Cuni-Sanchez, A., I. Twinomuhangi, A. Berta Aneseyee, B. Mwangi, L. Olaka, R. Bitariho, T. Soromessa, B. Castro, and N. Zafra-Calvo. 2022. Everyday adaptation practices by coffee farmers in three mountain regions in Africa. Ecology and Society 27(4):32.
https://doi.org/10.5751/ES-13622-270432

Research, part of a Special Feature on Everyday Adaptations to Climate Change

Everyday adaptation practices by coffee farmers in three mountain regions in Africa

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ABSTRACT. Mountain environments in East Africa experience more rapid increases in temperature than lower elevations, which, together with changing rainfall patterns, often negatively affect coffee production. However, little is known about the adaptation strategies used by smallholder coffee farmers in Africa. Using the lens of everyday adaptation, semi-structured interviews were carried out with 450 smallholder farmers living near the Bale Mountains in Ethiopia (n = 150), Mount Kenya in Kenya (n = 150), and Kigezi Highlands in Uganda (n = 150). We report similarities in adaptation strategies used (e.g., increased use of improved seeds, inputs, soil-conservation techniques) but also differences across and within regions (e.g., irrigation, coffee-farming abandonment), related to different biophysical, economic, and sociocultural factors. In all regions, access to land, funds, and limited mutual-learning opportunities between farmers and other agents of change constrained further adaptation options. Local people have capacity and means to determine how best they can adapt to climate change, and government agencies and NGOs could implement more participatory engagement with smallholder coffee farmers, attuned to the opportunities and constraints in everyday life to facilitate adaptation to predicted changes in climate.

Key Words: *adaptation; Africa; climate change; mountain regions; subsistence farmers*

INTRODUCTION

Mountain environments in East Africa, like mountain regions elsewhere, are predicted to experience more rapid changes in temperature than environments at lower elevations, because the rate of warming is amplified with elevation (Pepin et al. 2015). Apart from increased temperatures, increased rainfall, coupled with increased rainfall seasonality, is also predicted for most highlands in East Africa (Platts et al. 2015). Such changes are predicted to negatively impact the yields of numerous crops, including coffee (Bunn et al. 2015, Moat et al. 2017). Coffee, mostly grown by smallholder farmers in mountain regions, is a major cash crop in East Africa. In Ethiopia, coffee farming provides livelihoods for around 15 million farmers (Tefera 2015) and generates 25% of the country's export earnings (Minten et al. 2014). In Uganda, coffee generates 18% of the country's export value, and coffee farming employs 1.7 million smallholder farmers (UCDA 2015). In Kenya, there are about 700,000 coffee farmers, 99% of whom own less than five ha (Karuri 2020). Notably, beyond being a commodity crop, for some farmer communities coffee is a religious object, a communication medium, a heritage, and an inheritance (e.g., in the Jimma Zone of Ethiopia; Bulitta and Duguma 2021). For such farmer communities, coffee symbolically represents much of what is prized in life: procreation, human relationships, peace, wealth, prestige, access to credit, having an asset to pass to descendants, and a healthy, shaded, well-watered environment, among others (Bulitta and Duguma 2021).

Most coffee is produced from two species: 70% of global production is from the higher quality Arabica coffee (*Coffea arabica*) whereas Robusta coffee (*Coffea canephora* var. *robusta*) accounts for the remaining 30% of global production, according to the United States Department of Agriculture's production, supply, and distribution database (https://apps.fas.usda.gov/psdonline/app/index.html#/app/home). The negative effects of climate change are already evident for many Arabica and Robusta coffee farmers in East Africa. Changing rainfall patterns directly affect the flowering of the coffee plants which impacts coffee yields (Mwaura 2010, Mugo 2016). With increased temperatures, the coffee berry borer (*Hypothenemus hampei*), one of the most destructive coffee pests in the world, will continue to expand its distribution range to higher elevations (Jaramillo et al. 2011). Indeed, there is an increasing concern that climate change will negatively affect coffee yields and the livelihoods of the smallholder farmers that depend on them. For example, a modeling study by Moat et al. (2017) suggests that 39–59% of the current growing area of Arabica coffee in Ethiopia could experience climatic changes that are large enough to render them unsuitable for coffee farming by the end of the century. Modeling studies also show a decrease in habitat suitability for Robusta coffee in Uganda by 2050 (Bunn et al. 2015). Robusta coffee is generally more heat tolerant but is more susceptible to low temperatures than Arabica coffee (Wintgens 2009). Although Robusta can sustain higher temperatures than the higher quality Arabica, it is uncertain whether it can replace the latter on commodity markets (Bunn et al. 2015).

Smallholder coffee farmers have started to implement a wide range of coping or adaptation strategies. For example, in the Robusta coffee region of central Uganda (Luwero, Nakaseke, and Nakasongola districts) adaptation strategies include the use of inorganic fertilizers and pesticides and a change of crop varieties

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(Mulinde et al. 2019). In the Arabica coffee–growing Jimma region of southwestern Ethiopia, the most common adaptation measures are the adjustment of planting dates, changing the crop types and varieties, and increasing shade in coffee and mixed farming (Eshetu et al. 2021). However, to our knowledge, no cross-country comparative studies have been carried out so far. It is argued that better understanding of farmers' adaptation practices and processes at different levels will enable the formulation of more targeted and appropriate climate-change adaptation policies (Adger and Vincent 2005) and the creation of an enabling environment to support adaptation of smallholder subsistence farmers (Bryan et al. 2009).

Mountains are often biophysically and sociopolitically complex systems, where physical isolation and distance from centers of power and decision-making (i.e., urban centers) contribute to socioeconomic and political isolation and marginalization (Klein et al. 2019). Because of this, local peoples have often relied on autonomous interventions such as those initiated by local agents of change within their communities. Local agents of change are individuals, e.g., farmers, who influence others' innovation decisions in a direction deemed desirable for adaptation (Rogers 1995). Local agents of change also enable other farmers to learn the best ways of applying new and improved knowledge and technology and to judge their usefulness and effects (Monge et al. 2008). Local institutions are a key moderating force between large-scale adaptation plans and their adoption at the local level (Agrawal and Lemos 2015). Notably, lack of adoption of certain interventions has sometimes been allied with resistance to external power and interventions, which cannot see smallholder farmers' role as active partners, other than as aid recipients (Artur and Hilhorst 2012).

