Comparative Assessment of Societal Resilience to Climate-Induced Stresses in Rural Agricultural Communities in Northern and Southern Ghana

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ABSTRACT

Climate change-induced disasters, such as droughts and floods, are increasingly contributing to the vulnerability of rural agricultural communities, especially in sub-Saharan African countries like Ghana. Rural communities characterised by low resilience capacities experience devastating economic, social, and ecological impacts from climate-induced disasters, which are becoming more frequent and intense. Using a case study approach, this paper investigated the effects of droughts and floods on the vulnerability and resilience of four rural agricultural communities in two districts in northern and southern Ghana. A mixed-methods research design approach was employed to collect qualitative and quantitative data from secondary and primary sources on the impacts of climate change on purposively selected communities, as well as to assess their vulnerability and resilience. Purposive and random sampling techniques were used to collect information from relevant stakeholder groups in the four communities, and the data were analysed with the SPSS version 21 package. A key finding of the paper is that the resilience capacity of local communities in the two districts to manage natural disasters and reduce vulnerability effectively is woefully inadequate. The challenges of the vulnerability-resilience dilemma faced by communities are identified, and appropriate solutions are recommended for strengthening their adaptation and coping capacities.

Keywords: Adaptation capacity, agricultural communities, coping capacity, droughts, floods, natural disaster, resilience, vulnerability.

INTRODUCTION AND BACKGROUND

The impacts of climate change on the lives and livelihoods of the global poor are becoming increasingly unbearable, especially for smallholder farmers in semi-arid areas (Diallo et al., 2014; Adger et al., 2018). Climate change-induced natural disasters are increasing, particularly in Sub-Saharan African (SSA) countries, such as Ghana. According to the FAO (2021), these disasters are occurring three times more frequently than they did 50 years ago. Their impacts include heatwaves, droughts, floods, hurricanes and wildfires, which are causing huge socioeconomic and environmental costs in many developing countries, especially in SSA countries (UNDRR, 2021). The impacts of these events are being exacerbated by poverty, unplanned and unregulated land use practices, urbanisation, weak environmental controls, a chronic failure to enforce building standards, and other development activities (AUC, 2008; IOM, 2017; IMF, 2019). As the frequency and intensity of natural disasters are projected to increase, so too are the socioeconomic and environmental costs (Brundtland Commission, 1987; Walker et al., 2011; IMF, 2019). Between 2010 and 2018, disasters from natural hazards in Sub-Saharan Africa resulted in 47,543 deaths, and those associated with technological hazards led to 15,173 deaths. In the same decade, 225,237 injuries have been attributed to disaster events. Of these, 210,861 injuries were caused by natural hazards, while 14,376 injuries resulted from technological hazards (UNDRR, 2021). The unanticipated July 2021 floods in Europe and China drew the world's attention to the devastating socioeconomic and ecological impacts that climate change-induced natural disasters can inflict on human society and the environment. The consequent loss of life and livelihood sources makes rural agricultural communities, in particular, more vulnerable to future climate-induced natural disasters, such as droughts and floods.

In Ghana, these disasters are becoming more frequent and intense (World Bank, 2021; Atanga and Tankpa; Okyere, Yacouba, and Gilgenbach, 2013). For example, between 2011 and 2020, Ghana experienced 49 natural disasters, including floods and storms that affected the country. In 2020, three events happened, but this surged to 27 events in 2017 (Sasu, 2022). While disasters, especially flooding, have led to seasonal stress among inhabitants, floods and droughts are key indicators of the impacts of climate change in Ghana (Dovie, 2010; Almoradie et al., 2020; Yin et al., 2021). The term ‘flood(s)’ and “flooding” are not interchangeable. Whereas the first usually refers to flood as a hazard or a general phenomenon**,** ‘flooding’ refers to the disastrous impact of floods. Regular floods are expected and generally welcomed in many parts of the world, as they provide fertile soil, abundant water, and a means of transportation. However, flooding at an unexpected scale (damaging flood) and with excessive frequency causes damage to life, livelihoods, and the environment (ADPC & UNDP, 2005). Flood disasters can also be better appreciated by comparing them to droughts. Flood often refers to the situation in which precipitation exceeds evaporation, causing water to remain on the ground at or above normal levels for extended periods, thus leading to damage to the earth's surface. Drought, on the other hand**,** occurs when precipitation levels are significantly below normal, causing severe hydrological imbalances that adversely affect land resource production systems (Gitay et al., 2002). Local interpretations of drought refer to more extended periods of dryness. During these situations, there is limited or no water; consequently, drought is also categorised into hydrological and agricultural drought to emphasise the damage it causes to biophysical resources (Dovie, 2010). Damages associated with floods in Ghana include loss of crops and arable lands, livestock, seed and grain banks, destruction of physical infrastructure such as buildings, bridges, and roads, as well as the breaching of dams. In the case of droughts, the fallout includes the drying of water resources, a reduction in groundwater levels, a decline in land cover and vegetation, and general land degradation.

