Short Article

The Impact of Water and Climate Changes on Food Security in Middle-Low-Income Countries: A Case Study of Ghana and Vietnam

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Abstract

As a growing global concern, water and climate changes have had a notable influence on agriculture. The main factor of this issue is food security, particularly in terms of food production and food pricing. This study investigates how climate change affects food security in Vietnam and Ghana, where agriculture is essential to socio-economic growth. The main study methodologies include ethnographic techniques and in-depth interviews with 50 farmers in each nation; 100 farmers in total. Results show that agricultural production and farmer health in these areas are highly vulnerable to increasing temperatures and erratic precipitation patterns. Vietnamese farmers mainly face flooding, sea-level rise, and saltwater intrusion, which endangers rice production, whereas Ghanaian farmers are more susceptible to droughts, which limit the amount of water available for rain-fed agriculture. Food security necessitates a change to alternate, robust crop types and improvements in agricultural technologies to counter these risks. The study highlights the need for adaptive measures such as enhanced irrigation systems, drought-resistant seeds, and early-warning systems for severe weather. These insights can help governments, agricultural stakeholders, and consumers develop policies and practices that improve food quality and stability, supporting sustainable agriculture.

Keywords: Agriculture, Climate change, Food security, Ghana, Vietnam

Introduction

One of the most urgent issues facing the world today is climate change, which disproportionately affects countries that are already having difficulty with economic development and poverty (Levy & Patz, 2015). While its impacts are wide-ranging, agriculture is often cited as the hardest-hit sector, especially in hotter, lower-income countries where farming is a key source of livelihood (Uddin & Mamun, 2023). As climate change alters weather patterns and intensifies extreme weather events, it severely disrupts agricultural productivity, particularly through its effects on precipitation and temperature (Furtak & Wolińska, 2023). These two climatic factors are critical to crop growth and food production, and their variability directly influences agricultural output. Because agriculture is the primary source of income for millions of people, especially in developing countries, this has raised global concern, particularly about food security.

There is ample evidence of the detrimental effects of global warming on food security. Research has shown that changes in precipitation and rising temperatures negatively affect food production, while the economic consequences drive up food prices, making staple crops less affordable (Ahsan, Chandio, & Fang, 2020; Chandio, Magsi, Ozturk, 2020). Decreasing agricultural yields result in reduced food availability and higher prices, which particularly affect access for low-income populations. Consequently, food production and pricing emerge as critical factors influencing food security in this environment. Climate change has an impact on national, regional, and global food systems in

addition to individual farm households (Fanzo, Davis, McLaren, & Choufani, 2018). This poses a challenge to attempts to eradicate hunger and reduce food insecurity (Burchi, Fanzo, & Frison, 2011). Researchers and academics have emphasized the importance of this issue, pointing out that if substantial action is not taken, the world's agricultural production will decline and it will not fulfill its food security objectives (Stevanović *et al.*, 2016).

In the context of climate change, the increase in food costs worldwide has become an urgent concern. The agricultural industry is further strained by the rising demand for food brought on by population expansion and rising income levels (Rask & Rask, 2011). This pressure is exacerbated by the reduced land productivity caused by climate variability, which further hinders the ability of countries to meet their food production needs. These factors are expected to cause global food costs to continue rising, which will make it harder for vulnerable groups to get enough nourishment (Brinkman, de Pee, Sanogo, Subran, & Bloem, 2009). These price hikes highlight the clear connection between climate change and food poverty, as they are caused by decreased agricultural yields and losses in land productivity (Schmidhuber & Tubiello, 2007).

Climate change has had particularly negative effects on many rural areas, where agriculture is the main source of revenue and subsistence. Climate variability poses a particular threat to smallholder farmers, who comprise a substantial proportion of the agricultural labor force in nations such as Ghana and Vietnam (Baffour-Ata *et al.*, 2023). These farmers frequently do not have access to fertilizer, irrigation, or other necessary resources that would enable them to adjust to shifting conditions. Consequently, existing inequities between rural and urban people are made worse by climate change, which increases economic disparities (Adenle *et al.*, 2017; Lloyd *et al.*, 2018). In addition to impeding economic growth, wealth gaps brought on by climate sensitivity may perpetuate poverty cycles in rural regions where there are few options for generating money outside of agriculture (Leichenko & Silva, 2014). Climate change frequently exacerbates these socioeconomic disparities, making it more challenging for underprivileged populations to adapt and recover.

Despite the obstacles, efforts are being made to address the adverse effects of climate change on agriculture. Numerous adaptation measures have been investigated by researchers, such as the use of contemporary farming technology, enhanced irrigation systems, and the introduction of drought-resistant crops (Seleiman *et al.*, 2021). There have been demands for a shift in agricultural methods from traditional smallholder farming to more efficient and sustainable production systems in nations like Ghana and Vietnam (Altieri, Funes-Monzote, & Petersen, 2011). These initiatives seek to provide food security, foster economic stability in rural communities, and lessen the consequences of climate change.

Because of their particular difficulties and dependence on smallholder farmers, Vietnam and Ghana are ideal case studies for examining how climate change is affecting agriculture in low- and middle-income nations. About 60% of Ghana's grain output is maize, making it a vital crop for food security (Darfour & Rosentrater, 2016). Smallholder farmers, whose holdings are usually less than two hectares, are primarily responsible for the nation's agricultural industry. However, because of their substantial reliance on rain-fed agriculture and low financial means, these farmers confront enormous obstacles in adjusting to climate change. The lack of irrigation exacerbates the vulnerability of farming to erratic rainfall patterns. Farmers find it challenging to sustain output because of their inability to forecast rainfall and their limited access to fertilizers as a result of budgetary limitations. These problems have been intensified by climate change, leading to a greater degree of food insecurity when planting dates are disrupted by extreme

weather events and unpredictable rainfall. Destructive floods have also occurred in northern Ghana; for example, the 2007 flood put about 50,000 people in danger of food shortages for more than a year (Atanga & Tankpa, 2021).

