own them) were weighted 0.25 greater than those which were more commonly found. Cross-tabulation tables and chi-square tests were used to determine the significant relationships between wealth groups and adaptation strategies, following [8]. We used the wealth group as an explanatory variable, and adaptation strategies as response variables. We used a significance level of $p < 0.05$. The Statistical Package for Social Science (SPSS) version 28 was used for all of the data analysis.

3. Results

3.1. Characteristics of the Smallholder Farmers Studied

An overview of the characteristics of the smallholder farmers studied can be found in Table 1. Notably, only five Bafuliru households were female-headed (there was no husband or male relative living in the household); these included average and poor households. In total, 51% of the Bafuliru respondents had never completed primary school (including both males and females). Only 13 Lega households were female-headed (there was no husband or male relative living in the household); these included average and poor households. In total, 49% of the Lega respondents had never completed primary school (including both males and females). For the Bafuliru, the ten assets considered in the wealth analysis were (in increasing order of being common): a motorbike (2% of the respondents), a farm >2 hectares (5%), >two chairs (17%), a mobile phone (26%), a solar plate (27%), >two cows (28%), a radio (36%), >two children attending primary school (41%), two containers of 20 liters of water (49%), and a machete (78%). In total, 95% of the Bafuliru respondents owned their home. Large animals referred to goats (43% of the respondents), cows (29%), or sheep (5%), no respondent owned a pig.

Table 1. Wealth analysis of the two ethnic groups ($n = 150$ Bafuliru, $n = 150$ Lega).

Bafuliru	No Household	Adults (Mean \pm std)	Farm (ha) (Mean \pm std)	Large Animals (% Households)	Main Activities	Wealth Items
Poor	$n = 37$	3.4 ± 2.7	0.48 ± 0.4	16%	100% farming	<2 items
Average	$n = 95$	3.9 ± 2.7	0.6 ± 0.6	63%	96% farming	2–6 items
Rich	$n = 18$	4.5 ± 2.1	1.3 ± 1.2	62%	94% farming	>6 items
Lega	No household	Adults (mean \pm std)	Farm (ha) (Mean \pm std)	Large Animals (% households)	Main activities	Wealth items
Poor	$n = 35$	3.5 ± 2.4	0.55 ± 0.6	6%	100% farming	<2 items
Average	$n = 90$	4.9 ± 2.7	1.2 ± 0.9	28%	99% farming	2–6 items
Rich	$n = 25$	5.9 ± 2.4	1.3 ± 0.8	76%	100% farming	>6 items

For the Lega, the ten assets considered in the wealth analysis were (in increasing order of being common): a concrete floor (5%), > two children attending primary school (20% of the respondents), a mobile phone (24%), a radio (28%), a pisciculture pond (29%), >two chairs (43%), two containers of 20 L water (45%), a solar plate (49%), and a machete (76%). In total, 94% of the Lega respondents owned their home. ‘Large animals’ refers to goats (22% of the respondents), pigs (10%) and sheep (9%); no respondent owned a cow.

3.2. Climatic Changes and Impacts

In general, the answers from the two ethnic group studied were in agreement with regard to both climatic changes and impacts (see Figures 2 and 3). Overall, respondents from both ethnic groups reported 12 changes in climate and seven impacts (Figures 2 and 3), with most of the changes and impacts being noticed by a larger number of Bafuliru respondents. The changes which were most often reported by both ethnic groups (>60% of the respondents) were changes in rainfall distribution (dry spells, showers) and interannual variability, and there being fewer foggy days and increased hailstorms (Figure 2). Most Bafuliru respondents also reported increased temperatures, a lower amount of rainfall, the late onset of the rains, less frost and more droughts (Figure 2). The impacts most often reported by both ethnic groups (>60% of the respondents) were reduced cassava yields, an increase in cassava mosaic disease (CMD), and reduced human health (Figure 3). The respondents related the reduced human health to a perceived increase in malaria prevalence (Bafuliru) or cholera (Lega). About 40% of the respondents of both ethnic groups also reported increased soil erosion and increased diseases of livestock. The Bafuliru respondents highlighted impacts on cattle (Figure 3), which the Lega did not as they do not own cattle.

