University of Reading

Smallholder farmers' cropping decisions in rural North-west Ghana under climate variability and change

Article

Accepted Version

Dakurah, G., Osbahr, H. ORCID: https://orcid.org/0000-0002-0130-2313 and Arnall, A. ORCID: https://orcid.org/0000-0001-6218-5926 (2024) Smallholder farmers' cropping decisions in rural North-west Ghana under climate variability and change. Regional Environmental Change, 24. 30. ISSN 1436-378X doi: https://doi.org/10.1007/s10113-023-02168-2 Available at https://centaur.reading.ac.uk/116670/

It is advisable to refer to the publisher's version if you intend to cite from the work. See Guidance on citing.

To link to this article DOI: http://dx.doi.org/10.1007/s10113-023-02168-2

Publisher: Springer

All outputs in CentAUR are protected by Intellectual Property Rights law, including copyright law. Copyright and IPR is retained by the creators or other copyright holders. Terms and conditions for use of this material are defined in the End User Agreement.

www.reading.ac.uk/centaur

University of Reading

CentAUR

Central Archive at the University of Reading

Reading's research outputs online

Smallholder farmers' cropping decisions in rural North-west Ghana under climate variability and change

George Dakurah (1), Henny Osbahr (2) and Alex Arnall (2)

(1) Contact author: George Dakurah, dakurahg@yahoo.com, Department of Geography and Rural Development, College of Humanities and Social Sciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
(2) School of Agriculture, Policy and Development, University of Reading, Reading, UK

(Submitted to Regional Environmental Change)

Abstract

This study examines smallholder farmers' cropping decisions in North-west Ghana under climate variability and change (CVC). It aims to understand the matches and mismatches between farmers' perceptions and climatic data, characterise farmers' crop choice by identifying differences between current and past practices, and understand why smallholder farmers respond or not to CVC via crop selection. The study uses a parallel mixed methods approach, with 150 households interviewed, and employs theories of Drought Perception, Planned Behaviour, and Social Identity. Results show that farmers' perceptions of CVC mismatch climatic data. Farmers' attitudes largely shape their decisions to respond to CVC via crop choice. Negative attitudes, such as perceived poor yield and difficulty in cultivation, have led to the displacement of traditional varieties, while positive attitudes, such as perceived yield benefits, have led to cultivation of improved varieties of crops. The study highlights the need to support smallholder farmers in adapting to CVC and ensuring the availability and utilisation of culturally appropriate foods. Future research should explore the impact of climate change adaptation on the availability and utilisation of culturally appropriate foods.

Introduction

Climate variability and change (CVC) are among the major threats to the world in the twenty-first century (IPCC 2014; IPCC 2022). No sector or spatial area of the globe is devoid of the impacts of CVC. Agronomic-related studies suggest that agriculture is the sector most affected as compared with other sectors (e.g. Ericksen et al. 2011; Lobell et al. 2008; Thornton et al. 2011). The justification being that agriculture particularly within the development world is largely rain-fed; hence, climate perturbation would have great impact on agriculture. Similarly, as a dynamic phenomenon, vulnerability to CVC impacts has been shown to be spatially differentiated (IPCC 2014; IPCC 2022). It has been widely recognised that Sub-Saharan Africa (SSA) is the most vulnerable to climatic perturbations (IPCC 2014; IPCC 2022). The vulnerability of SSA to CVC impacts has been attributed to (i) greater proportion of the population of SSA been dependent on natural resource–based livelihoods which are highly sensitive to CVC (Osbahr et al. 2011; Wlokas 2008), (ii) SSA has limited

capacity or technology to cope (Gregory et al. 2005), and (iii) socio-economic processes (e.g. conflicts) exacerbate the vulnerability of SSA to CVC impacts (Gregory et al. 2005).

Recognising that CVC are global issues, there is that need for everyone to be concerned hence contribute to reducing the negative or/and maximising the positive effects associated with CVC (e.g. via research on the subject matter of CVC, via climate change adaptation interventions, or policy attention on formulating robust national, and international climate change policies or strategies). In that light, globally, several empirical studies have contributed to the subject matter of CVC (see, e.g., Asare-Nuamah and Botchway 2019; Antwi-Agyei and Nyantakyi-Frimpong 2021; Behailu et al. 2021; Guodaar et al. 2021; Talanow et al. 2021; Tessema and Simane 2021). Similarly, it is worth acknowledging that different empirical studies have looked at the subject matter differently. Key among the thematic areas on the subject of CVC that have gained attention include: (i) understanding only farmers' perceptions of CVC without comparing with climatic data (see, e.g., Asante et al. 2017; Derkyi et al. 2018; Kolleh and Jones 2015), (ii) comparing farmer perceptions with climatic data (see, e.g., Asare-Nuamah and Botchway 2019; Amadou et al. 2015; Behailu et al. 2021; Dapilah and Neilsen 2019; Dapilah et al. 2019), and (iii) the nexus between perception and adaptation to CVC impacts (see, e.g. Arbuckle et al. 2013; Guodaar et al. 2021; Maddison 2007; Menapace and Raffaelli 2015; Singh et al. 2018; Singh 2020; Talanow et al. 2021; Tessema and Simane 2021).

Notwithstanding the contributions of the above methodological approaches to knowledge on the subject matter of CVC, some concerns have been identified by this study that need attention. To start with, this study argues that the approach of teasing out only farmer perceptions without comparing with climatic data is problematic as it is difficult to reflect on the implications of local adaptation or potential mal-adaptations because it is not compared with patterns of actual meteorological data. Similarly, the literature review suggests that, in the context of Sub-Saharan Africa (SSA), studies on CVC and adaptation nexus that have incorporated the analysis of climatic data have focused largely on interannual climatic events (e.g. total rainfall distribution across different years) (see, e.g., Asare-Nuamah and Botchway 2019; Dapilah and Neilsen 2019; Dapilah et al. 2019) with limited attention on the analysis of intra-seasonal climatic events such as the start and end of the rainy seasons (see, e.g., Amadou et al. 2015; Dakurah 2020). This study argues that intra-season (or within season) climatic events such as the start and the end of the rainy season are more critical for farmers in terms of their cropping decisions. For example, at the beginning of every agricultural season, farmers would ponder through several questions like (i) when is the rainy season going to start? (ii) will the agricultural season be characterised by dry spells—and for how long? (iii) when will the rainy season end? and (iv) how long will the season be, and what sort of crops would do well under the prevailing climatic conditions?

To contribute to our understanding of farmers' cropping decisions under climate variability and change, this study uses Doggoh and Tie of North-west Ghana as a case study. Consequently, the study employed daily rainfall data on the Babile station from the Ghana Meteorological Agency (GMET) for the analysis of relevant intra-seasonal climatic events that are critical to farmers' cropping decisions. Broadly, the study seeks to understand which crops farmers are selecting under CVC and why? Specifically, the study seeks to (i) understand the matches/mismatches between farmers' perceptions and climatic data, (ii)

characterise smallholder farmers' crop choice by teasing out the differences between current and past practices, and (iii) understand why smallholder farmers are responding or not responding to CVC via crop selection. This study contributes to our comprehensive understanding of intra-seasonal climatic events in the study area, and the decisions that farmers are making in terms of crop choice. In terms of policy relevance, it would be an opportunity to reflect on how farmers can be supported in terms of their crops selection to reduce the risk of maladaptation.

Empirical documentation on the subject matter of climate variability and change in Sub-Saharan Africa

For Sub-Saharan Africa (SSA), several observations have been documented on rainfall and temperature. On rainfall, there is uncertainty about its projections for SSA (see, e.g., Rowell 2012; IPCC 2014; IPCC 2022). For example, projected change in rainfall over SSA for the mid and late twenty-first century remains unclear. It is documented that, in regions of high or complex topography (such as the Ethiopian Highlands), down-scale projections indicate likely increase in rainfall and extreme rainfall by the end of the twenty-first century (IPCC 2014; IPCC 2022). The IPCC reports that there is uncertainty in rainfall projections because most areas in SSA lack robust observational data to draw reliable conclusion about rainfall events (IPCC 2014; IPCC 2022). On temperature, the IPCC reports that near surface temperature over West Africa and the Sahel has increased over the last 50 years (IPCC 2014; IPCC 2022). The above projections have implications for agricultural activities, income of farmers, and also food and nutrition security issues in Ghana. The justification being that out of a total agricultural land of approximately 13 million hectares with 57.6% under cultivation, only 0.2% of the cultivated land is under irrigation (MoFA 2018). The situation is more problematic in the context of northern Ghana which experiences a uni-modal rainfall regime meaning farmers only have a single farming season.

Empirically, the subject matter of climate variability and change (CVC) has gained attention in Sub-Saharan Africa (SSA) (see, e.g., Aidoo et al. 2021; Antwi-Agyei and Nyantakyi-Frempong 2021; Asare-Nuamah and Botchway 2019; Azare et al. 2020). Similarly, it is worth acknowledging that different empirical studies in SSA have looked at the subject matter differently. To start with, some studies have only focused on teasing out farmers' perceptions of climate variability and change without comparing with meteorological data (see, e.g., Asante et al. 2017; Derkyi et al. 2018; Kolleh and Jones 2015). It is worth acknowledging that this approach is limited as it is difficult to reflect on the implications of local adaptation or potential mal-adaptations because it is not compared with patterns of actual meteorological data.

Having recognised the weaknesses of understanding CVC from only farmers' perceptions, some studies have shifted their methodological approach to comparing farmers' perceptions with climatic data (see, e.g., Asare-Nuamah and Botchway 2019; Amadou et al. 2015; Behailu et al. 2021; Dapilah and Neilsen 2019; Dapilah et al. 2019). For example, Behailu et al. (2021) in a study that focused on Ethiopia examined farmers' perceptions of climate variability and extreme climatic events and compared that with climatic data. To that end, they employed descriptive data analysis methods and simple linear regression, nonparametric Mann-Kendall test, and Sen's methods to examine farmers' perceptions

and also have a sense of the prevailing climatic conditions of their study area. Consequently, they found that farmers perceived the rise of temperature and reduction of rainfall in their locality. On the analysis of the climatic data, Behailu et al. (2021) established that there is increase in minimum temperature and maximum temperature. However, their study revealed a reduction in rainfall per decade. In the context of Ghana, Asare-Nuamah and Botchway (2019) contributed to our understanding of CVC via analysis of data on farmers' perceptions and analysis of available climatic data from the Ghana Meteorological Agency (GMET) for six agro-ecological zones from 1989 to 2015. Using descriptive statistics, the Mann-Kendall test, analysis of variance, and post hoc comparison (using Tukey's HSD test), Asare-Nuamah and Botchway (2019) found increasing trend of temperature and decreasing rainfall across ecological zones. On farmer perceptions, Asare-Nuaamah and Botchway (2019) reported late onset and early of rainfall.

Additionally, the subject matter of CVC has gained attention in the realm of understanding the nexus between perceptions and adaptation to CVC impacts (see, e.g., Antwi-Agyei and Nyantakyi-Frempong 2021; Talanow et al. 2021; Tessema and Simane 2021). For instance, using the Fincha's sub-basin of the Blue Nile Basin of Ethiopia, as a case study, Tessema and Simane (2021) contributed to the literature on CVC by focusing on smallholder farmers' perceptions of CVC, associated impacts on agricultural sector, and farmers' adaptation decisions. In terms of results, Tessema and Simane's study revealed that temperature is on the increase, there is also increase in the frequency and severity of extreme weather events (drought and flood), and there is overall change in seasonality of rainfall over the last 20 years (Tessema and Simane 2021). Accordingly, this has translated into decline in the length of growing period, deceased variability of water availability, and increased crop damage due to pests, insects, diseases, and weeds. Consequently, Tessema and Simane (2021) reported that, in response to the above perceived changes in climatic conditions and the associated impacts, farmers have resorted to modifying their crops and livestock, investing in land and water management.

In a study that focused on North-east Ghana, Antwi-Agyei and Nyantakyi-Frimpong (2021) similarly contributed to the discourse on climate change adaptation. To that end, Antwi-Agyei and Nyantakyi-Frimpong (2021) collected data from 555 households in six communities in North-east region of Ghana. In terms of results, Antwi-Agyei and Nyantakyi-Frimpong (2021) reported that households in their study employ a mixture of practices to address the challenges associated with climate variability and change including resorting to the planting of drought-resistant crop varieties, intensification of irrigation, diversification of crops, and adjusting planting dates. On the other hand, Antwi-Agyei and Nyantakyi-Frimpong (2021) reported the sale of non-farm assets, charcoal production, selling livestock, and non-farm jobs as the coping mechanisms. Additionally, Antwi-Agyei and Nyantakyi-Frimpong (2021) reported gender differentiation in terms of the barriers to climate change adaptation with more women than men facing barriers such as inadequate market for agricultural produce, land tenure insecurity, and inadequate labour for farm operations, and limited irrigation. Again, focusing on the Guinea-Savannah agro-ecological zone of Ghana, Assan et al. (2018) explored coping and adaptation measures adopted by farm household heads in a quest to minimise the impacts associated with CVC—particularly on their livelihoods and well-being. To that end, Assan et al. (2018) collected data using focus group discussions, household surveys, and interviews with key informants. Assan et al. (2018)

reported that farm households that are headed by males relied on the sale of livestock as a coping mechanism whereas the farm households headed by females rely on borrowed money from village loans groups and savings. On the aspect of adaptation strategies, Assan et al. (2018) found that farm households varied their planting and harvesting dates, resort to the usage of improved varieties of crops, and also diversifying their crops. Based on their research findings, Assan et al. (2018) suggested that dam and or dugouts improved access to credit and market, postharvest facilities, and adaptation capacity— building resources would build the adaptive capacity of farm households—so that they will be able to maximise the positive effects associated with CVC and minimise the negative impacts that come with CVC.

