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Vulnerability to changing climate: Locating smallholder farmers coping strategies in drought-prone districts of Cambodia and Nigeria

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សង្ខិត្តន័យ

យើងបានស្វែងយល់អំពីរបៀបទប់ទល់នឹងការប្រែប្រួលអាកាសធាតុដែលបណ្តាលមកពីការឡើងកំដៅខ្លាំងរបស់កសិករមានដីស្រែតិចតួចនៅតំបន់រាំងស្ងួតក្នុងស្រុកគាស់ក្រឡ ខេត្តបាត់ដំបង ប្រទេសកម្ពុជា និងស្រុកអ៊ីនគូរូ (Nguru) រដ្ឋយ៉ូបេ (Yobe) ប្រទេសនីហ្សេរីយ៉ា (Nigeria)។ ព័ត៌មានដែលត្រូវការសម្រាប់ការសិក្សានេះត្រូវបានប្រមូលតាមរយៈការសម្ភាសបែបស៊ីជម្រៅ ការពិភាក្សាជាក្រុម ដោយធ្វើជាមួយកសិកសំខាន់ៗនៅកម្ពុជា ចំនួន៧០ខ្នងផ្ទះ និងនៅនីហ្សេរីយ៉ា ចំនួន១១៦ខ្នងផ្ទះ។ ការសិក្សាបានគូសបញ្ជាក់ពីឧបសគ្គក្នុងការឆ្លើយតបទៅនឹងការប្រែប្រួលអាកាសធាតុរបស់សហគមន៍ដែលត្រូវបានជ្រើសរើសសម្រាប់ការសិក្សា។ ការសិក្សាបង្ហាញថា គ្រួសារដែលសមាជិកមានការងារជាក់លាក់ដូចជាធ្វើការអោយគេ ឬធ្វើសិប្បកម្ម ដែលផ្តល់ប្រាក់ចំណូលដល់គ្រួសារ ច្រើនតែរងគ្រោះតិចជាងគ្រួសារដែលមានសមាជិកធ្វើការរយៈពេលខ្លីៗ។ លទ្ធផលរបស់យើងបង្ហាញថា គ្រួសារភាគច្រើនមានជម្រើសតិចតួចក្នុងការប្រកបការងារដោយសារខ្វះជំនាញ ខ្វះដើមទន់ និងខ្វះកម្លាំងពលកម្ម។ មួយចំណែកនៃការខ្វះជម្រើសការងារនេះ

គឺបណ្តាលមកពីស្ថានភាពយេនឌ័រមានសភាពខុសៗគ្នា ទាំងតួនាទី ទាំងការទទួលខុសត្រូវ និងទាំងសមត្ថភាព ដែលនាំឱ្យស្ត្រីត្រូវបានផាត់ចេញពីការបំពេញការងារដែលខ្លួនពេញចិត្តខ្លាំង។ ផ្អែកលើលទ្ធផលនៃការវិភាគនេះ មានការផ្តល់អនុសាសន៍ផ្សេងៗទាក់ទងនឹងផ្នែកគោលនយោបាយ។

Abstract

We investigate how smallholder farmers in drought-prone Koas Krala district, Battambang Province, Cambodia and Nguru district, Yobe State, Nigeria cope with climate stress resulting from the impacts of climate variability and extremes due to drought. Information was collected for this study through a survey of 70 and 116 farm households, in-depth interviews, focus group discussions, and key informant interviews in the respective districts in Cambodia and Nigeria. The study highlights the constraints faced by the selected communities in responding to climate change. The study reveals that households where an individual can take on one specialized activity, such as employment or handicrafts, in the context of overall diversification of household income, were often less vulnerable than households where each individual is engaged in many activities at low intensity. In practical terms, our results suggest that many households have limited access to their favored coping practices due to a lack of skills, capital and/or labor. This lack of access is compounded by gender differences in roles, responsibilities and capabilities that have led to exclusion of women from carrying out these activities with sufficient intensity. Based on this analysis, policy recommendations have been suggested.

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Keywords: adaptation, vulnerability, coping strategies, climate change, Cambodia, Nigeria

Introduction

Vulnerability is a key term in the climate change literature that has been subject to various interpretations and uses. Although a variety of definitions has been proposed, a comprehensive description suggests that vulnerability is *"a state of susceptibility to harm from exposure to stresses associated with environmental and social change and the absence of capacity to adapt"* (Adger, 2006). Several scholars in recent climate change literature further suggest separating vulnerability into physical and social elements (Adger, 2006; Brooks, 2003; Gebreyes & Theodory, 2018), whereby the former refers to exposure to stress and crises resulting from physical hazards, and the latter refers to the capacity of individuals and communities to respond to

physical impacts (Eriksen et al., 2005; Adger et al., 2001; Smit & Wandel, 2006).

Discussion in the literature identifies three components of climate vulnerability: exposure, sensitivity, and the capacity to adapt. Coping strategies are subsumed under the definition of the last of these components, adaptability. However, coping and adapting are considered two distinct processes, with different timescales (Eriksen et al., 2005). Coping is defined as an array of short-term strategies adopted in response to a crisis. The aim of coping is to maintain various objectives of a household, including livelihood security, consumption, health and status, thus ensuring individual and/or collective well-being. On the other hand, adaptation generally refers to long-term change based on livelihoods that serve to reduce future vulnerability to climate stress (Adger, 2006; Adger et al., 2001; Smit & Wandel, 2006). The two processes are intrinsically linked. The strengthening of coping strategies acts as a means of facilitating adaptation (Eriksen et al., 2005).

