American Journal of Environment and Climate (AJEC)

ISSN: 2832-403X (ONLINE)

VOLUME 4 ISSUE 1 (2025)

PUBLISHED BY
E-PALLI PUBLISHERS, DELAWARE, USA

American Journal of Environment and Climate (AJEC)

Volume 4 Issue 1, Year 2025
ISSN: 2832-403X (Online)
DOI: https://doi.org/10.54536/ajec.v4i1.3874
https://journals.e-palli.com/home/index.php/ajec

Assessment of Smallholder Farmers' Responses to Flood Incidence in the Oti River Sub-Basin

Silas Uwumborge Takal[1*], Abdul-Wahab Tahiru[1]

Article Information

Received: October 04, 2024

Accepted: November 07, 2024

Published: January 22, 2024

Keywords

Floods, Oti River Sub-Basin, Response Strategies, Smallholder Farmers

ABSTRACT

This study aimed to assess the responses of smallholder farmers to incidence of floods in the Oti river sub-basin. The findings provide useful information for enhancing the adaptive capacity of smallholder farmers to respond to flood hazards and improve their resilience and disaster preparedness in the study area. This study used the simple random sampling procedure to select 399 farmers and descriptive statistics was used to identify and examine response strategies adopted by smallholder farmers. The results of the study showed that livelihood of smallholder farmers were greatly impacted by factors such as: Distance to River, Elevation of Communities below the River, Increase in Rainfall, Lack of Early Warning Systems and Lack of Emergency Response Systems. The results further showed that the farmers responded to flood incidence through: Building of Raised Beds, Crop Diversification, Livestock Relocation, the use of Conservation farming practices.The majority (87%) of the farmers stated that they were vulnerable to the impacts of floods in the study area. The findings of this study enhanced understanding on access to relevant and timely information such as an early warning to farmers during the start of the farming/ rainy season to support their adaptive responses to floods.

INTRODUCTION

Global food production is substantially dominated by smallholder farmers, ensuring food security, community and economic development, particularly in countries where agriculture is the dominant source of livelihood. It is estimated that 70-80% of the world's food is produced by smallholder farmers (Wolfenson, 2013; FAO, 2014; Samberg *et al.*, 2016). In Ghana, agriculture is predominantly on a smallholder basis, with most of the farm holdings less than 2 hectares (MoFA-SRID, 2021). Admittedly, smallholder farmers are the main drivers of Ghana's agriculture sector, accounting for 80% of the total food produced in the country (Asare-Nuamah & Mandaza, 2020; Rai *et al.*, 2024; Samuel, 2023) and ensuring crop diversity all over the world (Conway, 2011).

However, in both developed and developing countries, agricultural productivity and economic well-being of smallholder farmers have been exacerbated by the increasing frequency and intensity of floods, especially in flood-prone areas. This study focuses on the recurring flood situations in the Oti River Sub-basin of the White river basin and their impacts on smallholder farmers in the Saboba district of Ghana to assess the measures smallholder farmers hold to respond to flood incidence.

The Oti River Basin is a sub-basin of the White Volta River basin, spanning across the whole of West Africa (Takal *et al.*, 2023). This sub-region of Africa is characterized by a tropical climate with distinct wet and dry seasons and as such prone to floods especially during the peaks of rains (Ekwezuo & Ezeh, 2021). Compared to many countries in West Africa, Ghana has experienced a significant increase in flooding. For example, smallholder farmers along the basin stretch, river valleys and low-lying areas have suffered the worst flood incidence due to heavy rainfalls (Owusu, 2016). As a result, the most vulnerable smallholder farmers and communities alongside the paths of the river are hardest hit, potentially affecting their food, economic and health security and wellbeing. Floods with their destructive potential, result in substantial damage to crops, loss of livestock and damage to critical infrastructure that supports agricultural activities (Rehman, 2015; Mensah & Ahadzie, 2020; Atanga & Tankpa, 2021). The extant literature has shown that floods impact not only agricultural productivity but also hold significant health implications, with flood events leading to an increase in diarrhea, malaria, and hepatitis E in affected areas (Alderman *et al.*, 2012; Dotse-Gborgbortsi *et al.*, 2022). To this end, floods contribute to the spread of diseases and affect the overall well-being of people.

Floods have been a significant concern that affects livelihoods and food security. According to Atanga and Tankpa (2021) and Akwotajie (2024), floods result in loss of income-generating activities notably disrupting farms, pastures and livestock and causing substantial damage to critical infrastructure and socio-economic activities linked to the agriculture sector. These impacts of floods alongside the manifestation of climate change, a resultant effect of flood disasters, tend to reduce crop yields, animal production and food production. The recurrent flooding exacerbates the vulnerabilities of smallholder farmers who heavily rely on crops for their livelihoods. Hence, understanding how smallholder farmers in the Oti River sub-basin respond to these recurrent flood incidences becomes imperative.

[1] Department of Environment and Sustainability Sciences, University for Development Studies, Ghana
[*] Corresponding author's e-mail: takalsilas@gmail.com

Alare *et al.* (2018) highlighted that smallholder farmers in semi-arid regions of Northern Ghana have been exploring climate-smart agriculture practices to enhance their resilience to climate-related challenges like flood disasters. As noted by Bichet and Diedhiou (2018), climate change has led to changes in precipitation patterns, with some areas experiencing increased rainfall intensity. The increased rainfall intensity has severe impacts on livelihoods and has been evident in Northern Ghana, emphasizing the need for sustainable strategies to address the vulnerability of natural resource-dependent communities (Armah *et al.*, 2010). Research has highlighted the need for improved flood risk management practices in Ghana to enhance resilience (Almoradie *et al.*, 2020). Furthermore, a study of flood disasters in urban areas like Accra has revealed the interconnectedness of extreme weather events, health systems, and urban planning (Codjoe *et al.*, 2020). Urban households in flood-prone regions have shown varying levels of disaster risk perception, influencing their preparedness and response strategies (Qi *et al.*, 2021). Informal settlements in urban areas have been particularly vulnerable to flooding, highlighting the need for inclusive urban flood management strategies (Amoako & Inkoom, 2017).

The assessment of smallholder farmers' responses to flood incidence in the Oti River Sub-basin is crucial for understanding the challenges faced by vulnerable communities in Ghana. By examining the impacts of floods on agriculture, livelihoods, health, and urban settlements, this study aims to contribute to the development of sustainable strategies to enhance resilience and adaptation to flood disasters in the region.

