

Navigating complexities towards sustainable food crops production: local practices for climate change adaptation in rural Ghana

Daniel Dambeebo¹ · Francis Dakyaga^{2,3,4} · Emmanuel K. Derbile⁵

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Abstract

Globally, food crops production has been challenged by the impacts of climate change. Climate change scholars have argued that rural dwellers, particularly smallholder farmers who engage in food crops production, suffer the most due to their low capacity to adapt. A growing body of knowledge also suggests that local practices serve as safeguards, that enable smallholder farmers to lessen their vulnerability in food crops production. However, limited scholarly insight has been advanced about sustainable food production via the use of local practices. Through the mixed research approach, the study contributes to local practices and climate adaptation debates by examining the various local practices of smallholder farmers, the challenges they encounter with the use of such practices and the possibility for sustainable food crops production in the future in Ghana. The findings suggest that smallholders encounter multiple drawbacks in attempt to utilize local practices to adapt food crops production to climate change including the advent of modern farming inputs/practices. Even when multiple local practices (the planting of multiple crops' varieties, switching between crops and livestock rearing, reducing cultivatable land size) are utilized, only the increment in farm size, the use of income/remittances of rural–urban migrants to support food crops production, and early cultivation offered some possibilities of sustaining improvement in food crops production for the future. Therefore, the study concluded that local practices are not necessarily panaceas for sustaining food crops production under climate change. The study recommended that further studies pay attention to the sustainability of local practices under climate change.

Keywords Adaptation · Agriculture · Climate change · Local knowledge · Smallholder farmers

1 Introduction

About two-thirds of the world's population dwell in rural areas and engage in subsistence agricultural production [35]. Estimates suggest that rural dwellers own, occupy and use about 22% of the global land resources [48]. A growing body of knowledge also indicates that rural dwellers mainly rely on their local practices for food crops production, from which they earn a living [35, 40]. About one-third of the farmers utilize more or less local practices for food crops production [36]. Unfortunately, food crops farming as a source of livelihood has over the years been vulnerable to

✉ Daniel Dambeebo, ddambeebo@gmail.com; Francis Dakyaga, dakyaga@ubids.edu.gh; Emmanuel K. Derbile, derbile_uds@hotmail.com | ¹Masters Program in Infrastructure Planning, Faculty 2: Civil and Environmental Engineering, University of Stuttgart, Allmandring 6, 70569 Stuttgart, Germany. ²Department of Local Governance and City Management, SD Dombo University of Business and Integrated Development Studies, Bamahu – Wa Box WA64 Wa, Upper West Region, Ghana. ³Faculty of Spatial Planning, Technische Universität Dortmund, August-Schmidt-Str. 10, 44227 Dortmund, Germany. ⁴Department of Urban and Regional Planning, Ardhi University, P. O. Box 35176, Dar es Salaam, Tanzania. ⁵Department of Planning, Faculty of Planning and Land Management, SD Dombo University of Business and Integrated Development Studies, Bamahu – Wa Box WA64 Wa, Upper West Region, Ghana.



changes in climate [3, 19, 38, 53]. Studies in the global South reveal that drought, high temperature, erratic rainfall, flooding, soil erosion, insect infestations are key climatic events confronting smallholder farmers in earning a living through food crops production [26, 64]. These climatic events contribute to lowering food crops yields and increasing the vulnerability especially of smallholder farmers who engage in subsistence food crops' production [7, 28, 43, 57]. The reliance on rainfed agriculture, and climate-related effects on natural resources that augment smallholder farmers reinforce the vulnerability of smallholder farmers [8, 62]. In Africa, smallholder farmers are characterized as farmers whose cultivable lands do not exceed 1.28 hectares [22].

Some scholars have also drawn the attention of climate change scholars to the uneven geographies of climate change impacts, by showcasing the disparities in the vulnerability of farmers across geographies [3, 50]. In doing so, they brought to light the manifold climate-related factors that act as drawbacks to the food crops production of smallholder farmers [11]. Climate change scholars have also showcased the insurgent and the diversity of measures that farmers undertake to limit the vulnerabilities that arise from climate change, including the Sustainable Intensification Agriculture and Ecological Intensification Agriculture [2, 15, 32, 38]. Moreover, how such practices sustain food crops production among smallholder farmers remain unknown.

Studies, particularly in Africa context suggest that, Sustainable Intensification Agriculture (SIA), Ecological Intensification, soil and water conservation practices are evolving as feasible alternatives for fostering food crops' production due to arable land scarcity and for enabling easier management of farms [2, 15]. Moreover, in many parts of Sub-Saharan, the adoption of these approaches has been low among smallholder farmers and more or less shaped by the socio-economic and ecological factors such as credit constraints, rainfall pattern, farmer households' income status, social capital and network, the availability and access to market [30, 49, 60]. Again, a growing body of knowledge has demonstrated the use of local practices and their potentials in fostering climate change adaptations, enabling natural resource management, biodiversity conservation, disaster risk reduction/disaster management and endogenous development [1, 15, 20, 36, 48].

In the case of Ghana, the Ghana Statistical Service [24], reveal that about 88.8% of households in Ghana rely on agricultural activities drawing on local practices. Moreover, research on local practices and climate change adaptation, have largely grown along with; the perceptions of smallholders' farmers about climate change, how smallholder farmers cope and adapt to climatic events [16, 33], the vulnerability of smallholders to climate change [65], as well as the practices smallholder farmers engage in towards sustainable land management [29]. These studies have demonstrated the multiple trade-offs that smallholders in Ghana make to adapt food crops production to climate change. They revealed that, smallholder farmers sometimes compromise the production of certain food crops varieties for another in the given piece of land for an enhanced yield or may compromise the production of food crops, particularly, farming for poultry and livestock rearing or utilizing tractors to fasten ploughing of farmlands to meet the short pattern of the rainfall, and in turn pay for the cost of the ploughing after harvesting [2, 15]. Any of these decisions taken by smallholder farmers hold certain consequences in their efforts towards adapting food crops production to climate change.