Furthermore, the subject matter of CVC has been tackled from the angle of the role of indigenous knowledge influencing climate change adaptation (see, e.g., Guodaar et al. 2021; Zvogbo et al. 2022). For instance, Guodaar et al. (2021) study that focused on Ghana investigated how farmers are implementing indigenous adaptation strategies in relation to the climate risks—looking at both the household and community levels. In terms of scope, Guodaar et al. (2021) used three districts in northern Ghana as a case study and employed mixed methods approach. Guodaar et al. (2021) reported that farmers have perceived climate risks within their local area in terms of increased temperature, prolonged droughts, and erratic rainfall. This has consequently translated into affecting cropping calendars hence reducing crop productivity. According to Guodaar et al. (2021), farmers in response to these climate risks have employed indigenous knowledge—such as relocation of farms to water sources, neem leaf extract, organic manure application, and rainwater harvesting. Additionally, Guodaar et al. (2021) reported that there is an evolution of farmer's adaptation strategies over time as farmers are blending indigenous practices with modern technologies to enhance irrigation, planting drought resistant crops, crop diversification, and manure application.

Conceptual framework

This paper draws on the Drought Perception (TDP), Planned Behaviour (TPB), and the Social Identity (SIT) theories to guide the presentation of results. The TDP has been conceptualised along four constructs: memory, experience, definitions, and expectations. To Taylor et al. (1988), memory deals with the drought events that were part of farmers' direct experiences that can be recalled by farmers. Definition refers to a set of criteria, for example moisture shortage, for classifying a period as "drought" (see Taylor et el. 1988). Then, expectation of future drought includes how often farmers expect droughts to occur and how severe they expect droughts to be (Taylor et al. 1988).

In the 1970s, the Theory of Reasoned Action (TRA) was developed (Fisbien and Ajzen 1975). TRA posits that human behaviour is driven by behavioural intention, which is a function of two components—attitude and subjective norms. The former focuses on a persons' positive or negative feeling about performing a given behaviour while the latter represents the pressure from society about the performance of the behaviour. TRA assumes that behaviour takes place under volition; that is an individual deciding to perform a given behaviour or not at will. Having realised that certain forces outside an individual's volition could contribute to

their intentions and behaviour, the TRA was expanded by adding a third component that would influence an individual's intention, perceived behavioural control by Ajzen in the 1980s. Perceived behavioural control (PBC) refers to people's perceptions of their ability to perform a given behaviour.

The theory of social identity originates from two British social psychologists called Henri Tagfel and John Turner in 1979. Turner (1982) for example claimed that a person's sense of who they are is dependent on the group to which they belong. The main argument is that a person does not just have a personal selfhood, but a multitude of selves and identities associated with their affiliated groups. To that end, when a person perceives themselves as part of a group, that is an "in-group", and the other comparable groups that person does not identify with are called the "out-groups". To Turner (1982), SIT comprises three main processes that create the distinction between the in-group and the out-groups: *social categorisation*, *social identification*, and *social comparison*. The social categorisation element of SIT posits that categorisation is important to understand and identify people. The main rationale is that by people knowing the categories they belong to, they can understand themselves, and can define appropriate behaviour in accordance with the groups to which they and others belong. With the social identification element, the key message is that identification with an in-group goes along with the adoption of the group, and therefore people act according to the norms of the in-group. Lastly, social comparison means that the ingroup members compare themselves with other groups (i.e. out-groups). To maintain their self-esteem, Turner (1982) suggests that people and their group members compare their group favourably against other ones.

The above theories have been applied widely. For the TPB, see, for example, the following studies: Borges et al. (2014), Borges and Lansink (2016), Chin et al. (2016), Senger et al. (2017), Zeweld et al. (2017). And for the SIT, see, e.g., Terry and Hogg (1996), Terry et al. (1999), and White et al. (1994). In Fig. 1, the researchers argue that farmers' cropping decisions start with farmers' perceptions of CVC. Farmers' perception of CVC is shaped by farmers' memory, and other factors (including past experiences, climate information farmers receive from experts, and the cultural worldviews of farmers). However, this paper focuses only on farmers' memory—as it is easier to compare that with results from climatic data.

Again, in the framework, the researchers argue that perceptions of CVC shape farmers' attitude and PBC about cropping decisions under CVC. Likewise, this paper argues that farmers' attitudes and PBC will influence them to respond to CVC by selecting crops and crop varieties that are appropriately suited to the prevailing climate. For example, if farmers have a positive evaluation of cultivating a given crop under CVC, they will more likely cultivate that crop but where farmers have a negative feeling about cultivating a given crop, they will more likely displace it. Furthermore, farmers' identification with the *Dagaaba* tribe and its norms will potentially shape farmers' intentions to continue to grow some crops and not displace some other crops if they produce less yield under CVC due to the cultural value of these crops.

Additionally, the researchers suggest that farmers' cropping decisions under CVC are conceived along three pathways: (i) farmers focusing on yield maximisation by cultivating

crops or crop varieties that are better suited to the prevailing climate, or farmers displacing crops or crop varieties that are not better suited to the prevailing climate as the literature suggests (Kurukulasuriya and Mendelsohn 2007; Issahaku and Maharjan 2014), (ii) farmers not adapting to climate variability and change by still cultivating crops or crop varieties that are not suited to the prevailing climate (Ziervogel and Ericksen 2014; Chipanshi et al. 2003), and (iii) farmers cultivating both the varieties of crops that are suitable and not suitable to CVC.

Methodology

Site description

Doggoh and Tie villages of the Jirapa Municipality were selected to understand farmers' cropping decisions under CVC. The municipality is one of the 11 districts/municipalities that constitute the Upper West Region of Ghana (see Fig. 2 for the pictorial representation of the map of the Jirapa Municipality in relation to the Upper West Region of Ghana). Smallholder farm households were the primary unit of analysis. The rationale is that decisions about production, investment, and consumption are primarily taken at the household level in the northern part of Ghana (Van der Geest 2004).

Based on agro-ecological division, the Jirapa municipality is in the semi-arid Guinea-Savannah zone. This zone, unlike others (e.g. the coastal savannah, the deciduous forest, the transition zone, and the rainforest belts), is characterised by a single rainfall pattern which translates into farming taking place only once in a given year (MoFA 2018). Rainfall within the district lasts for about 5–6 months beginning from May to October, with a long-term mean precipitation of 900 mm Naab and Koranteng (2012). During April/May to October, the municipality experiences a single rainfall season induced by the moist monsoon winds with an intensity of 100–1100 mm per annum (GSS 2021). Mean annual temperature ranges between 28 and 31°C.

During the dry season (usually November to April) which however is variable, the area comes under the influence of the dry North-eastern trade winds affectionately called harmattan (Naab and Koranteng 2012). The municipality is characterised by intermittent tributaries of the Black Volta River—including Kaaba, Bapkong, Dazugri, and Telenbe (GSS 2021). These tributaries, however, do dry up during the long dry season, leaving the district with surface water catchment for domestic and agricultural purposes. The valleys of these tributaries have the potential for irrigation dams and dug outs—however, there are only a few small-scale dams and dugouts scattered around places such as Konzokalaa, Tizza, Chariea, and Ullo (GSS 2021). These dams, however, face many challenges including drying up quickly; hence, dry season agricultural activities do not go on for long (GSS 2021).

The municipality is predominantly characterised by agrarian activities with services, agro-processing, and other small-scale manufacturing activities on the low side. The 2010 Population and Housing Census (PHC) indicates that 67.1% of the population is engaged in agriculture, which is mostly subsistence in nature except for some few farmers who are engaged in large-scale production of cereals and legumes in Han and Mwankuri areas (GSS 2014).

Located about 5 km North-west of Jirapa (the capital town of the Jirapa Municipality), the inhabitants of Doggoh and Tie are predominantly peasant farmers who are into crop farming and livestock rearing. In addition, few people are into small-scale businesses such as petty trading, operation of beer bars, and sale of provision in shops (Dakurah 2020).

Method

The study employed both secondary and primary data. The former comprised rainfall data for Babile station that was obtained from the Ghana Meteorological Agency (GMET). The primary data was collected in the field. Mixed methods were employed to have a nuanced understanding of farmers cropping decisions. The research methods included wealth ranking by village leaders, village individual key informant interviews, semi-structured questionnaire, focus group discussions, and in-depth interviews. The research participants in this study involved 16 key informants (comprising both males and females, 8 in each village), 150 household heads (75 in each village), and 6 focus group discussions involving a combination of male and female farmers, only male farmers, and only female farmers (3 in each village). Also, the study engaged 34 in-depth household case studies (19 households in Doggoh and 15 in Tie). We targeted 20 household each for the case studies—however, the two villages were busy with funerals and farming activities. Therefore, the availability of respondents explained the difference between Doggoh and Tie in terms of the number of household case studies.

Multi-stage sampling was used for reaching out to the study respondents. The two villages were stratified into three wealth strata—poor, semi-rich, and rich via wealth ranking criteria that was developed by village leaders. The justification for the stratification was to ensure that different farmer groups (i.e. rich, semi-rich, and rich) were engaged in the study. Simple random sampling was applied in the selection of male-headed households (as the stratification established that many of the households in the two villages were headed by males). This gave every male-headed household within each of the wealth strata in the two villages an equal chance of being selected (Bryman 2016: 176). Given that few households are headed by females, care was exercised to include female-headed households in all the wealth strata to understand female cropping decisions under CVC. The participants for the FGDs, the HCS, and the VIKIs were purposively selected.

The data collection period was between January and October 2016[1]. The village key informant interviews involved the researchers engaging with people who were conversant with past and present agricultural systems, and a better understanding of the culture of the communities. Consequently, the village lead persons[2] suggested 16 persons (4 males and 4 females in each village) who were knowledgeable on farming systems in the communities.

[1] Note that this data was collected in 2016—hence, the results only apply to 2016 as farmers cropping decisions as at that time and now may not be the same.

[2] Village lead persons were two persons (1 male and 1 female) that the Assembly member (i.e. the representative of the Doggoh and Tie villages electoral area at the local government level) recommended to lead the researchers around the villages and make suggestions on key informants).

The themes covered included (i) crop cultivation in the past and now, and (ii) the value of the different farm fields now as compared to that of the past.

The wealth ranking was undertaken by village leaders who defined local criteria for the stratification of their villages into three wealth strata: rich, semi-rich and poor. The wealth stratification criteria included ownership of livestock, number of educated persons in a household, the nature of the household building, size of farm holding (reference was made to maize-w[3] farm size holding in the Doggoh village), number of married wives, and number of children of the head of the household. In the two research villages, there were some differentiation concerning the defined criteria concerning numbers (using wealth ranking criteria for the villages of Doggoh and Tie). Other criteria used for considering households as rich included the ownership of corn mills, stores, and drinking spots. Both men and women leaders were involved in the wealth ranking exercise.

Data was also collected from households using semi-structured questionnaire (SSQ). The SSQ had both open-ended and closed coded questions. The study administered the SSQ via the face-to-face method. The face-to-face technique permitted the interpretation of the questions in the local dialect (i.e. *Dagaare*). This was more appropriate as many of the respondents were unlettered, and it helped the research team to ask the questions in the local dialect. This led to a better understanding of the questions, with the respondents addressing the questions appropriately. Face-to-face allowed for prompting and probing which enabled respondents to understand and answer questions appropriately.

Household case studies (HCS) and focus group discussions (FGDs) were organised to have a nuanced understanding of why farmers are responding or not responding to CVC via crop selection. Several characteristics including the length of experience and involvement in agriculture, and the extent of knowledge about each of the villages were the criteria used for the selection of participants in the FGDs. In moderating the FGDs, care was taken in handling participants who wanted to over-dominate the discussions to enable less vocal participants present their views (Ricthie et al. 2014: 213). Generally, the female farmers were very quiet, and the male farmers were very dominant in all FGDs in both villages. Hence, separate focus group discussions were organised solely for individual sexes.

The study employed R-Instat (a statistical software application developed by the African Mathematics Initiative) for analysing the rainfall data. Daily rainfall data was first saved in acceptable formats that R-Instat would recognise and was inputted into R-Instat application. The starting point was to summarise the data from 1960 to 2016 looking out for years with lots of missing data. Of the years, 42 had very good data and 12 years (i.e. 1964, 1965, 1966, 1967, 1968, 1969, 1970, 1971[4], 1990, 2004, 2007, and 2008) were not good. R-Instat was used to perform statistical analysis for each of the rainfall events for the Babile station. In trying to make meaning from the results, two statistical steps were considered:

---

[3] Maize w – refers to maize (white colour).

[4] Note: 1971 for instance has about 31 missing data but the missing data was for the month of January, which is irrelevant in terms of the definition of the onset of the rainfall.

one was to fit a model for the start of the rainfall against year, and two, to generate statistical summaries of the climate events.

The data collected from the SSQ were analysed using the Statistical Package for the Social Scientist (SPSS). Questions with pre-coded alternatives were entered directly into the SPSS spreadsheet. In the case of open-ended questions, considerable amount of time was spent in going through all the questionnaires before editing and assigning codes. Interviews from qualitative data were first transcribed into English. The transcripts were inputted into Nvivo considering the significant themes and sub-themes of the research objectives and questions. The essence was to label words, phrases, and sentences through a process known as coding.

Results

Understanding the prevailing climatic conditions of North-west Ghana

This section presents results of the prevailing climatic conditions in North-west Ghana based on secondary data from the Ghana Meteorological Agency (GMET) followed by observations of farmers on the state of their local climate. Document review revealed that the Upper West Region has 13 climatic stations (GMET 2016)—see Table 1 in supplementary file. Two decisions were used in the selection of data for Babile climatic station: (i) proximity to the study villages in order to reduce the risk of spatial variability (Osbahr et al. 2011), and (ii) the quality of the available data. Per the quality of the available data, Wa station (100.0%) would have been the best station but it is far away from the study villages hence the decision to settle on Babile (85.4%) (the next after Wa with reasonable quality data).

The start of the rainy season

The start of the rain is critical as it influences the planting decisions of farmers (Antwi-Agyei 2012; Ingram et al. 2002). Similarly, other climatic events like the end of and length of the rainy season determine the sort of crops or crop varieties that farmers can cultivate in a given agricultural season (see, e.g., Dakurah 2020). The occurrence of dry spells is also problematic for farmers' cropping decisions as farmers may have to replant in the event of crop failure (Dakurah 2020; Horsefield 2016). In the context of this study however, the researcher computes the start of the rains with the consideration of no occurrence of dry spell conditions (i.e. definitions II and IV) as indicated in Table 1.