LITERATURE REVIEW

Smallholder Farmers' Responses to Floods

To understand smallholder farmers' responses to flooding, there have been extensive discussions and some empirical studies conducted to assess the response strategies employed by these farmers to respond to flood shocks (Alhassan, 2020; Enete *et al.*, 2016; Okeleye *et al.*, 2016). Most of these studies reported that smallholder farmers respond to flood shocks by adopting on-farm strategies such as early and upland planting, crop rotation and adoption of early maturing plants (Alhansan, 2020; Rahut 2020; Thennakoon *et al.*, 2020). For example, Alhansan (2020) examined the effect and determinants of flood adaptation strategies using a multinomial endogenous treatment effect model and ordered probit model and found that farmers respond to flood shocks through on-farm adaptation strategies such as early and upland planting, crop rotation and adoption of early maturing plants. Alhansan (2020) asserts that farmers who adopted these strategies had their food security situation improved and recovered faster from flood shocks. Furthermore, the empirics of Thennakoon *et al.* (2020) showed that farmers with contracted lands have a higher likelihood of implementing adaptation strategies in response to floods compared to farmers with rented lands.

While the growing body of studies believe that farmers adopt on-farm activities as their response strategies to floods, others argue that farmers engaged in non-farm activities notably petty trading and selling of assets such as livestock (Alhansan, 2020). For example, congruent to Alhansan's point of view about the non-farm response strategies of farmers to extreme weather conditions, Enete *et al.* (2016) in Nigeria viewed it in broader stratum, indicating that farmers engaged in the selling of assets, borrowed loans for livelihood diversification, temporal migration, social network support, compensation from agencies, and soil conservation practices as their strategic response to floods. Similarly, Iqbal *et al.* (2015) opined that varietal change, late sowing, and intensification of inputs are the adaptation strategies employed by farmers and the implementation of these strategies positively and significantly affect net revenues.

Literature also showed that early warning systems helped smallholder farmers prepare for and respond to flood incidents (Piennah *et al.*, 2023). By receiving timely information about impending floods, farmers can take proactive measures to protect their crops, livestock, and property. Early warning systems enable farmers to evacuate to safer locations, secure their belongings, and minimize potential losses during flood events. In addition to early warning systems, empirical evidence also points to the fact that farmers adopt crop and livestock insurance, bund-making, land-leveling, and tree planting, to combat the impact of localized floods (Ali & Rahut, 2019). Among these mitigating strategies, the authors indicated that tree plantation was ranked the best mitigating strategy followed by crop and livestock insurance, land leveling, and then bund making. Contrary to the empirics of Ali and Rahut, (2019), Okeleye *et al.* (2016) in Nigeria, assert that most smallholder farmers lack access to insurance facilities, timely and precise flood early warning systems, flood local signs and community flood management committees.

Locally, smallholder farmers respond to or manage floods through traditional and indigenous systems. The work of Fabiyi and Oloukioi, (2013) in Nigeria, though largely qualitative, indicates that farmers rely on sand filling, mud and concrete embankment, pathways for water, wooden bridge construction, and pile foundation building as response strategies to flooding. Social support, local public work have been identified as indigenous knowledge heavily relied upon to manage the devastating impacts of floods (Fabiyi & Oloukioi, 2013)

The adoption of these response strategies to floods among smallholder farmers is multifaceted and influenced by a combination of factors. For instance, Ali and Rahut (2019) noted that farmers' decision to adopt these measures is influenced by socio-economic variables such as education level, income, infrastructure and extension services received. Moreover, Thennkoon *et al.* (2019) highlight the importance of demographic factors, access to information, and social networks play a significant role in farmers' response capacity to adapt to

extreme weather events. According to Iqbal *et al.* (2015), soil fertility, farmer's tenancy status, size of holding, non-farm income, and access to certain extension sources are some of the factors that influence the adaptation strategy of farmers. Specifically, the authors contend that farmers who receive regular visits from extension agents are more likely to adopt climate-resilient practices such as crop diversification and soil conservation. This illustrates the pivotal role of extension services in promoting adaptive behaviours among smallholder farmers. Similarly, in the Builsa-North district of Ghana, the choice of response strategies is influenced by age, access to extension services, and the National Disaster Management Organization (NADMO) services (Kassim *et al.*, 2020).

From the forgoing discussions, it is evident that smallholder farmers respond to floods through on-farm and non-farm adaptation strategies which are shaped by socioeconomic, demographic, and environmental factors. For example, while education level may enhance farmers' awareness of climate risks, access to information and supportive social networks have a greater impact on farmers' ability to implement mitigation measures effectively. However, the extant literature showed notable gaps that need further exploration. The long-term effectiveness of different adaptation measures adopted by smallholder farmers has yet to be well documented and assessed by researchers to provide a roadmap for long-term policy directions. Additionally, gender-dimensional responses to floods remain relatively understudied. This study strives to provide insight into these gaps in the literature for a more comprehensive understanding of smallholder farmers' responses to floods.

MATERIALS AND METHODS

Study Area

Saboba District is situated in the northeastern corridor of the White Volta River Basin within the Northern Region of Ghana, which consists of sixteen districts (Chegbeleh *et al.*, 2020). Saboba town serves as the administrative capital of the district. The district spans an area of 1,751.2 square kilometres and is located between latitudes 24° and 25° North and longitudes 27° and 13° East. The Saboba District shares its borders with neighbouring districts. It is situated to the north of Chereponi and to the south of Tatale Sanguli. The Yendi and Gushiegu municipalities are next to the district on its western side. The River Oti serves as the delineation between Ghana and the Republic of Togo, establishing the eastern international boundary between the two nations. The vegetation pattern of the Saboba District is characterized by Savannah grassland featuring stunted trees, drought-tolerant trees, and clusters of shrubs dispersed throughout. Nevertheless, many human activities such as agriculture, controlled burning of vegetation, and construction are causing detrimental effects on the natural vegetation (Chegbeleh *et al.*, 2009). These activities present considerable obstacles to the conservation and long-term viability of the indigenous plant life. Construction projects frequently necessitate land clearance, which can result in the eradication of vegetation and the fragmentation of habitats. Bush burning, a prevalent tradition in the region, can lead to the depletion of flora and have adverse effects on the natural equilibrium of the area. Agricultural practices, although crucial for the sustenance of numerous inhabitants, can also lead to the deterioration of vegetation if not