Similar serious issues exist in Vietnam, particularly with regard to rice cultivation, which is essential to the nation's economic and food security. Despite the installation of irrigation systems, rising sea levels continue to threaten Vietnamese farmers with saltwater intrusion, leading to water shortages that negatively impact family water supplies and agricultural output (Thi Nhung, Le Vo, Van Nghi, & Quoc Bang, 2019). The frequency of extreme weather occurrences in Vietnam has resulted in increased food costs, worsening food security concerns, and economic instability. Households suffer large net economic losses in addition to the harm these occurrences cause, which makes it harder for them to withstand future climate-related shocks (Huong, Bo, & Fahad, 2019). Both at the governmental level and among individual farmers, adaptive techniques are desperately needed to solve these issues. Through policies aimed at promoting sustainable agriculture, the Vietnamese government has demonstrated a strong commitment to mitigating the effects of climate change (Dung & Sharma, 2017). However, long-term solutions require more precise guidance, financial support, and private-sector involvement.

Because of their reliance on agriculture and vulnerability to climatic unpredictability, Ghana and Vietnam are ideal examples of many other developing countries dealing with comparable climate-related issues. Ghana is an excellent illustration of a sub-Saharan African nation where the majority of agriculture is rain-fed and extremely vulnerable to droughts and irregular rainfall patterns. Like Ghana, many African nations rely on smallholder farms with little access to infrastructure, irrigation, or cutting-edge technology (Forkuor, Amponsah, Oteng-Darko, & Osei, 2022). As a result, they are more susceptible to climate change, which can cause crop failures and undermine food security. Ghana's struggle with unpredictable precipitation, extreme droughts, and a lack of resources for climate adaptation is representative of larger problems encountered by countries that depend on traditional practices and subsistence farming (Antwi-Agyei, Dougill, Stringer, & Codjoe, 2018).

Vietnam, on the contrary, serves as an example of the climatic issues that low-lying, coastal countries in Asia and the Pacific confront as a result of flooding, increasing sea levels, and saltwater intrusion. Like Bangladesh, the Philippines, and Thailand, climate-driven coastal expansion and shifting water salinity pose a threat to Vietnam's productive agricultural areas, endangering freshwater supplies and food production (Huynh, Lin, Ness, Occeña-Gutierrez, & Trần, 2013). Other countries with comparable environmental circumstances can learn useful techniques for handling these difficulties by looking at Vietnam's adaptation measures, such as the installation of irrigation and early warning systems (Trinh, Rañola, Camacho, & Simelton, 2018). Together, Ghana and Vietnam represent the dual realities of climate impacts: one affected by arid conditions and water scarcity, and the other by water abundance and coastal risks. Findings from these two nations offer a valuable framework for understanding the broader implications of climate change on agriculture and food security globally, especially for vulnerable, agriculture-dependent economies.

The objective of this paper is to examine the intricate connection between food security and climate change, with an emphasis on Ghana and Vietnam. To feed their populations and maintain food security, both nations mostly rely on agriculture, particularly staple crops. This study attempts to shed light on how climate change influences food production and pricing strategies in these nations. To support continued efforts to ensure a sustainable future for vulnerable communities, this research also aims to provide policy ideas and solutions to help mitigate the adverse effects of climate change

on agriculture.

Literature Review

The effects of climate change on agriculture, such as notable drops in crop yields, drops in farm income, and disturbances to agricultural production, have been extensively researched (Anh, Anh, & Chandio, 2023). The general loss in agricultural output has been attributed to several factors, including floods, unpredictable rainfall, temperature variations, and extreme weather events (Ahsan *et al.*, 2020; Chandio *et al.*, 2020; Ul-Haq *et al.*, 2022). Since reduced yields and agricultural underperformance make it more challenging to feed the world's expanding population, these environmental changes have been repeatedly connected to food insecurity (Anh *et al.*, 2023). But even with this abundance of information, there are still many critical gaps that need to be addressed.

The growing frequency of extreme heat occurrences is one of the main issues highlighted in the literature. Research shows that temperatures above 35°C have increased by 13% a year, which has a major impact on crop yields and the productivity of agricultural labor (Hatfield *et al.*, 2011). According to projections, surface temperatures might increase by more than 2°C by the end of the century, which would result in a major decline in yields, particularly for grain crops (IPCC, 2001). According to Lesk, Rowhani, and Ramankutty (2016), excessive heat caused a 9-10% drop in cereal output worldwide between 1964 and 2007. The shifting geographic distribution of diseases and pests exacerbates this issue by placing more strain on farmers and crops (Mora *et al.*, 2022). Despite these conclusions, a large portion of the research concentrates on regional or global temperature effects, frequently ignoring how particular local crop types or farming methods may exhibit differences in their resistance to or susceptibility to excessive heat. More regional research is required to examine how various people and agricultural systems adjust to warming in their unique environments.

While several studies highlight the significance of climate change in diminishing agricultural yields, less attention has been paid to smallholder farmers' adaptation techniques, which are especially sensitive to climatic variability due to their reliance on rain-fed agriculture. There is little empirical data on the long-term feasibility of these adaptation strategies in various agroecological zones, despite that some research has proposed adopting drought-resistant varieties and moving to tree crops like mango, cashew, and teak as potential solutions (Adjei-Nsiah & Kermah, 2012; Boon & Ahenkan, 2011; Fosu-Mensah, Vlek, & MacCarthy, 2012). Furthermore, smallholder farmers often face significant barriers to accessing crucial resources such as irrigation, fertilizers, and high-quality seeds, all of which are vital for enhancing productivity (Nakawuka, Langan, Schmitter, & Barron, 2018). Existing studies do not sufficiently address the socio-economic constraints that limit farmers' ability to adopt these adaptive measures.

