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Evidence of Climate Change Coping and Adaptation Practices by Smallholder Farmers in Northern Ghana

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Abstract: Evidence on how coping practices for immediate climate variations can transform into long-term adaptive capacity are relatively limited. This study addressed this gap by identifying the coping practices for short-term climate variations and the adaptation measures used by smallholder farmers to address future climate change in northeast Ghana. The paper used a mixed-methods approach, including household surveys, focus group discussions and key informant interviews. Data were collected from 555 households located in six communities across three districts in northeast Ghana. Results indicated that smallholder farmers were employing a host of practices to address the threats posed by climate change. Key adaptation practices included the planting of drought-tolerant crop varieties, the use of indigenous knowledge, intensification of irrigation, migration, adjusting the planting calendar, crop diversification, mixed farming, and sustainable land management practices. On the contrary, short-term coping practices reported by the study participants included the sale of non-farm assets, complementing agriculture with non-farm jobs, selling livestock, engaging in wage labor, charcoal burning and reliance on social networks. The results further revealed that barriers to climate change adaptation and coping practices differed by gender. The paper recommends that capacities of smallholder farmers in vulnerability hotspots should be enhanced to address immediate climate variations, as well as future climate changes. Ghana's climate change and agricultural policies should prioritize adaptations by smallholder farmers in addressing threats posed by climate change.

Keywords: adaptation; sustainable development; gender; livelihoods; food security

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1. Introduction

There is overwhelming evidence that anthropogenic-induced climate change will continue to adversely affect economic activities across the world. The Intergovernmental Panel on Climate Change (IPCC) has projected that global surface temperatures will increase by at least 1.5 °C by the close of this century [1]. Rain-fed agricultural systems, and agro-based livelihoods of rural communities located in dryland West Africa, will be particularly affected [1]. West Africa has been described as a climate change "vulnerability hotspot" [2], due largely to overreliance on rain-fed agriculture and the difficulty in adapting agriculture to changing climatic conditions [3,4].

Northern Ghana constitutes one of the climate change "vulnerability hotspots" in West Africa [4–6]. Temperature is projected to increase, whilst rainfall is expected to be highly variable across all agro-ecological zones in the country [7,8]. The occurrence of extreme events, including droughts and floods closely linked to climate change are expected to increase in frequency across Ghana [7]. This will certainly affect food production with serious consequences for the livelihoods of farming households [9,10]. Agriculture is an important economic sector in Ghana, contributing considerably to the country's Gross Domestic Product, as well as providing employment for majority of the labor force [11]. Despite its significance for the socioeconomic development of the country, agricultural production in

Ghana is highly vulnerable to the adverse impacts of climate change. This vulnerability is aggravated by non-climatic stressors, such as complex land tenure systems, land degradation, lack of ready markets and poverty, that interact with already harsh climatic stressors, including intense drought, dry spells and frequent flooding to affect food production systems [12–14]. Adaptation is critical if smallholder rain-fed agricultural systems are to withstand the adverse impacts of climate change.

The IPCC report on 1.5 °C global warming highlights that there are significant synergies between adaptation and sustainable development for agriculture [15]. Smallholder farmers in dryland farming systems have used their agro-ecological knowledge, accumulated over years of farming experiences, to manage non-climatic and climatic stressors, including drought and increasing temperatures [16]; yet, studies have started questioning the sufficiency of such coping practices in dealing with long term climate changes [17]. There is, therefore, the need to provide a conscious and concerted support to smallholder farmers in order to build their capacity to address the challenges posed by climate change in the medium and long term. Adaptation offers the best approach for addressing the threats posed by climate change for developing countries [6,18]. This is necessary in order to safeguard the livelihoods of rural communities and farmers to ensure household food security. It is crucially important to understand how smallholder farmers in Ghana's climate vulnerability hotspots are implementing coping and adaptation measures to manage climate risks.

Smallholder farmers' perceptions of the changing rainfall and temperature patterns in dryland farming systems are also critical in understanding how they respond to climate change. It is reported that farmers will be more willing to address climate risks if they can perceive changes in the climate [19]. However, most studies on climate change have focused on the impacts of climate change on food production [20–22] as well as the adaptation practices of smallholder farmers (including [23–26]). Still, others have explored factors influencing the choice of adaptation practices by smallholder farmers [27,28].

Whilst advancing the frontiers of knowledge on climate change adaptation, scholarship on how coping practices to immediate climate variations can be used to build capacity to address future climate changes are relatively limited. This paper therefore addresses this research need by identifying the coping practice to short-term climate variations and the adaptation measures used by smallholder farmers to address future climate change. The goal of this study was to understand the coping and adaptation mechanisms employed by smallholder famers in northeastern Ghana to manage climate change effects on their farming practices and livelihood activities. The specific objectives were to (1) determine the perceived impacts of climate change in North-Eastern Ghana; (2) assess the key coping and adaptation practices used by smallholder farming households; and (3) determine the barriers to the successful implementation of adaptation and coping practices by smallholder farmers in northeastern Ghana.

2. Coping, Adaptation, and Transformational Adaptation

Over the past two-and-a-half decades, coping and adaptation have become two key concepts in the literature on societal responses to climate change. The meaning of these concepts has attracted debate within the areas of research, policy and practice. Coping precedes adaptation in explaining social responses to environmental stress. It has its origin in the development studies literature, particularly the sustainable livelihoods framework [29]. Coping practices refer to short-term measures implemented by farmers to counteract the adverse effects of climate change [30]. These strategies tend to be oriented toward reducing exposure to anticipated or observed impacts from socio-ecological stressors [31]. They may not necessarily be economically or environmentally sustainable. As outlined by Ellis et al. [29], five main coping practices can be identified in the order in which they are likely to occur: pursuing new sources of income; drawing upon reciprocal obligations (sharing resources such as seed and labor); decreasing the size of the household through temporary migration; decreasing the size of movable assets (e.g., livestock); and selling of

fixed assets (e.g., land). Permanent distress migration is often the last resort used in coping, when all other strategies have been explored.