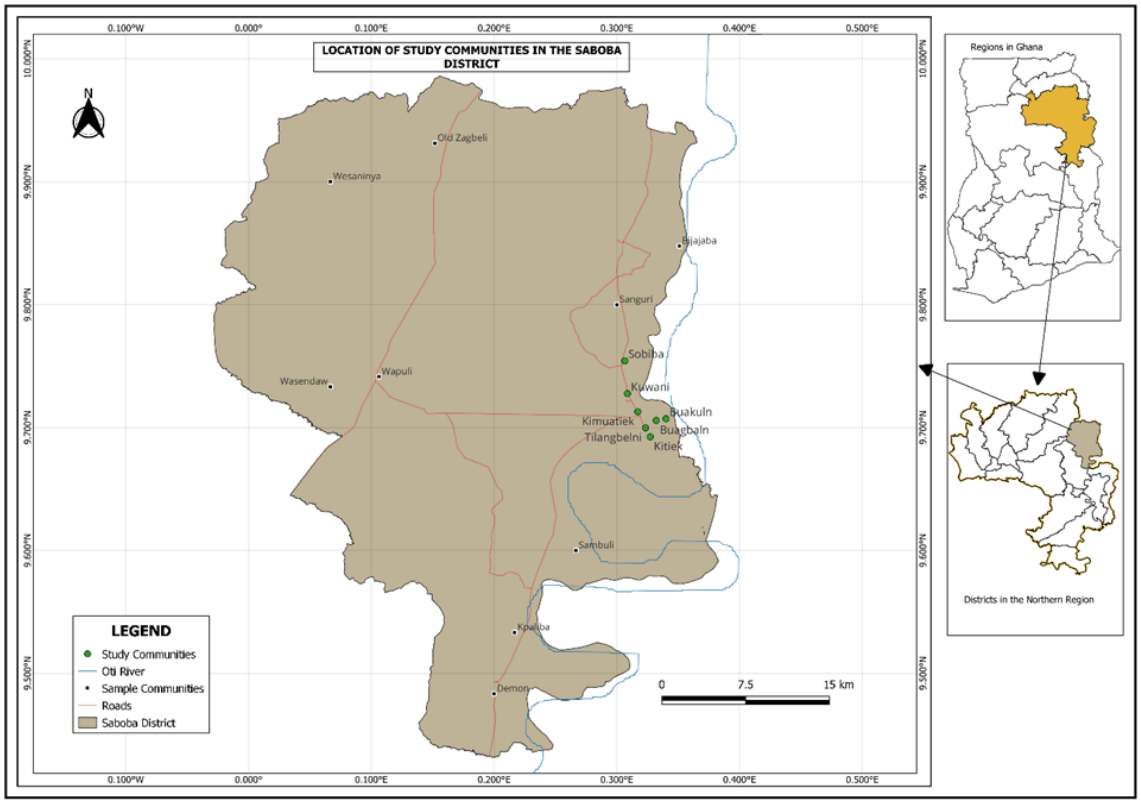

Figure 1: Study area map

conducted in a sustainable and responsible manner. The district is situated within the geographical region known as the Guinea Savanna agro-ecological zone (Antwi-Agyei *et al.*, 2012). This region is renowned for its Guinea Savannah vegetation, but it has undergone varying levels of deterioration over the years. The Saboba District is located in the Guinea Savannah agro-ecological zone, which is known for its abundant Guinea Savannah vegetation. The Saboba District is classified as having a tropical Savannah climate according to the Köppen-Geiger climate classification (Köppen-Geiger Climate Classification, 2017). The Savannah climate in the district is marked by two distinct seasons that occur throughout the year. The uni-modal rainfall season often spans from April or May to October or November, which usually floods the communities and farms along the Oti River, while the dry season generally extends from November to April or May. The dry season is distinguished by the presence of arid northeast trade winds commonly referred to as Harmattan. The current time frame is characterized by elevated levels of sunlight, especially throughout the months of March to May (GSS, 2010). According to Kursah *et al.* (2017), the district receives an annual precipitation ranging from 950 mm to 1050 mm. The Saboba District experiences consistently high temperatures throughout the year, with the temperature fluctuating between 21 and 41 °C (Dogbe *et al.*, 2013). This climatic attribute enhances the distinct ecosystem of the region. The district has a population of 95,683 people (GSS, 2021).

Study Design

Research designs are plans or blueprints for how a study will be carried out, as defined by Strydom, Fouche, and Delport (2005). The goal, starting point, and logic of a study are all carefully considered in the development of a research design. According to Huysamen (1993), "design" is the blueprint followed to collect data to study the research topics in the most efficient way possible. The decisions made on the study's sampling, data sources and processes, measurement issues, and data analysis strategies are all part of what other academics call the research design. Strydom, Fouche, and Delpot (2005) add that the research design employed varies according to the goals and aims of the study, the specifics of the research questions, and the researcher's expertise and access to relevant data. However, the study process will mirror the procedures of the selected design, as each design has its perspective and methods. Qualitative research designs are notable for their lack of predetermined guidelines or a set recipe for carrying out the research. Unlike qualitative research, where the researcher's decisions and actions inform the design, quantitative research is driven by the design. Simply put, researchers doing qualitative studies often develop an appropriate research strategy throughout their study or even base their entire study on that method. Therefore, the aforementioned strategies were considered when choosing the best research design for this study. The research used quantitative data. The research was conducted in the Saboba district of the Oti River sub- basin of northern Ghana. The area was chosen for the study because it is located in the Oti River basin and is thus susceptible to flooding during the wet season.

Sample Selection and Size

Sampling, as defined by Strydom, Fouche, and Delport (2005), is the practice of selecting a statistically meaningful subset of a larger population. The rule of thumb is that the smaller the sample size, the greater the population you can reasonably expect to represent. A larger proportion of the population should be represented in the sample if the population is small. Researchers can extrapolate more generalizable findings from larger samples and make more informed forecasts. In addition, Strydom, Fouche, and Delport (2005) claim that convenience is the primary driver of sampling. It is not always possible to reach every member of a population of interest, but it is always possible to cover the entire population. Time and money constraints make it unrealistic to try to locate, get in touch with, and analyze everyone who might be involved. As a result, information gleaned through sample analyses may be more reliable than if the full population had been examined. This is because it is far easier to focus resources (time, money, and effort) on a smaller subset of the population, resulting in higher-quality research, better tools, and more in-depth knowledge. The rural families included in this study were chosen using a simple random selection method. Saboba district is one of the nine districts that make up the Oti River basin in the Rural Savanna Geographic Division of northern Ghana. Kimuatiek, Kitiek, Buagbaln, Sobiba, Tilangbelni, Kuwani, and Buakuln were randomly chosen among the flood-prone settlements in the Saboba District.

Determination of the Sample Size

The sample size (n) was determined by applying the formula proposed by Yamane (1967) as shown in the equation below. Yamane (1967) provides a simplified formula to calculate sample sizes using a 95% confidence level and P = 0.05.

