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Local Context Capacity Building Needs for Climate Change Adaptation among Smallholder Farmers in Uganda: Policy and Practice Implications

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Abstract: Climate change impacts threaten sustainable development efforts. The magnitude of the impacts, however, varies with the socio-ecological characteristics of locations. This is the reason there is consensus on the necessity for climate change adaptive capacity building that is country driven, and based on, and responsive to, local needs. However, information on context specific capacity building needs in developing countries is not readily available. The objective of this study was to establish location specific awareness, training, educational research and technology capacity building needs for climate change adaptation among smallholder farmers in Uganda. Semi-structured questionnaires were used with 465 households from five agro-ecological zones, selected based on the level of vulnerability of agricultural systems to the main climate variation and change hazards. Results reveal substantial capacity building needs in all the zones. The majority of the farmers needed capacity building for interventions on soil-water conservation practices for adapting to drought and unpredictable rainfall. For all zones, education, research, and technology were perceived as key needs. However, the needs varied among zones. These results demonstrate the importance of context specificity in adaptation efforts. The study provides agro-ecological and social system specific information for climate change adaptation planning and policy interventions for effective capacity building.

Keywords: agriculture; agro-ecological zone; adaptive capacity; least developed countries; Paris Agreement

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1. Introduction

Climate change, manifested as increases in number, duration, frequency and severity of extreme weather events, is undermining efforts of nations geared towards the attainment of the sustainable development targets [1]. The effects of a changing climate cut across sectors, communities and nations [2]. In the agriculture sector, a range of impacts are being experienced. The impacts are mainly associated with either too little or too much rainfall [3]. The associated trends and events continue to lower agricultural land productivity, causing malnutrition, loss of livelihoods and hampering prosperity [4]. The effects are most pronounced and experienced in developing countries where rain-fed agriculture constitutes a major source of livelihood [5]. These impacts are also considered to be key drivers of human displacement and mass migrations [6], increased vulnerability of women and girls to violence (Nerini et al., 2019) and increased gender inequalities, such as the withdrawal of girls from school [7].

Developing countries are generally considered to be disproportionately vulnerable to, and impacted by, climate change [8], mainly because of poverty and heavy livelihood dependency on the increasingly threatened ecosystems [9]. In most of these countries, climate change adds another layer of complexity to already existing development challenges such as rapid population growth, underdeveloped financial markets and weak governance systems [10]. They are also particularly vulnerable due to very limited geographical and knowledge-based resources [11]. These attributes, plus the low adaptive capacity to climate change, are worsening vulnerable communities' lives and livelihoods [9,12]. There is, therefore, an urgent need for capacity building among communities to respond appropriately to the impacts of climate change. This, however, requires a tacit understanding of the context specific capacity needs.

Most assessments of adaptive capacity are largely rooted in Sen's capabilities theory and sustainable livelihoods framework [13,14]. The theory and framework present adaptive capacity as a function of entitlements to material assets and social opportunities. More entitlements are related to more capacity to adapt and lower vulnerability to climate change, and vice versa [10,15]. The assets mainly considered in assessing adaptive capacity include natural, physical, financial, social and human capitals [16]. Human capital covers educational considerations [17], which fall under the learning domain of adaptive capacity [18]. Learning is about the ability to generate, absorb, and process new information about climate change, adaptation options, and ways to live with, and manage uncertainty. It captures adaptive capacity aspects including experiential and experimental processes that enable people to frame or reframe problems, access to information, as well as building awareness [19].

Assessments show that adaptive capacity in developing countries is constrained by limited access to timely and reliable climate information for adaptation response to climate change impacts [8,20]. There is also limited access to resources/services for boosting adaptive capacity [21], including barriers to climate financing and skills services (including extension workers) [22,23]. Other barriers, such as the lasting social exclusion of the poor and marginalised communities have been documented [24,25]. Some communities are excluded from decision making processes and the use of technologies that might have been valuable in promoting social, physical, and human capital; hence, adaptive capacity.

The need for building climate change adaptive capacity in the developing world, especially for the least developed countries, has increasingly become an essential consideration in the climate regime [26]. Accordingly, the Paris Agreement (PA) sets out to enhance the capacity and ability of such countries to take effective climate change response actions. Article 11.1 of the Agreement stresses the importance of facilitating technology development, dissemination and deployment, access to climate finance, relevant aspects of education, training and public awareness, and the transparent, timely and accurate communication of information.

Under the PA, the Nationally Determined Contributions (NDCs) provide a means to communicate and track the various ambitions and commitments by Parties to the agreement. Through the NDCs, developing countries are expected to communicate their capacity building needs for effective climate change response actions [27]. The first round of NDCs highlight broad priority areas for capacity building in developing countries. Most of the needs are for adaptation, largely in the agriculture sector [26], with indication of capacity building in most of these areas as a condition for implementing other commitments [28].

However, most of the submitted capacity building needs in the NDCs lack specificity in terms of target sectors and capacity building elements of interest. They also lack clear alignment to the implementation of support arrangements, such as alignment to mechanisms like the financial systems, under the Paris Agreement [26]. That vagueness poses a challenge for efforts to track and measure the extent to which such needs have been addressed [29]. This points to the need for knowledge and scientific evidence to support the processes underlying the development of such policies and plans. Knowledge capability support systems for policy formulation and planning need to be country-driven, based on, and responsive to, national needs, and foster country ownership, including at the national, subnational and local levels [30].

