



# Climate Change, Flood Disaster Risk and Food Security Nexus in Northern Ghana

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This research reviews climate change, flood disasters impacts and food security nexus in northern Ghana. The impacts of climate change include flood disasters which in turn affect food production with subsequent impact on food security. While climate change impact can be positive in some regions, it can be negative in other regions as it could lead to excess or lack of water, which negatively affects food production. Most especially, flood disasters have reportedly become frequent with devastating consequences on food production. Literature further suggests that the frequency of floods and their impacts have the potential to increase in the future. Floods inundate farms, pastures and livestock, which could subsequently reduce crop yields and animal production. Floods also destroys physical infrastructure and disrupts socio-economic activities which are linked to agriculture sector and could affect food production. This eventually decreases food availability, accessibility, utilization, and stability in the region. Northern Ghana has experienced flood disasters with increased frequency, which are related to climate change impacts. Although there is research on climate change, flood disasters, and food security issues in northern Ghana, the literature thus far indicates no clear focus of studies that focuses on the nexus of climate change, flood disasters, and food security of the study site. Thus, this research seeks to review the nexus of climate change, and flood disaster impacts on food security in northern Ghana with their implications on food security in the region. This study has two main research objectives. The first objective of this research is to identify and understand the potential impacts of climate change and flood disasters on food production in the study site. The second research objective is to explain the connection between climate change and flood disasters and the implications of this relationship on food security in the study site. This review study focuses on climate change, flood disasters, and food production to understand the critical impacts of climate change and flood disasters on food security in the northern part of Ghana. The aim of this research is to contribute to literature and discussion of the nexus of climate change, flood disaster impacts and food security sub-Saharan Africa.

**Keywords:** food security, climate change, flood impacts, northern Ghana, nexus

## INTRODUCTION

This research analyses climate change, flood disaster impacts and food security nexus in northern Ghana. Climate change and its related impacts on agriculture in societies have attracted development and policy concerns among local, regional, and international levels [Clover, 2003; IPCC, 2007; Food Agricultural Organisation (FAO), 2015]. Literature on climate change suggests that current increase in greenhouse gases from activities of humans and natural events have contributed to high rise in the average global temperatures beyond levels of the pre-industrial era (IPCC, 2014, 2007). Increase in the average global temperatures gives rise to global warming which affects precipitation, sea level rise, tsunamis et cetera. The impacts of climate change on precipitation and increase in sea level rise have resulted in lack and excess of water in regions that could experience floods and droughts (White, 2010). These events have disproportionate impacts on regions, seasons, and sectors of societies. For instance, agricultural sector contributes to the livelihoods and food security of societies but impacts of the climate change related events threaten the sector. In developing nations, especially, the agricultural sector employs a majority of the working population, yet it faces the perils of climate change. The impacts of climate change and its related events on food production and food security are a sharp threat to African countries that already have protracted history of poverty and food insecurity for decades (IPCC, 2014).

The problem in parts of Africa continent has been described as a food crisis due to the high number of people without secured adequate availability, access, utilization, and stability of food year-round [Clover, 2003; Akudugu et al., 2012; Food Agricultural Organisation (FAO), 2015]. In explaining the food security threat in sub-Africa, Clover (2003) reveals how the problem of food security is a pan-African issue that cuts across regions and needs to be understood and addressed. Ngcamu and Chari (2020) studied the impacts of droughts on agriculture in rural Sub-Saharan Africa and confirmed that drought is a threat to food security which requires multi-strategy and multi-stakeholder framework mitigation approaches to ensure resilience to food security. Deressa et al. (2010) investigated climate change and agriculture as a problem with emphasis on the perception and adaptation of farmers to the impacts of climate change along the Nile basin in Ethiopia. Ola (2018) focused on the challenges of climate change of rural dwellers of Esanland in Nigeria and concludes that farmers are vulnerable to the adverse impacts of climate change. With more specific emphasis on floods, Akukwe et al. (2020) studied flooding as climate change hazard and its impacts on food security in southeast Nigeria. Results of their research confirmed that floods negatively affect food security by increasing the number of food insecure households in the study area.

There are several studies about climate change impacts on rural communities and food security in northern Ghana. Chemura et al. (2020) studied the impacts of climate change on agro-climatic suitability of main crops in rural communities with emphasis on savannah crops and confirmed that weather and climate change have impacts on agriculture with sorghum

and groundnuts most affected. Musah et al. (2013) in their studies on the effects of floods on livelihoods and food security in Tolon-Kubungu District in the Northern Region of Ghana confirmed that flood disasters affect socioeconomic activities communities that reduce food security in the region. In his studies, Quaye (2008) reviewed the food security situation in northern Ghana with emphasis on the coping strategies and the constraints being faced in the region. The studies indicate that erratic rainfall, droughts, floods, and poor infrastructure seem to dwindle farmers' capacity toward food security in the region. Cooper et al. (2019) studied hunger, nutrition, and precipitation issues in Ghana and Bangladesh, and revealed that the two countries face irregularities in rainfall and the ability to produce enough food for their populations. Agyei (2016) further observed that remittances from migrants contribute to access to farmland and food production toward food security in Ghana. This observation demonstrates that although outmigration may relocate labor away from agriculture in some regions, emigrants, in turn, support to achieve security in their home communities through remittances.