Thus,

$n=N/(1+N(e^2))$

Where n is the sample size, N is the population size (of the study area), and e is the level of precision. By applying the above formula proposed by Yamane (1967), where N=95,683, e=0.05, therefore n which is the sample size would be three hundred and ninety-nine (399).

Questionnaire Administration

Questionnaires were selected for multiple reasons, mostly due to their efficacy in obtaining accurate information regarding the practices and conditions that the respondents were assumed to be knowledgeable of. Additionally, questionnaires were deemed suitable for investigating the thoughts and attitudes of the subjects. Another rationale for selecting questionnaires was their

ease of completion and efficiency in terms of time, as opposed to alternative tools such as interviews. Ultimately, when managing a substantial number of participants, employing questionnaires is the optimal and most suitable method. The surveys included a combination of closed and open-ended questions. Regarding open-ended questions, respondents had the freedom to express their answers in a manner they considered suitable, using their own language and phrasing. Closed-ended questions were employed due to the predetermined response options, requiring respondents to select the option that best aligned with their agreement. The questionnaire was segmented into distinct sections. Section A focused on the demographic information of the respondents, whereas the subsequent sections were centered on the main goal of the study.

Method of Data Analysis

Descriptive statistical methods were employed for the data analyses. The quantitative data collected was analyzed using the statistical and data software v15 (STATA).

RESULTS AND DISCUSSIONS

Socio-Demographic Characteristics of Farmers

The socio-demographic information of smallholder farmers across the seven communities is presented in Table 1. Based on the results, a substantial majority (73.68%) of the farmers sampled were males with the remaining 26.32%, constituting female farmers. The prevalence of more male farmers shows an uneven participation in agriculture activities within the sampled population. The inequality stems from the varying levels of power in decision-making and control over resources, including land, which male farmers have over females in the study area. This observation is supported by the FAO (2012) report on Gender Inequalities in Rural Employment in Ghana, which revealed that men possess 3.2 times more total farms than women and 8.1 times more medium to large-sized farms (5 acres or larger).

Table 1 also shows that more than two-thirds (60.15%) of the respondents were married, approximately, 24.31% were single, 10.53% who engaged in farming were widowed and a significantly lower percentage (5.01%) were divorced farmers. Furthermore, an overwhelming majority (56.14%) of the farmers do not have any form of education. A few of them were tertiary graduates while about 40% had basic and secondary education. Admittedly, education plays a key role in farmers' income and productivity. For example, Oduro-Ofori *et al.* (2015) indicated that increased agricultural production and income generation are frequently linked to higher literacy rates.

The age distribution of farmers as presented in Table 1 reflects a diverse pattern of age groups. Based on the results, farmers between the ages of 36-45 age group were 4% higher compared to those within the 26-35 age range. This diversity in age groups highlights the intergenerational nature of farming, with individuals from various age categories contributing to agricultural production and livelihoods in the study area.

Furthermore, the data on FBO membership reveals that only 19.33% of the farmers were affiliated with Farmer-Based Organizations, while the majority (80.67%) were not members. FBOs play a vital role in promoting collective action, resource sharing, and accessing support services for smallholder farmers. Membership in FBOs can enhance farmers' market access, bargaining power, and resilience to shocks and stresses in the agricultural sector (Afari-Sefa *et al.*, 2018).

Additionally, access to credit is a crucial factor for farmers to invest in inputs, technology, and infrastructure that can enhance agricultural productivity and income. The data indicates that 56.67% of the sampled farmers have access to credit, enabling them to expand their operations, adopt new practices, and navigate financial challenges effectively. On the other hand, the low percentage (11.28%) of farmers who have received extension services underscores potential gaps in knowledge dissemination and capacity-building efforts in the study area. Increasing access to extension services can empower farmers with valuable information, training, and technical support to improve their skills, productivity, and resilience to external shocks.

Table 1: Socio-demographic characteristics of the sampled population

Variable	Frequency	Percentages
Sex		
Males	294	73.68
Females	105	26.32
Marital status		
Married	240	60.15
Single	97	24.31
Divorced	20	5.01
Windowed	42	10.53
Literacy level		
None	224	56.14
Basic	77	19.3

Secondary	79	19.8
Tertiary	19	4.76
Age Groups		
18-25 years	72	18.05
26-35 years	92	23.06
36-45 years	121	30.33
46-55 years	69	17.29
Above 55 years	45	11.28
FBO membership		
Yes	29	19.33%
No	121	80.67%
Access to credit		
Yes	85	56.67%
No	65	43.33%
Received extension services		
Yes	45	11.28
No	354	88.72

Source: Field Survey, 2023

Flood Risks and Their Impact on Farming Activities
Based on the results presented in Figure 2, it is evident that a significant proportion of smallholder farmers in the Oti River Basin are highly vulnerable to flood incidence. Specifically, 87% of the farmers indicated that they were highly vulnerable to floods, highlighting the substantial impact of flood events on their livelihoods and agricultural activities. In contrast, only 3% of farmers reported not being vulnerable to flood incidents.

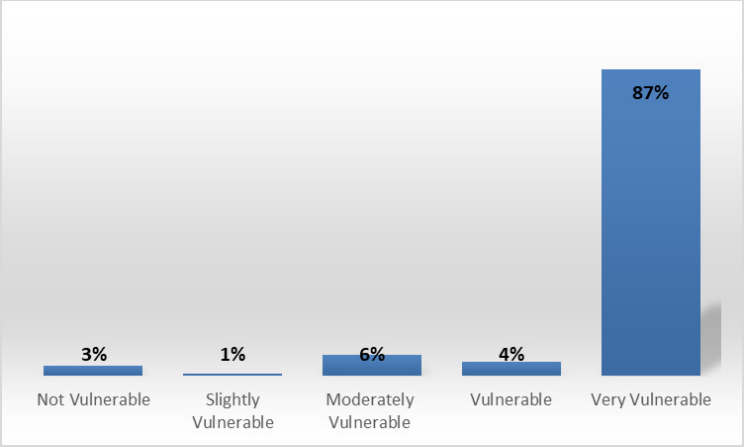

Figure 2: Vulnerability to Flood Incidence
Source: Field Survey, 2023

The findings from Table 2 highlight the various factors influencing the vulnerability of smallholder farmers to flood incidents in the Oti River Basin. In the first place, the proximity of farmers to the river emerges as a critical factor, with 96% of respondents acknowledging that their distance to the river impacts their vulnerability. Farmers residing closer to the river are at a higher risk of experiencing flood-related damages, potentially due to the increased likelihood of river overflow and the subsequent inundation of farmlands. Additionally, the elevation of communities below the river plays a significant role, as 79% of farmers recognize that communities situated at lower elevations relative to the river face heightened vulnerability to floods. This vulnerability stems from the natural flow of water downhill, increasing the susceptibility of low-lying areas to flooding and its associated consequences. These findings are affirmed by Fatemi *et al.* (2020) who explored physical vulnerability and local responses to flood damage and highlighted that factors such as proximity to rivers, elevation, and flood event characteristics influence the physical vulnerability of buildings during floods. Moreover, the data reveals that 82% of farmers perceive an increase in rainfall as a key factor contributing to their vulnerability to floods. Changes in precipitation patterns, including more intense rainfall events, can lead to waterlogging, soil erosion,

