Knowledge and perceptions of climate change among smallholder farmers in Ghana and the role of local ecological knowledge in climate change adaptation.

By

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Abstract

Climate plays a crucial role in the agriculture sector in ensuring food security and stable employment for the majority that depend on it for their livelihood. This study assessed smallholder farmers perceptions and adaptations to climate change and the role of local ecological knowledge in adaptation. A review of existing literature together with data from the 2017 Afrobarometer survey was used to answer the research questions. The focus of the study was on Ghana but a review of Nigeria was done in order to draw comparisons of the economic productivity and agricultural characteristics in the sector. Some farmers had heard about the term climate change while others had not; however, some of the farmers who had heard about the term did not fully understand it. Climate change was seen as evident in high temperatures, excessive rainfall, and a prolonged dry season. Despite the challenges with climate change, some farmers perceived it had limited effects. Perceptions were influenced by age, gender, education and length of stay in the farming community. Moreover, perceptions of climate change influenced the decision to adapt. The majority of adaptation measures used were borne out of local ecological knowledge, which has proven successful over time. The results suggest making government educational programs and adaptation techniques more accessible to farmers, especially those in both remote and urban` areas.

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Abbreviations

UNFCC	United Nations Framework Convention on Climate Change
LEK	Local Ecological Knowledge
TEK	Traditional Ecological Knowledge
FAO	Food and Agricultural Organisation
GDP	Gross Domestic Product
UN	United Nations
NCCP	National Climate Change Policy
CSA	Climate-Smart Agriculture
IPCC	Intergovernmental Panel on Climate Change

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Chapter 1

1.1 Introduction

Climate change in recent years has garnered a lot of attention as a result of its adverse impacts on humanity (Asante & Amuakwa-Mensah, 2015). With even a small temperature rise in global warming, the intensity and frequency of extreme weather events such as droughts, floods, tropical cyclones, and heavy precipitation will increase (UNFCC, 2010). The Intergovernmental Panel on Climate Change and the World Meteorological Organization predict a world temperature rise between 1.5℃ and 4.5℃ by the end of the 21st century (Ngaira, 2007). Climate change is a global challenge and unprecedented in scale; it requires attention from all regions of the Earth (Adedeji, 2014). Indeed, the problems associated with climate change cut across different sectors and also have links with other global challenges (Feulner, 2017). Issues of climate change are at the centre of global-level development discussions, unlike poverty, which is mainly limited to Africa (Asante & Amuakwa-Mensah, 2015). However, developing countries are the most susceptible to adverse impacts of climate change due to having inadequate technical, financial, and social resources to combat its effect (UNFCC, 2010). Some areas in Africa are now noted for highly variable climatic conditions, droughts and floods can occur in the same area within just months of each other, leading to famine and other interruptions in socio-economic wellbeing (UNFCC, 2010). The long-term impacts of climate change include changing rainfall patterns, reductions in food production leading to food insecurity, decreased fish production as a result of rising temperature, worsening water security, and

low-lying coastal areas being affected by sea-level rise (Asante & Amuakwa-Mensah, 2015).

Annual changes in climatic conditions are a determinant of fluctuations in crop yield (Isis & Devadoss, 2006). The rise in temperature will increase the stress related to agricultural systems and food security in Africa (Ngaira, 2007). Researchers have warned of decreased yield in grain production in developing countries as a result of global warming by using crop simulation models (Mandelsohn, 2014). The agriculture sector is extremely vulnerable to climate variabilities; different crops are affected differently by increasing temperatures and precipitation pattern changes (Nelson et al., 2009). Challenges of a warming climate for agriculture in Africa include soil erosion, ecological hazards of droughts and desertification, interference in ecosystem stability, and drying up of irrigation projects, among others (Ngaira, 2007). The effect of climate change on agriculture threatens food security globally and in developing countries, in particular, since these areas are already food insecure and are expected to be the worst affected (Gerald et al., 2009). This is a huge concern for Ghana especially, as it happens to be a developing country whose livelihood revolve around agriculture (Hanaan Dinko, 2017).

Temperatures in Ghana are generally high, with average yearly temperatures between 24℃ to 30℃, and there are instances where temperatures could be as low as 18℃ and as high as 40℃ in the north (Asante & Amuakwa-Mensah, 2015). Over the years, rainfall levels have been decreasing while temperatures in all ecological zones keep rising, and rainfall patterns are continuously becoming unreliable (Asante & Amuakwa-Mensah, 2015). There have also been reports of changes in the rainfall of the country: a vanishing rainfall season

and an extended dry season (Owusu et al., 2008). Certain impacts of climate change in the Ghana context are comparable to impacts worldwide; three primary pieces of evidence of climate change in the country are the changes in rainfall patterns, sea-level rise, and observed changes in temperatures (Ward, 2010). Other challenges faced by the country as a result of climate change are climate-induced disruption of agriculture systems, climate-related health problems, and low water levels for hydropower generation (Munasinghe et al., 2003).

Ghana, also faces inadequate adaptive capacity to combat the socio-economic and environmental effects of climate change (Asante & Amuakwa-Mensah, 2015). The inability of the country to cope with the variabilities of the climate causes food insecurity and prevailing poverty in the region (Lacombe, 2012). Generally, theu nderstanding of perceptions on climate change is essential in the design of effective mitigation and adaptive measures (Zampaligré et al., 2014) since perceptions have a higher impact on climate change adaptation than experience (Wang & Kim, 2018). Understanding perceptions of climate change also helps in the design of initiatives to address environmental challenges in agricultural activities (Hyland et al., 2016) and contributes to building community resilience towards climate change (Kupika et al., 2019). That is farmers' perceptions of risks of climate change can impact their decisions to adopt an adaptation strategy (Wang & Kim, 2018). These perceptions will also impact their decisions to participate in programs that seek to address the emissions of greenhouse gases in the agriculture sector (Hyland et al., 2016).

Strategies needed for adapting to climate change have become a matter of urgency (Glantz et al., 2009). Future generations are still bound to be affected by climate change even if there is a halt to the emissions of greenhouse gases, this in essence highlights the importance of adaptation (Responding to climate change, 2021). Climate change adaptation has been defined by Tompkins and Adger (2003, p. 4) as "the action of responding to experienced or expected impacts of changing climatic conditions to reduce impacts or to take advantage of new circumstances." The concept of effective adaptation measures better equips societies to cope with the challenges and uncertainties with climate change (UNFCC, 2010). The Food and Agriculture Organization promotes the incorporation of climate change mitigation and adaptation into food security measures; however, real results will demand close cooperation, comprehensive approaches, coordination, and synergy among institutions, policy planners, and local communities (Glantz et al., 2009). Thus, local knowledge is useful in the design of effective adaptation strategies in agriculture. Local knowledge has proven to be efficient in the development and implementation of sustainable development projects (Ajani, 2013). There are farmers who incorporate both local knowledge and modern-day approaches to adapt to climate change. Through the various processes of adaptations adopted by farmers, they can strengthen their resilience to extreme high and low temperatures, thus increasing their range of coping (FAO, 2012).

1.1.2 Small scale farming in Ghana

Agriculture is important in maintaining food security and improving the economic growth of rural dwellers but is faced with climate change challenges and resource scarcities that affect production (Masuku et al., 2017). Ghana’s current developmental objectives

prioritize improvement in the country's agricultural growth (Chamberlin, 2007). The rural environment is very important in this regard due to its central role in the national economy (Chamberlin, 2007). Agriculture in Ghana contributes 54% of GDP (FAO, 2021). Ghana's national strategy towards agriculture is focused on increased food production, increased production of export-oriented and high-value crops, improved access to transportation facilities in areas involved in crop production as well as offering marketing support for farmers (Chamberlin, 2007). Implicit among all these interventions is the goal of increasing the marketability of smallholder farmers' output (Chamberlin, 2007) since a significant number of the Ghanaian population are rural dwellers and highly dependent on smallholding agriculture for their livelihood (Asafo-adjei, 2016). It is estimated that about 43% of the country's population are rural dwellers (The world bank, 2020). Smallholder farming plays an important role in economic growth, food and cash crop production, job creation, poverty alleviation and rural ecosystem management in the country (Asafo-adjei, 2016). This type of farming supports a large part of the population through petty trading of farm products and other related activities (Asafo-adjei, 2016).

Smallholder farming generally connotes "limited land availability". Different scholars have created different definitions for smallholder farming. These definitions are centred around themes such as the size of holding, market orientation, and wealth and levels of risk vulnerability, but, holding size is the most typical theme (Chamberlin, 2007); smallholder farmers are characterized by small farm sizes (Koomson & Bukari, 2019). The Ministry of Agriculture (2006) maintains that Ghana's farming population is 90% the smallholder type with less than 2 hectares of land size. In Ghana, smallholder agriculture is characterized by

estimates of contributions towards the agriculture economy (Chamberlin, 2007). Smallholder agriculture is highly dependable for a good amount of food production at the domestic, regional and global levels (Proctor & Lucchesi, 2012). Smallholder farmers contribute 40% of Ghana’s rice production, 100% of Ghana’s starch staple foods and 85% of Ghana's cereals (Asafo-adjei, 2016).

Although smallholder farmers contribute significantly to food security, the farmers are challenged with pests and disease infestations, price fluctuations, low productivity and low financial power (Asafo-adjei, 2016). The sector's other challenges are the low level of mechanization, poor road infrastructure, land fragmentation, and inadequate access to agrochemicals (Abolhasan Sadati, 2010). Mehrabanian and Pourkakhaki (2007) also highlight issues such as low literacy rate, low knowledge of modern technology, outmoded farm cultivation methods and other challenges that impede productivity.

Globally, it is believed that about a million smallholder farmers reside in marginalized environment and rural communities and do not get the needed technical support for their farming activities (Modi, 2015). A challenge faced by smallholder farmers is access to credit facilities required to acquire modern technology to facilitate farming activities (Preprah et al., 2016). This challenge is mainly due to their farms' sizes and location; credit facilities base their eligibility for loans on the size of farms and land tenure (Preprah et al., 2016).

Furthermore, the financial sector perceives this sector to be a high-risk area due to the high variation and unpredictability in food production (Asafo-adjei, 2016). The farming system practiced in this sector is mostly rain-fed agriculture, which makes them highly susceptible

to climate change's negative impact (Asafo-adjei, 2016). This situation, coupled with the unpredictabilities in the sector, makes smallholders unattractive candidates to acquire loans from commercial banks and other financial institutions (Asafo-adjei, 2016). Smallholder farmers who do not meet these eligibility criteria resort to their savings to acquire farm input, the needed machinery and improved technology; however, they are unable to do much due to smaller savings earned from their farm activities (Preprah et al., 2016)

1.1.3 Climate change in Ghana

Climate change has become a common term and is a little confusing amongst rural dwellers, which tend to base their description on the experienced impact on their activities and livelihood (Yaro, 2013). Globalized communication plays a role in making the term known amongst farmers, who already have knowledge on the subject but describe it loosely with different terms based on causes and impacts (Yaro, 2013). Communities that rely on the natural environment for their livelihood are able to quickly detect the changes that occur in the environment. For example, farmers in the Sahelian region of Africa noticed a shortage in rainfall by observing changing settlement patterns, disappearing plants and shrinking water bodies (Yaro, 2013). Farmers possess valuable knowledge on climate and the weather, and they employ different adaptation measures borne out of their local ecological knowledge, an area that is gaining attention with time (Yaro, 2013). Farmers in Africa are reported to have a good knowledge of the climate and have clear opinions on the variabilities in rainfall and, changes in wind patterns and temperature (Yaro, 2013). A study by Gyampoh et al. (2011) on some local communities in Ghana reveals that these communities are well informed of changing climatic conditions around them, provide

concrete evidence to back their claims, and have knowledge of ways of adjusting to these changes to ensure sustainability.

Yaro (2013, p. 4), on small scale farmers' perceptions of climate change, also indicated that local farmers were aware of the ongoing climatic changes. These farmers defined climate change as "when the rains are too little or too much, which affects our crop yields". Farmers understand the parameters of climate change as it is closely related to their other forms of livelihood and their farming productivity. The most critical parameter is the rainfall, where farmers perceive a decline in rainfall quantities and associated variabilities with floods and droughts. They, however, predict strongly that the amount of rain will continue to reduce in the coming years (Yaro, 2013). Farmers also perceived that winds had become more destructive in recent years and even felt a rise in temperature since months that were normally expected to be cooler were still warm (Yaro, 2013). A study conducted by Boilat and Berkes (2013) on perceptions and adaptations to climate change among Indigenous people reveals varied local adaptation practices based on local ecological knowledge. These include adjustments in cultivation cycles, buffering strategies sustained in social networks, and diversification of income sources. Thus local people should not be regarded as helpless but instead active agents that are capable of developing multifaceted adaptation and coping strategies in the fight against climate change (Boilat & Berkes, 2013).

1.1.4 Agriculture and climate change policy in Ghana

The government of Ghana has adopted an environment and climate change policy since 1991. Ghana signed the United Nations Framework Convention on Climate Change (UNFCCC) in Rio de Janeiro in 1995 (Sarpong & Anyidoho, 2012). A first national

communication on the policy was announced in the year 2000. A second national communication in 2010, outlined the sources and medium for removing greenhouse gas emissions, examined the vulnerability of different sectors such as water, agriculture, industry and energy to climate change, identified strategies that will be employed for mitigation (Sarpong & Anyidoho, 2012) and the integration of effective adaption measures in all aspects of national development planning (Brakopowers, 2020). Ghana's motivation for developing a climate change policy stems from the fact that each country has a responsibility towards the global community to respond to climate change and is also driven by international climate change discussions and funding available for making policies and programming (Sarpong & Anyidoho, 2012). Until recently, the focus on climate change was centred on energy, forestry and the environment, but after 2009, agriculture and climate change discussions emerged and became a turning point on Ghana's climate change discussions (Sarpong & Anyidoho, 2012). Different frameworks support agriculture in the climate change discourse; this includes the "Ghana Goes for Green Growth: National Engagement on Climate Change" and Ghana's Shared Growth Development Agenda, highlighting the climate change impacts on agriculture (Sarpong & Anyidoho, 2012).

The National Climate Change Policy (NCCP) was formulated in the period of 2009-2012 and launched in 2014 (Echeverría et al., 2016). The policy is designed to provide an integrated response to climate change in Ghana. The content of the policy is geared toward national sustainable development (Pelicaric et al., 2008). It offers a pathway for addressing climate challenges while taking advantage of the benefits and opportunities of a green economy (Pelicaric et al., 2008). The vision of the NCCP is "to ensure a climate-resilient

and climate-compatible economy while achieving sustainable development through equitable low carbon economic growth for Ghana" (Pelicaric et al., 2008, pg ix). The objectives of the policy are to ensure effective adaptation, mitigation measures and social development. The NCCP recognizes five priority areas; Agriculture and Food Security, Disaster Preparedness and Response, Natural Resource Management, Equitable Social Development and Energy, and Industrial and Infrastructural Development (Pelicaric et al., 2008). Ghana is highly vulnerable to climate change since its impact is mostly felt in key sectors such as energy, agriculture, water, health, forestry, infrastructure, fisheries and land (Pelicaric et al., 2008). These happen to be sectors that the country is most reliant on for its economic power (Pelicaric et al., 2008).

1.2 Problem Statement

Recent evidence points to the fact that climate change will adversely affect the Africa continent more than other continents (Ndamani, 2016). The likely adverse effect of climate change on agricultural production and livelihood constitute a developmental challenge for the continent (Yaro, 2013) and threatens sustainable development, especially in drier regions (Ndamani, 2016) due to high physical and social vulnerability (Yaro, 2013). It imposes a high level of uncertainty on farmers whose livelihoods depend on the weather and climate (Aubert et al., 2012). The impact of climate change on agriculture cannot be underestimated since agriculture is the largest employer of the Ghana workforce (Ndamani, 2016). Agriculture offers employment to about 45% of the country's workforce, supplies 70% of the country's food needs, and contributes 21% to GDP (Ministry of Foreign Affairs, 2018). Climate change impacts theeconomic, environmental, and social systems and

tampers with prospects for food, health, and water security (Yaro, 2013). Climate change threatens agriculture and food security as a result of losses in food production through diseases and failure in crop production, and loss of livestock (Abubakari & Abubakari, 2015). In Ghana, climate change is expected to reduce food security significantly, aggravate water stress, displace numerous people due to floods associated with sea-level rise, potentially aggravate the transmission of vector-borne diseases and increase the negative impact from extreme weather events (Yaro, 2013).

Warming and drying increase stress in crops, affects available water for irrigation processes, causes a reduction in soil fertility as a result of oxidation; and increases the incidence of pest infestations, diseases, and weeds, leading to a decrease in crop yield (Issahaku & Maharjan, 2014). Heavy rains and associated floods cause damage to crops and pose several challenges to harvesting, transportation, and storage of agricultural produce (Ibn Musah et al., 2018). Generally, climate change variabilities affect crops differently (Issahaku & Maharjan, 2014), a low temperature has a positive influence on the growth of cassava but negatively affects yam and sorghum; increased rainfall works well for cassava and maize but is a negative factor for sorghum (Issahaku & Maharajan, 2014).

According to Amoah, a climate negotiator, in Ghana "climate change is said to decrease the yields of maize and other cereal crops by seven percent; therefore, there is the need to address the susceptibility of Ghana's agriculture sector and increase the resilience of agrarian communities to climate change by developing and implementing coordinated adaptation policies" (Lydia, 2019). The need to adjust to climate change is a high priority in the country as more drastic scenarios predict a rise in temperature by 4 degrees Celsius

by 2100 (Solomon, 2017). Farming households in Ghana are engaging different off and on-farming strategies to adapt to the variabilities of climate change and its impact on their livelihoods (Antwi-Agyei et al., 2014). Local knowledge can form the basis of climate change adaptation among smallholder farmers; however, it is mostly treated as secondary in climate change adaptation debates (Makate, 2019). An effective adaptation strategy is dependent on the perceptions and knowledge of farmers and the capability of policymakers to combine these with scientific knowledge systems (Yaro, 2013).

Smallholder farmers in developing countries are the worst affected by the adverse effect of climate change (Ndamani, 2016). Therefore, knowledge and perceptions of these smallholder groups are crucial in preparing farmers for the extreme weather conditions ahead (Ndamani, 2016). Agricultural policies and decisions should take into consideration experiences and empirical data from the local level to effectively address the challenges of climate change (Ndamani, 2016). The study will therefore seek to understand the knowledge and perceptions of these smallholder crop farmers and how best their views will be used to inform effective adaptation strategies.

1.3 Research objectives

The objectives of the study are to:

- Understand small-scale farmers' knowledge and perceptions of climate change and factors that influence these perceptions
- Understand the role of local ecological knowledge in climate change adaptation by small-scale farmers in Ghana.