In a different view, Sidibé et al. (2016) contended that there are opportunities for flood recession agriculture along floodplains in Ghana. The basis of this argument is that alluvial soils along floodplains after flooding provide fertile soils for farming activities to contribute to food security. Irrigation projects along floodplains can make use of the fertile soil for agricultural production. The literature further reveals that climate change and variability impact is a threat to crop production in the rain-fed agricultural system in Ghana with the potential to worsen the food insecurity situation of the vulnerable population (Asante and Amuakwa-Mensah, 2014). Relying on natural rainfall for agriculture is unsecured and needs to consider other means for food production. Again, destructions from floods disasters can damage physical infrastructure linked to agriculture and food supply chain which can deteriorate food availability, access, and stability in countries. For instance, Begum (2018) examined climate change related hazards such as droughts, floods, cyclones, and among others as common hazards that affect build infrastructure of countries with spiral impacts on agriculture and food security.

For instance, the ecological zone of northern Ghana carries a higher share of the country's burden of climatic hazards as compared to the southern zone. This is because the ecological zone of northern Ghana, which is already stressed with a high incidence of poverty and food insecurity, is highly susceptible to impacts of climate change (Armah et al., 2010). Over the years, frequencies and incidences of floods have been increasing in northern Ghana. Statistically, major floods occurred in 2007, 2010, 2012, 2017, 2018, and 2019 in the region due to heavy rains and spillage of the Bagre dam in Burkina Faso (Yiran and Stringer, 2016; Fiasorgbor et al., 2018). These flood events posed significant threats to agricultural production and rural livelihoods. Studies have revealed that floods sweep away crops, livestock, and homes which further leads to injuries and casualties (Yiran and Stringer, 2016; Fiasorgbor et al., 2018). The adverse impacts of flood events on the agriculture sector have resulted into perpetual poverty and food insecurity in

the northern zone of Ghana (Yiran and Stringer, 2016). For example, The World Food Programme in 2009 reported that ~453,000 people in Ghana are food insecure with 34% in the Upper West region, 15% in the Upper East, and 10% in the Northern region.

So far, the literatures show that the spate of climate change impacts in societies is becoming obvious and it detracts the global efforts to achieve food security, which is a key sustainable development goal. Studies carried out on climate change in the study area have rather focused on the impacts of specific climate related events such as floods and drought in relation to food security. Thus far, no studies have addressed the nexus of climate change, flood disaster impacts, and food security in northern Ghana. Accordingly, this is a knowledge gap that this research seeks to discuss.

Besides, the section on introduction to the background of this research, the rest of the research is structured into the following sections. The section climate change, flood disasters and food security nexus provided insights into existing research on climate change, flood disasters and food security of the study site. The section on research design and methods describes the study context and methods. The results sections consisted of flood disaster impacts on food production, climate change and flood disaster impact on food production in the study area. Results of the research are discussed in sections on climate change, flood disasters and food security nexus. The that followed next focused on future implications of flood disasters for food security in the study site. The final section focused presented conclusions and recommendations of this study.

## CLIMATE CHANGE, FLOOD DISASTERS AND FOOD SECURITY NEXUS CONCEPTS

Climate change is an issue of concern at the local, national and international levels due to its consequences on societies. Literature indicates although the causes of climate change are both natural and human-induced, they are more of the latter than the former (IPCC, 2014). Greenhouse gases such as carbon dioxide and methane can come from natural causes such as decomposition, earthquakes, and natural wetlands but most greenhouse gases are accrued to human activities as the main cause of climate change (IPCC, 2014). Increase in the amount of greenhouse gases in the atmosphere is the main cause of climate change. This increase in greenhouse gases in the atmosphere increases the average global temperatures. The amount of carbon dioxide in the atmosphere became more in the post-industrial age than before, which confirms the significant contribution of humans to the causes of climate change (Maslin, 2008). The mean global temperatures are estimated to stand between 1.4 and 5.8°C in the twenty-first Century with 0.6°C as the average rate of increase (IPCC, 2014). The impact of global warming seems to match with the corresponding increase in the rate of melting glaciers and the rise in sea levels. These predictions of global warming and its impacts may be higher in the future than currently estimated due to uncertainties (Singh and Singh, 2012).