Adaptation can be understood as a day-to-day learning process, a process by which some adaptation interventions become habitual components of everyday life. Indeed, it is crucial that interventions get incorporated into the everyday practices of agents to be effective (Vogel and Henstra 2015). Castro and Sen (2022) define everyday adaptation as "the shifted ways a person works, eats, lives, and thinks in response to climate realities." Farmers are learning each day in response to changing environmental conditions, which allows them to have more innovative production models and enhanced adaptive capacity (Tran 2020). Contextual opportunities and constraints such as availability of land, proximity to a water source, and availability of funds for adaptation investments have an impact on what adaptations become everyday practices, long-term, versus those that are experimented with and abandoned. Individual and cultural values (e.g., place attachment, identity, perception of what is a dignified life) also shape individuals' decision-making regarding everyday adaptation (Henrique and Tschakert 2022).

There is an increasing number of scholars who focus on a people-centric understanding of adaptation and limits, with a special focus on everyday adaptation (Henrique and Tschakert 2022, See et al. 2022, Castro and Sen 2022; see also other papers in this special issue). Paying attention to how adaptation unfolds in everyday spaces provides an entry point to understanding not only "where, when, and how barriers and limits to adaptation arise" but also "how and for whom adaptation is constrained and limited" to devise context-relevant adaptation efforts and just trade-offs (Barnett et al. 2015). As highlighted by other authors (e.g., See et al. 2022), local peoples have the capacity and means to determine how best they can adapt to climate change, and government agencies and NGOs can play an active role in supporting their own efforts and practices.

Here we use the lens of everyday adaptation (i.e., understanding adaptation as a day-to-day learning process linked to everyday practices) to investigate variations in smallholder coffee farmers' adaptations to climate change across and within three East African mountains. We focus on understanding the ongoing process of adaptation in everyday life rather than on the adaptation outcomes. We identify and discuss both similarities and differences in everyday adaptation practices across and within study regions; discuss main constraints affecting adaptation practices; and draw recommendations for local action in other mountain contexts in Africa.

METHODS

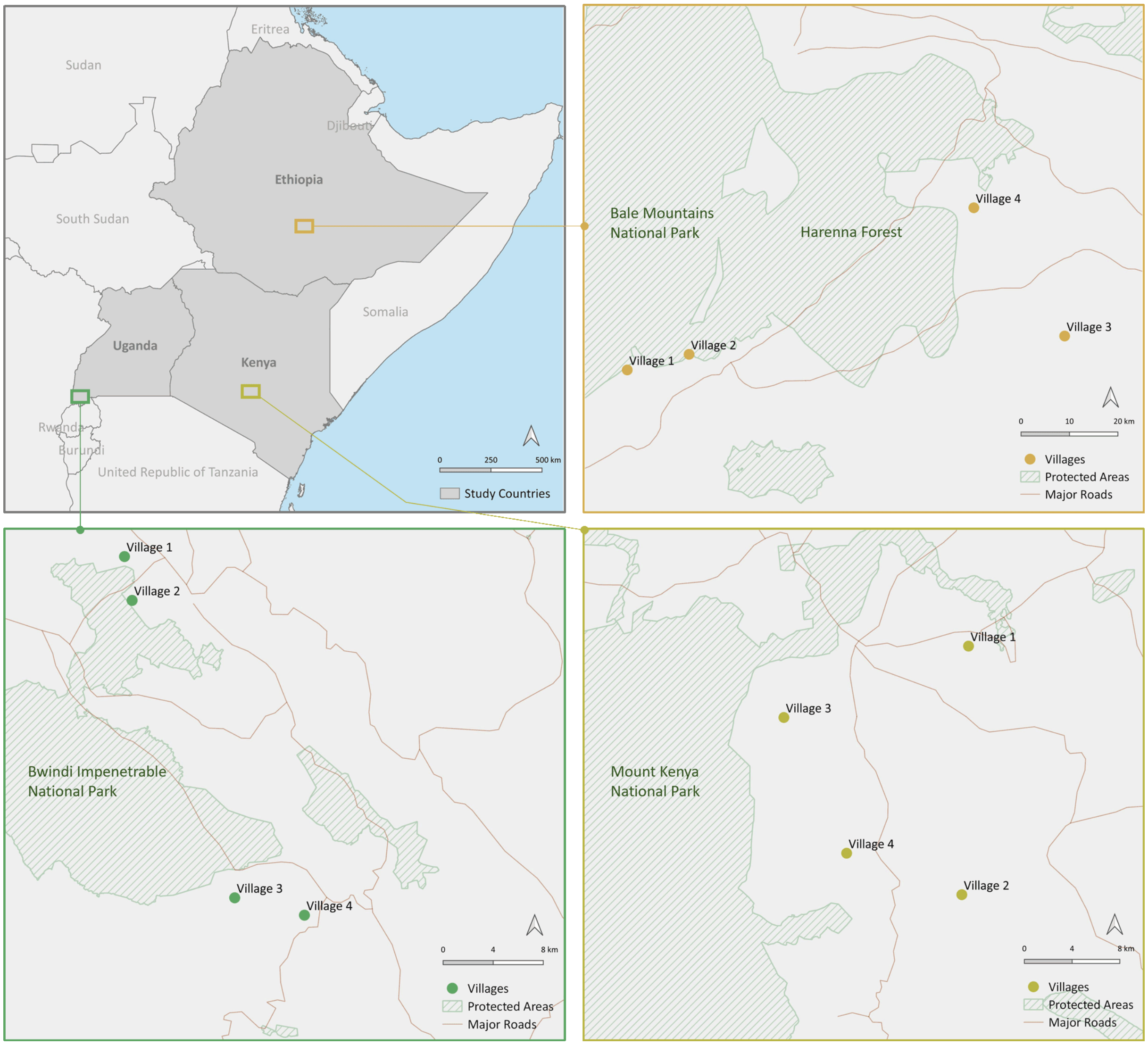
Study regions

We focused on the smallholder coffee-farmer communities living in three mountain regions in Africa: the Bale Mountains (Ethiopia), Mount Kenya (Kenya), and Kigezi Highlands (Uganda; Fig. 1). We selected these mountain regions to represent different socioeconomic (e.g., ethnicity, distance to capital) and political contexts. Whereas Arabica coffee is widespread in the first two sites, Robusta coffee is common in Kigezi Highlands.

The Bale Mountains are located in the Oromia region of southeast Ethiopia (Fig. 1). Around these mountains, coffee farming only occurs on the southern slopes, in the area adjacent to the Harenna Forest. The area around the Harenna Forest (1400–1800 m asl) has a bimodal rainfall regime with short rains (*arfaasaa* in the Oromo language) in April to June and long rains (*ganna*) from July to September. Rainfall and temperature change with increasing elevation and aspect. At Harenna Forest, mean annual rainfall is 1000 mm and mean annual temperature is 19°C (Schmitt et al. 2013). Population density around Harenna Forest is high, Oromo being the most abundant ethnic group. The Oromo people, of Cushitic origin, are the largest ethnic group in Ethiopia and represent 34.5% of Ethiopia's population (http://www.statsethiopia.gov.et). Around Harenna Forest, Oromo farmers cultivate both food (maize, teff, and mung bean) and cash crops (coffee and sesame; Alemayehu and Woldeamanuel 2017). Notably, local residents have managed and harvested wild coffee from Harenna Forest for centuries, with rights to harvest regulated by customary laws (Wakjira et al. 2013). Numerous Oromo farmers also raise animals, typically cows and donkeys (Abate et al. 2012). Most Oromo in the region are Muslim and men are often polygamous (Nigatu et al. 2014).