Moreover, in the sphere of local practices and climate change, few studies have explored the traditional ecological practices of smallholder farmers in adapting to climate change [9, 14]. These studies have shown that smallholder farmers utilize varieties of adaptive practices often including both on-farm and off-farm practices. These practices have been regarded as useful for lessening vulnerability of smallholder farmers [14]. Because of this, studies have advocated for the need to protect local practices for food crops production and to integrate farmer-based practices and scientific-based evidence towards enabling smallholder farmers to adapt food crops production to climate change [21, 27, 42]. These studies argue that whilst the adoption of technology may be influential for minimizing climate-related effects, the costs of modernized technologies are often beyond the financial capacities of smallholder farmers to enable their adoption [10, 34, 39, 44, 51].

Whilst scholarly debate on local practices has evolved steadily, limited scientific insight has so far existed about the extent to which local practices can sustain improvement in food crops production among smallholders to warrant their adoption and integration with modernized/scientific agricultural practices. Therefore, the study builds on the aforementioned debates on climate change and local practices concerning food crops production from the global South. The study examines the multiple practices smallholder farmers utilize for food crop production, the challenges they face with the use of local practices, and how such practices can sustain food crops production among smallholder farmers. Sustainable food crops production in this context entails farmers' perceived guarantee of improvement in food crops' yields presently and in the future with the use of local practices. This study is relevant to the global development agenda 2030 on sustainability (Sustainable Development Goals—SDGs) particularly SDG 1 and 2 "No poverty—eradicating extreme poverty among smallholder farmers" and "Zero Hunger—by achieving

food security, increasing sustainable productivity and ensuring access to safe, nutritious and sufficient food all year round" respectively [17].

The aim of this study is to examine how smallholder farmers navigate the complexities arising from climate change through the use of local practices and how that sustains improvements in food crops production in Ghana. Complexities in this context entails the challenges smallholder farmers encounter with the use of local practices towards adapting food crops production to climate change. To do so, the study draws a conceptual review from climate change and local practice as tools for adapting food crops production to climate change to; (1) explore the local practices of smallholder farmers towards adapting food crops production to climate change; (2) the challenges smallholder farmers face with the use of local practices; (3) farmers' perceived sustainability in terms of improvement in food crops production through the use of local practices. The paper is organized into five sections, Sect. 2, presents conceptual and empirical reviews on climate change, local practices and food crops adaptation. Section 3, presents the methods, and the study settings. Section 4, presents the results and discussions of the study, whilst the last section presents the conclusion of the study.

2 Climate change adaptation of smallholder farmer's food crop production in Sub-Saharan Africa

2.1 Climate change, local practices and sustainable food crops production

As discussed earlier, whilst scholarly debates about climate change and local practices have evolved over decades, scholarly insight linking local practices and how they sustain improvement in food crops production among smallholder farmers remains limited. Moreover, sustainability scholars have drawn attention to the need for studies to align research findings and perhaps map our progress towards the sustainable development agenda 2030 [17]. The Sustainable development paradigm gained historical roots in the 1980s, defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [17]. Moreover, this study defines sustainable food crops production, as production that guarantees continuous improvement in food crops yields through the use of local practices by smallholder farmers. Therefore, the study measures farmers perceived improvement of food crops yields through the use of local practices. According to Rankoana [56], climate change refers to the variation in temperature and rainfall patterns over a long period. This definition centres on an observed variation in the elements of weather over time. A study by Theodory [61] suggests that changes in the climate occur due to changes in the socio-economic activities of people, agricultural and environmental factors. Whilst the MFCS [40] observes that the concept of climate change in Ghana is associated with variations in the elements of weather for a long period of time that in turn result to persistent drought, and unpredictable rainfall.

The factors influencing climate change have been broadly categorized to include natural and human factors [12, 18, 37]. Some studies have shown that climate change or its threats are a result of natural phenomena [3, 12, 41]. The key natural climate stressors that adversely influence agricultural systems include erratic rainfall, high temperature and drought as well as flood [4]. Empirical studies in the Upper West Region (the study location) such as Derbile and others [18] states that the "primary stressor of environmental change are drought". Whilst reports of some studies such as [5] and [12] also suggest that climate change is a result of human activities. Moreover, some scholars [5, 18], attribute the causes of climate change in Ghana to human activities such as deforestation and land degradation. They explain that bad farming practices and bush burning are specific activities that lead to deforestation and land degradation and hence climate change. However, in terms of perception, Concha [12], notes that farmers associate supernatural forces such as curses from smaller gods/ancestors as factors propelling climate change.

However, available evidence also suggests that though smallholders may feel the effects of climate change through changes in their livelihoods [25], they may not understand climate change, especially regarding its causes, as much as researchers and policymakers [46]. Findings of Theodory's studies [61] support this claim. It reveals that smallholder farmers gain awareness of climate change because of their direct interactions with nature through exploitation of natural capital for their livelihoods. What this implies is that farmers in the rural areas in most developing countries derive their livelihoods from primary production activities such as farming, hunting or lumbering hence more vulnerable to climate change. Another school of thought [3, 52] maintains that smallholder farmers are not very ignorant about issues of climate change as argued by some scholars. They contend that farmers have been forecasting the weather long before the emergence of climate change as a global concern. Through this, the mass media and Civil Society Organisations are now building on indigenous knowledge to enable farmers to observe and predict climate change.

