Heliyon 9 (2023) e22162

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Farmers' choice for indigenous practices and implications for climate-smart agriculture in northern Ghana

Dramani Juah M-Buu File [a,*], Godwell Nhamo [b]

[a] Department of Environmental Sciences, College of Agriculture and Environmental Sciences, University of South Africa, Pretoria, South Africa
[b] Institute for Corporate Citizenship, University of South Africa, Pretoria, South Africa

ARTICLE INFO

Keywords:
Climate-smart agriculture
Indigenous knowledge
Climate change
Smallholder farmers
Ghana

ABSTRACT

Smallholder agriculture in Northwestern Ghana continues to suffer the increasing threats of climate change and variability. The extant literature has argued that climate-smart agriculture is the way forward for smallholder farmers to reduce the threats of climate change and variability in agriculture production. However, smallholder farmers continue to rely on indigenous knowledge and practices in their day-to-day agricultural activities. Few studies have explored the rationale and factors that explain smallholder farmers choice of local agriculture practices. This study explored the rationale and factors that explain smallholder farmers' choice of indigenous knowledge and agriculture practices. The mixed research method approach involving both quantitative and qualitative methods were employed for data collection and analysis. A survey, involving 305 household heads, 31 in-depth interviews and 18 focus group discussions were held with key participants for the data. The results showed that smallholder farmers' decisions to adopt indigenous practices for climate change adaptation were influenced by socio-demographic characteristics, access to farm capital, landscape and distance to farms, accessibility and reliability of practices, accessibility and cost of inputs, land tenure, access to extension services, and socio-cultural beliefs. These variables were statistically significant at 5 %. The paper concludes that these factors will continue to limit farmers' ability to adopt climate-smart and other improved agricultural practices. This will aggravate smallholder households' vulnerability to food insecurity and poverty. It is, therefore, recommended that climate-smart agriculture practices should be framed within the context of the aforementioned factors influencing farmers choice of indigenous farming practices in mainstreaming them into climate-smart agriculture.

1. Introduction

Smallholder agriculture remains a major source of livelihood for most rural people in sub-Saharan Africa (SSA) [1–3]. However, smallholder farmers are constrained by the effects of climate change and variability in their efforts to produce sufficient food to feed their families. Climatic elements (e.g. rainfall and temperature) in SSA are highly variable and unpredictable, thereby adversely affecting food crop production and household food security, especially in rural areas [4,5]. In addition, the frequency and severity of extreme weather events such as floods, droughts, and prevalence of pests and diseases are increasing due to climate change [6]. Although the impact of these changes may vary from one locality to the next, the implications for food security remain inevitably

* Corresponding author.
E-mail address: dramanifile@gmail.com (D.J.M.-B. File).

https://doi.org/10.1016/j.heliyon.2023.e22162
Received 27 October 2022; Received in revised form 1 November 2023; Accepted 6 November 2023
Available online 13 November 2023

severer for smallholder farmers [7,8].

In Ghana, climate change continues to manifest in poor rainfall pattern and high temperatures leading to poor crop yields, low production, and food security challenges among rural households. According to the [9], the Notre Dame Global Adaptation Index (ND-GAIN) ranked Ghana as 109 out of 181 countries which were considered to be vulnerable to climate change in 2020. This was after Ghana was ranked 101th country out of 188 countries vulnerable to climate change in 2016 by the ND-GAIN Index [10]. The report of the [10] further indicated that Ghana was the 68th most vulnerable country to climate change and 85th least prepared country to combat climate change. To this end, Ghanaian farmers will remain vulnerable and continue to suffer from the growing unpredictability and erratic rainfall patterns, prolonged dry spells during the cropping season, growing desertification, and longer periods of the dry season (Harmattan winds). Therefore, smallholder crop farming and other related livelihoods will face significant repercussions for sustainability.

In northern Ghana, including the Upper West Region (Northwestern Ghana), the people are predominantly food crop farmers. They engage in the cultivation of cereals such as sorghum, maize, millet, and rice; legumes such as beans, soybeans, Bambara beans and groundnuts; and roots and tuber crops such as yam, cassava, and potatoes as common staple crops to feed their families. Moreover, like any other geography in SSA, local farmers in Northwestern Ghana are struggling under climate change and variability to meet their food needs [11–13]. The situation is further aggravated by the fact that the guinea savannah ecological zone that hosts the study location (Northwestern Ghana) is characterised by a single rainfall regime which makes smallholder farming a one-season activity [14].

As a result, there is increasing call for smallholder agriculture to be climate-smart to achieve increased productivity to enhance food security, build resilience to climatic shocks, and mitigate emissions of greenhouse gases [15,16]. Climate-smart agriculture (CSA) is a transformational approach that simultaneously addresses climate change, food insecurity, poverty, and environmental degradation. Climate-smart agriculture increases smallholder farmers' ability to mitigate and adapt to climatic impacts, as well as ensure food security through innovative policies, practices, technologies, and services [16,17]. Under CSA, farmers are trained and used as extension agents to enhance coordination of farmer field schools and other climate-smart activities. The CSA approach provides opportunity to achieve food security through the integration of adaptation and mitigation interventions in agriculture. It integrates traditional and innovative practices, and services for adapting to climate change and variability in a context-specific manner to enhance resilience and sustainable increase in productivity with reduced greenhouse emissions [18,19].

In northern Ghana, there have been various policy interventions which have prioritised the reduction of economic vulnerability caused by climate change and variability among smallholder farmers. Many of these interventions target at promoting CSA practices and technologies such as irrigation, use of improved seeds and other inputs, provision of extension services, and agroforestry among smallholder farmers. For instance, the Government of Ghana, civil society organisations, and donor organisations have adduced policy interventions such as the provision of small-scale irrigation dams, supply of agriculture inputs and farm equipment, including training farmers on improved farming methods to enhance the adaptive capacities of farmers for food production [4,20,21]. These interventions seek to promote agricultural practices that are not only climate-smart but also climate compatible and can enhance food crop production and food security under climate change. The Government of Ghana through the Ministry of Food and Agriculture is subsidising fertilizer, improved crop seeds, and other inputs, construction of warehouses, construction of dams for villages in northern Ghana as well as duty-free importation of farm implements as measures to enhance and help farmers to adapt crop farming to climate change and variability [22]. Some civil society organisations have, over the years, also assisted farmers with improved seeds, extension services through farmer-field schools and providing alternative livelihood portfolios for farming households to enhance food production and food security. Yet, smallholder farmers' livelihoods remain precarious under climate change and variability in Northwestern Ghana due to low adoption of these practices [23].