Furthermore, the existing research provides little examination of the relationship between climate change and rural poverty. Many studies have shown that climate impacts on agriculture are widening income disparities (Dasgupta, Emmerling, & Soheil Shayegh, 2023; Paglialunga, Coveri, & Zanfei, 2022), but few have looked at how these disparities perpetuate poverty cycles, particularly in rural areas where agricultural livelihoods are the backbone of local economies. There is a critical need for research that investigates how climate-induced economic inequalities exacerbate existing vulnerabilities and how targeted interventions could alleviate poverty in climate-affected communities.

In conclusion, despite a significant amount of study on climate change and agriculture, several research gaps persist. These include an absence of regional research on the impacts of temperature and a lack of examination of adaptation tactics used by smallholder farmers. To build comprehensive measures to reduce the consequences of climate change on agriculture and food security, it is imperative

that these gaps be addressed.

Materials and Methods

Methodology

Using a subset of data gathered from a broader research project on environmental and socioeconomic concerns, this study focuses on how climate change affects agriculture in low-income nations. The information for this subgroup was collected in rural parts of low-income nations between May and August 2024, with an emphasis on places that mostly depend on subsistence farming. Although the larger dataset spans several nations on several continents, this study focuses on rural Vietnam and agricultural communities in Ghana. To investigate the coping mechanisms of farmers amid climate change, we opted for an ethnographic approach. This strategy is consistent with previous studies on the effects of the environment on community resilience. The inability of many smallholder farmers in these areas to obtain accurate information on climate change and its consequences has an impact on their decision-making and agricultural output. We offer an in-depth understanding of how climate change influences these people's daily lives, agricultural practices, and social networks by intimately interacting with them throughout our research.

Data Collection

The first author, a native Vietnamese speaker, conducted in-depth interviews with 50 farmers in rural regions of Vietnam, while the second author, a native Ghanaian speaker, simultaneously conducted interviews with 50 farmers in rural Ghana. Both studies used a combination of convenience and snowball sampling methods, leveraging the authors' connections within their respective agricultural communities.

In Vietnam, participants included 30 men and 20 women from diverse farming backgrounds, such as rice cultivation (40%), vegetable farming (30%), livestock raising (20%), and aquaculture (10%). In Ghana, the participants were 35 men and 15 women involved in maize cultivation (45%), cocoa farming (30%), and livestock rearing (25%). In both countries, the farmers relied on small-scale agriculture as their primary source of income and faced significant challenges due to climate change, which directly affected their livelihoods.

Prior to the research, Ghanaian farmers were involved in local agricultural groups, while many Vietnamese farmers were members of local farming cooperatives. Both groups exchanged information on farming methods and climatic variability coping mechanisms. Although traditional agricultural practices were prevalent, some farmers have embraced modern techniques through local training programs in Ghana and government or non-governmental organization programs in Vietnam.

The study provides a comparative viewpoint on how farmers in low-income nations are adjusting to climate change through these interviews. Despite geographic differences, farmers in Ghana and Vietnam developed techniques to cope with the increasing problems caused by climatic unpredictability, including changing planting dates, diversifying their crops, and depending on community networks.

Data Sources

Data sources for this study include formal interviews, informal conversations, ethnographic field notes, and observations in various agricultural and community settings. These observations took place in farmers' fields, local markets, community meetings, and informal gatherings. Additionally, we collected agricultural records, tools, weather-related documents, and photographs to enrich our understanding of the farmers' experiences. Each participant underwent a 1.5-2 hour-long interview. The interviews were conducted in different settings, including participants' homes, fields, and community centers.

Using first-person narratives, we encouraged participants to consider their involvement in agricultural cooperatives or local farming communities in light of climate

change. We were able to record rich narratives about the broader reality these farmers confront by promoting flexibility and depth throughout the interviews, which is crucial for comprehending their climate change adaptation capabilities and reactions (Guest & Taylor, 2016).

In order to quantify the effect size of each aspect, the research team asked interviewees both open-ended questions and customized follow-up questions (Table 1). Furthermore, experiments are conducted to determine whether certain elements have a substantial impact on agriculture as a result of climate change.

Table 1- Interview questions

	Questions	References
	Is the area being affected by climate change? Climate change indicators include hot temperatures, extreme climate events, and changes in rainfall patterns, as well as other climate change events.	(Anh *et al.*, 2023; Chandio *et al.*, 2020; Ul-Haq *et al.*, 2022)
Food production	Has the crop yield decreased slightly or significantly?	(Xu, Nghia, & Nam, 2023)
	Has the average time spent on the farm changed? Have they changed the times they work on the farm?	(Anh *et al.*, 2023)
	Has there been climate-induced migration? Has there been rural-urban migration among the youth?	(Bilak *et al.*, 2016; IPCC, 2022)
Food price	Do they sell less farm produce for the same amount of money? Or do they sell a smaller amount of farm produce for a higher amount of money? Or do prices remain unchanged?	(Anh *et al.*, 2023)
	What farm practices have changed? What measures are the farmers taking to reduce the devastating impacts of climate change?	(Yang *et al.*, 2024)
Food security	Can we alter the seasons of these crops (that is, the time of planting) to suit the change in the pattern of climate events?	(Guo *et al.*, 2024)
	How advanced are their farm practices? Do they make use of agricultural machinery?	(Yang *et al.*, 2024)

Data Rigor

Long-term participant involvement, in-depth observations, data triangulation, and member checks were used to guarantee the study's data quality, rigor, and reliability (Lincoln & Guba, 1985). The three researchers carried out in-depth ethnographic fieldwork in a variety of rural agricultural communities in Ghana and Vietnam over a period of three months. By spending a lot of time with farmers in their homes, fields, and local markets as well as at community events, the researchers were able to compile a comprehensive continuous dataset that documented the changing effects of climate change on agriculture.