- Understand the barriers to climate change adaptation by small scale farmers.

1.4 Research questions

- What are small scale farmers' perceptions on climate change and what factors influence these perceptions?
- How are small-scale farmers adapting to climate change?
- What is the role of local ecological knowledge in climate change adaptation by small scale farmers?
- What are the barriers to adaptation?

1.5 Justification of the study

Rain fed agriculture is an important livelihood source for many people in Ghana (Limantol et al., 2016). However, the agriculture sector is faced with challenges such as socio-cultural factors, inadequate basic infrastructure, negative consequences of climate change such as droughts and floods and challenges related to agricultural services (Limantol et al., 2016). Therefore, it is important to understand climate change from the farmers' perspective for building successful strategies to combat the sector's challenges. Firstly, there exist practical and conceptual differences in the way farmers perceive climate change; thus, understanding farmers perceptions of climate change and learning about their knowledge on climate change is crucial in designing initiatives and strategies targeted at improving environmental performance in agricultural activities (Hyland et al., 2016). Secondly, the perceptions farmers have regarding the changing climate impact their decisions to engage in activities that reduce greenhouse gas emissions and their voluntary participation in adaptation

strategies in the course of their agricultural activities (Hyland et al., 2016). Thus learning and building on their adaptation strategies is important since the extent to which small scale farmers will feel the adverse effect of climate change is primarily dependent on the kind of adaptation strategy adopted in response to the impact (Limantol et al., 2016).

Thirdly, the study identifies the understanding and importance of local ecological knowledge and its role in adaptation among small-scale farmers. There are projections that climate change is going to worsen in the future; owing to this, it is important to learn the views of farmers regarding the subject matter and create the opportunity for farmers to learn from each other in identifying sustainable and effective adaptation measures that will help in building their resilience in the future (Limantol et al., 2016). Furthermore, understanding their perceptions of causes, impacts, and responses will generate insights into building community resilience programs (Kupikal et al., 2019). However, the development and implementation of climate change policies require incorporating local ecological knowledge, farmers perceptions, and the level of risks they are exposed to (Sraku-Lartey et al., 2020). Furthermore, it will also guide policymakers, stakeholders and development agencies to design context-specific strategies and climate risk management initiatives (Damodar & Nibal, 2020).

1.6 Limitations of the study

The initial research plan was to conduct interviews among small-scale farmers in the study area; however, COVID-19 restrictions made this plan impossible. Moreover, targeted respondents were predominantly not Internet users; thus, recruitment of respondents was expected to be a substantial barrier, particularly without being able to recruit the

participants in person. I therefore made use of existing data from the Afrobarometer survey, which included questions on climate change, though this dataset set lacks distinctions among different kinds of agricultural workers. Both small scale and commercial farmers were all placed in the same category. Thus, there is a challenge in categorising the study results as representative of small-scale farmers. Also, the initial plan was to address all the research questions using a survey, but due to the challenge, the Afrobarometer survey could only help in addressing the first research objective which is the perceptions on climate change.

Organisation of thesis

The thesis is organised into five chapters. Chapter one provides an introduction and the background to the study, the problem statement, research questions and objectives, the justification of the study and the study limitations.

The second chapter of the thesis is the literature review that discusses relevant literature to the study matter and how the theory of planned behaviour helps understand motivations for adaptation. The chapter also contains a review on Nigeria on how it compares to Ghana on small-scale farming and adaptation.

Chapter three discusses the methodology for the study, which is mainly a review of existing documents and quantitative analysis of the afrobarometer survey.

Chapter four is the analysis and discussion section, whereas chapter five provides a conclusion, policy recommendations and a summary table for the research findings.

In all, the thesis represents small-scale farmers adaptation to climate change and highlights the role of local ecological knowledge in adaptation and choice of adaptation

Chapter 2

2.0 Literature review and theoretical perspective

This section reviews the existing literature locally and globally in climate change perceptions, climate change adaptation and local ecological knowledge. The literature used are from 1991 to 2021. The first section of the literature review is a review on farmers' knowledge and perceptions of climate change which is necessary in understanding the first research objective. In the section, how small-scale farmers understand climate change and what they know is assessed, as well as the determinants for all their knowledge on the climate change information they possess.

The second section is on small-scale farmers adaptation towards climate change which addresses the second objective of the study. This section discusses the different forms of adaptation and all the techniques employed by the farmers in adapting to the changes in the climate and how these methods have proven successful over time. Further discussion on what influences the decision to adapt to climate change is presented in the section.

The third section provides a review on local ecological knowledge which addresses the third objective of the study which is the role of local ecological knowledge in climate change adaptation. This section emphasises the importance of local ecological knowledge, how it impacts on successful adaptation and its relevance to policy.

The fourth section discusses the barriers to climate change adaptation by small-scale farmers and possible policy interventions. This section is necessary in addressing the third study objective.

The fifth section presents a review of Nigeria which is another country in the West African region with a large number of small-scale farmers. Although Nigeria is larger than Ghana in size, they have similar agricultural characteristics, specifically a larger part of their farmers being small scale farmers. This will show how Ghana compares to Nigeria. The chapter further reviews the theory of planned behavior and its role in building climate change perceptions.

2.1 Farmers' knowledge and perceptions of climate change

Public opinions and perceptions of climate change and the risks of climate change are gaining momentum in shaping environmental policy and defining management systems (Brody et al., 2008). Climate change has occurred in the past and continues to evolve; thus, there is the need to know and understand how farmers perceive and adapt to climate change (Deressa et al., 2011). Farmers develop perceptions about climate change and biophysical factors through continuous interactions with the physical environment (Nguyen et al., 2016). Understanding climate change perceptions of farmers is very important in dealing with climate change's negative impact (Acquah et al., 2019). It guides decision making in agricultural planning (Damodar & Nibal, 2020) and gives clarity to adjustments that might be done or will be done in dealing with climate change consequences (Tambo & Abdoulaye, 2013). Understanding local farmers' perceptions of climate change yields insights relevant to policy and dealing with sustainable agriculture challenges (Asrat & Simane, 2018).

As the world continues to face the realities of climate change, there have been increasing concerns among farmers about sustainable agricultural practices and adaptation measures

(Nguyen et al., 2016). The way farmers perceive climate change impacts the choice of adaption measures and influences their willingness to pay for any activity meant to mitigate against climate change (Acquah et al., 2019). Farmers are challenged with uncertainties about decisions regarding sustainable practices. They go through different adjustments in adapting to an uncertain future in the context of climate change; thus, these uncertainties influence farmers' perceptions of their farming activities as clouded with unpredictabilities, and impacting their income (Nguyen et al., 2016).

Some studies share the view that Africans have a poor understanding of climate change perception (Acquah et al., 2019). Farmers make farming decisions according to how they perceive the environment, and this is likely to result in mal-adaptations due to cognition errors, biased perceptions and unavailability of information (Nguyen et al., 2016).

Perceiving is a cognitive process by which humans learn and interpret their sensory impressions based on their knowledge, historical background, attitudes, and experience to provide meaning to their environment and act consequently (Robbins & Judge, 2012). Perceptions of climate change are guided by four elements as described by Damodar & Nobal (2020); these elements are memory, expectations, definition and experience. Experience is borne out of occurrences and events in the career of the farmer; memory describes farmers recall of the risks associated with climate change; expectations are associated with the future happenings and the risks associated with climate change; and is the basic description of climate change- the duration of changes in climate patterns and the intensity of changes in the climate change indicators (Damodar & Nibal, 2020).

According to Damodar & Nibal (2020), humans build their perception about the environment depending on the environmental characteristics. As climate change continues to manifest itself globally, people experience the changes locally based on the detectable evidence (Habtemariam et al., 2016). People build perceptions of the environment based on the environment's immediate characteristics and respond to it as such (Damodar & Nibal, 2020). People perceive climate change differently due to varying access to climate change information; moreover, there is a failure to perceive climate change in the absence of information. Also, individual differences in cognitive processes have an impact on how persons perceive climate change. Regarding cognitive differences, some may be unable to analyze the available climate change information (Habtemariam et al., 2016). Individuals experience climate change in some instances differently because climate change is variable across time and space, such as the beginning of the growing season, the length of the growing season and shifts observed in species distribution (Akerlof et al., 2013). Furthermore, climate change's political, cultural, economic, and environmental implications are not uniform; thus, individuals are likely to perceive climate change differently (Habtemariam et al., 2016). Likewise, perceptions on climate change vary depending on geographical variations (Habtemariam et al., 2016).

Several factors influence farmers' perceptions of climate change (Acquah et al., 2019). The varying perceptions across different human groups make it essential to understand both sources and the variability in perceptions (Habtemariam et al., 2016). These factors could be environmental (eg. soil types) or socio-economic (Deressa et al., 2011). Education, geographical sites (Deressa et al., 2011), gender, media exposure, family income, age

(Damodar & Nibal, 2020) and partisan affiliations (Liu et al., 2014) all influence perceptions.

2.1.1 Environmental conditions that impact perceptions

Human beings act according to what they see in the world around them. For instance, the presence of irrigation waters and fertile soils will likely influence farmers not to perceive climate change impacts (Acquah et al., 2019). Eggars et al. (2015) showed that farmers who had relatively lower quality soils had more climate change awareness than farmers who worked with higher quality soils. Farmers who worked with more sandy soils were very sensitive to climate change because sandy soils have an insufficient water holding capacity and are prone to stresses associated with drought (Eggars et al., 2015).

2.1.2 Age

Farmers' perceptions of climate change are also affected by their farming experiences, borne out of the amount of time they have been engaged in farming (Deressa et al., 2011). More extended periods of attachment to places increases recognition of environmental changes. Additionally, older farmers tend to have more knowledge of local climate changes due to the long period of knowledge accumulation (Habtemariam et al., 2016, Ishay & Abaje, 2008)). On the contrary, Eggars et al. (2015) study showed that demographic characteristics such as age and education had no significant impact on farmers perception on climate change despite the impression that young and educated farmers have access to new technology and thus are well informed on the scientific discourse regarding climate change.

2.2.3 Education

There exists a two-way relationship between perception and knowledge; perceptions shape knowledge, while knowledge, in turn, influences perceptions (Nguyen et al., 2016). Farmers' awareness of climate change is built through formal and informal education (Çelik et al., 2018). Informal awareness can happen through social media debates, family, community members and friends (Çelik et al., 2018). Regarding formal education, although Eggars et al. (2015) showed that education had no significant impact on farmers perception of climate change, Maddison (2007) found the opposite and emphasized the significant impact of access to information and education. Ajibefun and Fatuase (2011) also highlighted that literate farmers have a more scientifically accurate view of climate change and can access the needed climate change information. Educational activities, engagement by extension officers and access to extension offices, and experiences can influence farmers to perceive climate change impacts (Acquah et al., 2019). Agricultural extension officers who work for the government act as main information dissemination tools in many rural farming communities; their activities impact farmers' perception of climate change (Adesina et al., 2000).

2.2.4 Media

The media plays a role in building awareness and informing perceptions of climate change. The availability and accessibility of information determine the extent of farmers' knowledge, understanding and awareness of climate change (Ado et al., 2019). People form their judgement of the changing global phenomena based on information obtained from social media and climate experts (Habtemariam et al., 2016). Access to weather information

plays an important role in building perceptions of climate change too (Ochenje et al., 2016). The mass media tells farmers of climate change and sheds light on the negative impact of climate change (Deressa et al., 2011). Radio as a media source plays an important role in the dissemination of climate information, and this media channel is predominant among rural farming communities (Ochenje et al., 2016).

2.2.5 Gender

Gender is an important demographic factor that serves as an explanatory variable concerning environmental, concerns and climate change perceptions (Liu et al., 2014). There are various arguments about gender dynamics on climate change perceptions. One argument is that women concentrate on environmental issues that directly affect their families and communities (Habtemariam et al., 2016). These environmental issues are threats to the health and safety of families and the community at large (Liu et al., 2014). At the same time, men may be more focused on the scientific aspects of the environment (Habtemariam et al., 2016). However, Liu et al. (2014) study on farmers and ranchers showed that female partners' knowledge of climate change was more scientifically accurate than their male counterparts. As well, the females perceived that climate change poses a higher risk. The differences in scientific knowledge of climate change by gender do not determine the difference in environmental concern between males and females (Davidson & Freudenburg, 1996).

2.3 Climate change adaptation to climate change by small-scale farmers

Climate change is projected to continue through the next century at an unprecedented rate (Adger et al., 2003). Although the risks associated with climate change are enormous, the

precise degree of those risks remain incredibly uncertain (Adger et al., 2003). Adaptation is defined by Pettengell (2010, pg. 7) as "actions that people and institutions make in anticipation of, or response to, a changing climate; this includes changes to the things they do, and/or the way they do them". Dolan et al. (2001, p. 4) also define adaptation as "responses by individuals, groups and governments to actual or expected climatic stimuli or their effects to reduce vulnerability to adverse impacts or damage potential, or to realize opportunities associated with climate change". Agriculture is susceptible to climate change (Dolan et al., 2001). Adaptation in agriculture is necessary to control the impending risks associated with climate changes in the future (Howden et al., 2007). Issues of adaptation and mitigation are critical concerns in developing countries due to inadequate technology, knowledge, skills (Mugiya & Hofisi, 2017) and capacity to handle the shocks associated with climate change (Sanga et al., 2013). Besides, developing countries are expected to experience higher evaporation levels due to the already existing higher temperatures accompanied by the unlikelihood of an increase in precipitation which will aggravate the physical impact of climate change (Mertz et al., 2009). Through adaptation, farmers can preserve their livelihood security, food and income, despite the changing climatic conditions, including extreme weather conditions such as floods and droughts (Sanga et al., 2013). The concept of adaptation is broad and can be put into categories based on the motive for adaptation, who or what adapts and the timing of adaptation and other factors (Tol et al., 2008).

Adaptation can be categorized as either planned or autonomous in terms of outside interventions and preparation level and reactive or anticipatory in timing (Tol et al., 2008).

The FAO also identifies two main approaches to adaptation; planned adaptation and autonomous adaptation. Autonomous adaptation describes the spontaneous activities a farmer may adopt, such as changing planting dates and practising crop diversification as a response to changing precipitation patterns (FAO, 2014). Planned adaptation is more policy inclined; they are also strategies designed to facilitate specific adaptation practices or change the agricultural system (FAO, 2014). Planned adaptation is mostly strategies designed by the government (Dolan et al., 2001). Government adaptations are designed to enhance the adaptation capacity of the agriculture system. These adaptation strategies include adopting technology through crop development, offering assistance with crop diversification, early warning systems, providing financial support, encouraging water and land use options, and providing compensation to farmers suffering from climate change's adverse effects (Dolan et al., 2001). Additionally, anticipatory adaptations are measures taken before experiencing climate change impacts, whereas reactive adaptations are undertaken after experiencing the changing climatic conditions' effects (Dolan et al., 2001).

Adaptation to climate change can happen either by strengthening existing systems to reduce susceptibility to challenges associated with unusual events or through reducing dependency on vulnerable systems (Adger et al., 2003), for example, through diversification of food production away from drought-prone crops and refraining from building and setting up infrastructure in high impact-prone areas (Adger et al., 2003). Climate change adaptation is important in different ecosystems such as forests, coastal and marine ecosystems, agro-ecosystems, inland waters and woodland (FAO, 2014). Despite the high vulnerability of

agriculture to climate change, it still has the coping and adaptation capacity to manage the changing environmental conditions (Dolan et al., 2001).

Climate change adaptation at the farm level usually undergoes two stages; it starts with the farmer perceiving that the climate is changing, followed by the decision as to whether to adapt or not and the kind of adaptation measure they want to employ (Tessema et al., 2013). Farmers devise adaptation measures based on their perceived climate changes (Çelik et al., 2018). In adapting to the impacts of climate change, a good number of options are available to farmers. These options include, crop diversification, altering operations timing, approving conservation tillage practices, investment from public agencies, developing new plant varieties, and revising agricultural support programs (Dolan et al., 2001). Despite the prevailing challenges, several opportunities exist to help address climate change for small-scale agriculture (Phoebe et al., 2018).

Small-scale farmers may reduce the damaging effects of climate change by employing efficient measures to tackle the challenges associated with climate change (Sanga et al., 2013). Farmers have survived coping with climate change effects in different ways, although they are noted to have low adaptation capacity (Sanga et al., 2013). Adaptation choices of farmers are dependent on local conditions, the type of farming being practised (Dolan et al., 2001), the gender of the small-scale farmer (Assan et al., 2018), demographic and socio-economic factors, belief in the reality of climate change, access to resources, psychological factors, information and knowledge, and economic factors (Dang et al., 2019). Dang et al. (2019) put factors that influence adaptation into five main categories:

demographic and socio-economic factors, resources services and technology, institutional and political factors; social and cultural factors; and cognitive and psychological factors.

Climate change adaptation is a complex process; thus, it is necessary to include socio-economic and demographic characteristics as predictors of adaptation (Dang et al., 2019). The literature on adaptation shows that vulnerabilities to climate change are to an extent influenced by responsibilities, gender, caste, entitlement related to social status and class (Carr & Thompson, 2014). "Climate Change and Gender" (n.d.) expresses that out of the 1.4 billion poor population found in the developing countries, the majority are women; the majority of these women are mostly low income earners, have inadequate control of resources and are not given the necessary opportunity to become decision makers. All these characterictics have the tendency to make the women more vulnerable. The differences in climate vulnerabilities across gender are reason enough to suggest that adaptation is also impacted by gender (Adzawla et al., 2019). For example, women often face setbacks in accessing resources and making decisions that impact their livelihood, such as land ownership or tenure(Adzawla et al., 2019). Men and women also respond to climate change differently due to social processes such as inheritance rules, insufficient support from financial institutions, and prevailing land tenure systems (Wrigley-Asante et al., 2019). Women involved in agriculture may develop adaptation measures and locally efficient techniques to survive climate change (Carr & Thompson, 2014). Men may be more likely to take risks and adopt new technologies for their farming activities, while women may be more traditional; they prefer to stick to adaptation measures that they perceive safe and more comfortable (Dang et al., 2019). The socio-cultural differences and resources

available to males and females impact on the choice of crops grown for adaptation (Carr & Thompson, 2014). However, Dang et al. (2019) conclude that either sex being proactive regarding climate change adaptation techniques is instead contextual because some scholars also posit that females are also more likely to adopt techniques for climate adaptation due to their intensive and active involvement in some farm regions. Although the vast literature supports the level of vulnerability to climate change amongst women, there are varied opinions on how gender relates to adaptation.