The impact of climate change is not the same everywhere in the world (Clover, 2003). It is obvious that industrialized countries contribute more to global change than developing countries but impacts of climate felt *vice versa*. Whereas average temperatures are highest in the tropics, the temperate, and polar regions have lower temperatures. Consequently, the negative impacts of climate change are worse in economically vulnerable countries than the strong economies (Akukwe et al., 2020). The impacts of floods, droughts, cyclones, tsunamis, and storms due to climate change, are more predominant in tropics than in temperate regions. Global warming with its consequences of prolonged droughts, rainfall variability, and flood disasters has become more frequent in the parts of Africa than before. The spread of pests, diseases, and loss of fauna and flora are also argued to be linked to climate change impacts in societies. Flood disasters have increased, leading to direct, and indirect impacts on societies including agriculture productivity as well as food availability, accessibility, utility, and stability in communities. Akukwe et al. (2020) studied flood-induced food insecurity in parts of Nigeria and argued the impacts could be before and after flood events. Flood disasters physically cause damage to farms, crops, livestock, and physical infrastructure of agriculture and food supply chain to reduce agricultural productivity yields and food availability (Armah et al., 2010). Direct impacts of floods on crops and livestock can cause losses and a reduction in farm yields. Flood disasters can break down transportation networks and access to farms, food markets, and consumption points. Floods can cause financial loss to producers, suppliers, and consumers of food productions which could reduce individual's capacity to afford food in communities (Pacetti et al., 2017). Inability to afford food can reduce the ability to access and utilize food items with the required nutritional values for individuals. Direct and indirect impacts of floods also damage the ability to store food products to make food available to individuals in communities. Food stability hinges on the ability to maintain availability, access, and utility of food items in localities. Food security, therefore, exists where food is available, accessible, affordable, and stable for individuals in communities.

The concept of food security in the 1970s was about having enough food available at the global and national levels without much consideration for whether its accessibility and restriction of supply at local and individual levels. It became clear that available food at the global level does not mean everyone's entitlements to basic food are secured. The local availability and personal level accessibility become paramount. However, one can have access to food but may not be able to afford and make use of the available food with the required nutrition. It is therefore important to consider the ability to utilize and stabilize food for persons in communities for the concept of food security. Food supply should be stable so it can be always available in all seasons. Thus, food security considers factors for comprehensive analysis (FAO, 1996a; Clover, 2003). In the Rome Declaration on World Food Security in 1996, food security is seen as a situation in which food is always available, to which all persons have means of access, that is nutritionally adequate in terms of

quantity, quality, and variety, and is acceptable within the given culture (FAO, 1996b).

## RESEARCH DESIGN AND METHODS

### The Study Area

The focus of this study is on northern Ghana. Ghana is in West Africa and shares borders with Burkina Faso, Togo, Cote d'Ivoire, and the Gulf of Guinea in the north, east, west, and south, respectively. Ghana lies between latitudes 4.50°N and 11.50°N and longitude 3.50°W and 1.30°E. The political demarcation of northern Ghana is linked to the colonial era of the country, the then Gold Coast. During colonial time, this part of the colony was named the Northern Territories with Tamale as the administrative capital. It became northern and upper regions with Tamale and Bolgatanga as regional capital towns, respectively. The upper regions in the 1980s split into Upper East and Upper West regions with Bolgatanga and Wa as regional capital towns accordingly. Since 2018, new administrative regions have been carved out to include the Savannah Region with Damango as a regional capital, and the North East Region with Nalerigu as the capital town. This administrative background captures the current political delineation of northern Ghana.

The geographical description of the study site briefly mentions the biophysical attributes of the study area which influence the socioeconomic activities of the inhabitants. This description offers readers an understanding of the physical environment, the interaction between humans and the environment, and environmental issues of the study site. Northern Ghana can generally be described as high plains with tropical savannah ecological conditions. Northern Ghana has unimodal rainfall season yearly from March to November with further reduction of the season northwards. The rainfall season keeps dwindling and becoming more and more erratic in recent years, seemingly suggests evidence of climate change or variability. The average annual rainfall in the region stands between 700 and 1050 mm. The harmattan seasonal winds blowing from the Saharan desert southwards have dry and hot conditions of between 15 and 40°C annually. The hottest period is December to March. The study site is characterized by tropical savannah flora and fauna. The vegetation is mainly grassland and drought resistant trees, normally useful for the rearing of livestock and growing of cereals. These socioecological conditions indicate challenges and opportunities for agriculture and livelihood activities in the region.

Population density in northern Ghana is generally sparse in rural settings with economically poorer conditions than the southern part of the country (Yaro and Hesselberg, 2010). With high poverty and unemployment rates, the active population in the region emigrates to southern Ghana for livelihood opportunities in dry seasons annually. Thus, the region also serves as a seasonal source of labor for the southern part of the country. Although agriculture is the mainstay of Ghana, higher number of people in the study area rely mainly on rain-fed and irrigation agriculture. Infrastructurally, northern Ghana lags its southern counterpart in national development.