Adaptation, however, is an advanced form of coping. The IPCC defines climate change adaptation as "adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" [1] (p. 6). There have been many overlapping ways of characterizing adaptation. One distinction is incremental and transformational adaptation [31].

Incremental adaptations to changes in climate are extensions of actions and behaviors that already reduce the losses or enhance the benefits of natural variations in climate and extreme events. For most authors, it implies change that is more than routine [32,33]. Some authors argue that such adaptation approaches risk extending unsustainable practices in a changing environmental context [34,35]. This reactive approach to adaptation often adopts a strongly technocratic and managerial perspective, wherein potential climate threats are seen as a series of identifiable risks that require a variety of institutional and technological solutions to preserve the status quo in the face of climate change. As a result, calls have been made for what is now called *transformational adaptation*—the process of going beyond adjustments to existing practice.

Transformational adaptations are adopted at a much larger scale or intensity than those that are truly new to a particular region or resource system [31]. Transformation is based on the assumption that adaptation should challenge the underlying conditions that generate or perpetuate risk [33,36]. In other words, adaptation should not focus solely on addressing the surface symptoms of vulnerability, but rather target the underlying causes at a society-wide level [37]. Transformational adaptation is grounded within political ecology research that holds exposure to climatic shocks to be strongly determined by existing inequality, disempowerment and marginalization [38]. As described by Pelling et al. [39] (p. 114), adaptation as transformation means prioritizing actions that "have the reach to shift existing social systems (and their component structures, institutions and actor positions) onto alternative development pathways, even before the limits of existing adaptation choices are met." The present paper draws upon these ideas to assess the sustainability of current responses being used by smallholder farmers to address climate variability and change in northeastern Ghana.

3. Materials and Methods

3.1. Site Description

The study was conducted in Ghana's Upper East Region, which lies between Longitude 0° and 1° W, and Latitudes 10° 30′ N and 11° N [11] (Figure 1). The Upper East region was purposely selected because of the region's high climate change vulnerability, coupled with high incidence of poverty [6,11]. The region is located in the Sudan savannah agro-ecological zone and is characterized by high rainfall variability. It has a unimodal rainfall patterns, receiving an average of 1000 mm per annum [40]. There is a marked variation in the onset, intensity, and duration of the rainy season. Three local assemblies were selected for fieldwork, including Bawku West District, Kassena Nankana Municipal, and Talensi District, based on advice from regional agricultural development officers.

The Bawku West District has an estimated population of 90,034 and covers an area of approximately 1070 square kilometers [41]. The district experiences a unimodal rainfall regime lasting 4 to 6 months and a long dry period of 6 to 8 months in a year [41]. Agriculture provides income and employment for over 80% of the population in this district [41]. The Kassena Nankana Municipality has an estimated population of 109,944 [42]. The average annual rainfall in the municipality is 950 mm [42]. Agriculture provides employment to majority of the population [42]. The Talensi District has a population of 81,194 and a land area of 838.4 km^2 [43]. An estimated 90.7 percent of households in the district are engaged in agriculture. Two communities were selected from each local assembly, for a total of six study communities. These communities included Vunania and Saboro from

Kassena Nankana Municipal; Telli and Yarigu from Bawku West district; and Tindongo and Yameriga from the Talensi district.

