Indigenous knowledge and community-based risk assessment of climate change among the Fulani Herder Community of Kpongou, North-Western Ghana
Lambert Abatanie Napogbong, Maximillian Kolbe Domapielle and Emmanuel Kanchebe Derbile

ABSTRACT
Given rising concerns about climate change and development in Africa, this paper draws on Community Risk Assessment for mapping the risks of Fulani Herders to climate change in North-Western Ghana. Herder communities are seldom explored in climate change related studies although their livelihoods largely depend on the natural environment. Thus, a case study of the Fulani Herder Community of Kpongou in the Wa Municipality was conducted. The design employed Participatory Rural Appraisal instruments for data collection and analysis. The results reveal multiple indicators of climate change, including longer dry seasons and dry spells, shrinking sizes of water bodies, formation of iron pans on top soils, stunted growth of grass species, smaller grass stalks and less concentration of grasses. These have culminated into scarcity of fodder and water and increased distances of cattle herding under excruciating sunshine and temperatures in search of feed and water as an adaptive mechanism. The paper underscores that herder knowledge of climate change reveals a drying trend in climate and de-concentration in vegetation, especially grass species. The paper advocates climate change adaptation planning and policy attention to providing supplementary sources of water and feed in support of cattle herding and herder communities for climate change adaptation.

Key words | cattle herding, climate change and variability, community risk assessment, Fulani, indigenous knowledge

INTRODUCTION
Climate change and climate variability pose a threat to the expansion of the livestock sector, and could limit the demand for livestock and livestock products in Ghana and across the world. This threat requires serious attention because the livestock sector serves as a source of livelihood of one billion of the poorest people in the world. Additionally, it contributes significantly to global food security as the average global consumption of food products from livestock is about 13% in caloric terms and 28% of protein consumed worldwide (Falvey 2015). These figures are expected to rise as the global demand for livestock products is expected to double by 2050 (Rojas-Downing et al. 2017). In the specific context of developing countries, the livestock sector contributes significantly to sustainable rural development (Food and Agriculture Organization 2019). This notwithstanding, there is growing concern that the growth of the sector will be adversely affected by rising temperatures that will impact on the quality of feed crop...
and forage, water availability, livestock diseases and biodiversity (Rojas-Downing et al. 2017; Aburehman & Ameha 2018; IPCC 2018). These concerns call for research that will map climate-related risks facing the livestock sector to inform climate change adaptation planning (CCAP) in Africa and the world at large.

The Intergovernmental Panel on Climate Change (IPCC) (2019) report defines climate change as a persistent shift in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, usually over a decade or longer. The IPCC (2018) special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways confirms previous research findings that the climate is changing and the beginning of the 21st century has recorded the warmest period in the entire global instrumental temperature record. This poses a substantial threat to the livestock sector, wildlife and to the essential goods and services provided by nature, including food, timber and fibre, clean water, and the economic and cultural benefits derived from landscapes (Committee on Climate Change 2016).

A variety of studies have reported on early indicators of climate change. For example, Wang et al. (2019) researched the drivers of soil moisture variability in an arid region of China and concluded that precipitation had significant effects on soil moisture variability between 1982 and 2015. Similarly, studies on plants and vegetation-based indicators in the arid regions of northern China (Xu & Wang 2016), the grasslands of the Qinghai-Tibetan Plateau (Zhang et al. 2016) and the state of California, USA (Zeise et al. 2018) concluded that vegetation growth in these regions is declining in response to climate warming and high rates of evaporation respectively. Other scholars (Osbahr et al. 2011; Gonzalez et al. 2012; Amjath-Babu et al. 2016; Kahsay & Hansen 2016), who researched species decline in the Sahel and arid regions of Africa, have all reported dramatic increases in the trends of mean annual temperature covering decades. In regions with hot weather and low rainfall, evaporation can result in the loss of significant quantities of water, and subsequently, drought. For example, studies have projected that countries like Iran and Syria, which have witnessed severe and prolonged droughts in the past, may experience more severe droughts in the future due to a decline in precipitation. This will aggravate the water crisis and agriculture, which is an essential source of livelihood for rural populations (Qasem et al. 2019; Homsi et al. 2020).

Several other studies (Nyssen et al. 2004; Osbahr et al. 2011; Bhuvaneswari et al. 2015; Gelcer et al. 2015; Tesfahunegn et al. 2016) that sought to uncover climate change indicators within sub-Saharan Africa have found that drought frequently occurred and temperature has been increasing in the climate data. Frankl et al. (2015) observed the struggles of herdsmen and their herds in Ethiopia, arising from inadequate rainfall, to fully support agro-pastoral activities. These studies, however, fell short of reporting on the frequency and duration of dry spells, a knowledge gap that this paper has sought to bridge.