Climate change is one of the major challenges facing all categories of farmers globally in multifaceted ways due to its impact on agricultural yield and food security in the developing world, which require adaptation strategies. Agricultural production is particularly vulnerable to climate change in tropical Africa due to the impact of climate shocks such as heatwaves, erratic rainfall, and prolonged drought (IPCC, 2014). Water scarcity is a major dilemma for food production and sustainable development (Alemayehu & Bewket, 2017) as it affects smallholder farmers

in tropical Africa and Asia, whose agricultural production is reliant on rain-fed irrigation (Alemayehu & Bewket, 2017). Food insecurity is then caused by changes in rainfall and increased temperatures, which bring about prolonged dry spells that place stress on farming systems (Domenech, 2015).

It is difficult to provide a precise and universally accepted definition of drought due to its varying characteristics and impacts across different regions of the world on rainfall patterns and the way humans respond. However, drought is the interval of time during that rainfall at a given place consistently falls short of what is climatically expected. Conditions of drought appear when rainfall is deficient compared to the statistical multi-year average for a region, over an extended period (Ishaya & Abaje, 2008; Ayanlade, 2017). In this paper, we focus on meteorological droughts, which are based on the degree of dryness or rainfall deficit, and the length of the dry period.

Although Cambodia and Nigeria are separated by an enormous distance, both lie in the tropics. Despite the dominant role of commodities (Cambodia) and petroleum (Nigeria) in foreign exchange earnings, agriculture plays a significant role in each countries national economy. For instance, in 2018 in Cambodia, the agricultural sector contributed about 26.6% of the GDP and employed about 43% of the total labour force. Most people involved in agriculture are smallholder farmers with less than two hectares per household. The area of land under cultivation is 3.7 million hectares, 75% of which is assigned to rice production. Rice is the country's main crop and consequently the main source of income for most farmers. Industrial crops,

such as rubber and other food crops represent the remaining 25% of agricultural land use (Syngenta, 2018). Similarly, in 2017 in Nigeria, agriculture contributed about 21% of GDP and employed 67% of the labour force (IFAD, 2018). The agricultural sector in both countries is threatened by climate variability (UNDP, 2011).

Furthermore, each country is undergoing rapid population growth (1.7% per annum in Cambodia and 2.3% per annum in Nigeria) and possess a very young population, with about two-thirds of the population under 25 years of age (16.5 million people in Cambodia; and 178 million people in Nigeria). The per capita income of each country (1,269 USD in Cambodia; and 2,222 USD in Nigeria) sees both countries listed as lower-middle-income countries (World Bank, 2020). Besides, both countries are endowed with fragile natural resources, where a large proportion of the population are susceptible to natural hazards such as droughts, floods and sea-level rise (Norm, 2009; Ishaya & Abaje, 2008; Ayanlade, 2017).

The districts of Koas Krala in Battambang Province, Cambodia and Nguru in Yobe State, Nigeria have faced recurrent droughts for decades, with a magnitude and intensity that appear to be increasing (Norm, 2009; Mortimore, 2010). Hence, farmers in these districts have used coping strategies, or short-term responses to overcome immediate threats and manage unfavourable weather conditions. For this study, we consider coping strategies to be activities undertaken by households aimed at obtaining food or income during times of stress, either through production or through formal and informal means of exchange.

In this paper, we consider how smallholder farmers in drought-prone districts in Cambodia and Nigeria cope with climate stress and draw out the implications associated with the vulnerability of these farm households. We also consider how climate vulnerability might be reduced. In assessing household capacity to respond to drought, we examined the consequences of the short-term, seasonal droughts of 2004 in Koas Krala; and in 2008 in Nguru to access direct and experiential evidence of these strategies. These represent the worst drought years in recent times in each respective study area. Finally, we consider the implications of the process of adaptation and the policies that might facilitate adaptive management. Therefore, the findings of this study may provide smallholder farmers with an enhanced capacity to plan coping and adaptation strategies and improve crop production.

Conceptualizing vulnerability to climate change

Climate change is defined as *"any change in climate over time, whether due to natural variability or as a result of human activity''* (IPCC 2014), or by an enlarged definition as *"a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable periods"* (IPCC, 2014). Extreme temperatures, floods, droughts and water scarcity are expected as a result of climate change due to anthropogenic activities that lead to increased GHGs emission, as well as lower levels of precipitation. This reduces the availability of food resource needed for community livelihoods. Climate variability is expected to severely affect

agriculture across the globe. Global warming scenarios suggest that impacts may include increasing temperatures and declining rainfall, consequently reducing crop yields and quality, while increasing food insecurity.

Over the past few decades, tropical countries have been observed to be the most exposed regions to the impacts of climate change (IPCC, 2014; Niang et al., 2014). The World Bank (2013) has reported that around 64% of the labour force in developing countries in Africa and Asia are employed in the agricultural sector. Moreover, since 2000, agricultural activities have increased. Smallholder farmers in the tropics already face significant threats to agricultural production, while extreme changes to the climate are projected to have an even greater adverse effect on farmers, placing further risks on their livelihoods. Empirical studies indicate that smallholder farmers tend to be more susceptible to climatic impacts because of an over-reliance on rain-fed irrigation. Increased attention is being focused on tropical Africa and Asia due to increased vulnerability to climate stressors. There have been few studies conducted in developing countries that have analysed the role national and local governments can play in setting policies that promote adaptive strategies in response to a changing climate.

Adaptation is defined as an *"adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderate harm or exploits beneficial opportunities"* (IPCC, 2007; UNFCCC, 2013). The term *"adaptation"*, includes financial, socio-economic and institutional changes. Hence, adaptation to climate change involves a comprehensive set of activities by which a population responds according to

various climate pressures (Menike & Arachchi, 2016; Nyong et al., 2007). Such responses refer to systematic environmental, social and/or economic adjustments (Komba & Muchapondwa, 2015; IPCC 2014). Therefore, climate change adaptation is considered as *"a process by which individuals and communities alter regular activities to deal with climate change stimuli, irrespective of their intent, or spatial and temporal performance"* (Komba & Muchapondwa, 2015;).