Farm household size influences the type of adaptation practised and even the willingness to incorporate adaptation strategies into farming practices (Dang et al., 2019). Large-size farm household are more willing to adapt to climate change than smaller farm household (Ndamani & Watanabe, 2016). Large-size families have been associated with income diversification and increased crop production to meet their higher demand for food resources, which increases their willingness to adapt to ensure continued production of food to meet the family needs on food and income (Oyekale & Oladele, 2012). Farm household size has also been associated with labour endowment, consistent with the Atube et al. (2021) study on determinants of smallholder farmers adaptation to climate change. It has been argued that large-size farm household have the required labour size to enable technology adoption (Tessema et al., 2013). Age as a demographic characteristic not only impacts climate change awareness and perceptions; it also affects adaptation. Age influences adaptation in two different ways (Dang et al., 2019). The age of the head of the farm household either impacts the choice of adaptation positively or negatively (Belay et al., 2017). Farmers in the more senior age category have more experience at farming and

are more likely to adopt certain strategies to adapt to climate change (Dang et al., 2019). Older farmers have a higher level of farm experience and have more exposure to unproductive and unreliable crop varieties. They can more often determine the resistance of crops to climate change than farmers with less experience (Mabe et al., 2014). However, age may negatively impact adaptation since some older age groups are more reluctant to adopt technology innovation (Dang et al., 2019). Mabe et al. (2014) also argue that younger farmers are more likely to adapt to climate change than older farmers. Younger farmers are able to take more risks, energetic and innovative. They are more likely to try new technology and try different crop varieties that can withstand the changing climate's challenges (Mabe et al., 2014).

Farm income also influences the type of adaptation by the farmers (Mabe et al., 2014). Wealthy farmers are financially capable of adopting new technologies and are less hesitant in putting them to use (Tessema et al., 2013). Farmers who earn a significant amount of revenue from their farm activities are also more likely to change their crop varieties to adapt to climate change (Mabe et al., 2014). Furthermore, the more wealth a farmer has, the more likely they are to access information, extension services and credit facilities (Tessema et al., 2013). Farmers with higher annual income are also more likely to be able to afford fertilizers, pesticides and resistant crops than farmers with a lower annual income (Atube et al., 2021). A study by Belay et al. (2017) on smallholder farmers adaptation to climate change showed a positive relationship between the size of a farm and the farmer's choice of adaptation. Farmers with larger farm sizes are more likely to adapt to climate change, and the opportunity for diversification is more feasible due to their farm sizes. It gives the

farmer the space to plant fodder plants and the option to include livestock rearing to distribute the risks associated with the weather's unpredictabilities (Belay et al., 2017). This is also consistent with the study of Atube et al. (2021) which also showed that farmers with larger-size farm planted different crop varieties and more drought-resistant crops

Educational background plays a role in adopting new technologies in the adaptation process (Dang et al., 2019). Education positively impacts adaptation by small-scale farmers, increasing the willingness to come up with different measures to adapt to climate change (Belay et al., 2017). A study by Ndamani & Watanabe (2016) on the influence of socio-economic factors on climate change adaptation by farmers in some communities of the Lawra district in Ghana showed education to be significantly related to farmers' decision to adapt to climate change. Education influences adaptation positively by informing the farmers of existing and appropriate adaptation technologies and increases their chances of undertaking certain measures such as soil conservation and adjusting planting dates to suit the changing climatic conditions (Dang et al., 2019). Farmers with higher levels of education are more likely to employ advanced measures in adaptation due to their higher knowledge levels and exposure to information regarding climate change and adaptation (Ndamani & Watanabe, 2016). Access to extension services also grants small-scale farmers exposure to different adaptation options (Belay et al., 2017). A study by Atube et al. (2021) on adaptation determinants also showed that small-scale farmers who had access to extension services planted more drought-resistant crops and trees to adapt to climate change. Kom et al. (2020) found that higher education exposes farmers to improved

farming methods and their associated benefits and also motivates farmers to acquire information regarding climate change and variability.

The availability of and access to technology, resources and extension services significantly impacted the decision to adapt to climate change by small-scale farmers (Dang et al., 2019). Access to extension services has been proven to influence farmers' decision to adapt and the choice of various adaptation strategies (Dang et al., 2019). Access to credit facilities enables farmers to undertake adaptation practices such as irrigation facilities, changing planting dates and soil conservation (Dang et al., 2019). Lack of technological access is a significant barrier to adaptation; thus, the availability of technology improves farmers' adaptation process (Dang et al., 2019). Technology is a major driver of increased agriculture productivity among the existing agricultural practices (Clements et al., 2011). Technological adavances in crop varieties, water management and irrigation technologies and production inputs (eg. herbicides, pesticides, fertilizers) (Lybbert & Sumner, 2010) reduce the risks of exposure to climate change and helps develop improved crop species and labour enhancement devices (Clements et al., 2011).

Once adaptation measures are effective, they reduce the extent to which farmers are impacted and enables them to withstand all sorts of impediments associated with climate change (Masud et al., 2017). There is a need to understand these farmers' adaptation measures to enhance adaptation incentives' development (Sanga et al., 2013). There is also the need to support the small scale farmers' adaptation measures through efficient public policy, collective actions, and investment to increase the adoption of appropriate adaptation measures (Sanga et al., 2013). As we continue to build measures to adapt to climate change,

there is a need for civil society, national government, and the international community to address the barriers that face and limit adaptation (Tol et al., 2008).

Small-scale farmers require pertinent and new information to adapt to climate change efficiently (Abass et al., 2018). The role of formal and informal institutions in providing climate change adaptation information to small-scale farmers is gradually gaining prominence (Abass et al., 2018). Despite the locational differences in adaptation strategies, institutional support is necessary for effective adaptation strategies (Abass et al., 2018). There is a high tendency for adaptation strategies to fail under circumstances where governmental and institutional support is lacking (Abass et al., 2018). Lacking institutional support for climate change adaptation is evident in a study by Owusu et al. (2017); the adaptation strategies outlined in the national climate change policy of Ghana had not trickled down to some local communities. Thus, sensitization of farmers regarding adapting to the changing climate has proven to be inadequate in the country (Owusu et al., 2017). However, for some parts of the country, the situation is quite different. Representatives of formal institutions such as the Savannah Agricultural Institute, the Ministry of Food and Agriculture, the Environmental Protection Agency, and theMinistry of Environment, Science, Technology and Innovation (MESTI) in the Upper West Region work closely with farmers regarding adaptation guidelines (Abass et al., 2018). These institutions offered knowledge and technical supports such as tree planting, information on changing planting dates, income and crop diversification, investment in soil conservation and adaptation of varieties of the same crops (Abass et al., 2018). The extension officers in the region communicated to the farmers on the various strategies and weather information through

radio, contact persons or the chiefs (Abass et al., 2018). Non-governmental agencies also play a role in transferring knowledge and information among the local farmers in the region (Abass et al., 2018).

2.4 The concept of local ecological knowledge

The concept of local ecological knowledge (LEK) has been used to describe all forms of local knowledge, indigenous ecological knowledge, and traditional ecological knowledge (Cook et al., 2014). The concept of local ecological knowledge as defined by Berkes et al. (1999) and noted in the work of Ruddle and Davis (2013, p.84), is a "shared system of knowledge or another expression about the environment and ecosystem relationships, developed through direct experience within a specific physical setting, and transmitted between or among generations." Berkes (1993) described traditional ecological knowledge (TEK) as "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment". Local ecological knowledge emphasizes practical skills, incorporating scientific and relevant technical knowledge when it is available (Cook et al., 2014). "Until recently, traditional ecological knowledge was largely perceived as a vestige of the past that held – at best – folkloric interest and was bound to disappear with economic development. Yet, recent research from developed and developing countries has found that substantial pockets of TEK persist in many rural and urban areas that have been subject to modernization processes" (Gómez-Baggethun et al., 2013, p. 2).

Communities have maintained a close link with ecosystem dynamics throughout history and gathered knowledge, institutions, and practices to adapt to recurring disturbances in nature to secure their livelihood (Gómez-Baggethun et al., 2013). All forms of ecological knowledge are believed borne out of the experience (Cook et al., 2014). Traditional ecological knowledge co-evolved with social and ecological systems and can strengthen the capacity of human societies to accommodate disturbances and maintain ecosystem services (Gómez-Baggethun et al., 2013).

Local ecological knowledge comes off as cost-effective ecological data, very useful in making environmental decisions, offering information about the presence of species and population trends (Cook et al., 2014), and helping to understand ecosystems and ecological processes (Vinyeta & Lynn, 2013). Since the early 1990s, the concept of local ecological knowledge has been valued by researchers in the wake of acknowledging the Indigenous right to incorporating local ecological knowledge into conservation and development processes (Aswani et al., 2018).

In recent years, there have been arguments around scientific knowledge not being enough in dealing with the climate change crisis; this has increased awareness of traditional, local and indigenous knowledge on climate change and adaptation strategies (Ansah & Siaw, 2017). Traditional ecological knowledge has gained growing attention for its contribution towards building resilience in social-ecological systems in the context of accelerated global change and generalized decline in ecosystem service (Gómez-Baggethun et al., 2013). Appreciating specific susceptibilities, adaptive capacities, and concerns about climate change held by local people can produce insights to climate-induced changes and support

large-scale scientific research characterized by local precision (Ansah & Siaw, 2017). There is the potential for local ecological knowledge to play a pivotal role in climate change adaptation and assessment efforts in bridging the gap between the environmental system and humans (Vinyeta & Lynn, 2013). Local ecological knowledge also makes a tremendous contribution to ongoing broader climate discussions at the international, national, and regional levels (Vinyeta & Lynn, 2013).

Local ecological knowledge is needed in planning, understanding impacts, and adapting toclimate change by the government, communities, and academics as they build their understanding of climate change (Vinyeta & Lynn, 2013). Discovery of changes in the environment, the building of strategies to adapt to the changes, and putting in place of sustainable land-management activities are all items of climate action that can be informed by traditional ecological knowledge (Parrotta & Angolette, 2012). Researchers have started identifying ways in which science and local ecological knowledge can collaborate in research related to climate change (Vinyeta & Lynn, 2013). Indigenous people come up with creative ideas in reacting to and interpreting climate change; they draw on technology and traditional ecological knowledge, which helps cope with ongoing challenges (Salick & Ross, 2009).Traditional measures for adaptation to climate change have been put into two categories by Berkes (2008): 1) short term responses to environmental changes and 2) adaptative responses and cultural practices to the broader environment.

The perception of local ecological knowledge is gradually changing from being existent in an essential and static form to being seen as dynamic, hybrid and proficient in adapting to prevailing socio-economic and ecological conditions (Gómez-Baggethun et al., 2013). New

standpoints on the adaptive nature of local ecological knowledge have fostered an increased awareness of the value of this form of knowledge in environmental policy (Gómez-Baggethun et al., 2013). Yaro (2013, p. 1) also argues that "local knowledge and perceptions of weather and climate should not merely be acknowledged by policymakers, but should form the foundation of agricultural policies in a bottom-up approach". The Convention in Biological Diversity and the United Nations' Declaration on the Rights of Indigenous People encourage national governments to distinguish and protect local ecological knowledge for sustainable use and conservation of biological diversity and also promote its application in resource application (Gómez-Baggethun et al., 2013).

Local ecological knowledge has gained prominence among developing countries and international communities (Codjoe et al., 2014). Farmers have a reputation for responding to climate changes and the associated unpredictabilities for a long time (Owusu Ansah & Pokuah Siaw, 2017). Indigenous communities are socially and culturally distinctive compared to the mainstream societies; thus, policies and decisions intended for the larger population, although intended for a good purpose may prove insufficient for these communities (Owusu Ansah & Pokuah Siaw, 2017). Local ecological knowledge enables farmers to handle the challenges associated with the current variabilities in the climate and prepare them to cope with future challenges (Owusu Ansah & Pokuah Siaw, 2017). In the rural communities, the community dwellers analyse the changes in the environment by observing changes in the physical characteristics of trees, changes in the weather phenomena and how certain animal species behave (Owusu Ansah & Pokuah Siaw, 2017).

A focus on local knowledge thus clarifies the actual impact of the climate, guides policy direction while reflecting the actual concerns of the local people, and broadens the understanding around the various factors underlying the different livelihood adaptation measures (Yaro, 2013). Also, understanding the local perspective is key in the design of supportive adaptative and mitigative measures (Zampaligré, Dossa & Schlecht, 2014). Yaro (2013) argues that perceptions of local ecological knowledge and perceptions of weather and climate should form the basis of agricultural policies as a bottom-up approach and not merely acknowledged by policymakers. There is a gap in research concerning the effectiveness of these local adaptive strategies employed by local people.

2.5 Barriers to climate change adaptation

Climate change adaptation is often spoken about during international climate change debates. The focus is on how developing countries and the poorest countries grow their adaptive capacities for the impact of climate change (Neff, 2018). Adapting to the impacts of climate change is fraught with many challenges. Understanding the barriers to climate change adaptation is fundamental to developing strategies in handling these challenges and also provides a measure to evaluate policies and standards put in place to tackle existing challenges (Biesbroek et al., 2013), as well as reduce the adverse impacts of climate change on the national economies (Masud et al., 2017). Several questions have been raised regarding countries' adaptation capacities to climate change and the likely constraints in the adaptation process (Biesbroek et al., 2013). The IPCC (2007) defines adaptation barriers as "conditions or factors that render adaptation ineffective as a response to climate change and are largely insurmountable". Many factors hinder farmers' bid to cope with climate

changes (Masud et al., 2017). These factors include lack of institutional capacity, insufficient technology know-how, inadequate funding and insufficient knowledge on issues related to climate change (Masud et al., 2017).

Neff (2018) categorized the barriers to adaptation into three distinct but inter-related groupings: natural, human/ informational, and social. The natural factor comprises physical and ecological components or natural elements that impede adaptation, such as ecosystem thresholds and geological limitations (Neff, 2018). Understanding the natural factors limiting adaptation provides the opportunity for investigation through physical modelling- for instance, agriculture under the changing climate (Adger et al., 2009). The human and informational category contains knowledge, technology and economics components of limitations to adaptation. These factors describe uncertainties surrounding forecast modelling, inadequate financial resources to handle adaptation interventions, uncertain information, and a low level of climate change impact awareness for policymakers (Neff, 2018). Understanding the economic limitations to adaptation allows for the use of cost-benefit analysis and cost-effectiveness analysis in the wake of dealing with the limitations (Adger et al., 2009). Furthermore, the technological aspect allows the invention of structures linked to innovation analysis and technology mapping in addressing the barriers to adaptation (Adger et al., 2009). Lastly, the social category consists of institutional, cognitive and normative barriers (Neff, 2018). Neff (2018) uses a table to give examples of social barriers to adaptation.

Figure 1: Social barriers to climate change adaptation

Social barriers	Examples
Cognitive	• Belief that uncertainty is too great to warrant taking adaptation action now • Lack of acceptance of risks associated with implementing adaptation action • Change not yet seen as a problem: temptation to wait for the impact then react
Normative	• Cultural norms that discourage change and innovation: an unwillingness to adopt new practices • Traditional means of reacting to climate stress and shock may no longer be appropriate given that there is no cultural memory when it comes to future climate change • Restrictive traditional and religious norms (i.e. reliance on traditional means of weather forecasting and planting, restricted role of women in the household/community, dependence on traditional means of coping with climate hazard
Institutional	• Institutional inequities and social discrimination restrict access and entitlement for certain groups • Social/cultural rigidity: lack of institutional flexibility

Source: (Neff, 2018, p. 3)

Generally, challenges that create barriers to adaptation impedes the uptake of adaptation in policy, inhibit mobilizing of adaptive capacity, constrain individual engagement or action, hinder the implementation of adaptation measures, prevent the uptake of new frameworks and tools to support adaptation or lead to policy failure (Biesbroek et al., 2013). Challenges facing the agriculture industry warrant the integration of environmental, economic and social components of environmental sustainability that address the present challenges without leaving a negative impact on the future generations (Masud et al., 2017).

Farmers in developing countries are confronted with many challenges in dealing with the impact of climate change; this, in turn, exerts a lot of pressure on them (Masud et al., 2017). Small scale farmers are more negatively affected compared to large scale farmers (Morton, 2007). The high vulnerability of small-scale farmers to climate change is due to demographic, socio-economic and policy trends that inhibit their adaptive capacity

(Morton, 2007). A study by Masud et al. (2017) on barriers to adaptation by farmers in Malaysia revealed that poor information on weather conditions, high cost of farm input, inadequate credit facilities, insufficient water resources and insufficient agricultural subsidies may all hinder effective adaptation. The study goes on to describe lack of access to credit facilities, low levels of education, lack of access to agricultural extension services, low income levels, and limited access to agricultural markets. Insufficient management, legal status, and poor infrastructure are also barriers to climate change adaptation by small-scale farmers (Mugiya & Hofisi, 2017).

It is important that interventions designed to improve adaptation address the barriers to climate change adaptation, improving communities' resilience towards climate change (Neff, 2018).

2.6 Possible policy interventions for climate adaptive agiculture in Ghana

For this paper's purpose, the focus will be on the Agriculture and Food Security thematic area of the NCCP. Effective policies are a requirement for good governance that promotes both local and foreign sustainable investment opportunities (Mkunda, 2015). An effective agricultural policy will enhance food production, stabilize food security, enhance carbon sequestration, improve soil quality, protect watersheds, and improve socio-economic conditions (Pelicaric et al., 2008). The key principle of this thematic area emphasizes the importance of the agricultural sector in maintaining food security and the key role the sector plays in the sustainability of natural resources (Pelicaric et al., 2008).

One suggested Interventions to improve agriculture in Ghana is harmonizing and improving research activities in climate-smart agriculture (CSA). CSA is a technique to enhance food availability by scientifically strengthening agricultural processes (Mubeen et al., 2015). CSA "addresses the challenges of building synergies among climate change mitigation, adaptation and food security which are closely related within agriculture, and minimizing their potential negative trade-offs" (Branca et al., 2012, p. 12). Existing research on agriculture and climate change adaptation shows that climate-smart agriculture is an effective agricultural strategy that helps households deal with climate change's negative impacts (Makate et al., 2016). CSA is also a medium for achieving a green economy and attaining sustainability goals (Mubeen et al., 2015) whiles incorporating mitigation and adaptation measures (Branca et al., 2012). Several strategies exist under climate-smart agriculture to help address the challenges associated with climate change. These strategies include improved water management systems; introducing new crop varieties that can withstand salinity, drought, heat and flood; crop diversification; crop modelling; improved pest management; and effective management techniques (Mubeen et al., 2015).