Smallholder farmers continue to rely on their own knowledge, experiences, creativities, and ingenuities to build local resilience and enhance food crop production at the household levels. Indigenous knowledge represents the knowledge and experiences of smallholder farmers and it is collectively owned and includes the mental inventories of the characteristics of weather elements, animal breeds, local plants, crops and tree species and belief systems that enhance the livelihood of the people and protection of the environment [24]. Indigenous knowledge offers opportunity to smallholder farmers to develop context-specific strategies and practices in adapting to climate change. As a result, smallholder farmers are increasingly recognised as innovators and agents of change in the climate change adaptation discourse [23,25–28]. They have developed and implemented several climate change adaptation strategies through the application of indigenous knowledge that reduced their vulnerability to climate change [29].

In addition, local farmers employ traditional farming methods such as the use of manure (animal droppings), intercropping, use of indigenous seed varieties, use of local materials such as ashes, neem leaves and seeds for controlling pests and insects as measures for building resilient farming systems for food production [30]. [31]also indicated that the use of indigenous weather forecasting, mixed cropping, mixed farming as well as the use local short season crops are some indigenous farming strategies among smallholder farmers. Farmers use traditional forecast systems such as observing the behaviour and activities of plants, animals, insects, stars, clouds, and other natural phenomena to predict weather elements and plan crop farming accordingly. Thus, smallholder farmers have devised various means of adapting crop farming to climate change and variability over the years through their own indigenous knowledge and practices. This makes the application of indigenous knowledge and practices imperative in sustaining food production under growing climate change and variability [32].

It has been suggested that the preference for traditional weather information, indigenous crop varieties, and other indigenous farming practices over scientific climate information, improved varieties, and use of other modern practices presents a challenge to the implementation of improved approaches for agriculture production [33,34]. However, while climate change and variability adaptation strategies are hotly discussed, knowledge of how local farmers adapt to climate change and variability, and the factors that

inform their choice of indigenous adaptation strategies are yet to be fully projected in the steadily growing scientific literature. Many scholars have tended to focus much attention on low adoption of modern practices among smallholder farmers with little attention on smallholder farmers' continuous preference for indigenous knowledge and farming practices. This has created a gap in the literature on why farmers mostly rely on their own knowledge-based farming practices and technologies despite several efforts by governments, civil society organisations and development corporations to get them on modern and improved methods of food production. It is within this context that this study seeks to explore farmers' choice for indigenous practices and draws implications for the promotion of climate-smart agriculture in Northwestern Ghana. To achieve the study objective, the following research questions were raised.

1. How do smallholder farmers' socio-demographic characteristics influence their choice for indigenous practices in adapting to climate change?
2. What are the policy implications of farmers' choice for indigenous practices for climate change adaptation?

The following hypotheses were therefore tested to establish the statistically significant association between smallholder farmers' socio-demographic factors and their adoption of indigenous practices for climate change adaptation.

H0. there is no statistically significant association between smallholder farmers' socio-demographic characteristics and their choice of adopting indigenous practices for climate change adaptation.

H1. there is a statistically significant association between smallholder farmers' socio-demographic characteristics and their choice of adopting indigenous practices for climate change adaptation.

This study contributes to literature and knowledge on understanding the determinants of smallholder farmers' preference for indigenous practices in adapting to climate change. The study contributes to an understanding of how most demographic characteristics of farmers have become challenges to climate change. To this end, it may be useful to local government authorities in planning for sustainable smallholder food production through improved agricultural practices and services within the context of the decentralised development plan.

The paper is divided into five sections. The section following this presents the literature review while the next section presents the study area and methodology. Section four centres on the results and discussions of findings, while section five concludes the paper.

2. Literature review

2.1. Indigenous knowledge and climate-smart agriculture

The contributions and application of indigenous knowledge in climate change adaptation have been globally recognised to be very useful in reducing climate change vulnerability among smallholder farmers [35]. Many indigenous farming practices and technologies provide for the cultivation of several food crops on the same field as a means of maximising land use, soil fertility and improving crop productivity for household income and food security. It is argued that practices such as agroforestry, intercropping of cereals, tubers, and legumes, diversification, and mixed farming are not new to smallholder farmers in SSA and have been used in different ways to optimise food crop production under climate change [23,36,37]. Smallholder farmers have also relied on indigenous knowledge for weather forecast through the observation of natural phenomena such as changes and behaviour of trees, birds, insects, stars, clouds, wind, etc which are significant for reducing climatic uncertainty and risk as well as building resilience and adaptive capacities of smallholder farmers for food crop production [38].

There is enough evidence from literature that smallholder farmers have adapted to climatic change for several years in the form of agricultural risks reduction methods, techniques, and practices [27,39–42]. These strategies are developed from smallholder experiences of many years of practice, ingenuity, and socio-cultural beliefs and values which are transmitted from one generation to the next. Therefore, smallholder farmers have significantly contributed to the climate change adaptation trajectory [23,27]. Notwithstanding these efforts, the threats of climate change continue to undermine the effectiveness and efficiency of indigenous knowledge and practices in adapting agricultural livelihoods to climate change impacts [43]. Consequently, there have been efforts over the years to promote new farming methods and practices that can enhance crop yields and food production in the midst of the increasing threats of climate change and variability.