A lack of explicit information by countries on the kind of capacity building required limits the extent to which related policy and partnerships in practice can be guided and realised in respective countries [31]. There is need for context specific information that can support local level relevant capacity building policies and other interventions that can be actioned by different actors, including extension workers. In that way, learning from capacity building interventions in a manner that can contribute to meaningful aggregation of national and global climate change adaptation response targets can be realised [32]. Accordingly, lessons from subnational, national, and global processes can inform efforts aimed at updating and enhancing development and adaptation policies, programmes, and plans, by incorporating new, as well as location-appropriate information, and best practices [33].

This study seeks to contribute to the understanding of location-specific climate change adaptation needs in the agriculture sector, particularly smallholder farmers in Uganda. This information is useful in enhancing adaptation planning processes and supporting extension workers to facilitate local community-level adaptation practice. In a majority of developing countries, the agricultural sector is dominated by smallholder farmers. This study focuses on the agriculture sector, due to the global significance it commands in the first and second round of NDCs [26] and the importance of the sector to the livelihoods and the economy of Uganda [34]. Moreover, agriculture is one of the sectors that is most sensitive to changes in climate, with evident risks that threaten the associated livelihoods of many rural populations [35]. The importance of agriculture is similarly highlighted in some of the targets (e.g., 2.1, 2.1.2, 2.5.1, 2.a.1, 13.2.1) of the Sustainable Development Goals (SDGs). Implementation and realisation of the intended climate change responses that promote resilience and adaptation in agricultural production will require understanding and dealing with location-specific capacity building needs. Such understanding should be based on realities from local communities and contexts. Specifically, the objective of this study was to generate information to support planning, decision-making processes and actions aimed at the realisation of locally relevant capacity building for effective adaptation. The study addresses two questions: (i) What are the climate change adaptive capacity building needs for the agriculture sector in Uganda? (ii) Are there differences in climate change adaptive capacity building needs across different agro-ecological zones?

Framing the Research through Theory and Place

The study is anchored around two theoretical perspectives: the vulnerability and resilience perspective [36], and the political economy theory [37,38]. Differentiated vulnerability and resilience perspective underscores the variations in vulnerabilities of communities in the face of climate change impacts, shaped by distribution of the distinct exposures to hazards, sensitivity to changes, and their capacity to cope and adapt. It also recognizes that different communities have varying levels of resilience, depending on their socio-ecological context, which can influence their adaptation needs. However, this perspective is insufficient to account for the broader socio-economic, as well as political perspectives, which substantially influence the vulnerabilities and adaptive capacity of communities. For instance, it does not adequately account for differences in resource access, political influence, and decision-making processes, which are important in shaping adaptation needs. Thus, in addition, the political economy theory was taken up to complement the vulnerability and resilience perspective. The theory accounts for variations in distribution of power, resource access, political marginalization, and institutional constraints, which contribute to shaping adaptive capacity.

Additionally, this study builds on existing literature and evidence that argues for and justifies the need to shift from top-down to bottom-up approaches to capacity building for adaptation and development. Considering the fact that adaptation is predominantly location and context sensitive, focusing adaptive capacity building at local community level is critically important [39]. Studies have demonstrated that transformative adaptation requires capacity building that is informed by grassroots level knowledge, lived experiences and traditional knowledge [40].

The study took place in Uganda, a developing country in Africa that is highly dependent on natural resources. Uganda relies heavily on a rain-fed agricultural sector, which employs over 70% of the population, contributing nearly 25% of the GDP [41]. The agricultural sector in the country is climate sensitive, to the extent that 34% of crop damages are caused by climate-induced stimuli such as rainfall shortage [42]. Overall, these characteristics render the country very vulnerable to the impacts of environmental perturbations. Four hundred and sixty five small-scale farming households from different areas in Uganda were engaged to unravel location-specific climate change adaption needs, using methods detailed in the next section. This study provides evidence that supports context-specific planning for climate change adaptation. The study expands our understanding, and challenges the universality of adaptation strategies that come with top-down planning approaches. This is taken up in the discussion section of this paper. Lessons from this study are thus transferable to countries within similar contexts as that described for Uganda.

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted in five agro-ecological zones (AGEZs) of Uganda. The agro-ecological zones covered are the following: South-Western Grass Farmlands (SWGF); Western Medium-High Farmlands (WMHF); Western Mid-altitude Farmlands and the Semliki Flats (WMFSF); Lake Victoria Crescent and Mbale Farmlands (LVCMF); and North-Western Farmland Wooded Savanna (NWFWS). These AEZs are classified on the basis of distinct topography, climatic conditions, soils and cropping systems [43,44]. Despite these distinctions, all the zones are predominantly small-scale rain-fed agricultural systems [45]. Recent data indicate increasing temperatures and heightened rainfall variability as the most frequent and extreme weather events across the zones [46,47], affecting their cropping systems. The description of these zones is presented in Table 1. The study area covered five districts of Rubirizi, Mubende, Kikuube, Nebbi and Mbale (Figure 1). The respondents to this study were small-scale farmers engaged in crop and livestock faming activities. The majority of the respondents (69.2%) were male. Most respondents' age ranged between 30 and 60 years, and 61.7% of the respondents had primary level education. Most of the respondents (79.6%) were married. The heads of households were predominantly men (84.5%).