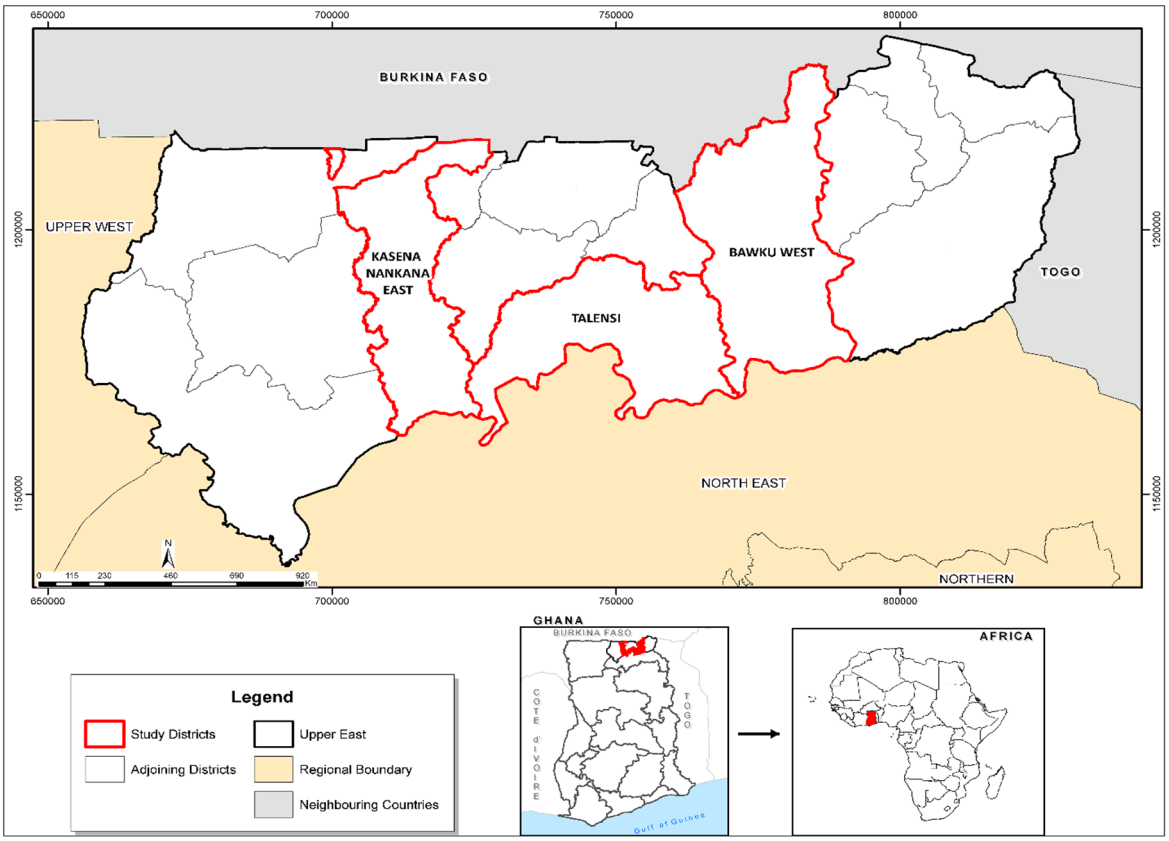

Figure 1. The Upper East Region showing the study districts.

3.2. Research Methods

A cross-sectional research design was used for this study. Data collection took place between September and October 2019, with a mixed-methods approach implemented in three phases (Table 1). Phase one involved two regional stakeholder workshops held in Navrongo and Bolgatanga in September 2019. These workshops provided an opportunity to understand general climate change issues in the study region. During the workshops, we also identified access to climate information services. Key informant interviews were held with opinion leaders and district and regional agricultural development officers to understand issues confronting various stakeholders in managing the threats posed by climate change.

Phase two involved a quantitative survey with 555 households across the six communities in the three local assemblies. Within each community, households were randomly sampled and the head or his/her representative was invited for the survey. A questionnaire was used for the survey, and included questions on socio-demographic characteristics, perceptions of climate change, access to climate information services, and the coping and adaptation practices employed by farmers to manage climate risks. During the household surveys, respondents ranked the most preferred coping and adaptation options, and this exercise was used to calculate the rankings for the various coping and adaptation practices. Coping and adaptation practices presented to households were selected from the literature and refined by agricultural development officers; extension officers and agents, as well as farmers, during the regional and district level interactive workshops (phase 1). The questionnaire was pre-texted with selected farmers and further modified based on concerns

raised during the pre-texting. On average, each household survey took between 45 min to 1 h 30 min and data were collected with the help of CSPro software.

Table 1. Summary of data collection methods.

Phase	Method	Sampling Strategy and Sample Size	Information Collected
I	Stakeholder workshops in Navrongo and Bolgatanga	• Purposive sampling. • 55 stakeholders.	• General climate change issues in the Upper East Region. • The landscape of climate information services in the study region.
II	Household questionnaire survey	• Random sampling. • 555 households in six communities.	• Climate change perceptions. • Access to climate information services. • Coping and adaptation practices.
III	Focus group discussions	• Maximum variation sampling. • 12 focus groups; six with women and six with men. • 136 participants in all focus groups.	• Discussion of gender-related issues prominent in the household surveys.

Phase three involved focus group discussions to triangulate some of the key issues captured during the household survey. Focus groups probed issues related to gender and the perceived impacts of climate change on livelihoods. In all, 12 gender-specific focus group discussions were held, with two in each community. Focus groups consisted of 7–18 participants, drawn from the farmers that demonstrated extensive agro-ecological knowledge during the household questionnaire surveys. The participants also reflected different socioeconomic characteristics including gender, education, and farming experiences and included community leaders, chief farmers, youth leaders and women's group leaders, where possible. Focus group participants were also farmers who have lived in the study communities for considerable period to understand and appreciate the local environmental and ecological changes that have taken place over time. Separate male and female FGDs were held in each community because of sociocultural barriers that prevented females from freely expressing themselves in the presence of their male counterparts. Discussions in the focus groups were moderated by the research team with support from local research assistants who acted as interpreters. Differentiated impacts of climate change on different genders were identified and the appropriate coping and adaptation mechanisms employed by households discussed. All FGDs were digitally recorded with the consent of participants.

The household surveys were analyzed using descriptive statistics. To determine the rank of each of the adaptation practices, we calculated Relative Importance Index (RII), which is a descriptive statistical technique. We used the mathematical formula below:

$$RII = \frac{\sum_{i=1}^{n} W_i \, n_1}{A \times N} \times 100$$

where W_i = weight of each i^{th} total response given by the respondents. In this case, it ranges from 1 to 5, n_i = total number responses in each response box, A = the highest response integer (5); and N = the total number of respondents [44].

Qualitative data from FGDs and key informant interviews were analyzed using thematic content analysis [45]. To make data identification manageable, unique alphanumeric codes were used to label all interview transcripts and field notes. Then, transcripts and field notes were hand-coded for recurrent themes, following analytical strategies, suggested by Miles et al. [46] and Patton [47].