Additionally, climate change research, risk mapping and adaptation studies tend to utilise remote sensing aerial photography and climate change modelling that relies on modern scientific tools. This technocratic approach to climate change assessment focuses on global and regional assessment and forecast to the neglect of smaller geographic specificities, socio-economic and localized assessments, although this is where the exposure and effects of climate change are felt by local populations. Although nationwide studies have contributed knowledge to the discourse on climate change, the methodology is often based on the use of scientific models that do not set the right tone or form a strong basis for localised climate change adaptation and mitigation planning. For instance, Haer et al. (2018) conducted a country-scale study of future flood risk in Mexico, illustrating how the application of global models can inform cost-benefit analyses to prioritise investments in flood adaptation strategies under future climate scenarios in data-scarce countries. Also, Mysiak et al. (2018) described the climate risk index for Italy through a detailed model ensemble data with a robust analysis, the results of which were used to rank the subnational administrative and statistical units according to the climate risk challenges, and inform financial resource allocation for climate adaptation in Italy. Furthermore, machine-driven approaches, including artificial neural network (ANN), adaptive neuro-fuzzy inference system (ANFIS), fuzzy genetic (FG), support vector regression (SVR) and the integrated models of these methods with other data pre-processing approaches, have been successfully applied in water related fields such as PE modelling (Qasem et al. 2018).
et al. 2019). Here, Goyal et al. (2014) applied ANN, ANFIS, least squares-SVR (LS-SVR) and fuzzy logic to increase the precision of PE estimation employing various meteorological variables, like daily rainfall, sunshine hours, minimum and maximum air temperatures and humidity. The outcomes exhibited that the LS-SVR and fuzzy logic can be utilized effectively in predicting PE values. Similarly, Guven & Kisi (2013) compared the precision of five different models in modelling PE, namely: ANFIS, ANN, FG, Stephens–Stewart (SS) and linear genetic programming (LGP) methods. The results showed that the LGP model has a better accuracy in comparison to other models and can be utilized to successfully estimate PE.

According to Homsi et al. (2020), recent knowledge of global climate change comes from general circulation models (GCMs). However, whereas these models have generated reliable data on a mean annual temperature for the planet, it has so far not managed to generate reliable data on regional and local temperature and precipitation due to their coarse spatial resolution (Flato et al. 2013; Lupo & Kininmonth 2013; Onyutha et al. 2016; Hausfather 2017; Sa’adi et al. 2017). Adaptation to climate change and localised studies in developing countries, particularly sub-Saharan African countries, is not optional but is in fact required because populations in these areas are already suffering negative impacts (Boko et al. 2007; Osbahr et al. 2011). The need for localised micro-level knowledge of climate change drawn from studies of smaller geographic specificities calls for advanced local research on climate change using more specific forecasting models that take into consideration cultures and experiences of local populations in the mapping of climate change risks and addressing climate change concerns. This approach would provide knowledge of the socio-cultural embedded practices in which adaptation is locally valued and approved, as well as the local political struggles that are caused by the introduction of the concept of adaptation to the climate change paradigm (de Wit 2015). The Local and Indigenous Knowledge Systems (LINKS) programme is of the view that adaptation actions be informed by the best available science and appropriate traditional knowledge, knowledge of indigenous peoples and local knowledge systems, aimed at integrating adaptation with appropriate socioeconomic and environmental policy actions (LINKS 2018).

Recent years have witnessed increased interest and reliance on participatory and community-based adaptation approaches to general development endeavours (Huq & Reid 2007; Ayers & Forsyth 2009; Ensor & Berger 2009; Warrick 2011; Forsyth 2013; Schipper et al. 2014; Gaillard & Gomez 2015). This has involved a shift of emphasis from top-down to bottom-up approaches in development programming, and from blueprint to adaptive approaches in the design and implementation of development interventions. This paradigm shift aims to create space for a participatory approach that integrates local knowledge and engages vulnerable communities in the formulation of adaptation plans that will be operable and most relevant to their unique geographic and sociocultural circumstances.

In Africa, as well as in other parts of the developing world, local herdsmen already practise different forms of adaptation practices in response to climate change. These practices rely heavily on their indigenous knowledge and experiences, which play critical roles in climate change adaptation. Their knowledge of adaption is thought to have accumulated from generations of experiences, involving careful observations and learning by doing (Grenier 1998). Throughout sub-Saharan Africa, there is evidence that different rural herder communities are actively establishing visible initiatives to adapt to climate change (Egeru 2012; Ajani et al. 2013). One significant step implemented by these communities in reducing vulnerability to climate risks is the development of an early warning system for the prediction of climate-related events and the importance of this in cattle production cannot be over-emphasised. It has been established that there is indigenous knowledge grounded in weather and climate forecasting which has helped the local communities to adapt to climate change (Ajibade & Shokemi 2003).

Research on adaptation planning for climate change and variability has gained popularity in the natural and social science disciplines in recent times (Eguavoen et al. 2015; Zhang et al. 2016). There has also been increased interest and engagement of local and international governments and non-governmental organizations (NGOs) in climate change adaptation initiatives. These notwithstanding, the integration of local communities, particularly their indigenous knowledge and experiences in climate change adaptation planning, has been observed to be insufficient.
(Eguavoen et al. 2015). This paper identifies and categorises risk indicators of climate change, focusing on climate risks identification and mapping by herder communities and the role of their indigenous knowledge in this process; identifying the progression of vulnerability from unsafe conditions to the triggers and showing the pivotal role of local knowledge and local coping mechanisms that feed into future risk reduction. At the foundation of all these is the many years of knowledge of their landscape, experiences in the wild and sometimes trial and error experimentation with the resources that their environment provide.

The paper begins by introducing the subject of climate change, climate risk assessment and its effects on livestock production. Next, the paper takes a look at community-based risk (CBR) assessment as the conceptual framework and the role of indigenous knowledge in facilitating and strengthening the process. The paper goes further to introduce the study community, the methodology, results and discussion along the lines of broad climate risk indicators, and ends with some implications for climate change assessment and policy planning to reduce future climate risks.