3.3. Adaptation Strategies

In terms of adaptation strategies, the answers from the two ethnic group studied were not in agreement (Figure 4). Overall, the Bafuliru had implemented thirteen adaptation strategies and the Lega had implemented eleven, although for the Lega only four strategies were implemented by >20% of the respondents. The strategies most often used by the Bafuliru (>40% respondents) were the increased use of improved cassava (which is resistant to CMD), the increased use of pesticides (to address CMD), sowing seeds earlier, changing farm locations to be closer to streams (to benefit from the high water table), increasing the use of soil conservation techniques (to avoid the effects of dry spells during the rainy season), and increasing veterinary care for cattle (Figure 3). Some of the farmers also increased their farm size or used fertiliser (to compensate for lower cassava yields) (Figure 4). The increasing use of pesticides is considered an adaptation strategy by the farmers interviewed, as they link changing rainfall patterns (in particular more showers during the dry season) to an increase of cassava mosaic disease (CMD), and in order to acquire a minimum cassava yield (to feed the family) they have to use pesticide.

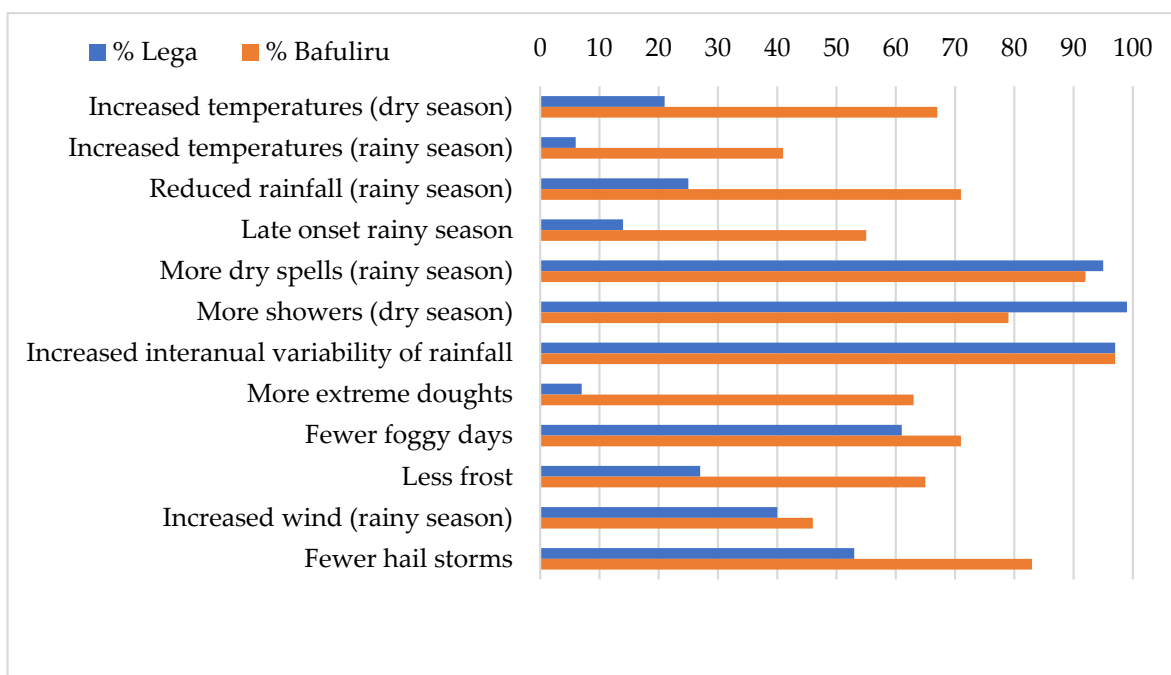


Figure 2. Perceived climatic changes per ethnic group ($n = 150$ Bafuliru, $n = 150$ Lega).