4. Results and Discussion

Results indicate that smallholder farmers were employing a host of practices to address the threats posed by climate change. Some of these strategies were short-term measures, which could be classified as coping practices. Others were long-term measures that could be referred to as adaptation practices. In addition, some were traditional, while others were newly introduced practices. Most adaptation and coping practices were said to serve multiple purposes and were strongly interrelated. These study results are presented below under four main sub-sections. The first sub-section briefly examines farmers' perceptions of the impact of climate change and variability. Next, farmer-identified adaptation practices are discussed, including a rank order of these strategies and how they differ by gender. The third sub-section presents results on coping practices, their ranked order of importance, as well as how these strategies differ by gender. The final part of the results focuses on the gendered nature of barriers to adaptation and coping practices.

4.1. Farmers' Perceived Impacts of Climate Variability and Change

There is a growing body of literature showing that, in order for farmers to initiate climate change adaptation or coping practices, they must first perceive extreme climatic events as a problem (see for example, Boillat and Berkes [48]; Deressa et al. [49]; Orlove et al. [50]). Thus, during the fieldwork for this study, both female and male farmers were asked if they have observed any changes in climate over time. For those who indicated experiencing extreme climatic events, they were also asked about associated impacts on livelihoods and daily life more broadly.

Overall, five main extreme climatic events were reported by the study participants. These included erratic rainfall, increased windstorms, and increased incidence of flooding. Others were increased temperature, and the drying up of water bodies. Table 2 summarizes some illustrative accounts by farmers explaining these extreme climate events. These findings are similar to those of other studies, including research comparing farmer perceptions of climate change and how these compare with the official climate data in Ghana's Upper East Region (for example, Fagariba et al. [51]; Nuhu and Matsui [52]; Issahaku et al. [53]).

In exploring the findings in Table 2 further, it is clear that these extreme climatic events have highly gendered impacts, a finding that is also consistent with the existing literature [54,55]. For example, while both women and men reported that erratic rainfall leads to lower crop yield, women indicated additional impacts not specifically reported by men. Some of the impacts that were unique to women included traveling far to fetch water for domestic uses. Another challenge of erratic rainfall unique to women was the difficulty in finding water points for livestock. However, there were other extreme climatic events where both women and men reported the same associated impacts. A typical example was increased temperature, where both women and men reported that there have been impacts linked to increased diseases. Such findings align closely with previous studies on the impacts of climate change in other parts of Africa. For instance, in a study of climate risk perceptions and impacts in South Africa [56], the authors found that while more men were worried about drought, more women recognized heavy rains as a major risk. Similarly, in Ethiopia, men were concerned about livestock prices, while women's concerns focused on food availability [57]. Such findings have been linked to gender-specific livelihood activities.

Table 2. Perceived impacts of climate variability and change.

Extreme Climate Events	Illustrative Quotes by Farmers	Impacts Reported by Men	Impacts Reported by Women
• Erratic rainfall	*"We used to receive rains earlier than we are experiencing these days. It is extremely difficult to predict the rains nowadays. The rains do not come early and when they come, you cannot predict for how long. This makes planning farm operations difficult."*	Low crop yield.	Travel far to fetch water for domestic uses. Difficulty in accessing water points for livestock. Our animals suffer. Low crop yield.
• Increased windstorms	*"Gradually, we are experiencing a lot of storms in these communities than we used to have. Nobody knows where these storms are coming from, but they can cause loss or havoc to properties including our farm crops."*	Destruction of trees, crops, animals, farms and houses. When trees are destroyed by windstorms, it causes land degradation and soil erosion.	Destruction of crops and economic trees like dawadawa (*Parkia biglobosa*), shea (*Vitellaria* sp.), and baobab trees. Destruction of animals.
• Increased incidence of flooding	*"Flooding has become a regular occurrence now. We do not have regular rains in these communities and when the rains do finally come, they come in high volumes and this often causes flooding of our farm lands, destroying our crops."*	Destruction of household properties. Destruction of farm crops	Increase in insects from White Volta. Crops are destroyed. Houses are affected.
• Drying up of water bodies	*"Our water bodies are drying up especially during the dry season. This is not what we inherited from our parents in these villages. Drying up of the water bodies puts lots of stress on our women."*	Losing livestock because when there is no water, animals travel long distances in search of water and sometimes get lost. No water for home gardening.	Travel far to fetch water for domestic uses. Difficulty in accessing water points for livestock.
• Increase in temperature	*"The weather has become warmer than we used to experience in the 1970s. For instance, the harmattan is now very intense compared to when I was growing up in this village. The nights also become hotter and sometimes you cannot even sleep in the room."*	Increased in sicknesses (CSM), anthrax and airborne diseases	Increased diseases. Drying of river bodies. Animals cannot get water

4.2. Farmer-Identified Adaptation Practices by Gender

Results further showed that farmers use a range of adaptation practices to address climate variability and change. The strategies that farmers identified specifically as "*adaptation*" (i.e., more than routine and not short-term in nature) included migration, the use of drought-tolerant crop varieties, intensification of irrigation, the use of indigenous knowledge, adjusting the planting calendar, crop diversification, mixed farming, and sustainable land and soil management practices (e.g., mulching, crop residue retention, zero tillage), among others (see Table 3). Among these strategies, the top three, by rank order, were crop diversification, planting drought tolerant crop varieties, and complementing agriculture with non-farm jobs (see Table 4). About 87% of females and 85% of male farmers reported the use of drought-tolerant crops to reduce the impacts of climate change on agriculture. The use of drought tolerant crops has become an important adaptation strategy in these vulnerability hotspots, where changes in the rainfall patterns present significant challenges

to farmers. Many farmers save drought-tolerant varieties of seeds, such as millet, corn, and wheat, and use them as an adaptation to climate change. Previous studies have suggested that farmers in drought-prone areas resort to the use of improved varieties of crops, such as planting drought tolerant crops in managing crop yield losses and pest attacks (see, for example, Dapilah and Nielsen, [10]; Fisher et al. [58]; Mwase et al. [59]).