COMMUNITY-BASED RISK (CBR) ASSESSMENT AND INDIGENOUS KNOWLEDGE

The term ‘indigenous knowledge’ refers to the knowledge systems developed by societies with long histories of interaction with their natural environments, as opposed to the sophisticated scientific knowledge of the natural world that is generally referred to as ‘modern’ knowledge. In many rural communities, indigenous knowledge informs decision-making about important aspects of their day-to-day activities (Ajibade 2005). Its value goes beyond the boundaries of the culture in which it evolves to being the source of knowledge for scientists striving to improve living standards in rural areas. In line with this view, the discourse on adaptation planning for climate change has placed local people at the heart of decision-making and implementation of climate change risk management activities. Unlike GCMs, ANFIS, ANN, FG, SS and LGP methods, which provide global data on the climate change, reliance on indigenous knowledge has the advantage of providing specific and contextualised evidence of climate change adaptation as well as creating workable adaptation strategies that are cost-effective, participatory and sustainable (Makondo & Thomas 2018). It has been observed that the integration of these context specific indigenous knowledge systems into other scientific evidence bases of knowledge could lead to a more effective and sustainable implementation of climate change adaptation. In this regard, the CBR assessment framework, which involves hazard assessment, vulnerability assessment, capacity assessment and people’s perception of risk, has proved to be an effective participatory approach for engaging local people and using indigenous knowledge in adaptation and climate change mitigation planning. Evidence of this is extracted from a variety of CBR assessments which have shown that the approach fosters community engagement in climate risk reduction (Chambers 1994; Bruce et al. 2006; African Development Bank 2010). In these contexts, integration is fostered by capturing local knowledge and experiences through bottom-up risk assessment. These are organised and moderated by the community folk to identify and build local capacities, bringing on board all those with relevant generational knowledge and with the willingness to participate. An assessment of climate change risks is often the starting point, such that the people work in teams to establish their climate change challenges and the risk that they face in the course of their economic activities (Warrick 2011). Unlike GCMs, which rely on computer generated quantitative data for understanding the climate, and forecasting climate change at a global or regional scale, the CBR assessment framework adopted is in tune with the qualitative methodological orientation of the study. This approach made it possible to zoom in on the smaller geographic specificities, socio-economic and localized assessments of the exposure and effects of climate change. Although we have alternatives approaches such as the Holistic Risk-Based Environmental Decision Making model (Arquette et al. 2002), CBR appear to provide a stronger community orientation and focus. The steps imbedded in the framework made it possible to draw extensively on and analyse herders’ in-depth knowledge and experiences of persistent shift in the state of the climate in the area, the risks this poses to cattle herding and related livelihoods activities, and adaptation strategies in the Kpong Community.
Figure 1 outlines the steps of conducting a community-based risk assessment process, beginning with the establishment of a context for climate change adaptation, followed by risk identification, up to the point of implementation planning.

Risk assessment can be a useful tool in adapting to the negative aspects of climate change since it can be used to address a range of climate-related impacts with both a high or low likelihood of occurrence (Bruce et al. 2006). The completion of each step leads logically to the next, or ends the process if the particular climate change risk is resolved. It is iterative, and each step can be revisited if new information becomes available.

STUDY AREA AND THE FULANI PEOPLE

The study community is Kpongu, located in the south-western part of the Wa Municipality.

Kpongu is one of the five Zonal Councils (Wa, Busa, Kperisi, Kpongu and Boli) that are in the municipality. The Wa Municipal Assembly is one of the eleven district/municipal assemblies that make up the Upper West Region of Ghana. Kpongu occupies a small landmass of the municipality’s surface area (234.74 km²), and has existing functional relationships with other settlements throughout the municipality. In terms of distance, Kpongu is about 7 km south of Wa, the Central Business District. It lies at approximately 2°35’N latitude and 10°00’W longitude (Figure 2).

Long term climatic data from 2006 to 2017 show that the community experiences a unimodal rainfall pattern, usually from May to October, with an annual rainfall of between 1,000 and 1,400 mm. For instance, rainfall and temperature records from the Wa Meteorological Agency show a trend of a steady rise in temperature and a reduction in the number of rainfall days from 2006 to 2017. The peak of the rains is from July to September. It also experiences the north-east trade winds that leave the Harmattan conditions in its trail from November to March (The Harmattan is a season in the West African subcontinent which occurs between the end of November and the middle of March. It is characterized by the dry and dusty north-easterly trade wind, of the same name, which blows from the Sahara Desert over West Africa into the Gulf of Guinea). The average sunshine is about 7.5 hours per day from July to September and much longer during the Harmattan, with average prevailing wind speeds of less than 10 km/hr. Temperature is generally high all year round with the highest occurring in March. The average monthly temperature ranges between 25.5 and 35.0°C (Ghana Meteorological Agency 2017).

The vegetation is Guinea Savannah, characterised by shrub and grass undergrowth, interlaced with short, drought-resistant trees (EPA/MES 2004). The grasses are short, stocky and sparsely spaced. The dominant trees are dawadawa (Parkia biglobosa), shea (Vitellaria paradoxa), and neem trees (Azadirachta indica). Other trees are kapok (Ceiba pentandra) and baobab (Adansonia digitata). Cashew (Anacardium occidentale) and mango (Mangifera indica) are exotic species growing well in the area. Pasture grass is mainly guinea grass (Panicum maximum). The grass serves as a nutritious diet for free-range livestock and herded cattle, and raw materials for making thatch roofing.