Attention has focused on climate-smart agriculture which has over the years been widely advocated in SSA [44–46]. It is suggested that CSA provides for achieving increased food production, food security and environmental sustainability for smallholder farmers. CSA does not only promote agricultural practices and technologies that are climate-smart, but it also identifies climate financing mechanisms, and appropriate policies and institutional frameworks that can promote sustainable agriculture under climate change. Nevertheless, the implementation of climate-smart agriculture in SSA countries including Ghana still faces significant challenges and adoption has been poor over the years [44,46–48]. It is suggested that climate-smart agriculture practices are mostly beyond the reach of smallholder farmers leading to the low adoption [49,50]. It is further indicated that smallholder farmers continuous preference for traditional agricultural practices over climate-smart practices [47] is due to their inability to obtain credit, improved seeds, farm implements, weather information services, amongst other climate-smart practices [51,52]. Furthermore, many climate-smart practices have not been contextualised within the domain of indigenous practices, beliefs, and values of smallholder farmers to make them acceptable [52]. This is because CSA is not a one-size-fit-all approach, and so the practices and technologies must be specific to the social, economic, and environmental conditions within specific locations [53]. Therefore, any inability to appropriately identify, prioritise and promote CSA practices and technologies within the context of specific socio-economic and environmental conditions in

different areas, may affect adoption and implementation of CSA strategies among smallholder farmers [18].

Smallholder farmers are also influenced by their levels of education, age, gender, years of farming experience, family size, annual income, labour availability, awareness, and access to extension services to prefer indigenous practices [3]. [54]also indicated that location or type of agro-ecological zone, slope and distance of plot, membership to groups, access to micro-credit and access to input market also influence smallholder farmers to adopt indigenous practices for agriculture production. It is further suggested that smallholder farmers' choices for indigenous farming practices are motivated by their levels of perceptions of climatic risks and traditional values, beliefs, knowledge, and experiences [55,56]. According to Ref. [57], farmers' choice for risk management strategies are not only influenced by factors such as farm size, age, educational level, off-farm income, and farming experience but that farmers' attitudes and perceptions of risks are major factors affecting their adoption decisions [58]. also indicated that the frequency of agricultural extension services, the distance between farmers' homes and location of farms, household income, and scale of farming are key determinants of farmers decisions and technical efficiency. According to Ref. [59], smallholder farmers' decisions to adopt indigenous practices relate to their level of access to improved farm services and practices, level of farming experience, household size, household income, farmer group membership, geographical location as well as their participation in off-farm work. In exploring the urgency of the customary values and traditions in farm management systems among smallholder farmers in Indonesia [60],observed that indigenous knowledge and practices are deployed at various stages of farming, from identification of farm site through to harvesting and performance of traditional thanksgiving services [61].also found that the contributions of indigenous pastoralists to household income through livelihood diversification were significantly influenced by their access to credit, market, age of household head, use of farm inputs, frequency of extension contacts, market access, and ownership of assets. In Burkina Faso [38], found that the ability or inability of smallholder farmers to pay for improved climate services were determined by their socio-demographic characteristics such as the level of education, age, gender, and level of awareness on climate information [20]. also observed that smallholder farmers' production decisions are influenced by their level of access and participation in government subsidies and related programmes, perceptions and experience about improved production services, access to alternative livelihood activities and source of agricultural information.

In Ghana, many farmers continue to adopt indigenous practices and services for agricultural production despite several efforts made by the government, non-governmental organisations, and other development agencies to improve access to improved agricultural systems to achieve productivity and food security. The level of education, farm size, age, land ownership, household size, cost of inputs, participation in extension training programmes are significant determinants of farmer choices for indigenous practices for