Mount Kenya is an extinct volcano located in central Kenya (Fig. 1). The region has a bimodal rainfall regime with long rains (*mvua refu* in Swahili) falling between March to May and short rains (*mvua fupi*) from October to December. On the southeastern slopes, annual rainfall is 2300 mm (KFS 2019). The slopes of Mount Kenya have high population density: 318 people per km² (County Government of Meru 2018), Meru being an important ethnic group in the area. The Meru or Amîîrú people are a farmer ethnic group of Bantu origin whose ancestral lands are the eastern slopes of Mount Kenya. There are about two million of them in

Fig. 1. Selected study areas.



Kenya (KNBS 2019). The Meru cultivate both food (maize, beans, Irish potatoes) and cash crops (coffee, tea, bananas, avocados, macadamia, and khat). Most Meru also raise animals, typically cows and goats. Most Meru are Christian.

Kigezi Highlands are located in southwestern Uganda (Fig. 1). The area has a bimodal rainfall regime with long rains (*katumba* in Rukiga) falling between March to May and short rains (*musenene*) from October to December. At about 1600 m elevation, mean annual rainfall is 2000 mm and temperature ranges between 15–30°C (Mann 2013). Kigezi Highlands have high population density: 300 people per km² (Bamwerinde et al. 2006), Bakiga being an important ethnic group in the area. The Bakiga or Kiga people, of Bantu origin, are a farmer ethnic group of southwestern Uganda and northern Rwanda, their ancestral lands being Kigezi Highlands. There are about 2.3 million of them in Uganda (UBOS 2016). The Bakiga cultivate both food (maize, sweet potatoes, beans, and sorghum) and cash crops (coffee and Irish potatoes). Some Bakiga also raise animals, mostly goats and pigs. Despite most of them being Christian, there is prevalence of polygamy in Bakiga culture (Just and Murray 1996).

In all three regions, farmers cultivate small farms (< 5 ha), often located on steep slopes and marginal areas. Because of this, soil degradation and erosion challenge farming activities in Kagezi (Hartter et al. 2015), Mount Kenya (County Government of Meru 2018), and Bale (Hailemariam et al. 2016). In all three study regions, the mechanization process is limited due to steep slopes and complex terrains.

Data collection

Data collection took place between February and June 2021. In all study regions, we first conducted exploratory focus-group discussions (FGDs) with four to five elders in four villages, two villages located at higher and two at middle elevations (Fig. 1). These were used to modify a common semi-structured questionnaire to each study context and to build trust among the communities. During the FGDs we also gathered information on change agents, such as who initiated a given adaptation strategy; how interventions usually get incorporated, or not, into the everyday practices of farmers; and which factors were the main constraints to adaptation.

Then, we administered semi-structured questionnaires to 150 randomly selected household heads while also aiming at equal numbers of males and females (50% male and 50% female) in the same villages. Questionnaires addressed household characteristics and assets, adaptive strategies used to cope with or adapt to observed changes, and information on three factors that could enhance or limit adaptation: access to improved seeds, weather forecasts, and climate-change literacy (Appendix 1). Climate-change literacy was defined as a combination of climate-change awareness (having heard of the concept of climate change) and the knowledge and acceptance of its anthropogenic cause. Climate-change literacy is recognized with high confidence by the IPCC as contributing toward climate action (IPCC 2019). The methodological approach and the questionnaire followed the guidelines of local indicators of climate-change impacts (LICCI), a project focused on providing data on the contribution of local and indigenous knowledge to climate-change research (https://licci.eu/). The same approach was used to survey coffee farmers in Mount Kilimanjaro in Tanzania (Kaganzi et al. 2021; see questionnaire in Appendix 1).

The exploratory FGDs and the interviews were carried out in Oromo (the Bale Mountains), Swahili (Mount Kenya, with some clarifications made in English, Kikuyu, or Meru), and Rukiga (Kigezi Highlands), and were facilitated by three of the co-authors between March and June 2021. All study participants (FGDs and interviews) were selected on a voluntary basis and were first informed that the aim of the study was to better understand their everyday practices with respect to climate-change adaptation. Free, prior, and informed consent was orally secured after reading a consent form in the local language, which clarified the study aim, voluntary participation, confidentiality, and procedure for withdrawal from the study. We followed the guidelines on ethical research of the British Sociological Association (BSA 2017) when conducting interviews. The research was approved following ethical review at University of York.

Researcher positionality, i.e., an individual's worldview and the position they adopt about a research task and its social and political context, is known to affect the process of data gathering and results interpretation (Coghlan and Brydon-Miller 2014). In each target country, data gathering was led by a researcher from the same ethnic group studied, who had previously worked in the study area targeted: someone who could be considered an insider. Because of this, and also because of, first, the use of a standardized questionnaire and, second, the engagement in reflexive practice during eight webinars used to coordinate results interpretation across sites, we consider that researchers' positionality across sites was rather uniform.

Due to the predominance of agriculture-based livelihoods and historical sedentary settlements and culture, throughout the paper we refer to our study respondents as farmers, but we acknowledge multiple livelihood strategies. Percent of respondents was the main unit of analysis for each mountain. First, we explored main patterns and differences across mountains. Then, we explored differences within mountains, by pooling respondents into the four different villages sampled in each mountain.

RESULTS

Main household characteristics of farmers studied can be found in Table 1. Household characteristics in Mount Kenya and Kigezi Highlands were more similar to each other than in the Bale Mountains, where farm size was smaller (0.5 versus 2–3 ha), average household size was greater, and primary school education was not widespread. Fewer households in Kigezi Highlands compared to Mount Kenya owned domestic animals or a radio. Notably, whereas 89% of households interviewed in Ethiopia engaged in coffee farming, 40–50% of households interviewed in Mount Kenya and Kagezi Highlands engaged in coffee farming (Table 1). Numerous households in these latter sites mentioned having cultivated coffee in the past, but having abandoned it due to low (or fluctuating) coffee prices, and/or reduced yields.

Table 1. Main household characteristics of the farmers studied in each site.