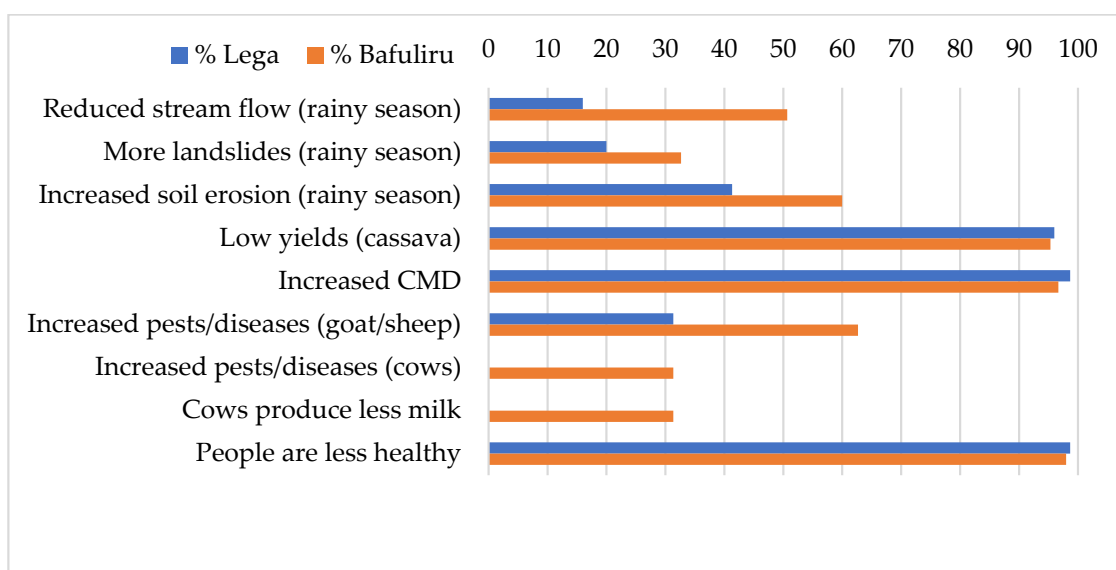


Figure 3. Perceived impacts per ethnic group ($n = 150$ Bafuliru, $n = 150$ Lega). CMD: cassava mosaic disease.

The strategies most often used by the Lega (>40% respondents) were the increased use of improved cassava, and sowing seeds earlier (Figure 4). Pesticides are difficult to find in any shop in Lega villages, and soil conservation is not widespread due to the more gentle slopes in Lega villages (compared to those of the Bafuliru).

Very few Bafuliru or Lega farmers diversified their livelihoods (e.g., animal rearing, growing and selling vegetables) to obtain other food products or cash to buy food and compensate for lower cassava yields. Notably, labour was only mentioned by one Lega respondent. Only one of these adaptation strategies—improved cassava—had been initiated by external actors, i.e., a local Non-Government Organization (NGO) (Figure 4).