Table 1. Description of agro-ecological zones of the study areas.

Agro-Ecological Zone (District)	Description of Agro-Ecological Zone	Cropping Systems
SWGF (Mubende district)	Bimodal rainfall ranging from 1000 to 1200 mm per year; mean altitude is 1235 m above sea level, generally flat, with short hills, rounded tops and lowland areas. The soils are generally deep, with moderate levels of organic matter.	Diverse; mainly bananas, beans, sweet potatoes and maize.
WMHF (Rubirizi district)	Bimodal rainfall ranging from 1000 to 1200 mm per year; mean altitude of 1198 m above sea level, generally rugged terrain, with undulating slopes and shallow soils.	Major crops include bananas, maize, beans and sweet potatoes. Cattle rearing, in some few cases, is practiced on a large scale.
WMFSF (Kikuube district)	Bimodal rainfall above 1200 mm per year; mean altitude is 1099 m above sea level, generally undulating, with steep slopes and lowlands. The soils are generally deep in lowlands and shallow on the upper slopes.	The major crops grown include bananas, maize, sweet potatoes and beans. Coffee and tobacco are the main cash crops.

Table 1. *Cont.*

Agro-Ecological Zone (District)	Description of Agro-Ecological Zone	Cropping Systems
LVCMF (Mbale district)	Bimodal rainfall above 1200 mm per year; mean altitude is 1213 m above sea level, varying with steep slopes near Mount Elgon and gentle slopes in western Mbale. The soils are generally red-brown loam and clay, with high organic matter content.	Major crops include bananas, sweet potatoes, beans and maize. Coffee is the main cash crop.
NWFWS (Nebbi district)	Unimodal rainfall ranging 1000 to 1200 mm per year; mean altitude is 732 m above sea level, generally flat, with narrow valleys. The soils are generally sandy, with low organic matter content.	The main crops grown include sorghum, maize, sweet potatoes, millet, and cassava. Moderate livestock rearing is practiced.

Source: Adapted from Wortmann and Eledu [44].

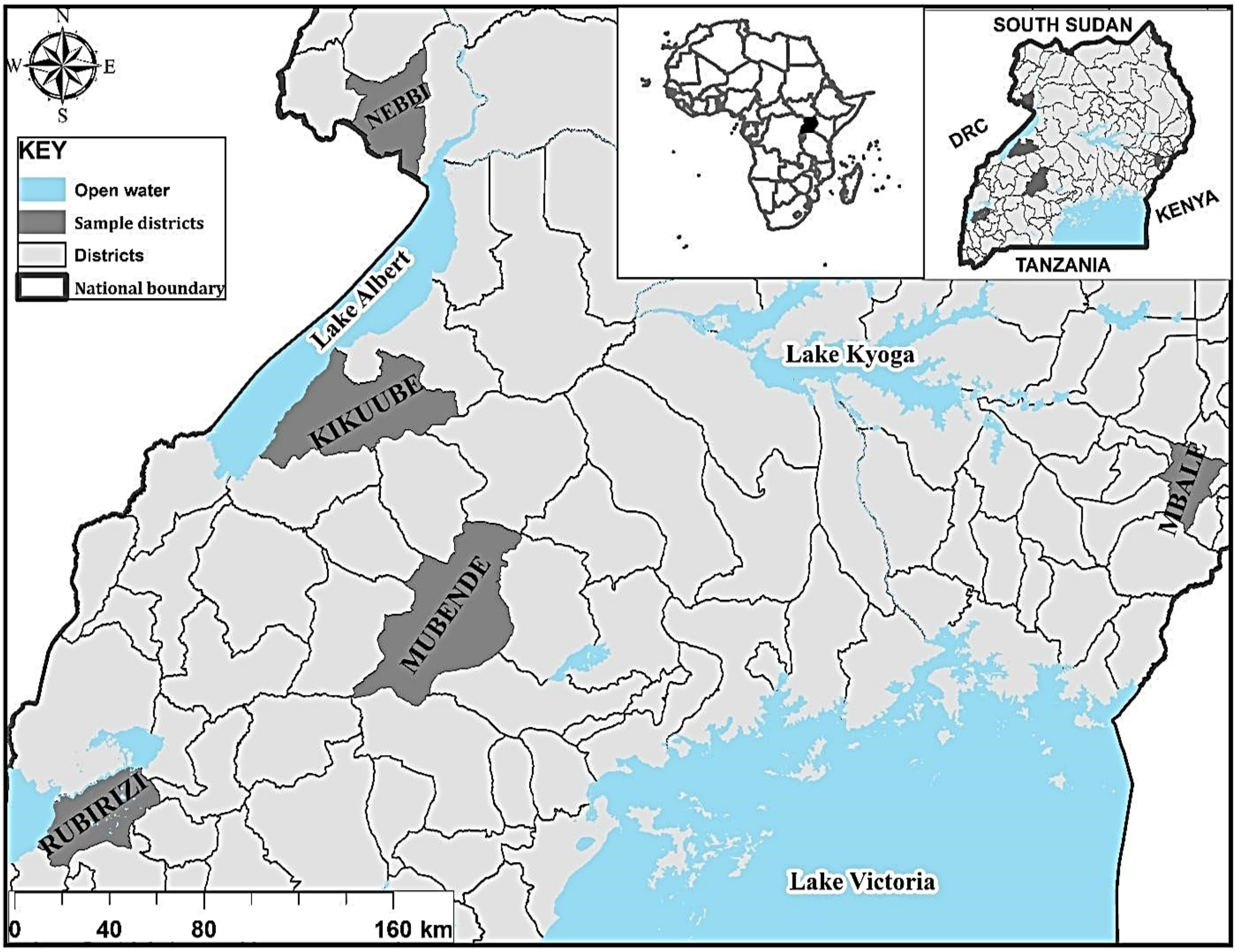

Figure 1. Location of study area.