Table 3. Farmer-identified adaptation practices by gender.

Adaptation Practices	Female		Male		Difference		
	%	S.E	%	S.E	%	S.E	T-Value
Intensification of irrigation	56.3	0.497	52.9	0.500	3.4	0.043	0.800
Using of indigenous knowledge	74.3	0.438	71.2	0.454	3.1	0.039	0.819
Adjusting planting calendar	82	0.385	83.8	0.369	−1.8	0.033	−0.549
Planting drought tolerant and early maturing varieties of crops	87.4	0.333	85.6	0.352	1.8	0.030	0.611
Migration to work elsewhere	24.8	0.433	24.6	0.431	0.2	0.037	0.040
Crop diversification	92.8	0.259	94.6	0.226	−1.8	0.021	−0.843
Complementing agriculture with non-farm jobs	44.1	0.498	32.4	0.469	11.7 **	0.042	2.813
Sustainable land and soil management practices	91	0.287	90.1	0.299	0.9	0.026	0.353
Mixed farming	96.8	0.175	95.5	0.208	1.3	0.016	0.798

Note ***, **, and * denote significant levels of 0.01, 0.05, and 0.1, respectively.

Table 4. Ranking of adaptation practices.

Adaptation Practices	Activity		WAI	Rank
	No	Yes		
Crop diversification/mixed cropping	34	521	93.87	1
Planting drought tolerant or resistant crop varieties	166	389	90.45	2
Complementing agriculture with non-farm job	349	206	86.31	3
Use of indigenous knowledge	153	402	70.09	4
Intensification of irrigation	254	301	64.68	5
Sustainable land and soil management practices	53	502	43.42	6
Migration to work elsewhere	418	137	37.12	7
Adjusting planting calendar	94	461	24.68	8

Farmers reported switching to drought-tolerant crop species and others indicated switching to something better suited to the new climate they face. In the face of climate change, farmers choose different varieties based upon projected rainfall variations for a given season. Previous studies (see, for example, Dapilah and Nielsen, [10]; Fisher et al. [58]; Westengen and Brysting, [60]) have also suggested that adaptation practices employed by some farmers lessen the adverse effects of climate change. Limited availability of alternatives and the costs and perceived risks associated with adopting a new variety of crop species have often been reported as some of the constraints to the adoption of new varieties of crops.

Although irrigation is quite an important adaptation strategy in dryland farming systems, the results showed that only 56% of the female farmers and 53% of the male farmers indicated using this practice to address the threats posed by decreasing rainfall patterns (Table 3). Irrigation provides opportunity to supplement inadequate and erratic rainfall and improves groundwater storage due to water lost from the soil because of high evapotranspiration rate. The percentage of farmers who reported using irrigation was quite high and this could be attributed to the presence of the Tolon irrigation dam that provides

opportunities to farmers at Vunania. Farmers are also changing their planting calendars in response to the changes in the onset and cessation of the rainfall patterns occasioned by climate change and variability. The results revealed that 82% of females and 84% of males reported having changed their planting calendar to reduce the effects of climate change. Our results compare favorably with previous studies that have indicated that farmers have resorted to early or late planting depending on the onset of the rains and the length of the rainy season to maintain or increase crop yields in the face of a changing climate [61–63].

About 24% of all the households sampled reported that a member of the households had migrated in the past because of inadequate rainfall that prevented them from undertaking their farming practices (Table 3). Migration is considered as an off-farm practice where farmers or those affected by climate extreme events travel to other places to work to make a living. Study respondents indicated that most of them travel to southern Ghana to undertake different menial jobs and remit their families from the wages obtained from these jobs. Many farmers reported that climate change is making smallholder agriculture increasingly unviable, thus necessitating the need to find alternative livelihood strategies, including migration. One key informant summarized the frustration farmers face in Ghana's northern region, and why some decide to choose non-farm livelihoods:

> *No rains mean no farming in this village. This is the frustration of farmers in this village. We depend on agriculture for our livelihoods, but we also need rains for our farm produce. Without the rains, many of us are switching to non-farming livelihoods that are difficult to find. Many of our people are therefore migrating to the south.*
>
> **(Key informant interview, Bolgatanga, October 2019)**

In Ghana, Luginaah et al. [64] and Rademacher-Schulz et al. [65] have reported that erratic rainfall patterns cause rural smallholder farmers to migrate to communities or places where they can sustain their livelihood. Previous studies (see, for example, Scheffran et al. [66]; Black et al. [67]) have also suggested that migrants have transferred remittances, technology, knowledge and other resources to the communities of origin, thereby improving development and building the social resilience of those communities to the shocks of climate change.

The results further showed that smallholder farmers are increasingly diversifying their crops (see Table 3). This serves as an insurance mechanism against total crop failure due to erratic rainfall and high temperature patterns associated with climate change. Some of the most common crops used in diversified farming systems include corn, millet, sorghum, groundnuts, and bambara beans. The in-depth interviews provided rich accounts explaining why farmers chose crop diversification. During focus group discussions, participants indicated that they employed crop diversification as a strategy not only to improve soil fertility, but also to reduce the risk of crop failure. For example, the inclusion of leguminous crops, such as cowpea, can add nitrogen to the soil. One female farmer justified the need for crop diversification:

> "*We [farmers in the community] plant different crops during the farming season including millet, sorghum and bambara beans and some maize. This is to ensure that we have something to feed my family.*
>
> **(Female farmer, Focus group discussion, Talensi district, October 2019)**

Previous studies (for example, Vincent et al. [26]; Makate et al. [68], McCord et al. [69]) have reported that majority of farmers have adopted crop diversification to increase productivity as well as to enhance their resilience to climate change. According to the authors, the farmers prefer this adaptation strategy because it helps to improve the productivity of crops, nutrition, income and food security at the household, district and regional levels. In Southern Ghana, similar results have been reported [24] suggesting that famers employ climate adaptation measures such as changes in farm location, changes in crop variety, irrigation, migration, and diversification to non-farm activities.