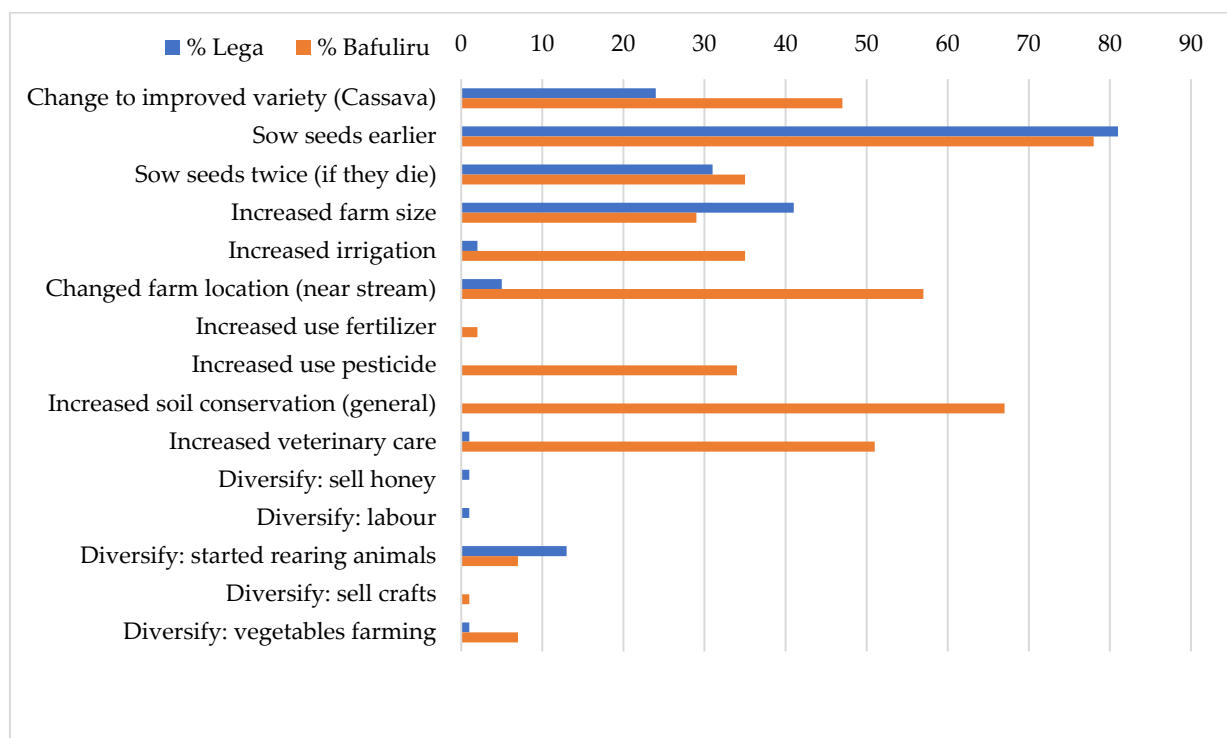


Figure 4. Adaptation strategies used per ethnic group ($n = 150$ Bafuliru, $n = 150$ Lega). Diversion ditches are the most common soil conservation technique used by the Bafuliru.

3.4. The Effects of Wealth

Among the Bafuliru, there were some significant differences across wealth groups. The wealthier households increased the use of improved cassava, sowed seeds twice (if they die due to a dry spell during the rainy season) or used veterinary care (Table 2), which would be expected given that financial means are needed to implement these strategies (e.g., to buy seeds again if they die). Contrary to our expectations, irrigation (with manually made canals) and soil conservation techniques were practiced by a similar percentage of households across the Bafuliru wealth groups—even if wealthier households should have greater financial means to pay for labour to implement these. Among the Lega, there were no significant differences across wealth groups (Table 2), probably because only four strategies were implemented by >20% of the respondents (see Figure 4).

Table 2. Differential adaptation responses by wealth groups among the Bafuliru ($n = 150$) and the Lega ($n = 150$). ‘%’ refers to the percentage of respondents within a wealth group. Bold values and * indicates significant differences across the wealth groups at $p < 0.05$, using cross-tabulation tables and chi-square tests.

Bafuliru	Rich (%)	Average (%)	Poor (%)
Change to improved variety (cassava) *	33.3	31.6	8.1
Increased irrigation	33.3	35.8	35.1
Changed farm location (near stream)	55.6	55.8	59.5
Sow seeds earlier	94.4	76.8	73.0
Sow seeds twice (if they die) *	50.0	40.0	16.2
Increased use fertiliser	0.0	2.1	2.7
Increased use pesticide	50.0	34.7	24.3
Increased use soil conservation	61.1	66.3	73.0
Increased use veterinary care (cows) *	27.7	31.5	5.4
Increased use veterinary care (goat/sheep) *	50.0	28.4	10.8

Table 2. Cont.

Bafuliru	Rich (%)	Average (%)	Poor (%)
Diversify: sell crafts	0.0	1.1	0.0
Diversify: vegetable farming	16.7	5.3	5.4
Diversify: started rearing animals	5.6	8.4	2.7
Lega	rich (%)	middle (%)	poor (%)
Change to improved variety (cassava)	16.0	11.1	8.6
Increased irrigation	4.0	2.2	0.0
Changed farm location (near stream)	12.0	4.4	0.0
Sow seeds earlier	88.0	81.1	74.3
Sow seeds twice (if they die)	36.0	32.2	22.9
Increased use veterinary care (goat/sheep/pig)	8.0	0.0	0.0
Diversify: honey	0.0	2.2	0.0
Diversify: vegetable farming	0.0	2.2	0.0
Diversify: labour	0.0	1.1	0.0
Diversify: started rearing animals	12.0	12.2	14.3

4. Discussion

4.1. Climatic Changes

The results indicate that climatic changes have already been perceived by smallholder farmers in the Itombwe Mts, and that in general, these perceptions do not differ between ethnic groups. Overall, respondents from both ethnic groups reported changes in rainfall distribution within and between years, reduced fog and hailstorms but increased strong winds during the rainy season. Most Bafuliru respondents also highlighted increased temperatures and the reduced duration and amount of rainfall during the rainy season. Most likely, these small differences in perceptions observed are related to diverging local climates on different sides of the Itombwe Mts chain. Although field measurements of rainfall and temperature are unavailable [17], based on the vegetation patterns the northeastern side (which the Bafuliru inhabit), it is drier than the northwestern side (which the Lega inhabit) (see [19]). Therefore, it is most likely that small changes in temperatures or rainfall are more pronounced in the areas which are drier and hotter. The overall agreement between Bafuliru and Lega perceptions of climatic changes support the notion that different ethnic groups inhabiting nearby areas report similar changes in climate (e.g., [4]).