In Africa and Asia, most smallholder farmers depend on farming activities for their livelihood, food security, and resilience (Garcia de Jalon et al., 2018; Hou et al., 2015). Hence, these farmers are sensitive to variations in climate, particularly precipitation and temperature (Atedhor, 2019; FAO, 2008). Agricultural production in this context is characterized by low crop yields, because of prolonged drought, variable precipitation, heatwaves, and high temperatures (Maponya & Mpandeli, 2013). However, Uddin et al. (2017) report that addressing climate variability issues has in recent decades placed more emphasis on minimizing the release of greenhouse gases. Nonetheless, minimal progress has been made in this regard, whilst climate change has persisted in having negative impacts on agricultural production in various nations in Sub-Saharan Africa. As a result, attention has shifted from halting greenhouse emissions to adaptation strategies that minimize vulnerability to the impacts of a changing climate (UNFCCC, 2013).

Adaptation to climate change is not a new phenomenon within developing countries, where it has been a common focus in recent years due to the context of climate variability (Mubiru et al., 2015; Burton et al., 2006).

However, at the commencement of the United Nations Framework Convention on Climate Change (UNFCCC), mitigation was employed as a primary strategy to deal with the climate dilemma. Since that time, it has been recognized that policy responses focus on mitigation alone, cannot address climate change. Thus, adaptation has now been placed on an equal footing with mitigation (Mubiru et al., 2015; Hill, 2008). The concept of adaptation recently evolved into a research area that is influential in many fields of study (Perego, 2019; Van Aalst et al., 2008). It has become an imperative policy response to the negative effects of climate change alongside mitigation (Burton et al., 2006; Devi et al., 2017).

Further, the concept of adaptive capacity is closely related to many other common terms such as coping ability, adaptability, robustness, flexibility and resilience (Jianjun et al., 2015). Its definition varies from the local community to community, from individual farmer to farmer. This variation is dependent on its contextual nature and value in any particular environment. The magnitude of adaptation is dependent on the ability of a farming household to respond to climate shocks and over the short term, the level of support from the community or environment (Smit & Wandel, 2006; Adegnandjou et al., 2018). The capacity for local farmers to adapt may be affected by such factors such as farm size, access to information and financial resources, availability of technology and infrastructure, institutional settings and political will, and the environment in which adaptation occurs (Adger et al., 2001; Smit & Wandel, 2006; Ayanlade et al., 2017; Mkonda et al., 2018). The objective of this study is to investigate the negative impacts of climate

change on the activities of small-scale farmers and how they determine the choice of adaptation strategy.

Research Methodology

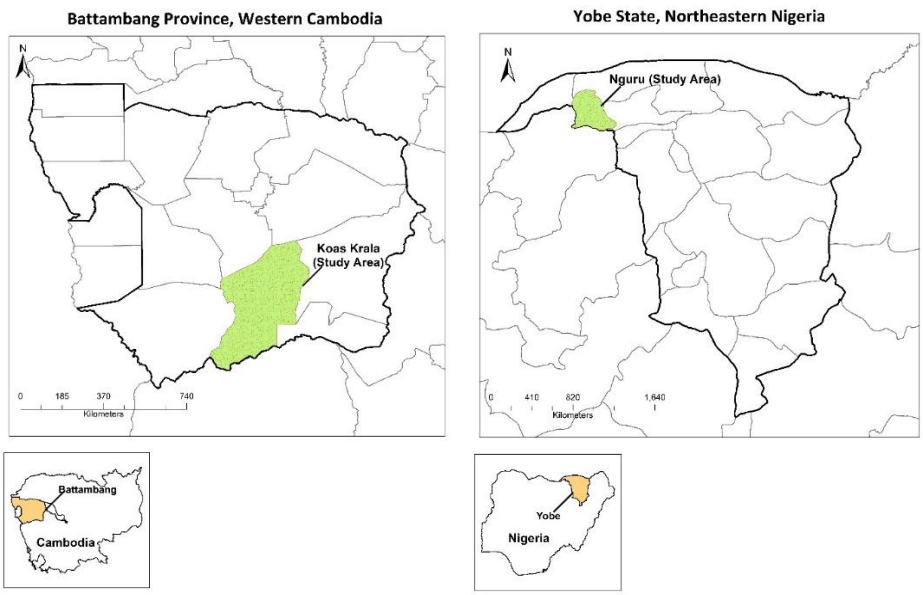
The two study districts selected for this study are located in areas that are affected by drought and climate change, where subsistence mixed farming is a major means of household livelihood. Koas Krala is situated in Battambang Province, Western Cambodia (Figure 1). While, Nguru district is situated in Yobe State, Northeastern Nigeria (Figure 2). The characteristics of each district are summarized in Table 1. As in any agrarian community, access to land is of crucial importance. However, in both districts, new allotments of farming plots are becoming increasingly rare. It is almost impossible to find virgin arable land surrounding villages in these areas (Norm, 2009; Mortimore, 2010).

There is also great inter-household variation in the size of landholdings, with the majority of farmers owning lands under an inheritance system. In the case of Koas Krala, inheritance is matrilineal, while in Nguru it is patrilineal. Drought is the most impactful climate hazards in these districts and the livelihoods of the communities within them have evolved under variable climatic conditions over time (Norm, 2009; Yila, 2013; Mortimore, 2010).