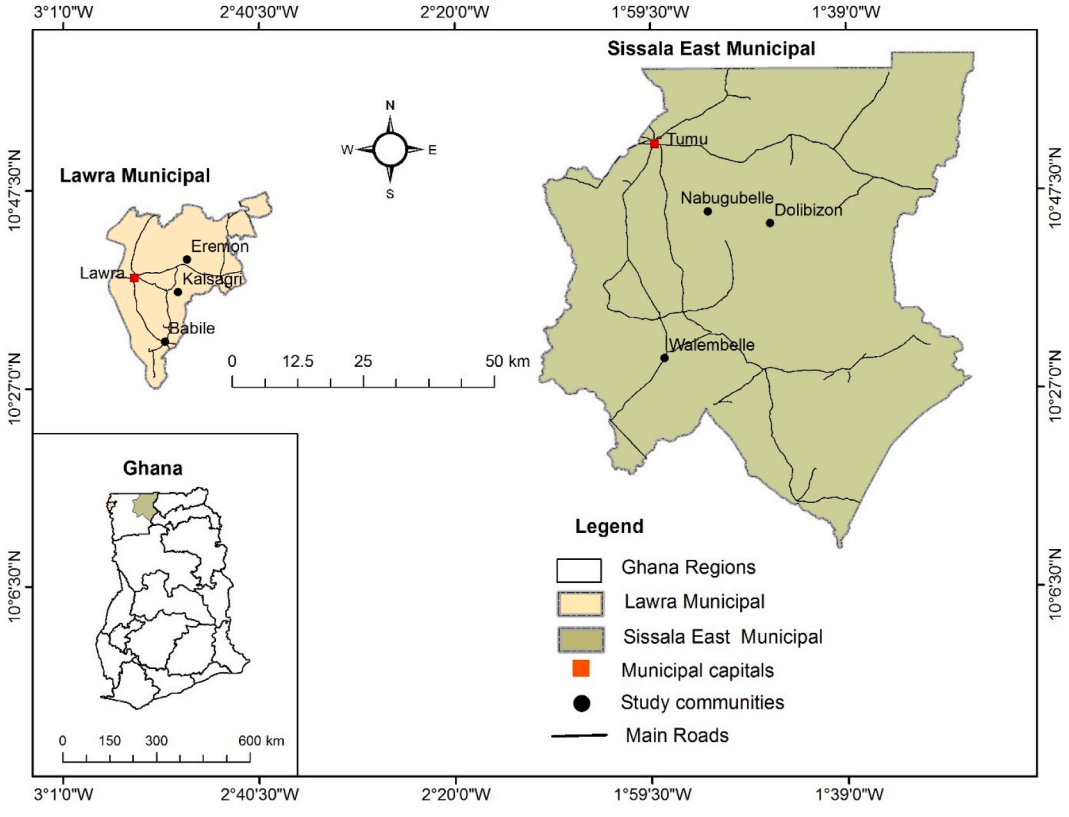

Fig. 1. Map of the study sites.
Source: Authors' construct, 2021

agriculture production [62]. [63] also reported that the level of reliability of indigenous knowledge in predicting climate and weather forecast influence smallholder farmers to prefer indigenous forecast over scientific forecast information in Ghana. Trust and reliability of indigenous knowledge and practices further influence farmers to adopt the cultivation of some indigenous crop varieties, engage in early or late planting, and diversification of crops as adaptation strategies at the household level. Household demographic features such as length of farming experience, gender, age of farmer, educational level, household size, access to extension services, low awareness and membership to farmer-based organisations are significant determinants of adoption of indigenous farming practices [21,45,64,65]. However [2], argued that the gender and level of education of smallholder farmers are insignificant to influence farmers not to adopt improved agricultural practices in Ghana. They believe other factors than gender and level of education have significant influence on farmers to prefer indigenous practices over climate-smart practices [66]. also found that smallholder farmers' decisions to adopt climate-smart agriculture practices were influenced by socio-psychological factors such as farmers' attitudes about the benefits they intend to derive, perceived behaviour control of the practices and the social pressure on farmers on the need to use improved practices.

3. Materials and methods

3.1. Study area

The study was conducted in the Upper West Region of Northwestern Ghana where subsistence agriculture is the major livelihood activity among households. Food crop farming is mainly rainfed and it is significantly affected by climate change and variability which manifest in recurrent droughts and floods, bush fires, extreme temperatures, emergence of pests and diseases and depleting soil fertility. These adversely affect food crop farming in the region. The Upper West Region is bordered to the north by Burkina Faso, Upper East, and North-East Regions to the east, Northern and Savannah Regions to the south and to the west by Côte d'Ivoire. The region lies between latitudes 9°35′ N and 11° N, and 1°25′W and 2°50′ W with a total land area of 18,476 square kilometres, which represents about 12.7 % of the total land area of Ghana [67]. The region has a total population of 901,502 with male population constituting 48.8 % (n = 440,317) and 51.2 % (n = 461,185) being female population [68]. The Upper West Region fall within the Guinea Savannah agroecological belt which has drought resistant trees such as shea, baobab, dawadawa and neem.

The region experiences a single rainy season from April to September, with annual rainfall averaging about 115 cm. It is also characterised by a prolonged dry season, with early November to March through to April being the harmattan and heat seasons. The mean monthly temperature ranges between 21 °C and 32 °C with maximum temperatures of 40 °C in March and minimum (20 °C in December during harmattan. The topography of the region is mostly flat with few hilly areas. The types of soils favour the cultivation of different food crops in the region. Households cultivate food crops such as maize, sorghum, guinea corn, millet, rice, soya beans, groundnuts, yam, cowpea, and groundnuts. Two municipalities, namely Sissala East and Lawra Municipalities (Fig. 1) were selected for the study. These municipalities are largely rural and dominated by subsistence agriculture which is affected by climate change and variability. Smallholder farmers in these municipalities do not have adequate access to extensions services and modern practices and mostly, therefore, rely much on local knowledge systems for food crop farming activities.

3.2. Study design

The study adopted the mixed methods research approach which combined quantitative and qualitative research approaches in data collection, analysis, and making inferences [69]. This approach allowed multiple data gathering methods and data triangulation. The data collection was operationalised through a survey (by administering questionnaires to selected household heads), in-depth interviews with key participants, focus group discussions and making observations of some farm practices on the field.

3.3. Sampling and sampling procedures

The study employed multiple sampling approaches to select the communities and the research participants. Firstly, purposive sampling technique was employed in selecting the study municipalities (Lawra and Sissala East) because they are closer to the Sahel of Burkina Faso and are more vulnerable to the threats of climate change and desertification. The second stage involved the selection of the study communities using simple random sampling technique where three farming communities were selected from the list of communities in each of the two municipalities using the lottery method. The communities included Dolibizon, Nabugubelle and

Table 1
Study communities and respondents.

Sissala East Municipal		Lawra Municipal	
Community	No. of respondents	Community	No. of respondents
Dolibizon	50	Babile	51
Nabugubelle	51	Kalsagri	51
Walembelle	51	Eremon	51
Total	**152**	**Total**	**153**

Source: Author's construct, 2022

Walembelle (Sissala East Municipal) and Babile, Kalsagri and Eremon (Lawra Municipal) as shown in Fig. 1. At the third stage, 305 farming household heads (see Table 1) with more than 10 years of farming experience were selected through the cluster and random sampling techniques. Each community was put into clusters of five sections, comprising of compound houses as it pertains in northern Ghana. From the five sectional clusters, 10 compound houses, which comprised of many households, were randomly selected. Then, a household each was selected from the 10 selected compound houses using the simple random sampling technique, and a questionnaire administered to the head of the selected household. Households were selected through the fish-bowl lottery strategy where the household heads in the compounds were numbered on pieces of paper, put in a bowl and the researchers randomly picked from the bowl. Thus, the unit of analysis for the survey was the household. Household heads were selected because in agrarian households, they make key decisions regarding the types of crops to grow, acquisition of land, and the farming methods and practices to adopt. The simple random sampling technique ensured easy and equal chance of each participant being selected and therefore minimised personal influence and bias in the selection process [70]. The sample size was determined by using [71] formula: $n = N/1+N(e)^2$; where, n = sample size, N = population, e = level of precision (0.05). However, the sample sizes for the various communities were judgmentally selected by the researchers where the overall sample size of 305 was divided among the six communities to have almost equal number of respondents regardless of differences in sizes of total household populations in the communities. Except Dolibizon community, all the other communities have the same number of respondents as in Table 1.