The study team met bi-weekly to explore emergent trends from continuing interviews and fieldwork. We used both etic (outer) and emic (insider) viewpoints to triangulate information from a variety of sources, such as field notes, agricultural records, interview transcripts, and artifacts. We were able to cross-check the data and get a thorough grasp of the farmers' experiences thanks to this strategy. Each interview transcript was distributed to the participants in order to increase the study's rigor. This allowed them to

offer insightful comments and other information, guaranteeing that their stories were accurately represented.

Findings

How Agriculture is Affected by Climate Change

Agriculture in Ghana and Vietnam is deeply intertwined with the countries' economies, providing livelihoods for millions and ensuring food security. However, in recent decades, global climate change has posed significant threats to the agricultural sectors in both nations. These impacts have been wide-ranging, manifesting through shifts in weather patterns, rising temperatures, increased incidences of floods and droughts, and greater frequency of extreme weather events (Patz, Grabow, & Limaye, 2014). Farmers in both countries are finding it increasingly difficult to maintain crop yields, and food security is at risk.

Ghana: Changing Rainfall Patterns and Food Security

One of the most profound effects of climate change in Ghana is the alteration of rainfall patterns, which has become a common challenge for farmers across the country's diverse ecological zones. Traditionally, many of Ghana's crops rely on predictable, seasonal rains. However, this predictability has waned (Owusu, Darkey, & Boadi, 2018). Precipitation levels have been inconsistent in recent years, with some regions experiencing prolonged droughts while others are hit with heavy rainfall, often causing floods.

In the eastern region, where maize is a staple crop, Kwame Adjei, a 47-year-old farmer, expressed concern over these unpredictable patterns. "It is difficult to predict the rain now. When it comes, it pours too much, and then it disappears for long stretches. Our crops suffer because we cannot plan around such erratic weather," he shared. Kwame's experience echoes the broader sentiment of farmers who are struggling to adapt to erratic rainfall. Excessive rain often leads to floods, which drown crops, reduce yields, and lead to losses. On the other hand, periods of drought that follow heavy rain can be equally damaging, as they reduce the moisture needed for crop growth.

The shortened growing season in Ghana further compounds these problems. In years past, the rainy season was more consistent, allowing farmers to plan and cultivate multiple crops within a given period. However, with rains arriving later and leaving earlier, the growing window has narrowed (Vlam, Baker, Bunyavejchewin, & Zuidema, 2013). This has particularly affected crops like maize, millet, and cassava, which require sufficient time and moisture to grow. This shortening season has direct implications for food security, as farmers are forced to reduce their planting schedules, leading to lower yields and less food available for local markets.

Vietnam: Rising Temperatures and Saltwater Intrusion

In Vietnam, particularly in the Mekong Delta, rising temperatures and shifting rainfall patterns have become the new normal. The region, known as the "rice bowl" of the country, has been a major rice producer for decades. However, climate change is threatening this status, particularly due to the rising temperatures that have accompanied global warming.

Tran Van Phuc, a 52-year-old rice farmer, lamented: "The rice does not grow the same; it suffers from the heat." As temperatures rise, rice cultivation is particularly vulnerable. Rice is a water-intensive crop that thrives in cooler temperatures, but in many parts of Vietnam, daytime temperatures regularly exceed 35°C. These extreme temperatures stress crops, reducing their ability to photosynthesize and grow efficiently, which results in lower yields.

Another significant problem in Vietnam, particularly in the Mekong Delta, is saltwater intrusion. Due to rising sea levels and reduced freshwater flow from upstream rivers, saltwater is increasingly contaminating the farmlands (Helton, Bernhardt, & Fedders, 2014). Once fertile fields are becoming saline, they are unsuitable for traditional rice cultivation. Le Thi Hoa, a coffee farmer in the

Central Highlands, emphasized the impact of this on her livelihood: "We have less fresh water for our crops. The saltwater ruins the soil, and it is becoming harder and harder to grow anything. We are looking at other crops to see what can survive." This forced adaptation is indicative of how farmers across the region are seeking more resilient crops that can tolerate saline soils, such as cassava and sugarcane.

Increased Frequency of Flooding in Both Ghana and Vietnam

Flooding has emerged as another common thread in how climate change is affecting agriculture in both countries. In Ghana, certain regions experience seasonal flooding, particularly in the Northern and Upper East regions. While farmers historically managed to cope with flooding, climate change has made these events more severe and unpredictable. Majid Ababio shared how floods have wiped out entire maize fields in recent years: “We used to prepare for the floods, but now they come too fast, and we lose more crops than before. I have seen my neighbors lose all their maize just a week before harvest.”

Vietnam, too, is facing increasingly severe floods, particularly during the annual monsoon season. Farmers in the northern regions of the country have been hard hit, with the flooding season starting earlier and lasting longer than in previous decades. Nguyen Minh, a farmer from northern Vietnam, remarked: “The floods are worse than before. In the past, we could prepare, but now they come quickly, and the damage is severe. We have lost entire crops in some seasons.” Floods not only wash away crops but also destroy critical agricultural infrastructure such as irrigation systems and farm buildings, leaving farmers in financially precarious situations (Sandberg, 2010).