Changing climatic conditions pose significant threats to agriculture and agricultural communities in Ghana. The sector’s heavy reliance on an increasingly erratic rainfall regime is a key threat to farm productivity and the livelihoods of many rural agrarian communities (Chemural et al., 2020). Climate change impacts are manifested by erratic rainfall; high and increasing temperatures; long dry spells, frequent droughts; ecosystem deterioration, and concomitant losses of arable land through desertification; outbreaks of crop and livestock pests and diseases; increase in postharvest losses; and, in the coastal areas, salinization of agricultural soils from sea level rise and tidal flooding that make land unproductive (World Bank, 2020). Land degradation and desertification in Ghana are more prevalent in the Guinea and Sudan Savannah zones, with aridity indices ranging from 0.60 for the Northern Region to 0.54 for the Upper East and West Regions (Dovie, 2010). Due to an erratic rainfall regime, most rural communities in Ghana are experiencing frequent and intense perennial disasters, such as drought and floods (Dovie, 2010). Other key environmental and socio-economic problems encountered in the two regions include deforestation, overgrazing, soil erosion, water pollution, inadequate access to potable water, poaching, and habitat degradation. From an economic perspective, vulnerability in a community may be caused by a significant natural disaster and always results in a loss of resources for the territorial system as a whole (Pesaro, 2018). On the other hand, social fragility is measured by variables that aim to capture issues related to human welfare, such as social integration, mental and physical health, at the individual, household, community, regional**,** and national levels (Ogie et al., 2019). Environmental vulnerability, on the other hand, relates to environmental degradation, settlement patterns, livelihood choices and behaviour that contribute to disaster risk, which**,** in turn**,** adversely affect human development and contribute to further environmental degradation (UNEP, 2021). Simultaneously adopting climate risk-sensitive solutions and building adequate resilience capacity tailored to the local context is an effective way to mitigate the fundamental challenges of climate change-induced disasters and the vulnerability of local communities.

Problem Statement, Objectives and Questions

Agricultural productivity is seriously affected by the impacts of climate change such as high and increasing temperatures; more extended periods of Harmattan (dry winds); the erratic rainfall patterns; shorter dry seasons; frequent droughts and floods; ecosystem deterioration, losses of arable land through desertification; outbreaks of crop and livestock pests and diseases; increasing postharvest losses; and, in coastal areas, increased salinization

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of agricultural soils due to sea level rise and tidal flooding that make the land unproductive (World Bank, 2020). Most municipalities and districts in the two case-studied regions are predominantly agricultural. Four rural agrarian communities in two different ecological zones (the Guinea Savanna and Forest Ecological Zones in the Upper West Region of northern Ghana, and the Western Region in southern Ghana, respectively) were case studies.

Objectives and Assumptions

The primary objective of this paper is to investigate the impact of climate change on agricultural productivity in rural communities and their associated vulnerability in Ghana. The sector's heavy reliance on an increasingly erratic rainfall regime is a key threat to agricultural productivity and the livelihoods of many rural agrarian communities. The specific objectives of the paper are the following:

a) To analyse climate change impacts and related natural disasters in four rural agricultural communities in the Lambussie District of the Upper West Region (UWR), and the Jomoro District of the Western Region (WR).

b) To examine the vulnerability of households in these four communities to the impacts of droughts and floods.

c) To analyse the resilience of the selected communities and their short-term coping and long-term adaptation strategies.

d) To recommend strategies and mechanisms for strengthening the resilience of the case-studied communities to manage future climate change-induced disasters effectively.

The key assumptions of the paper are the following: a) climate change impacts are significantly derailing the sustainable development process in the two case studied districts; b) under-investment in resilience building strategies in the districts is a major contributor to the decline in agricultural production, food and nutrition insecurity, and the vulnerability of the population; and c) a good grasp of the link between disaster risk management and adaptation to climate change impacts will enable rural communities to be better prepared to cope with and adapt to climate change-induced disasters such as drought and floods, and reduce vulnerability.

STUDY LOCATIONS, CONCEPTUAL FRAMEWORK AND METHODS

Study Locations

Ghana has a tropical climate characterised by distinct rainy and dry seasons. Evidence of a temperature increase in the country over the past decades has been established. Mean annual temperature has increased (reports range from +0.4 °C over 100 years to +1 °C over 50 years), with the most substantial increase between April and July (+0.27 °C per decade). The rate of increase has been more rapid in the northern part of the country than in the southern part (Ministry of Foreign Affairs of the Netherlands, 2018). Moreover, the number of 'hot days' and 'hot nights' has increased significantly in all seasons (by 13.2% and 20% respectively between 1960 and 2003), while the number of 'cold days' and 'cold nights' has decreased (by 3.3% and 5.1% respectively over the same period). Average annual temperature is projected to increase by between 1.7°C and 3.7°C by 2080, with northern inland areas experiencing the most significant impact (OECD, 2020). According to the World Bank (2020), climate change is apparent and widespread in Ghana. Temperatures have been increasing since the 1960s, and Ghana's current climate is the driest on record (since 1901). It is estimated that the impacts of climate change will worsen, particularly from March to June, as precipitation is projected to decrease by 4% annually by 2040. Temperature increases are expected to continue, particularly in the north, with projections of 1.4-4.2°C, and up to 90% of days exceeding 35°C by 2100. Rainfall in Ghana is often characterised by intense storms of short duration (with an average of 44 mm per day), heavy runoff, and erosion, especially at the beginning of the rainy season. Ghana is divided into different eco-climatic zones, characterised by specific climate, vegetation, and soils. The paper case studies two districts located in two contrasting ecological zones in Ghana. The Upper West Region (UWR) is located in the northern part of Ghana and falls within the Guinea Savannah Ecological Zone (GSEZ) and the Sudan Savannah Zone (SSZ). On the other hand, the Western Region is located in the southwestern part of the country and is characterised by an Equatorial Monsoon-type climate.