3.4. Data collection and analysis

Data were collected through household survey, in-depth interviews, focus group discussions, and field observation. The data collection was done between July 2020 and December 2020. The survey was conducted through a standardised questionnaires administered to 305 smallholder farmer households. The questions on the questionnaire instrument were structured to provide easy responses and processing using statistical tools [72], and covered issues relating to factors that influence farmers' adoption decisions in adapting to climate change. The questionnaire was approved as a standard instrument by Health Research Ethics Committee of the University of South Africa. Data were also collected through in-depth interviews and the participants included community elders, earth priests (locally called *Jantina/Tindaana*), farmer-based group leaders (women and youth leaders), and officers from the municipal assemblies (Municipal Directors of Agriculture, and extension officers). These people were assumed to possess in-depth knowledge and experience on climate change, adaptation, farming, and indigenous knowledge. Face-to-face interviews were conducted with interviewees and interactions were guided by the researchers using interview guide. Engagements usually lasted for about 35 min with each participant at a suitable venue for both the interviewee and the interviewer. Interactions were done in the local languages (*Sisaali* and *Dagaare* for participants in Sissala East and Lawra Municipalities respectively) except the staff of the Municipal Assemblies. A total of 31 in-depth interviews were conducted. The researchers probed for and into new issues that emerged during the interviews. Interactions were recorded with prior permission from participants for transcriptions.

Focus group discussions were held separately with men, women, and youth groups in each community to allow for detail and free expression of views by participants since women and youth in northern Ghana mostly do not actively dominate discussions in the midst of elderly men as part of their cultural values and traditions [13]. This resulted in a total of 18 focus group discussions conducted across the six communities. Suitable venues in the respective communities were identified and used for discussions. Discussants were usually briefed on the subject matter of the discussions at least three days before engagements to enable them to prepare well. Discussants were also informed of the researchers'' control of anonymity and confidentiality but urged members to ensure anonymity and confidentiality of one another on the issues under discussion. Membership in each group ranged between 6 and 12 participants [73]. Discussions were done in the local languages (*Sisaali and Dagaare*). Tape (audio) recordings were made after permission was granted by the discussants. The researchers also observed how farmers were interfacing various indigenous farm practices and technologies on their farms to adapt to climate change [74]. Issues observed were written in notepads and compared with farmers' narratives during analyses.

The data collected from in-depth interviews and focus group discussions were transcribed, analysed, and presented through detail descriptions, direct quoting and paraphrasing of information given by the participants [75]. The qualitative data were mostly edited after the interviews and discussions to identify emerging issues and build on them during the next engagements. The audio recordings during interactions were transcribed and quoted and/or paraphrased during the presentation of the results. These were used to support the quantitative data on the findings of the study. The quantitative data collected from the household survey were inputted into SPSS (version 20) and analysed using descriptive statistics and Chi-Square test analysis. The results were linked to and discussed with the qualitative data within the context of determinants of smallholder farmers' choice for indigenous knowledge and practices for climate change adaptation in Northwestern Ghana and the implications thereof.

3.5. Limitation of the study

The study was conducted during the year of the global pandemic COVID-19 and so required strict adherence to the safety protocols. Hence, there was the need for acquisition of personal protective equipment such as nose masks, alcohol-based hand sanitizers, and liquid soap. These came as extra cost to the researchers. The requirement to wash hands with soap under running water and social distancing among other protocols mostly caused delays in start of engagements. This was because participants had to wash their hands and sanitised in turns.

3.6. Ethical considerations

This study is part of a PhD thesis conducted by Dramani Juah M-Buu File under the supervision of Prof. Godwell Nhamo, University of South Africa, Pretoria. The study was conducted in accordance with the methodological and other processes outlined and approved under the guidelines of the Health Research Ethics Committee of the University of South Africa under ethical clearance number 2019/CAES_HREC/197. As part of the ethical clearance application process, letters of permission to engage participants were received from their gatekeepers and attached to the ethical application. Request for permission letters were sent to these gate keepers which included Lawra and Sissala East Municipalities, and Upper West Regional House of Chiefs. The consent of participants was sought, and a consent form signed to indicate their willingness to participate in the research before interviews and discussions. This was after the participants were made to understand the aim and objectives of the study. Confidentiality and anonymity of participants were also assured, and they were made to understand that the study was primarily for academic purposes.

4. Results

4.1. Respondents' profile

Most of the participants (94 %) surveyed were subsistence food crop farmers within the age groups of 50–59 (46 %) and 60–69 (25

Table 2
Profile of respondents.

VARIABLE		
Age	Frequency	Percent
30–39	10	3
40–49	49	16
50–59	140	46
60–69	76	25
70+	30	10
Total	**305**	**100**
Gender		
Male	230	75
Female	75	25
Total	305	100
Level of education		
No formal education	141	46
Primary	61	20
Junior High School	39	13
Vocational School	22	7
Senior High school	34	11
Tertiary	8	3
Total	**305**	**100**
Farming as major occupation		
Yes	287	94
No	18	6
Total	**305**	**100**
Farming experience		
11–15	2	1
16–20	16	5
21–25	19	6
26–30	30	10
31–35	43	14
36–40	62	20
41+	133	44
Total	**305**	**100**
Average size of farm (acres)		
1–2	86	28.2
3–4	76	24.9
5–6	52	17.0
7–8	25	8.2
9–10	25	8.2
11+	41	13.4
Total	**305**	**100**
Farmland acquisition		
Family	232	76.1
Gifted	55	18.0
Temporal farmland	18	5.9
Total	**305**	**100**

Source: Field Survey (2020)

%) years as indicated in Table 2. Also, most (75 %) were men while 25 % were women. This comes as no surprise considering the fact the household heads were involved. In northern Ghana men are socially accepted as households' heads with women only becoming households' heads in the absence of a man. A recognisable proportion of the respondents (46 %) did not have formal education, 20 % had primary education whereas the remaining proportion attained Junior High (13 %), Senior High (11 %), Vocational School (7 %) and Tertiary Education (3 %). The majority (78 %) of the respondents had more than 30 years of farming experience while 22 % had between 11 and 30 years of farming experience. In addition, about 53 % of the respondents cultivate on less than five acres of land with the rest cultivating above five acres. Farmlands were mostly acquired through family inheritance (76 %), gifting (18 %) and temporal acquisition (6 %).

4.2. Determinants of farmers' choice for indigenous knowledge and practices

Table 3 presents results on the factors influencing smallholder farmers' adoption of indigenous practices in adapting to climate change and variability in Northwestern Ghana. The results show that the decision to adopt indigenous practices among smallholder farmers was dictated by several factors which relate to social, cultural, economic, and demographic conditions.