Furthermore, Marrakesh [38] explains that smallholder farmers can use their cultural practices (guided by indigenous knowledge) to forecast the weather and can guide their daily production decisions as a response strategy to climate change. Consistent with this position, further studies [37] in Zimbabwe show that local practices may be used to determine the timing of important agricultural activities such as ploughing and planting. These traditional practices may be based on conjecture and are not supported by statistical tests [12]. Supportively, others argue that, all over Africa, local practices serve as a viable tool in food crop production [36]. Primarily, farmers can observe and forecast the nature of the changing environment and take decisions towards managing their farms [40, 59]. Marrakesh [38] adds that it may occur through observation of the biophysical entities including the stars, winds, livestock, insects, birds, trees and wildlife. In Malawi, South Africa, Tanzania, Uganda, Zambia and Zimbabwe, Mafongoya and others [36] find that traditional methods such as tree phenology, animal behaviour and astronomical observation are the basis of a seasonal weather forecast. In Senegal, local practices have been proven to be critical in improving the quality of climate forecasting services for farmers [63]. As indicated earlier, the review of the aforementioned studies, suggest that the causes of climate change, awareness of smallholder farmers about the causes of climate change, the challenges that arise due to climate change as well as smallholder farmers' perceptions of causes of climate change are somehow known in the literature. Therefore, what remains less known is how smallholder farmers navigate the complexities that arise due to climate change towards food crops production through the use of local practices and how such practices sustain improvement in food crops production. The next section provides further conceptual understanding of local practices as a tool for climate change adaptation.

2.2 Local knowledge and practices for adapting to climate change

Local knowledge is synonymous with the culture or indigenous practices of a group of people that have been handed down from generation to generation [48, 51, 54]. This means that the cultures, values, norms and beliefs of farmers are tied to indigenous knowledge, which often manifests through practice. "Local knowledge refers to the knowledge and know-how that has been accumulated across generations, which guide human societies in their innumerable interactions within their surrounding environments" (Nakashima et al. 2012). Therefore, the term does not only connote current practices but also include those that have been practised sometimes in the past. Theodory [61] agrees with this perspective about local knowledge but maintains that the concept includes daily practices of indigenous people, learning and lessons regarding their lives. Such experiences shape water conservation and soil management practices in farming as well as knowledge in the systems of farming.

Whilst Kpandonou et al. [32] indicate that climate discussions have assumed a global dimension and larger in context while the benefits associated with adaptation and mitigation efforts affect local communities and rural livelihoods. Farmers have noted the diversity of climate change impact and thereby develop their local response strategy in multifaceted ways [12]. The main indigenous strategies/approaches developed fall under adaptation and or mitigation [36, 38, 59]. According to Nzeadibe et al. [52], adaptation is a proactive process because it envisages possible future changes in the climate. Adaptation is associated with ones' preparedness towards managing climate change-related risk on food crops production [52]. Indigenous knowledge in practice contributes to the co-creation of farm-led knowledge on climate change adaptation [36]. It strengthens adaptation measures in multiple ways; by providing a wealth of observation and insight beyond the power of external experts, embedding solutions in local cultures and broadening the values and viewpoints of stakeholders [63]. Several empirical studies have acknowledged the potentials of indigenous practices in fostering farmers ability to adapt to climatic shocks and stressors [1, 6, 32, 41, 59]. This suggests that indigenous practices perhaps hold some potential for sustaining rural livelihoods even without the integration of scientific technologies.

Most studies have also pointed out how adaptation measures have manifested in resource management and subsistence agricultural practices [3, 4, 50, 58, 59]. Other studies reveal that intercropping serves as the main indigenous adaptation strategy for food crops production [23]. In Mutoko (Zimbabwe), farmers substitute maize cultivation with millet and sorghum, which increases their farm yield, and reduces their level of vulnerability to climate change [42]. Theodory [61] notes that practices such as the cultivation of crops in wetlands facilitate food crops production in drought-prone regions and help farmers adapt to the short-term rainfall pattern. In Nigeria, regular weeding of cropped farmlands, early planting of crops such as maize and cassava, preservation and selection of seeds of next planting season are some of the adaptive measures identified by Nzeadibe et al. [52]. According to Gyampoh et al. [25], farmers in Ghana cultivate food crops that thrive well under prevailing conditions. In Northern Ghana, farmers preferably cultivate traditional crop varieties as opposed to hybrid or synthetic ones because of perceived suitability to the local conditions [50]. Consistent with these observations, Saitabau [59] reports that farmers in Loita Maasai have maintained indigenous strain of livestock

which they believed can survive prolonged dry conditions. This implies that different ecological zones utilise specific indigenous practices as strategies to adapt to climate change.

Furthermore, local practices such as mulching, kraal manure, among others are commonly adopted by some farmers to adapt to climatic events such as drought and shortening rainfall patterns in Sub-Saharan Africa [15, 42, 52, 56]. Also, the practice of agroforestry as both mitigation and adaptation strategy has been found essential in building food crops adaptation to climate change [5, 47]. Most farmers recognize the importance of having trees on their farms to shade crops from intense sunshine [2, 15]. Some of the widely adapted measures identified in the Niger Delta Region of Nigeria include; the cultivation of cover crops like a melon for soil moisture conservation, zero tillage to limit the exposure of the soil [52].

With regards to water shortage management, studies have shown that smallholders create temporary walls at river banks and stone bonds at farm levels as a kind of indigenous knowledge practices towards water conservation [15, 45]. The adoption of water conservation measures is in response to a reduction of soil fertility and the occurrence of erratic rainfall and drought [40]. In conclusion, the potentials of local knowledge and practices concerning food crops production are somehow known in the literature from the Sub-Saharan African context. However, what remains less known in literature is how smallholder farmers navigate the complexities or the challenges arising from climate change through the use of local practices and how such an attempt can sustain improvements in food crops' production.