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The Guinea Savannah Ecological Zone

Northern Ghana's five regions are located in the Guinea Savannah Zone (GSZ), with the Western Region in the southwest characterised by an equatorial monsoon climate and evergreen forests. Data show that the GSZ's temperature increased by 27.5°C from 1961 to 2000, with a 1.0°C rise across Ghana, especially in the north. Projections suggest a 1.0 to 3.0 °c increase by the 2060s and up to 5.2 °C by the 2090s, with the fastest change in northern Ghana. The GSZ faces droughts, bushfires, and one rainy season from May to November, with annual rainfall of 992 mm in SSZ and 1115 mm in GSZ, less than the over 2000 mm in the southern evergreen forest zone. Farming is primarily traditional, lacking advanced practices, amidst the expanding desertification. The GSZ encompasses seven land types, primarily agricultural, characterised by fire-tolerant trees and grasses exceeding 1.5 m in height. Over 50% of the land is used for farmland or pasture, where crops such as maize, cassava, yams, rice, and vegetables are cultivated, with some areas also reserved for livestock grazing. Ecological resilience is measured by the disturbance of biodiversity and the potential for land recovery, considering changes in land use and shifts in species or soil composition.

Lambussie District, with Lambussie as its capital, is one of 11 districts in Ghana's Upper West Region, located in the north-west. It was established in 2007 from the Jirapa-Lambussie District, covering an area of 811.9 km². Bounded by Jirapa to the south, Sissala West to the east, Nandom to the west, and Burkina Faso to the north, it has a population of 51,654, with 48.4% males and 51.6% females. The district's age dependency ratio is 98, with 86.7% of the population residing in rural areas. Food insecurity is high due to reliance on rain-fed agriculture, climate vulnerability, limited resources, and poverty, threatening sustainable development. Droughts harm crops, livestock, and human health, reducing food security and increasing the risk of disease. Floods damage crops and disrupt livelihoods, while water scarcity, poor health, debt, and limited opportunities drive youth migration.

Equatorial Monsoon Climatic Zone

Jomoro District, located in Ghana's Western Region, falls within the Equatorial Monsoon Ecological Zone (EMEZ). It has a climate characterised by high rainfall, two distinct wet seasons, and high temperatures, making it ideal for tropical crops such as cassava, oil palm, and maize. The district experiences year-round rainfall, peaking between May and October, with approximately 1380 mm annually, and temperatures around 26 °C. Its population was 205,016 in 2010, expected to reach 270,222. The majority of the population resides in rural areas, where over 98% of settlements have fewer than 1,000 people. The study's locations are depicted in Figure 1.