CSA is being promoted and adopted in Ghana's semi-arid northern region (Alare et al., 2018). Examples of CSA agriculture activities being practiced in this region are contour ploughing, intercropping, manure application, residue management, crop rotation and minimal tillage (Alare et al., 2018). These adopted practices have been proven to improve soil fertility and boost food production, thus enhancing household food security (Alare et al., 2018). CSA is effective when the socio-economic and geographic conditions of the place of intervention are taken into consideration. Furthermore, combining CSA activities

with poverty alleviating programs increases adaptation (Alare et al., 2018). A survey among cocoa farmers in the Western and Ashanti regions of Ghana showed an increase in productivity and income among farmers who have adopted the CSA system (Akrofi-Atitianti et al., 2018).

Another possible intervention in agricultural policy is the enhancing of crop diversification as a coping strategy and boosting income generation (Pelicaric et al., 2008). Crop diversification is an aspect of CSA that deserves its own attention. Crop diversification is defined as "the practice of cultivating more than one variety of crops belonging to the same or different species in a given area in the form of rotations or intercropping" (Makate et al., 2016, p.2). Crop diversification is one of the efficient strategies small-holder farmers adopt to deal with the agricultural uncertainties (Makate et al., 2016). Crop diversification improves yield stability, soil fertility, and nutrition diversity as well as controls for pests and diseases (Makate et al., 2016). Crop diversification also contributes significantly towards Sustainable Development Goals 15 (life and land crop diversification contribute to environmental protection), 13 (climate action- crop diversification contribute to climate mitigation and adaptation), 12 (crop productivity- diversification contributes to crop productivity), goal 8 and 10 (decent work and economic growth and reduced inequalities- crop diversification provides employment opportunities and increment in incomes) (Feliciano, 2019).

A third intervention is to enhance farmers' support through the building and strengthening of extension officers capacity in climate smart-agriculture. Economies dependent on agriculture utilize extension services to educate farmers on-farm technologies, aid farmers

build their technical and managerial skills and assist with rural adult learning (Danso-Abbeam et al., 2018). Agriculture extension services have been an effective technique for addressing food security and rural poverty (Danso-Abbeam et al., 2018). A study on the impact of extension services on farm productivity in the Northern region revealed an increase in farmers' income due to an improvement of their welfare through extension services (Danso-Abbeam et al., 2018).

Another potential policy intervention is to document and encourage appropriate local ecological knowledge and best practices. The first steps in the adaptation strategy comprise understanding the processes that affected people have developed to cope with the changes (Gyampog, Benjamin & Asante, Winston, 2011). Local ecological knowledge is a variable resource people use to predict the changes of the climate and plan accordingly (Gyampog, Benjamin & Asante, Winston, 2011).

Additional interventions for climate change adaptation outlined in Ghana's climate change policy are: promotion of capacity building and building climate change awareness for farmers and fishers; capacity building for community-level collection of weather data and analysing and dissemination the information for agricultural planning; developing of livestock systems and climate-resilient cropping; promotion of diversified land use practices; adopting farming technologies to improve agricultural productivity; and the provision of sustained support in the use of water conservation and simple agronomic soil which is connected to organis farming (Pelicaric et al., 2008).

2.7 Nigeria in review

Ghana and Nigeria are both located in the West Africa region (Delitzsch et al., 2019). Nigeria has an estimated population of over 182million, and is the most populated country in Africa. The major ecological zones of Nigeria include the Guinea Savannah, the Rainforest, Mangrove Swamp Forest and Coastal zone, Sudan Savannah, Montane vegetation, Fresh Water Swamp Forest, Derived Savannah, Sahel Savannah and the Jos Plateau ecological zone(Federal Department of Forestry, 2019). The guinea savannah is very wide and found in the middle belt, it is made up of trees and grasses. The rainforest region is significant in Nigeria and includes preserved multi-tiered forest areas. The Mangrove swamp forest is mostly found along the delta and coastal areas. The sudan savannah is the most populated area in the country and a heavy producer for varying economic crops(Federal Department of Forestry, 2019). The fresh water forest forms a wide belt in the inland region with most of it converted to urban and agricultural lands (Federal Department of Forestry, 2019). The derived savannah region is greatly impacted by human activities which has led to a significant reduction in plant and vegetation species. The sahel savannah is found in the extreme Northeast and Northwest and basically const of grass, whereas the Jos plateau is characterised by the distinctive nature plateaus's vegetation (Federal Department of Forestry, 2019).

As part of Nigeria's objective of improving their economy, there is a lot of focus on agriculture and food security, energy and power, employment and wealth creation, land reform, mass transportation and security (Delitzsch et al., 2019). Similarly to Ghana (Breisinger et al., 2008), agriculture contributes significantly to Nigeria's economy

(Mgbenka et al., 2015). Agriculture in Nigeria contributes as food for the population, and contributes 33% to gross domestic product (Olusayo et al., 2019). The sector employs about 1/3 of the population and constitutes a significant part of rural livelihood (Olusayo et al., 2019). About 80% of farmers in Nigeria practice small-scale farming (Mgbenka et al., 2015), comparable to 80-90% in Ghana (Plantwise et al., 2020, Ministry of Agriculture, 2006). Small-scale farming is the backbone of agriculture and small scale farms are the biggest suppliers of foods to the inhabitants of Nigeria (Mgbenka et al., 2015). Small -scale farming increasingly known for simple farming methods: the slash and burn practice, and the use of simple farm tools and manual labour (Umeghalu et al., 2012). Ghana's small-scale farmers also use simple farming practices, the use of simple farm tools such as hoes and cutlasses as well as bush burning (Kansanga et al., 2019). However, some small-scale farmers use tractors, weedicides and other pesticides, and fertilizers in Ghana (Kansanga et al., 2019). Again, small-scale farming in Nigeria is dominated by men with about 13% of farms being headed by females (FAO, 2018).

Although small-scale farming contributes significantly to Nigeria's GDP, it is not without challenges (Mgbenka et al., 2015). A critical challenge of the sector are the climatic conditions (Mgbenka et al., 2015). These climatic conditions include unpredictable sunshine hours, irregular rainfall patterns, extreme flood and droughts events (Idowu et al., 2011), and extremely high temperature, which affects agriculture (Umeghalu et al., 2012). In addition, the sector is faced with challenges such as lack of credit facilities, which is one factor that inhibits small-scale farmers from adopting new technologies since they lack financial access and adequate information on agriculture. Although information on

agriculture is necessary in enhancing the sector's activities, it is poorly disseminated, and in most cases, farmers do not have access to information on agriculture (Mgbenka et al., 2015). Inadequate extension services to the farmers is also another challenge facing small scale farmers. Extension services are a means through which farmers obtain information, and with a ratio of only one extension worker for every 3000 farmers, the trickle-down process of peer-to-peer knowledge sharing is one of the main ways through which information is disseminated (Mgbenka et al., 2015). The challenge here is the inadequate extension programs, poorly thought out programs offered by extension officers, and the inability of some agricultural information to produce the desired attitudinal changes (Mgbenka et al., 2015). Furthermore, inefficient policies have contributed to the poor performance of the small-scale farmers in the sector (Mgbenka et al., 2015). Umeghalu et al. (2012, pg. 70) are of the view that the "Nigerian government has not been disposed to providing enabling environment for the small-scale farmers to adopt modern technologies that will boost their agricultural production."

2.7.1 The impact of climate change on small scale farming in Nigeria

About two-thirds of Nigeria's lands are susceptible to desertification and droughts (Falaki et al., 2013). Agriculture in Nigeria is typically rain-fed, thus prone to the challenges associated with climate change (Odozi, 2015). Nigeria is one of the African countries highly vulnerable to climate change (Tambo & Abdoulaye, 2013). This vulnerability is heightened due to the high population density of the country (Tambo & Abdoulaye, 2013). The population density of Nigeria is currently at 221 per km square (Amoo et al., 2020). Existing evidence shows challenges with the country's ecology can be attributed to the

changing climate (Bello et al., 2012). While the country's northern zone is threatened with desertification, the guinea savannah is experiencing a temperature rise, and the southern ecological zone is facing rainfall irregularities (Bello et al., 2012). Climate change is anticipated to exacerbate rural poverty issues since it directly affects agriculture, which is the rural population's principal livelihood (Farauta et al., 2013). The coastal zone is also facing water contamination, persistent flooding, and the transmission of water-borne diseases, contributing to the displacement of the coastal inhabitants (Bello et al., 2012). These environmental difficulties are causing some farmers to switch to non-farming activities since their livelihood is directly impacted (Bello et al., 2012). These non-farm activities include carpentry, petty trading, masonry and other non-farm economic activities (Danso-Abbeam, 2021). Nigeria has attempted to mitigate and adapt to climate change; however, the country's effort is said to be rudimentary (Farauta et al., 2013). Nigeria has low awareness of climate change (Tambo & Abdoulaye, 2013), inadequate technological resources and an insufficient institutional and legal framework to combat the prevailing negative consequences of climate change and the predicted climate changes (Falaki et al., 2013).

A study by Falaki et al. (2013) on farmers perceptions of climate change showed that a majority (71.9%) of the farmers perceive an increase in temperature, following the meteorological records. The majority of farmers also perceive recurring droughts and a latr annual onset of rainfall in the past 20 years (Ayanlade et al., 2017). The majority of farmers perceived the climate was changing and attributed the changes to human activities such as deforestation, farming, bush burning, industrialization and overgrazing of animals (Ishaya

& Abaje, 2008). These farmers believed that climate changes were a critical issue that needed urgent attention (Ishaya & Abaje, 2008). Household size, age, sex and education of the farmer household head correlated with how climate change was perceived (Falaki et al., 2013).

2.7.2 Small-scale farming adaptation to climate change in Nigeria

Various forms of adaptation have been adopted by farmers globally; these adaptations can include farm management and technological practices, diversification of farm and off-farm activities, farm financial management, knowledge management, government interventions in infrastructure, health measures, and risk reduction (Tambo & Abdoulaye, 2013). These methods are not one-size-fits-it-all. Some adaptations are peculiar to specific regions, while others are adopted globally (Tambo & Abdoulaye, 2013). Several adaptation methods are combined and used in different countries (Tambo & Abdoulaye, 2013). In Nigeria's rainforest zone, the farmers' main adaptation measures are soil conservation techniques, use of irrigation, crop diversification, planting of trees, changing planting dates, and change of tillage operations (Tambo & Abdoulaye, 2013). However, the northern part of the country uses shorter planting seasons, planting of different varieties of crops, use of drought-resistant/ early-maturing resistant crops, relocating of farms, changes in the size of land designated for crop production and sale of assets. This is because the northern region experiences more negative impacts from climate change (Tambo & Abdoulaye, 2013).. Additionally, mulching and land sheltering are used to conserve soil moisture (Ishaya & Abaje, 2008) and soil management (Otitoju & Enete, 2016). Crop farmers also use plot fragmentation and cover cropping to adapt to climate change (Otitoju & Enete, 2016)

2.7.3 Barriers to climate change adaptation by small scale farmers in Nigeria

Some constraints facing small scale farmers' adaptation to climate change are low awareness level, lack of access to improved crop varieties, lack of information, irregularities surrounding extension services, and insufficient attention by the government to challenges of climate change (Nzeadibe et al., 2011). Other barriers hindering adaptation by the farmers include limited knowledge/ information on adaptation methods, insufficient labour force, public and institutional capacity, inadequate subsidies on planting materials (Nzeadibe et al., 2011) and the exorbitant price of quality seeds (Ishaya & Abaje, 2008). Otitoju & Enete (2016) described low labour, public and institutional capacity to include inadequate government policies to encourage the farmers, lacking awareness of and insufficient access to NGOs that offer extension services by providing information on climate change adaptation. Low labour is also a result of the expensive cost of hiring farm labour and the general shortage of farm labour, which impedes adaptation (Enete, 2013). 81% of the participants involved in a study by Nzeadibe et al. (2011) on small-scale farmers' adaptation did not know of the existing climate change bill in the national assembly. This can be attributed to the inadequate public awareness measures and legislative advocacy on the bill. Information is essential in the era of climate change adaptation (Enete, 2013). Limited information poses critical challenges to farmers' coping strategies because they will be losing out on effective adaptation practices and the necessary readjustments (Enete, 2013). Neighbourhood norms, land issues and religious beliefs also act as constraints to climate change adaptation (Otitoju & Enete, 2016). More specifically, these constraints include poor access to and control of land, the land ownership system as described below, high cost of farmland, household religious beliefs as well as norms,

cultures, customs and traditional beliefs against climate change adaptation (Otitoju & Enete, 2016). In traditional communities, some farmers enjoy user rights to the land but do not have title to the land; this doesn't ensure security since the land can be taken back by the custodian of the land (Enete, 2013). The extensive religious engagement with nature also positively influences the communication of adaptation strategies to climate change (Schuman et al., 2018). However, farmers could be apprehensive in accepting certain norms and changes that are not directly synchronized with religious beliefs (Schuman et al., 2018). On the other hand, pro-environmental religious also directly impact climate change adaptation (Schuman et al., 2018). They determine the willingness to adapt to climate change and the capacity to adapt (Schuman et al., 2018). Enete (2013) has also established societal factors as constraints to climate change adaptation by the farmers. The societal factors are those limitations from the society that the farmer has no control over. This includes poverty constraints, which affect the farmers' ability to purchase farm inputs and afford the necessary farmland sizes for adaptation (Enete, 2013).

2.8 Theoretical Perspective

2.8.1 The theory of planned behavior

In 1991, Ijzen proposed the theory of planned behaviour, a derivative of reasoned action theory (Senger et al., 2017). The theory of planned behavior model is predominantly used to explain pro-environmental behaviour (Smith, 2003). It is relevant in understanding farmers behaviours and decisions and has been used by many researchers in this regard (Senger et al., 2017). The theory of reasoned behavior also expressed that individuals make rational decisions and choices by analysing the cost and benefits of available options and selecting the one that guarantees the best outcome (Smith, 2003).

There are three main determinants to explain the behaviour intention: perceived behavioural control, attitude and subjective norm (Smith, 2003) as demonstrated in figures 2 and 3. These three determinants predict the intention and subsequently predict the behaviour (Smith, 2003). The theory postulates that behaviours are best predicted when people are asked about their intent to behave in a certain way (Smith, 2003). Intentions are characterized by motivational factors which affect behaviour (Ajzen, 1991). They tell how much effort people are willing to invest in performing the desired behaviour (Ajzen, 1991). Behaviours are more likely to be expressed if the intention to engage in the said behaviour is stronger (Ajzen, 1991). Some behaviours' performance is to an extent based on prevailing non-motivational factors such as cooperation of others, money, skills and time, and availability of necessary information (Ajzen, 1991). However, the intention to perform the specific behaviour will not produce the behaviour when there are prevailing barriers or physical impossibilities to perform the action (Smith, 2003).

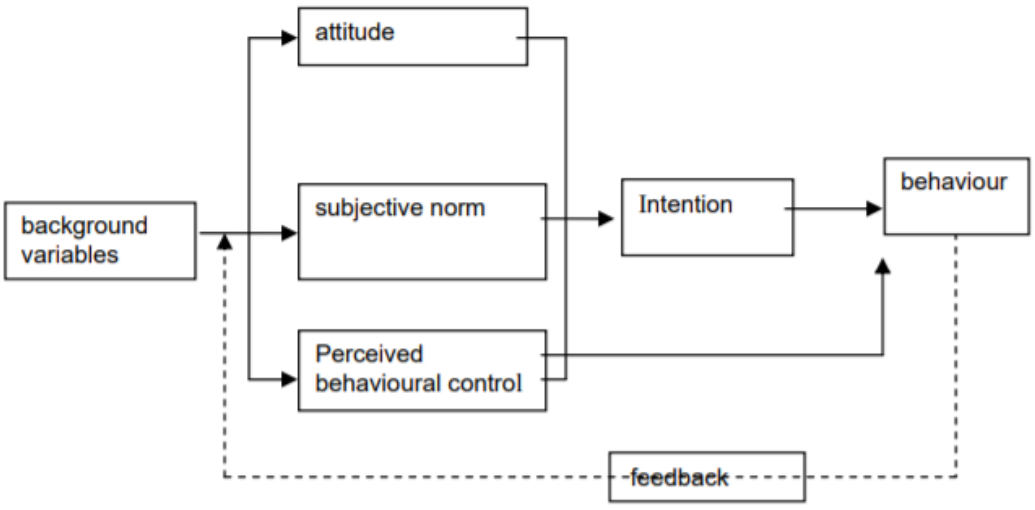
Perceived behavioural control describes the individual's perception of how easy or cumbersome to perform the behaviour of interest (Ajzen, 1991). Behavioural intention and perceived behavioural control can be used together to predict a behavioural achievement (Ajzen, 1991). Also, perceived behavioural control could substitute for actual control measure depending on the perception's accuracy (Ajzen, 1991). The amount of information available also affects the formation of perceptions (Ajzen, 1991). Perceived behavioural control in some instances may not be realistic when the individuals have inadequate information about the behaviour, when they encounter unfamiliar elements or when they observe changes in available resources (Ajzen, 1991). When these conditions exist, perceived behavioural control may not adequately predict the behaviour (Ajzen, 1991).

Attitude as a determinant of behaviour intention describes the individual's favourable or unfavourable evaluation of the behaviour in question (Ajzen, 1991). Subjective norms also refer "to the perceived social pressure to perform or not to perform the behaviour" (Ajzen, 1991, pg. 188). An individual's intention to perform a behaviour is stronger when the perceived behavioural control is strong and the subjective norms and attitude are both favourable. The three determinants (perceived behavioural control, subjective norms and attitude) of behavioural intention vary across different scenarios (Ajzen, 1991). In some instances, all of the three determinants significantly impact behavioural intention, whereas, in some cases, just one or two of them would substantially impact behavioural intention (Ajzen, 1991).

The theory also assumes that behaviour is a function of beliefs relevant to the behaviour in question (Ajzen, 1991). Thus the three determinants of the behaviour are also determined

by ensuing beliefs (Forward, 2009). These salient beliefs determine a person's intentions and actions (Ajzen, 1991). Moreover, the personal, cultural and situational factors have an impact on an individual's belief of a particular object (Tikir & Lehmann, 2011). Ajzen (1991) outlined three central beliefs; normative beliefs, which determine the subjective norms, behavioural beliefs that impact the attitude towards the behaviour, and control beliefs that form the basis of perceived behavioural control (Ajzen, 1991). The theory builds on the assumption that individual self-interest is essential in understanding humans' behaviour; rational behaviour results from cognitive deliberation and emphasizes the importance of attitude, which is an internal factor (Smith, 2003). In terms of relevance to policy intervention, policy makers should ensure that the targeted population has access to relevant information to guide decision making (Smith, 2003).