The decision to use the above two definitions is backed by the following reasons. Some farmers that may want to plant early in April once the rain begins (i.e. risk tolerant farmers) and other farmers who would not want to take the risk (i.e. risk averse farmers) hence will wait until May to begin to plant when they can say the rains are now reliable. Similarly, the consideration of whether there will (not) be a dry spell is necessary because a rainfall that is followed by a dry spell is not an effective rainfall as farmers may have to replant and that translates into acquiring farm inputs such as seeds and fertiliser (Dakurah 2020). This will be problematic for smallholder farmers in rural North-west Ghana who are characterised by high poverty levels (GSS 2021).

In trying to make meaning from the results, two statistical steps were considered: one was to fit a model for the start of the rainfall against year, and other was to generate statistical summaries of the climate events. On the April and May definitions with the consideration of the no occurrence of a dry spell condition, the model showed no statistical significance for both April (i.e. *p*-value of 0.23) and May (*p*-value = 0.33)—see Figs. 3 and 4, and Table 2 for the details.

The end of the rainy season

Aside the start of a rainy season, the end of the rainy season is equally critical as the two climatic events will determine how long or short a given agricultural season will be and hence the decisions that farmers can make. In this study, the simple water balance equation as suggested by Stern et al. (2006) was used to define the end of the rainy season. In this definition, it is assumed that the soil capacity is 100 mm, and evaporation is taken as 5 mm per day (Stern et al. 2006). Based on soil capacity and evaporation, the end of the rainy season is defined as the first occasion after the 1st of September when the water balance drops to zero. The result presented in Fig. 5 depicts no trend (*p*-value = 0.81) in the end of the rainy season from 1960 to 2016, but a variability in the end with the earliest end being 02 September 1983, the mean being 23 October, and the latest 23 November 1969.

Understanding farmers' perception of climate variability and change

This section explored how farmers interpret climate patterns, through their own memory. Understanding farmer perceptions of CVC has been documented to have diverse policy relevance including (i) to understand farmers' behaviour about adjustments they (will) make in their farming practices in response to climate change consequences (Maddison 2007; Nguyen et al. 2016; Tambo and Abdoulaye 2012), (ii) to understand how perception influences farmers willingness to adopt adaptation practices is critical for the development of effective and efficient climate response strategies (Habiba et al. 2012; Li et al. 2017; Nguyen et al. 2016), and (iii) understanding of farmers' knowledge of risk perceptions can enable policy makers and outreach professionals to target information or to 'de-bias' incorrect subjective beliefs (Arbuckle Jr et al. 2013; Dohmen et al. 2009; Patt and Schroter 2008).

Farmers' memory of climatic events

The results showed that the rainfall pattern in the past (in the context of this study, past meant 20–25 years ago—i.e. the 1990s) and now are not the same for both Doggoh and Tie. Farmers perceived a shift in the onset and cessation of rainfall from March to June and from November to October respectively in both villages (see Figs. 6 and 7). There are similar reports on shift in the onset and cessation of the rainy season in Sub-Saharan Africa (see, e.g., Amadou et al. 2015; Asare-Nuamah and Botchway, 2019; Codjoe and Owusu 2011; Osbahr et al. 2011). For example, in a study that focused on the deciduous agro-ecological zone of Ghana, Asare-Nuamah and Botchway (2019) reported a delay in onset and early cessation of rainfall.

On temperature, all the respondents in Doggoh and Tie observed that temperature is now warmer than that of the past. Likewise, on climate extreme events, the majority of respondents in Doggoh (70.7%) and Tie (92.0%) indicated there are more floods now than that of the past. However, on droughts, the majority in Doggoh (52.0%) observed increased in droughts and the majority in Tie (42.0%) observed a decrease in droughts now as compared to that of the past.

Understanding farmers cropping decisions in Doggoh and Tie villages

Current crop choices

(a) Main crops cultivated by farmers

The respondents were asked to mention the crops that they currently cultivate. In both villages, maize (w)[5] (i.e. zea mays), groundnuts (i.e. arachis hypogea), sorghum (i.e. bicolor/vulgaris), maize (y)[6] (i.e. zea mays), beans (i.e. vigna unguiculata), bambara [7](i.e. vigna subterranea), and yam (i.e. dioscorea spp.) were the crops named. It emerged that all the crops are cultivated for household food needs except groundnuts that is mainly sold. Accordingly, the cash from groundnuts has a variety of uses including paying for school fees, medical bills, and for funeral activities. A participant observed "as we do have funerals, funeral guests come. Yesterday's funeral for instance, if I did not have cash, I would have sold 1 or 2 bag (s) of groundnuts. Then the money would have been used to buy drinks for funeral guests. Similarly, the money could have also supported the purchase of a coffin. Furthermore, someone could come to the funeral and fall sick and the money could have been used to cater for that person" (HCS-4-D-Male).

In terms of the farmland size allocation for crops, the respondents in Tie cited maize (w), groundnuts, sorghum, and beans as the largely cultivated crops. In addition to the above largely cultivated crops in Tie, the respondents in Doggoh mentioned bambara groundnuts and maize (y) as among the largely cultivated crops now (see Fig. 8).

How different are the crops cultivated now, as compared to that of the past? The results from the SSQ illustrated that the magnitude of cultivation of crops as manifested in the farmland size allocation for different crops has changed now as compared to that of the past for both Doggoh and Tie (see Fig. 8). The respondents ranked sorghum, followed by millet (i.e. pennisetum cinereum), and maize (y) as the most important crops in the past. On the other hand, farmers ranked maize (w), followed by groundnuts, and sorghum as the most important crops regarding the magnitude and the number of farmers who cultivate them now in both Doggoh and Tie. Comparing the results in Fig. 8, millet has lost its place as among the main crops cultivated in both Doggoh and Tie villages. Similarly, sorghum has also lost its position to maize (w) as the highest ranked crop among the main crops.

[5] Maize (w) – this refers to maize white colour.
[6] Maize (y) – this refers to maize yellow colour.
[7] Throughout the paper b. groundnuts will be used to represent bambara groundnuts.

(b) Spatial location of crops: understanding why crops are assigned to different farm fields

The results showed that households in both Doggoh and Tie have compound, riverbank, and bush farm fields (VIKI Interviews, Doggoh and Tie). Similarly, it emerged from the VIKI data that women and children are tasked to cater for the bush farm fields where they go to the farms in the morning and return in the evening—in the case of the bush farm fields that are not far away from their houses. In the context of the distant bush farm fields, tents are constructed to house the farm care-takers who only get back home after the crops are harvested. In all of these contexts, men also engage in the farming activities but usually get home when they are done with their farming tasks (VIKIs, Doggoh and Tie). Furthermore, it emerged from the data that different crops are suitable for the above farm fields. Specifically, respondents noted that sorghum, maize (y), maize (w), and millet (in small quantity) are cultivated on the compound farm fields. Accordingly, the compound farm fields are fertile due to (i) the dumping of refuse (SSQ26-T-Male, SSQ3-D-Female, SSQ16-D-Female, SSQ29-T-Male), and (ii) the presence of animal droppings (SSQ27-T-Female, SSQ11-D-Male, and SSQ8-T-Female). The respondents observed that they cultivate the above crops because these crops need very fertile land to do well. However, the results revealed that maize (w) can be cultivated outside the compound farm fields on condition that the farmer applies fertiliser as detailed by a participant in a focus group discussion in Tie as follows: "… unless you have fertiliser, maize (w) will not do well in any bush farm field. When the seeds are sown, they germinate nicely but fail to grow, and yield properly. Once the fertiliser is not available, it will not do well" (FGD, Female participant, Tie Village).

In terms of the bush farm crops, it emerged that Bambara groundnuts, beans, millet, and groundnuts are grown there. It emerged that groundnuts and bambara groundnuts are not ideally suited to be cultivated around the compound farm fields because there will be more vegetative growth as against less reproductive growth that will lead to pods/seeds production as they do not need very fertile land. A participant in Doggoh noted "If you cultivate the Bambara groundnuts around the house, it will not do well. When you farm them around the house, they will only grow well but will not yield. That is why we have to send them the bush. It in the bush that I that I farm my bambara groundnuts. The nutrients will make them grow well but will not yield, if you farm around the house" (HCS-5-D-Male).

How has the spatial allocation of crops changed now, as compared to the past? The results indicated that farmers now allocate less attention to the bush, and riverbank farm fields, and more time for the compound farm fields due to climate change, women now been engaged in diverse economic activities, migration[8] of young energetic males to southern Ghana, priority in sending children to schools, and high labour demands of river bank farm fields (VIKIs, Doggoh and Tie).

On the aspect of climate change, results from the data revealed that climate change is problematic for all farm fields as the rainfall pattern now is no longer reliable as compared to that of the past. Consequently, the crops that are grown in the bush farm fields (particularly millet are not suitable to the prevailing climate). For example, a participant in

[8] Note that these able young men migrate seasonally and return to assist in farming activities later in the farming season (VIKIs, Doggoh and Tie).

the FGD observed "…it does no longer rain the way it used to rain in the past. So, if we cultivate the bush farm fields and sow millet and sorghum that were largely cultivated in such farm fields, they will not do well" (FGD, Male Participant, Tie). On the diversification of women's livelihood activities, a participant in Tie noted "now you see, after sowing crops, I may want to brew pito[9] or sell koosee[10]. So, if I go to sell koosee at the market square, who will be there to take care of the crops in the bush farm fields" (FGD, Female participant, Tie). Here, it can be deduced that, because of multiple activities that women are now engaged in, and the distance of the bush farm fields, they are no longer available to engage in the bush farm fields. As for the compound farm fields, the distance permits women to spend part of their time in catering for the crops and also engaging in other economic activities such as brewing and sale of pito, and frying and selling of koosee. Additionally, the participants in the FGDs pointed out that riverbank farm fields are labour intensive that require energetic-abled young men to raise big mounds. However, it emerged that due to the migration of the younger generation to the southern part of Ghana in search for "greener pastures", leaving behind the aged at home, many households no longer cultivate the riverbank farm fields. A participant in Doggoh observed "my son, the riverbank farm fields require that we raise big mounds for the crops. So, right now, I am the only farmer at home as the young ones are in school and the bigger sons have migrated to farm in the south. So now that the rainfall is no longer regular, I have decided to focus on the compound farms that require less labour as I am old and weak" (HCS-15-D-Male).

Understanding farmers' responses to climate variability and change

The results in the previous section revealed that farmers' perceptions (changes in rainfall) have largely disagreed with meteorological data (variability in rainfall events). Whether variability or changes in climate, it is worth acknowledging that the two are problematic to farmers in terms of their agricultural decisions. Consequently, this section attempts to specifically tease out how smallholder farmers are responding to climate variability and change (CVC) via crop selection.

To conceptualise the findings of this section, the study employed the Theory of Planned Behaviour (TPB) and the Social Identity Theory (SIT). In terms of structure, the researchers first present results by characterising farmers in terms of those who are responding or not responding to CVC. Next, the study presents results on how farmers' attitude, perceived behavioural control (PBC), and social identification shape cropping decisions under CVC.

Characterising farmer responses to climate variability and change

The results revealed two pathways regarding farmer cropping decisions under CVC for Doggoh: (i) farmers who cultivate the improved variety of groundnut only (i.e. kyaana) and farmers who cultivate both kyaana, and traditional variety of groundnuts (dagasinkaa). It emerged that kyaana is also known as kpankpaaba groundnut (VIKIs, Doggoh and Tie). However, in Tie, three pathways emerged: (i) farmers who cultivate only kyaana, (ii) farmers who cultivate only dagasinkaa, and (iii) farmers who cultivate both the kyaana and

[9] Pito is a local alcoholic beverage made from sorghum.

[10] Kosee – these are cakes made using oil and beans flour.

dagasinkaa—note the focus was only on groundnuts as results from the SSQ indicated that it was groundnuts that farmers cultivate both the local and improved varieties. Therefore, the focus of this subsection is on understanding those farmers who have changed variety entirely, kept both varieties, and farmers who have not changed the dagasinkaa.

Doggoh village: who cultivates the traditional variety, and who grows the improved variety? In terms of sex, age, wealth status, and level of educational attainment, the results showed that more female farmers, farmers aged 21–40 years, poor farmers, and uneducated farmers cultivate the improved variety of groundnuts as compared to their respective counterparts. Similarly, the results revealed that more male farmers, old farmers, semi-rich farmers, and educated farmers cultivate the both improved and local varieties than their respective counterparts (see Table 3 for detailed statistics).

Tie village: who cultivates the traditional variety, and who grows the improved variety? On the elements sex, age, wealth status, and level of educational attainment, the results revealed that more female farmers, farmers aged 21–40, poor farmers, and uneducated farmers cultivate the improved variety of groundnuts as compared to their respective counterparts. In terms of cultivation of the local variety of groundnuts, the results showed that more male, old farmers, and educated farmers undertake that as compared to their respective counterparts. For farmers who cultivate both the improved and local varieties of groundnuts, the results showed that more male, old, rich farmers cultivate that than their respective counterparts. However, the results indicated that same proportion of educated and uneducated farmers cultivate both local and improved varieties of groundnuts (see Table 4 for detailed statistics).

Farmers' attitude and responses to climate variability and change

Ajzen (1991) argued that attitude is the degree to which we have a favourable or unfavourable evaluation of the behaviours we perform. In the context of this study, smallholder farmers' attitudes are the negative or positive evaluations of their crop selection decisions under climate variability and change (CVC).

(a) Farmers' negative attitudinal belief constructs and cropping decisions

Farmers observed perceived poor yield, perceived difficulty in crop cultivation, and processing of yield, and perceived short duration of the rainfall season as the constructs of unfavourable evaluation of cultivating crops under CVC. The details are discussed in the following.

Perceived poor yield and farmers' intention to displace or reduce the farm size of crops. The results from the HCSs demonstrated that farmers' evaluation of the unsuitability of the local varieties of sorghum (i.e. the *gyibaraa*, *kaziedanbille*, and *konye*) and groundnuts (i.e. *dagasinkaa*) because they produce poor yield under the prevailing climate, has weakened farmers' intention to grow such varieties.

For sorghum, results indicated that the short duration of the current pattern of rainfall and the displacement of bush farm fields have contributed to the displacement of the *konye* and

kaziedanbille varieties. A participant detailed "for now, the varieties of sorghum that we used to grow are no more. I will not get them again. For the gyibaraa variety for instance, it takes a long time to mature. There was a time that we cultivated it but it did not mature. We farmed very late that year hence it did not mature well. Because of that, we have changed it to a different variety called kundabuo. You see, the rainfall is no more raining as it used in the past. In those days, around February, we used to sow kaziedanbille. Then in March, we sowed konye, then in May, we sowed the gyibaraa around the compounds. But now, the rain, what time does it come? Even in June, sometimes it does not start. Sometimes it is always in July" (HCS-5-D-Male).