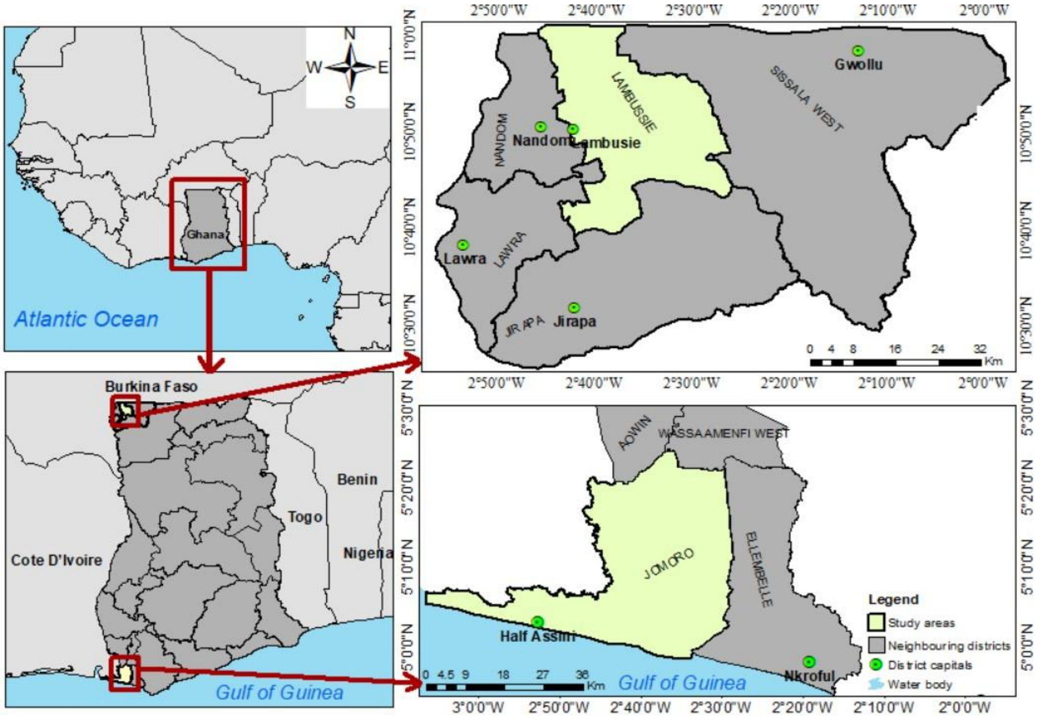

Figure 1: Map of Study Locations

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Conceptual Framework and Methods

Conceptual Framework

The conceptual framework principally consists of four interrelated elements: a) climate change-related risks (climate-induced stresses), b) vulnerabilities (context + inherent capacity to deal with disturbance), c) resilience outcomes, and d) recommendations for strengthening the coping and adaptation capacities of rural agricultural communities in Ghana. As illustrated in Figure 2, the concept of resilience comprises four main components: context, disturbance, capacity, and reaction. To improve comparative assessments of disaster resilience at the local or community level, Cutter et al. (2008) developed the Disaster Resilience of Place (DROP) model. However, the conceptual frameworks developed by DFID (2021) and Keating et al. (2017) are more recent and have been adapted to guide the preparation of this paper. This conceptual framework can guide smallholders in agricultural communities in Ghana in increasing productivity, incomes, and building adequate resilience to combat the extreme impacts of climate change and vulnerability (Lewis et al., 2018). Since the two case-studied districts rely on agriculture to improve livelihoods and food and nutrition security, climate risk-sensitive and innovative agricultural practices should be considered integral components of sustainable development strategies. The concept of resilience offers an opportunity to connect and, perhaps, coordinate information from different disciplines, which is seen as instrumental in practical sustainability science. Deploying the concept of resilience to respond to natural disasters implies building the ability to bounce back and return to normal despite the devastation and destruction that follow a disaster. This can occur at multiple levels: at the individual, the family, the community, and the city or nation. Unlike individual traumatic events, natural disasters have the propensity to act simultaneously on the individual, the family, and the community.