2.2. Methods

In each agro-ecological zone, one district (Table 1) was selected, based on the level of vulnerability of agricultural systems to the main climate variation and change hazards in Uganda. These districts are particularly vulnerable to unpredictable shifts in rainfall patterns, as well as uncertainty in the length and intensity of dry seasons, which in the recent past have been characterised by recurrent drought [42,48–50]. A multistage purposive sampling method was used to select the districts and sub counties of study. The choice of parish and village administrative units of study was guided by district and sub county local government leaders, based on their knowledge and experiences of context diversity and socio-ecological vulnerability in their respective areas of jurisdiction. The sampling frame was all households that carry out smallholder farming, which is farming carried out on less than one hectare of land in a cropping season, using rudimentary and labour-intensive technology, especially hand hoes, and owning a few heads of livestock [34]. Farming products are primarily for household consumption, while some surplus of the produce is also sold [34,51]. In rural areas of Uganda, most households are engaged in small-scale rain-fed agriculture [51,52]. Households were the target of this study, because critical decision making about farming happens at a household level [53]. Their daily lived experiences uniquely position them to understand and articulate their immediate needs, challenges, and adaptive capacities. Accordingly, four hundred and sixty five (465) households were randomly selected in the identified parishes. This was achieved with the support of local council leaders, who provided lists of households in each of the selected villages. The high number of respondents were considered, in order to increase reliability of the study results. The respondents were distributed in thirty four villages, ten parishes and five sub counties of the five districts. The number of respondents per parish was determined based on population proportions that were calculated based on the Uganda National Census data of 2014 [34]. The sample population was calculated according to the formula in [54]:

$$n = \frac{N}{1 + N(e)^2}$$

where n is the sample size, N is the total population, and e is the level of precision.

Accordingly, we obtained 101 farmers from SWGF, 90 farmers from WMHF, 100 farmers from WMFSF, 90 farmers from LVCMF and 84 farmers from NWFWS. Field data collection was conducted by a team of five well trained research assistants, with one assistant in each district of study. These were helped by the local government and community leaders, who acted as field guides because they were well known to the local people and understood the geography of the study areas. Data were collected in 2021, using a semi-structured questionnaire that sought information on the following: climate change hazards and impacts being experienced by the farmers, and capacity building needs for adaptation in their farming activities. Respondents were given a set of alternatives, with an option to mention any other that they would specify. All answers were considered in the analysis. The questions were designed in simple formats, in a manner understandable to respondents. This was further ensured through testing of the questionnaire. For instance, interviewees were asked which adaptation practices they were aware of, which ones they were using, and why they were not using some practices they were aware of. Additionally, the trained interviewers were native speakers of the local languages of each of the locations of this study. The questionnaire was pre-tested before actual data collection. The pre-testing was carried out in different local languages for consistency and reliability in the data collection.

The criteria for categorising the specific needs were based on capacity building elements derived from the Paris Agreement (mainly, but not limited to, Articles 11, 12 and 13) and Articles 5 and 6 of the UNFCCC. These elements are the following: education, training and public awareness, and research and technology.

2.3. Data Analysis

The data collected from the field were coded and entered into Statistical Package for the Social Sciences (SPSS) software version 25. Using the same software, descriptive statistics for the capacity building needs in each AGEZ were generated. A one-way analysis of variance (ANOVA) and a post hoc Turkey's Honestly Significant Difference (HSD) tests were carried out to ascertain the statistical differences among capacity building needs in the AGEZs, at 95% significance level [55]. For each respondent, the number of specific needs selected under a broad capacity building category (awareness, education, training, and research and technology) were tallied and assigned a numeric score. The scores were aggregated to come up with scores for the corresponding capacity building need at the broad category level. Relatively lower scores were interpreted as having a relatively low need for a given capacity building category, while high scores implied a high need for a given category, as shown in Table 2.

Table 2. Computation of the score of capacity building needs for each respondent.

Capacity Building Needs	Specific Needs Selected by Each Respondent	Capacity Building Need	Score of the Capacity Building Need	Interpretation
$Respondent_1$	$R_1, R_2, R_3 \ldots R_n$	$\sum(R_1, R_2, R_3 \ldots R_n)$		
	$R_1, R_2, R_3 \ldots R_n$	$\sum(R_1, R_2, R_3 \ldots R_n)$	$1 \rightarrow N$	Low $\rightarrow$ High
	$R_1, R_2, R_3 \ldots R_n$	$\sum(R_1, R_2, R_3 \ldots R_n)$		
$Respondent_n$	$R_1, R_2, R_3 \ldots R_n$	$\sum(R_1, R_2, R_3 \ldots R_n)$		

The mean score of capacity-building needs for each AGEZ was computed in SPSS. One-way ANOVA was used to compare the mean score of the different AGEZs, to ascertain if there were statistically significant differences between the means. The aim of this test was to find out if there were any significant differences in needs across the AGEZs. A post hoc Turkey's HSD test was then run to determine which of the AEZs had differences in needs [55]. The mean score of capacity building need corresponding to the reference AGEZ was labelled "*i*", and the mean score of the capacity building need corresponding to the AGEZ to be compared was labelled "*j*". The post hoc Turkey's test was run, based on the expression "*i-j*".