The above suggests that HCS-5-D-Male is reasoning along maximising yield hence, in order to meet that objective, he has traded off the long duration varieties of sorghum (i.e. *kaziedanbille*, *gyibaraa*, and *konye*). The above results are similarly reported in the literature (e.g. Issahaku and Maharjan 2014). It is not surprising at all that the *kaziedanbill*e and *konye* varieties of sorghum (which are bush farm field crops) are been displaced as results in the "Farmers' memory of climatic events" section demonstrate that bush farm fields are no longer attached much importance due to farmers' unfavourable evaluation of cultivating crops there.

Perceived difficulty in harvesting, and processing of crops. The results indicated that farmers' evaluation of the difficulty involved in the processing of *dagasinkaa* under either been displaced by some households or the farm size for its cultivation has been reduced by some households because of the difficulty involved in processing it after harvesting.

For *dagasinkaa*, farmers argued that the ground becomes so hard due to the early cessation of rainfall. Farmers added that, during harvesting, they must manually use a hoe to knock the ground to get it softened before the *dagasinkaa* can be uprooted. A participant noted: "The harvesting of dagasinkaa is difficult. When you farm it, the rain stops by the time it gets to the time for harvesting. Hence you cannot uproot it with your hands. And if you do not hire labour or get voluntary labour, me sitting like this I cannot harvest dagasinkaa unless I beg someone to come and harvest for me. So, I chose to cultivate the one that is easy for me to harvest. That is why I no longer cultivate the dagasinkaa" (HCS-10-D-Female).

For millet, the results from the village key informant interviews (VIKIs), household case studies (HCSs), and the participation observation revealed that the *zie-kpong*[11] has been displaced by all households and the farmland size for the *zie-lee*[12] has been reduced. CVC have been noted by all the households as the major drivers of millet cropping decisions. In addition, farmers reported the difficulty and cost associated with the processing of millet, and young women's resistance to process it as it is associated with dirt and itches the skin also account for its displacement. A HCS opined "you see, the processing of millet is very difficult- you need to plead with people to come and help thresh it after harvest. In that regard, when people come, you need to cook for them and brew pito for them… women

[11] *Zie-kpong* – interviews with the village key informants suggest that *zie-kpong* takes longer time to mature.

[12] *Zie-lee* – even though this is a shorter duration variety than the *ziekpong*, the village key informants indicated it is equally not suitable to the prevailing changing climate.

need to winnow millet again you cannot rely on only family labour to do that. Also, you see, the young ladies these days are modern girls and do not want to winnow millet, get dirty and scratch around their skin. There is also high cost involved in processing it hence we just cultivate it little because the food from it tastes good (HCS-9-D-M**)**.

(b) Farmers' positive attitudinal belief constructs and cropping decisions

The results revealed that farmers are utilising the opportunities associated with the changing climate via the cultivation of improved varieties of crops that are better suited to the new climate. It emerged that perceived yield benefits and perceived economic advantages are the factors shaping farmers' cropping decisions. Perceived yield benefits and farmers' cropping decisions The results revealed that, apart from millet that respondents claimed they do not have any improved variety, there are improved varieties for groundnuts, sorghum, beans, and maize (both white and yellow colours).

For sorghum, even though it has lost its place as the highly cultivated crop to maize (w) and groundnuts as indicated in Fig. 8 for both Doggoh and Tie, all households have switched from the traditional varieties to the cultivation of two new varieties known as *kundabuo* and *pookye.* The word *kundabuo* literally means "cannot buy a goat" (VIKI-1-D-Male).

Several interpretations have been given to the meaning of the names given to the new varieties of sorghum. A male participant in Tie explained *kundabuo* as follows: "Ok, it means, it matures very fast, and you also eat it very fast, so how can you buy a goat? Hahahah. It finishes very fast. So, you cannot buy a goat. So, it cannot last for long. So that is why they call it *kundabuo*" (HCS-15-T-Male). In Tie, a participant gave a different meaning to *kundabuo* as he opined that "You see, instead of you getting a goat to go and sell in the market to buy food to eat, God has blessed us with this variety that matures so early hence no need to send any goat to the market to sell as we rely on that. That is why we call that *kundabuo*" (FGD, Male Participant, Tie). For *pookye*, HCS15-D-Male detailed its meaning as "Ah, the *pookye*, ah, when you sow it today, 'the next two days', it ready for harvesting. We just farmed this one just recently and just now it is almost ready for harvesting. So, in few days, it will be ready for harvesting. So that is why we call it *pookye*".

On the element of beans, it emerged that farmers have switched from the traditional varieties (i.e. *beng-gbere* and *wongtelle*) to the cultivation of two improved varieties, *tigboro* (also known as *pogba-bawullo*[13]) and *oomongdoo*[14] which are better suited to the prevailing climate (VIKIs, Doggoh and Tie). A male HCS in Doggoh noted that the *pogbabawullo* variety of beans produces very good yield hence warrants the farmers (i.e. men) who cultivate it to be prepared in terms of the labour demands (HCS-7-D-Male). Similarly, HCS-7-D-Male gave details of the *oomongdoo* variety as follows "… hahaha, we call it *oomongdoo* because the woman will sit and when she sees the husband going somewhere, she quickly puts it on fire and it gets ready soon and she will finish it before the husband comes back" (HCS-7-D-Male).

---

[13] *Pogba-bawullo* – from the interviews, it emerged *ti-gboro* is also known as *pogba-bawullo* (literally meaning how many wives) or *Pogba pie* (10 wives) (VIKI-3-D-M, VIKI-3-T-M).
[14] *Oomongdoo* literally means eat without men (VIKI-4-D-F, VIKI-4-T-F).

Perceived economic advantages. Moving beyond climate as the primary driver of farmers' cropping decisions, it emerged that economic factors also play a role. Specifically, farmers reported that market women prefer *kyaana* to *dagasinkaa.* To that end, farmers observed that traders buy *dagasinkaa* if it is in large quantity as noted by HCS-10-D-Female "…for *dagasinkaa* only a few traders will buy it. Because they do not get much to meet their needs hence fewer traders buy the *dagasinkaa*. So, if you take few bowls of *dagasinkaa* into the market, they will not buy" (HCS-10-D-Female). Similarly, it emerged that traders conditionally buy few bowls of *dagasinkaa* where the farmer is offered lower than normal price as observed by a case study participant "in some instances, one can send the *dagasinkaa* to the market but will not get a buyer; you are then compelled to transport it back to the house. Sometimes too, the buyer will offer to buy at cheaper price" (HCS-5-D-Male).

Similarly, the data showed that *kyaana* attracts higher price than the *dagasinkaa* hence influence farmers to cultivate more the former. Farmers observed that the preference and the higher market value of *kyaana* are explained mainly by it containing more oil and availability in large quantities that readily meets the market needs of traders. A participant observed: "it is the *kpankpaaba* that traders will buy first. Because, those of us that farm *dagasinkaa* are not many. Maybe, someone needs a bag of groundnuts and he will not get enough *dagasinkaa* to fill the bag early. So, if you send the *kpankpaaba* to the market, it will finish early because, many farmers send that to the market hence market women can easily get a bag of groundnuts. In the market, if *kpankpaaba* will cost GH₵ 8.00 *dagasinkaa* will cost GH₵7.00" (HCS-9-T-Male).

Farmers perceived behavioural control and crop selection decisions

To the TPB, perceived behavioural control (PBC) is our perceived ability or inability to perform a given behaviour (see, e.g., Ajzen 1985). In the context of this study, smallholder farmers' PBC is how they feel about their ability or inability to select crop under CVC. This suggests that farmers' perceived ability will drive their intention to perform the behaviour (i.e. select crops under CVC), and their perceived inability will constrain their intention to perform the behaviour.

(a) Farmers' perceived ability and cropping decisions under CVC

The results from the interviews with farmers and stakeholders[15] revealed that agricultural information and support farmers receive from stakeholders have contributed to their PBC. Farmers reported that they have displaced some crop varieties and cultivate some due to the information they receive from stakeholders. A participant revealed that "You see, the staff of Ministry of Food and Agriculture (MoFA) tell us not to cultivate the traditional varieties of sorghum and maize. Therefore, we usually go to the office of MoFA and get the improved variety of maize known as obaatanpa as it does well under the prevailing changing climate" (HCS-7-T-F).

[15] Stakeholders – Ministry of Food and Agriculture (MoFA) and Non-Governmental Organisations (NGOs).

Similarly, it emerged from the stakeholders that they have crop demonstration fields where local and improved varieties of same crops are cultivated, and after harvest, farmers can see the yield differentials hence take decisions as to which variety to cultivate. A stakeholder from the Savannah Agricultural Research Institute (SARI) who works for Climate Change, Agriculture, and Food Security (CCAFS) observed "you see, in the village of Doggoh, we have a demonstration field where we cultivate the old varieties and improved varieties of crops together with farmers- then by the end of the agricultural season, they make a decision as to which variety to cultivate" (SIKI-2-CCAFS-M). Likewise, stakeholders support farmers with improved varieties as noted by a MoFA staff "there is this new variety of maize we call 'wongdata' which we provided free-of-charge to farmers last year- those farmers that have cultivated this, others have seen how suitable it is to the climate and people are calling for this variety- next year we doubt if we can even meet the demand for that variety" (SIKI-1-MoFA-M).

(b) Perceived inability and farmer cropping decisions under CVC

Inadequate labour and the displacement of crops under CVC The results indicated that households' inability in terms of inadequate labour has led to the displacement, and the reduction of farm size allocation of zie-kpong and zie-lee varieties of millet respectively in both Doggoh and Tie. A participant noted "… now we do not longer cultivate millet in large quantity-those days, we were many in the household but now I am alone. When I farm small, I get tired hence cultivate millet small because it needs longer duration of rainfall to mature well but the rainfall ceases early" (HCS-15-T-Male).

Similarly, it emerged that the wongtelle variety of beans which is cultivated on the riverbank farm fields has also been displaced by households. A participant observed "…you see, I do not longer cultivate the wongtelle variety of beans because I do not have a farmer- my husband is dead. He used to cultivate the farm field around the riverbank but now these children do not want to cultivate around the riverbanks. But wongtelle is a riverbank crop" (HCS-16-D-Female).

Economic inability, and farmer cultivation of crops. The results revealed that the traditional variety of groundnuts improves the nutrients of the soil hence even though farmers understand that it produces less yield under CVC, they still cultivate it as an alternative to purchasing fertiliser. A male participant indicated that he practices crop rotation by cultivating maize (w) on the farm fields where dagasinkaa was cultivated in the last season—and this reduces the burden of applying fertiliser to the maize (w) as follows: "It means that, the way the dagasinkaa are, they have fertiliser. If you look at the dagasinkaa, when I farm here like this, the next season when I farm maize, if you look at this side, can you not see the maize there, last season, I farmed the dagasinkaa there. It means that because I farmed the dagasinkaa there, I have not applied fertiliser to maize there as I would have done on the portion, I farmed the Kyanna. This is because the dagasinkaa has manure than the Kyanna. Is the yielding that is not always up to the Kyanna but is because of the manure that I farm for it makes the farm to have dirt for me to farm later in the next season. That is why I cannot stop farming the dagasinkaa". (HCS-9-D-Male). The illustration here by respondent

"HCS-9-D-Male" indicates a trade-off of getting better yield to ensuring that the soil fertility is improved via the cultivation of the dagasinkaa variety of groundnuts.

Social identification, and farmers' intention to select crops under CVC

"When you grow up to see your father doing something, you do not have to abandon it. For example, if you grow up to see your father with cattle you cannot chase them away unless a thief comes to steal them, you must take care of them. That is why I still cultivate the dagasinkaa" (HCS-13-T-M).

As argued in the "Conceptual framework" section, the researchers are of the view that the identification of farmers in Doggoh and Tie with the *Dagaaba* tribe (i.e. the in group) comes with living along the cultural pathways of the group as suggested by Tajfel and Turner (1979). It emerged from the key informants' data that sorghum and *dagasinkaa* variety of groundnuts have cultural values. Specifically, the following themes emerged from the data to buttress the need to cultivate sorghum and dagasinkaa under CVC include (i) continuation of the cultural pathways of the forefathers, (ii) symbolic and ritual aspects of the uses of sorghum, (iii) good food taste from *dagasinkaa*.

(a) Continuation of the cultural pathways of the forefathers

The results revealed that because of social identification which comes with farmers in Doggoh and Tie being socialised along the farm culture of their forefathers, some farmers still cultivate *dagasinkaa* as a way of not displacing what has been handed over to them from their forefathers. In Tie, a participant explained "when you grow up to see your father doing something, you do not have to abandon it. For example, if you grow up to see your father with cattle you cannot chase them away unless a thief comes to steal them, you take care of them. That is why I still cultivate the *dagasinkaa*" (HCS-13-T-M).

(b) Cultural food, and farmers' intention not to displace *dagasinkaa* under CVC

The results indicated that social identity similarly manifests itself in the food culture of people of Doggoh and Tie. Even though results in the previous sections revealed many advantages of *kyaana* over *dagasinkaa*, the data revealed that the preference for soup made from the latter increases farmers intention to cultivate it in small quantity. The justification is to ensure they do not compromise the good soupy taste from *dagasinkaa*. In Doggoh, a participant argued "you see, once you prepare groundnuts soup with either *kyaana* or *dagasinkaa*, they both alike but not the same. The soup from the latter is heavier and tastes better than soup from the former. The two are just like *tuo-zaafi* from maize and sorghum in which the latter has more 'weight' than the former" (HCS-8-D-Male).

Similarly, VIKIs reported that groundnuts within the *Dagaaba* culture are eaten also in the form of being roasted or boiled. It emerged that the *Dagaaba* people prefer to eat the groundnuts that is *dagasinkaa* variety than the *kyaana* variety. Key informants explained "the *dagasinkaa* has less oil as compared to that of the *kyaana* hence you can eat more of the former than the latter when they are roasted" (VIKIs, Doggoh and Tie).