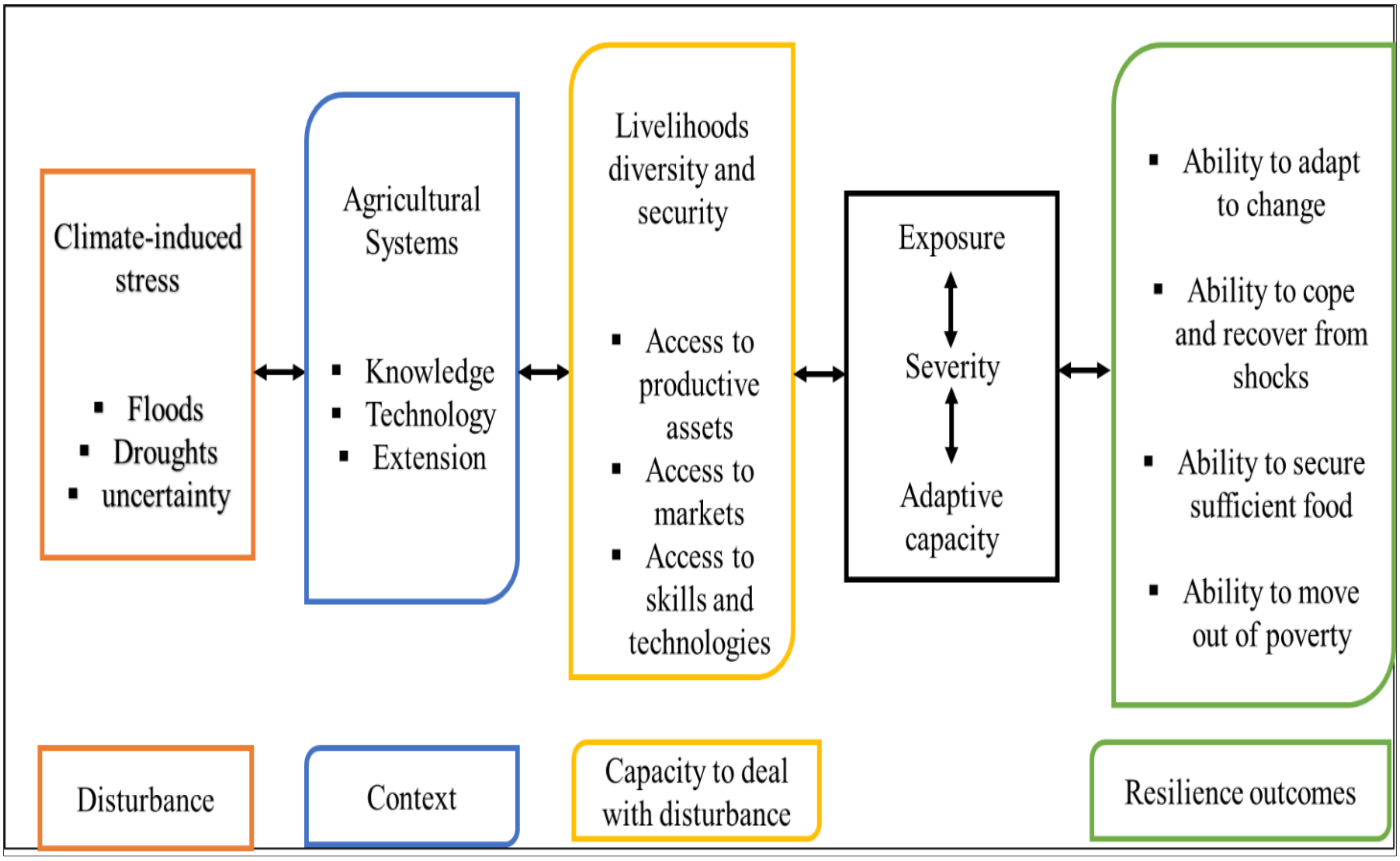

Figure 2: Conceptual Framework, Source: Adapted from DFID (2021) and Keating et al. (2017)

As illustrated in Figure 2, resilience refers to a dynamic process encompassing positive adaptation within the context of significant adversity. Resilience has been described as processes and patterns of positive adaptation in development during or following threats to adaptation. The concept has four common essential elements—

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context, disturbance, capacity, and reaction—which constitute the resilience framework. The context should always be clearly explained to permit a good understanding of its meaning. It can be studied in various contexts, such as within a social group, socio-economic or political system, a specific environmental context, an institution, a household, a community, or a district. The level of resilience of each of these systems to natural or artificial disasters may be different. In the case of the two study locations (Lambussie and Jomoro Districts), strengthening the resilience of the population also involves establishing the necessary resources and leadership structures to help cope with and recover from a natural disaster, such as drought, while maintaining key services and functions. To ensure the sustainability of the two districts, resilience must be prioritised, and vulnerability effectively reduced to enable the districts to cope with associated inevitable future climate-associated disasters such as droughts and floods. Low resilience forces the population to prioritise short-term, basic survival needs over long-term sustainability. The ability to spur renewal and develop innovative solutions in response to a shock is a critical aspect of developing resilience. Merely returning to “normal” does not strengthen resilience - it only consolidates it, which may not be enough with respect to long-term sustainability.

Methods

The paper employed multidisciplinary and participatory methods to identify and analyse the principal climate change impacts that male and female smallholder farmers experience, as well as the level of their vulnerability and adaptive capacities. A mixed-methods research design approach was employed to collect qualitative and quantitative data from secondary and primary sources on the impacts of climate change on four purposively selected communities in two contrasting ecological zones in northern and southern Ghana. Purposive and random sampling techniques were used to collect information from 150 stakeholder groups in the four communities, and the data were analysed using the SPSS version 21 package. Concrete recommendations are proposed for reducing the vulnerability of rural agricultural communities in the four surveyed communities, specifically those located in the targeted ecological zones, along with strategies to strengthen their resilience, adaptive capacities, and coping mechanisms.

A multi-disciplinary and participatory approach

Gößling-Reisemann et al. (2018) trace the evolution of resilience from disciplines such as physics, biology, and ecology, evolving into a multidisciplinary concept (Turner et al., 2003; Cutter et al., 2008; de Bruijne et al., 2010; Thorén, 2014a). Recently, it has expanded into human activities, such as disaster management (Holling, 1973; Thorén, 2014a). Some, including Brand and Jax (2007) and Strunz (2012), see resilience as heterogeneous, connecting natural and social sciences. Its prominence increased with COVID-19 and the July 2021 floods in Europe and China. Mattietto (2021) argues that COVID-19 highlights human impacts on ecosystems, affecting livelihoods, especially in SSA. Resilience describes the capacity of organisations, communities, or societies to recover from disasters (Moloney, 2021).

As shown in Figure 3, the concept involves a transdisciplinary approach to analysing social-ecological systems, such as droughts and floods affecting rural communities in Ghana (de Bruin et al., 2017). Its application spans various levels —individuals, organisations, technical components, and societies —and multiple disciplines, including engineering, ecology, economics, social sciences, and security, across policy fields such as security, development, and climate. The increasing frequency of natural disasters and terrorist threats emphasises resilience in terms of resistance and regenerative capacity, or 'survivability' for disaster management (Hannisch, 2016). The COVID-19 pandemic underscores the need for increased investment in pre-disaster risk reduction and preparedness for climate-related hazards, such as droughts and floods (Hannisch, 2016; Moloney, 2021; LSE, 2020). This paper employed multidisciplinary, participatory methods to analyse the impacts of climate change on smallholder farmers, their vulnerability, and adaptive capacities (see Figure 3). Structured interviews and Focus Group Discussions (FGDs) gathered data from diverse stakeholders, fostering a holistic understanding of natural disaster risks, their drivers, interactions, and impacts on households and communities in Lambussie and Jomoro Districts.