The majority (87 %) of the respondents indicated that they adopted indigenous practices because of easy accessibility and reliability. These are knowledge and practices that are transmitted through personal interactions, social events, and other local networks. As result, farmers can access indigenous practices and instigate the feeling of ownership and reliability of these practices. The Chi-square test of no association of accessibility and reliability with respect to farmers adoption of indigenous knowledge and practices in adapting to climate change and variability was statistically significant (P-value <0.05). In-depth interviews corroborate and present further insight into why local farmers rely on indigenous practices in navigating through the challenges posed by climate change and variability. Response from an experienced elder, aged 57 was captured as follows:

> *"Our own knowledge systems are available to us for free and one does not need any money to acquire it or any (formal) training on how to apply it. We got it from our grandparents and parents through our traditions and farming activities. I do not need to travel anywhere to learn and acquire them. That is why we adopt indigenous farming activities"* (In-depth interview, Nabugubelle 2020).

The response appears to suggest that local farmers believe their own practices are reliable and useful in adapting to climate change and variability. Furthermore, it emerges from the survey that smallholder farmers were more inclined to the use of indigenous farming practices such as use of ashes and other local materials for controlling pests and insects than improved practices like use of chemical pesticides and insecticides. The simplicity in applying indigenous knowledge, regardless of their levels of education and formal training received, also influenced the adoption decisions of smallholder farmers.

It emerged that access to credit determines the use of farm inputs such as fertilizer, pesticides, and use of improved seeds as well as the use of farm implements such as tractors, harvesters, planters among farmers. It was discovered that most of the respondents (89 %) had no and/or inadequate access to credit and could not purchase farm inputs and hire the services of farm implements. To this end, we found that 74 % of the respondents were influenced to adopt the use of manure, hand hoes for tilling, use of local crop seeds, and other indigenous practices in crop farming. Some farmers also relied on out-growers for supply of inputs and services of farm implements under unfavourable terms and conditions. This exposed them to extreme exploitation by agro-business companies.

In addition, the findings revealed that smallholder farmers had inadequate access to extension services such as meteorological weather information, improved seeds, inputs, and improved farm practices. As a result of this, the majority (92 %) of the respondents depended on indigenous farming practices and knowledge for advisory services in food crop farming. The inability of smallholder farmers to have access to forecast weather information, farmer-field school services and other improved services deprived them of the opportunity to build resilience and enhance their knowledge, skills, understanding and preparedness for increased crop productivity

Table 3
Factors determining smallholder households' adoption decisions (N = 305).

Do the following factors influence your adoption decisions?	YES	NO	DON'T KNOW	χ^2
Accessibility and reliability	266 (87 %)	33(11 %)	6 (2 %)	0.000
Land ownership and accessibility	289 (95 %)	11 (3.6 %)	5 (1.4 %)	0.016
Size of farm & labour force	280 (92 %)	14 (5 %)	11 (4 %)	0.006
Level of education	285 (93 %)	20(7 %)	0 (0 %)	0.000
Awareness of practice/technology	297 (97 %)	8 (3 %)	0 (0 %)	0.000
Gender	277 (91 %)	9 (3 %)	19 (6 %)	0.000
Age & years of experience	279 (92 %)	15 (5 %)	11 (4 %)	0.000
Access to credit	270 (89 %)	22 (7 %)	13 (%$)	0.000
Landscape of farm	278 (91 %)	22 (7 %)	5 (2 %)	0.000
Distance of farm from home	271 (89 %)	12 (4 %)	22 (7 %)	0.000
Accessibility & Cost of inputs	305 (100 %)	0 (0 %)	0 (0 %)	n/a
Belief systems	269 (88 %)	31 (10 %)	5 (2 %)	0.000
Access to extension services	281 (92 %)	24 (8 %)	0 (0 %)	0.000
Membership to farm groups	263 (86 %)	13 (4 %)	29 (10 %)	0.000
Simplicity of practice	305 (100)	0 (0)	0 (0)	n/a

Note: n/a = not applicable, responses were uniform.
Source: Field Survey (2020)

through improved farming methods. It emerged that 86 % of the respondents did not belong to any farmer-related groups and were found to have adopted more indigenous practices while 14 % of the respondents who belonged to farmer groups adopted more improved strategies. In both municipalities, it emerged that women groups were common and were used for multiple purposes including agricultural programmes, village savings and loans, social and other activities. We, consequently, found that female farmers were adopting improved practices than male farmers in both municipalities. This was corroborated during a focus group discussion where a participant noted that

> *"The women groups are many and they are engaged in many activities. Organisations mostly work with them than us [men] because they [women] have groups. Women receive training and support in farming every year. They receive seeds and farming advisory services on how to cultivate different crops"* (FGD, Walembelle, 2020).

This response suggests that membership to farmer-based groups by women exposes them to extension services which positively influenced the adoption of improved practices among them.

The results further showed that ownership and access to land for farming was statistically significant (p-value <0.05) in both municipalities. Most (95 %) respondents were influenced to adopt indigenous practices due to their land tenure statuses. We found that most farmers were cultivating on family lands (76 %) while others were cultivating on gifted (18 %) and temporarily acquired (6 %) lands. These were the major modes of acquiring farmlands in both municipalities. It emerged during in-depth interviews and group discussions that, it was for the purposes of conserving, preserving, and maintaining land through good farming practices that landlords do not rent out lands for agricultural purposes.

Also, the sizes of farms and labour force available to smallholder farmers determined their preferences for indigenous practices and technologies for crop farming. It was revealed that most of the respondents (92 %) adopted indigenous practices relative to the sizes of their farms and labour force at the household level. A participant from Dolibizon narrated that

> *We adopt strategies that match with the size of our farms and source of farm labour. If your farm is small, it may require few labour force, and large farm sizes will also require large labour force to work. Farmers with large farm sizes require more labour force or may employ modern farm implements for planting, harvesting, processing, and transporting the produce home. They may even employ both local and modern practices in some instances. We (farmers) usually employ a mixture of practices depending on the size of your farm and labour force available to you"* (in-depth interviews, Eremon 2020).