3. Results

3.1. Adaptive Capacity Building Needs

Overall, a large proportion of respondents involved in this study expressed having experienced unexpected changes in weather events within the last 12 months. The events most experienced were unpredictable rainfall and drought. However, farmers in SWGF and WMHF experienced this more frequently than farmers in WMFSF, LVCMF and NWFWS AGEZs. As for adaptive capacity needs, the majority of farmers (over 60%) revealed a need for capacity building to respond to drought and unpredictable rainfall hazards, irrespective of AEZ. Table 3 shows the capacity building needs reported by farmers in the five AGEZs. The need for education and research and technology registered the highest number of respondents across all AGEZs for both drought and unpredictable rainfall. The SWGF and WMHF zones reported the highest needs for capacity building.

Table 3. Percentage of respondents with different capacity building needs for climate change adaptation among small-scale farmers in five AGEZs.

Hazard	Capacity Building Need	Agro-Ecological Zone (Percentage of Respondents)				
		SWGF	WMHF	WMFSF	LVCMF	NWFWS
Drought	Awareness	94.1	96.1	64.5	86.7	65.3
	Education	94.7	96.7	97.7	77.2	87.3
	Research and technology	98.0	96.7	100.0	93.3	92.9
	Training	89.0	84.7	77.8	71.1	96.4
Unpredictable rainfall	Public awareness	87.3	99.8	80.6	88.2	67.6
	Education	98	95.6	96	93.3	88.1
	Research and technology	96.0	88.9	96.0	83.1	78.6
	Training	73.8	89.4	91.0	64.0	93.5

Table 4 shows the specific adaptive capacity building needs for adaptation to drought. The majority of the farmers in all AGEZs needed capacity building for the following:

interventions on soil-water conservation practices such as planting cover crops, agroforestry, and mulching; practices for planning for cropping activities, such as changes in crop varieties and planting dates; and irrigation technologies which can be used on the farm, including the use of wastewater. Farmers also sought capacity for water harvesting and storage technologies such as the construction of percolation tanks and valley dams, post-harvest management techniques for seed drying and storage, to avoid seed spoilage and reduce losses, and technologies for increased livestock-stocking capacity on the farm.

Table 4. Percentage of respondents with specific capacity building needs for drought.

Need	Specific Areas of Need	Agro-Ecological Zone (Percentage of Respondents)				
		SWGF	WMHF	WMFSF	LVCMF	NWFWS
Public awareness	Planning of cropping activities	96.0	99.9	46.0	97.8	70.3
	Water harvesting technologies	99.0	100.0	97.0	96.7	84.6
	Irrigation technologies	97.4	100.0	96.9	66.7	55.7
	Proper animal stocking	92.1	100.0	53.0	83.3	66.7
	Soil-water conservation practices	98.0	100.0	98.0	96.6	70.3
	Post harvest management techniques	87.1	92.2	90.0	81.1	79.7
	Onset and cessation of rains	92.0	84.4	3.0	64.5	20.3
Education	Soil water conservation practices	92.6	95.0	96.5	69.1	86.3
	Harnessing water stored in ecosystems	44.6	84.4	70.0	87.6	83.3
Research and technology	Water harvesting technologies	87.0	95.5	100.0	60.7	87.0
	Irrigation technologies	70.1	91.0	98.0	75.0	90.9
Training	Water harvesting technologies	99.0	98.8	100.0	91.0	100.0
	Irrigation technologies	85.7	90.0	66.3	75.0	86.4
	Planning of cropping activities	49.5	49.4	50.0	45.5	50.0
	Soil-water conservation techniques	76.0	95.6	100.0	78.7	95.2

For unpredictable rainfall, the majority of the farmers needed capacity building for the following: interventions on soil conservation practices, such as construction of terraces, planting crops on ridges, planting cover crops; techniques for draining excess water from the farm, like digging channels in the garden; and cropping strategies, such as delays in planting, planting new crop varieties that can survive in excess water, and crops that are early maturing. Farmers also needed technologies for water harvesting and storage, including the use of percolation tanks, animal-care techniques such as keeping animals indoors, and post-harvest management technologies to avoid seed spoilage and losses (Table 5).

Table 5. Percentage of respondents with specific needs for capacity building, to respond to unpredictable rainfall.