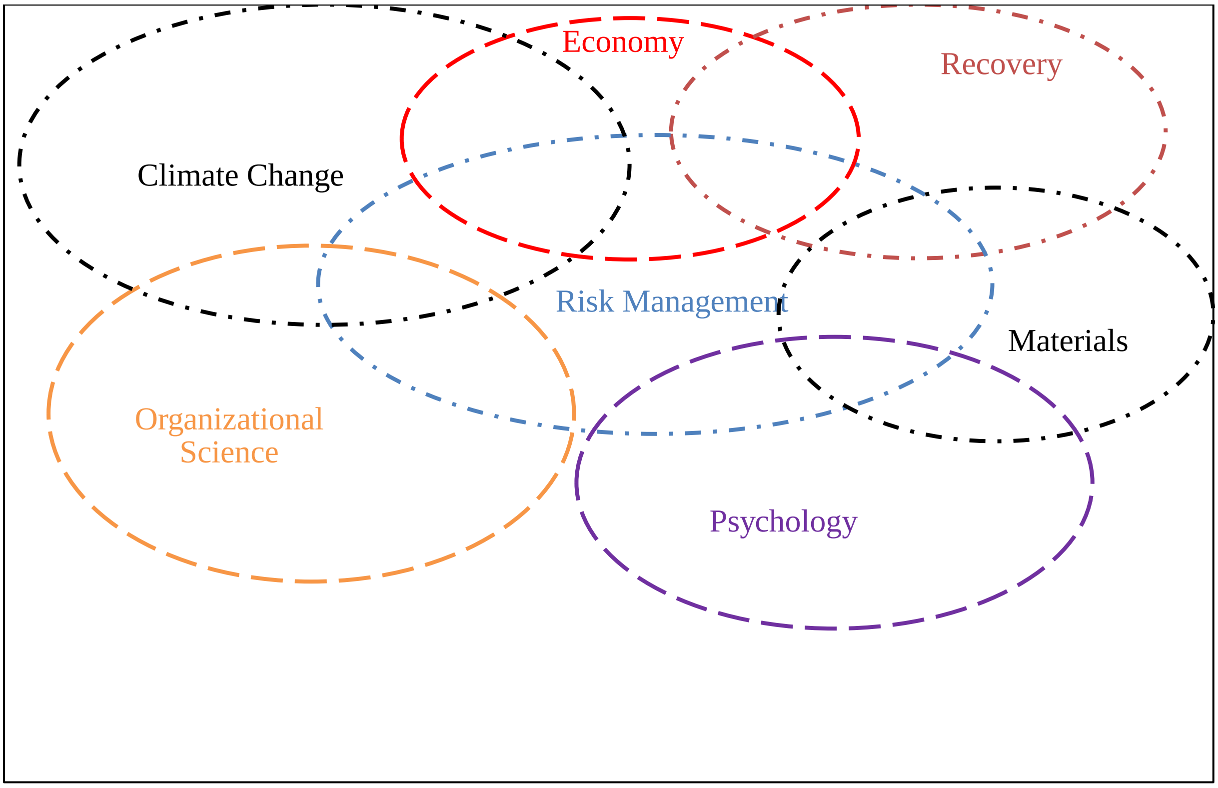

Figure 3: The multidisciplinary aspect of resilience; Source: Adapted from Reghezza-Zitt et al., 2021.

The methodology of this paper comprises a collection of methods and data analytical techniques. The first component is the use of a case study approach. As has already been mentioned, Lambussie District in the Upper West Region (UWR) and Jomoro District in the Western Region were purposively selected and case-studied, particularly because of the distinct differences in their socio-economic characteristics and contrasting contexts regarding climate change impacts and the vulnerability of their local communities. Yin (2014) posited that case study is the preferred design when trying to decide, a) "when", "how" or "why" questions are being asked in any given social research project; b) when the investigator has little control over events; and c) when the purpose is to examine specific contexts with a limited number of subjects (Yin, 2018). Lambussie District serves as the gateway to Burkina Faso and is predominantly characterised by rural agricultural communities that are totally dependent on an erratic seasonal rainfall regime. Poverty is endemic, and its dynamics are strongly influenced by seasonality and weather-dependent production systems. Smallholder farmers cultivate a variety of food crops, including grains (such as millet, sorghum, and maize), roots and tubers (like sweet potatoes and yams), and legumes (like groundnuts and beans). The farmers also actively engage in rearing livestock, including cattle and small ruminants. According to population data published by the Ghana Statistical Service (2021), the district's population is predominantly young people and women, which has implications for its sustainable development perspectives (Boon et al., 2022). Agriculture is also the backbone of the Jomoro District's economy, employing nearly 70% of the labour force. Major cultivated food crops include cassava and maize, while coconut and cocoa constitute the predominant cash crops. Very few people are engaged in animal husbandry, focusing on pigs, sheep, goats, cattle, and poultry. Agriculture is rain-fed chiefly and influenced by a seasonal rainfall regime.