As suggested in the above narrative, it was observed that households with small-size farms were using manure, mulching, and less chemical inputs on their farms. Households with available labour force were observed to have adopted mixture of indigenous and improved practices against households with less labour force. The findings further showed that level of formal education, age and gender were important determinants of farmers' choice for indigenous practices and strategies. It emerged that most (93 %) of the respondents had no/low levels of formal education and this significantly (p-value <0.05) influenced them to adopt indigenous practices. Unlike science-based farm practices, the understanding and application of indigenous practices do not require any formal education nor formal training, hence their preference for local practices. It was further revealed that most of the respondents (91 %) were influenced by their gender to adopt indigenous strategies for crop farming. Female farmers mostly adopted practices that matched their abilities while practices and technologies that were much masculine-oriented were adopted by male farmers. Female farmers were also more reluctant in adopting practices that were perceived to be expensive, complex, and labour-intensive than their male counterparts. Farming practices such as making ridges, mounds, indiscriminate use of agro-chemicals, and practices that related to traditions and culture were commonly adopted by male farmers than female farmers. Therefore, most smallholder farmers (88 %) were influenced by their traditional belief systems to adopt indigenous farming strategies. Smallholder farmers had strong ties to their traditional beliefs, culture, norms, and values which shaped their lives and livelihood activities. Farmers adopted practices that were more compatible with their traditions and cultural values and norms than practices that conflict them. On the other hand, women mostly diversified strategies to include village savings and loan schemes, petty trading, cultivation of leguminous crops and use of information from extension workers than male farmers.

Similarly, most (62 %) of the respondents also adopted practices relative to their ages and years of experience. It was observed that older farmers who also have many years of farming experience mostly preferred to use local materials like ash, cow dung, shea butter residue, wastewater from boiled dawadawa seeds, etc. to control pests and insects on their farms than using chemical pesticides. A discussant indicated that

> *"Spraying with knapsack requires strong men; an old man like me cannot carry the heavy knapsack with the chemicals on my back to spray. But I can sprinkle ash on my crops to control pests because it requires less energy. Also, I can carry poultry droppings with my bicycle to the farm, but I cannot carry a bag of fertilizer to the farm. I will need somebody to carry it there for me. The chemical inputs are also dangerous to our health as old men"* (FGD, Kalsagri 2020).

The response indicated that some indigenous practices are more favourable for older farmers compared to science-based practices. It was observed that older and experienced farmers adopted practices that related to protecting and conserving the environment and natural resources in addition to food production. Youthful farmers were observed to easily adopt the use of herbicides, pesticides, and chemical fertilizer because of immediate and high crop yields without recourse to environmental effects.

Landscape or topographical characteristics were found to have also influenced smallholder farmers' decisions in adopting indigenous practices. The majority (91 %) of farmers were found to have adopted practices contingent to whether their farms were upland, lowland, flood plains and waterlogged areas. Farmers whose farmlands were located on hilly and stony areas in Lawra Municipality adopted stone bunding and digging trenches to trap rainfall water for crops. Such farmers also engaged in planting of indigenous

sorghum (red sorghum) and millet which were resilient to such landscape characteristics. It was further revealed that the distances of farms from homes of smallholder farmers influenced them to adopt indigenous practices. Farmers whose farms were near their homes (backyard farmers) adopted indigenous practices than farmers whose farms were far from their homes. It was further observed that backyard farmers were more careful and avoided indiscriminate use of synthetic inputs like fertilizer, herbicides, and pesticides on their farms than farmers with long-distance farms. It was indicated, during interviews and group discussion sessions, that backyard farmers were conscious of the health risks associated with indiscriminate use of synthetic inputs on backyard farms since humans including children, could encounter some edible farm crops since the farms were near homes. Backyard farmers also engaged in practices such as agroforestry, natural regeneration of the vegetation, less/no bush burning, and use of manure than farmers whose farms were far from homes.

5. Discussions

The findings revealed that multiple factors account for smallholder farmers' choice for indigenous farming practices in Northwestern Ghana. Indigenous practices and knowledge systems were easily accessed by farmers and were also considered to be more reliable since they understood their application. These were consistent with similar views expressed by scholars that easy access to information, knowledge and farm practices greatly influence the adoption decisions of farmers in SSA [76–78]. There were significant levels of awareness among farmers on indigenous practices in both municipalities than scientific practices. They understood the application processes and implications of indigenous practices and that enhanced their adoption as observed by Ref. [79]. Indigenous practices were also not complex for farmers to use compared to scientific practices. Accordingly, it is observed that most smallholder farmers in northern Ghana do not use scientific climate information and practices because of perceived complexity [27,80]. Besides, low level of awareness on improved practices among farmers exacerbate this perception and consequent poor adoption attitude towards climate-smart agricultural practices as indicated by Ref. [3].

Also, the inability of smallholder farmers to access credit undermines the efforts of promoting climate-smart agricultural practices. This exposes farmers to the exploits of out-grower businesses which supply them with fertilizer, improved seeds, and tractor services under exorbitant terms and conditions. Inadequate access to credit and (high) cost of farm inputs and services have been reported as significant barriers to the use of sustainable agricultural practices among smallholder farmers in SSA [54,61,81]. The findings also corroborate [82] who observed that lack of access to and availability of improved seeds and inputs have partly been responsible for low adoption of climate-smart practices in Ghana.

Generally, land ownership and accessibility are significant factors that affect smallholder farming in northern Ghana, particularly as it relates to land accessibility for crop farming [14,83]. Farmlands in northern Ghana are mostly acquired through family inheritance and also seen as a source of social and cultural identity which must be preserved and conserved for both present and future generations as indicated by Ref. [41]. To this end, the farming practices of farmers were mostly influenced within the context of land as an identity, spirit and as life of the local people which need to be preserved and protected. Consequently, households mostly adopt traditional practices such as the use of manure, mulching, and use of less chemical inputs on their farms as means of conserving farmlands. Therefore, smallholder farmers' decisions in adopting indigenous practices were influenced by their land tenure status [29,54].