According to Luu, Von Meding, and Kanjanabootra (2017), floods in Vietnam are responsible for an average of 533 fatalities annually, underscoring their widespread human and economic costs. Flooding also exacerbates the problem of saturated soils, which can stunt crop growth and lead to poor harvests in the aftermath of a flood.

Impact on Pests and Diseases

In Ghana and Vietnam, variations in rainfall and temperature have also spread to agricultural illnesses and pests. Higher temperatures in Ghana have made it possible for pests like the autumn armyworm to multiply, destroying fields and harming crops like maize (Mlambo *et al.*, 2024). Increased pesticide spending has been recorded by Ghanaian farmers, significantly lowering their profit margins. Similar to this, fungal infections have spread over rice fields in Vietnam as a result of rising temperatures and increasing humidity. Sheath blight and rice blast are two diseases that flourish in warm, humid environments, which further reduces yields (Asibi, Chai, & Coulter, 2019).

Ghana and Vietnam's agriculture faces a number of interrelated issues as a result of climate change. Farmers are unable to generate consistent agricultural yields due to irregular rainfall, increasing temperatures, saltwater intrusion, and increased floods. Food security has already significantly decreased as a result of these challenges, particularly for smallholder farmers who lack the means to adjust (Ziervogel & Ericksen, 2010). How successfully governments, scientists, and farmers collaborate to create and execute climate-resilient plans will have a significant impact on the future of agriculture in these nations.

How is Climate Change Reducing Farm Productivity in Vietnam and Ghana?

Climate change has affected agricultural productivity in multiple ways, influencing not only crop yields but also the amount of time that farmers can work in the fields. Both Vietnam and Ghana are grappling with the impacts of extreme weather conditions, from excessive heat to increased labor migration, which complicate farmers' abilities to maintain productivity (Taylor, 2014).

Vietnam: Decreased Field Time Due to Extreme Heat

As a result of climate change, Vietnam is

experiencing rising temperatures, with several regions, particularly the Mekong Delta, frequently surpassing 35°C. This extreme heat has impacted how much time farmers can work outdoors, leading to shorter working hours and, ultimately, lower productivity (Lundgren, Kuklane, Gao, & Holm, 2013). During interviews with local farmers, many shared how difficult it is to keep up with their tasks in the face of rising temperatures. For instance, Hong Thi Tham, a farmer in the Mekong Delta, explained: "By noon, it is too hot to stay outside. We have to stop working early, and that means we get less done each day." Her experience is not unique; for many farmers, midday work has become almost unbearable, as temperatures around noon can peak at 40°C or higher.

This reduction in working hours has direct consequences for farm productivity. When farmers spend less time in their fields, there is less opportunity for tasks such as planting, weeding, and harvesting. In turn, the shortened work hours have a cascading effect on crop yields, leading to fewer products reaching the market and impacting food supply chains (Davis, Downs, & Gephart, 2020). Studies have shown that Vietnam's average time spent on farms has declined sharply since 2000, with a reduction rate of about 2% per annum (Anh *et al.*, 2023). This decline is not only due to extreme heat but also due to the rising attractiveness of non-farm jobs in urban areas.

In addition to shortened field hours, heat stress impacts the health of farmers themselves, leading to dehydration, heat exhaustion, and sometimes heatstroke. These conditions have contributed to a rising trend of farmers leaving agricultural work. The highest recorded temperature in Vietnam reached 44°C, and such extreme weather causes widespread physical exhaustion among farmers. As a result, many opt for non-farm occupations that are less physically taxing and less vulnerable to climate fluctuations (Lanjouw & Lanjouw, 2005). This shift away from farming not only reduces agricultural productivity but also creates labor shortages in rural areas, which further exacerbates the challenges for those who remain in the sector.

Ghana: Extreme Heat and Labor Migration's Impact on Farming

Ghanaian farmers face similar difficulties with heat, though the situation is compounded by labor migration trends. In rural Ghana, rising temperatures affect productivity by making it harder for farmers, especially older ones, to manage their fields without assistance (Antwi-Agyei & Nyantakyi-Frimpong, 2021). For example, Martha Nyarko, a 60-year-old cocoa farmer, described how the labor shortage has left her struggling: "My children have all moved to the city because farming does not pay well anymore. I am too old to work the farm alone, especially in this heat. I have to hire help, but it is not easy."

The migration of younger generations to urban centers leaves older farmers like Martha with limited support. Younger people are increasingly seeking work in non-farm sectors, where wages are higher and the working conditions are more predictable (Leavy & Hossain, 2014). This labor shift has resulted in a decline in agricultural productivity, as fewer people are left to manage the farms. Cocoa, a crucial export crop in Ghana, is heavily dependent on manual labor. Therefore, this labor shortage hampers farms' ability to achieve the yields they produced in previous years (Kissi & Herzig, 2023). Without enough hands to work the land, tasks such as pruning cocoa trees, clearing brush, and harvesting pods become unmanageable, further reducing productivity.

The impact of heat on labor in Ghana is exacerbated by limited access to modern tools and machinery, which would otherwise allow farmers to work more efficiently and with less physical strain. In contrast to Vietnam, where some mechanization exists, Ghanaian smallholder farmers often rely on manual labor for nearly all farm activities (Kansanga et al., 2018). Thus, when temperatures soar, the productivity of Ghana's farms plummets even further. As extreme heat becomes more common, farmers are forced to take longer breaks, which reduces the overall time

available for essential tasks (Tripathi & Mishra, 2017). Like in Vietnam, Ghana's highest temperatures are reaching unprecedented levels, sometimes exceeding 40°C, pushing farmers to limit their working hours and seek shelter during the hottest parts of the day.