The second aspect of the adopted methodology is the use of a mixed research design approach, which combines qualitative and quantitative methods. The decision to use this approach is based on its relevance and merit. For example, it provides a better explanation of a research problem and offers a better understanding of a phenomenon (Creswell, 2016). Patton (1990) also observed that this research design approach enables investigators to answer the research questions related to social phenomena with as little interruption of the natural settings as possible. A comprehensive desk search was conducted on the topic, and the findings informed the design of the field data collection instruments. Questionnaires and a structured interview guide were used to collect qualitative and quantitative information from representatives of relevant target groups, including policymakers, traditional rulers, landowners, smallholder farmers, farmer-based organisations, youth and women's groups, and non-governmental organisations, for analysis. Finally, focus group discussions (FGDs) were organised for representatives of the specified target groups to discuss the impacts of natural disasters on households in three local communities, the level of vulnerability, and the best strategies that should be deployed to build adequate resilience capacity. The qualitative information was subjected to content analysis, while the quantitative data were treated using correlation and regression techniques. The results are presented in the form of descriptive statistics and cross-tabulations, and discussed with respect to the research problem, objectives, questions, and the study's guiding conceptual framework.

LITERATURE REVIEW

Climate Change Impacts

Climate change impacts and natural disaster risks are a primary societal concern, threatening economic, social, and environmental stability at any time. Increasing disasters will cause lasting macroeconomic effects on vulnerable communities and regions (IMF, 2019). The IPCC (2018) highlights Sub-Saharan Africa and Southeast Asia as the most affected. Many are killed, properties destroyed, and weak sectors worsened (Carreño et al., 2017). Disasters can reduce global incomes and exacerbate income inequality, primarily through the agriculture and food systems (Burke et al., 2015; Hallegatte et al., 2016). People with low incomes are disproportionately affected by floods, droughts, and extreme temperatures. In Ghana, climate change is projected to raise temperatures by 1.7°C to 3.6°C by 2080, leading to increased disasters and pushing over 100 million people into extreme poverty by 2030 (OECD, 2021). Agriculture, vital for livelihoods and contributing about 20% of GDP and half the labour force in 2018, is especially vulnerable. It consists mainly of smallholder farms under 2 hectares, yet produces 80% of the output (OECD, 2021; Boon and Anuga, 2019).

Most smallholder farmers reside in rural areas, heavily relying on natural resources. Their inability to adapt to climate change disasters contributes to high poverty and vulnerability. People with low incomes are more affected due to their location in high-risk areas, low income, lack of savings, weaker social networks, few assets, and dependence on agriculture. They face higher income, asset losses, and mortality in disasters compared to the non-poor (UN-ESCAP, 2017; Hallegatte et al., 2016; Winsemius et al., 2015). Marginalised groups like women, minorities, migrants, and disabled people are disproportionately impacted (Cardona et al., 2012; FAO, 2019). Climate disasters are costly, requiring strategies to improve preparedness, minimise impacts, and accelerate recovery (Botzen et al., 2009; AfDB Group, 2016; IMF, 2019).

The IPCC (2018) states that a 1.5°C rise above pre-industrial levels will increase climate risks, especially in SSA countries like Ghana, acting as a poverty multiplier. Rising natural disasters threaten lives and development (FAO, 2019). Income inequality, regional disparities, and poverty make many in SSA vulnerable (IOM, 2017). Ghana's tropical climate has experienced a 1.0°C temperature rise since 1960, accompanied by a 2.4% decrease in rainfall, and is projected to increase by 1.7°C to 3.7°C by 2080 (OECD, 2020). Future precipitation is uncertain, with an increased likelihood of more extreme dry and wet periods, which risks all sectors, especially those affected by 80% of climate-related disasters (OECD, 2020; World Bank, 2020; Dovie, 2010). Extreme events, such as floods, droughts, and fires, threaten agriculture, water, health, and fisheries, destabilising food systems and incomes (OECD, 2021; Dovie, 2010; Holleman et al., 2020). Climate change worsens food insecurity, poverty, and rural vulnerability. The ACP-EU highlights the toll of SSA disasters on vulnerable populations, setting communities back years (UNDRR, 2021). This paper addresses these challenges and international goals, such as the Paris Agreement and the SDGs, advocating for integrated climate risk management. It focuses on environmental strategies to mitigate droughts and floods in rural Ghana.