Figure 2: Theory of planned behavior model



Source: (Smith, 2003)

2.8.2 Theory of planned behaviour and climate change adaptation

In line with the TPB, farmers' decision to practice diversification, a mode of adaptation, stems from their intention (Senger et al., 2017). Consistent with the theory, studies have shown the relationship between climate change adaptation attitudes and adaptation behaviours (Mase et al., 2017). The attitude allows farmers' evaluation of the possibility of diversifying agricultural products on their farms, subjective norms allow for verification of the social pressures perceived by farmers for production diversification whiles perceived behavioural control relates to the farmer's perception on being able to use the strategy on the farm (Senger et al., 2017). A study by Mase et al. (2017) on climate change beliefs showed that perceptions of climate change, risk to farm activities, adaptation attitudes and innovation are determinants of adaptation behaviours. Farm income, agricultural experience, effective climate change adaptation communication and social capital also significantly increase farmers' willingness to adapt to climate change (Arunrat et al., 2017). However, farmers who did not perceive climate change but still exhibited adaptation behaviours were driven by social capital's impact on their beliefs (Arunrat et al., 2017). Farmers' intention to adapt to climate change is primarily driven by perceived behavioural control (Arunrat et al., 2017). Subjective norms, perceived behavioural control and attitude impact behavioural intention, which is likely to create pro-environmental behaviour (Masud et al., 2016).

2.9 Conclusion

Farmers perceptions influence climate change adaptation. There exist locational differences in perceptions of climate change due to the variability in climatic changes across space. Farmers perceptions are influenced by conditions in their environment, observations from the length of time they have engaged in farming activities, formal or informal education through extension services and their interactions with the various media platforms. The kind of adaptation techniques observed by the small-scale farmers are both autonomous and planned with regard to the possible policy interventions outlined in the NCCP. The different forms of autonomous adaptation options available to the farmer on varied factors, especially the resource the farmers have at their disposal and some existing cultural values which may favor one gender to adapt more efficiently. Furthermore, local ecological knowledge has evolved and comes in handy when farmers are deciding on the best possible adaptation option.

Chapter 3

3.0 Methodology

The chapter describes the study area and the method used to answer the research questions. The study mainly uses review of existing documents, supported by selected survey questions in the Afrobarometer questionnaire.

3.1 Study Area

Ghana is located in the West Africa region and covers 238,535 square kilometres of land. The country has a population of 30.8million, 50.7% of the population are females and 49.3% are males (Ghana Statistical Service, 2021). The country has a population density of 137 people per sq. km (The World Bank, 2020). Ghana country can be found between longitude 3.5˚W and 1.3˚E on the west coast of Africa and between latitude 4.5˚N and 11.5˚N. 42% of the total land favors agricultural activities; this is estimated to be 10 million hectares of land (Gyimah et al., 2020). There are different climatic and ecological zones in Ghana. There exist the coastal savannah which can be found in the far south of the country, the humid rainforest in the southern half of the country, and the dry and hot Sahel region can also be found in the north (Ministry of Foreign Affairs Government of Ghana, 2019). The total annual rainfall exceeds 2000 mm in the extreme southwest of the country, exceeds 750 mm in the southeastern coastal tip and is below 1100mm in the north (Ministry of Foreign Affairs Government of Ghana, 2019). The mean temperatures in Ghana ranges from 26 to 29 degrees Celsius with a daily fluctuation between 6 and 8 degrees Celsius along the coast and between 7 and 17 degrees Celsius in the North (Gyimah et al., 2020). The variations in the temperatures are greater in the northern part of the country, the highest

temperatures are experienced at the beginning of the dry season whereas the lowest temperatures are experienced at the beginning of the wet season (Ministry of Foreign Affairs Government of Ghana, 2019).

Figure 3: Map of Ghana

Source: Grid-Arendal, 2021

3.2 Method

The objectives of the study were achieved through a desk-based review of secondary sources and existing documents on smallholder farmers' knowledge, perceptions, local ecological knowledge and climate change adaptation practices. Data was also sought from Afrobarometer to help answer the study objectives. Afrobarometer is a scientific project that commits to systematic and cross-national surveys that precisely measure public attitudes in Sub-Saharan Africa using nationally representative samples (Inoguchi & Fujii, 2008).

3.3 Data collection

3.3.1 Document review

The document review method describes the data collection procedure by reviewing existing documents (Centre for Disease Control and Prevention, 2018). A literature search was completed using online sources such as the Memorial University of Newfoundland library, peer-reviewed journals and policy documents from databases such as Google Scholar, Jstor and Sage publications, news items and other relevant materials. Over 200 publications were reviewed to gather the necessary insights to answer the study objectives. Key search terms and phrases included: climate change in Ghana, perceptions of climate change, factors that affect perceptions, theory of planned behavior, small scale farming, climate change adaptation, local ecological knowledge in climate change adaptation, the role of perceptions in climate change adaptation, climate change in Nigeria, perceptions of climate change in Nigeria, perceptions of climate change by smallholder farmers in Nigeria, climate change adaptation in Nigeria, climate change policy in Ghana, agriculture policy in Ghana,

review of agriculture and climate change policy in Ghana, the relationship between theory of planned behavior and climate change adaptation in Ghana. The articles and journals obtained as a result of these keywords and phrases were examined for relevance to the research questions of this study. The snowball literature search method was used to obtain relevant publications from the references provided in selected articles and journals. A snowball literature search describes the review of references and citations of relevant research publications to identify new relevant papers (Badampudi, Wohlin & Petersen, 2015). The snowball literature search is efficient as a database search but has the potential to be more reliable (Badampudi, Wohlin & Petersen, 2015). The differences and similarities shown in the reviewed articles and journals are communicated in the results section in chapter 4. A review of articles and journals from these sources aided in understanding the concept of local ecological knowledge in climate change adaptation and exploring successes and failures related to climate change knowledge and adaptation

3.3.2 Afrobarometer

The afrobarometer survey was selected for this thesis since it had survey questions which were relevant to the thesis. Afrobarometer is a policy-relevant project that focuses on civil society issues, democracy and markets (Inoguchi & Fujii, 2008). The Afrobarometer survey is run by three core institutions: Ghana Center for Democratic Development, The Institute for Democracy in South Africa, and Michigan State University, as well as research partners from private firms, African national research partners and non-governmental organizations (Inoguchi & Fujii, 2008). The survey project measures public opinion on relevant social, political and economic issues (Bratton & Gyimah-Boadi, 2015). Study findings from the

Afrobarometer are disseminated to the general public through national and global policy discussions (Inoguchi & Fujii, 2008).

The Afrobarometer survey adopts a probability sampling method. Probability sampling gives equal opportunity for every member of the population to be included in the desired sample, while alleviating bias and granting optimum freedom (Taherdoost, 2018). Furthermore, probability sampling produces a sample that is representative of the population (Showkat & Parveen, 2017) and allows researchers to make inferences for the larger population (Nur, 2018). There were 34 countries involved in the survey, and a sample size of either 1200 or 2400, depending on the population's size (Afrobarometer Network, 2017) of adults aged 18 years and above, which is representative of the adult population (Afrobarometer, 2021). The first stage of the data collection procedure is the stratified sampling design process (Afrobarometer, 2021). Stratified sampling involves drawing random samples after dividing the population into groups; it ensures adequate representation of the population (Taherdoost, 2018). At this stage, the sample is broken down into the number of administrative regions in the country and further into urban and rural residential locations (Afrobarometer, 2021). The next stage is the clustering stage, where the sampling areas are clustered into units, enumeration areas or households. The Afrobarometer follows a multi-stage sampling design. The multi-stage sampling consists of the breakdown from a larger sample to a smaller sample; it allows the representation of samples which are concentrated in a few geographical regions (Taherdoost, 2018). The data process begins with a random selection of primary units, which results in a random selection of households and random selection of individual respondents. The gender of

respondents is alternated in each household to ensure a balance in gender (Afrobarometer, 2021)

Afrobarometer surveys are conducted through face to face interviews (Inoguchi & Fujii, 2008). Face to face interview is the oldest form of conducting survey research and offers significant advantages (Gideon, 2012), such as high-quality data (Mathers, Fox & Hunn, 1998). Face to face interviews derives its strength from direct human interaction with the respondent. It allows the researcher to see, meet, and listen to the research respondent (Gideon, 2012). Direct interaction with the respondent improves their motivation to answer research questions and cooperate (Gideon, 2012). Face to face interviewing has a high response rate since respondents are not very likely to turn down interviewers at their doorstep. Continued interaction processes in face to face interviews allow for interviews of a longer duration to be done (Gideon, 2012). Through the process of the interviewer/ researcher building rapport with the respondent, it creates a sense of trust and allows respondents to provide more honest answers to the survey questions (Gideon, 2012). Face to face interviews also allow interviewers to probe into respondents' answers that appear unclear and ambiguous; this helps generates more meaningful answers to survey questions (Gideon, 2012).

3.4 Data Analysis

Data analysis was completed using the R and R Studio software. The R software is integrated software that allows data manipulation, graphical representation and calculation of data (Harris, 2018). Both descriptive and inferential statistics used to achieve the study objectives have been included in this thesis.

Research Questions and Analysis Structure

1. **What are small scale farmers' knowledge and perceptions on climate change and what forms the basis of these perceptions?**

   Primarily, existing literature will be used to answer the research question. However, data from the Aafrobarometer will help understand the general perceptions of the need/necessity of protecting the environment amongst farmers. Question 71 in the Round 7 of the Afrobarometer survey asked for participants' views on the changing climate: "In your experience, would you say climate conditions for agricultural production in your area have gotten better, gotten worse, or stayed about the same over the last ten years or haven't you heard enough to say?" (Afrobarometer round 7 questionnaire, 2018, p. 23). Also, question 95A talks about the occupational groups which include farmers; "What is your main occupation?" (Afrobarometer round 7 questionnaire, 2018, p. 29). A cross-tabulation of the farmers' occupational group and the views on climatic conditions on agriculture production was used to address farmers' knowledge and perception on climate change. Additionally questions 72-75 of the questionnaire asks about knowledge on the causes of climate change and the perceived meaning of climate change which are as follows:

   > *72. In your experience, over the past 10 years, has there been any change in the severity of the following events in the area where you live? Have they become more severe, less severe, or stayed about the same?*
   > *73A. Have you heard about climate change or haven't you had the chance to hear about this yet?*
   > *73B. What does the phrase "climate change" mean to you?*

74. People have different ideas about what causes climate change. What about you, which of the following do you think is the main cause of climate change, or haven't you heard enough to say?
75. Do you think climate change is making life in Ghana better or worse, or haven't you heard enough to say" (Afrobarometer Round 7 questionnaire, 2018, pp. 23-25).

Additionally, questions 72 to 75 will be cross tabulated with question 71 which to ensure we are only seeing answers from farmers.

2. **How has the acquired knowledge and perceptions impacted on their agricultural activities and their adaptation to climate change?**
3. **What adaptation measures are being practised?**
4. **What are the barriers to adaptation?**

Existing literature will be used to address research questions 2 to 4 as outlined in the document review section.

5. **What are the means of acquiring information, and how has it impacted on perception and knowledge formulation?**

Question 12 in the Afrobarometer round 7 questionnaire explores the media sources of participants and the frequency of usage.

Figure 4: Afrobarometer survey question

12. How often do you get news from the following sources? *[Read out options]*						
	Every day	A few times a week	A few times a month	Less than once a month	Never	Don't know *[DNR]*
A. Radio	4	3	2	1	0	9
B. Television	4	3	2	1	0	9
C. Newspapers	4	3	2	1	0	9
D. Internet	4	3	2	1	0	9
E. Social media such as Facebook or Twitter	4	3	2	1	0	9

Source: (Afrobarometer round 7 questionnaire, 2018, p. 6).

The analysis includes descriptive statistics on the information sources farmers use to get access to information. Descriptive statistics describe the variables in the sample or population and describe the data in a more organized manner (Kaur, Yellapu & Stoltzfus, 2018). Descriptive statistics present the data's quantitative analysis and help break large data into its simplest form (Sharma, 2019). I will also rank the information sources to know the ones they used more frequently and significantly influence. The analysis will also be done using the Afrobarometer to know if informational sources impact farmers' views on the environment. Inferential statistics will also be used to draw conclusions on the larger population. Inferential statistics are used in making generalizations on the interested population based on the findings from the sample; it embodies the varied statistical significance tests which are used in making generalizations from the sample data (Allua & Thompson, 2009).

3.4 Data analysis

3.4.1 Correlational analysis

Correlational analysis helps to explore the relationship between different variables. Generally, correlation provides information on both the strength and direction of the relationship (Schober & Schwarte, 2018). The linear correlation is used to represent the closeness of one variable to another (Senthilnathan, 2019). The linear correlation coefficient is represented with r, and it represents the extent of closeness in the relationship between two variables (Senthilnathan, 2019). The Pearson Product Moment Correlation Coefficient is used in this study to measure the relationship among the variables; this type

of coefficient measures the strength of the linear relationship between the variables (Senthilnathan, 2019). The Pearson coefficient is preferred due to its extensive use in social science research and applied statistics (Walker, 2017).

3.4.3 Test for normality

Many statistical procedures are based on an assumption of a normal distribution for the data (Ghasemi & Zahediasl, 2012) or a distribution close enough to a normal distribution (Drezner et al., 2010); these statistical procedures include regression, t-test, correlation and analysis of variance (Ghasemi & Zahediasl, 2012)- as mentioned above, this study is determining the correlation between farmers and perceptions of climate change. A normality test is very important in drawing reliable and accurate conclusions (Ghasemi & Zahediasl, 2012). A normality test supplements the visual assessment of normality. There are different forms of normality tests; these include the Anscombe-Glynn kurtosis test, Anderson-Darling test, Shapiro-Wilk test, and Kolmogorov-Smirnov (K-S) test (Ghasemi & Zahediasl, 2012). The K-S test is the most popularly known test for normality (Drezner et al., 2010). The Kolmogorov-Smirnov test is used in this thesis to assess the normality of the data. The Kolmogorov-Smirnov test is an "empirical distribution function (EDF) test in which the theoretical cumulative distribution function of the test distribution is contrasted with the EDF of the data" (Öztuna et al., 2006, pg. 173). A limitation to the Kolmogorov-Smirnov test is its high sensitivity to extreme values (Ghasemi & Zahediasl, 2012). Before performing the correlational analysis on each type of data, it will be first determined whether the distribution is close enough to a normal distribution for the analysis to work.

Chapter 4

4.0 Results and discussion

The chapter is made up of the results and the discussion sections. The result section presents the results from the relevant questions from the Afrobarometer survey. The discussion section presents the findings from the Afrobarometer survey and review of relevant literature from the databases outlined in the methodology section. The result and discussion session together address the research questions.

4.1 Results

4.1.1 Sample description

611 (25.46%) of the respondents from Ghana were involved in agricultural activities while 256 (16%) of the respondents from Nigeria were involved in agricultural activities. The results indicate that more participants worked in the agriculture sector in Ghana compared to Nigeria. All subsequent results are within the respondents who worked in agriculture.

4.1.2 Demographics

This section will describe the demographic components of the survey respondents for both Ghana and Nigeria.

Gender

60% of the respondents involved in agriculture in Ghana were males and 40% were females while in Nigeria, 75.8% of the respondents involved in agriculture were males and 24.2% were females. As demonstrated in chapter two, majority of persons involved in agriculture for both Ghana and Nigeria are males.

Age distribution of respondents

The table below describes the age of people employed in agriculture across the two locations.

Table 1: Age distribution of respondents

Age distribution of respondents				
	Ghana (N=610)		**Nigeria (N=256)**	
Age Range (yrs)	**Freguency**	**Percentage**	**Frequency**	**Percentage**
18-24	72	12%	37	14%
25-35	159	26%	87	34%
36-45	124	20%	62	24%
46-55	109	18%	33	13%
56-65	77	13%	21	8%
66-75	43	7%	15	6%
76-85	20	3%	1	0.4%
86 and above	6	1%		

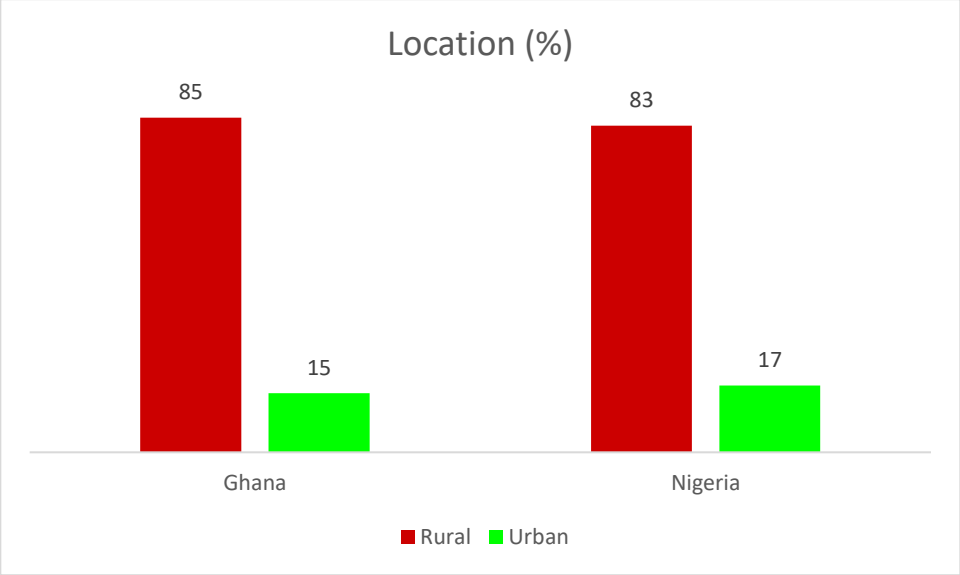
Source: Afrobarometer, 2017.

The results from the tables indicate that the majority of the workers in Ghana were aged between 25 to 55 yrs and 25-45 yrs for Nigeria. Thus, the agricultural workforce in Nigeria appears to be a bit younger than Ghana's.

Location of farmers

Figure 5 below describes the locations of the farmers in both Ghana and Nigeria.

Figure 5: Location of respondents



Source: Afrobarometer, 2017

From Figure 5, 85% of the respondents involved in agriculture in Ghana were located in the rural regions and 15% in the urban regions while in Nigeria, 83% of the respondents involved in agriculture were located in the rural regions and 17% were located in the urban regions. The results from the data indicate that farmers were predominantly located in the rural communities of both countries.