Kpongu was selected as the study community mainly because it is the largest and one of the earliest Fulani cattle-herder settlements in the Upper West region of Ghana. Contrary to the nomadic lifestyle that is typical of pastoral Fulani in Ghana, the group in Kpongu have been permanently settled in the community for over six decades, which made it possible to identify participants who have experienced changes in the climate over several decades.
and were willing to share such experiences. The Fulani herders in the community are originally a nomadic group with transcending knowledge in pastoralism. A third of the global Fulani population are pastoralist, the largest nomadic community in the world (Levinson 1996). The Fulani people form a large ethnic group in the Sahel, and are widely dispersed across the West African subregion, mostly in Nigeria and Guinea. Ghana has a significant Fulani population, and although there number is not known, they were estimated to be more than 14,000 (Bukari & Schareika 2015). The Fulanis in Kpongú are an illiterate group that often keep to themselves by settling on the fringes of the community. However, their lack of formal education does not make them any less resourceful or ignorant of their indigenous knowledge and experiences as pastoralists. Demonstrating a blend of indigenous knowledge and conventional wisdom, their responses mirror a deep understanding of pastoralism and the resources of nature around them. Their main means of livelihood is livestock keeping, particularly cattle production. Historically, they are nomads that are always on the move with their families and cattle. In recent times, they are becoming sedentary and settle depending on the dictates of the climate. They depend on the returns that they obtain from their stockbreeding practices, such as cattle for the animal markets and cows’ milk for sale or for barter/trade. As they assume a sedentary life, they combine their stockbreeding responsibilities with the cultivation of food crops in the rainy season to meet the consumption needs of their families.

**RESEARCH CONTEXT AND METHODOLOGY**

A case study research approach was adopted for this study. Case studies are in-depth studies of a few units with multiple variables aimed at obtaining as complete a picture as possible of a situation, a phenomenon or event. A unit in this sense refers to an individual, a group, or a local community. An in-depth study of a specific unit provides greater insight for understanding the interaction between a specific context and a phenomenon under investigation (Bryman 2001). This approach was adopted in this study because it allowed room for an up-close and detailed exploration of the phenomenon of climate change adaptations as well as its related contextual issues in the specific case of cattle herding in the Kpongú community.

**SOURCES OF DATA**

This study employed diverse qualitative tools for gathering data from the Kpongú community and relevant institutions in the Wa Municipality. These include key informant
interviews (KIIs), focus group discussions (FGDs), seasonal calendar and observation. The use of these tools was influenced by the qualitative orientation of the study – to dig deeper for greater insights into herder experiences of climate change as the basis for analysing indigenous knowledge and adaptation to the phenomenon. It also made it possible to triangulate conflicting responses for clarification before proceeding to analyse the data. These tools were mostly applied sequentially so that the findings from the use of initial tools informed the design of succeeding ones. This approach was helpful in filling gaps in the data collected as well as exploring some interesting issues that emerged from initial interactions.

Key informant interviews

The first source of data for this research was through key informant interviews. A total of 18 in-depth interviews were conducted with key informants at the institutional and community levels. The selection of participants was based on their knowledge and experiences of climate change and willingness to participate in the study. At the institutional level, interviewees included two animal production officers and a veterinary officer from the Municipal Office of the Ministry of Food and Agriculture. The rest included two officers from the regional meteorological agency, and two assistant planning officers at the Wa Municipal Assembly. These participants were purposively sampled to share insights and experiences of climate change variability and the institutional support mechanisms given to herdsmen to strengthen their adaptation strategies. The meteorological office provided statistical data on rainfall patterns from 2006 to 2017. These data were useful for understanding and analysing climate change variability and indigenous adaptation strategies. At the community level, 11 in-depth interviews were conducted with herdsmen, and one each with the chief and the assemblyman of the Kpongou Community. They shared their knowledge and experiences of climate change variability and adaptation strategies of herdsmen.

Focus group discussion

Four FGDs followed the completion of key informant interviews. These were conducted with youth and elderly groups in the community. By way of complete enumeration, all herdsmen aged 15 years and above participated in the focus group discussions. Membership of these groups ranged between six and 10 people. The youth were 16 in number (eight per group), aged between 15 and 35 years. The elderly, aged 36 years and above, were 20 in number (10 per group). This composition of the FGDs was a deliberate strategy aimed at giving every herdsman in the community an opportunity to express their views on climate change adaptations in their cattle production. The main advantage of adopting FGDs was to draw upon participants’ individual and group experiences and reactions to climate change in a way where other methods are not applicable. Because of inherent power differences, FGDs gave the youth, in particular, an opportunity to freely share their experiences of climate change and adaptation strategies adopted in the community. Their accounts were consistent with those of the elderly, aside from the elderly having longer experiences and adaptation to the phenomenon.

Direct observation

Non-participant observation was also carried to compliment data gathered via interviews. Three observation visits were made by authors to the community and cattle grazing fields to obtain firsthand physical information on climate change and adaptation strategies employed by herdsmen in the community. The purpose was to generate supplementary data to triangulate important findings that emerged from the KIIs and FGDs. By employing this tool we were able to obtain physical evidence of climate change and climate variability affecting the pasturing activities of herdsmen in the community. We also observed indigenous adaptation strategies to climate change, particularly the diverse strategies adopted by herdsmen to source varieties of feed, and the ways in which they manage the stress of cattle.

Seasonal calendar exploration and analysis

This tool was used in conjunction with interviews and focus group discussions to collect data mainly from herdsmen. Used in a group setting, local communal events such as festivals and agro production cycles were highlighted to refresh the memory of participants and to ensure that they
maintained the chronology of identifying the native names for the months of a lunar calendar. These were plotted in a tabular form, corresponding to the various activities or phenomenon reported. It has the advantage of guaranteeing a robust data collection and analytical process as it draws on the memory and perspectives of participants, supplemented by large-scale meteorological data and external social records. The data collected using this instrument were analysed by drawing linkages between the monthly events and occurrence to identify triggers of climate risks and precursors of vulnerability. Data were also analysed by looking at periods of resource fluctuations or even loss and how these create changes in livelihood for the herdsmen and their households. The seasonal calendar was also analysed by looking out for patterns and inconsistencies that could form the basis for further probing.