(c) Symbolic and ritual significance of crops and farmers' cropping decisions

Even though results in the previous sub-sections indicated that farmers have displaced the traditional varieties of sorghum (i.e. *konye*, *kaziedanbille*, and *gyibaraa)* and now cultivate the improved varieties (i.e. *kundabuo*, and *pookye*), the data similarly revealed that farmers' future intentions are that they would be unwilling to displace the available varieties of sorghum if they are not suitable to the prevailing climatic conditions. For example, results from the Likert scale (see Fig. 9) revealed that all (i.e. 100%) and 86.7% respectively Doggoh and Tie have the intentions not to displace the available varieties of sorghum in the future if they are not suitable to the prevailing climate.

The results revealed that sorghum is critical in the sociocultural lives of the people of Doggoh and Tie. It emerged that funeral is one of the social activities that bring and unite the people of Doggoh and Tie with the surrounding villages and towns (VIKIs, Doggoh and Tie). Also, the results indicated that sorghum is core in the activities of funeral activities of the people of Doggoh and Tie, and for that matter, the *Dagaaba* people at large (VIKIs, Doggoh and Tie). The respondents observed several roles of sorghum in funerals. It emerged that *kagyin* (tight pieces of sorghum as shown in Fig. 10) is placed on *paalaa* (where dead bodies are staged during funerals—VIKIs, Doggoh and Tie). Accordingly, the *kagyin* represent the farming trade of the deceased when he/she was alive and is a "must" during funerals. A VIKI in Doggoh observed "okay, you see, when someone dies here, it is a must that his/her trade is exhibited at the funeral ground to signify that was his/her trade while alive on earth. That is why it is a must that when someone dies in my household as a father, I need to get kagyin. If I do not even have it, it is a must that I get it from somewhere. When you tell people, you need kagyin for funeral issues, no one will deny you that. If elderly people come for funerals and realise that there is no crop on the paalaa especially kagyin, they will ask 'he did not farm or what? Or have you finished eating all the farm produce or what?'". (VIKI-2-T-Male).

Secondly, the data revealed that sorghum is used for brewing *pito* (an alcoholic beverage) to cater for the food and thirst needs of funeral guests. VIKIs reported that during funerals in Doggoh and Tie, *ko-kouw* (literally funeral "water") which manifests largely in the form of *daga-daa* (i.e. *pito*) or beer or any other alcoholic beverage is offered to funeral guests. A participant noted "if you observe well, you will realize that in every funeral where pito is not available, it is often tough to celebrate such funerals. The attendants become stranded on the funeral ground and try to find their own ways of quenching their thirst. When it's like that many of them leave the funeral ground premature". (HCS-6-D-Male).

Thirdly, it emerged that *kagyin* is used by the undertakers to perform ritual sacrifices to cleanse themselves of the dirt associated with undertaking the decease. A participant explained "they say the guys who dig the grave and in-charge of burying the corpse, there is usually some dirt associated with their work. So, the first sand that they get in trying to dig the grave is picked and then once they grind the crops meal for them at the funeral, they add part of the sand to that perform some rituals in order to cleanse themselves. They say 'bobo' (some illness) can get someone and the fellow begins to lose their hair. But once rituals are performed, they are 'bobo' free" (VIKI-7-T-Male).

Discussion

This paper sets out to understand farmers' cropping decisions under climate variability and change (CVC) using Doggoh and Tie of North-west Ghana as a case study. To that end, the paper specifically looked at the following: (i) to understand the matches/mismatches between farmers' perceptions and climatic data, (ii) to characterise smallholder farmers' crop choice by teasing out the differences between current and past practices, and (iii) to understand why smallholder farmers are responding or not responding to CVC via crop selection. The study employed the Theory of Drought Perception (TDP), Theory of Planned Behaviour (TPB), and Social Identity Theory (SIT) to conceptualise the findings.

On objective 1 of this study, the findings of the study revealed that farmers' perceptions (i.e. changes in climatic events) largely mismatched that of meteorological data (i.e. no evidence of a change but rather variability in climatic events). Specifically, farmers reported a shift in the onset month of rainfall from March to June and cessation month from November to October. The late onset and early cessation of rainfall now, based on farmer perceptions, is similarly reported by other studies in Sub-Saharan Africa (SSA) (see, e.g., Asare-Nuamah and Botchey 2019; Cherinet and Mekonnen 2019). For example, Cherinet and Mekonnen (2019) in their study in Ethiopia reported that farmers have perceived a shift in the onset of rainfall month from June to July. Unlike this study, findings from Cherinet and Mekonnen's (2019) study suggests that farmers' perceptions of the onset of the rainfall agree with that of the meteorological data. It is also worth acknowledging that, unlike this study, climatic data showed variability whereas farmers' perceptions indicated change in climatic events; some studies have findings where both farmers' perceptions and meteorological data agreed that there is variability in climatic events (see, e.g., Rapholo and Makia 2020). In the context of Ghana, it is worth acknowledging the farmers' perceptions of late onset and early cessation of rainfall have been reported by studies in other agro-ecological zones in Ghana—for deciduous forest zone (see, e.g., Asare-Nuamah and Botchway 2019; Codjoe and Owusu 2011) and sudan savannah zone (see, e.g., Amadou et al. 2015).

In terms of objective 2, the results of this study revealed changes in the crop choice of Doggoh and Tie as manifested in households attaching more attention to compound farm fields, and less attention to bush and riverbank farm fields. Farmers identified CVC as the primary driver accounting for the less attention to the bush and riverbank farm fields. In addition to CVC, farmers identified increased diversification of women's livelihood activities, increased priority in sending children to school, and the migration of abled young men to southern Ghana. Consequently, the above factors have translated into the availability of less labour force to cater for crops in the bush and riverbank farm fields. Farmers emphasised that the riverbank farm fields come along with the raising of big mounds that require young and energetic labour force. Similarly, it is evident from this study that farmers have responded to variability and changes in climate by growing crops that are better suited to the prevailing climate conditions. Specifically, millet has lost it place among the main crops cultivated in Doggoh and Tie because it produces less yield under the current climatic conditions. There is similar reportage in the literature. For example, Issahaku and Maharjan (2014) suggested in their study in Ghana that farmers would allocate less land to crops that produce low yield. Specifically, Issahaku and Maharjan (2014) reported that farmers will allocate more land for the cultivation of sorghum, cassava, maize, and rice, and

less land for the cultivation of yam because findings from their study project that the yields of sorghum, cassava, maize, and rice will increase and that of yam will decrease under climate variability and change. Additionally, Adjei-Nsiah and Kermeh (2012) reported that, under CVC, cocoa has been replaced with maize by farmers in the Wenchi Municipality of Bono East region of Ghana.

On objective 3, it emerged that farmers' attitude (i.e. positive and negative feelings about cultivating crops—under climate change), farmers' behavioural control (i.e. ability or inability to cultivate crops under CVC), and farmers' social identity have influenced their responses to CVC via crop selection. On farmers' negative feeling, the study showed that the displacement of the traditional varieties of sorghum, traditional varieties of groundnuts, and millet (except few households that cultivate that in small quantity) are influenced respectively by farmers perceived low yield, perceived difficulty in harvesting, and perceived difficulty in processing under the prevailing changing and variable climatic conditions. On the other hand, it is evident from the results that farmers' positive feeling about growing crops (i.e. perceived yield benefits in the context of, for example, farmers growing improved varieties of sorghum under CVC). In terms of farmers perceived behavioural control (PBC), it is evident from the data that farmers have displaced millet because of the cumbersome process involved in the processing of millet after harvest and then the harvesting of the traditional varieties of groundnuts. Even though farmers have adapted to CVC by cultivating crops which are suitable to the prevailing climatic conditions, few farmers because of their social identification as Dagaaba still cultivate the traditional variety of groundnuts on small quantity which gives them less yield because of the better food taste that they derive from it, and also as a means of preserving the cultural farm ways of their forefathers. The results of farmers being rational under CVC are similarly reported in the literature (see, e.g., Issahaku and Maharjan 2014; Kurukulasuriya and Mendelsohn 2007; Seo and Mendelsohn 2008).

Conclusion

The results from this study—as in climate change (per farmers' perceptions) and climate variability based on the results from climatic data—imply that climate variability and change (CVC) are real problems in Doggoh and Tie and for that matter North-west Ghana. Potentially, if nothing is done about that, CVC can translate into low food productivity with antecedent consequences such as low income for households, food and nutrition security challenges for farm households, and the general public as well. Therefore, this study recommends that adaptation measures should be intensified to increase the resilience and reduce the vulnerability of farmers to CVC impacts.

Similarly, it is evident from this study that, because of climate change, farmers have adjusted their farming systems, and crop choice by paying more attention to compound farm fields, than bush and river bank farm fields; displacing crops that are not suitable to the prevailing changing climate; and growing crops that are better suited to the prevailing climatic conditions. These findings imply that potentially, there can be a trade-off of the cultural food crops of households if these are the ones that are grown around the bush and river bank farm fields, or if they are the ones that have been displaced under the prevailing climatic conditions. Consequently, going forward, future research could focus on

understanding how adaptation to CVC could translate into affecting the availability and utilisation of culturally appropriate foods. Additionally, based on these findings, the study suggests that adaptation measures (e.g. on crop selection) should take into consideration the cultural foods, and cultural uses of crops in people's lives so that climate change issues can be addressed in a socially justified manner.

Author Contributions: This study was part of the first author's PhD thesis. He conceived of the study, formulated the research objectives, designed the methodology, collected the data, performed the statistical analysis, interpreted the data, and wrote the reports. The second and third authors supervised the PhD hence gave relevant advice throughout the PhD period.

Funding: This study was funded by the British Government under the administration of the Commonwealth Scholarships Commission (UK). The author was awarded a Commonwealth PhD Scholarship.

Ethical approval: This study was approved by the University of Reading Research ethical clearance committee. The researchers obtained informed consent from all the participations before collecting data from them.

References

Adjei-Nsiah S, Kermeh M (2012) Climate change and shift in cropping system: from cocoa to maize based cropping system in Wenchi Area of Ghana. British J Environ Climate Change 2:137–152. https:// doi.org/10. 9734 BJECC/ 2012/ 1220

Aidoo DC, Boateng SD, Freeman CK, Anaglo JN (2021) The effect of smallholder maize farmers' perceptions of climate change on their adaptation strategies: the case of two agro-ecological zones in Ghana. Heliyon 7(11):e08307. https:// doi. org/ 10. 1016/j. heliyon. 2021. e08307

Ajzen I (1985) From intentions to actions: a theory of planned behavior. In: J K, J B (eds.) Action control. SSSP Springer Series in Social Psychology. Berlin, Heidelberg: Springer

Ajzen I (1991). The theory of planned behaviour organisational behaviour and human decision processes 50, 179-211. https:// doi. org/10. 1016/ 0749- 5978(91) 90020-T

Amadou ML, Villamor GB, Attua EM, Traore SB (2015) Comparing farmers' perceptions of climate change and variability with historical climate data in the Upper East Region of Ghana Ghana. J Geogr 7:47–74

Antwi-Agyei P (2012) Vulnerability and adaptation to of Ghana's food production systems and rural livelihoods to climate variability. University of Leeds, England

Antwi-Agyei P, Nyantakyi-Frimpong H (2021) Evidence of climate change coping and adaptation practices by smallholder farmers in Northern Ghana. Sustainability 3(3):1308. https:// doi. org/ 10. 3390/ su130 31308

Arbuckle JG, Prokopy LS, Haigh T, Hobbs J, Knoot T et al (2013) Climate change beliefs, concerns, and attitudes toward adaptation and mitigation among farmers in the Midwestern United States. Clim Chang 117:943–950. https:// doi. org/ 10. 1007/ s10584-013- 0707-6

Asante WA, Acheampong E, Kyereh E, Kyereh B (2017) Farmers' perspectives on climate change manifestations in smallholder cocoa farms and shifts in cropping systems in the forest-savannah transitional zone of Ghana. Land Use Policy 66:374–381. https:// doi.

org/ 10. 1016/j. landu sepol. 2017. 05. 010
Asare-Nuamah P, Botchey E (2019) Comparing smallholder farmers' climate change perception with climate data: the case of Adansi North District of Ghana. Heliyon. https:// doi. org/ 10. 1016/j. heliyon. 2019. e03065
Assan E, Suvedi M, Olabisi LS, Allen A (2018) Coping with and adapting to climate change: a gender perspective from smallholder farming in Ghana. Environments https:// doi. org/ 10. 3390/ environments508 0086
Azare IM, Dantata IJ, Abdullahi MS, Adebayo AA, Aliyu M (2020) Effects of climate change on pearl millet (Pennisetum glaucum [L. R. Br.]) production in Nigeria. J Appl Sci Environ Manag
24(1):157. https:// doi. org/ 10. 4314/ jasem. v24i1. 23
Behailu G, Ayal DY, Zeleke TT, Ture K, Bantider A (2021) Comparative analysis of meteorological records of climate variability and farmers' perceptions in Sekota Woreda, Ethiopia. Climate Serv 23. https:// doi. org/ 10. 1016/j. cliser. 2021. 100239
Borges JAR, Emvalomatis G, Laansinl OA (2014) Adoption of Innovation in agriculture: a critical review of employed models Working Paper. Wageningen University. https:// doi. org/ 10. 1504/ ijisd. 2019. 096705
Borges JAR, Lansink AGJM (2016) Identifying psychological factors that determine cattle farmers' intention to use improved natural grassland. J Environ Psychol 45:89–96. https:// doi. org/ 10. 1016/j.jenvp. 2015. 12. 001
Bryman A (2016) Social research methods. Oxford Oxford University Press Codjoe SNA, Owusu G (2011) Climate change/variability and food systems: evidence from the Afram Plains, Ghana. Reg Environ Chang 11:753–765. https:// doi. org/ 10. 1007/ s10113- 011-0211-3
Cherinet A, Mekonnen Z (2019) Comparing farmers' perception of climate change and variability with historical climate data: the case of Ensaro District, Ethiopia. International Journal of Environmental Science and Natural. Resources 17(4). https:// doi. org/
10. 19080/ ijesnr. 2019. 17. 555966
Chin H, Choong WW, Alwi SRW, Mohammed MAHB (2016) Using theory of planned behaviour to explore oil palm smallholder planters' intention to supply oil palm residues. J Clean Prod. https:// doi. org/ 10. 1016/j. jclep ro. 2016. 03. 042
Chipanshi AC, Chanda R, Totolo R (2003) Vulnerability assessment of the maize and sorghum crops to climate change in Botswana. Clim Chang 61:339–360. https:// doi. org/ 10. 1023/b: clim. 00000 04551. 55871. eb
Dakurah G (2020) How do farmers' perceptions of climate variability and change match or and mismatch climatic data? Evidence from North-west Ghana, GeoJournal. https:// doi. org/ 10. 1007/ s10708- 020- 10194-4
Dapilah F, Nielsen JO (2019) Climate change extremes and barriers to successful adaptation outcomes: disentangling a paradox in the semi-arid savannah zone of northern Ghana, Ambio. https:// doi. org/ 10. 1007/ s13280- 019- 01275-x
Dapilah F, Nielsen JO, Friis C (2019) The role of social networks in building adaptative capacity and resilience to climate change: a case study from northern Ghana, Climate and Development. https:// doi. org/ 10. 1080/ 17565 529. 2019. 15960 63
Derkyi M, Adiku SGK, Nelson V, Dovie BD, Codjoe S et al (2018) Smallholder farmers' perception of climatic and socio-economic factors influencing livelihoods in the transition zone of Ghana. AAS Open Research, 1. 10.12688/aasopenres.12839.1