3 Study settings and methods

3.1 Study area

The study was conducted in the Wa East District, located in the South-Eastern part of the Upper West Region of Ghana. The district shares boundaries with West Mamprusi to the northwest, West Gonja to the south-east and the Sissala East district to the north [24]. The area has a landmass of about 4297.1sq/ km², and it is located between latitudes 9° 55" N and 10° 25" N and longitude 1° 10" W and 2° 5" W. Fig. 1 shows the district and the communities studied.

Like most communities in northern Ghana, the climate of the Wa East district is characterized by the guinea savannah, which experiences both hot and wet seasons within a year. The district is also characterized by high annual temperatures ranging between 22 °C and 42 °C. The single rainfall pattern occurs between May to October. This rainfall pattern limits all-year-round food crop production. The vegetation is made up of scattered trees, shrubs and grasses. The common tree species found included shea, baobab, kapok, Dawadawa, acacia, neem, ebony, mangoes, cashew and ache apple. The economy of the district has three major sectors (agriculture, industry and services). Agriculture engages (85%) of the workforce, industry (10%) and the services sector (5%). Food crop production is the major activity of the majority of inhabitants in the district. About (96%) of the farmers in the district are subsistence food crop producers and the major crops cultivated include sorghum, yam, millet, maize, cowpea, groundnuts, rice, soya beans, cowpea, cassava and vegetables [24].

3.2 Material and methods

A mixed approach was used to examine how smallholder farmers navigate the complexities or challenges arising from climate change with the use of local practices and how such practices sustain food crop production in their communities. Both quantitative and qualitative data were collected for the study through households' surveys, in-depth interviews, Focus Group Discussions (FGD). The mixed-method was useful for a descriptive and in-depth exploration of local practices. A three-stage multi-stage sampling procedure was used to select the study communities. The first stage involved the selection of local government areas (district within the region). The aim was to select a district dominated by smallholder farmers and where residents are actively engaged in food crops farming. Therefore, the Wa East district was selected. The second stage involved the selection of communities more dominated by smallholder farmers in the selected district. Concerning this, six (6) communities were purposively selected including *Loggu, Bunaa, Bulenga, Tissaa, Baayiri and Kundugu* towards the households' sampling and the data collection.

A total of 196 smallholder farmer households were surveyed out of the district population of 89,194 (GSS, 2020. Projections), comprising 13,352 households. The six studied communities had a total of 1401 farmer households with an average of 7 persons per household. The households in the selected study communities were disproportionately sampled for the survey (see Table 1).