### Methods

This research employed thematic data analysis strategy to analyse data from secondary documents. The thematic method of analysis is popular for its ability to illuminate detailed interpretation of qualitative data obtained from secondary sources. Braun and Clarke (2013) explain that this approach is beneficial for obtaining insights from secondary sources of data. Thematic method of data analysis helps researchers to make meaning of textual materials. The strategy is useful further because it has advantage of drawing comprehensive meanings and nuances of the data obtained (Babbie, 2012). Using this method, a descriptive theme is explicit in its expression of the topic being studied and subsequently allows the analyst to sift out a clear interpretation from the textual data. This approach enables researchers to aptly apply the thematic data analysis method to identify and analyse patterns of secondary data sources to explain a scientific problem (Braun and Clarke, 2006). In fact, this strategy allows researchers to reflexively engage with textual data to develop a story from the data (Neuendorf, 2019).

This review research is a synthesis of recent relevant literature covering topics on climate change, flood disasters, and food security nexus in sub-Saharan Africa with specific emphasis on northern Ghana.

### Data Search Strategy

The approach to searching for relevant data purposively sought literature from electronic data bases and libraries using general to specific themes of the research. Literature on the broad themes about climate change, flood disasters, and food security was engaged to obtain global perspectives about the problem. This search opened doors to specify the data search to the geographical location and objective relevance of the topic. Thus, climate change impacts and food security nexus, flood disasters and their impacts on agriculture and food security in Africa and northern Ghana were deliberately used in finding relevant literature. To ensure quality and authentic relevant literature sources and peer reviewed publications, covering the themes were considered in the search. Data from such sources as journals of African Security Review, Climatic Change, Environment, and Earth Science were used. Policy and technical documents including those from the Food and Agricultural Organization (FAO), Intergovernmental Panel on Climate Change (IPCC), and the Ministry of Agriculture in Ghana have been informative. Analysis of data from the relevant sources employed specific words, phrases, sentences, and excerpts that describe the specific themes of the literature as useful data. For instance, nexus, climate change, flood disasters, food security, and impacts as well as Sub-Saharan Africa, and northern Ghana helped to identify the most relevant excerpts for careful paraphrasing and interpretation. As recent as literature dating from the year 2000 were used to ensure the information is relevant and speaks to the issues being research. **Table 1** summarizes the key points from the key literature that was explored.

**TABLE 1 |** Summary findings climate change, and flood disaster impacts drawn from literature.

References	Research focus	Study Context	Methodology	Direct and indirect impacts of floods		Summary
				Direct impacts	Indirect impacts	
Okyere et al. (2013)	Analysis of disasters in Accra	Flood disasters in Ghana	Literature review and secondary data.	Deaths of about 1,133 people from 1980 to 2010 Huge economic costs, Halt businesses, physical damage houses, transportation and communication and other infrastructure.	Eviction of Old Fadama community Outbreak of cholera Long term economic impacts, trauma on individuals.	Floods are caused by natural and human-induced factors and their impacts are devastating to lives and property.
Douglas (2017)	Review of flood disasters in sub-Saharan.	Sub-Saharan Africa	Case studies and secondary data.	Loss of lives and property, diseases, displacement of people and homelessness, damage to road surfaces and inundation of farms.	Increase in food prices, reduction in economic activities, increase in poverty.	Floods are climate change related and caused deaths, economic loss, damage to infrastructure and environment.
Akukwe et al. (2020)	Research question: "Do floods affect food security?"	Comparative study of pre- and post-flood households' food security statuses in South-Eastern Nigeria	Quantitative Survey of 400 households in eight communities using stratified and random sampling methods.	Floods affect food security by increasing the number of food insecure households to 92.8% with regression coefficient of $-0.798$ , indicating a very strong negative effect of flooding on household food security.	Flood disasters can make communities food insecurity hotspots which would need long-term food assistance.	Flood disasters are indicative of climate change impacts and they induced food insecurity in the affected communities.
Alhassan and Akudugu (2012)	Impacts of climate change on household food security, livelihoods and social safety in Northern Ghana	Rural areas in Northern Ghana	Observations and desk review method were used.	Decline in rainfall reduce crop yields, pasture for livestock and food availability. Floods damages infrastructure for production, transportation, market structures, storage and processing of food. Floods impacts include financial loss to producers, consumers, and suppliers of food. All reduces food access, utilization, and stability of food.	Inadequate water and after flood events cause diseases and pests which reduce farm yields. Harvested crops get rotten on farms due to wet conditions of floods. Drought conditions also causes food production and fire outbreaks.	Droughts and floods are double tragedy for food security and nutrition safety. Development and implementation of climate change adaptation is recommended for the region.
Abdul-Rahaman and Owusu-Sekyere (2017)	How climate variability affected the production maize, millet, rice, and groundnuts in north-eastern Ghana	North-eastern part in the Upper East Region of Ghana	384 in-depth interviews from 6 communities and climate data on rainfall and temperature variability.	Climate change impacts seen in rainfall variability, reduction in period and heavy downpours, and affect crop production in downward trend. Temperature increases and droughts also affect crop yields.	Excessive rainfall affected the prospects of these crops and crops get rotten on farms.	There is negative relationship between climate variability and food crop production in north-eastern Ghana.
Adu-Boahen et al. (2019)	Assessed climatic patterns, and impacts on food crop productivity	Bawku West District in the Upper East Region of Ghana	Quantitative and qualitative approaches using questionnaire, structured interview guide and field observation.	Destruction of farm, farm produce including maize, millet, rice, sorghum and cowpea, livestock, homes, and food storage and processing facilities. Droughts reduce crop yields and livestock production.	After flood impacts on health, finances and loss of valuables can affect security.	Climate change impacts on rainfall variability and droughts affected food production in the study site.
Braimah et al. (2014)	Assessed the causes of flooding and its attendant socio-economic conditions on the livelihoods of people	Sawaba in the Bolgatanga Municipality of Upper East Region, Ghana	Qualitative and quantitative methods.	Destruction of homes, dwelling houses injury of individuals, loss of property and finances.	Disrupted businesses, and daily activities of people.	Flood caused by heavy rains, poor drainage, waste disposal, and compact soil and poor soil percolation.