The Broader Impact of Non-Farm Job Availability

Another significant factor contributing to the reduced time spent on farms in both Vietnam and Ghana is the rising availability of non-farm jobs (Do, Nguyen, Halkos, & Grote, 2022). In Vietnam, urbanization and the expansion of manufacturing industries in cities have provided alternative employment opportunities. Many rural workers, especially younger ones, are opting to leave the demanding work of agriculture in favor of more stable, less physically challenging jobs (Bryceson, 1996). These positions offer a steadier income and are not as directly impacted by climate-related issues, making them an appealing alternative to farming.

This shift to non-farm jobs has created a labor gap in agriculture, where only the older population, who are often less able to endure the physical demands of farming, remain in the sector. In Ghana, this issue is compounded by limited infrastructure and mechanization, as many small farms lack the necessary equipment to operate efficiently with fewer laborers (Ngeleza, Owusua, Jimah, & Kolavalli, 2024). As a result, the shortage of young workers in the agricultural sector impacts both productivity and food security, as there are fewer hands available to plant, maintain, and harvest crops.

Long-Term Consequences for Food Security and Livelihoods

Food security and rural livelihoods will be severely affected in the long run by Ghana and Vietnam's decreased agricultural yield as a result of climate change. Crop sales are the main source of income for rural communities in both nations. In addition to having an impact on farmers' earnings, declining productivity also reduces the amount of food available in local markets, driving increasing costs and putting consumers under financial duress (Christiaensen, Rutledge, & Taylor, 2020). This is particularly troublesome in Ghana, where labor shortages in the agriculture sector and climate constraints are contributing to an increase in food insecurity.

Both nations run the risk of losing the generations-old agricultural expertise that has been passed down as fewer people continue farming. If younger generations keep leaving rural regions, the knowledge and techniques that allow for successful farming in certain soil types and climates might be lost (Altieri & Nicholls, 2013). Future farmers may find it more challenging to handle the effects of climate change as a result of this knowledge gap.

Ghana and Vietnam's agricultural productivity and labor patterns have shifted due to climate change, making both countries susceptible to lower yields and food insecurity. Extreme heat and the migration of younger farmers to non-farm sectors are diminishing field time and straining those who remain. The farming industries in both nations may experience acute labor shortages if present trends continue, endangering both the general food supply and the welfare of rural populations (Calicioglu, Flammini, Bracco, Bellù, & Sims, 2019). To ensure a more resilient future for agriculture in Ghana and Vietnam, addressing these issues calls for an array of policy assistance, agricultural technology investment, and an emphasis on climate adaptation.

Adaptation Strategies of Farmers in Ghana and Vietnam Amidst Climate Change

Farmers in Vietnam and Ghana have been attempting to adapt their farming methods in response to the difficulties presented by climate change. However, the survival of traditional agricultural practices, limited access to modern technology, and budgetary constraints hinder these attempts (Altieri *et al.*, 2011). Many farmers are at risk from continuous environmental changes since adaptation has been delayed, despite that the effects of climate change are noticeable in

both nations (Khan & Akhtar, 2015).

Ghana: Shifts Toward Resilient Crops and Fertilizer Use

To better handle harsh weather conditions, smallholder farmers in Ghana are increasingly using crop types that are resistant to drought (Aniah, Kaunza-Nu-Dem, & Ayembilla, 2019). For example, because tree crops like cashew and mango are more tolerant of hot and dry periods, some farmers are moving away from basic crops like maize and cassava. Tree crops are a desirable alternative for farmers in the drier areas of the nation since they can withstand dry spells and yield a comparatively steady income. This change is not without difficulties, though. Many smallholders cannot afford the time and initial investment needed to switch from traditional crops to tree crops (Jerneck & Olsson, 2013).

While some farmers have started using fertilizers to improve soil fertility and boost yields, this alone has proven insufficient to counter the full impact of climate change. According to Efua Oko, a farmer from Ghana's Eastern Region, "We have started using fertilizers, but it is not enough. The yields are still lower than before, and we do not have the money to buy better equipment. If the government were to support us in acquiring better tools, I think we could improve our harvests."

Unfortunately, the use of hybrid seeds and mechanized equipment remains rare in Ghana. Only about 5% of farmers utilize hybrid seeds, and even fewer have access to agricultural machinery (Pauw, 2018). The lack of technological advancement is a significant factor behind the country's low productivity levels. This limitation makes Ghana's agriculture heavily reliant on traditional methods and rain-fed irrigation, which are increasingly vulnerable to unpredictable rainfall and extreme temperatures (Laube, Schraven, & Awo, 2011).

Vietnam: Technology Adoption in Urban and Specialized Farming

Vietnamese farmers are also grappling with climate impacts but have made some strides in adopting technology to improve agricultural resilience. For example, farmers in urban and peri-urban areas, especially those engaged in organic farming, have been more receptive to technological innovations (Follmann, Willkomm, & Dannenberg, 2021). Younger farmers are more open to adopting advanced techniques, such as precision farming, which allows them to use resources like water and fertilizer more efficiently (Tey & Brindal, 2012).

Nguyen Van Muoi, a coffee farmer from Vietnam's Central Highlands, shared her approach to coping with reduced rainfall: "We have installed drip irrigation to conserve water. It is expensive, but it is the only way we can keep the coffee plants alive." Although this method is more efficient than traditional irrigation systems, it is also costly, making it unattainable for many smallholders. Without financial support, most farmers, particularly in rural areas, continue to rely on traditional methods that are labor-intensive and less resilient to climate fluctuations.

Drip irrigation and other water-saving technologies are still rare in rural regions due to high upfront costs and limited access to financial services (Chathuranika, Khaniya, Neupane, Rustamjonovich, & Rathnayake, 2022). Nevertheless, those farmers who have managed to adopt these technologies have reported improved productivity and reduced water usage, highlighting the potential benefits if more farmers could afford them. A study by Nicolas, Nguyen, and Tuan (2021) found that technology adoption in Vietnamese agriculture is concentrated around urban areas where financial resources are more accessible. However, in rural areas, where over 60% of Vietnam's farmers reside, these advancements remain largely unavailable.