Analysis of data

The framework approach to thematic analysis was employed to analyse the data. The analytical framework employed for this research – CBR Assessment and Indigenous Knowledge – has four interrelated components: hazard assessment, vulnerability assessment, capacity assessment and people’s perception of risk. This framework places people at the heart of decision-making and implementation of climate change risk management activities. Bearing this in mind, the analytical process started right from the stage of developing the tools for data collection where the questions were structured in line with the four dimensions of the framework. The process involved transcribing the responses and narratives, reading each transcript carefully and noting down repetitions, similarities and differences that were relevant to the research question. It also involved writing down on the margins of each page the main themes emerging from the responses. Following this preliminary analysis, the themes were examined a second time and then put into thematic networks. The final phase involved using soft copies of the transcripts to pull together the segments of the data which represented each theme and developed qualitative analysis by analysing in detail what participants said about these themes and what they signified in relation to the research question.

RESULTS

The results show that the indigenous knowledge of the Fulani herder community on climate change was strongly tied to their experiences of climate change and climate change impacts over a long period of time, across generations. Their narratives and knowledge of climate change revolve around five main indicators of climate change. These include: (1) lengthening dry season and dry spells, (2) increased frequency and longer dry spells, (3) shrinking sizes of water bodies, (4) formation of iron pans on top soils, (5) stunted growth of grass and less concentration of grass species.

Lengthening of the duration of dry seasons and dry spells

The Fulani herdsmen of Kpongou have observed a change in the climate, which, according to them is evident in lengthening of the duration of dry seasons and dry spells. The dry season is not favourable for pastoral activities and, as such, herdsmen are keen about when the dry season starts, what happens during the period and when the season ends. There was a general consensus among the herdsmen that in the last three decades the conditions that mark the dry season used to last for five months, starting in the month of Sewtoranu (November) and ending in Gaanii (March). However, they have observed an increase in the duration from five to seven months, starting earlier than before in the month of Juldanu (October) and stretching further to Nii Gaanii (April). For the herdsmen, conditions that mark the dry season include strong winds from the east (waking of the sun), trees shedding their leaves, lower temperatures at dawn, drying up of grasses (that facilitate bush fires) and diminished water sources for their cattle.

Recounting some youthful experiences in relation to an extension in the duration of the dry season, one elderly herdsman mentioned during a focus group discussion that the rains used to start earlier than they do now. In his own words, he said:

‘I remember that when I was learning pastoralism, the duration of the dry season was shorter than now. The rains usually started early with less intense winds and
the dry season was about five months each year (Zibrim Baari, FGD, 14/11/2017, Kpongu).

Speaking on this phenomenon during a focus group discussion, one herdsman made a very profound statement that relates to the implication of this phenomenon for their pastoral activities and their general livelihoods. He said that:

‘Now we observe that the dry season is becoming longer than before, meanwhile the number of months in the year are still the same. This means that the rainy days have become fewer and we have to endure a lot more hardships in taking care of our herds (Iddrisu Ahmadu, FGD, 14/11/2017, Kpongu).’

Similar to the increase in the length of the dry season is the increase in the frequency and duration of dry spells during the rainy season. Each year, the rainy season is known to be punctuated by a number of days without rainfall. Such a prolonged period during the rainy season without rainfall is referred to as a dry spell. The herdsmen reported how the number of dry spells used to be few or far between and only lasted for a maximum of one week. According to them, the situation is no longer the same. The herdsmen reported that the dry spells during the rainy season are now more frequent and that they also last longer than they used to. From the narratives of the herdsmen, there are some signs that characterise the occurrence of dry spells with little or no cloud cover; higher temperatures, the leaves of trees begin to coil and twist and various grasses, which serve as fodder for cattle, lose their freshness.

Apart from the more frequent occurrence of the dry spells, the herdsmen were also concerned about the length of the dry spells. It was revealed in a focus group interaction that dry spells during the rainy season are now longer as compared to what used to be the case some three decades ago. From a maximum of a one-week period of dry spell experienced in the past, dry spells can last for as long as two weeks. The experiences shared in their narratives reveal that frequent dry spells caused distortions in the amount and quality of fodder that is available for their cattle. In the course of a key informant interview, one herdsman underscores this and other impacts when he said that:

‘A lot of heat accompanies dry spells and that causes distress in the animals. The grasses in grazing fields always start to lose their freshness when a dry spell sets in. Leaves would begin coiling up and twisting in the heat and the animals are unable to feed well (Iddrisu Adama, KII, 08/10/2017, Kpongu).’

The narratives of the herdsmen are corroborated by data on the number of rainy days that was obtained from the Wa Station of the Meteorological Agency. The data covers several years, from 2006 to 2017, and is shown in Table 1. It reveals the non-occurrence of rains during the months that make up the dry season and also reveals by inference, the length of dry spells that occurred during the rainy seasons of those years.

Table 1 shows that although the total number of rainy days increased between 2006 and 2009, a significant decrease was observed between 2012 and 2017. The statistics also show that August recorded as high as 20 rainy days in both 2008 and 2009. However, the number of rainy days for the same month dropped over the years, with 2017 recording as low as 10 rainy days for September. The highest record of rainy days was in 2013, with a record of 21 days. In subsequent years, the number of rainy days for September started reducing to its lowest record of six rainy days in 2017.

The narratives of the herdsmen regarding the lengthening of the dry seasons corroborates the data on the number of rainy days (Table 1). From 2006 to 2008, less than 90 rainy days were recorded. Although 2009 recorded as high as 101 rainy days, the records show a consistent decline in number of rainfall days. From 95 rainy days in 2012, the number of rainy days declined consistently over the years to as low as 64 in 2017.