(Continued)

TABLE 1 | Continued

References	Research focus	Study Context	Methodology	Direct and indirect impacts of floods		Summary
				Direct impacts	Indirect impacts	
Owusu et al. (2016)	Investigated the degree of smallholder farmers' vulnerability to floods	Conducted in the Tolon District of northern Ghana	Mixed methods, involving qualitative and quantitative approaches.	Flood affected farms located low-lying areas and floodplains, loss and injury to livestock, injured people, damage and loss to property, financial loss and infrastructural breakdown.	Degradation of farmlands and reduction in livestock production.	Farms, livestock and communities are vulnerable to climate change and flood impacts. Mitigation to floods and adaptation to climate change impacts are recommended.
Armah et al. (2010)	Explored impact of floods on natural resource dependent communities	Floods from excessive rainfall and the Bagre Dam in the Northern of Ghana	Survey method with 220 randomly selected respondents.	death of 20 people, loss of livestock, destruction to farmlands, houses, bridges, schools and health facilities, damage to water supply, irrigation systems, food storage and processing facilities in the study area.	Spread of diseases and pests. Wet conditions caused affected crops on farms.	Seasonal variations in agricultural output and floods are less sensitive.
Derbile et al. (2016)	Vulnerability of agriculture to climate variability Upper West Region of Ghana and the policy implications for climate change adaptation planning	Upper West Region of Ghana	Quantitative and qualitative methods.	Floods inundate farmlands, fell and wash away of plants and food crops. After flood disaster cause poor yields, stunted growth, rotting of grains and soil erosion.	Wilting and dying of crops, diseases and pest infestation, Poor seed and tuber development and rotting of harvest.	Smallholder agriculture significantly vulnerable to climate variability in north-western Ghana. The article highlighted three layers of vulnerability, which begins with double tragedy of farmer exposure to droughts and heavy precipitation events.
Sidibé et al. (2016)	Flood Recession Agriculture for Food Security in Northern Ghana	Food Security in Northern Ghana:	Literature review and secondary data.	After flood impacts include fertile Soils in floodplains agriculture, water for irrigation and opportunities for after flood agriculture.	Post agriculture and food production in floodplain areas.	Flood recession is not fully taken seriously although it has a potential in the region to contribute to food security.
Hazran et al. (2017)	Impacts of flood on the farming community in Malaysia	Kelantan farming community in Malaysia	Empirical research using quantity.	Impacts on farms, infrastructure, labors and food security.	Emotional and psychological impacts as well as economic losses.	42.9% of respondents suffered economic losses from flood disasters. The flood negatively affected low-income earners
Jonathan et al. (2020)	Economic effect of flood disaster on food security	Southern guinea savanna zone, Nigeria	Quantative techniques using surveys.	Flood destroys farms, food, homes, social and economic activities. Floods have negative impacts economies of households.	Post flood impacts include psychological and economic impacts.	Increase in flood disaster occurrence leads to more food insecurity of farming communities.
Alhassan (2020)	Effect of on-farm and non-farm flood adaptation strategies on farm households' food security	Food security in the Upper East region, Ghana	Multinomial endogenous treatment effect model was used.	Flood shocks have direct impacts farms which reduce farm yields and induce food insecurity in households.	Indirect impacts is post flood impacts and increase in food shortages in households affected by floods.	Social network, extension services and information on flood occurrences are helpful for adaptation decisions to flood shocks.

## CLIMATE CHANGE AND FLOOD DISASTER IMPACTS ON FOOD PRODUCTION

Climate is a primary factor for food production through agriculture activity, such that any change in climate affects plant and animal production (Shongwe et al., 2014). Thus, climate change can affect food production through flood directly and indirectly. Intensification of rainfall extremes (Wasko and Sharma, 2015; Wasko et al., 2016) and increasing volume (Trenberth, 2011; Mishra et al., 2012) have been linked to the higher temperatures expected with climate change. This increase in the possibility of extreme rainfall and its intensity creates a higher risk of destructive flood events that cause a threat to food production, particularly in vulnerable regions where the mechanism or infrastructure has not been designed to cope with these increases. With the increasing frequency of floods associated with climate change, agricultural production will decline to result in a decreased state of food production with high malnutrition (Kumsa and Jones, 2010).