Smallholder farmers are gradually shifting from agriculture to non-farm jobs as an adaptation strategy. About 44% of females and 32% of males sampled indicated shifting to

non-farm jobs. This is confirmed by previous studies [70,71] where the authors reported that some farmers have entered into other non-farm activities including mining, manufacturing, trade, communication, transportation among others to obtain a source of income that they consider as efficient as farming. For example, different types of maize were planted to take advantage of differing eco-niches and to reduce the risk of losing a whole crop during droughts or dry spells. There are more than ten different varieties of maize in the study area. Some are high-yielding, early maturing, weed competitive, and tolerant of major pests. In the face of climate change, farmers choose different varieties based upon projected rainfall variations for a given season.

One of the common adaptation practices is land management. This includes practices such as mulching, planting cover crops, and the construction of ridges that seek to protect the land and conserve water in the soil. Land management practices are employed by resource-constrained farmers to control soil erosion, manage and enhance soil fertility, prevent and mitigate land degradation, and improve soil water storage. This practice is closely linked to farmers' use of indigenous knowledge, which represents a form of social capital to reduce the effects of climate change on their farming activities. The use of indigenous knowledge has been reported in previous studies (see for example, Jiri et al. [72]; Nkomwa et al. [73]) as playing vital role in climate change adaptation, especially by farmers who have limited or no access to weather and climate information services. However, the long-term effectiveness of indigenous knowledge has been questioned as famers are becoming worried lately because of how the weather has become difficult to predict [74]. Nonetheless, previous studies [75–77] all recommend the integration of indigenous knowledge and scientific knowledge to build the adaptive capacity and resilience of farmers to the changing climate.

Another key strategy is planting of early maturing varieties of crops. In terms of crop species variety, farmers mentioned the use of seeds with variations in genetic and phenotypic characteristics. For example, different types of maize were planted to take advantage of differing eco-niches and to reduce the risk of losing a whole crop during droughts or dry spells.

4.3. Farmer-Identified Coping Practices by Gender

The study participants identified eight coping practices used to manage the impacts of climate change on a short-term basis (Table 5). Coping practices often included formal and informal approaches. An example of a formal coping mechanism was receiving assistance from the government during natural disasters, such as flooding. Other existing research (for example, Nti, [78]) has revealed similar formal coping practices to addressing the impacts of climate change among smallholder farmers in Ghana's Upper East Region. The effectiveness of such government assistance programs, however, has often been questioned in Ghana and other African countries, as not all households in need are able to access such resources [79]. Similarly, research has shown that such formal coping practices do not sufficiently address the needs of women of different identities, thus posting gender and other social justice concerns [80,81]. Informal approaches to coping with climate change included the sale of non-farm assets, selling livestock, and engaging in wage labor. A farmer remarked during a focus group discussion that:

> *Depending on only crops is becoming dangerous in many of our communities. In addition to crop cultivation, many of the farmers in this community are also producing livestock. We sell our livestock on market days to buy food to feed our families. This keeps us going until we begin to harvest our crops after the rains have finally come.*
>
> **(Male farmer, Focus group discussion, Bawku West district, October 2019)**

Other approaches were petty trading (e.g., selling "*pito*"—locally-brewed alcohol), charcoal burning, skipping meals and/or cutting back on food consumption, and relying on social networks, such as friends and neighbors. With the latter, some specific key strategies involved reciprocal exchanges of resources, including sharing food, and lending

money, among others. Such strategies stem from social responsibilities, which tend to be more prominent among kin groups and rural communities in Ghana [82,83].

Table 5. Farmer-identified coping practices by gender.

Coping Practices	Female		Male		Difference		
	%	SE	%	SE	%	SE	T-Value
Sale of non-farm assets	21.2	0.409	20.4	0.404	0.8	0.035	0.213
Receiving assistance from the government	20.7	0.406	22.5	0.418	−1.8	0.036	−0.506
Selling livestock	59.5	0.280	61.0	0.342	−1.5	0.042	−0.354
Engaging in wage labor	8.6	0.095	13.5	0.077	−4.9 *	0.027	−1.792
Petty trading (gari processing, pito brewing, basket weaving, selling firewood)	24.3	0.430	7.5	0.264	16.8 ***	0.003	5.209
Charcoal burning	4.5	0.208	4.2	0.201	0.3	0.033	0.169
Reducing food consumption	76.1	0.427	81.4	0.390	−5.3	0.026	−1.470
Relying on social networks (friends, neighbors)	23.9	0.427	25.5	0.437	−1.7	0.008	−0.442

Note ***, **, and * denote significant levels of 1%, 5%, and 10%, respectively.