Shrinking sizes of water bodies

One of the most critical means of existence for cattle, apart from forage, is a source of water. However, it has been observed by many herdsmen, particularly the aged, that their water bodies have been reducing in size over the
years. This forms another experience and a way by which the herdsmen recognise and measure climate change. From the narratives of the herdsmen, the water bodies are not only shrinking in overall size but also lose significant amounts of water during dry spells and often completely dry up in the dry season.

Recounting his experience regarding the shrinking water bodies that are sources of drinking water for their livestock, one herdsman commented that:

‘Growing up, we used to swim in that pond, even in the dry season. We often left the animals by the riverside and went for a swim. Now the water in the pond cannot even reach my knee level during the dry season, let alone enough for swimming (Zibrim Baari, FGD, 14/11/2017, Kpongu).’

This reflects the herdsman’s experience of climate change and the challenge this poses to livestock herding in the area. Their cattle used to stay at the banks of the pond to graze and drink because the pond was so large and deep that the cattle would not risk going into the water. There is now a change in the climate and the cattle can easily wade through the water and cross over to the other side. During prolonged dry seasons, the pond is reduced to a murky mass of suspended particles and the cattle can hardly drink from it. One such pond in the community that has shrunk in size is shown in Figure 3.

Figure 3 is one of the water bodies that the herdsmen depend on as a source of water for their livestock. The picture shows a pond that contains the muddy remains of water. Based on its large size, it can be extrapolated that it used to hold large volumes of water. The area around the pond still has some traces of grass, the survival of which is made possible by the presence of the water. However the pond has lost most of its water due to the reduction in rainfall in the area.

During a focus group discussion with the herdsmen, the issue of shrinking water bodies was probed further so as to

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estimate the extent to which the water in the pond has reduced. In response, one of the herdsmen cited an example, saying:

‘It is now possible for some community members to comfortably mould bricks and leave them at the edge of the water, without any fears that they would be washed away. Some years past, nobody could mould bricks there since that space was filled with water (Iddrisu Ahmadu, FGD, 14/11/2017, Kpong).’

The fact that water bodies in the community are shrinking, and the fact that they easily dry up in the dry season, presents some implications for pastoralism and the livelihoods of the herdsmen as a whole. As a coping strategy herdsmen have to plan and reroute their movements in the dry season. Very often they take the option of trekking in the direction of other communities where they are assured of water for their animals. This means enduring longer trekking distances and the likelihood of drinking water of very poor quality is high. This situation was confirmed by the Regional Veterinary Officer (RVO) during an interview. This is what he said regarding the kind of water that the animals drink:

‘When I go round on inspection and treatment, it is clear that some illnesses that attack the animals are due to the kind of water that they drink. Sometimes I ask questions and in response the herdsmen would say that their options of water sources are limited (RVO, KII, Wa19/10/2017).’

The herdsmen admitted that they know that the water quality is poor in the dry season but conceded that they allow the cattle to drink it because they have always preferred this option to the option of trekking several kilometres for good quality water, with the risk of exposing the animals to severe heat and stress.

Formation of iron pans on top soils

One of the experiences of climate change as recounted by herdsmen is the widespread incidence of iron pans. An iron pan on the surface of a piece of land is a form of clay that is rich in iron but very poor in humus, resulting in the hardening of top soils. This kind of hardened top soil is unable to support the growth of grasses that herdsmen require to feed their herds. The increasing formation of these iron pans on hitherto humus land surfaces is one indicator of climate change for the herdsmen.

The herdsmen are well aware that several factors contribute to the exposure of top soils to heat, aridity and eventually the formation of iron pans. These include erratic and fewer rains, higher temperatures, deforestation through charcoal burning and bush burning (wild fires) that destroy the land surface. This in-depth understanding of the climate and climate variability by the herdsmen is corroborated by the responses of the Senior Veterinary Officer at the Regional Veterinary Unit of the MoFA in Wa. He revealed that through his interactions with herdsmen there is an appreciable understanding amongst them that temperatures are now higher and intolerable, the weather patterns are unpredictable, that rainfall is now more erratic than ever, and the distribution across the landscape is also intermittent and unreliable.

During a key informant interview, one herdsman noted with concern the numerous locations where iron pans can be found when they go away from their homestead with their herds. This is what he had to say:

‘Some years ago, we only saw iron pans in rocky or stony areas. This situation has changed now. We see them in any direction that we move. Iron pans have now taken over grasslands. The way it is now, grasses cannot grow there again (Key Informant, KII, Kpong, 20/10/2017).’

According to the herdsmen, the spread of iron pans on vegetation in plains that once had grasses is only one aspect of the impacts of climate change. They observed that the iron pans are increasing in size, expanding further to affect the surrounding forage. This is the apprehension of another key informant. Expressing this uneasiness, he mentioned that:

‘The iron pans are growing and are taking over our grazing fields, spreading into many areas. The rate of the spread might be gradual but they are becoming bigger as compared to when we first saw them. Now we are afraid of..."
Herdsmen who spoke on the issue of the formation of iron pans observed that the appearance and spread of iron pans happens gradually. **Figure 4** gives a visual impression of an iron pan. The picture was taken during the data collection at Kpongu in 2017.

The iron pan that is shown in **Figure 4** is located in the northern extremes of the study community, next to a stretch of green field. The herdsmen reported that this area was previously a grassland that is losing its green forage. This is evidenced by the fact that the area still has some patches of grass as the iron pan is expanding. The few patches of grass that remain would be lost in the coming years as the iron pan is expected to expand over a wider area.