Financial Barriers: A Common Hurdle

Financial limitations continue to be a major obstacle in the adoption of resilient agriculture methods in both Ghana and Vietnam (Antwi-Agyei, Abalo, Dougill, & Baffour-Ata, 2021). Because of the perceived risks of climatic unpredictability, such as crop failure from

drought or flooding, banks are sometimes reluctant to lend to farmers. Smallholders find it difficult to acquire loans since, when they are available, the interest rates are frequently unaffordable. Farmers are less able to invest in essential adaptations like hybrid seeds, fertilizers, and automated tools due to high input prices and restricted finance availability.

According to a research by Karlan, Osei, Osei-Akoto, and Udry (2014), farmers are more inclined to engage in adaptable methods when they have access to weather insurance packages. For instance, insured farmers in Ghana and Vietnam are able to purchase better inputs, such as drought-resistant seeds, which increase their ability to resist the effects of climate change. Therefore, weather-indexed insurance may be a useful instrument for assisting farmers, offering them financial security, and promoting investments in climate-smart farming.

Limited Government Support and Policy Challenges

Because current agriculture policies have not yet adequately addressed the issues posed by climate change, government support has been limited in both nations. Additional research has to be undertaken to address other urgent concerns, such as irrigation or equipment subsidies; however, government actions in Ghana have concentrated on boosting fertilizer subsidies, which have helped some farmers increase their yields (Ragasa & Chapoto, 2017). In order to keep up with the increasing effects of climate change, farmers like Kosi Do have urged for further government support in obtaining new equipment.

Even though the Vietnamese government has implemented rules that promote sustainable practices, many rural farmers still lack access to financial help. Large-scale, high-tech agricultural projects are frequently the focus of the nation's policies, which typically favor wealthy farmers or agribusinesses over smallholders. Thus, despite government initiatives to promote new practices, small farmers still face challenges related to a lack of resources and assistance.

Climate change is changing agriculture in both Ghana and Vietnam, putting farmers under tremendous strain. Some have responded by implementing new technology like drip irrigation, using fertilizers, and moving to more tolerant crops (Reddy, 2014). However, the broad adoption of these methods is hampered by a lack of funding, restricted access to technology, and inadequate government backing.

Moving forward, a thorough strategy incorporating financial assistance, political backing, and technological accessibility is necessary. Agriculture's ability to adapt to climate change will rely on both farmers' willingness to do so and the support networks that enable them to do so (Azadi *et al.*, 2021). In order to preserve smallholder farmers' livelihoods and provide food security in these vulnerable areas, coordinated measures from the public and private sectors will be essential as climate change worsens.

Discussions and Conclusion

The results of this study highlight the significant effects of climate change on food security in Vietnam and Ghana, two emerging countries that heavily depend on agriculture. Sea level rise, unpredictable rainfall, rising temperatures, and extreme weather events like floods and droughts are changing agricultural productivity and lives in both nations (Praveen & Sharma, 2019). In order to educate stakeholders and promote climate-adaptive policy, the research identifies common issues, variations in vulnerability, and viable resilience-boosting tactics. Climate change and agricultural output are directly related in Ghana and Vietnam, with major ramifications for food security. Rising temperatures and more frequent droughts are the main threats to maize production in Ghana, while floods, sea level rise, and saltwater intrusion brought on by climate change pose serious concerns to rice farming in Vietnam. With its rain-fed agricultural system, Ghana is still quite susceptible to drought, which lowers farmer income and crop output (Kanchebe, Bonye, & Yiridomoh, 2022). In a country where a

sizable portion of the populace relies on subsistence farming, this dependence on rainfall and restricted access to sophisticated irrigation systems worsen food insecurity. Vietnamese farmers are equally challenged, though primarily by sea-level rise and saltwater intrusion, which degrade soil quality in the Mekong Delta—a key rice-producing region. Salinity reduces agricultural output by interfering with rice growth and contaminating freshwater supplies (Fahad *et al.*, 2019). Each nation has distinctive problems as a result of these geographic vulnerabilities, but they are also constrained in their ability to adapt quickly because of technical and financial barriers.

While the pace of adaptation remains slow, farmers in both nations have begun adjusting their practices to cope with climate impacts. Ghanaian farmers have started adopting drought-resistant crop varieties, like millet, which can tolerate arid conditions better than traditional staples such as maize. There is also a growing trend among Ghanaian farmers to diversify into tree crops, like cashew and mango, that are more resilient to climatic stressors (Asare-Nuamah, Antwi-Agyei, & Dick-Sagoe, 2022). However, lack of resources, limited access to technology, and insufficient support systems restrict the adoption of climate-smart practices like hybrid seeds, mechanized farming, and irrigation systems. In Vietnam, some progress has been made in introducing modern irrigation technologies, particularly among urban and specialized farms. Innovations like drip irrigation help mitigate the impacts of drought, yet they remain out of reach for most rural farmers due to high costs (Levidow et al., 2014). Financial support systems are scarce, and without affordable loans or insurance packages, smallholders are reluctant to invest in costly adaptive technology. Studies indicate that farmers with access to weather insurance are more likely to adopt climate-smart practices, underlining the potential of such financial instruments to support agricultural resilience.