Based on the survey analysis, some significant differences were found between the ability of women and men to rely on these informal coping measures (Table 5). For example, petty trading (Difference = 16.8, SE = 0.003, $p < 0.05$) and skipping meals or cutting back on food consumption (Difference = −5.3, SE = 0.026, $p < 0.05$) were mentioned more frequently by women than men. Male farmers, however, engaged more in wage labor (Difference = −4.9, SE = 0.027, $p < 0.05$) compared to female farmers. This can be explained by the labor market rigidities that favor men compared to women [84]. Among the coping practices identified, the top-three, by ranked order, were reducing food consumption, selling livestock, and relying on social networks for support (Table 6). Reducing food consumption entailed the modification of eating patterns, restricted food sharing practices to conserve resources, and food replacement. A female farmer narrated:

> *Most of us [farmers] have started reducing the food consumption in our households. This is in direct response to inadequate food due to erratic rainfall patterns that have become more pronounced in the last few years. We do not get enough food from our own farms and we do not also have money to purchase so, we reduce how much we consume. Most farmers are now changing our favorite diets to eat whatever food maybe available to us.*
>
> **(Female farmer, Focus group discussion, Kassena Nankana Municipal, September 2019)**

Primary caregivers of food insecure households often skipped meals so that their children could eat. Although livestock serve as an important source of wealth in the study area, some farmers indicated selling their animals in times of socio-ecological stress. The two least-ranked coping practices were engaging in wage labor and charcoal burning. Charcoal production was perhaps less popular due to its forest degradation nature, especially in ecologically fragile environments in sub-Saharan Africa [85,86].

4.4. The Gendered Nature of Barriers to Adaptation and Coping Practices

Despite farmers' efforts to adopt different adaptation and coping practices to deal with climate change, they nonetheless face different barriers, many of which were discussed during the focus groups and in-depth interviews (Table 7). These barriers differed by

gender. For example, more women than men mentioned such barriers as an inadequate market for agricultural produce, lack of irrigation facilities, land tenure insecurity, and lack of labor for farm operations.

Table 6. Ranking of coping practices.

Activity	No	Yes	WAI	Rank
Dietary management (reducing food consumption)	115	440	79.28	1
Selling livestock	220	335	60.36	2
Relying on social networks	335	220	39.64	3
Receiving assistance from the government	434	121	21.80	4
Sale of non-farm assets	440	115	20.72	5
Petty trading	476	79	14.23	6
Engaging in wage labor	491	64	11.53	7
Charcoal burning	531	24	4.32	8

Table 7. The gendered nature of barriers to adaptation and coping practices.

Barriers	Sex	Mean	Std. Deviation	Std. Error Mean	T-Value	*p*-Value
Inadequate credit facilities	Female	0.88	0.322	0.022	−0.443	0.658
	Male	0.89	0.307	0.017		
Inadequate market for agricultural produce	Female	0.82	0.389	0.026	1.712	0.087
	Male	0.75	0.431	0.024		
Poor institutional support	Female	0.91	0.280	0.019	−1.004	0.316
	Male	0.94	0.243	0.013		
Lack of irrigation facilities	Female	0.91	0.287	0.019	1.420	0.156
	Male	0.87	0.336	0.018		
Lack of climate information on agriculture	Female	0.89	0.311	0.021	0.944	0.345
	Male	0.86	0.342	0.019		
Land tenure insecurity	Female	0.41	0.493	0.033	1.617	0.107
	Male	0.34	0.475	0.026		
High cost of farm inputs (seeds and fertilizers)	Female	0.90	0.299	0.020	1.471	0.142
	Male	0.86	0.349	0.019		
Lack of labor for farm operations	Female	0.71	0.456	0.031	2.083	0.038
	Male	0.62	0.486	0.027		

By using the various adaptation and coping practices mentioned above, farmers are able to harvest crops in abundance. However, they face challenges in accessing markets to sell the extra produce. This barrier was particularly key for women, who are culturally responsible for selling produce in the market. Inadequate market for agricultural produce was mentioned by 82% of the female farmers who were sampled in the study communities. One key informant summarized a recurring concern raised in many of the interviews and focus group discussions:

> *Smallholder farmers struggle for so many months without water to cultivate crops. When the rains have finally come for you to get some farm produce, the marketing also becomes a problem because of lack of ready markets. Some of our women have to walk long distances to get to markets. Market women sometimes take advantage of these farmers especially when we have certain farm produce in abundance and cannot get buyers. They determine the prices and our women are compelled to sell even at such lower prices.*

(Key informant interview, Navrongo, October 2019)

Most of these farmers contract loans for farming operations and the lack of markets present considerable challenge in meeting the repayment of such loans. Additionally, the lack of markets most often compels these farmers to sell their farm produce cheaply. Other studies have reported similar challenges in Northern Ghana [25].

Women also face problems related to land tenure insecurity. The study area has complex land tenure arrangements, which work to affect women. A female farmer shared her experiences with this complex land tenure system, especially how it can affect access to fertile land for climate risk management:

> *Complex land tenure issues and cultural practices sometimes make it difficult for women to get access to prime fertile land for farming activities. Most women depend primarily on their husbands for farmlands and this is not helpful in building the capacity of smallholder farmer to manage climate risks.*

(Female farmer, Focus group discussion, Bawku West district, October 2019)

Other key informants reinforced the land tenure concerns raised by the female farmers during focus groups and interviews. For example, because women often get access to lands that are less productive, they need access to complementary inputs, such as fertilizer and ploughing services, in order to raise yields. Yet women also have limited access to such inputs due to the gendered nature of resource access and control in the region. The following quotation reflects some of these gendered barriers to adaptation faced by women:

> *Women suffer more and are more vulnerable when it comes to climate change. The men determine the choice of where to farm. Mostly, women are given marginal lands that may be unproductive. In addition, they hardly have access to agricultural inputs and labour. Bullocks are used on male farms to plough and prepare their lands for the new season before women have access to them. Most times, the planting time would have elapsed.*
>
> **(Key informant, agricultural development officer, Bawku West district, October 2019)**

Lands are typically allocated to individual families, with the family head serving as the primary right holder. However, because of patriarchal cultural norms, intra-household transfer of land is only by inheritance through adult men [87]. Inadequate land tenure security for women in the Upper East region serves as a disincentive, which prevents farmers from long-term investment in land and soil, thereby affecting farm productivity and increasing the vulnerability of such farming households to climate change [25,80].