Level of education of respondents

Table 3 below summarises the educational level of the respondents in both Ghana and Nigeria

Table 2: Education level of respondents

	Ghana Freq (%)	Nigeria Freq (%)
No formal schooling	199 (32.57)	29 (11.33)
Informal schooling only (including Koranic schooling)	10 (1.64)	25 (9.77)
Some primary schooling	96 (15.71)	58 (22.66)
Primary school completed	99 (16.20)	65 (25.39)
Intermediate school or Some secondary school / high school	137 (22.42)	58 (22.66)
Secondary school / high school completed	54 (8.84)	14 (5.47)
Post-secondary qualifications, other than university e.g. a diploma or degree from a polytechnic or college	9 (1.47)	-
Some university	2 (0.33)	-
University completed	4 (0.65)	-
Post graduate	1 (0.16)	7 (2.73)

Source: Afrobarometer, 2017

The results from the table indicate that the majority of the agricultural workers in Ghana had no formal education and more workers also had an intermediate school or some secondary school / high school. However, the majority of the agricultural workers in Nigeria had completed primary school education and more people had some primary schooling and intermediate school or Some secondary school / high school. A very few participants had a post graduate degree across both countries. Generally, the numbers for higher education were very low for both Ghana and Nigeria.

4.1.3 Sources of information

The Table 4 below describes the media type and the frequency of usage between Ghana and Nigeria

Table 3: Media usage

	Sources of information freq (%)									
	Never		**Less than once a mth**		**A few times a mth**		**A few times a week**		**Everyday**	
	Ghana	**Nigeria**	**Ghana**	**Nigeria**	**Ghana**	**Nigeria**	**Ghana**	**Nigeria**	**Ghana**	**Nigeria**
Radio	77(13)	34(13)	27 (4)	16 (6)	39 (6)	29 (11)	127 (21)	64 (25)	341 (56)	113 (44)
Television	310 (51)	136 (54)	46 (8)	31 (12)	42 (7)	30 (12)	76 (12)	38 (15)	137 (22)	19 (7)
Newspaper	561 (94)	203 (80)	14 (2)	22 (9)	10 (2)	13 (5)	6 (1)	10 (4)	8 (1)	7 (3)
Internet	558 (94)	211 (83)	11 (2)	4 (2)	6 (1)	7 (3)	7 (1)	18 (7)	13 (2)	15 (6)
Social media such as facebook and twitter	552 (94)	215 (85)	7 (1)	4 (2)	8 (1)	5 (2)	9 (2)	16 (6)	13 (2)	14 (6)

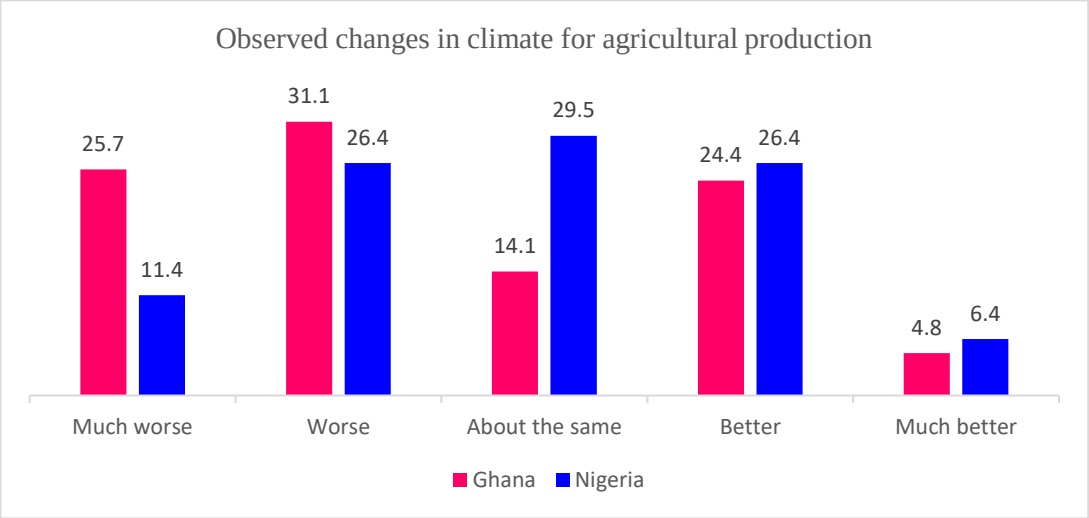
Source: Afrobarometer, 2017

From Table 4, the majority of participants who used radio as a source of information, used it everyday in Ghana. This is similar to Nigeria which had 44% of participants who used radio daily as a source of information. The majority of people in Ghana (90%) and Nigeria (84%) had never used social media. With regards to the internet, 94% in Ghana had never used internet whereas 83% of persons in Nigeria had also never used the internet. More than half of study participants in Ghana (51%) and Nigeria (54%) never used the television for information. However, 34.8% in Ghana used television few times a week to every day but only 7% of participants in Nigeria used television at this frequency.

4.1.4 Perceptions of climate change

Figure 6 describes the respondents responses to the question: “In your experience, would you say climate conditions for agricultural production in your area have gotten better, gotten worse, or stayed about the same over the last 10 years?” (Afrobarometer, 2017).

Figure 6: Observed changes in climate for agricultural production



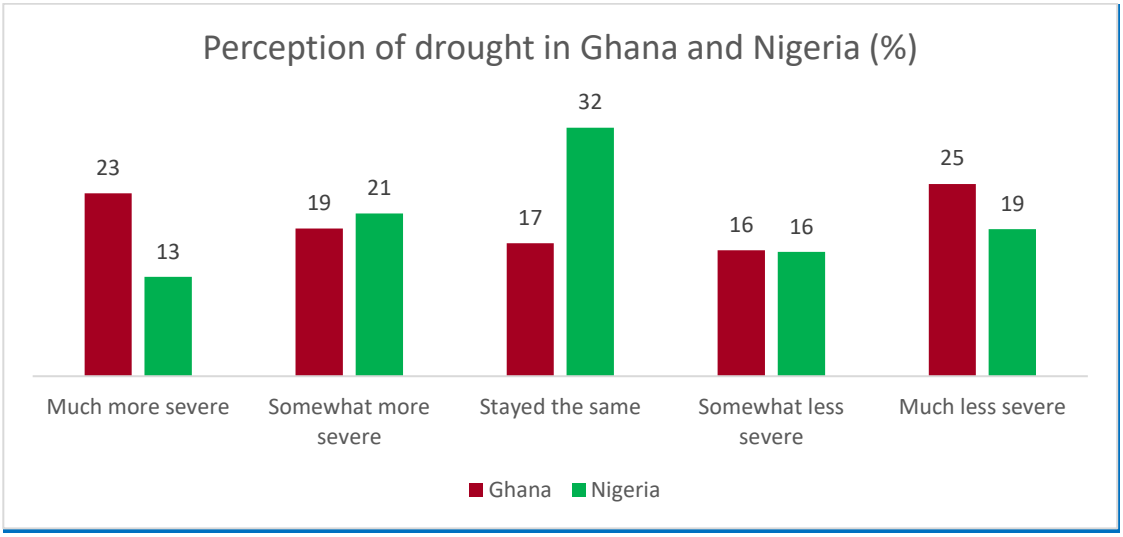
Source: Afrobarometer, 2017

From Figure 6, in Ghana, 130 (25.7%) persons perceived that the climate had gotten much worse in the past 10 years, 157 (31.1%) perceived that the climate had gotten worse, 71 (14.1%) also thought the climate was about the same, 123 (24.4%) perceived the climate has gotten better, 24 (4.8%) perceived the climate has gotten much better. In Nigeria 25 persons representing 11.4%% perceived that the climate had gotten much worse, 58 (26.4%%) perceived that it was worse, 65 (29.5) perceived that the climate had not changed much, 58 (26.4%%) also perceived that the climate had gotten better, 14 (6.4%) perceived that it had gotten much. From the results, perceptions were more positive in Nigeria than for Ghana.

4.1.5 Perceptions on climate change- drought

The Figure 7 describes the respondents responses to this question; “In your experience, over the past 10 years, has there been any change in the severity of the Drought in the area where you live? Have they become more severe, less severe, or stayed about the same?” (Afrobarometer, 2017).

Figure 7: Perception on drought conditions



Source: Afrobarometer, 2017

From the Figure 7, 42% of participants in Ghana perceived drought conditions had gotten much severe and somewhat severe whiles 41% perceived the drought conditions had gotten much less severe and somewhat less severe. In Nigeria, 34% of participants perceived drought conditions had gotten much severe and somewhat severe whiles 35% perceived the drought conditions had gotten much less severe and somewhat less severe. The results indicate a higher percentage in Ghana (42%) perceived drought conditions worsened than Nigeria (35%).

4.1.6 Perception of drought across the regions in Ghana

Table 5 below describes the responses to the perceptions of drought across all the regions in Ghana.

Table 4: Perceptions of droughts across the Ghana regions

Perception of Drought across the regions in Ghana (%)										
	Western	Central	Greater Accra	Volta	Eastern	Ashanti	Brong Ahafo	Northern	Upper East	Upper West
Much more severe	40	3	19	18	11	35	9	19	32	62
Somewhat more severe	24	13	31	24	12	12	20	25	26	11
Stayed the same	4	10	19	30	9	13	29	33	6	3
Somewhat less severe	3	26	19	20	32	19	12	9	15	11
Much less severe	29	49	13	8	37	21	30	14	21	14

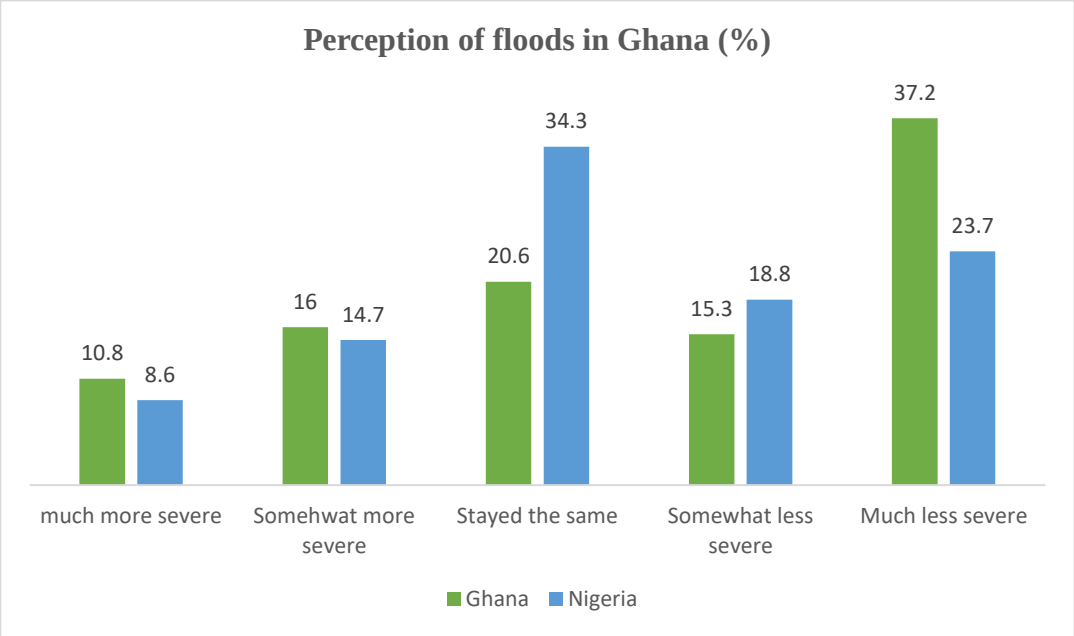
Source: Afrobarometer, 2017

From Table 5, 40%, 35%, 32%, and 62% of the respondents in the Western, Ashanti, Upper East and Upper West regions respectively perceived droughts were much more severe. On the other hand, 49% in the Central region, 37% in the Eastern region and 30% in the Brong Ahafo region perceived drought conditions as much less severe. The results from the table indicate that the majority of the respondents in the Western, Ashanti, Upper East and Upper West regions perceived drought conditions had worsened over the past ten years whiles the majority in the Eastern, Central and Brong Ahafo regions had experienced a much less severe drought conditions.

4.1.7 Perceptions of flood in Ghana

Figure 8 below describes responses to the following question; In your experience, over the past 10 years, has there been any change in the severity of the Floods in the area where you live? Have they become more severe, less severe, or stayed about the same?

Figure 8: Perceptions of floods in Ghana



Source: Afrobarometer, 2017

From Figure 8, 61(10.8%) persons in Ghana and 21 (8.6%) in Nigeria perceived flood conditions have been much more severe in the past ten years. 91 (16.0) and 36 (14.7%) person in Ghana and Nigeria, respectively, perceived flood conditions had been somewhat more severe. Also, 117 (20.6%) and 84 (34.3%) in Ghana and Nigeria, respectively, perceived flood conditions had stayed the same over the period. Furthermore, 87 (15.3%) in Ghana and 46 (18.8%) participants in Nigeria perceived flood conditions were somewhat severe, whereas 211(37.2%) persons in Ghana and 58 (23.7%) persons in Nigeria also believe the flood conditions had been much less severe. The

results indicate that majority of participants in Ghana (52.5%) perceived flood conditions were somewhat less severe and much less severe. Also, for Nigeria, the majority (42.5%) participants perceived flood conditions were somewhat less severe and much less severe. A t-test result between Ghana and Nigeria was significant at p =.01. This shows the differences in responses between Ghana and Nigeria as statistically significant. A Kolmogorov-Smirnov test had p>.005. The results indicate a normal distribution for the data.

4.1.8 Perception of floods across the Ghana regions

Table 5: Perceptions of floods across the Ghana regions

Perception of floods across regions in Ghana (%)										
	Western	Central	Greater Accra	Volta	Eastern	Ashanti	Brong Ahafo	Northern	Upper East	Upper West
Much more severe	10	0	12	12	5	32	1	18	15	3
Somewhat more severe	12	8	24	29	5	10	20	28	26	0
Stayed the same	14	21	24	27	8	25	26	37	18	0
Somewhat less severe	18	18	0	23	30	16	8	7	15	3
Much less severe	47	54	41	9	51	18	45	11	26	94

Source: Afrobarometer, 2017

The results from Table 6 indicate that the majority of the populations in the above-mentioned regions perceived floods as much less severe. The majority of the respondents in Northern and Volta regions perceived flood conditions stayed the same, whereas the majority in the Ashanti region perceived flood conditions had gotten much more severe. For the Upper East, the majority of the participants perceived flood conditions had gotten somewhat more severe or much less severe. The results however indicate that, although

the general perception is a much less severe flood condition for the country, some local differences also exist.

4.1.9 Awareness for climate change

Below is the description of respondents responses to the question; “Have you heard about climate change or haven’t you had the chance to hear about this yet?” (Afrobarometer, 2017). 49.4% of the respondents have not heard about climate change, and 50.6% have heard about climate change in Ghana, while in Nigeria, 51.8% of the respondents have not heard about climate change, and 48.2% have heard about climate change. The results from the Table indicate that more than half of the participants in Ghana and almost half of Nigeria's participants had heard about climate change. 50% is a surprisingly low awareness rate for climate change in these countries, given all the impacts and issues described in the literature review

4.1.10 Understanding of climate change

Table 7 below describes the respondents responses to this question; “what does the phrase “climate change” mean to you?” (Afrobarometer, 2017)

Table 6: Understanding of climate change

	Ghana (%)	**Nigeria (%)**
Yes, Negative changes in the weather like more droughts, floods or extreme heat	157(48.75)	67(54.00)
Yes, Positive changes in the weather, like better rainfall patterns or longer growing seasons	77(23.91)	39(31.45)
Yes, Other changes in weather patterns	59(18.32)	17(13.70)

Don’t Know/ Haven’t heard enough	29(9.0)	1(0.80)

Source: Data from Afrobarometer, 2017

From Table 7, 48.75% of the respondents in Ghana and 54% of the respondents in Nigeria understood climate change as negative changes in the weather like more droughts, floods or extreme heat. The results from the Table indicates that less than 50% of the participants and the majority of the participants in Nigeria who had heard about climate change associated climate change to the negative changes in the weather. This demonstrates that there is a surprising amount of room for further education on climate change for both countries.

4.1.11 Perceived causes of climate change

Table 8 describes the respondents responses to this question: “people have different ideas about what causes climate change. So what about you, which of the following do you think is the main cause of climate change, or haven't you heard enough to say?” (Afrobarometer, 2017). Below are responses from participants who have heard about climate change.

Table 7: Perceived causes of climate change

	Ghana (%)	**Nigeria (%)**
Human Activity, like burning fuel and other activities that pollute the atmosphere	39.13	44.35
Natural processes	32.91	37.90

Both human activity and natural processes	18.94	15.32
None of these	0.62	1.61
Don't Know/ Haven't heard enough	8.07	0.80

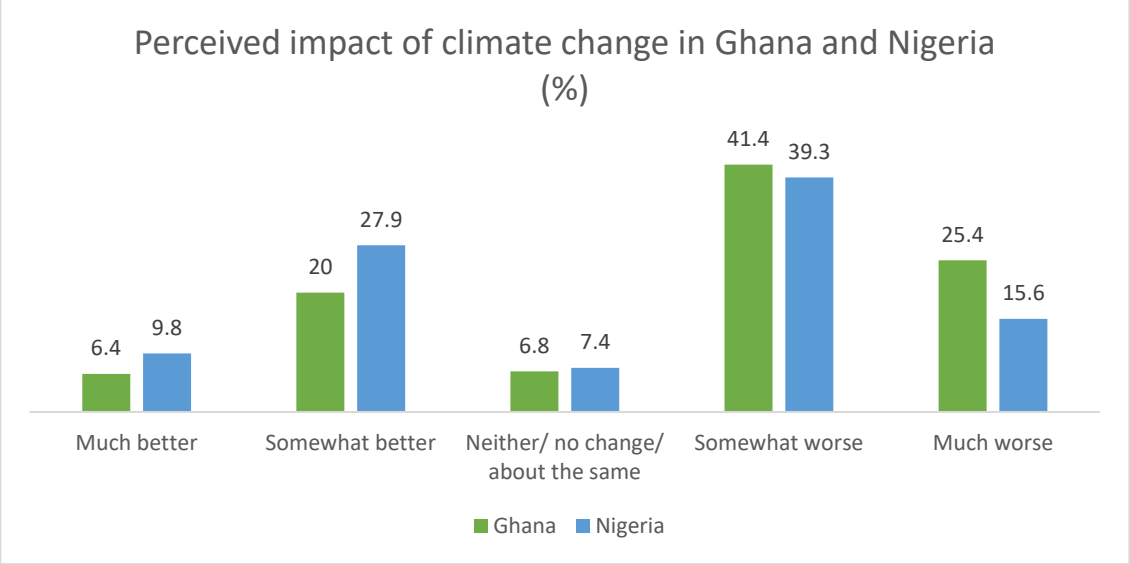
Source: Afrobarometer, 2017

From Table 8, 39.13% of the respondents in Ghana and 44.35% in Nigeria perceived climate change is caused by human activity like burning fuel and other activities that pollute the atmosphere. The percentage of participants who didn't know or haven't heard enough about the causes of climate change were higher for Ghana (8.07) than for Nigeria (0.80%).