Results from the normalized rainfall index in each study area are also presented in Figure 3 and Figure 4 for Koas Krala and Nguru, respectively. These graphs show that both study areas have experienced ongoing mild to severe drought events over time. For instance, in Koas Krala, severe drought

conditions occurred in 1987, 1990, 1991, 1993, 1994, 2002, 2004, 2010 and 2013; moderate droughts conditions occurred in 1997 and 2017; while mild drought conditions occurred in 2006 and 2015 (Figure 3).

Figure 1. Koas Krala District, Cambodia **Figure 2.**Nguru District, Nigeria



In Nguru District severe droughts occurred in 1987, 1989, 1991, 1993, 2000, 2004, and 2008; moderate droughts occurred in 2009, 2011, 2015 and 2017; while mild droughts occurred in 1995 and 2013 (Figure 4). Though droughts have often caused local food shortages, there have also been other factors in play, such as social unrest and floods (Norm, 2009; Mortimore, 2010). To ensure food security and overall well-being, these communities have depended upon adaptation via multiple coping strategies deployed in response to changing conditions. Men and women have each played key roles in the process of diversifying local livelihoods to contribute to food security at the household level.

Data were collected between October 2008 and February 2009 in Koas Krala and December 2010 and April 2011 in Nguru. This data was supplemented with new data collected in July 2019 in Koas Krala and August 2019 in Nguru, as well as secondary data from other research.

Table 1. Key characteristics of each study district

Characteristic	Factor	Koas Krala, Cambodia	Nguru, Nigeria
Demographic	Population	68,876	159,632
	Household size	5.2	6.6
Economic	Average land size per household	4.2 ha	3.2 ha
	Major crops	Rice, red corn, soya bean, cassava, peanut, sesame, sweet potato, mixed vegetable	Millet, sorghum, maize, cowpea, sesame, and groundnuts
Climatic	Average annual rainfall	1150 mm	557 mm
	Average annual temperature	31^{o}C	32^{o}C
	Altitude	45 m	327 m

Source: Reviews, August 2020

A range of techniques was employed to generate information and triangulate insights to build a progressively more detailed picture of the conditions of vulnerability and the coping strategies employed by households. These included focus groups discussions, semi-structured interviews, open-ended discussions, key informant interviews, and household questionnaires (Table 2).

Figure 3. Normalized rainfall index for Koas Krala, Cambodia

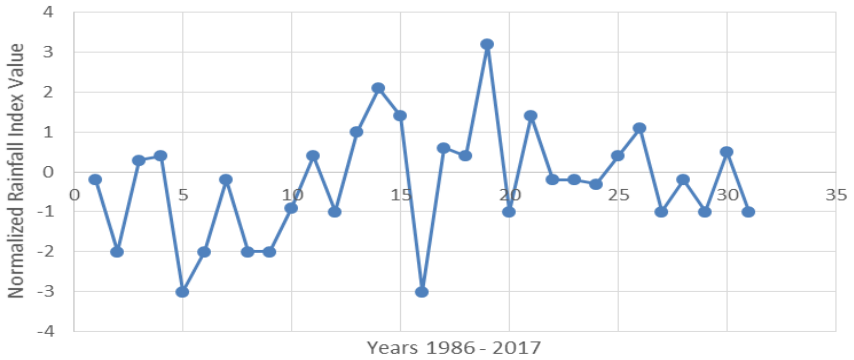
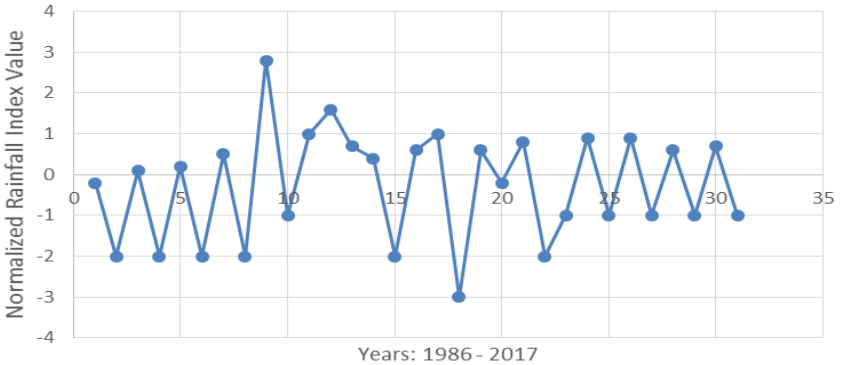


Figure 4. Normalized rainfall index for Nguru station, Cambodia



Source: Nigerian Meteorological Agency Abuja, August 2020.

A two-stage sampling process was applied to select the farmers for the survey. Initially, Koas Krala and Nguru were purposively selected as historically drought-prone districts that have a high dependence on rain-fed agriculture and as a result include farmers with a long-term experience on which to draw form. Then, in consultation with local project partners, four villages from each district were selected to sample from. Factors considered in selecting the study villages included the past occurrence of repeated drought, the size of the village and the willingness of the women to

participate in the survey. All villages were within 5 to 10 kilometres of the district headquarters. The sample sizes in each village were determined proportionately to the total number of households (Table 3).

Table 2. Sample size by surveyed village and district

District	Study villages	Sample size	Total
Koas Krala, Cambodia	Chhnal Moan	16	70
	Krang Svat	20	
	Banteay Char	15	
	Samraong	19	
Nguru, Nigeria	Konkon	25	116
	Musari	42	
	Balewa	23	
	Dudiri	26	
Total			186

A list of the households in each village was obtained from the village head, with households numbered from 1...n. Every third household was selected for an interview. The interviews were conducted at each respective houses. When households were found unoccupied, a return visit to conduct the survey was completed the following day. The heads of the households were interviewed in their role in making decisions about farming activities and household coping strategies. Table 3 summarizes the primary data collection strategy. Relevant secondary data available from scientific reports, maps and statistical abstracts were also used to supplement this data.