The climatic changes reported by the Bafuliru and Lega generally agree with the changes reported by farmers around Mt. Kahuzi [4] and Bukavu [27], who noted increased temperatures, shorter and less rainfall during the rainy season, the increased occurrence of dry spells and strong winds during rainy season, and more rain showers during the dry season. Compared with other studies in mountains in the Albertine Rift region, increased temperatures were also reported by farmers in the Rwenzori Mountains (Uganda), while a late (or unpredictable) onset of the rainy season was also reported in Kibale National Park (NP, Uganda) and Volcanos NP (Rwanda) [28,29]. Overall reduced rainfall was reported from Kibale NP, as in our study, but increased rainfall—mostly due to fewer but heavier precipitation events—was reported in the Rwenzori Mountains [29,30]. Reduced rainfall was also reported by farmers in Mt. Kilimanjaro and the Udzungwa Mountains in Tanzania (see [8]).

Likewise, in our study, the farmers around Mt. Kahuzi also reported less fog and fewer hailstorms [4]. The farmers in Mt. Kilimanjaro and the Udzungwa Mountains also reported reduced fog [8], while Mt. Elgon in Uganda (which is not in the Albertine Rift region) reported increased hailstorm frequency [31]. Most studies on farmers' perceptions of climatic changes do not investigate fog or hailstorms, even if both can have important impacts on crop yields, e.g., fog can extend the length of the growing season for beans [32] while hailstorms can destroy crops. In summary, our study highlights that smallholder farmers report numerous climatic changes beyond rainfall and temperature, as highlighted

by other authors (e.g., [4]). In areas where no meteorological data are available, local perceptions can help us to understand local climates and impacts [1,2].

4.2. Impacts

Similarly to the climatic changes, the results indicate that in general, the perceptions of impacts do not differ between ethnic groups. Overall, respondents from both ethnic groups reported a reduction in cassava yields, an increase in CMD, and reduced human health, while the Bafuliru also mentioned reduced health for cattle and an increase in soil erosion and floods. Because the Lega do not own cattle, they could not report such changes. With regard to an increase in soil erosion and floods, the area where the Bafuliru live might be more prone to floods and soil erosion during intense rains, because of steeper terrains next to the Rusizi floodplain. Farmers in Mt. Kahuzi also reported increased soil erosion and floods [4], which they related to both climatic changes and increased deforestation in the area where they lived. In this study, some Bafuliru also mentioned local deforestation as a potential driver of increased soil erosion. Increased soil erosion associated with heavy rains was also reported by local farmers living around Volcanos NP, and increased floods and landslides were reported in Mt. Elgon [28,31].

In Mt. Kahuzi, about 60% of the farmers reported reduced cassava yields, and that goats were now less healthy [4]. Reduced cassava yields were not reported by other studies in the mountains of Uganda, Rwanda or Tanzania, but cassava is not the main staple crop on such mountains. However, the farmers on such mountains also reported reduced crop yields, which they linked to climatic changes, e.g., maize and beans [8]. CMD is known to be the principal constraint of cassava production in sub-Saharan Africa [33,34]. Beyond climatic changes, new strains and certain agronomic practices are favourable to the virus' spread [35]. In our study area, the participants linked an increase in showers during the dry season to increased disease prevalence. Given that cassava is the source of food and income for about 70% of the population in DR Congo—not just in mountain areas—CMD represents an important threat to food security in this country [35]. The integration of farmers' perceptions of drivers of crop disease could open pathways towards potential solutions for the increased spread of this disease. As highlighted by Labeyre et al. [36], the increased integration of farmers' knowledge can complement the limited scope of current agricultural research on the impacts of climate change, which is focused on a small number of cereal crops.

With regard to cattle health and reduced milk production, such impacts have been reported in other mountains, e.g., in northern Kenya [32] or Mt. Kilimanjaro [8]. In Kenya, reduced cattle health and milk production were related to reduced fodder availability and quantity, which were in turn related to changing rainfall patterns. In this study, the Bafuliru farmers also linked it to reduced fodder availability in the area, and increased diseases such as foot-and-mouth disease. As highlighted by other authors (e.g., [37]), local perceptions can help identify impacts that may be largely overlooked by government and development agencies. The integration of farmers' perceptions of drivers of cattle disease could also help to address such challenges.