Flooding is by far the most destructive type of weather extremes that strikes humans and their livelihoods around the world (Harvey et al., 2014). In recent times, there have been disastrous flooding experienced globally (Thomas, 2017), with a high proportion of people that suffer its negative impacts living in rural areas, especially in less developed countries (LDC). For instance, rural communities in developing countries are largely affected by these flood extremes due to their high dependence on rain-fed agriculture and their limited capacity to respond to climate-induced disasters (IPCC, 2012).

Ghana is one of the vulnerable countries to floods in Sub Sahara Africa (Aggrey, 2015; Amoateng et al., 2018, Almoradie et al., 2020) with devastating effects, especially for the urban poor and farmers in the northern part of the country (Okyere et al., 2013). For example, in 2017, Ghana experienced extreme floods that affected about 1 million people (IFRC, 2017; Adegoke et al., 2019).

The frequency and severity of floods in northern Ghana over the years have increased considerably (Armah et al., 2010), which has a far-reaching effect on food production in the region. Consequently, floods are among the most regular natural disasters that affect livelihoods especially farming in the region (Owusu et al., 2016). The region's agriculture is typically rain-fed and largely on a subsistence basis with about 90% of farm holdings being <2 hectares in size (MoFA, 2012), thus, the incidence of a flood event directly affects their farm output and livestock. Northern Ghana is considered one of the flood-prone areas in Ghana. For instance, over the years, heavy rainfall, and the spillage of water upstream from the Bagre dam in Burkina Faso have resulted in perennial flood situations. For instance, within a space of 10-year period, 2004 to 2014, the region was traumatized by six (6) different flood events in the following years; 2004, 2007, 2008, 2009, 2010, and 2012. Besides, in 2018, floods caused by high-intensity rainfall combined with water releases from the Bagre Dam in Burkina Faso affected 100,000 people and destroyed 196 km<sup>2</sup> of farmland in northern Ghana (Floodlist, 2018).

The flood events direct and indirect impacts on food crops, livestock, infrastructure and people that can induce food insecurity in northern Ghana. The flood events have caused loss of lives and labor useful for agricultural productivity. Direct physical floods can destroy farm produce and livestock to reduce food availability in communities. During and after flood events, floods can cause damage to food produce as well destroy potential for good crop yields.

The key infrastructure include transportation, food stores, and process factors that are also vulnerable to impacts of floods that can reduce access, utility, and stability of food in the region which also impoverished. For example, the August 2007 floods affected about 3,000 hectares of farmlands and damaged major crops including maize, groundnuts, yam, cassava, and rice. The outbreaks of environment and sanitation-related diseases such as malaria, cholera, and diarrhea amongst children were also noted.

According to studies carried out by Derbile et al. (2016), there are two types of food crop farming risks related to flood in northern Ghana. Floods arising from heavy rainfall is noted as flash flood, which is common form of flood in the region. It occurs annually and may occur several times during the rainy season. The second is heavy floods arising from either prolonged heavy rainfall or high volumes of water originating from higher lands in Burkina Faso. These types of floods do not occur frequently. On average, heavy floods have occurred every 5–10 years over the past five decades. Both forms of floods negatively affect food crop farming in different ways in the region. Flash floods affect food crop production more frequently but the adverse effect is often far smaller than the effects of heavy floods arising from a long period of heavy rainfall. Derbile et al. (2016) identified eight adverse effects of floods on food crop farming in the northern sector of Ghana which includes poor seed development, pest, and diseases infestation, death of crops, soil nutrients erosion, rotting of crops, stunted crops growth, poor yields as well as felling and washing away of plants.

The common impacts are destruction and washing away of plants. Again, Derbile et al. (2016) flood disaster impacts food crop in the region can be inundation in water through which cereals, tubers, and legumes including maize, millet, guinea corn, cowpeas, beans, groundnuts, bambara beans, rice, potatoes, yams, and cassava can die or get rotten on farms besides been carried away from farms. Crops get rotten on farms under wet conditions and poor sunshine due heavy rainfall as well as moisture and moldy weather conditions. Besides, spillage of water from the upstream Bagre Dam causes floods that affect humans, crops, and livestock in the region. These effects lower agricultural productivity and food availability in rural communities and markets. Subsequently, the food security is threatened. The impacts of flood events on road infrastructure, which is the main means of carrying foodstuff to marketplaces as well as storage facilities is also affected. With physical destruction of transportation network and food storage and processing facilities, which are already inadequate, access, and stability of food in the region become major question marks with risk to food security.