	Bale Mountains	Mt Kenya	Kigezi Highlands
Annual rainfall (mm)[†]	1000 (bimodal)	2300 (bimodal)	2000 (bimodal)
Main ethnic group	Oromo	Meru	Bakiga
No. adults per household	5.9	3	2.6
Farm size (hectares)	0.54	1.1	2.1
Farming as main livelihood strategy	97%	98%	99%
Farming coffee	89%	43%	48%
Owner of domestic animals	90%	89%	68%
Owner of a radio	78%	100%	64%
House owner	95%	100%	95%
Completed primary school	14%	97%	93%

Domestic animals refer to at least one goat, sheep, cow, or donkey, and exclude, e.g., chicken and rabbits.
[†] Rainfall estimates from the elevation range and part of the mountain studied, see main text.

Adaptation patterns and differences across regions

Numerous adaptation strategies were used in all three regions, related to farming, animal rearing, and livelihood diversification. There were similar strategies, rather than identical responses, across regions (Table 2). For farm coffee, whereas increased shade was reported across regions by > 60% of the respondents, (1) increasing inputs were mentioned by most (> 85% respondents) in Mount Kenya and the Bale Mountains but by few (15% respondents) in Kigezi Highlands; and (2) using improved varieties of coffee was only cited in Mount Kenya and Kigezi Highlands. In the Bale Mountains, where farmers also harvest wild forest coffee, 80% of the respondents highlighted changing management practices of this type of coffee.

For food crops, changing planting dates, sowing seeds twice if they die, farming new crop species, increased use of improved varieties, inputs (pesticide, fertilizer), and soil-conservation

Table 2. Adaptation strategies reported by study respondents (n=150 in each mountain). E refers to strategies initiated by external actors (NGOs, government). Empty cells refer to strategies not cited in that study area.

	Kigezi Highlands (%)	Bale Mountains (%)	Mt Kenya (%)
Change to improved variety (maize)	88 E	60.7 E	92
Change to improved variety (beans)	92 E		55.3
Change to improved variety (Irish potato)	50 E		
Change to improved variety (farm coffee)	64 E		87.5 E
Increased shade in farm coffee	61	55.3	75
Increased inputs in farm coffee (pesticides, fertilizers)	15	86.7	90.6
Changed pruning (forest coffee)		80 E	
Adopted new crop species[†]	54	43	64
Changed farm location (near stream)	2.6	25.3	5.3
Increased irrigation	3.3	67.3 E	68.7
Sow seeds earlier	80	76	38.7
Sow seeds twice (if they die)	17.3	42.7	42.7
Increased use soil conservation	68 E	58.7 E	82.7 E
Increased use fertilizer	38	59.3	98
Increased use pesticide	60	41.3 E	99.3
Increased use veterinary care (cows)	11.3 E	66 E	18.7
Increased use feed (cows)[‡]	1.3 E	69.3 E	14.7
Increased use veterinary care (other animals)	65.3 E	75.3 E	8.7
Diversify: sell firewood[§]	4	41.3	14.7
Diversify: sell hunted animals		6.7	
Diversify: timber			16
Diversify: labor	49.3	77.3	33.3
Diversify: started rearing animals	24.6	90	80.7
Diversify: vegetable/fruit production	42	82 E	73.3
Diversify: crop-related business		53.3	

[†] New crop mostly refers to Irish potatoes (Bale, Kigezi), banana (Bale, Mt Kenya), and pineapple (Kigezi).
[‡] Feed mostly fresh grass manually harvested (Kigezi), both fresh grass harvested and crop residues (Bale), dry straw (poor), and granulated feed (rich; Mt Kenya).
[§] Firewood is extracted from natural forest whereas timber is extracted from private *Grevillia robusta* plantations.

techniques were reported across regions but by different percentages of respondents. For example, changing planting dates was cited by > 75% respondents in Kigezi Highlands and the Bale Mountains but by only 43% in Mount Kenya. The most widely used soil-conservation technique also differed across regions: ditches in Kigezi Highlands (86%), grass strip in Mount Kenya (66%), and mulching in the Bale Mountains (58%). Similarly, the most widely cultivated new crops (for cash) also differed across regions: green and sweet bananas in Mount Kenya (64%), sweet banana or Irish potatoes (43%) in the Bale Mountains, and Irish potatoes and pineapple in Kigezi Highlands (54%). Notably, increased irrigation was cited by > 60% of the respondents in Mount Kenya and Bale, but only by 3% in Kigezi Highlands. In Mount Kenya, each village has a system of water pipes, and farmers pay a small fee to access water from the pipes, whereas in the Bale Mountains, farmers construct small canals for water diversion, which makes irrigation challenging far from streams.

With regard to animal rearing, increased use of veterinary care was cited by > 60% of the respondents in Kigezi Highlands and the Bale Mountains, but only by 18% in Mount Kenya. Increased use of supplementary feed for cows was cited by 69% respondents in the Bale Mountains, but by few respondents in other regions. The exact meaning of supplementary feed was not the same across regions. In all regions, farmers had diversified their livelihoods. They had started vegetable or fruit production, animal rearing, selling firewood, or labour jobs, each cited by a different percentage of respondents in each site. Selling timber from plantations was only cited in Mount Kenya, whereas selling hunted animals and starting a crop-related business were only mentioned in the Bale Mountains. No respondent mentioned permanent or seasonal migration to urban areas to secure income stability, nor potential relocation to other parts of the country. One study participant in Kigezi Highlands noted, "our land, even if small, has fertile soils and it is not affected by severe droughts like in other parts of the country." Respondents in all regions made similar commments. Likewise, no respondent mentioned insurance mechanisms. In Mount Kenya, where these are available, respondents reported that they do not think they are useful because they are too expensive to acquire.