4.1.12 Perceived impact of climate change

Figure 9 describes the respondents responses to the question; "Do you think climate change is making life in Ghana/ Nigeria better or worse, or haven't you heard enough to say"? (Afrobarometer, 2017). Below are responses from participants who had heard about climate change.

Figure 9: Perceived impact of climate change



Source: Afrobarometer, 2017

The results from Figure 9 indicate 66.8% of participants in Ghana perceived climate change had made life somewhat worse and much worse. Also, 54.9% in Nigeria perceived climate change had made life somewhat worse and much worse. From the results, more than half of the participants perceived climate change had worsened life. However, the percentage was higher for Ghana (66.8%)

A Pearson's product-moment correlation test result between Ghana and Nigeria shows a $p = 0.147$. This shows that the differences in responses between Ghana and Nigeria as statistically not significant.

4.1.13 Relationship among media sources, gender and awareness for climate change

Tables 9 and 10 below describe a correlation matrix among the media sources, gender and awareness for climate change in Ghana and Nigeria.

Table 8: Correlation with gender, awareness and media sources (Ghana)

	Radio		***Television***		***Newspaper***		***Internet***		***Social media***		***Gender***		***Awareness***	
	p-value	**cor**	**p-value**	**cor**	**p-value**	**cor**	**p-value**	**cor**	**p-value**	**cor**	**p-value**	**cor**	***p-value***	**cor**
Radio	***0***	(1.00)												
Television	***0***	(0.21)	***0***	(1.00)										
Newspaper	***0.04***	(0.09)	***0***	(0.18)	***0***	(1.00)								
Internet	*0.13*	(0.06)	***0***	(0.23)	***0***	(0.47)	***0***	(1.00)						
Social media	*0.24*	(0.05)	***0***	(0.25)	***0***	(0.40)	***0***	(0.84)	***0***	(1.00)				
Gender	***0***	(-0.15)	*0.09*	(-0.07)	*0.1*	(-0.07)	*0.58*	(-0.02)	*0.9*	(-0.01)	***0***	(1.00)		
Awareness for climate change	***0***	(0.14)	***0.01***	(0.11)	*0.91*	(0.00)	*0.11*	(0.07)	*0.17*	(0.06)	***0.01***	(-0.11)	***0***	(1.00)

Source: Afrobarometer, 2017

From table 9, there exists a significant relationship between climate change awareness and radio ($p<.001$), awareness and television ($p<.001$), and awareness and gender ($p<.001$) in Ghana. This demonstrates that a significant number of farmers who used the radio and television were aware of climate change. From the data, the majority of the males were aware of climate change while the majority of females were not aware of climate change.

Table 9: Correlation with gender, media sources and awareness (Nigeria)

	Radio		***Television***		***Newspaper***		***Internet***		***Social media***		***Gender***		***Awareness***	
	p-value	**cor**	**p-value**	**cor**	**p-value**	**cor**	**p-value**	**cor**	**p-value**	**cor**	**p-value**	**cor**	***p-value***	**cor**
Radio	***0***	(1.00)												
Television	***0.02***	(0.15)	***0***	(1.00)										
Newspaper	*0.09*	(0.11)	***0***	(0.29)	***0***	(1.00)								
Internet	***0***	(0.19)	***0.05***	(0.12)	***0***	(0.48)	***0***	(1.00)						
Social media	*0.08*	(0.11)	***0.04***	(0.13)	***0***	(0.42)	***0***	(0.79)	***0***	(1.00)				
Gender	*0.06*	(-0.12)	***0.2***	(0.08)	*0.81*	(-0.02)	*0.12*	(-0.10)	*0.57*	(-0.04)	***0***	(1.00)		
Awareness for climate change	*0.81*	(-0.01)	***0.01***	(0.17)	***0.1***	(0.10)	***0***	(0.21)	***0.01***	(0.16)	*0.44*	(-0.05)	***0***	(1.00)

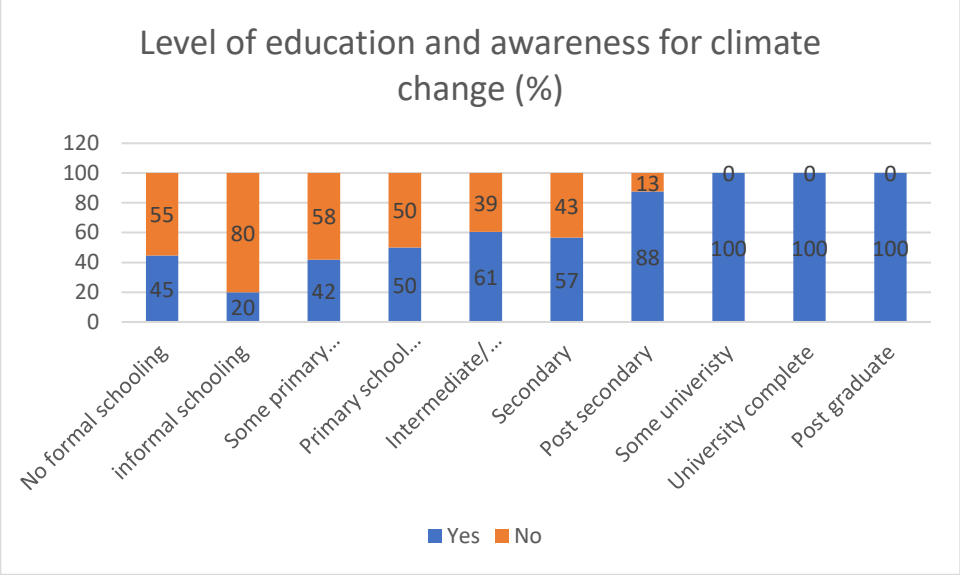
Source: Data from Afrobarometer, 2017

The correlation test from table 10 indicates a significant relationship between climate change awareness and television (p =.01), awareness and social media (p =.01), and awareness and internet (p <.001) in Nigeria. This demonstrates that the farmers who used television, social media and internet were significantly aware of climate change.

4.1.14 Level of education and awareness for climate change for Ghana

The Figure 10 below describes the responses of participants to whether they have heard about climate change or not, cross-matched with their level of education in Ghana.

Figure 10: Level of education and awareness for climate change- Ghana



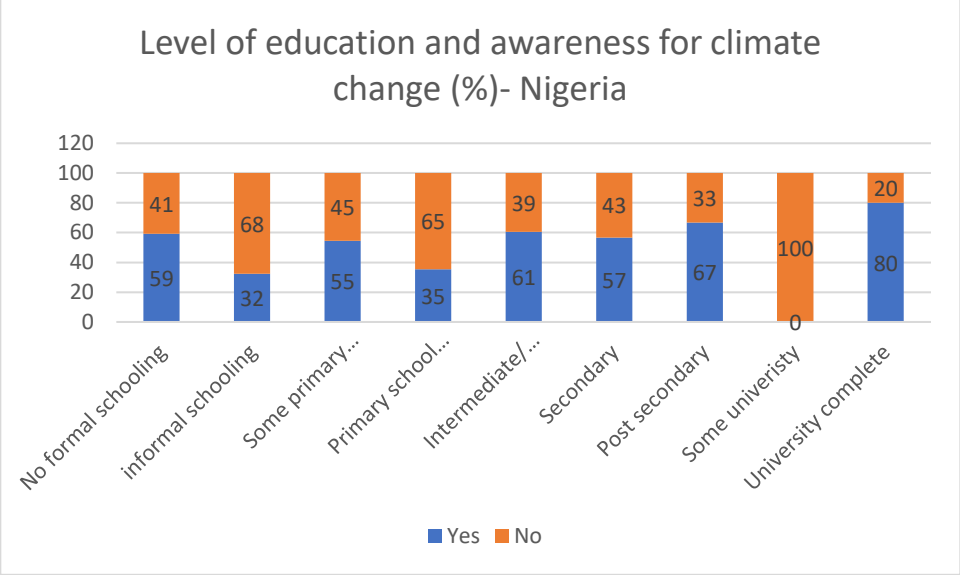
Source: Afrobarometer, 2017.

From Figure 10 above, participants who had attained some university education to post graduate level all knew about climate change. The majority of participants who had attained below primary school level education did not know about climate change. Thus, the results indicate that awareness of climate change increases with the level of education; hence education has an impact on awareness.

4.1.15 Level of education and awareness for climate change for Nigeria

Figure 11 below describes the responses of participants to whether they have heard about climate change or not, cross-matched with their level of education in Nigeria

Figure 11: Level of education and awareness for climate change- Nigeria



Source: Afrobarometer, 2017.

From the results, the majority of participants who had no formal schooling, some primary education, intermediate and above, except for some university had knowledge of climate change. Also, the majority of participants who had informal schooling, primary school complete and some university had no knowledge of climate change in Nigeria. Unlike the results from Ghana that showed a clear trend with increasing awareness with the level of education, the same cannot be said of Nigeria, which has the majority of participants with no formal schooling with knowledge of climate change.

4.1.16 Correlation between location(rural/ urban) and awareness for climate change

There was no significant relationship between location and awareness for climate change both in Ghana (p = 0.608) and Nigeria (p = 0.766). This demonstrates that awareness of climate change is not impacted by the location of the farmer.

4.2 Discussion

The section addresses the research questions previously outlined by using the results from the afrobarometer survey in the result section and the review of existing literature. The section starts by describing the demographic characteristics and media usage by the participants from the Afrobarometer survey. This is followed by the awareness and perceptions of climate change and the factors that impact the awareness and perceptions from the Afrobaromater survey and existing literature. It further describes how small scale farmers adapt to climate change, the role of local ecological knowledge in climate change adaptation and the barriers to climate change adaptation by small-scale farmers.

4.2.1 Demographic characteristics and media usage

Agriculture is comprised of persons in fishing, farming, agriculture and forestry. In the data, more people worked in the agriculture sector in Ghana as compared to Nigeria. Although the data showed about a quarter of people are employed in agriculture in Ghana, the World Bank Group (2017) shows that agriculture in Ghana employs almost half of the workforce and forms the major livelihood source for many impoverished households. Similarly, in Nigeria, about 70% of households are involved in crop farming (Varrella, 2020), although the data showed 16% of the population is involved in agriculture. 60% of persons involved in agriculture in Ghana were male, while 76% of persons involved in agriculture in Nigeria were male. The number of females in Agriculture were lower in both countries but comparatively higher in Ghana. This corresponds to the FAO (2018) that shows that 46% of employed males in Ghana were involved in agriculture, whereas 38% of employed females were also involved in

agriculture. Also, the FAO (2018) on agriculture showed that 13% of smallholder farm households were headed by females.

The majority in both participating countries had never used newspapers as a source of information. In the study findings, the dominant media source for information were the radio, television and newspaper. This is evident in Anaglo et al. (2020); farmers accessed information predominantly through other farmers, with radio, television and newspaper ranked low. Opara (2008) data also support that radio is mainly used by farmers in Nigeria, followed by television.

4.2.2 Awareness and perceptions of climate change by small scale farmers and factors that influence the perceptions.

The majority of participants in the study in Ghana were of the view that climatic conditions for agriculture in their region had gotten worse while others perceived that conditions were pretty much the same, and a significant number of participants (24.4%) perceived the climate had gotten better. However, Ghana is already experiencing a mean temperature increase of 1 degree Celsius per decade since 1960 (Pinto et al., 2012). Trends in temperature show warming across all the regions from 2010 to 2050, with the warmest regions being the Upper East, Upper West, and Northern regions (Asante & Amuakwa-Mensah, 2015). Temperatures in the three Northern regions are expected to increase between 2.1 and 2.4 degrees Celsius by 2050 (Asante & Amuakwa-Mensah, 2015). However, the Brong Ahafo region is projected to have the lowest temperature rise between 1.4 and1.6 degrees Celsius (Asante & Amuakwa-Mensah, 2015). Some studies show the decline of mean annual rainfall to be worse in the southwestern areas, which are divided by

the Kwahu plateau. Also, the Volta basin is experiencing prolonged dry seasons (Pinto et al., 2012). The region is expected to have a temperature rise of 1.7 and 2.0, and this predicted rise is the same for the Western, Ashanti, Central and Eastern regions (Asante & Amuakwa-Mensah, 2015). Although the majority of participants surveyed in Nigeria perceived climatic conditions in their region had gotten better or stayed the same, others also perceived it had gotten worse or much worse. However, research in the region shows a decrease in crop production due to the increase in sunshine hours, pest infestation, erratic rainfall, and an increase in temperatures (Lal, 2006). The existing literature shows the negative changes brought about as a result of climate change which contradicts the views of persons who perceive the climate has gotten better over the past years; this is likely due to the reason that these participants might not have taken note of the ongoing occurrences in their environment. This could also be due to inadequate education and inadequate access to information for some of the participants.

As demonstrated in the literature review, a significant number of farmers are aware of the concept of climate change. A survey of cocoa farmers in rural Ghana demonstrated that farmers in all the rural communities were aware of climate change and its impact on their farm activities (Codjoe et al., 2013). In a study by Nwobodo & Agwu (2015) on the level of climate change knowledge held by young farmers, 92.4% of them had some knowledge about climate change; the information they had was mainly sourced from radio, friends and neighbours, their own observations and from the members of their families. The predominant cause of climate change is perceived to be human activity and natural processes for both Ghana and Nigeria. Additionally, cocoa farmers in rural Ghana perceive

that climate change is predominantly caused by human activities such as deforestation, indiscriminate bush burning, heavy machines on land, illegal mining and farming along river bodies (Codjoe et al., 2013). Some believe in Supernatural factors such as God's plan that signify the end of the world (Codjoe et al., 2013). Although some studies reviewed in chapter two demonstrated the impact of media sources and awareness for climate change, a study by Sraku-Lartey (2020) shows that although the study participants had access to media types such as radio, newspaper and television, these did not impact the level of knowledge and awareness on climate change.

The majority of farmers in Ghana have observed changes in the climate over the past thirty years (Limantol et al., 2016). Despite the observed changes in the climate, some small-scale farmers in Ghana do not fully know and understand the term climate change. Some small-scale farmers define climate change as when the rains are too much or too little with adverse impacts on crop growth (Yaro, 2013). Sraku-Lartey (2020) study on farmers perceptions of climate change in the Offinso area showed that less than half of the study participants had heard about climate change, and less than half of the participants had heard about climate change really knew and understood the term. Although some of the participants had heard about the term, they could not fully link it to the observed changes. Their perceptions of climate change were high temperatures, excessive rain, low and irregular rainfall, prolonged dry season and strong winds. Farmers also perceive that the most significant impact of climate change was the effects it had on their farm activities, facilitated forest fires and affected water supplies (Sraku-Lartey, 2020). Other perceived impacts of climate change include intermittent drought during the crop growth stage, poor

rainfall amount and high variation in the onset of planting seasons (Limantol et al., 2016), as well as highly unreliable rainfall, occasionally excessive rainfall, shorter rainy seasons, destructive winds and inadequate cool breeze from the sea (Yaro, 2013). Notwithstanding these observations, climate change affects different farming communities differently. Kusakari'a (2014) study on farmer perceptions of climate change showed that the different perceptions of observed climate changes differed even in the same locality.

There is also the perception that there are varying degrees in the impact of climate change, which is dependent on resilience, the level of exposure and adaptive capacities (Limantol et al., 2016). The majority of Sraku-Lartey (2020) participants perceived that climate change and its impact were important to them, while others perceived it as slightly important or remained neutral. Similarly, Limantol et al. (2016) found that most participants perceived climate change had extreme and multiple effects, while others perceived it had manageable to limited effects. Climate change is perceived to be caused by a wide range of natural and human activities. Small-scale farmers perceive climate change is caused by factors such as deforestation, urban expansion, immoral behaviours, punishment from God and inadequate rains to cool the earth (Yaro, 2013)

Regarding factors that affect knowledge and perceptions of climate change, it was evidenced that gender, age, education and length of stay in the community all had an effect (Sraku-Lartey, 2020). Participants who had stayed longer in the community were more familiar with the changes in the climatic conditions as compared to participants with a shorter stay in the community (Sraku-Lartey, 2020). Similarly, Kusakari (2014) study on farmer perceptions in the Wa West district in Ghana showed that gender and age impacted

perceptions. The majority of participants who perceived the climatic conditions have worsened over time coincides with the relevant literature that points out the unpredictable onset of rainfall, severe flood and drought conditions as characteristics for the ongoing impact of climate change. Furthermore, regarding factors that influence awareness and perceptions of climate change, the data shows that gender, education and media impacted awareness and perception, which is in line with the existing data.

4.2.3 Climate change adaptation by small scale farmers in Ghana.

Most adaptation techniques used by small-scale farmers in the country are borne out of years-long experience in farming and the amount of knowledge accumulated over time (Benson et al., 2015). Different farming practices are employed in the country to help combat climate change. Adaptation practices used by the farmers are predominantly borne out of local ecological knowledge (Owusu et al., 2017). Some of these practices include growing drought-resistant crops, rainwater harvesting, change in crop varieties, crop diversification, planting of crops with shorter planting dates (plants that have shorter maturity dates), charcoal burning and change in planting dates (Benson et al., 2015). In some communities in Ghana, the improved crop varieties have been introduced by non-Governmental organisations and facilitated by the agricultural extension officers in the communities (Dapilah & Nielsen, 2020). Other methods of adaptation include greenhouse farming, irrigation farming, apiculture, fishing activities (Benson et al., 2015) and application of farm inputs such as fertilizer (Bawakyillenuo et al., 2016). The application of fertilizers increased the growth of crops during the short rainy seasons (Dapilah & Nielsen, 2020). Late planting (waiting for the rains before the start of planting), watering

of plants (Owusu et al., 2017), and off-farm activities such as carpentry and driving, and seasonal migration (Bawakyillenuo et al., 2016) have also emerged as options for adaptation. Although the off-farm activities are not necessarily an adaptation of agricultural activities to climate change, they help ensure the income flow and subsidise income generated from the reduced yield from the farm activities. Irrigation farming has proven to be an effective method for continuing crop production amidst unpredictable weather conditions (Bawakyillenuo et al., 2016). Irrigation is done by digging shallow wells in areas where the water table is shallow, whereas some farmers connect diesel pumps to nearby river bodies (Bawakyillenuo et al., 2016). In the study of Bawakyillenuo et al. (2016), participants gave testimonies on how hand-dug irrigation systems have affected income generation from their vegetable farms as they could not survive only on rain-fed agriculture. The ability to use irrigation as an adaptation measure depends on access to water/ irrigation facilities and financial capabilities (Bawakyillenuo et al., 2016).