Some of the narratives expressed by the herdsmen brought to light their understanding of the causative linkage between the occurrence of drought and frequent dry spells on the one hand and the formation of iron pans on the other hand. Their narratives are indicative of the fact that periods of prolonged droughts and dry spells influence the occurrence of iron pans in such a way that make the iron pans become more visible, and the top soils become more hardened.

Speaking on this linkage, a key informant mentioned that:

‘**When we experience continuous rains, the iron pans are not able to form or expand easily. In the rainy season** when we spot the iron pans, they become partially covered by creeping plants. So if the rains are continuous, we might not even be able to locate the iron pans again (Key Informant, KII, Kpongu, 13/10/2017).’

The herdsmen reported the impacts of the iron pan formation on their pastoral activities and by extension, their livelihood. The first and obvious impact is that some grazing fields have been replaced by iron pans. Fields that previously served as grazing fields for cattle no longer have grasses, even in the rainy season. The reason is that anywhere iron pans are formed; the conditions of the top soils are such that they impede drainage of water and restrict the growth of plant roots. As grazing fields become limited, herdsmen and their herds are compelled to trek longer distances in search of feed. This situation has negative consequences on both the quality of feed as well as the health of the herds and herdsmen.

**Stunted growth, smaller stalk sizes and less concentration of grasses**

The herdsmen in Kpongu have made another observation that has become a part of their own understanding, measurement and experience of climate change. Apart from the fact that the availability of forage for cattle is cyclical (rainy and dry seasons) and influenced by the amount of rains, there is also the issue of the length or height of the grasses. They reported that another way in which they have experienced climate change and climate variability and their impacts is by gauging the growth of various grass species.

During various interactive sessions with the herdsmen, they were unanimous in indicating that the grasses that their herds depended on have experienced diminutive growth over the years. On a lighter note, some of the herdsmen believe that their animals have stunted growth because they do not have to stretch to reach for tall grasses and weeds. Describing how short the species of grasses have become, this is what one herdsman had to say during a focus group discussion:

‘**So many years ago, when we went into the bush, the grasses were so tall that they would prevent us from seeing far ahead. Grasses that hitherto could shield and match up to the height of a fully-grown man have now**...’
shrunk to about half that size. The grasses have become so short even when we are experiencing heavy rains (Discussant, FGD, 14/11/2017, Kpongu).'

To measure the actual height of the grasses, the best period would be at the peak of the rains when the grasses would have grown to their tallest possible height. The herdsmen added that at this time the grasses would not be heavy at the top as a result of the formation of pods (for some species) and they have not reached the point where they begin to bend downwards.

Similarly, the herdsmen have also observed the size of the stalks of grasses, in terms of their width. They reported that that the sizes of the stalk have become smaller over the years. The stalks are cut from their base at the time that they begin to show signs of drying up. This is usually done between the months of Juldanu (October) and Sewtor-anu (November), early enough before the grasses are destroyed by the blaze of wild fires.

Regarding the smaller size of stalks, one key informant spoke about the weight of a bundle of stalks. The herdsmen recounted his experiences regarding the weight of a bundle of wet or freshly cut stalks which, as children, they struggled to carry from the bush to their homestead. He had this to say:

‘A single twine of fibre often holds one bundle of grass stalks together. Some years ago, such a bundle was so heavy that, as children, we could not carry the load home. Nowadays, we have to cut a lot more grass stalks to make up a bundle of the same weight (Key Informant, KII, 20/10/2017, Kpongu).’

In current times, the grasses have become shorter, the stalk sizes are smaller and the bushes are not as dense as they used to be. All of these factors and experiences have adaptation implications for the pastoral activities, particularly as it relates to the quantity and quality of forage available to livestock.

It is obvious that the limited quantity and poor quality of feed due to climate change would impact negatively on the health and general growth of livestock. During a focus group discussion, a herdsman underscored the importance of good forage with large stalks and leaves, saying that they usually observe the cow dung to determine if the cattle are getting enough fibre from the grass. Demonstrating his understanding and experience, he reported that:

‘Our animals need regular and sufficient fibre, especially young ones that have just started feeding on grass. As the grasses are becoming smaller and less concentrated, we observe that the cattle excreta is lighter and sometimes watery. Good grasses with lots of fibre make the dung appear dark, solid and compact (Discussant, FGD, 14/11/2017, Kpongu).’

The discussant also reported that the period when calves start to feed on grass is the most critical time that determines how well they would grow and how their health would be impacted. Calves that are weaned off at the start of the dry season are the ones that tend not to grow well. This is the time when grasses are not fresh and even the dry grasses are mostly scorched by bush fires.
In summary, the results have demonstrated that herdsmen in the Kpongu Community are up to speed with the reality and dimensions of climate change and climate variability. They have made observations that have become a part of their own understanding, measurement and experience of climate change and climate variability. These observations were made over decades and the information has been transferred from one generation to the next. Their narratives demonstrate their depth of knowledge and understanding of climate change and climate variability arising from experiences accumulated over many years.

DISCUSSION

The indigenous knowledge of the Fulani revealed three broad indicators and patterns of climate change and climate variability closely connected with their livelihood and way of life. These include precipitation and temperature, vegetation and soil-based indicators and experiences (Figure 5).

First, precipitation and temperature-based indicators include experiences of longer dry seasons, longer dry spells, high and increasing temperatures and shrinking sizes of surface water bodies. The ensuing discussion on herder knowledge of early indicators of climate change is relevant to the discourse around climate change adaptation planning and climate change decision-making.