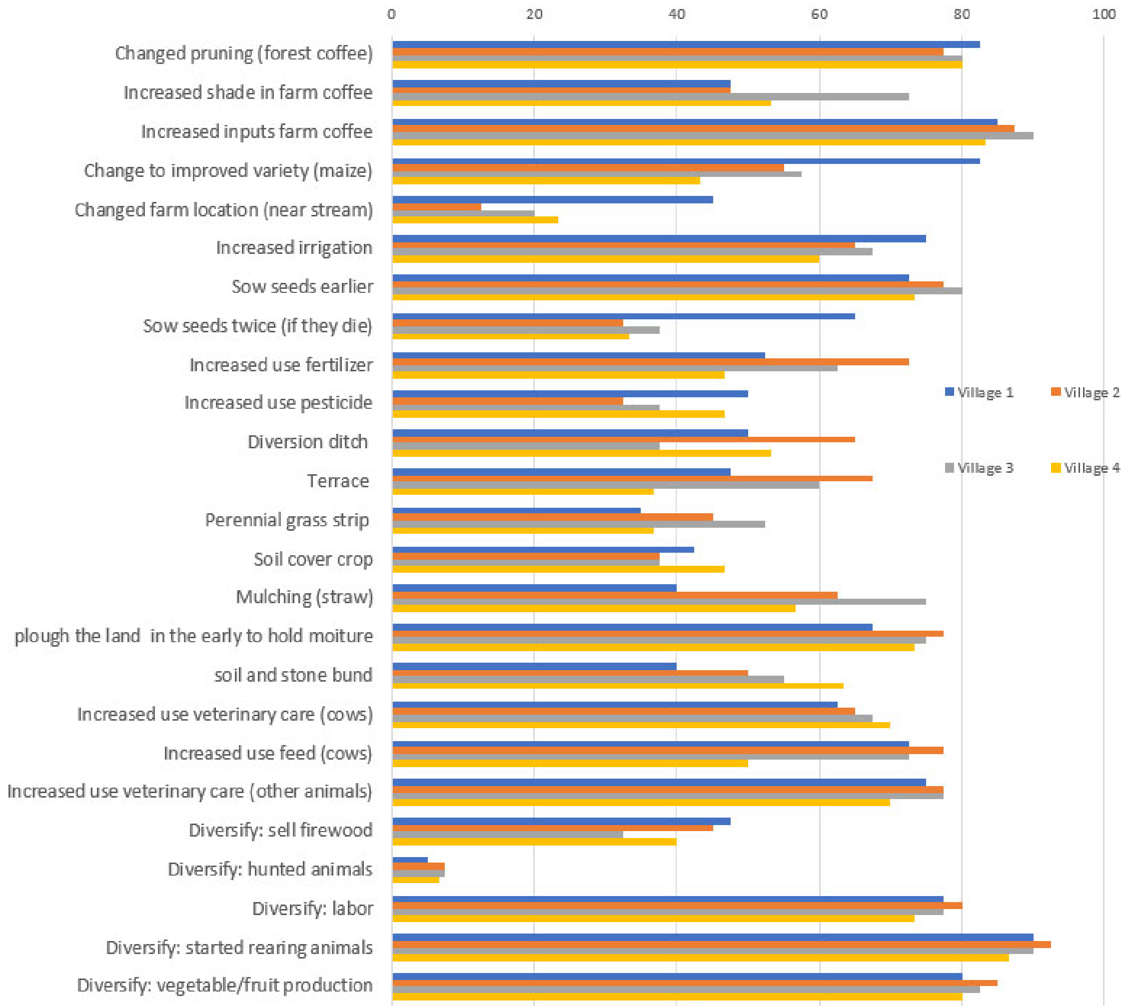
In the Bale Mountains and Kigezi Highlands, some strategies had been initiated by external actors, but these were not the same (Table 2). For example, farming new crop species, irrigation, increasing farm inputs, and starting vegetable farming were initiated by government or NGOs in the Bale Mountains but not in Kigezi Highlands, where these strategies had been initiated by farmers themselves, without external support. Study participants highlighted that government extension services or NGOs explained to farmers what to do (e.g., and gave seedlings) but did not conduct further visits to listen to their experiences. There was no room for mutual learning, which explained farmers' abandonment of certain interventions.

Remarkably, in Mount Kenya, most strategies had been initiated by local farmers without external support, often by following advice from top farmers, i.e., rich farmers who have better access to information, technology, and inputs, who are keen to advise their fellow farmers by, for example, giving them some improved seeds to try out. Such top farmers were also found in Kigezi Highlands and the Bale Mountains, but as NGOs and extension services were also available, their role was less conspicuous. Contrary to external interventions, top farmers created space for mutual learning, increasing farmers' trust and confidence. We found that adaptation occurs through the everyday practice of learning through trial and error. In all regions, farmers highlighted the gradual, experimental, and everyday nature of adaptation, regardless of if strategies had been externally or autonomously initiated. One study participant in Mount Kenya noted, "if you have the chance to try something new, you try it, but if you are not happy with the outcome, you stop that and maybe try something else next growing season."

Adaptation differences within regions

Differences were also observed within regions, because certain strategies were more widespread in some villages than in others (Figs. 2, 3, 4). Different factors could explain these differences. In Mount Kenya, for example, there was more widespread use of terraces and irrigation at higher elevation villages because of ecological factors, and there was greater engagement in timber production in the village located closer to an urban centre because of economic factors. Change-agent presence was also important: there was a greater use of cow feed in the village where a top farmer had started milk production, and more widespread use of

Fig. 2. Adaptation strategies used by percent of respondents in each of the four villages sampled in the Bale Mountains. Number of respondents per village is 37 or 38 (total at the Bale Mountains is 150). Access to urban markets is greater in village 1.