Limited access to agricultural extension services among smallholder farmers also accounted for the use of indigenous practices, which farmers trusted and practiced for many years [47,84]. This corroborated with the suggestion by Ref. [85] that limited access to extension services for smallholder farmers in northern Ghana is a major constraint to adoption of CSA practices. Therefore, creating access to extension services will enhance adoption of climate-smart practices among farmers [45,86]. Farmer groups which are instrumental in promoting adoption of improved farming practices were limited among farmers, particularly male farmers. However, women farmers mostly belonged to multi-purpose groups, and this aided their adoption of improved practices over male farmers. This agrees with [87] who indicated that farmers who do not belong to groups mostly adopt indigenous farming practices over improved farming practices. Farmer groups help provide access to training and agriculture information to farmers [54,88].

The findings further showed that demographic characteristics of smallholder farmers such as level of education, age, gender, and years of farming experience among farmers were important factors that influenced their decisions in adopting indigenous practices. Most science-based farm practices require formal training and education to understand which is almost lacking among many farmers due to their low levels of education. This agrees with suggestions that low literacy among smallholder farmers is a major barrier to promoting improved agricultural practices in SSA [79,89,90]. Therefore, stakeholders should consider education and training as critical to building the capacities of smallholder farmers to equip them with the ability to understand, apply, and adopt climate compatible practices to enhance food production. Climate-smart practices were perceived to be expensive, complex, and labour-intensive were avoided by female farmers. Men were equally reluctant in adopting climate-smart practices that conflict with their traditions and culture. Most indigenous practices were considered to be compatible with the traditions, beliefs, and cultural values and norms of smallholder farmers as indicated [91]. The findings agree with [92] who found that smallholder farmers in Zimbabwe usually adopt practices that reflect their local beliefs, values, and local realities. Similarly, smallholder farmers in Botswana were reported to have refused to use scientific forecast information because it did not reflect their socio-cultural values and beliefs [33].

The findings further showed that farmers with long years of farming experiences were more conservationists while youthful farmers with less farming experience were productivists in practice. Youthful farmers were more focused on immediate yields and adopted practices that offered higher yields but have potential adverse long-term implications on the environment. Similar findings attested that it is more difficult for older and more experienced farmers to adopt new farming [2,93]. The findings also support the observation

by Ref. [94] that the ages of farmers in SSA correlate to their crop farming practices at the household levels.

Landscape and farm distances from settlements influenced farmers' choice for indigenous practices. The choice for indigenous crops such as red sorghum, and millet which were cultivated on stony and hilly landscape areas was because these crops are resilient to such landscape characteristics. Also, bambara beans, groundnuts, local beans were cultivated on low fertile lands. Furthermore, backyard farmers adopted conservation practices such as manuring, agroforestry, natural regeneration, and moderate use of synthetic inputs while far distance farmers mostly engaged in indiscriminate use of chemical fertilizer, herbicides, pesticides, and extensification practices that degrade forest and land resources. This agrees with similar findings that suggested that the distances of farms from homes significantly determines farmers' adoption decisions on agricultural practices [54,94]. To this end, climate-smart agricultural practices should be designed within the context of the differences in landscape and farm distances to promote adoption among smallholder farmers.

6. Conclusions and policy implications for climate-smart agriculture

The study explored farmers' choice for indigenous practices and knowledge in crop farming in Northwestern Ghana despite efforts by government and non-governmental organisations to promote climate-smart and other improved agricultural practices among smallholder farmers. The increasing threats of climate change affect the efficacy of indigenous farm practices in achieving high crop yields and food security. The findings showed that smallholder farmers' decisions to adopt indigenous farming practices were variedly influenced by multiple factors such as accessibility and reliability of indigenous practices, land tenure system, landscape and distance to farms, access to farm capital and socio-demographic characteristics of smallholder households such as age of farmer, years of farming experience, gender, level of education and socio-cultural beliefs. These have significant policy implications for the promotion of climate-smart agricultural practices for enhancing food crop production and food security. Smallholder farmers' choice for indigenous practices calls for significant efforts at integrating indigenous and scientific knowledge and farming practices in the design and development of CSA practices to enhance adoption among farmers. The determinants of farmers preference for indigenous practices vary within the context of location and socio-demographics of households, hence the promotion of climate-smart agriculture will require significant multi, inter and transdisciplinary approaches in the formulation of context-specific practices and strategies to enhance adoption.

The findings also imply that smallholder farmers may continue to adopt indigenous practices over climate-smart practices and strategies if they continue to face limited access to credit and high cost of climate-smart practices and services. In view of this, government monetary policies should consider differential interest rates for agriculture with traditional banks like the Agriculture Development Bank and Rural Banks in Ghana to provide affordable credit to smallholder farmers. Issues of gender are also topical that could affect adoption of climate-smart practices if gender dynamics are not considered and mainstreamed into the process of designing climate-smart farming practices.

It is therefore, recommended that the Department of Agriculture and all related stakeholders should create access to credit as well as incorporate the dynamics in socio-demographic features of farmers and households in the formulation and implementation of climate-smart agriculture practices to make them acceptable for adoption among smallholder farmers. There is also the need for effective education, sensitisation, and training for smallholder farmers on climate-smart practices to enhance understanding and adoption to achieve increased productivity and food security.

The Department of Crop Science in the Ministry of Food and Agriculture and the Savannah Agricultural Research Institute (SARI) should leverage on farmers' preference for indigenous crop seeds to develop different varieties that are more resistant to changes in rainfall, early maturing, and pests to reduce vulnerability of crop farming.

Lastly, we recommend for further research on the dynamics, synergies, and trade-offs in integrating indigenous practices into existing agriculture and climate-smart agriculture policies and programmes and the outcomes thereof.

Funding statement

The study is part of PhD work of Dramani J.M. File, and he received University of South Africa (UNISA Master & Doctoral Bursary support), Pretoria, South Africa.

Data availability statement

Data will be made available upon request and due process followed.

Additional information

No additional information is available for this paper.

CRediT authorship contribution statement

Dramani Juah M-Buu File: Writing – review & editing, Writing – original draft, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Godwell Nhamo:** Writing – review & editing, Validation, Supervision, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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