4.3. Adaptation Strategies, Wealth, and Adaptation Gaps

Contrary to perceptions of climatic changes and impacts, large differences were observed between the Bafuliru and the Lega, with the Bafuliru implementing several adaptation strategies, and the Lega implementing fewer. The Lega mostly sowed seeds earlier, sowed seeds twice if they died, increases their farm size (to compensate for lower yields), used improved cassava varieties (which were resistant to CMD) and increased veterinary care for goats—all of which were cited by farmers in Mt. Kahuzi [4]. Notably, sowing seeds twice if they die could be perceived as a 'coping mechanism', rather as an adaptation strategy, as it is a mechanism which is often constrained by the availability of enough resources (seeds or cash to buy seeds again). Several factors might explain why Lega implemented fewer adaptation strategies. First, market access is limited for the Lega; therefore, there is a

limited availability of inputs (e.g., pesticide) and room for selling crop surplus, vegetables or crafts (therefore, there is no motivation to diversify into such strategies). Second, the environmental context is different to that of the Bafuliru: the terrain is less steep (there is less need for soil conservation techniques) and rainfall is generally more abundant (there is less need for irrigation). Third, culture is also likely to explain some differences, as Lega do not place a high value on farming (as a livelihood activity defining identity or social status), but they place higher value on, e.g., pisciculture or hunting.

All of the adaptation strategies mentioned by the Bafuliru have been reported by previous studies, such as in Mt. Kahuzi [4] or elsewhere in the Albertine Rift. For example, changing planting dates, soil conservation practices, irrigation and agroforestry were mentioned by farmers in the Rwenzori Mountains [29]. An important difference with other studies is the fact that only one Lega mentioned labour as a livelihood diversification option. This can be explained by the limited availability of labour jobs—such as engaging in tea plantation, timber plantation, transporting goods in a market town, or being a shop assistant in market town—in the study areas. Furthermore, diversifying into off-farm activities such as mining, timber harvesting, or charcoal production—strategies mentioned in Mt. Kahuzi [4]—were not cited in our study as adaptation strategies. However, diversifying into mining is common among the Lega, but this is mostly driven by economic motivations, and it is not considered a climate change diversification strategy.

In our study, wealth had an effect on the adaptation strategies used amongst the Bafuliru but not the Lega. Numerous studies have documented that wealthier households generally have more options for adaptation, as they have greater access to land, and greater resources to buy inputs such as improved seeds or pesticides, to pay for irrigation, or even to access information and technologies (e.g., [8]). However, our findings show that wealth effects are not so straight-forward. For the Lega, due to their disconnection from markets, wealthier households were not able to implement more strategies, highlighting how important it is to consider the local socioeconomic context(s), not just wealth.

With regard to the three components of adaptation gaps (exposure, realisation and coherence) [11], the main difference between ethnic groups is realization. It could be argued that exposure (the gap between the magnitude of climatic exposure and the sum of all of the adaptation options) is similar for both groups, as both ethnic groups live in the same mountain and report similar climatic changes and impacts. For coherence, the gap between actual adaptation action and the proportion of adaptations that are in alignment with 'national or international' established goals, it could also be argued that it is similar for both groups, as both are located in the same political context, i.e., DR Congo. However, realization (the gap between all adaptation options and actual adaptation action) is different, as the Bafuliru are using more adaptation strategies compared to the Lega. Both soft limits (access to inputs, markets, and information) and culture (less interest in farming, less capacity to organize into groups) seem to explain the differences in the realization gap.

4.4. Limitations and Future Research

Our study approach has some limitations. First, we only studied four villages per ethnic group. In our study area, biophysical or socioeconomic differences across the villages of one ethnic group are rather limited (e.g., market access or the presence of external change agents). However, it is possible that by including more villages, different adaptation strategies could be identified. We also only focused on two ethnic groups living around the Itombwe Mts, but there are others, including, e.g., the Banyamulenge, for whom cattle rearing is the main livelihood activity. In order to obtain an overview of the adaptation options in these mountains, future research should consider the different ethnic groups. As highlighted by [38], the exchange of knowledge not just between local farmers and scientists but also among different communities and mountains could be vital in order to devise efficient adaptation. Furthermore, although we interviewed female respondents, most of the female respondents were married. Future work should also investigate adaptation options for female-headed households. Last but not least, we should acknowledge that

we focused on climatic changes as the main challenge to farmers' livelihoods. However, other drivers of change are likely to act synergistically with climatic change, constraining adaptation options, including insecurity, as we further discuss below.