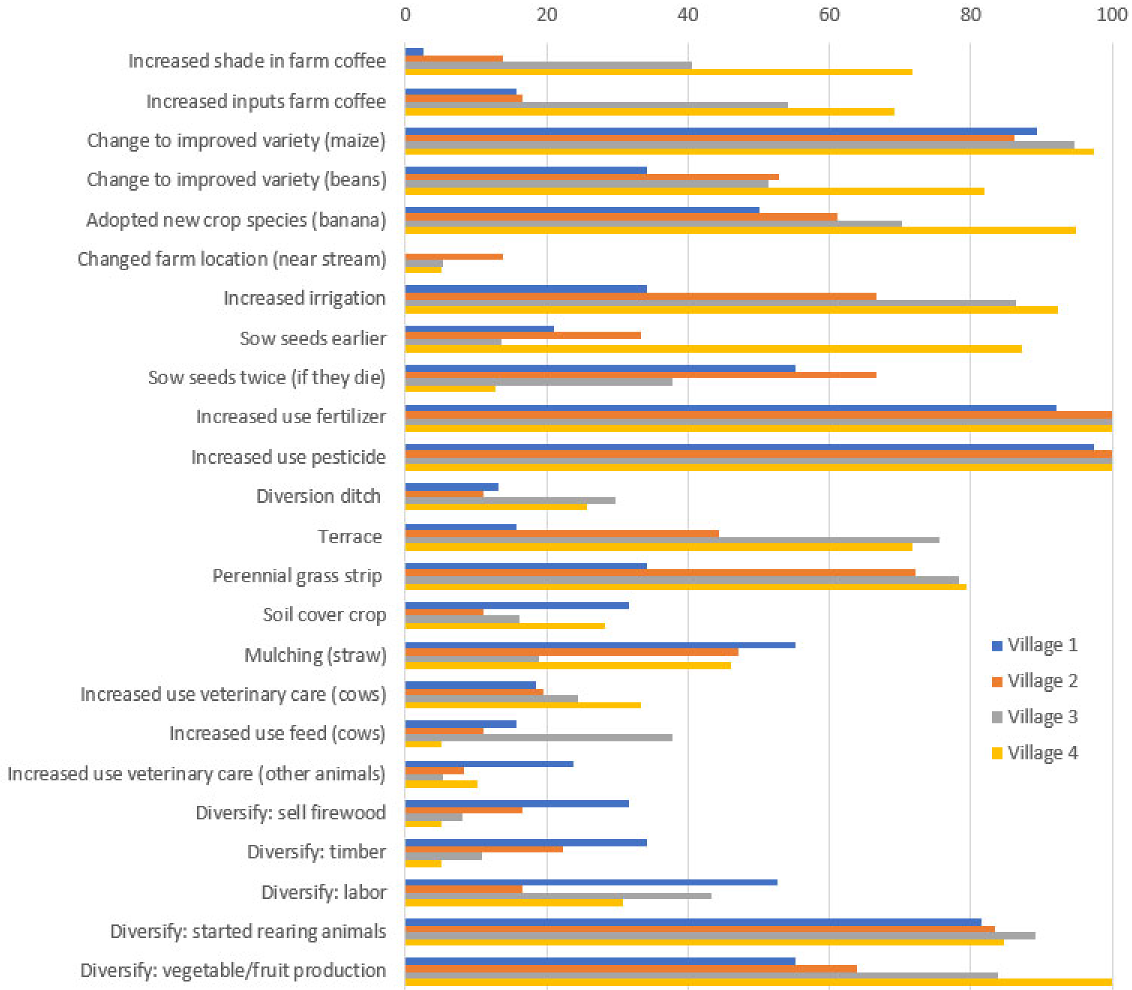
improved coffee varieties in a village engaged in certified organic coffee initiated by a small NGO. In Kigezi Highlands, Irish potatoes were widely cultivated at high elevation villages but not in middle elevation villages because of ecological-zone differences; choice of crop change was partially driven by greater access to urban markets for pineapple in villages 1 and 2 because of economic factors. Change agents' presence also explained some differences, e.g., NGO-promoted mulching in villages 1 and 2. In the Bale Mountains, no major differences across villages were observed, which may be explained by the presence of the same government extension services in all villages, and extended social networks across villages: if a strategy is started in one village, it quickly spreads to others.

Factors affecting adaptation practices

In all regions, land constraints and lack of funds (to invest in improved seeds, inputs, or technologies) were identified as two of three main constraints on adaptation during the FGDs. Other important constraints were access to technical skills (the Bale Mountains, Mount Kenya) and lack of access to markets (Kigezi Highlands). With regard to the three aspects we investigated in detail, access to improved seeds varied across regions: in the Bale Mountains the main source was from extension services at a subsidized cost (75% respondents) whereas in Mount Kenya and Kigezi Highlands most farmers bought the seeds from a seed company (92% and 58%, respectively). This suggests lack of funds can hamper access to improved seeds in the latter two regions. In terms of farmers' associations, which may facilitate access to credit, technical training, or marketing, no such organizations were found in the Bale Mountains. In Mount Kenya and Kigezi Highlands, respondents mentioned being members of a women's microfinance association (22% and 14%, respectively), agricultural associations (18% and 3%), savings associations (6% and 57%), and business associations (3% and 0%).

The percentage of climate-change literate respondents differed across regions: 82% in Mount Kenya, 79% in the Bale Mountains, and 49% in Kigezi Highlands. However, few climate-change

Fig. 3. Adaptation strategies used by percent of respondents in each of the four villages sampled in Mount Kenya. Number of respondents per village is 37 or 38 (total at Mount Kenya is 150). Villages 3 and 4 are located at higher elevations, where coffee farming is more widespread. Access to urban markets is greater for village 1.



literate respondents used weather forecasts on the radio to determine when to sow seeds. This was the case in Mount Kenya or Kigezi Highlands, where most respondents (82% and 95%, respectively) used their personal experience or information from elders or relatives/neighbours to decide when to sow seeds, related to traditional ecological knowledge. When asked, respondents said that they believed that weather forecasts on the radio were not accurate or too short notice, and that not all farmers have access to extension-services advice on when to sow seeds. In the Bale Mountains, 70% of the respondents used extension-services advice to help them decide when to sow seeds.