	Specific Need	Agro-Ecological Zone (Percentage of Respondents)				
		SWGF	WMHF	WMFSF	LVCMF	NWFWS
Public awareness	Planning for cropping activities	99.1	100.0	100.0	98.9	69.1
	Soil conservation practices	100.0	100.0	98.0	91.1	65.5
	Water harvesting and storage	58.4	100.0	24.0	74.4	86.9
	Animal-care techniques	84.2	100.0	81.0	78.9	42.9
	Post-harvest management techniques	95.1	98.9	100.0	97.8	73.8
Education	Soil conservation practices	97.0	93.3	96.0	62.9	84.5
	Ecosystem management	100.0	31.4	94.3	16.7	80.0
Research and technology	Water harvesting and storage	98.7	88.9	97.9	93.7	92.8
Training	Off-farm employment	84.0	75.6	81.6	31.0	97.5
	Water harvesting and storage	90.9	94.4	72.2	86.9	88.5
	Soil conservation techniques	14.3	82.2	82.5	45.2	87.2

3.2. Variation in Climate Change Adaptive Capacity Building Needs across Agro-Ecological Zones

Whereas all agro-ecological zones showed a high need for capacity building, the level of needs varied. Results of one-way ANOVA (Table 6) show that the capacity building needs were significantly different ($p < 0.05$) across the agro-ecological zones. The overall order of the needs is the following: public awareness, training, education, and research and technology. For both drought and unpredictable rainfall hazards, zones SWG and WMHF revealed higher needs for awareness than WMFSF, LVCMF, and NWFWS. Research and technology was observed as the lowest need for communities in all zones, for all hazards. The major need for LVCMF is public awareness, for both drought and unpredictable rainfall.

Table 6. Results of one-way ANOVA for the adaptive capacity building needs in the different agro-ecological zones.

Hazard	Need	Agro-Ecological Zones SWGF	WMHF	WMFSF	LVCMF	NWFWS	*p*-Value
Drought	Public awareness	17.48 ± 4.35	17.73 ± 2.93	8.47 ± 2.82	14.63 ± 4.18	9.15 ± 5.15	0.000 *
	Education	3.63 ± 1.32	4.07 ± 0.97	4.36 ± 0.94	2.49 ± 1.08	4.18 ± 1.73	0.000 *
	Research and technology	1.56 ± 0.54	1.84 ± 0.45	1.98 ± 0.14	1.28 ± 0.58	1.67 ± 0.61	0.000 *
	Training	8.52 ± 3.10	11.08 ± 2.40	13.30 ± 0.90	6.72 ± 2.88	14.61 ± 3.03	0.000 *
Unpredictable rainfall	Public awareness	10.98 ± 2.56	13.23 ± 1.14	8.83 ± 2.15	9.04 ± 2.94	5.82 ± 3.34	0.000 *
	Education	2.51 ± 0.74	3.39 ± 0.99	2.57 ± 1.08	2.04 ± 0.88	3.29 ± 1.40	0.000 *
	Research and technology	0.96 ± 0.20	0.89 ± 0.32	0.96 ± 0.20	0.83 ± 0.38	0.79 ± 0.41	0.000 *
	Training	4.33 ± 1.74	7.01 ± 1.19	7.43 ± 1.01	2.65 ± 1.39	7.36 ± 1.53	0.000 *

*—the mean difference is significant at 0.05 level.

3.3. Mean Differences in Capacity Building Needs for Drought between Any Two Agro-Ecological Zones

The results of Turkey's HSD test for drought showed that, on average, SWGF and WMHF zones had significantly higher public awareness needs, relative to other AGEZs ($p < 0.05$). In these zones, the need for public awareness and education was not different. However, the need for research and technology and training was significantly higher in WMHF. LVCMF had significantly lower capacity building needs for education, research and technology, and training ($p < 0.05$). Compared to NWFWS, the need for research and technology was significantly high in SWFG. However, training needs for drought response were more significant in NWFWS and WMFSF than for any other AEZ ($p < 0.05$); see Table 7.

Table 7. Results of Tukey's HSD test showing the mean differences in capacity building needs for drought. Positive and negative values represent higher and lower needs, compared to other AEZs.

Agro-Ecological Zone		Public Awareness	Education	Research and Technology	Training
i	*J*	*i-j*	*i-j*	*i-j*	*i-j*
SWGF	WMHF	−0.26	−0.43	−0.28 *	−2.56 *
	WMFSF	9.01 *	−0.72 *	−0.42 *	−4.78 *
	LVCMF	2.84 *	1.14 *	0.30 *	1.80 *
	NWFWS	8.32 *	−0.54 *	−0.11	−6.09 *
WMHF	SWGF	0.26	0.43	0.28 *	2.56 *
	WMFSF	9.26 *	−0.29	−0.14	−2.22 *
	LVCMF	3.10 *	1.57 *	0.56 *	4.36 *
	NWFWS	8.58 *	−0.11	0.18	−3.53 *
WMFSF	SWGF	−9.01 *	0.73 *	0.42 *	4.78 *
	WMHF	−9.26 *	0.29	0.14	2.22 *
	LVCMF	−6.16 *	1.87 *	0.70 *	6.58 *
	NWFWS	−0.68	0.18	0.31 *	−1.31 *

Table 7. *Cont.*

Agro-Ecological Zone		Public Awareness	Education	Research and Technology	Training
LVCMF	SWGF	−2.84 *	−1.14 *	−0.28 *	−1.80 *
	WMHF	−3.10 *	−1.57 *	−0.56 *	−4.36 *
	WMFSF	6.16 *	−1.87 *	−0.70 *	−6.58 *
	NWFWS	5.48 *	−1.68 *	−0.39 *	−7.89 *
NWFWS	SWGF	−8.32 *	0.55 *	0.11	6.09 *
	WMHF	−8.58 *	0.11	−0.18	3.53 *
	WMFSF	0.68	−0.18	−0.31 *	1.31 *
	LVCMF	−5.48 *	1.68 *	0.39 *	7.89 *

*—the mean difference is significant at 0.05 level.