Dohmen T, Falk A, Huffman D, Marklein F, Sunde U (2009) Biased probability judgment: evidence of incidence and relationship to economic outcomes from a representative sample. J Econ Behav Organ 72:903–915. https:// doi. org/ 10. 1016/j. jebo. 2009. 07. 014
Ericksen PJ, Thornton PK, Cramer L, Herrero JP (2011) Mapping hotspots of climate change and food insecurity in the global tropics. [15th January 2022]
Fisbien M, Ajzen I (1975) Belief, attitude, intention and behaviour: an introduction to theory and research. Reading.
Ghana Meteorological Agency (2016) Statistics on missing and available data from stations in the Upper West Region Accra Ghana Meteorological Agency
Gregory PJ, Ingram JS, Brklacich M (2005) Climate change and food security. Philos Trans R Soc Lond Ser B Biol Sci 360:2139–2148. https:// doi. org/ 10. 1098/ rstb. 2005. 1745
GSS (2014) 2010 Population and housing census district analytical report. Jirapa District, Accra, Ghana
GSS (2021) 2021 Population and housing census district analytical report. Jirapa Municipality, Accra, Ghana
Guodaar L, Bardsley KD, Suh J (2021) Indigenous adaptation to climate change risks in northern Ghana. Clim Chang 166:24. https://doi. org/ 10. 1007/ s10584- 021- 03128-7
Habiba U, Shaw R, Takeuchi Y (2012) Farmer's perception and adaptation practices to cope with drought: perspectives from Northwestern Bangladesh. Int J Disaster Risk Reduct 1:72–84. https:// doi.org/ 10. 1016/j. ijdrr. 2012. 05. 004
Horsefield GD (2016) Investigating the factors that lead to the construction of gendered perceptions of climate variability and change of communal framers in agro-ecological zones II and III of Zimbabwe. PhD University of Reading
Hulme M, Adger N, Dessai S, Lorenzoni I, Naess LO et al (2007) Limits and barriers to adaptation: four propositions. Working Paper Ingram JSI,
Roncoli M, Kirshen P (2002) Opportunities and constraints for farmers of West Africa to use seasonal precipitation forecasts with Burkina Faso as a case study. Agric Syst 74:331–349. https://doi. org/ 10. 1016/ s0308- 521x(02) 00044-6
IPCC (2014) Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team,
R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp. https:// doi. org/ 10. 1017/ CBO97 81107 415324. 004
IPCC (2022) Climate change 2022: impacts, adaptation, and vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp. https:// doi. org/ 10. 1017/ 97810 09325 844.
Issahaku AZ, Maharjan LK (2014) Crop substitution behaviour among food crop farmers in Ghana: an efficient adaptation to climate change or costly stagnation in traditional agricultural production system? Agricult Food Eco 2. https:// doi. org/ 10.
1186/ s40100- 014- 0016-z
Kolleh JB, Jones MT (2015) Rice farmers' perception of climate change and adaptation strategies in the Ketu North District of the Volta Region of Ghana. Afr J Agric Res 13:782–791. https://doi. org/ 10. 5897/ ajar2 017. 12904

Kurukulasuriya P Mendelsohn R (2007) A Ricardian analysis of the impact of climate change on African cropland. Policy Research Working Paper; No. 4305. Washington, World Bank
Li S, Juhasz-Horvath L, Harrison PA, Pinter L, Rounsevell MDA (2017) Relating farmer's perceptions of climate change risk to adaptation behaviour in Hungary. J Environ Manag 185:21–30. https:// doi. org/ 10. 1016/j. jenvm an. 2016. 10. 051
Lobell DB, Burke MB, Tebaldi C, Mastrandrea MD, Falcon WP et al (2008) Prioritising climate change adaptation needs for security in 2030. Science 319:607–610. https:// doi. org/ 10. 1126/ scien ce. 11523 39
Maddison D (2007) The perception of and adaptation to climate change in Africa policy research working paper. https:// doi. org/ 10. 1596/ 1813- 9450- 4308
Menapace L, Raffaelli CGR (2015) Climate change beliefs and perceptions of agricultural risks: an application of the exchangeability method. Glob Environ Chang 35:70–81. https:// doi. org/ 10. 1016/j. gloen vcha. 2015. 07. 005
MoFA (2018) Agriculture in Ghana facts and figures 2017. Accra Statistics, Research and Information Directorate
Naab JB, Koranteng H (2012) Gender and climate change research results: Jirapa, Ghana. In: Working Paper No. 17. CGIAR Research Program on Climate Change, Agriculture and Food
Security (CCAFS), Nairobi Kenya
Nguyen T, Mula L, Cortignani R, Seddaiu G, Dono G et al (2016) Perceptions of present and future climate change impacts on water availability for agricultural systems in the western Mediterranean region. Water 8:523. https:// doi. org/ 10. 3390/ w8110 523
Osbahr H, Dorward P, Stern R, Cooper S (2011) Supporting agricultural innovation in Uganda to respond to climate risk: linking climate change and variability with farmer perceptions. Exp Agric 47:293–316. https:// doi. org/ 10. 1017/ s0014 47971 00007 85
Patt A, Schroter D (2008) Perceptions of climate risk in Mozambique: implications for the success of adaptation strategies. Glob Environ Chang 18:458–467. https:// doi. org/ 10. 1016/j. gloen vcha. 2008. 04. 002
Rapholo MT, Makia LD (2020) Are smallholder farmers' perceptions of climate variability supported by climatological evidence? Case study of a semi-arid region in South Africa. Int J Climate Change Strategies Manag 12(5):571–585. https:// doi. org/ 10. 1108/ ijccsm- 01- 2020- 0007
Rowell DP (2012) Sources of uncertainty in future changes in local precipitation. Clim Dyn 39:1929–1950. https:// doi. org/ 10. 1007/ s00382- 011- 1210-2
Ricthie J, Lewis J, Nicholas CM, Omrston R (2014) Qualitative research practice a guide for social science students and researchers London Sage
Singh S (2020) Farmers' perception of climate change and adaptation decisions: a micro-level evidence from Bundelkhand Region, India. Ecol Indic 116:106475. https:// doi. org/ 10. 1016/j. ecoli nd. 2020. 106475
Stern R, Cooper P (2011) Assessing climate risk and climate change using rainfall data: a case study from Zambia. Exp Agric 47:241. https:// doi. org/ 10. 1017/ s0014 47971 10000 81
Stern R, Rijks D, Dale l, Knock J (2006) Instat climatic guide. University of Reading Statistical Services Centre
Senger I, Borges JA, Machado JAD (2017) Using the theory of planned
behavior to understand the intention of small farmers in diversifying their agricultural production. J Rural Stud 49:32–40. https:// doi. org/ 10. 1016/j. jrurs tud. 2016. 10. 006

Seo SN, Mendelsohn R (2008) Measuring impacts and adaptations to climate change: a structural Ricardian mode of African livestock management. Agric Econ 38:151165. https:// doi. org/ 10. 1111/j.1574- 0862. 2007. 00289.x
Singh C, Osbahr H, Dorward P (2018) The implications of rural perceptions of water scarcity on differential adaptation behaviour in Rajasthan, India, Regional Environmental Change. https:// doi. org/10. 1007/ s10113- 018- 1358-y
Tajfel H, Turner JC (1979) An integrative theory of inter-group conflict. In: Austin WG, Worche S (eds) The social psychology of inter-group relations. Brooks/Cole, Monterey, CA, pp 33–47
Tambo JA, Abdoulaye T (2012) Smallholder farmers' perceptions of and adaptations to climate change in the Nigerian savanna. Reg Environ Chang 13:375–388. https:// doi. org/ 10. 1007/ s10113- 012- 0351-0
Talanow K, Topp EN, Loos J, Martin-Lopez B (2021) Farmers' perceptions of climate change and adaptation strategies in South Africa's Western Cape. J Rural Stud 81:203–219. https:// doi. org/ 10. 1016/j.jrurs tud. 2020. 10. 026
Taylor JG, Stewart RT, Downton M (1988) Perceptions of Drought in the Ogallala Aquifer region. Environ Behav 20:150–175. https://doi. org/ 10. 1177/ 00139 16588 202002
Terry DJ, Hogg MA (1996) Group norms and the attitude behaviour relationship: a role for group identification. Personal Soc Psychol Bull 22:776–793. https:// doi. org/ 10. 1177/ 01461 67296 228002
Terry DJ, Hogg MA, White KM (1999) The theory of planned behaviour: self-identity, social identity and group norms. British J Social Psycho 38:225–244. https:// doi. org/ 10. 1348/ 01446 66991 64149
Tessema I, Simane B (2021) Smallholder farmers' perception and adaptation to climate variability and change in Fincha sub-basin of the Upper Blue Nile River Basin of Ethiopia. GeoJournal 86:1767–1783. https:// doi. org/ 10. 1007/ s10708- 020- 10159-7
Thornton PK, Jones PG, Ericksen PJ, Challinor AJ (2011) Agriculture and food systems in Sub-Saharan Africa in a 4 C+ world. Philos Trans R Soc 369:117136. https:// doi. org/ 10. 1098/ rsta. 2010. 0246
Turner JC (1982) Towards a cognitive redefinition of the social group. In: Tajfel H (ed) Social identity and intergroup relations. Cambridge University Press
van der Geest K (2004) We're managing! Climate change and livelihood vulnerability in Northwest Ghana, African Studies Centre
White KM, Terry DJ, Hogg MA (1994) Safe sex behaviour: the role of attitudes, norms, and control factors. J Appl Soc Psychol 24:2164–2192. https:// doi. org/ 10. 1080/ 08870 44930 84019 28
Wlokas HL (2008) The impacts of climate change on food security and health in Southern Africa. J Energy South Africa 19:12–20. https:// doi. org/ 10. 17159/ 2413- 3051/ 2008/ v19i4 a3334
Zeweld W, Huylenbroeck G, Tesfay G, Spelman S (2017) Smallholder farmers' behavioural intentions towards sustainable agricultural practices. J Environ Manag 187:71–81. https:// doi. org/ 10. 1016/j. jenvm an. 2016. 11. 014
Ziervogel G, Ericksen PJ (2014) Adapting to climate change to sustain food security. Climate Change. https:// doi. org/ 10. 1002/ wcc. 56
Zvogbo L, Johnston P, Williams PA, Trisos HC, Simpson NP (2022) The role of indigenous knowledge and local knowledge in water sector adaptation to climate change in Africa: a

structured assessment. Sustain Sci 17:2077–2092. https:// doi. org/ 10. 21203/ rs.3. rs-774241.

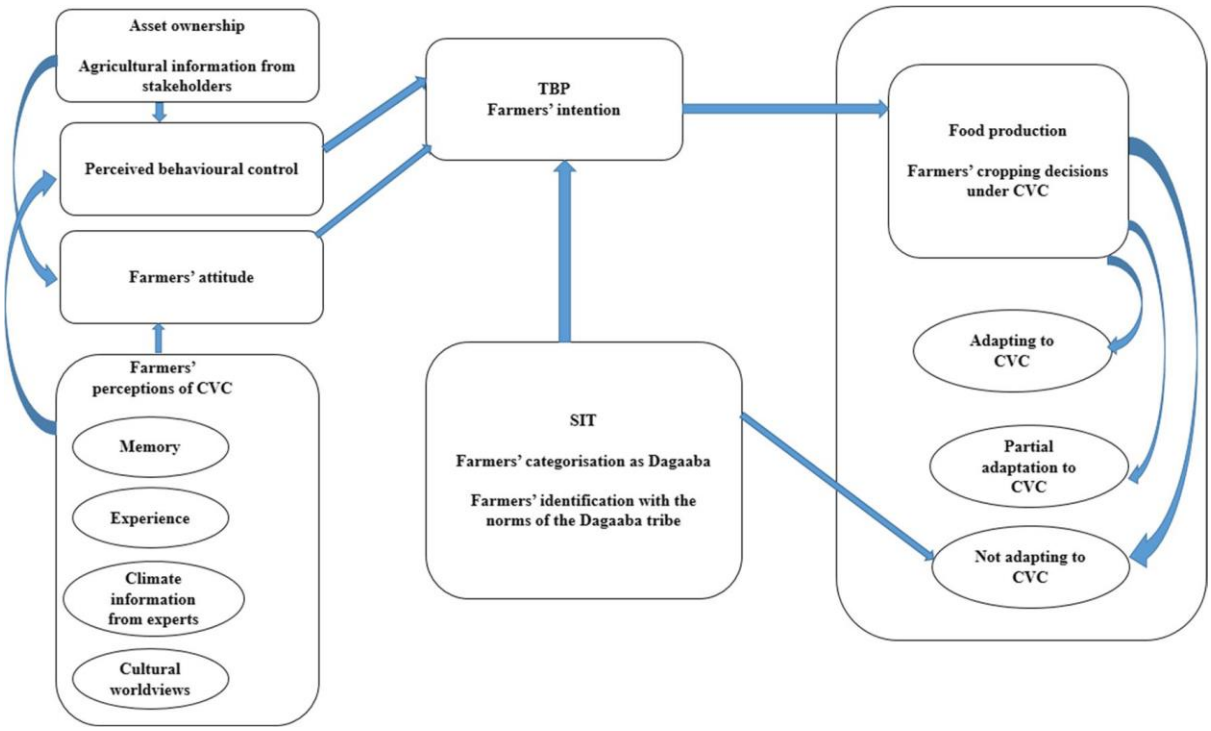


Fig. 1 Conceptual framework. Source: Authors' construct adapting the Theory of Planned Behaviour, Social Identity Theory, and Drought Perception Theory