The results highlight important differences in sociocultural contexts, even within one 'remote' mountain, calling for more a collaborative approach to adaptation planning and action. In order to address soft limits, the smallholder farmers we studied need external support, together with greater implementation resources. External support should focus on mutual learning among actors, in order to ensure the sustainability of the adaptation strategies implemented (e.g., [39]). One option for this 'isolated' mountain context is to foster social capital, e.g., in parts of the Andes, farmers' organizations provide an alternative to non-existing government support [40]. The Lega, who seem to show weaker social capital, might need more support than the Bafuliru to enhance organization. In order to address hard limits (infrastructure, insecurity, and the technical solutions available), external support is also needed. Accessibility to markets depends on the infrastructure and transport system in a region, which can make farm-households more vulnerable if they are inadequately developed [41]. Although there have been numerous attempts to tarmac the N2 national road between Bukavu and Mwenga (the main town among the Lega studied), none of them have been successful. Apart from improving roads and the mobile phone network—which can, e.g., facilitate access to microcredit—increased security from the rebel groups present in the Itombwe Mts, who control illegal mining sites [42], would also be beneficial, as farmers would be more keen to invest in strategies which can only benefit farmers in the mid-term (e.g., investment in irrigation infrastructure, agroforestry, and cash crops). More scientific research is also needed on climate change impacts on cassava. Beyond CMD, whitefly, brown streak disease, and cassava mealybug are predicted to be major challenges to this crop in the future [43]. We also recommend the urgent establishment of several meteorological stations around the Itombwe Mts, in order to help understand local microclimates, monitor climatic changes, and help prepare detailed weather forecasts, which could help, e.g., to advise farmers on planting dates.

5. Conclusions

This study aimed to investigate climate change perceptions and adaptations among smallholder farmers in the Itombwe Mountains of eastern DR Congo. The results show that numerous climatic changes and impacts have already been perceived by farmers, and that these perceptions do not differ between ethnic groups. The results also show that farmers have used up to 13 adaptation strategies, and that the adaptations differed between ethnic groups due to soft limits and culture (less interest in farming, less capacity to organize into groups).

Overall, apart from helping to understand the effects of culture (ethnicity) and wealth on adaptation, our findings on climate change perceptions and the adaptation strategies used by the Bafuliru and Lega smallholder farmers of the Itombwe Mountains in eastern DR Congo contribute to filling in the data gap on indigenous adaptation strategies used in Central Africa [44]. This is key information which will be needed if the IPCC is to better integrate indigenous knowledge in this continent (e.g., [44,45]).

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/land11050628/s1>, Figure S1. Top left: fog as a common climatic feature at high elevations. Top right: example of a farm with cassava intercrop with beans. Bottom left: example of weeds left to dry out and act as soil cover to maintain soil moisture. Bottom right: examples of farms on steep slopes (terracing is not common in both study areas).

Author Contributions: Conceptualization, G.I., A.C.-S. and B.R.; Methodology, R.K.A. and A.C.-S.; Data gathering, R.K.A. and R.B.; Formal analysis, R.K.A., G.I. and A.C.-S.; Writing—original draft preparation, R.K.A., B.R., G.I., N.Z.-C. and A.C.-S.; Revisions: R.K.A., G.I. and A.C.-S. All of the authors reviewed the final draft of the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: We acknowledge funding from Ecole Régionale d’Aménagement et Gestion Intégrés des Forêts et Territoires Tropicaux (ERAIFT) and Rainforest Foundation Norway (RFN).

Institutional Review Board Statement: Ethical review and approval were received for this study from the Ethics Committee of Integrated Management of Tropical Forests and Lands’ Department of Ecole Régionale Post-universitaire d’Aménagement et Gestion Intégrés des Forêts et Territoires Tropicaux (ERAIFT).

Informed Consent Statement: Informed consent was obtained orally from all of the subjects in the study.

Data Availability Statement: The data that support the findings of this study is available for scientific purposes from first author upon reasonable request.

Acknowledgments: We are deeply grateful to our study participants, who graciously shared their time, energy, and stories. We thank our field assistants and facilitators for making this research possible.

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

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