Results and Findings

Farmers' perceptions of droughts and climate change

Choosing coping strategies in response to drought is a two-step process. First, the farmers perceive the occurrence of drought, then they act to apply

a strategy (Mortimore, 2010). The perception of drought is thus a prerequisite for the initiation of a coping strategy. Studies reveal that a majority of farmers already perceive drought as a recurring feature of their environment (Mortimore, 2010; Mertz et al., 2009; Deressa et al., 2009). Almost all farmers in each study area, 93% of respondents in Koas Krala and 95% in Nguru regard drought as the interval of time during which rainfall at a given place fell consistently short of what was expected (the remaining respondents did not provide an explanation). Further, 54% of farmers in Koas Krala and 56% in Nguru distinguished drought as a prolonged period of at least two seasons without precipitation. For the farmers in these districts, 'duration' was an important factor in defining drought, consistent with an agro-ecological definition.

The frequency of drought changes the decision frameworks for farmers and can influence households coping strategies and actions. Among the respondents, 68.1% of households in Koas Krala and 74.8% in Nguru perceive that drought is becoming more frequent. Worthy of note is that a small percentage (3.1% in Koas Krala and 1.7% in Nguru) perceive drought as becoming less frequent (Table 4). The response is consistent with the drought incidence in these two areas, as the incidence of drought is greater in Nguru due to its semi-arid environment.

Long-term temperature and precipitation changes, as well as the wind, are key parameters related to climate change in each study district. The perception of these climate parameters was assessed at the household level (Table 5). The surveyed households were asked questions about their

understanding and observations in the patterns of temperature, rainfall and wind over the past 20 years.

Table 4. Perception of drought frequency*

Response	**Koas Krala n=70 (%)**	**Nguru (n=116) (%)**
Becoming more frequent	68.1	74.8
No change	20.5	16.5
Becoming less frequent	3.1	1.7
Don't know	6.4	7.0

* Percentage of farmers from each district. Differences between districts are significant at chi-square 0.001 level

The majority of the farmers (86% in Koas Krala and 84% in Nguru) perceive the temperature to be increasing, thus, farmers' perceptions corroborate with the statistical records in the study area. According to Norm (2009), the average maximum temperature in Koas Krala has been rising, from a baseline of 32^0C in 1982 to an average of 34-35^0C in recent years (Fig. 3). The data between 1901 and 2005 for Nguru also shows an increasing trend (Figure 4).

The overall perception of long-term changes in precipitation is that both districts are getting drier and that there are pronounced changes in the timing and frequency of drought vents. The majority of respondents revealed that rainfall has become highly unpredictable in recent years and that the onset and amount of seasonal rainfall are erratic. The prevalence of mid-season dry spells was also reported to have increased. Recorded annual rainfall data between 1982 and 2008 for Koas Krala reveals irregular rainfall conditions for the past 27 years. The last heavy annual rainfall event was

recorded in 1999 (1,500 mm). Outside of this outlier, annual rainfall has ranged between 1,000mm and 1,200 mm, with the lowest level recorded in 2004 (Fig. 3). Nguru district recorded a significant decline in annual rainfall between 1934 and 2005, with an average reduction of 8mm per year (Figure 4). This is consistent with the survey, where 88% of farmers reported a decrease in precipitation.

The information collected during the focus group discussions generally corroborated with the household surveys. Respondents expressed concern about increasing dry and wet season wind speeds (Table 5). However, the nuanced opinions on rainfall trend expressed in the household surveys, where there was agreement on the declining and negative trend in rainfall were not verified in the focus group discussions.

An overall analysis of perceptions shows that farmers in each district have a quite elaborate knowledge of climate-related factors and that most farmers are aware of the fact that temperatures are increasing and the level of precipitation is decreasing. In the focus groups, female respondents were more animated in their concern about climate change compared to male respondents. One key finding that emerged was that all farmers reported changes in climate variability over the past twenty years. These perceptions could be confirmed with records that indicate that the two districts have a history of worsening drought conditions. Male and female farmers both reported similar or identical observations of temperature and rainfall trends over time. This demonstrates that memories of historical climate trends can be a useful resource for understanding historical climatic trends.

Nevertheless, additional research is needed to confirm whether there is a difference in farmer perceptions of climatic trends and records over different timescales

Strategies for coping with drought

In both districts, farmers were found to practice a variety of coping strategies that are representative of their different capacities to manage risk and take advantage of new opportunities in the agricultural sectors of each country. Most respondents identified autonomously (implemented without external intervention) and responsive (implemented in reaction to climatic events and impacts) strategies. These strategies have been categorized into past and present mechanisms. Past coping strategies are those adopted before the extreme droughts that occurred in 2004 in Koas Krala and 2008 in Nguru, while present strategies are those that occurred after these drought events (Table 5). It should be noted that past and present coping strategies are not mutually exclusive, as a respondent may have adopted a strategy in the past that they still use now.

We found that coping strategies are not fixed or generic across different households, rather they vary according to the particular exogenous and endogenous context of each household. Understanding how these factors are shaped by the interaction of different processes is key to understanding the changing patterns of vulnerability within a community and across a region (Eriksen et al., 2005). Exogenous factors are those factors that shape coping options but are largely beyond the control of communities and households. These include local economic and political factors, as well as

local climate and ecology, culture and infrastructure. Factors endogenous to the household include demographic and socio-economic characteristics.