and elevated flood risks, thereby impacting agricultural productivity and livelihoods. Furthermore, the quality of buildings and building materials in farming communities is highlighted, with 39% of respondents identifying poor infrastructure as a factor influencing vulnerability to floods. Inadequate housing materials and infrastructure can exacerbate the impact of floods, resulting in property damage, loss of shelter, and disruptions to farming activities.

Lastly, the lack of early warning systems emerged as a significant concern, with 68% of farmers recognizing the absence of timely alerts as a factor influencing their vulnerability to floods. Piennah *et al.* (2023) argue that early warning systems help smallholder farmers prepare for and respond to flood incidents. By receiving timely information about impending floods, farmers can take proactive measures to protect their crops, livestock, and property. Early warning systems enable farmers to evacuate to safer locations, secure their belongings, and minimize potential losses during flood events. Effective early warning systems are crucial for preparedness and evacuation measures, enabling farmers to safeguard their assets and mitigate the risks associated with flood events. By elucidating these factors influencing vulnerability to floods among smallholder farmers in the Oti River Basin, the study underscores the complex nature of flood risks and the specific challenges faced by farmers in the region. Understanding these factors is essential for designing targeted interventions, risk reduction strategies, and resilience-building initiatives to enhance the adaptive capacity of smallholder farmers and promote sustainable agricultural practices in flood-prone areas.

Table 2: Factors influencing Vulnerability to floods

Factors Influencing Vulnerability	**Female**		**Male**		**Total**	
	Freq (Yes)	**%**	**Freq (Yes)**	**%**	**Freq (Yes)**	**%**
Distance to River	101	25%	283	71%	384	96%
Elevation of Community Below the River	81	20%	233	58%	314	79%
Increase in Rainfall	87	22%	242	61%	329	82%
Poor Buildings and Materials	43	11%	112	28%	155	39%
Lack of Early Warning Systems	77	19%	194	49%	271	68%
Lack of Emergency Response Systems	78	19.55%	197	49.37%	275	68.92%
Inadequate Awareness & Education	47	11.78%	117	29.32%	164	41.10%
Lack Flood Control Measures	58	14.54%	122	30.58%	180	45.11%
Impervious Rate/ Soil Type	5	1.25%	35	8.77%	40	10.03%
Population	7	1.75%	19	4.76%	26	6.52%

Figure 3 provides a visual representation of the prevalence of flooding incidents among smallholder farmers in the Oti River Basin over five years. By analyzing the data, it is evident that a significant proportion (91%) of farmers in the region have been directly impacted by flooding events during this timeframe. The frequency of flooding experienced by farmers serves as a critical indicator of the recurrent nature of flood hazards in the area and underscores the persistent threat posed by such disasters to agricultural activities and livelihoods as shown in Figure 4. Seventy four percent (74%) of farmers indicating they experience flooding events almost every year is a strong sign of the level of threat floods pose to the farmers living around the Oti River Basin. The high incidence of flooding reported by farmers over the past five years highlights the ongoing vulnerability of agricultural communities in the Oti River Basin to flood-related risks. These recurrent flood events not only disrupt farming operations but also result in crop damage, livestock losses, and infrastructure destruction, thereby jeopardizing food security, economic stability, and overall well-being. The cumulative effect of multiple flooding episodes can exacerbate the challenges faced by smallholder farmers, particularly those who heavily rely on agriculture for their livelihoods.

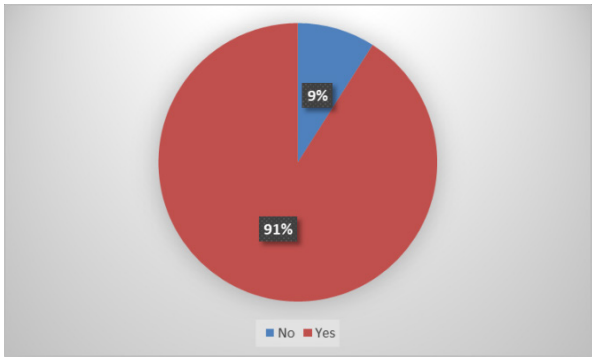

Figure 3: Experienced flooding over the last five years
Source: Field Survey, 2023

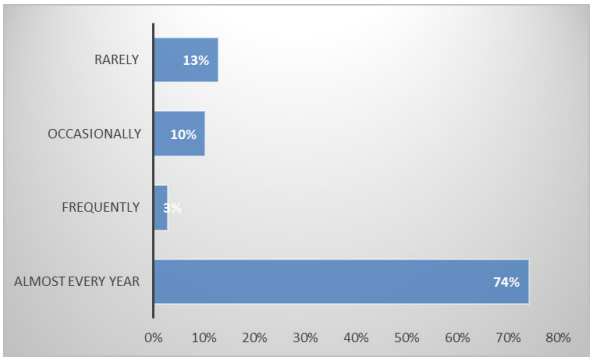

Figure 4: Frequency in Flood Occurrence
Source: Field Survey, 2023

Table 3 provides valuable insights into the diverse impacts of floods on smallholder farmers' households in the Oti River Basin. The data presented in the table sheds light on the extent of damages incurred by farmers and their households as a result of flood events. By examining the various impacts of floods, we can better understand the challenges faced by farmers in the region and the implications for their livelihoods and well-being. The table reveals that a significant proportion of farmers' properties and households have been affected by floods, with varying degrees of damage reported across different categories. For instance, 82% of respondents indicated that their crops were impacted by floods with maize (55%) being the most affected as indication on Figure 5. This highlights the substantial loss of agricultural produce due to inundation and water damage. Staple crops, essential for food security and income generation, were particularly vulnerable, with 80% of farmers reporting damage to these crops (maize, soya beans and rice).