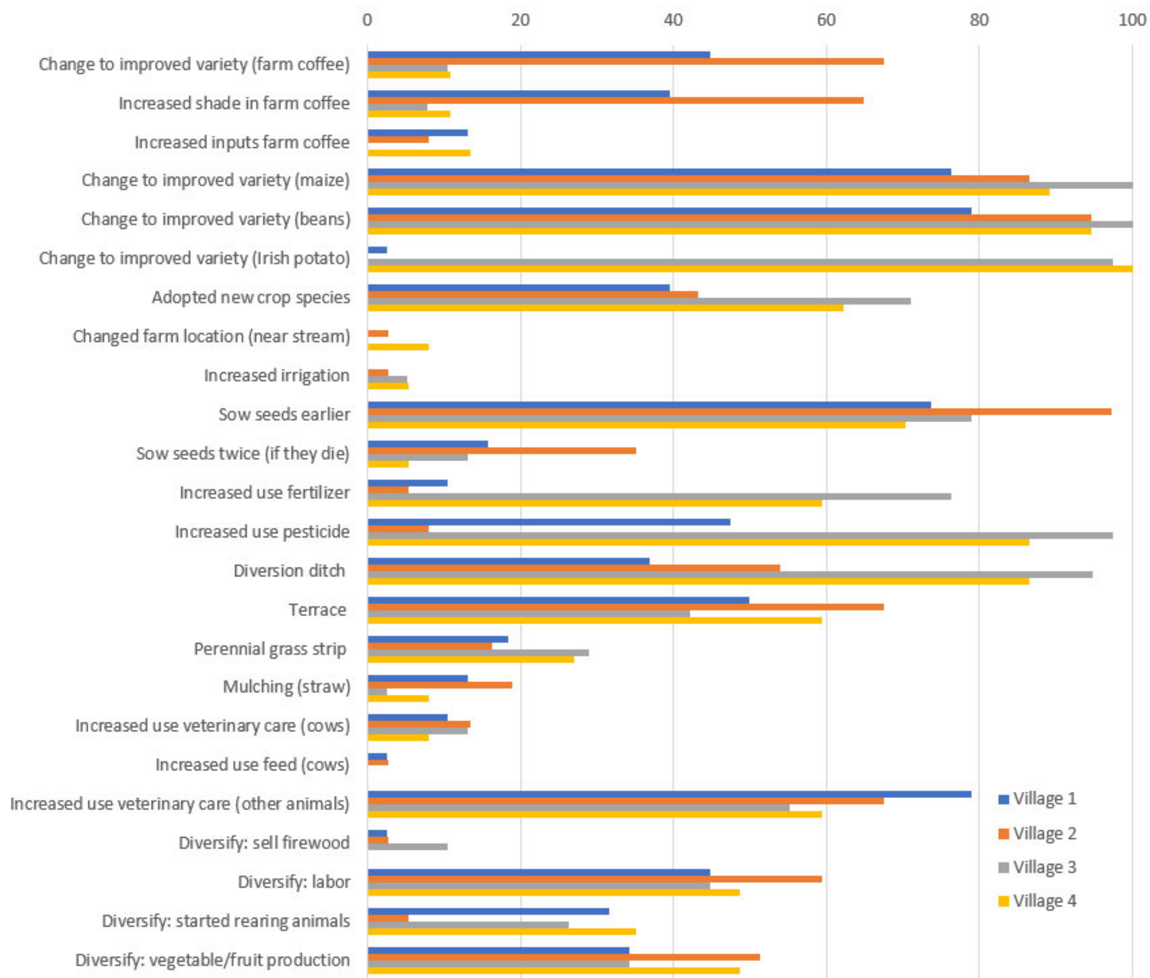
DISCUSSION

Adaptation strategies and main constraints

Overall, there were similarities across regions: most farmers increased the use of improved seeds, inputs, and soil-conservation techniques, trends also reported for the mountains of East Africa (Kaganzi et al. 2021). However, there were also differences across regions, e.g., irrigation was used in the Bale Mountains and Mount Kenya but not Kigezi Highlands. Differences were also observed within regions, driven by local biophysical (e.g., village elevation), economic (e.g., market access), or sociocultural (e.g., exposure to a new strategy initiated by a top farmer) factors. Clearly, in mountain regions, considering local contexts is very important (Klein et al. 2019).

In terms of Arabica coffee, adaptation options generally relate to improvements in productivity or quality, or migration to higher elevations (Moat et al. 2017). In all studied regions, respondents focused on improved productivity, including increasing shade and inputs, and use of improved varieties, all reported by coffee farmers elsewhere in East Africa (Eshetu et al. 2021, Kaganzi et al. 2021). Irrigation, identified as the single most cost-effective agronomy adaptation measure for coffee farming in Ethiopia by Moat et al. (2017), was only identified as a key strategy by some study participants. Improving coffee quality and certification to offset unit-area yield reductions related to climatic changes was

Fig. 4. Adaptation strategies used by percent of respondents in each of the four villages sampled in Kigezi Highlands. Number of respondents per village is 37 or 38 (total is 150). Villages 1 and 2 are located at middle elevations, coffee farming is more widespread, and Irish potatoes are rare. Villages 3 and 4 are located at higher elevations; few farmers engage in coffee, whereas Irish potato cultivation is widespread (with greater use of fertilizer and pesticides for this latter crop). Access to urban markets is higher in villages 1 and 2, where new crops refer to pineapple (and not Irish potatoes, as in villages 3 and 4).



only cited in one village in Mount Kenya that had received external support. Such interventions could also address changing coffee prices, which also affect farmers decisions. One study participant in Mount Kenya noted, “If I knew that coffee prices would remain stable over time, I would invest more of my farm into coffee.”

Several authors have highlighted that coffee certification can contribute to farmers’ adaptation (Karuri 2020). Given ongoing increase in coffee shading in our study areas, access to carbon finance could also benefit coffee farmers, as suggested by Fairtrade International (https://www.fairtrade.net/issue/climate-change). As for coffee certification, external support would be needed for such intervention.

It is important to highlight that in Mount Kenya and Kigezi Highlands several farmers interviewed mentioned that they had cultivated coffee in the past but had stopped doing so due to low yields and/or low or fluctuating coffee prices. It is possible that, in the Bale Mountains, coffee abandonment was not mentioned because of the strong cultural attachment and symbolic value of this plant in Ethiopia (Bulitta and Duguma 2021). Respondents in both Mount Kenya and Kagezi Highlands highlighted that, even if it has no religious value, coffee farming was of cultural importance for them, with comments such as, “a nice coffee farm is related to wealth, prestige, and access to credit, and it is an asset to pass to your children” (study participant, Kigezi Highlands). As highlighted by Henrique and Tschakert (2022), cultural values also shape individuals’ decision making concerning everyday adaptation.

Beyond coffee, there was a tendency toward increased intensification of both farming of other crops and animal rearing, which was often driven by external agents of change. Apart from offsetting unit-area yield reductions related to climatic changes, such interventions also targeted reduced farm sizes related to increased populations, reduced soil fertility, and market drivers. Increased intensification of farming and animal rearing has been reported by other studies. For example, increased use of improved varieties and fertilizers has been reported in the Jimma Mountains of Ethiopia, central Uganda, Mount Elgon, and Mount Kilimanjaro (Tiyo et al. 2015, Mulinde et al. 2019, Eshetu et al. 2021, Kaganzi et al. 2021), and increased use of irrigation had been reported for the Rwenzori Mountains (Zizinga et al. 2017).

Across study regions, some farmers had also invested in diversifying their livelihoods, mostly without external agents of change. However, these activities were often limited to wealthier farmers due to high investment costs (participants' comments during FGDs). Study participants in all regions also used some short-term responses implemented after shock (i.e., coping strategies) such as sowing seeds twice if they die, or finding labour jobs when crops fail (Table 2). This highlights the wide range of strategies used, and the everyday nature of the adaptation process.

Study participants cited land limitations, lack of funds, lack of access to technical skills, and lack of market access as main constraints to adaptation. Although these constraints related to the practical, rather than the political or the personal, sphere of the transformation processes for climate-change adaptation (O'Brien and Sygna 2013), respondents indirectly cited the two other spheres when addressing the lack of mutual learning in strategies initiated by external actors, and the importance of trust, for example how farmers in Mount Kenya trusted top farmers and followed their advice and opportunity for experimenting when given seeds.

Everyday adaptation

Our study shows how different adaptation practices become part of everyday life. Practices initiated by NGOs, extension services, or top farmers are progressively incorporated or modified by more farmers following their own perceptions of practices' effectiveness. Farmers are proactive agents: they continuously look for options to make ends meet and improve their livelihoods. Notably, beyond adapting to climate-change impacts, increased access to market opportunities also drives crop change (Labeyre et al. 2021) and livelihood diversification, particularly for wealthier households who can invest in them. Our study also shows how adaptation interventions may fail to have an appreciable effect when not incorporated into the everyday: despite relatively widespread climate-change literacy, and access to radios and weather forecasts, most study participants in Mount Kenya and Kigezi Highlands still prefer to use traditional knowledge to determine planting dates.