Table 5. Coping strategies identified by respondents

Strategy	**Past**		**Present**	
	Koas Krala	Nguru	Koas Krala	Nguru
	(n= 70)	(n=116)	(n= 70)	(n= 116)
Drought resistant varieties	23	26	20	22
Crop diversification	32	29	34	31
Livestock diversification	15	12	13	15
Mixed cropping	71	78	82	84
Early maturing crop varieties	24	19	22	21
High yield varieties	12	18	18	20
Replanting	14	12	8	10
Taking waged labour	27	23	33	34
Labor migration	25	31	32	36
Selling productive assets (livestock and agricultural products	16	19	22	21
Farm relocation	3	2	1	1
Food storage	45	47	34	38
Seed banks	11	9	7	6
Share cropping	8	6	5	5
Diversifying household income	33	29	38	34
Irrigation	8	7	16	7
Mortgaging land	4	3	6	3
Taking loans	8	11	13	15

Food storage, diversification of family income, crop diversification, taking waged labour, labour migration, as well as selecting high yielding and/or drought-resistant varieties are popular coping strategies in each district. Among these strategies, food storage is the most popular past coping

strategy. However, more recently, the number of people using food storage strategy has declined. The likely reason for this is that most households have had insufficient food even in good years to enable them to store food as a hedge against drought.

Other strategies that have declined in use include the replanting of crops, cultivation of drought-resistant varieties, and seed banks, Most of the farmers (93%) mentioned that benefits from these strategies are less than what was expected, or that the costs of inputs needed to implement them, such as chemical fertilizers and fuel to operate pumping machines are beyond the reach of their household. To reduce the possible risk of food shortages arising from uncertain rainfall, farmers perceive that they have no other option but to intensify waged labour, labour migration and diversified income strategies to minimize risks. In particular, respondents mentioned that labour migration serves as a safety valve in a situation where there are multiple uncertainties. In years where there is normal rainfall, this strategy helps them to increase their income by making efficient use of what is produced. Even though gaining a maximum return on their labour is perceived as important, the ultimate goal of respondents was reported as achieving stable production and food security. This shift in strategies is evidence that respondents are willing to change and adopt new coping strategies.

There was significant evidence generated that existing gender roles act as constraints to adopting some coping strategies. For instance, in Konkon village in Nguru district, Hadiza, who is a widowed household head, cares for

three school-aged children. She previously grew vegetables for sale, however, declining rainfall in recent years has constrained her activity as she cannot afford the cost of diesel to pump water for irrigation. Combined with the loss of income from her husband, this has placed her household in a precarious situation and she now relies upon her mother conducting petty trade to buy food. In the same village, a man named Hamisu abandoned farming due to several seasons of low rainfall. He was able to find employment in a local tanning factory and is now able to support his family. For Hadiza, such an option would be much more difficult, partly because she only has a primary school education, but also because she needs to stay close to the household to care for her children.

In Koas Krala district, prolonged drought has had a significant impact on rain-fed rice cultivation. Farmers now rarely transplant seedlings from seedbeds as they did in the past when rainfall was regular. Instead, many have turned to direct sowing. Further, they have abandoned the practice of cultivating a second crop during the rainy season to ensure adequate rice supply for achieving a surplus for sale at the market as this is no longer tenable. To redress this shortfall, many men have diversified into collecting fuelwood for charcoal production and other non-timber forest products. Others have turned to driving motorcycle taxis or taking waged labour. A sizeable number now regularly migrate to Thailand to work in the construction industry. Many women have taken to waged labour, while some are involved in raising livestock, brewing local beer and supporting their husbands work in charcoal production.

Farmers access to institutional support

Cambodia and Nigeria have both recently undergone political and institutional change. Although households can make decisions that reduce their vulnerability to climate change and drought, these decisions are embedded in the institutional framework. Until 1979, Cambodia was led by the brutal and repressive Khmer Rouge regime, while in Nigeria democracy returned after a long period of military rule in 1999. Before this, traditional governance systems prevailed, based on communal authority in both countries. Local-level institutions and collective action based on social capital were the main mechanisms for responding to livelihood risks. Since these changes, households in Koas Krala and Nguru have had access to democratic governance structures and associated policy frameworks, and a wide variety of institutions now influence livelihood decisions in these contexts. This has had implications for vulnerability to drought, as decisions at the household level are now embedded within a new framework, within a landscape that can intentionally or otherwise influence local coping strategies.

In response to increasing vulnerability, external policies and institutional interventions have become more prevalent in relieving communities of droughts impacts. Farmers are prompt to point out that many of these measures are reactive and often lack foresight. The concerns expressed are many interventions have further weakened the coping capacity of communities. In some cases, measures have been identified as constraints to community-level innovation in coping strategies and have exacerbated inequalities. Much less than one-quarter of respondents in each district

reported receiving assistance (information, training, and materials) from government institutions. This result was found to be significantly gendered, with 23% of men and only 9% of women receiving institutional support.

Whilst access to the new policy frameworks within new democratic governance structures is often intended to be equal, in reality, this is often not the case. Policies at the national level are directly and indirectly aimed at reducing absolute vulnerability to climate change and drought. However, local-level implementation is variable, and access to policy frameworks differs between households heads based on differences in both human (education) and social capital. Overall, men are better informed and have access to wider networks through which knowledge can be dispersed. Thus, male-headed households tend to have greater access to opportunities afforded through new policies and institutions. The result is creating differential levels of vulnerability, where male-headed can apply coping strategies that are supported by institutional structures, while female-headed households are still largely dependent on traditional governance structures and informal institutions when responding to climate risks.

Discussion

Adaptation and coping strategies applied in response to climate change at the farm level

Farmers in Koas Krala and Nguru have had to adopt different strategies to respond to climate change in light of farming being the primary occupation of the majority of the local community. Based on survey data collected from 186 smallholder farmers, supplemented by semi-structured interviews, and focus-group discussions, perceptions on climate change of

respondents have been analysed to better understand coping and adaptation strategies. This is important as smallholder farmers face precarious futures due to climate change and this call for innovative livelihood strategies. The situation is even more acute for marginalized smallholder farmers in Nguru District, Nigeria. For the near future, the farmers in these two case studies have no other option but to cope with, or ideally, adapt to a changing climate.