3.4. Mean Differences in the Capacity-Building Needs for Unpredictable Rainfall between Any Two Agro-Ecological Zones

The results of Turkey's HSD test revealed significant differences in public awareness needs, with SWGF and WMHF having a higher need for public awareness, compared to NWFWS ($p < 0.05$). The study also revealed significantly higher training needs in NWFWS, while LVCMF revealed an overall low need for adaptive capacity building ($p < 0.05$); see Table 8.

Table 8. Results of Turkey's test showing the mean differences in capacity building needs for unpredictable rainfall. Positive and negative values represent higher and lower needs, compared to other AEZs.

Agro-Ecological Zone		Public Awareness	Education	Research and Technology	Training
i	*J*	*i-j*	*i-j*	*i-j*	*i-j*
SWGF	WMHF	−2.25 *	−0.87 *	0.07	−2.68 *
	WMFSF	2.15 *	−0.06	0.00	−3.10 *
	LVCMF	1.94 *	0.47 *	0.13 *	1.68 *
	NWFWS	5.16 *	−0.77 *	0.17 *	−3.03 *
WMHF	SWGF	2.25 *	0.87 *	−0.07	2.68 *
	WMFSF	4.40 *	0.82 *	−0.07	−0.42
	LVCMF	4.19 *	1.34 *	0.06	4.36 *
	NWFWS	7.41 *	0.10	0.10	−0.346
WMFSF	SWGF	−2.15 *	0.06	0.00	3.10 *
	WMHF	−4.40 *	−0.82 *	0.07	0.42
	LVCMF	−0.21	0.53 *	0.13 *	4.78 *
	NWFWS	3.01 *	−0.72 *	0.17 *	0.07
LVCMF	SWGF	−1.94 *	−0.47 *	−0.13 *	−1.68 *
	WMHF	−4.19 *	−1.34 *	−0.06	−4.36 *
	WMFSF	0.21	−0.53 *	−0.13 *	−4.78 *
	NWFWS	3.22 *	−1.24 *	0.05	−4.71 *
NWFWS	SWGF	−5.16 *	0.77 *	−0.17 *	3.03 *
	WMHF	−7.41 *	−0.10	−0.10	0.35
	WMFSF	−3.01 *	0.72 *	−0.17 *	−0.07
	LVCMF	−3.22 *	1.24 *	−0.05	4.71 *

* the mean difference is significant at 0.05 level.

4. Discussion

Understanding the specific climate change adaptive capacity needs at local level is critical in designing location sensitive policies, programs, and other interventions for adaptation [56]. This is because vulnerability characteristics vary across regions and scales [57]. In this study, we assessed climate change adaptation needs across five agro-ecological zones in Uganda, a relatively small country. Results of this study showed that there were substantial capacity building needs to adapt to climate change in all AEZs. However, the specific needs varied across the zones, and depended on the type of weather and climate events and trends most encountered in a locality. This is interesting for a small country like Uganda, where homogeneity would be the expected outcome. This discussion explores the policy and practice strategy implications of these results for the predominately rural natural resource dependent communities in developing countries.

4.1. The High Need for Climate Change Adaptive Capacity Building, Irrespective of AEZ

The findings of this study reveal a considerable need for capacity building, regardless of the AEZ. The agro-ecological zones considered in this study exhibit varying climatic, social and ecological characteristics. For instance, while the LVCMF is a relatively wet area, with bimodal rainfall distribution and mean annual rainfall above 1200 mm, the NWFWS experiences unimodal rainfall ranging from 1000 to 1200 mm [44,47]. In terms of socio-economic context, the LVCMF is known to have greater access to assets and resources, compared to other AEZs considered in this study [58,59]. It was anticipated that areas with better socio-economic characteristics would have a better adaptive capacity, hence lower capacity building needs, and vice versa. However, results of this study are incongruent with this expectation, as a considerable need for capacity building was evident across all AEZs.

The considerable need for adaptive capacity building shown by the results of this study can be explained in terms of Uganda's low level of development. According to UNDP [60], Uganda is among the poorest nations, ranked 164th out of 187 countries, based on the Human Development Index (HDI). Thirty eight percent of its population live below the income poverty line, while 33% live in absolute poverty [61]. Over 70% of the population depend on climate sensitive agriculture, and contribute nearly 25% of the GDP [62]. These characteristics render the country, as a whole, very vulnerable to the impacts of environmental perturbations. Since the dominant livelihood activities in all AEZ included in this study are mainly agro-based, the substantial need for adaptive capacity building, irrespective of zone, is conceivable. This low level of adaptive capacity undermines the realization of the country's adaptation strategies and development aspirations, including the sustainable development goals. It particularly limits the attainment of SDG 2, which targets ending hunger, achieving food security, improving nutrition, and promoting sustainable agricultural systems. The situation also complicates the country's aspiration for modernising the agricultural sector; in the face of climate change, this will require significant investment in the planning and implementation of adaptation response efforts such as irrigation, new seed varieties suited to new conditions, and improved post-harvest management systems, strengthening agricultural extension services, among others, with regard to the capacity building specific needs of communities.