Farmers also mentioned increasing labor shortages as a problem that hinders the implementation of climate adaptation and coping practices with proven benefits. Some of these labor shortages were due to migration itself as a coping strategy to deal with climate change. For example, due to increasing youth out-migration to look for non-farm employment in other parts of Ghana, some study participants complained that agriculture is currently being performed by elderly and less active household members:

> *Most of our youth are migrating to the southern parts of the country because of lack of employment opportunities in this region. The poverty levels are high and general lack of development in this region has compelled our youth to migrate leaving the less able-bodies especially during the lean season. Some of these youth come back during the farming season but a lot of them do not come back, leading to shortages of labour.*

(Focus group discussion, Talensi District, September 2019)

Aside from migration, labor shortages were also attributed to the gender division of labor and cultural practices requiring that women spend time in their own fields, as well as that of the household collective field. These competing labor demands on the part of women affect their ability to properly till their own individual plots. One female farmer explained this problem by saying:

> *Sometimes as a woman, you are expected to spend time in your husband farm and that leaves with less time to attend to your own farm. This could lead to missing certain farm operations during certain critical period of the season including the timing of planting, and the application of fertilizers (both organic and inorganic).*
>
> **(Female farmer, Focus group discussion, Kassena Nankana Municipal, September 2019)**

Farmers also highlighted the lack of climate information as a key barrier impeding their adaptation efforts. Previous studies (for example, Antwi-Agyei et al. [62]; Makate et al. [68]; Fagariba et al. [88]; Singh et al. [89]) have shown that lack of information is implicated in farmers' inability to adapt to climate change across SSA.

The lack of irrigation facilities was also mentioned as a barrier to effective climate change adaptation. Women raised this concern more often than men. The key informant interview participants particularly mentioned that even if irrigation facilities are available, they tend to be controlled by men to the detriment of women:

> *Irrigation facilities are mostly not available in most of these communities. Even when they are available; the male farmers control these facilities, with women having little or no control over these facilities. These are also crucial especially during dry season when you need these facilities to function as a farmer.*
>
> **(Key informant interview, Bolgatanga, September 2019)**

Overall, these findings show the complicated challenges that farmers, in particular women, face as they try to navigate the difficulties posed by climate variability and change. A growing body of literature on the gendered implications of climate change in agrarian settings support the findings here. More specifically, this literature highlights how gendered patterns of labor and responsibilities produce both differentiated and distinct vulnerabilities at different scales, from the household to the national level (e.g., [90,91]). Our results compare favorably with other studies, suggesting that men and women adopt different on-farm and off-farm adaptation practices to address the threats by climate change [92,93].

5. Conclusions and Policy Implications

Climate change presents significant threats to rain-fed agricultural systems, and this hampers the attainment of the Sustainability Development Goals, particularly the goals relating to poverty reduction (Goal 1) and food security (Goal 2). This study explored the coping practices to short-term climate variations and the adaptation measures used by smallholder farmers to address future climate change in Northeast Ghana. It also identified the key barriers impeding the successful implementation of coping and adaptation practices by smallholder farmers. Farmers have, over the years, employed different adaptation practices to manage climate risks. The key adaptation practices included the planting of drought-tolerant crop varieties, the use of indigenous knowledge, intensification of irrigation, migration, adjusting the planting calendar, crop diversification, mixed farming, and sustainable land management practices. Coping practices often tend to be short-term responses to climate variations and include the sale of non-farm assets, complementing of agriculture with non-farm jobs, receiving assistance from the government, charcoal burning, selling livestock, engaging in wage labor, and reliance on social networks.

Whilst these practices address short-term climate risks, their effectiveness in building the capacity of the smallholder farmers to address future climate changes has been questioned [74]. Most of the adaptation and coping practices, such as reliance on social networks and selling livestock and charcoal, do not address the underlying causes of climate vulnerability. Such practices often lead to maladaptation where the capacity of the farmers to address climate change is compromised [94]. Migration as an adaptation practice can also cause maladaptation. If it involves men, the left-behind women could suffer land tenure insecurity, which is needed for successful adaptation [14]. This calls for a cautious exploration of these adaptation and coping practices to understand how they can be used to build the capacity of smallholder farmers to address both immediate and future

climate changes. There is the need for transformational adaptation practices that are more sustainable and can withstand the harsh climate changes projected to occur in the future.

The study further identified the key barriers to the implementation of climate change adaptation and coping practices. The barriers included lack of access to credit facilities, inadequate access to ready markets, complex land tenure systems, poor institutional support, high cost of farm inputs and lack of irrigation facilities. These socio-economic barriers do not act independently but rather interact to hamper the effectiveness of various adaptation and coping practices. Barriers to climate change adaptation and coping practices differed by gender and, therefore, there should be concerted efforts by policy makers to introduce gender-based climate change interventions to safeguard the livelihoods of the most vulnerable in such communities. The paper recommends the need to provide financial compensation for transformative changes that are deemed necessary for long-term viability, particularly for smallholder farmers. There is also the need for policy changes to address gendered cultural norms in this part of Ghana. Without addressing existing cultural and gender-based practices that affect women, transformation adaptation would be difficult.

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