The results reveal longer dry seasons, more frequent and longer dry spells and increasing temperatures that are unbearable for humans and livestock. The dry season is becoming longer each year, increasing from about five months in 2006 to seven months in 2017. Water run-offs from rainfall are channelled down slope into dams and dug-outs and then serve as a source of drinking water for livestock. Thus, frequent and longer dry spells during the rainy season have been observed to significantly cause the reduction in the volumes of water stored in dams and dugouts in the area. This is consistent with findings from previous studies that reported increases in mean annual temperature over prolonged periods of time in the arid regions of China and sub-Saharan Africa (Osbahr et al. 2011; Gonzalez et al. 2012; Amjath-Babu et al. 2016; Kahsay & Hansen 2016; Qasem et al. 2019; Wang et al. 2019). Although these studies have provided relevant, up-to-date insights on temperature and precipitation-based indicators of climate change, our paper takes a step further into the more specific herder knowledge and experiences of early indicators of climate change which include longer dry seasons, longer dry spells, high and increasing temperatures and shrinking sizes of surface water bodies.

Longer dry seasons and frequent dry spells in the rainy season have also been observed to have a significant influence on the formation of iron pans and the growth of various grass species. Dry seasons bring winds with little moisture content. Intense temperatures and solar radiation also leaves the top soils very parched and cracked. These become the perfect conditions for the formation of iron pans. As the iron pans spread out with such harsh conditions, grasses easily fizzle out, leaving the ground bare. Any surviving grasses in such an area would most likely suffer stunted growth and develop a smaller stalk size. Similarly, the shrinking of water bodies has implications for surrounding vegetation which in turn influences the formation of iron pans. The fields that surround water bodies are the rallying points for herdsmen to graze their cattle in the dry season. Moist and humid conditions in these places make them conducive for the sprouting and growth of grasses. However, as the water bodies are shrinking in size, the vegetation in the surrounding areas of the water bodies would begin to wilt. As the volumes of water diminish, the muddy and saturated banks begin to lose moisture and deteriorate to the disadvantage of the greenery that is surviving there. Similarly, as the surrounding vegetation

![Figure 5](https://example.com/image.png)
starts to wilt, coupled with the effects of the dry seasons and dry spells, the top soil becomes more exposed, and triggers the formation of iron pans. Similar findings are observed in previous studies in arid and semi-arid areas where vegetation production is reported to be declining in response to climate warming and high rates of evaporation (Osbahr et al. 2011; Xu & Wang 2016; Zhang et al. 2016; Zeise et al. 2018; Qasem et al. 2019). Mention must be made, however, that whereas these studies used scientifically based measurements that track trends in climate change, our study relied on a combination of narrations of herdsmen based on their local and indigenous knowledge and experiences of climate change over decades, and meteorological data of rainfall pattern in the Wa Municipality for the period 2006–2017.

The findings that have emerged from this study reinforce a primary view of the LINKS programme, that adaptation action be based on and guided by the best available science and, as appropriate, traditional knowledge, knowledge of indigenous peoples and local knowledge systems, aimed at blending adaptation with appropriate socioeconomic and environmental policy decisions (LINKS 2018). This perspective stresses the point that pastoral peoples (in this case, Fulani) reside in places that have high variability and exposure to climate stress. They observe and respond to local weather and climate over a long period, and take critical decisions in relation to their well-being and that of their herds based on their knowledge and experiences of the changes that occur in their environment. Through knowledge and experience, they adapt and maintain resilience in the face of climate change. This background brings to the fore the need to establish platforms to assemble together pastoral peoples, meteorologists and climate scientists to dialogue and exchange knowledge by comparing, contrasting and combine forecasting capacities and techniques to improve knowledge for climate change adaptation planning and decision-making.

**CONCLUSIONS AND IMPLICATIONS FOR CLIMATE CHANGE ADAPTATION PLANNING**

As a result of multiple and independent lines of evidence, it can be concluded that climate change and climate variability and the risks associated with these are understood and measured by herder communities according to how they experience climate change impacts. The indigenous knowledge (IK) of the Fulani reveals three broad indicators and patterns of climate change and climate variability. These are closely linked to their livelihood and way of life as agro-pastoralists. These indicators and experiences are linked to precipitation and temperature (longer dry seasons, frequent dry spells and shrinking sizes of water bodies), vegetation (stunted grass growth, smaller stalks and less concentration of grass species) and the nature of the land and top soil around them (formation of iron pans). The Fulani demonstrate a deep understanding of climate change and climate variability as part of their IK, derived from an intergenerational accumulation of experiences they have lived and shared. The impacts of climate change impede their efforts at sustainable cattle production. Their battles to deal with the climate forms part of the rich and holistic experiences that they hold about climate change and their livelihood. Over many years, their observations have become a part of their understanding, measurement and experience of climate change and climate variability, and this will likely be passed on to the next generations of Fulani through informal learning and knowledge exchange mechanisms in their localized context.

Although the findings are limited due to the small sample and geographic scope (the Fulani of Kpongou), they present very useful learnings and likely adaptable policy implications for most places in semi-arid and arid parts of Ghana and West Africa at large. The paper presents two policy related recommendations for enhancing climate change adaptation planning (CCAP). First, at the local level, municipal development planning should adopt a multi-stakeholder approach to participatory planning that benefits from the relevance of Fulani IK of climate risk assessment. This is imperative for achieving inclusivity and equity in CCAP at the local level within the context of decentralization in Ghana. Second, that the learnings from this study can inform larger scale studies that will provide expanded climate risk assessments among herdiers for informing CCAP in Ghana and sub-Saharan Africa in general.
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