Fig. 2 Map of the Upper West Region of Ghana showing the Jirapa Municipality

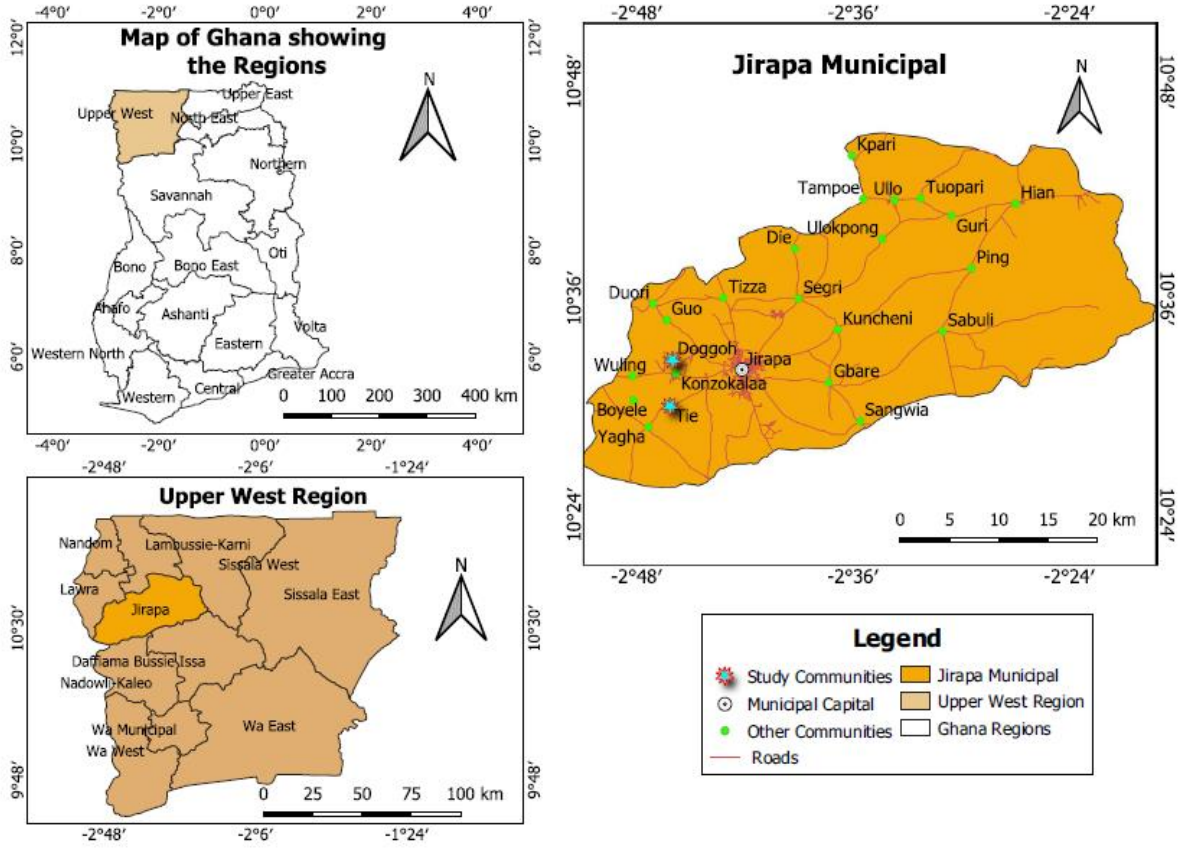


Fig. 3 First occasion after 01 April that records more than 20 mm of rainfall with no dry spell of more than 9 days in the next 30 days

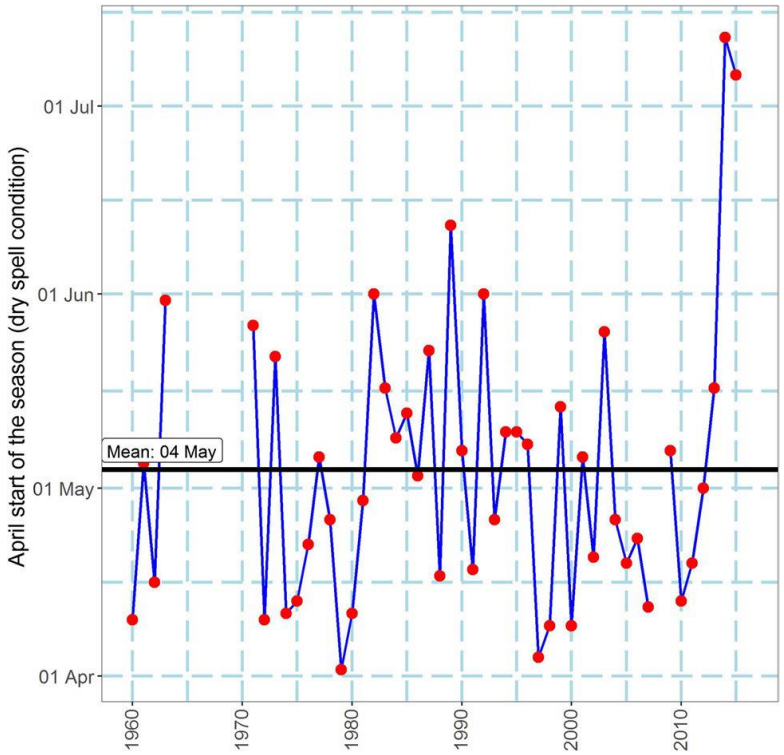


Table 1 Four definitions of the onset of rainfall (1, A dry spell here is defined as any day with less than 0.85 mm of rainfall according to Stern et al. 2006)

Definition I	The first occasion after April 01 that records more than 20 mm of rainfall in one or two consecutive days without factoring in any dry spell [1]condition
Definition II	Definition two draws on definition I but incorporates the element of no dry spell of more than 9 days in the next 30 days after the first day of recorded rainfall of at least 20 mm as suggested by Stern and Cooper (2011).
Definition III	The first occasion after May 01 that records more than 20 mm of rainfall in one or two consecutive days without factoring in any dry spell condition
Definition IV	Definition four draws on definition III but incorporates the element of no dry spell of more than 9 days in the next 30 days after the first day of recorded rainfall of at least 20 mm as suggested by Stern and Cooper (2011).

Fig. 4 First occasion after 01 May that records more than 20 mm of rainfall with the consideration of dry spell conditions

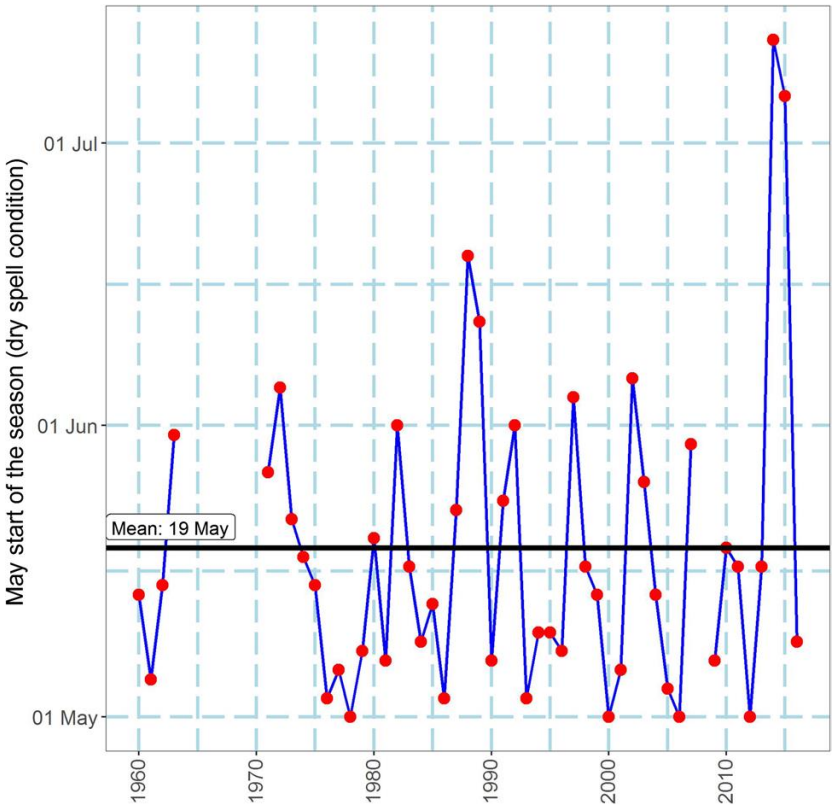


Fig. 5 The first occasion after the 1 of September when the water balance drops to zero

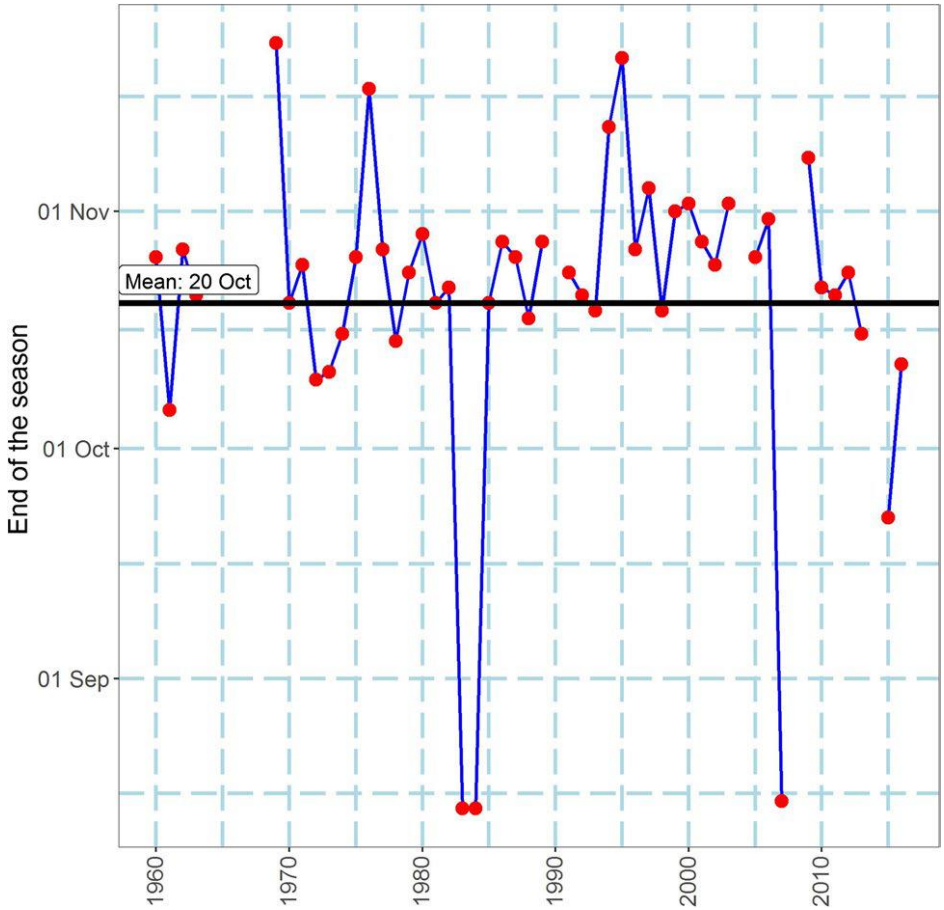


Table 2 Details of the date of start of the April and May definitions of the rainy season in Babile (1960–2016) with factoring in no occurrence of dry spell conditions

Definition	Earliest start date of the rainy season	Latest start date of the rainy season	Mean start date of the rainy season
April (dry spells)	02nd April	12th July	04th May
May (dry spells)	01st May	12th July	19th May

Fig. 6 Percentage distribution of farmers' perceptions of the onset and cessation months of rainfall in the past and now in Doggoh village