Results also demonstrate how the everyday practice of adaptation has no necessary emancipatory or disruptive potential. Mountains are often biophysically and sociopolitically complex systems, with socioeconomic and political isolation and marginalization (Klein et al. 2019). In the Bale Mountains and Kigezi Highlands, which are more isolated than Mount Kenya, farmers are keen to engage with external interventions even if there is currently little room for feedback and mutual learning. As shown in Mount Kenya, the opportunity of discussing concerns face-to-face with technical experts is vital. Indeed, learning as an everyday adaptation practice is very important for rural societies (Tran 2020). As has often been shown, mutual learning among actors is key for the sustainability of adaptation strategies implemented (Mapfumo et al. 2017, Eriksen et al. 2021). Also, increased integration of farmers' knowledge can complement the limited scope of current agricultural research on the impacts of climate change that is focused on a small number of crops (Labeyre et al. 2021).

Our findings also highlight how the practice of everyday adaptation is shaped by both constraints and opportunities. In general, the changes farmers would like to implement require greater investments, so lack of funds and land are major constraints (Bryan et al. 2013). Whereas limited access to land is difficult to address in highly populated areas, access to financial means could be addressed through low-interest microfinance mechanisms. Access to markets and technical skills could be improved by increasing organizational capacity of farmers, so that existing farmers' associations or new ones can facilitate both. Accessibility to markets depends on the infrastructure and transport system in a region. Farm households can be more vulnerable if inadequately developed (Alam et al. 2017), which is the case in mountain regions with hilly terrain such as our study areas.

In terms of opportunities, awareness of climate-change impacts, interest in learning new skills, and a proactive mentality enable creative adaptation options in our three study regions. This is particularly evident in Mount Kenya: organic coffee certification, started by an NGO and top farmers, has promoted increased coffee farming among other farmers in the village. Coffee is a major cash crop in East Africa. Thus, governments are keen on maintaining coffee exports. Rather than using a top-down technocratic approach for coffee farmers' adaptation to climate change, a more holistic approach would be preferred, one that considers both other globally driven pressures on coffee farming (e.g., low and fluctuating coffee prices) and farmers' knowledge systems, learning, and individual and cultural preferences. Indeed, such an approach would be preferred not just with regard to the coffee sector, but with regard to mainstream climate-adaptation decision making (Eriksen et al. 2021). As highlighted by See et al. (2022), local peoples have the capacity and means to determine how best they can adapt to climate change, and government agencies and NGOs could play an active role in supporting such local efforts by, for example, targeting the constraints identified by them.

Our cross-country comparative study shows that some constraints can be found across sites, highlighting their importance. An example is limited room for mutual learning, something not targeted in dominant adaptation paradigms based on technocratic approaches. Mutual learning can happen across scales: everyday community-adaptation responses can inform the practices of multilateral institutions, states, and NGOs (See et al. 2022). Indeed, the importance of facilitating learning, information exchange, reflection, innovation, and anticipation, all of which are key elements in the practical reality of the adaptation process, has been stressed for years (Tschakert and Dietrich 2010). We call for NGOs and support agencies to co-produce adaptation interventions in a more participatory engagement with smallholder coffee farmers, using, for example, science-with-society rather than science-for-society approaches (Steger et al. 2021). For instance, increasing access to mobile-phone networks and virtual communication could be used to enhance not just information exchange and mutual learning among different stakeholders, but also reflection, anticipation (e.g., for pest and disease spread), and innovation (e.g., new herbal pesticides that can help limit disease spread).

We did not investigate the efficiency or sustainability of the adaptation strategies mentioned by study participants. For instance, increased adoption of water-demanding horticultural crops could threaten farmers' adaptive capacity in the long term, if future climatic conditions limit water availability (Labeyre et al. 2021). Financial-capital requirements (Baloch and Thapa 2018) or potential, negative ecological impacts (Antwi-Agyei et al. 2018) could also raise questions about the long-term viability of some adaptation practices. Also, efficiency or sustainability could differ across sites. Rather than suggesting best practices, our list of multiple adaptation strategies used in these three mountain contexts (Table 2), could help inspire interventions for experimentation in other mountain regions, to be gradually modified, maintained, or abandoned in smallholder farmers' everyday practices.

CONCLUSION

This research has provided a cross-country study on everyday adaptation by smallholder coffee farmers in East Africa. Results show that farmers across sites use similar everyday adaptation strategies, rather than identical responses. We report general patterns in everyday adaptation practices (e.g., increased use of improved seeds, inputs, and soil-conservation techniques) but also differences across and within regions (e.g., irrigation), related to different biophysical, economic, and sociocultural factors. We also report major constraints to everyday adaptation processes across sites, including limited mutual-learning opportunities among agents, something not targeted in dominant adaptation paradigms. Local people have the capacity and the means to determine how best they can adapt to climate change, and government agencies and NGOs could implement more participatory engagement with them to facilitate their adaptation.

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. We also acknowledge the Mountain Research Initiative (MRI), the Sustainability and Development Initiative (SDI), and the Initiative on Climate Adaptation Research and Understanding through the Social Sciences (ICARUS) for funding support.

Data Availability:

The data that support the findings of this study are available for scientific purposes from first author upon reasonable request. Ethical approval for this research study was granted by University of York.

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Appendix 1. Semi-structured questionnaires.
Note that the lists in part 2 of the questionnaire were modified according to responses in the focus group discussions.

Part 1. General information
Village name
Household composition (adults M and F)
Farm size (ha)
Farming as main livelihood (Yes/No)
Farming coffee (Yes/No)
List animals your household has
Does your household have any of these items? House (Yes/No) Radio (Yes/No)
Did you complete primary school? (Yes/No)

Part 2. Adaptation
Which of the following adaptation strategies have you used?
Change to improved variety (maize)
Change to improved variety (beans)
Change to improved variety (Irish potato)
Change to improved variety (farm coffee)
Increased shade in farm coffee
Increased inputs farm coffee
Changed pruning (forest coffee)
Adopted new crop species
Changed farm location (near stream)
Increased irrigation
Sow seeds earlier
Sow seeds twice (if they die)
Increased use soil conservation
Increased use fertilizer
Increased use pesticide
Increased use veterinary care (cows)
Increased use feed (cows)
Increased use veterinary care (other animals)
Diversify: sell firewood
Diversify: sell hunted animals
Diversify: timber
Diversify: labor
Diversify: started rearing animals
Diversify: vegetable/fruit production
Diversify: crop-related business

Part 3
Does your household belong to a farmer association? If yes, which one?
How do you determine when to sow your seeds?
Where do you get improved seeds from?
Have you heard of the term climate change, and can you explain what it means?