Furthermore, the data shows that floods have led to a decrease in farm income for 87% of the surveyed farmers, underscoring the economic repercussions of flood events on agricultural productivity and financial stability. These findings correspond with Pirngadi (2024) findings which indicated that the substantial reductions in production yields caused by floods, lead to significant losses in farm income. The increase in farm expenses reported by 85% of respondents further exacerbates the financial strain experienced by farmers in the aftermath of floods, as they incur additional costs for recovery and rehabilitation efforts. In addition to the economic impacts, floods have also affected farmers' household infrastructure, with 37% reporting damage to farm and household infrastructure such as tools, equipment, and housing materials. The disruption of water sources (45%) and the prevalence of sickness (78%) among household members with 97% and 76% indicating having contracted malaria/fever and diarrhea due to these floods respectively (Figure 6). This further highlights the broader consequences of floods on health, sanitation, and overall well-being within farming communities.

Table 3 highlights the multifaceted nature of flood hazards and their far-reaching effects on agricultural livelihoods and rural communities. The data presented in the table underscores the urgent need for targeted interventions, risk mitigation strategies, and support mechanisms to enhance the resilience of smallholder farmers in the Oti River Basin against future flood events. Addressing the challenges identified in Table 3 is essential for promoting sustainable agriculture, safeguarding food security, and improving the overall socio-economic resilience of vulnerable farming households in the region.

Table 3: Impacts of Floods on Farmer's Household

Damages to Farmers' Properties & Household	**Yes**		**No**	
	Freq	**%**	**Freq**	**%**
Farm & Household Infrastructure (Bed, Boat, Fishing net, Radio, Plough, Hoe etc)	148	37%	251	63%
House	79	20%	320	80%
Crops	329	82%	70	18%
Staple Crops	319	80%	80	20%
Food Stocks	302	76%	97	24%
Decrease in Farm Income	346	87%	53	13%
Increase in Farm Expenses	339	85%	60	15%
Water Source	181	45%	218	55%
Sickness	312	78%	87	22%
Total Sampled	**399**			

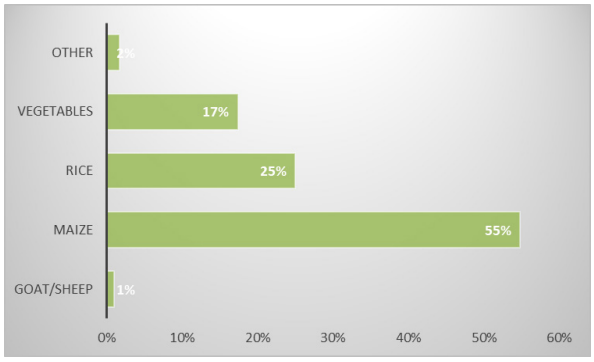

Figure 5: Crop or Livestock Affected by the Floods
Source: Field Survey, 2023

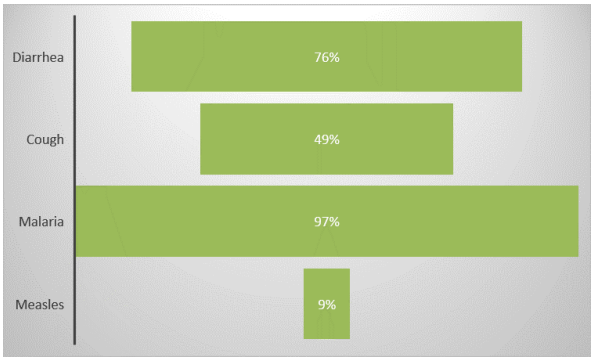

Figure 6: Diseases Experienced by Farm Households
Source: Field Survey, 2023

Response Strategies Adopted Against Flood Impacts

Figure 7 provides a visual representation of farmers who have adopted specific response strategies in the Oti River Basin to mitigate the impact of floods on their agricultural activities and livelihoods. The data presented in figure 7 shows that only 7% of the farmers have adopted certain strategies to mitigate the devastations caused by floods.

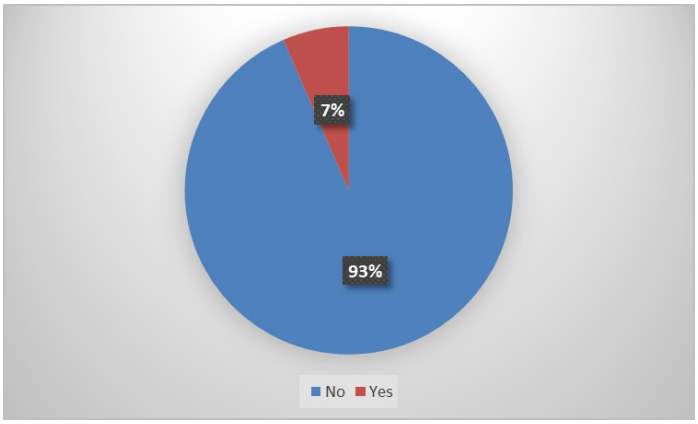

Figure 7: Adoption of Specific Strategies to Mitigate the Impact of Floods on Farms
Source: Field Survey, 2023

Table 4 provides detailed information on the specific responds strategies adopted by smallholder farmers in the Oti River Basin to mitigate the impact of floods on their agricultural activities. The data presented in the table offers valuable insights into the proactive measures taken by farmers to enhance their resilience against flood hazards and minimize the adverse effects of inundation on their farms and households.

Building raised beds emerges as a popular response strategy, with 58% of farmers adopting this approach to elevate their crops above flood levels and reduce waterlogging. Raised beds have been shown to offer various benefits in agricultural practices. Studies have indicated that utilizing raised beds can aid in improving drainage, preventing water stagnation, and safeguarding crops from water-related damages (Holmes *et al.*, 2021; Lham *et al.*, 2022).

In addition, crop diversification is another prevalent response strategy, with 81% of farmers opting to cultivate a variety of crops to spread risk and ensure food security in the face of flood-related disruptions. Diversifying crop production can help farmers mitigate the impact of crop losses during floods, maintain income stability, and adapt to changing environmental conditions, thereby enhancing their overall resilience and sustainability. This has been affirmed by Bellon *et al.* (2020) who argued that diversifying crop production can lead to increased income stability, as farmers who practice diversification can have a continuous flow of income from crop sales throughout the year.

Furthermore, livestock relocation is also a commonly adopted strategy, with 81% of farmers relocating their livestock to safer areas during flood events to prevent animal losses and safeguard their assets. By moving livestock to higher ground or secure shelters, farmers can reduce the risk of livestock casualties, ensure animal welfare, and preserve their livelihood assets in the event of flooding. This finding is supported by Okuku *et al.* (2015) and Kharismafullah *et al.* (2022) who indicated that it is important to utilize the available resource assets around the location of the livestock business to enhance resilience and livelihood stability and that strategies that safeguard livelihood assets, such as moving livestock to higher ground during flood events, are essential in rural areas where livestock livelihood are significant to the farmers.