The mismatch in the level of assets and resources and capacity building needs in the different AEZs, depicted by the results of this study, is consistent with the literature, which suggests that the levels of adaptive capacity cannot be solely explained by material assets and social opportunities in a socio-ecological system [16]. It is, therefore, essential to recognise that adaptive capacity is a multifaceted and dynamic concept [33,63,64]. This observation implies a need for development of adaptation strategies to facilitate the translation of assets and resources into effective adaptation action, leading to a reduction in vulnerability. Recent studies have demonstrated that translation of assets and resources in a socio-ecological system into adaptive capacity requires consideration of many domains, including psychosocial factors. These factors include risk attitudes, personal experiences, level of trust, and expectations in authorities, competing concerns, and household composition dynamics [16,64]. Capacity building strategies to address adaptation needs, therefore, should be designed with due consideration of the different domains and factors.

4.2. The Variation in Specific Needs across AEZs

Although we observed a generally high need for capacity building irrespective of the AEZ, there were differences in the nature of needs across the zones. These differences mirror the contrasting climate risks and impacts encountered in each agro-ecological zone. For instance, zones such as WMHF and WMFS, prone to severe drought events, exhibited substantial needs for drought-related adaptive capacity, whereas LVCMF, characterized by high rainfall, exhibited lower capacity needs for drought adaptation. These findings underscore the need for location-specific planning and tailored adaptation strategies, which address the unique combinations of climate risks and adaptive capacity needs at the micro-level. In line with the global climate change policy regime, Uganda has progressively developed policies intended to provide an enabling environment for local-level adaptive capacity building. However, the high and varied needs revealed by this study present a substantial gap between the current policy framework and the realities on ground. For example, Uganda's policies and plans [65–69] emphasise a devolved, inclusive, and people-centred implementation of adaptation action to create autonomous and resilient societies. NDPIII identifies the Parish Development Model (PDM) as an implementation mechanism to achieve inclusive socio-economic transformation (including capacity building) of households. The updated NDC recognises climate change education, research, training, public awareness, technology development and transfer as critical elements needed to transform Uganda into a climate resilient society and for achieving the Paris Agreement's goals. However, this study reveals that the policies and plans have not necessarily translated into adaptive capacity building reality at local level. Similar studies have reported considerable gaps in policy design and implementation, including the lack of proactive engagement of communities, limitations to access of timely and reliable climate information, inadequate structures and services (such as a community-level extension system) and resources, including financial resources, to boost local response actions. This results in a persistent lack of tailored adaptation actions, which leads to failure to address local needs [70,71]. Therefore, proactive engagement of local communities in developing and implementing adaptive capacity building strategies that translate the existing, as well as new, national policy and legal frameworks into practice is urgently needed. Such strategies will require the establishment of a network of agriculture extension workers, to support the implementation of the different capacity building elements.

This study and other studies, including [70,72,73], reflect two perennial policy criticisms in the policy formulation process in developing countries. First, policies are developed out-of-sync with local realities, leading to lack of congruence with local needs of communities; and therefore very difficult to mainstream such policies into local communities' contexts. Second, there is a continued use of top-down approaches to policy formulation and implementation, which promote elite monopoly of custodianship of information and the associated marginalization and vulnerability of communities [74]. Such approaches have been criticized for perpetuating historical power imbalances, brought about by centralised and exclusive decision making [75]. It also hinders ownership and implementation of policy at the local level, because of the disconnect with the needs and priorities at the local community level [76]. The manifestations of the limited in-country capacities and capabilities to implement locally driven adaptation responses, especially in the nature-based agricultural sector, include food insecurity, water shortages, and a constrained economic growth, which, in turn, have aggravated health impacts, hunger, poverty, migration and conflict over diminishing natural resources and agricultural productivity [77]. These undermine Uganda's efforts towards attaining the desired higher income status and the UN's Sustainable Development Goals.

As climate change continues to threaten the livelihoods and lives of people, especially among the most vulnerable communities in Least Developed Countries, it is imperative that different actors, including policymakers researchers, and practitioners, including extension workers focus on addressing location specific adaptation needs. This is most important for local communities that are heavily dependent on agriculture, which is currently highly vulnerable to the impacts of climate change [1,78]. Such efforts should intentionally aim at promoting meaningful local community level leadership and participation in strategies and actions for achieving vulnerability reduction and strengthening resilience. Failure to bridge the gap between global and national climate change response efforts and local level needs of communities could exacerbate the already existing challenges, including increased environmental degradation, decreased crop yields, food insecurity, increased vulnerability to extreme weather events, and poverty, hence compromising the well-being and livelihoods of those who rely on agriculture. Moreover, without effective adaptation strategies, LDCs will continue to struggle to keep pace with global developments, and will find themselves increasingly impacted and marginalised by climate change. Therefore, it is crucial that LDCs prioritize climate adaptation policies and practices that are tailored to their specific local needs and circumstances.

5. Conclusions

Results of this study have demonstrated a high need for adaptive capacity building in Uganda's agriculture sector, irrespective of geographical location characteristics. Differences in access to material assets and social opportunities depicted by different agro-ecological zones do not translate into differences in climate change adaptive capacity. Resource endowment is therefore not an accurate adaptive capacity predictor in countries like Uganda. Additionally, the study has shown that the nature of adaptive capacity needs is location- and context-specific, and varies considerably across locations, even within the same country. Strategies to enhance adaptive capacity must, therefore, be context-specific, to avoid the likely failures associated with generalisations, including ineffective uses of resources.

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