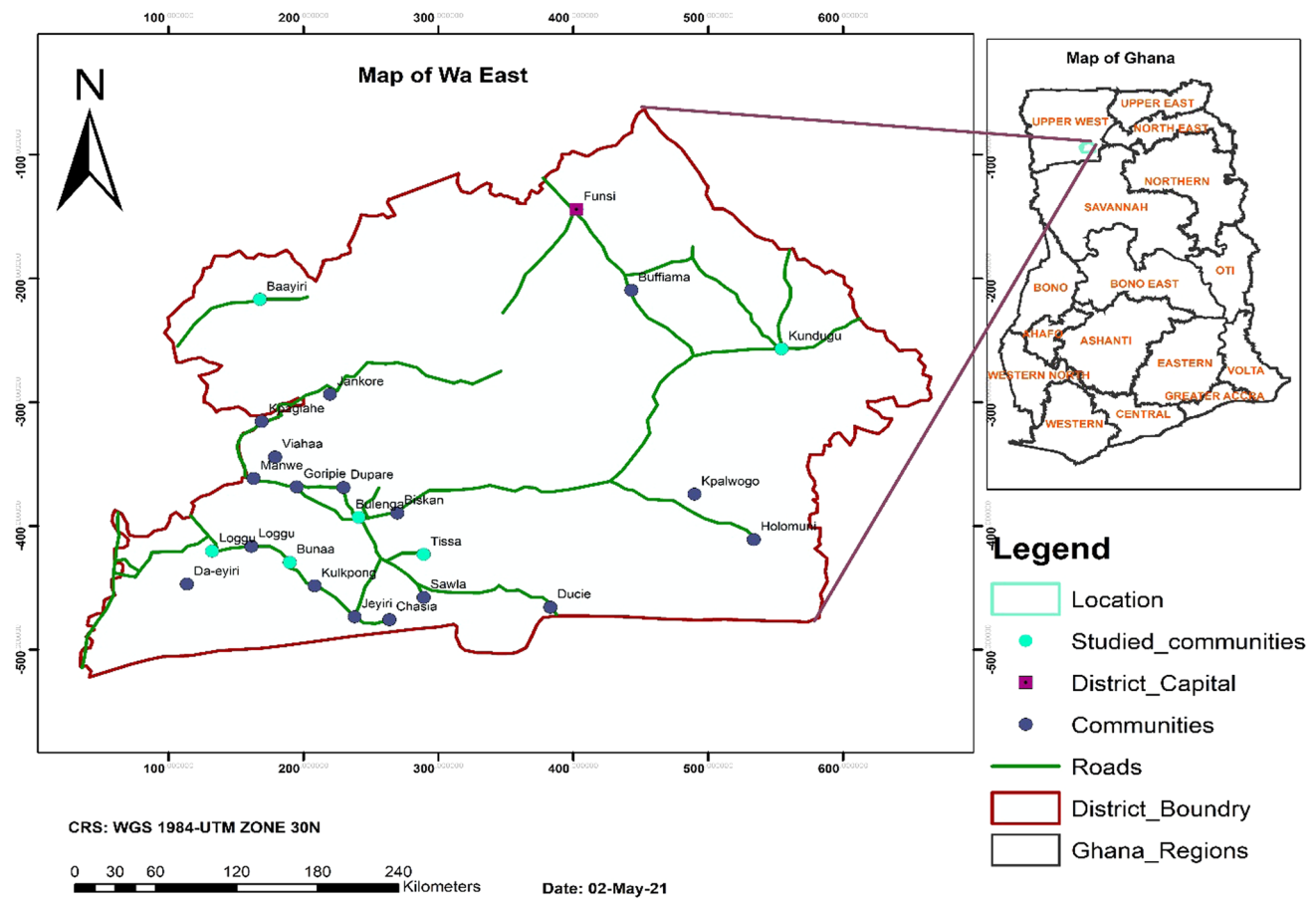


Fig. 1 Map of study areas. Source: Digitized and modified from GSS, 2014

The Ghana Statistical Service (2014) reports that 85% of households in the study communities- *Loggu, Bunaa, Bulenga, Tisaa, Baayiri and Kundugu* were engaged in food crops farming. The representativeness of the 196 households was determined using Panneerselvam [55] sample size determination formula.

$$n = \frac{Z^2 * P(1 - P)}{M^2}$$

where n = required sample size; Z = confidence level at 95% (standard value of 1.96); P = estimated prevalence of respondents in the population; M = margin of error at 5% (standard value of 0.05).

The value of P (percentage of households in agriculture in the Wa East District) is 85%. Hence the sample size is:

Table 1 Basic characteristics of the study population

Study communities	Population	Households	Sampled households
Loggu	1199	182	24
Bunaa	1179	179	23
Bulenga	1224	185	27
Tiisaa	1749	265	32
Baayiri	1550	235	40
Kundugu	2344	355	50
Total	9245	1401	196

Source: Estimate data based on GSS (2014) report

$$n = \frac{1.96^2 * 0.85(1 - 0.85)}{0.05^2}$$

$$n = \frac{3.8416 * 0.1275}{0.0025}$$

$$n = 196$$

Sample size = 196 farmer households.

The household's survey was conducted with 196 randomly selected farmer households. Heads of households and persons directly engaged in food crops farming were targeted. In each of the selected communities, households were randomly approached for the survey. The surveys were conducted during the farming season, where some farmers were engaged in farming activities and not available at their various households. This limited the random approach for the conduct of the surveys. The study addressed this limitation through random approach of the next household(s) for survey on occasions where no head of household or persons engaged in food crop production was found for the conduct of the surveys. Throughout the survey, the semi-structured interview guide comprised closed and open-ended questions. These were used to unearth the practices of smallholder farmers and the associated navigations towards climate change adaptation, and for sustaining improvement in food crops production. Field data were gathered on the demographic characteristics of households, the local practices of smallholder farmers, the challenges farmers encounter with the use of local practices towards adapting food crops' production to climate change. The study also questions smallholder farmers whether there are possibilities of the use of local practices to sustain improvement in food crops production now and in the future. The essence of this question was to draw smallholder farmers' experiences and understanding of the local practices concerning future food crops' production.

An in-depth interview was conducted with three (3) leaders of farmer groups. Elderly farmers were purposively selected based on their experiences and long-term engagement in food crop farming in the study communities. Data was collected on local practices they have utilized over the years, the challenges they have observed with the use of such practices for food crops production at present, and their perception of the existing practices to sustain improvement in food crops production now and in the future.

In addition, Focused Group Discussions were also conducted with three (3) farmer groups in the selected communities to complement the household surveys and the data gathered through the in-depth interviews. The FGDs were conducted at Loggu, Bulenga and Kundugu due to the existence of farmer-based groups. The interviews validated the data collected from the households' surveys and that of the in-depth interviews collected from key informants. Data were also gathered on the various local practices of smallholders that enable adaptation to climate change, the challenges they face with the use of local practices towards adapting food crops production to climate change, and the possibility of local practices to sustain food crops production.

The data was collected between 10th February to 8th April 2018. The data collection process was assisted by three Research Assistants (RA), native speakers of Waala, Dagaare, and Sisaala (the dominant local languages spoken in the study communities). The qualitative data were analysed thematically. The quantitative data collected were edited, coded and processed with SPSS spreadsheet version 21. Descriptive and inferential statistics/cross-tabulation were used to differentiate the use of the local practices among the socio-economic groups of farmers studied. Chi-tests were conducted to determine the association between the use of the various local practices by smallholders' farmers and sustainable improvement in food crops' production. Cross-tabulation analyses were conducted to examine the differences among smallholder farmers in terms of practices undertaken and the complexities that smallholder farmers encounter with the use of local practices for food crops production. The two forms of data were integrated, to harness their synergies [13]. Ethical clearance for field study was obtained from Wa East District Assembly, and the University of Stuttgart, Germany in January 2018 for the conduct of field studies for a Master dissertation undertaken, at the University of Stuttgart, Germany.

4 Results and discussion

4.1 Demographic characteristics of the respondents

From the household's surveys, the majority (75%) of the respondents were males as presented in Table 2. Just a few females were found as household heads. This limited the study in obtaining perspectives from female-headed households' farmers. Besides, most of the respondents were married (85%). In terms of ethnicity, most of the respondents were Waalas, who were affiliated with the Islamic religion. The gender distribution also implies that decisions making regarding the practice to adapt food crops production to climate change were taken mostly by males in the district. The results suggest that local practices towards food crops production in the district were shaped by the culture of the dominant ethnic group, the Waalas. Because local practices are more or less tied to the culture, values, norms and beliefs of smallholder farmers [48, 51, 54, 61], in the study communities. With diverse values, beliefs and norms, the beliefs, values and norms of the dominant ethnic group, in turn, shape the practices of the engaged group of farmers, manifest and utilized as a collective whole. In the context of this study, the Waalas who constituted the major ethnic group influenced the practices, values, norms that smallholder farmers applied towards adapting food crops production to climate change. The findings also suggest that the beliefs and the practices of the few ethnic groups are often influenced by that of the dominant groups of farmers.