Additionally, conservation farming practices, such as soil conservation, mulching, and agroforestry, are embraced by 58% of farmers to improve soil health, water retention, and crop resilience to floods. These practices promote sustainable land management, enhance ecosystem services, and mitigate the impact of floods on soil erosion and nutrient loss, contributing to long-term agricultural sustainability and climate resilience.

Erkossa *et al.* (2015) affirmed that the implementation of soil and water conservation practices can minimize financial costs associated with erosion, thereby improving the sustainability of the agriculture sector. Additionally, Yan *et al.* (2005) also added that the reduction of soil erosion through conservation measures can help preserve soil carbon pools and enhance soil carbon sequestration, which are vital for soil health and fertility.

By analyzing the adoption of specific response strategies depicted in the table, we gain valuable insights into the proactive measures taken by smallholder farmers in the Oti River Basin to mitigate the impact of floods on their agricultural livelihoods. These strategies do not only enhance farmers' resilience to flood hazards but also promote sustainable agricultural practices, improve food security, and strengthen the overall adaptive capacity of farming communities in the face of climate-related challenges. Encouraging the adoption of these response strategies and supporting farmers in their implementation are essential steps towards building a more resilient and sustainable agricultural sector in flood-prone regions like the Oti River sub-basin.

Table 4: Specific Mitigation Strategies Adopted

Mitigation Strategies Adopted	Number of People Adapting Strategy	Percentage
Building of Raised Beds	15	58%
Crop Diversification	21	81%
Improved Drainage Systems	2	8%
Use of flood-resistant crop varieties	7	27%
Livestock Relocation	21	81%
Crop Insurance	4	15%
Conservation farming practice	15	58%
Total Number of Farmers Adopting Response Strategies	**26**	

Source: Field Survey, 2023

It is important to highlight that the approaches embraced by the farmers primarily serve as coping mechanisms to address the challenges posed by floods on their agricultural lands and yields. Notably, there is a lack of emphasis on implementing strategies for adaptation, such as exploring alternative livelihoods that could offer income or sustenance during the scarcity of the dry season, when they may face shortages of both food and finances resulting from losses experienced during flood periods. This aspect presents an intriguing avenue for future research exploration.

CONCLUSION

The comprehensive assessment of smallholder farmers' responses to flood incidence in the Oti River sub-basin has shed light on the multifaceted nature of flood vulnerability, the frequency of floods over the last 5 years, the impacts of floods, and the specific response strategies adopted by farmers to mitigate the adverse effects of flood events. By examining these highlighted areas, this study has provided valuable insights into the challenges and opportunities for enhancing resilience in flood-prone regions.

The analysis of vulnerability factors, including proximity to rivers, elevation of communities, changes in rainfall patterns, building quality, and early warning systems, has highlighted the diverse factors influencing farmers' susceptibility to flood hazards. Understanding these vulnerability factors is crucial for developing targeted interventions and adaptive strategies to reduce the impact of floods on agricultural activities and livelihoods.

The study's exploration of past flood experiences over the past five years has underscored the recurrent nature of flood events in the Oti River Basin, emphasizing the need for proactive measures to address the increasing frequency and intensity of floods. The impacts of floods on farming activities, including crop damage, livestock losses, and disruptions to livelihoods, have highlighted the significant challenges faced by smallholder farmers in the region and the importance of building resilience against flood hazards.

Moreover, the identification of specific mitigation strategies adopted by farmers, such as building raised beds, crop diversification, improved drainage systems, flood-resistant crop varieties, livestock relocation, crop insurance, and conservation farming practices, has demonstrated the proactive measures taken by farmers to mitigate the impacts of floods and enhance their adaptive capacity. These strategies not only help farmers cope with immediate flood risks but also promote sustainable agricultural practices, improve food security, and strengthen community resilience in the face of climate-related challenges.

The findings from this study emphasize the importance of holistic and community-driven approaches to flood risk management, including early warning systems, capacity-building initiatives, sustainable land management practices, and multi-stakeholder collaboration. By addressing vulnerability factors, enhancing adaptive capacity, and promoting the adoption of effective mitigation strategies, stakeholders can work together to build a more resilient and sustainable agricultural sector in the Oti River Basin, ultimately improving the well-being and livelihoods of smallholder farmers and communities in Ghana.

Acknowledgments

The authors thank everyone who has contributed to improving the quality of this study.

REFERENCES

Alare, R., Owusu, E., & Owusu, K. (2018). Climate-smart agriculture practices in semi-arid northern Ghana: Implications for sustainable livelihoods. *Journal of Sustainable Development, 11*(5), 57. https://doi.org/10.5539/jsd.v11n5p57

Alderman, K., Turner, L. R., & Tong, S. (2012). Floods and human health: A systematic review. *Environment International, 47,* 37–47.

Alderman, K., Turner, L. R., & Tong, S. (2012). Floods and human health: A systematic review. *Environment International, 47,* 37–47.

Alhassan, H. (2020). Farm households' flood adaptation practices, resilience and food security in the Upper East region, Ghana. *Heliyon, 6*(6), e04069.

Ali, A., & Rahut, D. B. (2019). Localized floods, poverty and food security: Empirical evidence from rural Pakistan. *Hydrology, 7*(1), 2.

Almoradie, A., Brito, M., Evers, M., Bossa, A., Lumor, M., Norman, C., & Hounkpè, J. (2020). Current flood risk management practices in Ghana: Gaps and opportunities for improving resilience. *Journal of Flood Risk Management, 13*(4), e12664. https://doi.org/10.1111/jfr3.12664

Amoako, C., & Inkoom, D. (2017). The production of flood vulnerability in Accra, Ghana: Re-thinking flooding and informal urbanisation. *Urban Studies, 55*(13), 2903–2922. https://doi.org/10.1177/0042098016686526

Amouzou, K. A., Lamers, J. P., Naab, J. B., Borgemeister, C., Vlek, P. L., & Becker, M. (2019). Climate change impact on water-and nitrogen-use efficiencies and yields of maize and sorghum in the northern Benin dry savanna, West Africa. *Field Crops Research, 235,* 104–117.

Armah, F., Yawson, D., Yengoh, G., Odoi, J., & Afrifa, E. (2010). Impact of floods on livelihoods and vulnerability of natural resource dependent communities in northern Ghana. *Water, 2*(2), 120–139. https://doi.org/10.3390/w2020120

Asare-Nuamah, P., & Mandaza, M. S. (2020). Climate change adaptation strategies and food security of smallholder farmers in the rural Adansi North District of Ghana. In *Handbook of climate change management: Research, leadership, transformation* (pp. 1–20). Springer.