Across each district, most smallholder farmers attributed reductions in crop yields to changing precipitation patterns and rising temperatures. Although the perceived impacts varied in each district, the magnitude of climate change impacts was found to have become more significant over the past two decades. The most commonly observed changes include an increase in temperature (94% of respondents); low rainfall (92%); rainfall variability (93%) and an increased recurrence of drought (71.5%). Most respondents reported altering their farming practices to minimize their vulnerability and/or to adjust to the changing weather conditions in response. These coping strategies include diversifying crops and planting new crop varieties. The findings show that farmer perceptions about climate change have had an impact on their livelihoods, as they have been the basis for decisions made in response (Yila & Resurreccion, 2013). Findings from similar studies have also concluded that perceived changes in their local climatic conditions are a significant driver in the implementation of various coping and adaptive measures.

Table 6 demonstrates that out of the 186 farmers surveyed at the two research sites, 19% have used improved seeds (hybrid) or diversified to new crops, as a climate change adaptation strategy over the past two decades. Similar findings were highlighted in a study conducted in Sri Lanka by Gunathilaka et al. (2018). Also, 21.5% of participants agreed that cultivation of early maturing crop varieties makes up for decreased household food sources; 74.5% claimed to have adopted cultivation over shorter cycles; 78.6% of households have adopted more drought-tolerant crop varieties; while 78.5% have delayed planting some crops until later in the season. Similar studies by Epule et al. (2017) have shown that changing crop planting dates is employed as a climate change adaptation strategy in the Sahel region as a result of prolonged dry spells.

Higher yielding crop varieties

Another result from the study demonstrates that smallholder households have adapted to climate shocks, such as heatwaves, prolonged dry spells, drought, declining rainfall, and temperature increases by applying shorter cycle cropping with hybrid seeds and abandoning indigenous crops. The focus group discussions discovered that over the last 20 years farmers have slowly transitioned from growing traditional rice, maize, and bean varieties due to declining yields and increased impacts from pests and diseases. This is consistent with a similar study by Setimela & Kosina (2006), who confirmed that respondents in South Africa now select open-pollinated varieties (OVPs), such as Zm521 (maize) as it enables comparatively more stable production, early maturity, and greater resistance to drought. It is also supported by the

findings of Dedewrwaerdere & Hannachi (2019) in Yunnan Province, China who examined the socio-economic factors related to the co-existence of landraces and modern crop varieties; as well as findings by Gunathilaka et al. (2018), who studied the barriers and policy implications of climate adaptation approaches in perennial cropping systems in Sri Lanka.

Despite differences in the perceptions and awareness of smallholder farmers about climate challenges at each research site, the focus group discussions and interviews held with the extension workers and farmers revealed that adaptation strategies are similar in both Nigeria and Cambodia. However, it was of paramount interest to this study to assess in-depth data about differences in the adaptation and coping strategies from one area to another. Farmers at each site all adopted coping strategies that focused on changing the crop varieties with high yield potentials. The preference for high yielding varieties cut across all typologies of farmers despite differences in the types of crops cultivated in each village. For example, in Nguru, farmers preferred crops including maize, groundnut, sweet potatoes, rice, beans, and tomatoes. The survey results indicate that 56.8% of farmers selected hybrid maize varieties, with an improved yield to replace open-pollinated maize varieties (Table 6). Farmers in Musari village replaced maize crops with beans, sweet potatoes, and hybrid sorghum. In Dudiri village, others have identified sesame and improved maize as higher-yielding crops. While in Konkon village, smallholder farmers have reported that rice and onions have higher-yielding potential.

Further, extension officials reported that for smallholder farmers to accept new cultivars that they must first demonstrate higher yields than traditional varieties in support of farmer preferences for crops that achieve higher prices at the market (Dedewrwaerdere & Hannachi, 2019). Higher market prices have been shown to influence smallholder farmer decisions on the crop variety to plant. It is therefore important to understand that low crop varieties have low-income returns and this affects the livelihoods of the majority of smallholder farmers in Koas Krala and Nguru districts. This finding agrees with the results of a study conducted by Perego (2019) analyzing crop prices and land titles in Uganda, where crop prices had a strong influence on when smallholder farmer had access to a marketplace.

Changing planting dates using shortened crop cycle varieties

The majority of smallholder farmers were found to cultivate shorter-cycle crop varieties to adapt to uncertain climatic conditions, especially when they are not able to access climate advisory information. This strategy was employed by farmers in Musari, Balewa, and Banteay Char, where there is seasonal rainfall variability. In these instances, farmers have adopted crop varieties with shorter cycles as part of a climate change adaptation strategy. Continuously changing climatic conditions have forced smallholder farmers to change planting date patterns. Similar studies by Singh et al. (2014) on cotton and peanuts in West Africa attest to this. While Loison et al (2017) argue that it is only partially true, as this decision should also take genetic variability into account.

Drought-resistant crops varieties

Unpredictable, prolonged dry spells and abnormally increased temperatures have contributed to negative impacts on crop production. However, smallholder farmers in the study areas have used moisture and stress-tolerant crop varieties as an adaptation strategy during droughts. For instance, in response to low precipitation, smallholder farmers have chosen to apply drought-tolerant crop varieties. Information obtained from focus group discussion and interviews revealed that maize, rice, sweet potatoes, millet, beans, and onions, were the main crops that alternative varieties had been selected.