In terms of age, the modal age of most of the respondents was 36 depicting the prevalence and the engagement of the younger and active labour in food crops production in the studied communities. On education, most of the respondents had basic level education with an average of 8.92 years of formal education experiences and training which perhaps informed their reliance on local practices. From interviews, respondents demonstrated knowledge of low exposure to modern farming practices and technological innovations. Moreover, the study also realized that respondents obtained a greater proportion of their income from farming activities as their main livelihood activities, suggesting the relevance of food crops production to the livelihood of residents in the study communities.

4.2 Local practices of smallholder farmers for adapting food crops' production to climate change

Farmers engaged in multiples and wide ranges of local practices towards adapting food crops production to climate change. These included changing the planting times of food crops, the cultivation of local/traditional crops varieties, maintaining a balance between food crop production and livestock and poultry rearing, reducing farm size

Table 2 Demographic characteristics of the respondents

Variable	Frequency	Percent
Gender		
Female	49	25.0
Male	147	75.0
Marital status		
Single	13	6.6
Married	167	85.2
Divorced	8	4.1
Widowed/Widower	8	4.1
Ethnicity		
Waala	137	69.9
Dagaare	49	25.0
Sissala	10	5.1
Religion		
Christianity	40	20.4
Islam	153	78.1
Traditional African Religion (TAR)	3	1.5
Total	196	100

Source: Field Survey (2018)

amongst others. In reference to the perspective of Sustainable Intensification Agriculture (SIA), farm size reduction enables farmers to concentrate the application of inputs on the smaller plots and effectively manage production to enhance food crops yields, that perhaps might not have been achieved in larger cultivable areas (44, 38, 2). From the surveys, smallholder farmers revealed to have been reducing their farm sizes overtime for adequate management towards enhancing food crops yields. Whereas these practices have also been observed elsewhere in Sub-Saharan Africa [15, 42, 52, 56], the findings suggest that variation often exists across the ages, sex and religious affiliations of smallholder farmers in terms of the adoption and usage of these practices towards adapting food crops production to climate change. Whilst most farmers (86.7%) utilized local practices towards adapting food crop production to climate change, particularly the short-term pattern of the rainfall by practicing early cultivation of food crops, younger smallholder farmers particularly between the ages of 19 and 48 were the dominant group of farmers actively engaged in all the local practices towards adapting food crop production to climate change. From the in-depth interviews, elderly smallholder farmers demonstrated adequate knowledge about the use of local practices, based on their accumulated farming experiences over the years. However, they were less actively engaged in food crop farming activities as compared with younger and active farmers. This implies that younger farmers currently engaged in food crops production might have acquired such knowledge and experiences from the elderly farmers over the years. Also, more males were engaged in local practices for climate change adaptation compared to females. This might have been shaped by the domination of males in terms of decision-making regarding food crop production in the rural communities [50]. As indicated earlier, the dominant religious group such as the Muslims were the dominant group of smallholder farmers engaged in local practices. The findings suggest that, beyond the commonly reported utilization of local practices, there are usually remarkable variations in terms of socio-economic groups. This has often been ignored in the climate change and local practices' reportage. As disclosed by a farmer, *"Because of the change in rainfall pattern, we now plant early maturing crops, change in the time of planting, planting of okra. We now rear a lot of livestock than before. We also sell cooked food to support the farm income"* (March 2018 an In-depth interview with the women group leader at Buffiama). This finding confirms Kom's [31] observations where smallholder farmers engage in the early planting of food crops to adapt to the changes in climate and for early harvesting. In effect, the finding demonstrates more or less the commonalities of these local practices across geographies, particularly, within the African continent (Table 3).

The findings also suggest that smallholder farmers rely on off-farm practice, particularly rural–urban migration through which they earned income to augment their farm produce [14]. Again, this practice was more engaged in by the young and active labour force. As disclosed in the course of the FGD, *"Some of the young ones now migrate to the city to find other jobs. We also shift the farms very often to different locations. We apply fertilizer to some of the crops too"* (March 2018 an In-depth interview with the women group leader at Jankore). In addition to these practices, farmers collected and developed stones bonds as soil water conservation practices which they acquired through experiences and as generational knowledge and local practices. In addition, some farmers gathered stones and sold for income to augment food crops production. Discussants demonstrated the conduct of this practice as follows; *"We also collect stones during the dry season and sell to developers and building contractors to support our annual farm harvest"* (March 2018 an In-depth interview with the women group leader at Holomuni). These indigenous practices were applied by farmers in different places as confirmed in previous studies [4, 51, 54, 59].

4.3 Complexities with the use of local practices for adapting food crops production to climate change

Having revealed the varied local practices that smallholder farmers utilize towards adapting food crops production to climate change, here the study demonstrate the various complexities that smallholder farmers encounter with the use of local practices for adapting food crops production to climate change in their everyday engagement. The study revealed that whilst local practices have been useful for adapting food crops production to climate change the practices are not without challenges (see Table 4). From the household's surveys, increasing incidences of bushfires, the depletion of water resources, limitations of arable lands as well as the diminishing in the adoption of local practices were found as drawbacks to the use of local practices for food crops production. Moreover, these challenges were socio-demographically associated among smallholder farmers studied. Specifically, rampant bushfires, limited arable land and the depletion of water resources were disclosed as major hindrances to the short-term pattern of rainfall, shifting cultivation and engaging in dry season gardening. Others included the extinction of indigenous practices due to the advent of modern farming practices and farm inputs and the reduction of livestock and poultry