Atanga, R., & Tankpa, V. (2021). Climate change, flood disaster risk, and food security nexus in northern Ghana. *Frontiers in Sustainable Food Systems, 5,* 706721. https://doi.org/10.3389/fsufs.2021.706721

Bellon, M., Kotu, B., Azzarri, C., & Caracciolo, F. (2020). To diversify or not to diversify, that is the question: Pursuing agricultural development for smallholder farmers in marginal areas of Ghana. *World Development, 125,* 104682. https://doi.org/10.1016/j.worlddev.2019.104682

Bichet, A., & Diedhiou, A. (2018). West African Sahel has become wetter during the last 30 years, but dry spells are shorter and more frequent. *Climate Research, 75*(2), 155–162. https://doi.org/10.3354/cr01515

Codjoe, S., Gough, K., Wilby, R., Kasei, R., Yankson, P., Amankwaa, E., & Griffiths, P. (2020). Impact of extreme weather conditions on healthcare provision in urban Ghana. *Social Science & Medicine, 258,* 113072. https://doi.org/10.1016/j.socscimed.2020.113072

Conway, G. (2011). On being a smallholder. In *Paper presented at the IFAD Conference on New Directions for Smallholder Agriculture* (Vol. 24, p. 25).

Dotse-Gborgbortsi, W., Dwomoh, D., Asamoah, M., Gyimah, F., Dzodzomenyo, M., Li, C., & Wright, J. (2022). Dam-mediated flooding impact on outpatient attendance and diarrhoea cases in northern Ghana: A mixed methods study. *BMC Public Health, 22*(1), 1134. https://doi.org/10.1186/s12889-022-14568-w

Ekwezuo, C. S., & Ezeh, C. U. (2020). Regional characterisation of meteorological drought and floods over West Africa. *Sustainable Water Resources Management, 6,* 1.

Enete, A. A., Obi, J. N., Ozor, N., & Mba, C. L. (2016). Socioeconomic assessment of flooding among farm households in Anambra State, Nigeria. *International Journal of Climate Change Strategies and Management, 8*(1), 96–111.

Erkossa, T., Wudneh, A., Desalegn, B., & Taye, G. (2015). Linking soil erosion to on-site financial cost: Lessons from watersheds in the Blue Nile Basin. *Solid Earth, 6*(2), 765–774. https://doi.org/10.5194/se-6-765-2015

Food and Agriculture Organization of the United Nations. (FAO). (2012). *Gender inequalities in rural employment in Ghana—An overview.* Food and Agriculture Organization of the United Nations.

Food and Agriculture Organization of the United Nations. (FAO). (2014). *The state of food and agriculture 2014 in brief.* Food and Agriculture Organization of the United Nations.

Fatemi, M. N., Okyere, S. A., Diko, S. K., Kita, M., Shimoda, M., & Matsubara, S. (2020). Physical vulnerability and local responses to flood damage in peri-urban areas of Dhaka, Bangladesh. *Sustainability, 12*(10), 3957. https://doi.org/10.3390/su12103957

Holmes, L., Kandel, H., Mehring, G., & Schmitz, P. (2021). How raised beds and Fe-chelate affect soybean iron deficiency chlorosis and yield. *Agricultural Sciences, 12*(7), 755–768. https://doi.org/10.4236/as.2021.127049

Iqbal, M., Ahmad, M., & Mustafa, G. (2015). Impact of farm households' adaptation on agricultural productivity: Evidence from different agro-ecologies of Pakistan.

Kharismafullah, K., Azizah, S., & Budiarto, A. (2022). The strategy of sustainable livelihoods for beef farmers in Bima Regency after the flood disaster in April 2021. *Buletin Peternakan, 46*(3), 193. https://doi.org/10.21059/buletinpeternak.v46i3.74113

Lham, P., Norbu, K., & Phuntsho, U. (2022). Evaluation of locally fabricated machine attached to tractor for making suitable raised bed for vegetable cultivation. *Bhutanese Journal of Agriculture, 5*(1), 162–171. https://doi.org/10.55925/btagr.22.5113

Samuel, O. K. (2023). Assessment of Youth Unemployment Impact on the Socio-Economic Development of Ondo State: A Study of Akure South Local Government Area. *American Journal of Social Development and Entrepreneurship, 2*(2), 37-49.

Okeleye, S. O., Olorunfemi, F. B., Sogbedji, J. M., & Aziadekey, M. (2016). Impact assessment of flood disaster on livelihoods of farmers in selected farming communities in Oke-Ogun region of Oyo State, Nigeria. *International Journal of Scientific and Engineering Research, 7*(8), 2067–2083.

Okuku, E., Bouillon, S., Ochiewo, J., Munyi, F., Kiteresi, L., & Tole, M. (2015). The impacts of hydropower development on rural livelihood sustenance. *International Journal of Water Resources Development,*

32(2), 267–285. https://doi.org/10.1080/07900627.2015.1056297

Owusu, A. B., Jakpa, J. T., & Awere, K. G. (2016). Smallholder farmers' vulnerability to floods in the Tolon District, Ghana. *Interdisciplinary Environmental Review, 17*(3–4), 286–311.

Rai, P., Gurung, T., & Sonam, T. (2024). Sustainability of agricultural practices in various agro-ecological zones of Bhutan. *American Journal of Environment and Climate, 3*(1), 63–77.

Pienaah, C. K., Batung, E., Saaka, S. A., Mohammed, K., & Luginaah, I. (2023). Early warnings and perceived climate change preparedness among smallholder farmers in the Upper West Region of Ghana. *Land, 12*(10), 1944. https://doi.org/10.3390/land12101944

Pirngadi, R. S., Rahmawaty, Ayu, S. F., & Rauf, A. (2024). Estimation of loss of rice farmers due to flood at Krueng Kluet Watershed (with the ECLAC method approach). *IOP Conference Series: Earth and Environmental Science, 1302*(1), 012125. https://doi.org/10.1088/1755-1315/1302/1/012125

Qi, Y., Ntim-Amo, G., Ran, R., Xu, D., Ansah, S., Hu, J., & Tang, H. (2021). Flood disaster risk perception and urban households' flood disaster preparedness: The case of Accra Metropolis in Ghana.

Takal, S. U., Tahiru, A.-w., & Owusu-Sakyere, E. (2023). The role of local level institutional arrangements in climate change adaptation of rural dwellers in northern Ghana. *Iranica Journal of Energy & Environment* (Articles in Press).