A study on small-scale farmers' climate change adaptation in the Yatta district in Ghana showed a significant relation between farmers' age and the planting of drought-resistant crops. Older farmers are more likely to plant drought-resistant crops due to their years of accumulated knowledge of the region's climate modalities (Benson et al., 2015). The educational level of farmers also influenced their decision to plant drought-resistant crops (Benson et al., 2015). Drought-resistant crops have the characteristic of withstanding high heat and low water conditions and yield sufficient harvest even under lower rainfall conditions (Benson et al., 2015). The burning of charcoal was also used as a form of livelihood diversification. Some farmers burn charcoal to help afford their domestic needs

(Benson et al., 2015). Farmers with higher knowledge of climate change were less likely to cut down trees for charcoal due to their knowledge of tree cutting's adverse effects (Benson et al., 2015). However, farmers with low knowledge used charcoal burning to support their daily expenses (Benson et al., 2015). Some farmers also engage in on-farm activities such as rearing livestock to supplement their farm produce (Owusu et al., 2017). A study by Owusu et al. (2017 on the impact of climate variability on small scale farmers showed 13% of the participants received remittances from family and friends outside the local community. A part of the remittance was saved as collateral for bad weather days, and another part was used to hire casual labour.

According to the theory of planned behavior, adaptation to climate change is sparked by behavioral intent (Mase et al., 2017). Although some behaviors are based on whether one wants to perform the behavior willingly or not, some behaviors are based on the availability of resources and requisite opportunities such as money, skills, time, the cooperation of others, and other factors which altogether determines the level of control the individual has on the behavior (Ajzen, 1991). In line with the theory, climate change adaptation strategies by smallholder farmers as outlined above are influenced by household size, education, access to information, annual household income and credit (Ndamani & Watanabe, 2016).

Adaptation practices in Ghana are not different from what is practised in the African continent broadly. Standard practices across the African region for adaptation are the diversification of livelihood activities, selling of labour and modifications to farming practices (Benson et al., 2015).

4.2.4 The role of local ecological knowledge in climate change adaptation

Climate change, with its associated changing rainfall patterns, poses a challenge to the traditional means by which farmers adjust to the periodic changes that occur in their farm activities (Gyampoh et al., 2009). Smallholder farmers in Ghana have come up with varied ways of dealing with the negative impacts of climate change and uncertainties with environmental conditions (Laube et al., 2012). Farmers' adaptation to this challenge and risks is the planting of different crops, especially crops that will survive under the changing conditions (Gyampoh et al., 2009). These farmers use different off-farm and on-farm adaptation mechanisms to limit the damaging ecological and climate change effects on their livelihood (Aniah et al., 2019). For instance, some farmers have replaced the growth of cocoa with cassava, which are more drought-resistant or have started planting vegetables in river plains to have more access to water (Gyampoh et al., 2009). Most resort to soil conservation strategies, growing drought-resistant crops, and growing plants with different maturity dates.

Local farmers have devised means of adapting to droughts, bush fires, and flooding, which are the extremes of climate change. Measures adopted to adapt to drought include the use of shallow tube wells, adoption of organic agriculture, the building of water impounding basins, storing food for unfavorable conditions, planting of early yielding crops or drought-resistant crops, the building of windbreaks and shelter banks to enhance resilience (Ansah & Siaw, 2017). Other measures include planting cover crops and more trees, adjusting to planting dates and crop variety, rotation irrigation during water shortages, traditional water harvesting, and monitoring the rate of deforestation (Ansah &

Siaw, 2017). In dealing with flooding, the farmers cease farming or building in lowland areas, build embankments, and construction improved drainage systems (Ansah & Siaw, 2017). Fire prevention education, improvement of farm maintenance techniques, and installation of fire belts or controlled burning are mechanisms adopted to fight against bush fires associated with extremely dry conditions (Ansah & Siaw, 2017). Farmers also adapt to the decreasing yield of farm produce by allocating more land areas to cultivation (Issahaku & Maharjan, 2014). This method of adaptation has led to increasing deforestation through the clearing of new forest frontiers (Odame Appiah et al., 2018). But this method is not without challenges. It has proven unsustainable; farmers face limitations which acquire excess land, challenges with managing large tracts of land, loss of forest cover, and inadequate labor (Breisinger et al., 2009).

In recent times, the changes observed in the climate have become more complicated, and most of the parameters indigenous persons used to make predictions in the environment are becoming unreliable (Owusu Ansah & Pokuah Siaw, 2017). As mentioned earlier, most of the small-scale farmers' adaptation practices towards climate change in Ghana are borne out of the local ecological knowledge. Arku (2013), in their study on local adaptative practices towards climate change, differentiated between local practices used by men and women to adapt to climate change. The women tended to referred practices such as petty trading, rearing domestic animals (e.g. sheep, goats), irrigation farming for vegetable growing, and working as hired labours. Also, the men tended to prefer working as hired labourers on irrigated farms, rearing domestic animals for consumption and sale (e.g., sheep, goat), working off-farm jobs (e.g. carpentry, masonry, blacksmithing), whiles

others operated irrigated farms. Owusu Ansah & Pokuah Siaw (2017) classified local farming adaptation practices into five categories: network, knowledge management and governance; farm management and technology; farm financial management; diversification; and government interventions. Indigenous adaptation practices in Ghana have had mixed success (Gyampoh et al., 2009). In Arku's (2013) study, about 90% of the participants agreed that the local practices had impacted their livelihood positively, whiles about 10% were of the view that the local adaptation practices have had an insignificant impact on their livelihood. However, the effectiveness of local indigenous practices should be used as the basis for agricultural policies by governments and donor agencies in handling climate change in most drought-sensitive regions (Nyantakyi-Frimpong, 2013).

4.2.5 Barriers to climate change adaptation by small scale farmers in Ghana

Some parts of the country have reported crop failures, food and water shortages as the new normal, which signifies the extent of damages by the ongoing climatic changes (Benson et al., 2015). Although farmers are doing their best to adapt to the challenges mentioned above, different factors hinder their progress. Researchers worldwide have launched studies to understand the different reasons for the barriers to successful adaptation by smallholder farmers (Owusu Ansah & Pokuah Siaw, 2017). The IPCC classifies barriers to climate change adaptation into lack of human resources, awareness and technology, economic factors, social and cultural factors, biological hindrances, government and institutional processes, financial factors and the physical environment (Barnett et al., 2015).

In Ghana, the unpredictable nature of the weather impedes small-scale farmers ability to adapt to climate change (Fagariba et al., 2018). The farmers find it challenging to obtain suitable adaptation measures when they do not know what to expect in the future regarding the changes in the climate (Fagariba et al., 2018). Poor access to farm inputs such as fertilizer affects farmers adaptation process (Bawakyillenuo et al., 2016). Although subsidies exist for fertilizer application, some local farmers are still unable to purchase it; this is due to the poor communication channels around the fertilizer acquisition process, lack of financial ability for some farmers and insufficient institutional arrangements (Bawakyillenuo et al., 2016). The support from the government to help farmers combat the challenges of climate change is perceived as inadequate; the inadequate support from the government is evidenced in the high cost of farm inputs such as tractors and improved seeds (Fagariba et al., 2018). Insufficient access to weather information by some farmers also affects their ability to adapt to climate change (Fagariba et al., 2018). There is insufficient knowledge regarding rural communities' current and future vulnerabilities (Owusu Ansah & Pokuah Siaw, 2017). Early warning systems and weather forecasts are inadequate in certain rural communities due to ineffective implementation and operational resources (Owusu Ansah & Pokuah Siaw, 2017). Also, the flow of weather information from the Ministry of Food and Agriculture and the Meteorological Service Department to farmers in other communities is perceived as insufficient (Fagariba et al., 2018).

The nature of land tenure also impacts farmers ability to adapt (Fagariba et al., 2018). Some farmland used by small scale farmers is owned by the government, communities and even families; this does not motivate individual farmers enough to commit resources in

managing the farmland to keep up with the ongoing changes, because they could lose the farmlands at any time (Fagariba et al., 2018). Antwi-Agyei et al. (2015) observed differences in adapatation by migrant farmers and farmers who owned their farmlands. Whiles farmers who rent farm lands (tenants) resorted to short term soil conservation practices such as fertilizer application and mulching, farm owners resorted to more long term adaptation practices such aas agroforestry. Farmers who farmed on rented farmlands were prohibited from undertaking certain adaptation practices such as tree planting. In effect, the land tenure system affects impacts on the choice of adaptation. Some female small scale farmers in the northern part of Ghana have reported challenges with the land acquisition (Lawson et al., 2020). Culturally, while some of these farmers could not inherit farmlands from their fathers, others borrowed lands from relatives or received them as gifts; this amounted to low land ownership among the female farmers (Lawson et al., 2020). Antwi-Agyei et al. (2015) study on land tenure impact on adaptation showed 85% of women who ae challenged with adaptation as a result of the existing land tenure system. These women were from different parts of the country who basically farmed on their husbands lands and are faced with restrictions pertaining to the activities on the land. Whiles some of the women are not allowed to use the lands as collateral to attain loans from credit facilities in order engage in off-farm activities as a form of adaptation, others did not also have access to the fertile lands. The less security surrounding land tenure system among some females impact negatively on adaptation (Antwi-Agyei et al., 2015). Furthermore, some older female farmers cannot perform labour-intensive adaptative methods, while others are prevented from undertaking diversified livelihood opportunities (Lawson et al., 2020). Some of the men in the area perceive that the women will replace

them as household heads when they achieve financial independence through alternative livelihoods and are so resistant to these changes (Lawson et al., 2020).

Socio-cultural factors also affect adaptation by smallholder farmers in Ghana. Societal norms and values are often a major barrier to implementing adaptation strategies (Antwi-Agyei et al., 2015). Cultural practices, strongly held beliefs, the value system, and individual views affect how one perceives climate change, which subsequently impacts adaptation and choice of the adaptation method (Antwi-Agyei et al., 2015). For example, migration is a form of adaptation strategy in some farm communities (Gyimah et al., 2020). However, this strategy mostly favours men (Gyimah et al., 2020). This is because the existing cultural norms find it more reasonable for men to migrate to acquire an alternative living source, while women are restrained in making this same decision (Gyimah et al., 2020). Thus, the decision to migrate is mainly made by the men, which is typical of the semi-arid region (Gyimah et al., 2020). This cultural limitation reduces the number of adaptation options available to female small scale farmers, which in the long run affects food security (Antwi-Agyei et al., 2015). Additionally, adaptation strategies that are seen as gender insensitive, implementation of gender insensitive agricultural practices negatively impact female smallholder farmers (Gyimah et al., 2020). The government-led adaptation strategies are mostly centred on cash crops dominated by men (Gyimah et al., 2020).

Institutional barriers have also emerged as a common factor that affects adaptation to climate change by small scale farmers. Institutions can be defined as “formal legal rules and informal social norms that govern the behaviour and shape how individuals and

organizations interact" (Berman et al., 2012, pg. 87). Institutions, such as formal legal rules and informal social norms, have the power to enable or keep certain adaptation practices, whereas they can also restrain these same practices or exclude some actors (Berman et al., 2012). But, more importantly, the strengthening of local institutions can facilitate farmers adaptation towards climate change (Antwi-Agyei et al., 2018). Chiefs, farmers market women groups, and association producers also form local or informal institutions. The local institutions in Ghana offer adaptation support such as sensitization on relevant climate change information, awareness creation and enforcing set laws (Abass et al., 2018). Many smallholder farmers in Ghana perceive that inadequate institutional support from the government impacts the adoption of efficient adaptation strategies (Gyimah et al., 2020). A study by Laube et al. (2012) on smallholder farmers adaptation to climate change detailed institutional challenges such as inadequate governmental support in the provision of adequate extension services, inadequate government support in providing the needed climate information, absence of support from the government and the high cost of irrigational facilities.

Chapter 5

This highlights particular analyses and conclusions from both the literature sources used in the study and results from the Afrobarometer survey. Further policy recommendations based on these analyses are made.

5.0 Conclusion

Summary Table

Perceptions of climate change in Ghana	**Evidence of climate change:** ✓ High temperatures ✓ Unpredictable rainfall patterns ✓ Droughts ✓ Floods **Causes** ✓ Both natural and artificial (man-made activities) **Impact of climate change** ✓ Variation in the onset of planting season ✓ Reduced crop production ✓ Crop failures
Perception predictors	✓ Length of stay in the community ✓ Education ✓ Gender ✓ Age (farming period) ✓ Age of the farmer ✓ Media

Adaptation techniques	✓ **On-farm techniques-** drought-resistant crops, adjusting planting dates, plants with different maturity dates, cover crops, reduced deforestation, wind brakes, shelter banks, irrigation farming ✓ **Off-farm activities**- carpentry, driving, seasonal migration, masonry and blacksmithing
Impact of local ecological knowledge on adaptation	✓ Positive impact on the livelihood
Barriers to adaptation	✓ Financial challenges ✓ Poor access to farm inputs ✓ Insufficient institutional arrangement ✓ Poor communication channels ✓ Land tenure system ✓ Cultural barriers- e.g. Gender associated limitations
Policy recommendations	✓ Communication of climate change impact and adaptation measures through radio and television ✓ Intensify extension services to both rural and urban farming centres ✓ Behavioral interventions to increase uptake of adaptation strategies

Developing countries are highly prone to the harmful impacts of climate change due to insufficient economic and social resources. Climate change has a direct impact on agriculture which is the socio-economic backbone of a number of countries. Ghana is heavily reliant on agriculture for income, job creation and food security. A part of the country's goal is to increase the marketability of smallholder farmers produce since they

contribute immensely to food security and serve as a livelihood source to most rural dwellers. The impact of climate change is increasingly felt in Ghana with rising temperatures with unpredictable rainfall patterns. Understanding the farmers' perception of climate change, its causes, and impacts are necessary to design efficient adaptation strategies. Perceptions play a role in the modification of environmental and climate change policies. Generally, perceptions are built from experience, memory, and definition. Factors that affect perceptions can be either socio-economic factors or environmental. Climate change is perceived as evident in high temperatures, unpredictable rainfall patterns, floods and droughts. Furthermore, climate change is perceived to be caused by both natural and man-made activities. The impact of climate change on agriculture is noticeable in reduced crop yields, variations in the onset of planting season and failures of some crops.

From the review, factors that affect farmers perceptions include age, gender, environmental conditions, education and the media. The environmental conditions consider the physical attributes of the environment; however, the social environment also feeds into that. The age of farmers not only describes how old farmers are but also their age regarding farming activities. The more time farmers spend on farming activities, the more appreciative they are of the changing conditions of the environment. Education of farmers could be formal or informal. Extension workers provide informal education by getting closer to farmers to educate them on the subject matter. However, both forms of education impact the way farmers build their knowledge of the environment. The media is a common way farmers gain information. The data shows that radio is predominantly used. Climate information announced through the media sources used by farmers goes a long way to impact their

perceptions. Also, the survey results showed no significant relationship between awareness for climate change and the location (urban, rural) of the farmers, thus, policy interventions should target rural and urban farmers equally.

On-farm techniques are basically the main strategy for adaptation, and this is however supported by off-farm activities as well. The different types of adaptation are influenced by gender differences, farm household size, income, educational background, age and access to technology. Spontaneously, some farmers adapt through their local ecological knowledge built over a long period. Local ecological knowledge is gradually gaining prominence, and it is considered proficient and efficient in adapting to climate change. Locally, farmers have devised means of adapting to the changing climatic conditions, bush fires, droughts and floods. Local ecological knowledge has proven efficient in adaptation strategies and has positively impacted farmers' livelihoods. Despite the prevailing strategies in place for adaptation, some barriers still exist, natural, informational, human, land tenure system and socio-cultural factors.

Psychological, biophysical and social factors influence adaptation policies. Adaptation strategies can be improved by taking into consideration behavioural models and theories such as the theory of planned behavior (Somda et al., 2017). Behavioral theories are important in the goal of achieving great policy outcomes. Changing the behavior of the smallholder farmers is essential in effectively delivering the policy outcomes of both agriculture and climate change. The behavior theory helps understand the farmers' decision-making process and the kind of barriers they encounter in adapting their future behavior towards adaptation (Dang, Li & Bruwer, 2012). Thus, climate change adaptation policies

should consider behavioral change theories in their design, incentives and financial support to ensure adaptation behaviors are started and sustained. Gifford et al. (2011) study on behavioral dimensions and climate change outlined some form of behavioral interventions that can be applied in the context of increasing adaptation. These interventions include antecedent strategies that tend to motivate the performance of the behavior, this can be done by awareness creation through communication, organising information campaigns and prompting the farmers on all the necessary adaptation measures. Another form of intervention is the consequence strategy that either rewards, punishes, or provides feedback after the behavior is performed. This influences the likelihood of the behavior to be repeated or abandoned. Also, in comparison to Nigeria, perceptions of climate change was similar across both countries.

5.1 Policy recommendations and future research

The country faces challenges with adaptative capacity, which necessitates policy-driven initiatives to yield fruitful results. The agricultural and climate change policies have set programs in place to support successful adaptation strategies by farmers. These policies approves the documentation of local ecological knowledge and provides education and support for farmers through extension services. Although the policy has clear goals and objectives, the study reveals some lapses. The existing policy should continue to support the implementation of local ecological knowledge in climate change adaptation since its proven successful by the farmers. Also, there should be gender driven initiatives that

specifically target adaptation strategies for women. From the literature, women are sometimes are at a disadvantage due to existing socio-cultural norms and land tenure systems that do not favor women.

The study sought to contribute to strengthening climate change and agricultural policies by understanding the farmers' perceptions and how local ecological knowledge impacts adaptation. From the data from Ghana, awareness for climate change increased as people moved higher on the educational ladder; thus, there should be a conscious effort to provide some form of formal or informal education through extension officers to equip the farmers with the necessary information. Furthermore, there should be an integrated communication strategy to increase the awareness of climate change and efficient adaptation practices to the farmers. Climate information and practical adaptation strategies should be communicated through to the most remote places. The farmers predominantly used the radio as a source of information, followed by the television; as such, information can be passed on through this channel.

Further research should be made into the regional differences in perceptions and adaptations to climate change to plan more relatable adaptation measures since locational differences in the local ecological knowledge is a strong determinant for the choice of adaptation and motivation to adapt.

Existing evidence points out to the importance of climate change and the role it plays in food security. Small-scale farming is practiced by the majority of farmers and continue to play huge role in maintaining consistent food supply and helping to ensure food security. Thus, it is very important that they practice sustainable adaptation measures. The literature

reveals the importance of awareness on perceptions and adaptation. Thus, the conscious effort to increase awareness creation on climate change and adaptation will go a long way to increase adaptation uptake.

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