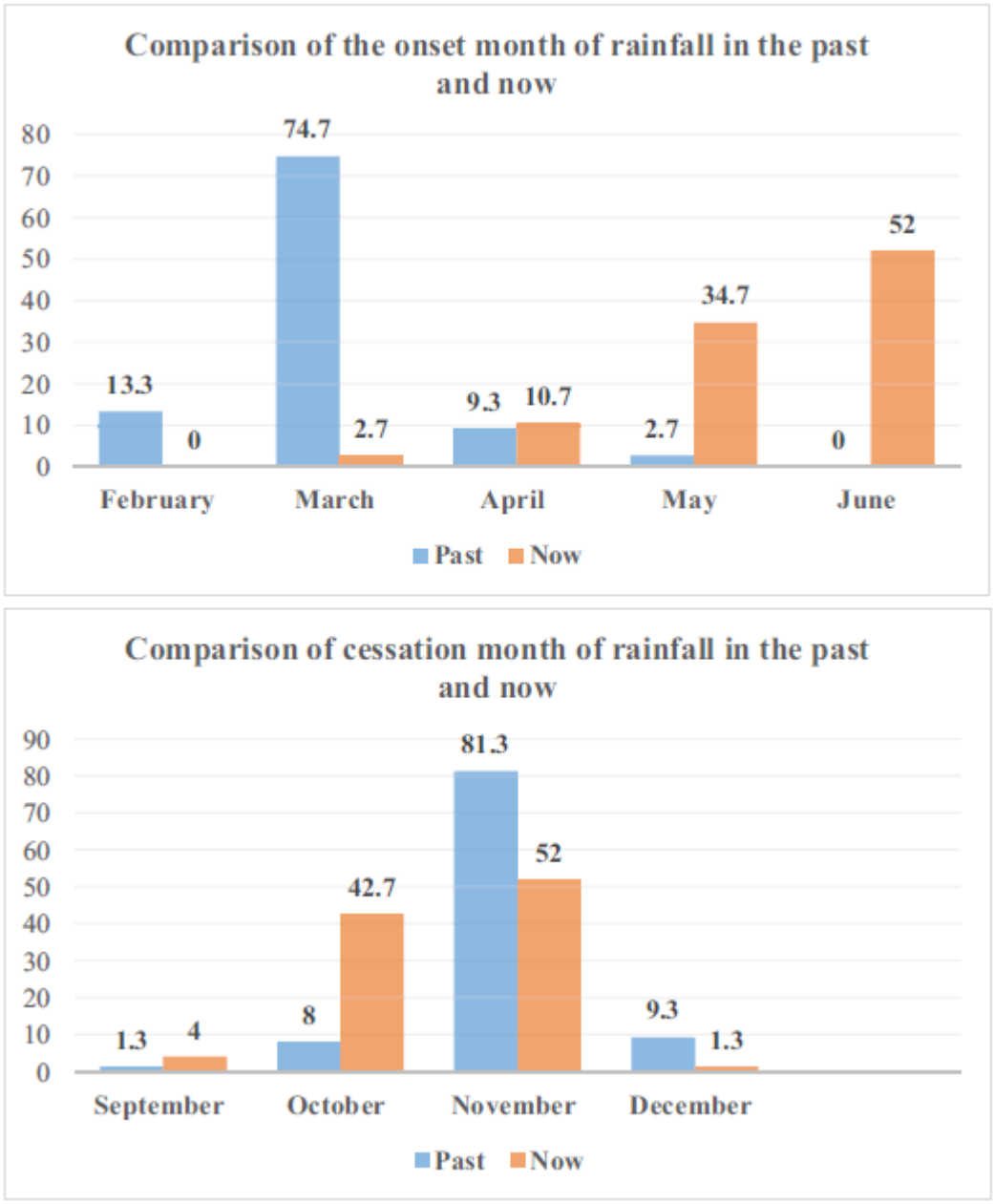


Fig. 7 Percentage distribution of farmers' perceptions of the onset and cessation months of rainfall in the past and now in Tie Village

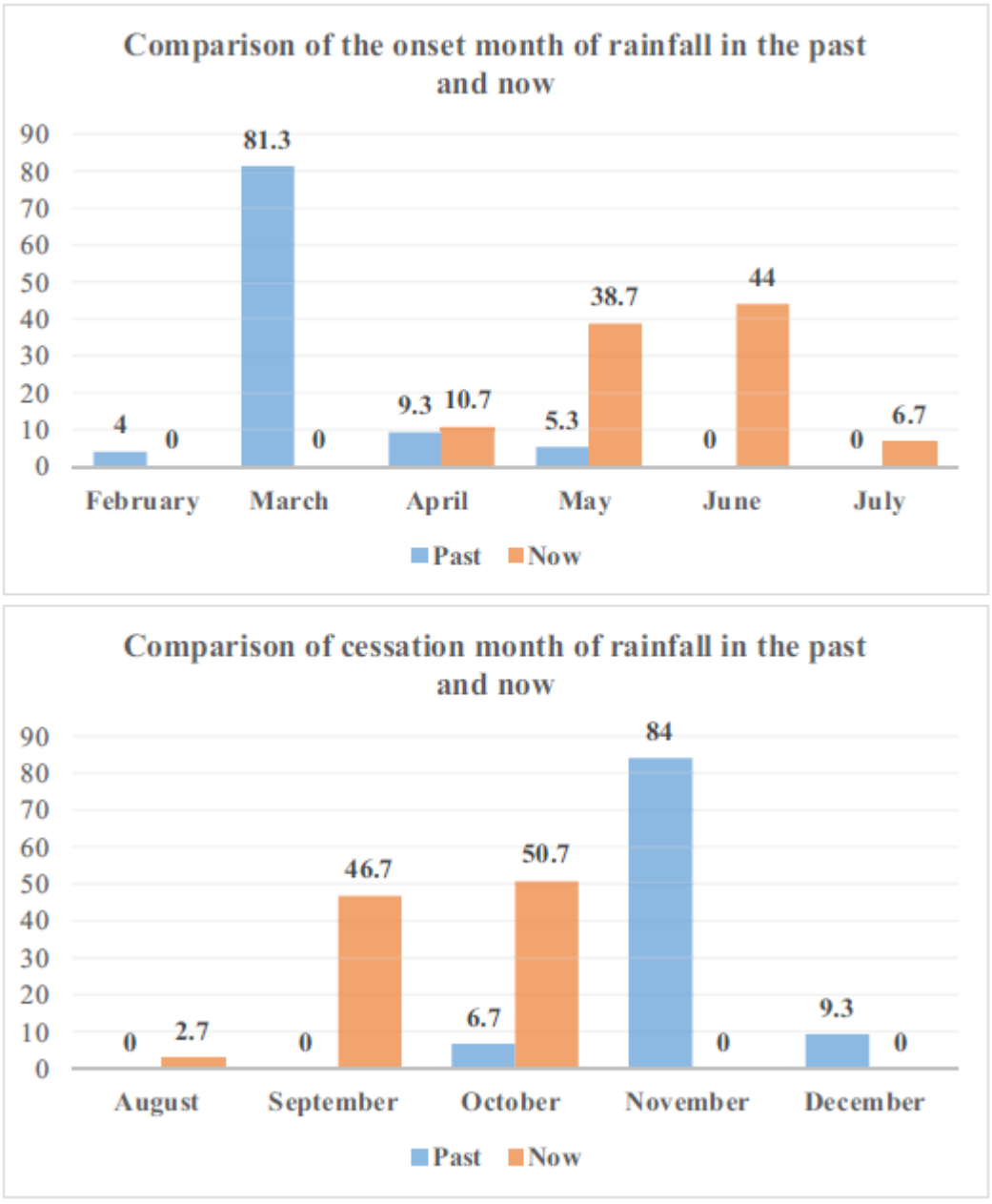
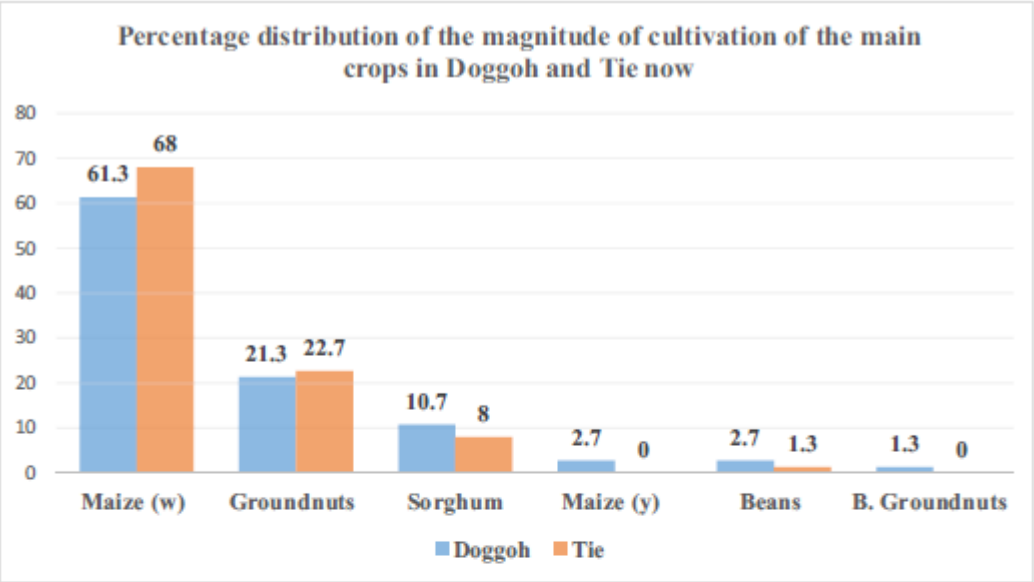


Fig. 8 Percentage distribution of the magnitude of cultivation of the main crops in Doggoh and Tie now and in the past



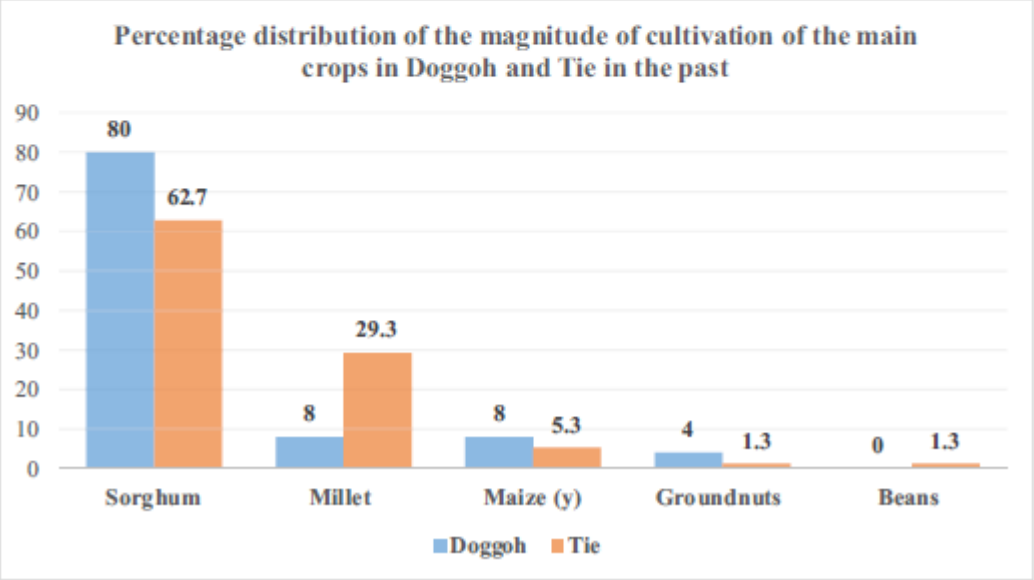


Table 3 An illustration of farmers who are adapting or not adapting to CVC via the selection of groundnuts in Doggoh (*N*=75)

Table 3 An illustration of farmers who are adapting or not adapting to CVC via the selection of groundnuts in Doggoh (*N*=75)

Variable		Variety of groundnuts	
		Kyaana only (*n* %)	*Kyaana* and *dagasinkaa* (*n* %)
Sex	Male	56 (93.3)	4 (6.7)
	Female	15 (100.0)	0 (0.0)
Age	21–40	17 (100.0)	0 (0.0)
	41–65	37 (94.9)	2 (5.1)
	66–95	17 (89.5)	2 (10.5)
Wealth	Poor	25 (100.0)	0 (0.0)
	Semi-rich	24 (88.0)	3 (12.0)
	Rich	24 (96.0)	1 (4.0)
Education	Educated	13 (86.7)	2 (13.3)
	No formal education	58 (96.7)	2 (3.3)

Table 4 An illustration of farmers who are responding or not responding to CVC via the selection of groundnuts in Tie (*N*=75)

Variable		Variety of groundnuts		
		Kyaana only (*n* %)	*Dagasinkaa* only (*n* %)	*Kyaana* and *dagasinkaa* (*n* %)
Sex	Male	45 (86.5)	2 (3.8)	5 (9.6)
	Female	23 (100.0)	0 (0.0)	0 (0.0)
Age	21–40	18 (94.7)	0 (0.0)	1 (5.3)
	41–65	33 (94.3)	0 (0.0)	2 (5.7)
	66-90	17 (81.0)	2 (9.5)	2 (9.5)
Wealth	Poor	25 (100.0)	0(0.0)	0 (0.0)
	Semi-rich	22 (88.0)	1 (4.0)	2 (8.0)
	Rich	21 (84.0)	1 (4.0)	3 (12.0)
Education	Educated	54 (90.0)	2 (3.3)	4 (6.7)
	No formal education	14 (93.3)	0 (0.0)	1 (6.7)

Fig. 9 Percentage distribution of households' unwillingness to displace sorghum in the future

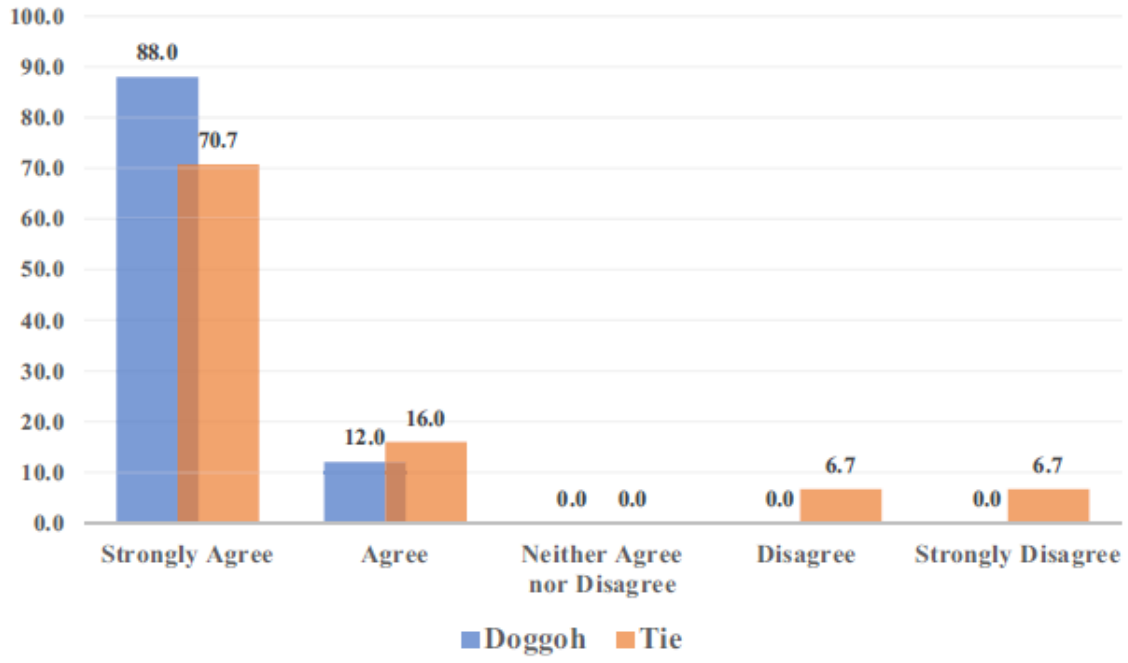


Fig. 10 An illustration of kagyin that is usually placed besides deceased on paalaa