## CLIMATE CHANGE, FLOOD DISASTERS AND FOOD SECURITY NEXUS

The connections between floods and food security are very relevant, particularly in developing countries where food availability can be highly threatened by flood events which impair food availability, access, utility, and stability at the community, national, and global level through direct and indirect impacts on agriculture (Pacetti et al., 2017). Evidence in the literature exists on the pathways by which floods can affect food security (Funk et al., 2008; Cooper et al., 2019), with subsistence farmers being predominantly vulnerable (Morton, 2007; Awojobi and Tetteh, 2017). The most direct influence of flood due to high rainfall levels on food security is physical flood impact and damage to farms, crop yields, livestock, and decreasing the overall food availability in a location (Hanjra and Qureshi, 2010; Schlenker and Lobell, 2010; Afifi et al., 2014; Cooper et al., 2019). For example, in rain-dependent agricultural economies, erratic rainfall causing unexpected floods can create devastating impacts on the food security of the people and their livelihoods (Ramakrishna et al., 2014; Toubes et al., 2017). The Intergovernmental Panel on Climate Change (IPCC) states in the Fifth Assessment Report with high confidence that climate change will increase the risk of food insecurity through impacts such as flooding and shifting precipitation patterns (IPCC, 2014). While rates of undernutrition and food insecurity have been falling overall for the past few decades, there have been recent increases in these statistics in some locations, which is somewhat attributable to flood shocks (Cooper et al., 2019).

Food security exists when all people, at all times, have physical, social, and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life (FAO, 1996a,b). According to literature, the four pillars of food security are availability, access, utilization, and stability. Hence, flood risk is connected to all four dimensions of food security. Food availability looks at the “quantities of food available on a consistent basis” and the expression “food access” refers to the possibility to have access to enough food for a healthy diet (Pacetti et al., 2017). Food utility is defined as the ability to use it for nutrition and care, which is linked to adequate water and sanitation. A decrease in food availability can have constraints on food access: when yields and livestock productivity decrease, food prices increase, making food access difficult for poor households (Devereux, 2007; Webb, 2010; Brown and Kshirsagar, 2015). At the same time, households that rely on sales of agricultural products can experience decreasing incomes, while those relying on agricultural wage labor or trading with farmers can also be negatively affected (Pandey et al., 2007; Cunguara et al., 2011; Bola et al., 2014; Udmale et al., 2015). Finally, excessive rainfall can increase the risk of infectious diseases such as malarial, parasitic, and diarrheal disease, in turn harming proper food utilization and increasing rates of undernutrition (Delpla et al., 2009; Paterson and Lima, 2010). Pacetti et al. (2017) also concluded that flood events will lead to a reduction in farm produce and livestock, destruction of stored food, damage of cultivation site due to soil erosion, and destruction

of feeder roads to farmlands. All these parameters of food security and therefore reflects the link between flood and food security.

Floods and their impacts on food security in northern Ghana is not a new phenomenon, and whenever heavy floods hit, farm crops and livestock would be one of the severely affected properties owing to their vulnerability with respect to flood events. Evidence of relationships between flood events and food security is clear in northern Ghana, relative to other parts of the country. For instance, due to the periodic excessive rainfall coupled with the spillage of excess water upstream from the Bagre Reservoir in Burkina Faso, extensive floods in many districts of the region have occurred. Consequently, these floods have caused severe damage including the loss of livestock, the destruction of farmlands, as well as damage to water supply, irrigation systems, food storage, and processing facilities. Besides, many of the flooded areas are often inaccessible due to the breakdown of key infrastructure, including bridges and roads. According to assessments carried out by the Ministry of Food and Agriculture (MoFA), about 70,500 hectares was affected (Armah et al., 2010) resulting in an estimated production loss of 144,000 Metric Tons (MTs) of food crops (including maize, sorghum, millet, groundnuts, yam, cassava, and rice). As a result of flooded roads and submerged bridges, not all food commodities were readily available at all markets. An estimated 50,000 people in Northern Ghana were expected to remain vulnerable to food insecurity and at risk of malnutrition for at least 15 months beyond the early harvest in October 2008 (UNOCHA, 2007; Armah et al., 2010). Also, the main diet in most Ghanaian homes constitutes mostly cereals—millet, sorghum, maize, and rice—which are produced mainly in the Northern part of Ghana. A decrease in the production of these commodities because of flood events would deteriorate the already alarming threat of food security, particularly in the northern sector of Ghana, and severely affect the economic development of the region (Adu-Boahen et al., 2019). Again, Armah et al. (2010) posited that in some parts of Northern Ghana, flooding during August and early September 2007, led to the destruction of key infrastructure, food stocks and livestock, which contribute to food insecurity in the region.