Table 3 Local practices for adapting food crops production to climate change

Local practices		Age of farmers				Sex		Religion		
		19–33	34–48	49–63	64–78	Male	Female	Christianity	Islam	TAR
Change in planting date	Count	76	83	10	1	126	44	38	129	3
	Expected	78.1	79.8	9.5	2.6	127.5	42.5	34.7	132.7	2.6
Cultivation of local crops varieties	Count	70	83	8	3	125	39	32	129	3
	Expected	75.3	77.0	9.2	2.5	123	41	33.5	128	2.5
Shifting cultivation	Count	35	28	2	1	49	17	16	50	0
	Expected	30.3	31.0	3.7	1.0	49.5	16.5	13.5	51.5	1.0
Balancing between food crop farming and livestock production	Count	6	9	6	0	18	3	2	17	2
	Expected	9.6	9.9	1.2	0.3	15.8	5.3	4.3	16.4	0.3
Reduction in farm size	Count	20	22	3	1	36	10	11	35	0
	Expected	21.1	21.6	2.6	0.7	34.5	11.5	9.4	35.9	0.7
Increasing cultivated areas	Count	9	4	0	0	9	4	0	13	0
	Expected	6.0	6.1	0.7	0.2	9.8	3.3	2.7	10.1	0.2
Use of irrigation	Count	16	20	4	0	37	3	2	38	0
	Expected	18.4	18.8	2.2	0.6	30.0	10	8.2	31.2	0.6
Use of shade and shelters	Count	22	33	4	0	37	12	11	38	0
	Expected	22.5	23.0	2.8	0.8	36.8	12.3	10.0	38.3	0.8
Rural–urban migration	Count	32	24	7	0	59	4	16	45	2
	Expected	28.9	29.6	3.5	1.0	47.3	15.8	12.9	49.2	1.0
Off-farm jobs	Count	56	52	11	0	108	11	21	98	0
	Expected	54.6	55.9	6.7	1.8	89.3	29.8	24.3	92.9	1.8
Increase in faith and Prayer	Count	27	33	3	0	47	16	15	46	2
	Expected	28.9	29.6	3.5	1.0	47.3	15.8	12.9	49.2	1.0
Use of manure	Count	56	52	2	0	86	24	19	89	2
	Expected	50.5	51.6	6.2	1.7	82.5	27.5	22.4	85.9	1.7

Source: Field Survey (2018)

rearing, whose droppings usually serve as manure and input for the preparation of compost. As observed elsewhere, this study revealed that the extinction of local practices in the study communities is due to improper dissemination of local practices concerning food crops production, due to poor knowledge sharing culture among the present generation [36, 37].

As disclosed in the course of FGD; “We use to have so much water flowing through our rivers, but it is now less because of the reduced rainfall pattern. There is now a lot of bush fires and overgrazing by the Trans-Nomadic farmers” (March 2018, leader of the women group at Jankore)” (Table 5). The discussants further revealed that few farmers cultivated a local variety of guinea corn and millet due to their late maturity nature and the rising incidences of bush fires in their communities.

4.4 Farmers’ perceived possibility of sustainable improvement in food crops production

In this section, the study presents farmers’ perceptions about the sustainability of food crops production via the use of local practices. Thus, the perceived guarantee of improving food crop yields over the years through the use of local practices. By analyzing the varied local practices of smallholder farmers that mediate food crops production, the findings suggest that most smallholder farmers (70%) were optimistic about the possibility of sustaining food crops production via the use of local practices in the future. However, about 30% of the smallholder had low confidence in the capability of local practices to sustain improvement in food crop production.

Moreover, following the analysis, the local practices found included the changes in planting dates, planting of local crops varieties by smallholders to adapt to changes in the weather, and shifting cultivation amongst others. However, whilst most farmers were optimistic about future improvement in food crops production through the use of local practices, not all the local practices were found relevant in shaping sustainable improvement in food crops production.

Table 4 Complexities with the application of local practices

Background		Rampant bushfires	Extinction of knowledge	Extreme farming practices	Limited arable land	Depletion of water resources	No idea	Total
Age								
19–33	Count	9	8	3	11	11	46	90
	Expected	6.4	9.6	3.7	11.0	11.5	46.4	90.0
	%	64.3	38.1	37.5	45.8	44.0	45.5	45.9
34–48	Count	5	11	4	11	14	47	92
	Expected	6.6	9.9	3.8	11.3	11.7	47.4	92.0
	%	35.7	52.4	50.0	45.8	56.0	46.5	46.9
49–63	Count	0	1	1	2	0	6	11
	Expected	0.8	1.2	0.4	1.3	1.4	5.7	11.0
	%	0.0	4.8	12.5	8.3	0.0	5.9	5.6
64–78	Count	0	1	0	0	0	2	3
	Expected	0.2	0.3	0.1	0.4	0.4	1.5	3.0
	%	0.0	4.8	0.0	0.0	0.0	2.0	15
Sex								
Male	Count	12	18	6	18	14	76	147
	Expected	10.5	15.8	6.0	18.0	18.8	75.8	147.0
	%	8.2	12.2	4.1	12.2	9.5	51.7	75.0
Female	Count	2	3	2	6	11	25	49
	Expected	3.5	5.3	2.0	6.0	6.3	25.3	49.0
	%	4.1	6.1	4.1	12.2	22.4	51.0	25.0
Marital status								
Married	Count	10	18	7	24	21	84	167
	Expected	11.9	17.9	6.8	20.4	21.3	86.1	167.0
	%	6.0	10.8	4.2	14.4	12.6	50.3	85.2
Single	Count	2	0	0	0	2	9	13
	Expected	0.9	1.4	0.5	1.6	1.7	6.7	13.0
	%	15.4	0.0	0.0	0	15.4	69.2	6.6
Divorced	Count	2	2	0	0	0	4	8
	Expected	0.6	0.9	0.3	1.0	1.0	4.1	8.0
	%	25.0	25.0	0.0	0	0.0	50.0	4.1
Widowed	Count	0	1	1	0	2	4	8
	Expected	0.6	0.9	0.3	1.0	1.0	4.1	8.0
	%	0	12.5	12.5	0.0	25.0	50.0	4.1