Group discussions revealed that farmers have also altered their planting calendar to adjust to when it now rains. This suggests that numerous drivers influence farmer decisions about how to introduce new crop varieties in an area because of climatic conditions. In Krang Svat village, one elderly respondent stated, *"the growing season for the crop is determined by the climate. If there is no rainfall, then farmers do not plant"*. These findings are similar to studies by Komba & Muchapondwam (2012) and Mpandeli (2006) conducted in Limpopo River Basin in South Africa. Maponya & Mpandeli (2013) also revealed that smallholder farmers use drought-tolerant varieties as an adaptation strategy. This is also in alignment with the findings of Fisher *et al.* (2016), who highlighted how drought-tolerant varieties were used to promote climate-secure farming practices in Ananthapur District in India. In Samraong village, sweet potato and beans have been adopted as drought-resistant crops in response to extreme weather conditions.

Mixed cropping farming

Many farmers were found to employ mixed cropping methods as a traditional method of adapting to the changing climate conditions. Around 83% of farmers in the study cohort were found to use this practice to improve crop yields (Table 6). By this approach, selected varieties of crops are cultivated simultaneously on the same plot of land to reduce the depletion of soil moisture and nutrients. Smallholder farmers apply this practice this technique to guarantee a harvest when other crops fail because of climate shocks. A study by Mkonda et al. (2018) in Tanzania reported that most cultivated fields within the study area cultivated two or more crop types depending on the location of the farm and the preferences of the farmer. For instance, farmers in dryland areas of Nguru district in Nigeria intercropped maize with beans and groundnut with sesame. During a field survey, it was observed that most of the farms in Koas Krala District cultivated more crops per plot than those in Nguru. In Chhnal Moan mixed cropping was applied in conjunction with drought-resistant crops, such as beans and okra. These practices support empirical evidence that suggests that growing both trees and crops on the plot farmland has the benefit of decreasing evapotranspiration during heatwaves (Eze, 2017; Sze, 2018. Eze et al., 2018). This is useful for farmers in Dudiri, as the study area is located in a semi-arid ecological zone with high temperatures.

Conclusion

This study outlines how climate variability has influenced small-scale farmers to employ coping and adaptation strategies at the local scale. Focus

group discussions, questionnaires, and interviews were used to collect data. It was revealed that adaptation is a process of recognizing the impacts of climate change and adapting to the changed conditions. Due to their perceptions about the impacts of climate change, farm households were shown to have adopted on-farm activities to improve their resilience to climate change impacts. Small-scale farmers use strategies to adapt to climate impacts on crop yields by planting several crop varieties, including drought-resistant and short cycle crops, as well as intensifying production by using furrow irrigation. In line with the results of this study, adaption strategies require a detailed understanding of the determinant small-scale farmer decisions to have an impact. These strategies need to respond to both socio-economic and physical variables to influence the adaptive capacity of farming households. In this study, the determinant that affected farmer decisions were found to include: the educational level of the household head, the size of the landholding, access to information about climate change, off-farm activities, and changes in rainfall and temperature.

The success of climate change adaptation strategies is largely reliant on effective planning. Government departments and community actors play an important role in influencing the extent to which the vulnerability of farmers can be overcome in response to climate hazards. Strategic planning at the national level should be informed by the decisions at the farm-level, with clear accountability and supported by sufficient financial capital. It is important to identify strengths in the roles different stakeholders play in adaptive planning how activities may be coordinated. Concern about

vulnerability to drought and its adverse impacts on livelihoods have led to farmers in each study district adopting different coping strategies. However, this varies from household to household, dependent on various social, institutional and ecological factors.

Although the findings in this study relate primarily to coping strategies, they are also relevant to adapting to long-term climate change impacts as they provide insight into how farmers do and do not cope with changes to livelihoods and food security. Understanding how smallholder farmers have responded to climate variability in the past and how they can respond now, including the nature of institutional support that is available; provides a baseline for designing long-term adaptation strategies. As agricultural production remains the main source of livelihood for most rural communities, climate adaptation is imperative for protecting the livelihoods of the poor. This will require the involvement of multiple stakeholders, including policymakers, extension agents, NGOs, researchers, communities, and farmers. Effective policies are critical for creating an enabling environment for adaptation. Important policy areas include education, access to extension services, credit, pricing and market policies, the distribution of food commodities, and research and development.

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Appendix

Table 3. Data collection methods

Activity	Selection	Koas Krala, Cambodia	Nguru, Nigeria	Topic and focus of activity
Semi-structured interviews and open-ended discussions	Households of poor, medium and high socioeconomic status	16 people in the 4 study villages.	20 people in the 4 study villages.	Explore farmers´ risk perceptions and their attitudes regarding coping with drought
Household questionnaires	Systematic random sampling. Every third household was selected for an interview.	70 households	116 households	1) socioeconomic profile of the respondent; 2) climate variability and extremes experienced in the last two decades and their impacts; 3) household's vulnerability in terms of food availability, livelihood, etc.; and 4) coping strategies.
Focus group discussions	Men only; women only, and mixed groups	Three in Koas Krala	Three in Nguru	Employed a combination of participatory techniques such as timeline analysis, stakeholder analysis, participatory vulnerability assessment, and community mapping of vulnerable areas
Key informant interviews	Local officials, representatives of agricultural services (extension, credit and research) at provincial and state agricultural offices, NGO personnel, leaders of farmer unions and associations	Mainly at the district headquarters and study villages	Mainly at the district headquarters and study villages	Contemporary information on local institutions and policies on climate change and drought
In-depth discussions	Individuals from households classified as high and low drought impact	Eight men and eight women in total (two men and two women each in the 4 study villages)	Eight men and eight women in total (two men and two women each in the 4 study villages)	Pattern of coping by households during drought