## IMPLICATIONS OF FLOOD DISASTERS ON FOOD SECURITY IN THE STUDY SITE

Climate change related events including prolonged droughts and floods affect food security in the site (Baba et al., 2018). Akudugu and Alhassan (2013) demonstrated that climate change in northern Ghana affects food availability, access, utility, and stability spiral impacts on household nutrition of individuals. Northern Ghana is largely rural livestock keepers and agricultural producers using rainfall and irrigation. The climate change impacts and rainfall variability, the main concern of flooding has been the destruction of farms, food crops, livestock as well as seeds stores, resulting in a decline in food production. A decline in food production can lead to starvation which may in some cases last several months after each episode of floods (Akukwe et al., 2020). Starvation together with a decline in environmental



quality resulting from flood related damage promotes the desire of people to migrate out of these rural areas. The reduction in food production resulting from floods also means loss of income for people in these communities which further reduces their ability to purchase food and thereby contributing to increase the problem of food shortages and starvation within households. Also, one important aspect of floods in northern Ghana is the damage they inflict on seeds. Most small-scale farmers safeguard the most viable portions of their produce as seed for the next planting season (Akudugu and Alhassan, 2013).

In the 2007 floods, significant damage of food crops just nearing harvest meant that the farmers' seed supply for the coming agricultural year was jeopardized. Floods may therefore affect seed supply either through affecting crop production (on farms) or destroying seed stores (in homes). Either way, the lack of seeds for subsequent planting could generate a reinforcing effect of lower food production and another resulting lack of seeds. Farmers may be able to supplement their seeds with limited bought supplies—either to make up for a deficiency or introduce produce with better traits into their stock. However, by reducing food production, floods may limit household income and reduce farmers' ability to buy seeds which also creates another reinforcing effect of lower production and even lower ability to increase household income enough to afford seed purchases (Owusu et al., 2016). Though many households in northern Ghana depends on poultry and livestock rearing for livelihoods, diseases, and pest caused by the frequent flood events undermine production (Armah et al., 2010). Also being the poorest and most agricultural dependent region of Ghana, the impact of flood is devastating. A clear example is the 2007/2008 prolonged drought season which was followed immediately by a devastating flood in entire Northern Ghana. Several food crops and livestock were destroyed (some washed away by the flood) causing severe food shortage; farm income declined; buildings, roads, and other infrastructure collapsed; yield from crops declined and countless people were rendered homeless (Nti, 2012).

The direct and indirect impacts of floods on farms, food produce, livestock, physical infrastructure, and labor dwindle the amount of food that can be available to farmers and markets for consumers. Destruction of farmlands and agricultural infrastructure reduces how much food can be available. Access to food relies on transportation network which is also damaged by flood impacts to reduce the capacity to convey food to communities in need. During and after flood events, emergency food aid gets to communities outside through transportation. Where there is a breakdown of infrastructure, this can be a problem. Utility of food when available also based on ability of communities to transform the food stuff into consumable state with required nutrients. This will require converting the food from raw state to cooked state. Food production in the region is highly seasonal and requires storage system or regular marketplace to ensure stability of supply to people in communities. Impacts of rainfall on storage systems can be destructive to food security.

## CONCLUSION

This study was set out to review climate change, flood disasters impacts and food security nexus in northern Ghana. Evidence of the review identified the impacts of climate change in region as extreme weather-related events as droughts, rainfall variability, and flood events. Evidence from the literature suggested that floods events from extreme rainfall and spill of Bagre Dam are climate change related events have the potential disrupt agricultural production and food security in northern Ghana. The results further demonstrate the connection between climate change and flood disasters with implications for worsening food insecurity in the study site. Climate change impacts are seen in droughts, rainfall variability and frequent flood events in the region. Flood disasters affect food availability, access, utility and stability in the region as food insecurity seems to be a common problem. Climate change and flood events seem to be on the increase and could potentially deteriorate the undesired food security problems in the region if not addressed.

A major limitation of this research was seen in the limited focus on flood disaster events and the inability to engage with primary data for the analysis of issues. This shortfall did not allow the researchers to have practical primary evidence to make emphatic assessment of the connection between climate change, flood disasters, and food security in the study site.

Climate change related events in region are obvious with clear reduction in the rainfall season, erratic rains, prolong droughts, and flood disasters. These climates related events affect food production with subsequent impact on its availability, access, utility, and stability in the communities and households. Reportedly, floods have become frequent with devastating consequences on food production. Literature seems to suggest that the frequency of floods and their impacts could potentially increase in the future. Floods inundate farms, pastures, livestock, food storage and procession facilities, and infrastructure which could reduce crop yields and animal production. Generally, these impacts could affect future food security in the region if not curbed.

To reduce the impacts on food security in the region, climate change and flood disaster impacts mitigation need to be practiced. One potential advantage of after flood events is flood recession agriculture in flood plains in the region. Traditional crops of the region can be modified to adapt to climate change conditions by crops with short maturity periods. Animals and food storage systems need to be sited on highland areas that have low flood risk. Flood waters should be harvested in dams for irrigation agriculture. Alternative means of food supply and livelihood strategies need to complement over reliance on agriculture in the region.

## AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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