Both countries could benefit from targeted governmental interventions. In Ghana, there is significant potential to improve food security by expanding irrigation infrastructure, especially in areas most affected by erratic rainfall (Atanga & Tankpa, 2021). Government support for hybrid seed varieties and mechanized farming could also help increase crop resilience to changing climate patterns. Additionally, establishing early warning systems and climate information services would enhance farmers' preparedness, providing timely updates on weather patterns to optimize planting and harvesting schedules. Vietnam's policy efforts have largely focused on encouraging sustainable practices in the agricultural sector. However, these initiatives are generally concentrated in high-tech agricultural zones, leaving small-scale farmers without adequate resources. By focusing more on rural farming communities, Vietnam could better support smallholders facing climate-related threats (Phuong, Biesbroek, Sen, & Wals, 2017). Implementing disaster risk management plans, enhancing early warning systems, and increasing investment in coastal protection measures could further protect the country's agriculture sector from rising sea levels and frequent floods.

To foster resilience against climate change, a multi-pronged strategy is needed. Policymakers in both countries should consider financial support for farmers by offering low-interest loans, subsidies for hybrid seeds, and weather-indexed insurance packages (Devereux, 2016). These resources will enable farmers to invest in resilient practices, thereby reducing vulnerability to climate impacts. Expanding access to irrigation systems in Ghana would significantly mitigate the impact of droughts. In Vietnam, investments in coastal defenses and soil salinity management are essential to protect arable land from sea-level rise and saltwater intrusion (Toan, 2014). Establishing community-based learning platforms can empower farmers to share knowledge and adopt practices like agroforestry, conservation agriculture, and precision farming. This approach could build capacity and enable local

solutions for climate resilience. Both countries can benefit from adopting successful climate adaptation models from other nations. Learning from countries with similar challenges, like Bangladesh's coastal protection strategies (Shariot-Ullah, 2024) or India's agroforestry programs (Puri & Nair, 2004), could enhance food security, reduce operation costs, and increase yields. The promotion of alternative, resilient crops, such as millet in Ghana, could help offset losses from climate-sensitive crops like maize. Diversifying crops based on climate suitability could enhance food security and reduce vulnerability to climate-related disruptions.

This study reveals that climate change seriously threatens food security in Ghana and Vietnam, but both countries possess unique opportunities for resilience. For Ghana, investing in irrigation infrastructure and alternative, drought-tolerant crops could reduce dependency on erratic rainfall, while in Vietnam, policies targeting flood control and salinity management are critical for maintaining rice production. The findings underscore the necessity of tailored strategies that account for each country's unique climate risks. By adopting climate-resilient practices, enhancing governmental support, and expanding access to financial tools, both Ghana and Vietnam can strengthen their agricultural sectors against climate-related challenges. Ultimately, collaborative efforts among governments, local communities, and international stakeholders will be essential to securing food security and supporting the livelihoods of millions in the face of climate change. The insights provided here highlight the urgent need for sustainable development measures. This research offers a framework for policymakers, farmers, and food consumers to take actionable steps in response to climate change, fostering resilience across diverse agricultural contexts and contributing to global food security.

Authors Contribution

Tri Tai Truong: Tri Tai is responsible for data acquisition in the studied area of Vietnam, creating the first draft, and editing the paper

Joel Selassie Nortey: Joel is responsible for data acquisition in the studied area of Ghana, methodology, and creating the first draft

Nguyen Thai Hung: Lecturer Hung supervises and provides feedback regarding the completion of the paper

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مقاله کوتاه

تأثیر تغییرات آب و هوایی بر امنیت غذایی در کشورهای با درآمد متوسط و کم: مطالعه موردی: غنا و ویتنام

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چکیده

تغییرات آب و هوایی، به‌عنوان یک معضل نگران‌کننده در سراسر جهان، تاثیر قابل‌توجهی بر کشاورزی داشته است. عامل اصلی این موضوع امنیت غذایی به‌ویژه در حوزه تولید و قیمت مواد غذایی است. این مطالعه چگونگی تاثیر تغییرات آب و هوایی بر امنیت غذایی در ویتنام و غنا را ارزیابی می‌کند، کشورهایی که کشاورزی در آن‌ها برای رشد اقتصادی- اجتماعی ضروری است. روش‌های اصلی مطالعه شامل تکنیک‌های قوم‌نگاری و مصاحبه‌های عمیق با ۵۰ کشاورز از هر کشور است؛ در مجموع ۱۰۰ کشاورز. نتایج نشان می‌دهد که تولیدات کشاورزی و سلامت دام در این مناطق به‌طور قابل‌توجهی تحت تاثیر افزایش دما و الگوهای بارندگی نامنظم است. کشاورزان ویتنامی عمدتا با سیل، افزایش سطح دریا و نفوذ آب شور مواجه هستند که تولید برنج در دلتای مکونگ را به خطر می‌اندازند، در حالی‌که کشاورزان غنا بیشتر تحت تاثیر خشکسالی هستند که میزان آب موجود برای کشاورزی دیم را محدود می‌کند. پایداری امنیت غذایی، مستلزم رعایت مواردی از جمله تناوب کاشت، استفاده از محصولات جایگزین و مقاوم و همچنین بهبود فناوری‌های کشاورزی برای مقابله با این خطرات است. نتایج این مطالعه ضرورت اقدامات تطبیقی مانند سیستم‌های آبیاری پیشرفته، بذرهای مقاوم به خشکی و سیستم‌های هشدار اولیه تغییرات شدید آب و هوایی را برجسته می‌کند. برای مقابله با آسیب‌های ناشی از تغییرات آب و هوایی، این نتایج می‌توانند به دولت‌ها، سهامداران کشاورزی و مصرف‌کنندگان کمک کنند تا سیاست‌ها و شیوه‌هایی را توسعه دهند که کیفیت و ثبات غذا را بهبود می‌بخشند.

واژه‌های کلیدی: امنیت غذایی، تغییرات آب و هوایی، غنا، کشاورزی، ویتنام

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