Source: Field Survey, (2018)

Instead, the variation in the planting date of food crops was found significant with farmers perceived sustainable improvement in food crops farming. *"We have noticed that when we plant early maturing crops, and as well delay in the planting date, we get improved yield"* (Leader of the farmer group at Kundugu, April 2018). About, 67.1% of the respondents adopted the variation of planting dates and disclosed to have observed some level of improvements in food crops yields and more optimistic of future improvements. The chi-square test reveals a test value of 4.910 which is significant at 5% (P -value < 0.05). The results also revealed that the planting of local crops by farmers has a significant influence on their farm outputs (see Table 5).

Farmers engaged in both food crops' production, livestock and poultry rearing were optimistic of attaining sustainable improvement in food crops production also in the future. As disclosed by a key informant, *"When we keep livestock in addition to the crop farming, we are better off than only crop farming, we can sustain ourselves and become sufficient"* (March 2018, leader of a farmer group at Loggu). Other practices with the possibility of improving food crops production included a reduction in cultivation areas, that enables adequate management of the farm/plants and the application of the scarce manure. This is supported by the findings of Antwi-Agyei and others [4]. When smallholder farmers increase

Table 5 Local practices and perceived improvement in food crops farming in the future

Local knowledge/Practices	Possibility of sustaining improvement in food crop production in the future		Total (100%)	Chi-square	P-value
	Yes (%)	No (%)			
Change in planting date	23 (88.5)	3 (11.5)	26	4.910	0.018**
Planting of local crops	18 (56.2)	14 (43.8)	32	3.386	0.054*
Variations of plots	89 (68.5)	41 (31.5)	130	0.379	0.328
Balancing between food crops farming and livestock	126 (72)	49 (28.0)	175	3.430	0.058*
Reduction in cultivated land	110 (73.3)	40 (26.7)	150	3.585	0.045**
Increase in cultivated land	124 (67.8)	59 (32.2)	183	5.996	0.008***
Use of irrigation	112 (71.8)	44 (28.2)	156	0.254	0.171
Use of shades and shelters	103 (70.1)	44 (29.9)	147	0.008	0.531
Rural–urban migration	104 (78.2)	29 (21.8)	133	13.540	0.000***
Off-farm jobs	59 (76.6)	18 (23.4)	77	2.726	0.067*
Increase in faith and prayer	94 (70.7)	39 (29.3)	133	0.119	0.426
Use of manure	54 (62.8)	32 (37.2)	86	3.679	0.039**

Source: Field Survey (2018)

*, **, and ***, represent significance at 0.1, 0.05, and 0.001 level

the size of cultivable land to include fallow and virgin lands, as identified by Baruah and others [11], it leads to significant increase in crop yield and promising for food crop sustainability. Moreover, these local practices were never panaceas but rather requires careful application/usage to attain the desired output. However, local practices such as the use of shades and shelter, and rising faith and praying to God were not significant practices that could sustain improvement in food crops yields over the years.

5 Conclusions, policy implications for planning and further research

This study examined how smallholder farmers navigate complexities that arise from climate change towards sustainable food crops production. The study contributes to climate change and local knowledge debate by examining the various local practices smallholder farmers utilize, the challenges they encounter and the possibility of such practices to sustain improvement in food crops production. By drawing a review on local practices and climate change, the study contributes to existing scholarly debates on local knowledge and climate adaptation in Sub-Saharan Africa. The findings suggest that smallholder farmers encounter multiple challenges that range from increasing incidences of bushfires, extinction of local practices to limited arable land, amongst others. These challenges limited smallholder farmers' ability to adapt food crops production to climate change through the use of local practices. Even where multiple practices were used, such as switching between food crops farming and livestock rearing, reducing cultivatable land size amongst others, only the increment in farm size, the use of remittances from rural–urban migrations to support food crops production, and early cultivation offered possibility of sustaining improvement in food crops production of farmers in the future. Therefore, the study concluded that local practices are not necessarily panaceas for sustaining food crops production under climate change. The findings suggest that food crops production at the local levels have been more or less influenced by hybrid practices, knowledge and actors such as individual farmers' characteristics. Overall, given the multiplicity of local practices as well as the ecological diverse geographies in which these practices manifest, it is imperative that future research focuses on placed-specific analysis of local practices of smallholder farmers in relations to food crops production to limit the overly generalization of efficacy of local practices by unearthing the appropriate practices that can sustain food crops production in a given space. The study therefore recommends that officials of the Ministry of Food and Agriculture and policy-makers pay attention to the evolving alternative practices engaged in by smallholder farmers, either by promoting, improving smallholders' farmers' capacities to continuously undertake such practices or by promoting inter-community farmer-based learning, where farmers can cross learn from one another to limit the complexities that arise with use of local practices for adapting food crops production to climate change presently and in the future.

Authors' contributions DD: drafted the manuscript drawing data from his Master of Science thesis conducted in the University of Stuttgart, Germany. This included the introduction of the paper, the review of literature and the development of the findings and conclusion. FD: Reviewed and organized introduction, the literature review and the findings and conclusion section of the manuscript. He further added literature to the introduction section. EKD edited the paper and made recommendation for further improvement and submission to the journal. All authors read and approved the final manuscript.

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Declarations

Ethics approval and consent to participate The study obtained ethical clearance prior to the field data collection from the Wa East District Assembly, and the University of Stuttgart, Germany in January 2018. In addition, informed consent was sought from each respondent and confidentiality assured before the conduct of interviews.

Competing interests The authors declare no competing interests.

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