Understanding the Concept of Resilience

Effective climate hazard management requires understanding the link between disaster risk frameworks and resilience-building programmes. Supporting resilience in impoverished rural communities enables them to leverage resources and withstand natural disasters. Resilience, a concept studied in fields such as physics, ecology, and psychology, remains ambiguous and subject to varying interpretations (Hussain, 2013). Much understanding stems from Holling's work on maintaining complex systems after disturbances. International agreements like the Hyogo Framework, SDGs, and the Paris Agreement endorse the concept. However, LSE

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(2020) notes it is often unclear what resilience means in policy or investment. This paper uses the UNISDR (2009) definition:

> *The ability of a system or community exposed to hazards to resist, absorb, adapt, and recover effectively while preserving essential structures and functions.*

A scientific concept of resilience implies the following: a) to specify the particular objects to which the concept refers; b) to decide whether particular states in nature are resilient or non-resilient; and c) to assess the degree of resilience of a particular state. Two significant developments regarding the concept are distinguishable. Firstly, it denotes 'returning to the reference state (or dynamic) after a temporary disturbance' (Grimm and Wissel, 1997: 325; Clark, 2008; Thorén, 2014) and secondly, it relates to the distinction between stability and resilience:

> *"Resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and persist. In this definition, resilience is the property of the system, and persistence or probability of extinction is the result (Holling, 1973: 17).*

On a normative basis, Brand and Jax (2007) regard the concept as follows:

> *"By resilience, we mean the capacity of linked social-ecological systems to absorb recurrent disturbances such as hurricanes or floods to retain essential structures, processes, and feedback. Resilience reflects the degree to which a complex adaptive system is capable of self-organisation (versus lack of organisation or organisation forced by external factors) and the degree to which the system can build capacity for learning and adaptation". (Adger et al., 2005, 1036)*

Folke et al. (2002: 438) also described the concept thus:

> *"Resilience, for social-ecological systems, is related to (i) the magnitude of shock that the system can absorb and remain within a given state; (ii) the degree to which the system is capable of self-organisation; and (iii) the degree to which the system can build capacity for learning and adaptation."*

Clearly, resilience may be regarded as the process of effectively negotiating, adapting to, or managing significant sources of stress or trauma. Assets and resources within the individual, as well as their life and environment, facilitate this capacity for adaptation and 'bouncing back' in the face of adversity. However, according to Windle (2017), the experience of resilience may vary from community to community and over time, as witnessed in the arguments seen below:

> *"The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, and recover from the effects of a hazard in a timely and efficient manner."*

For the United Nations International Strategy for Disaster Reduction, resilience is:

> *"The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change", while the Intergovernmental Panel on Climate Change regards it as "The capacity of a system to absorb disturbance and reorganise while changing." (DFID, 2011)*

Keating et al. (2017:78) regard disaster resilience as:

> *"…the ability of a system, community, or society to pursue its social, ecological, and economic development and growth objectives, while managing its disaster risk over time in a mutually reinforcing way."*

Holling (1973) introduced the concept of resilience as the time it takes for a system to return to equilibrium after a natural disaster. Still, it has since expanded to include social change dimensions. Resilient systems are less vulnerable than non-resilient ones (Walker et al., 2004; Gallopín, 2006). Resilience relates to a system's persistence, while vulnerability involves transformation (Gallopín, 2006). Resilience often stems from vulnerability, used in poverty analysis to indicate limited response ability (Adger, 2006). Folke (2006) distinguished between initial resilience focused on robustness and later notions emphasising disturbance, reorganisation, transformability, learning, and innovation (social-ecological resilience). Folke et al. (2021) broadened the concept of resilience as a system's capacity to adapt and develop in the face of change, utilising shocks such as financial crises or climate change as opportunities for renewal and innovation. Resilience is a dynamic process of adapting positively in the face of adversity. Brand and Jax (2007) identified two types of resilience: a precise ecological concept and a vague, cross-disciplinary communication tool. Thorén (2014) traced resilience to local and global forms. Essential resilience requirements include exposure to significant adversity, access to resources to mitigate its effects, and the ability to adapt positively or avoid adverse outcomes.

Community Resilience to Natural Disasters and Vulnerability Risks

One of the resilience concepts from Holling's work is "community resilience," which is a community's ability to handle disasters (Holling, 1973; Klein et al., 2003; Bruneau et al., 2006; Wamsler, 2007). A recovered community may still have components vulnerable to hazards. In resilience thinking, a community is a social system embedded in an ecological system (Blackshaw, 2010). Resilience goes beyond just recovery or "bouncing back. " Berkes and Ross (2013, p. 6) define community resilience as the capacity of its social system to unite for a common goal. A resilient community has enough physical and social capacity for self-organisation amid environmental changes (De Bruijn, 2005; Cutter et al., 2008; Firth et al., 2011). Its ability to reduce vulnerability includes adjusting to or resisting disruptions, dealing with damage, seizing opportunities, and coping with changes (Gallopín, 2006).

Community resilience refers to a group's ability to cope with change and crises by learning from shocks, monitoring social and ecological factors, and diversifying its sources of livelihood. A lack of resilience threatens vulnerable groups, leading to slow community decline if they are repeatedly exposed to shocks. Strong resilience helps communities withstand shocks, recover quickly, and reduce costs (De Moel et al., 2015; Moloney, 2021; De Sousa et al., 2017). It is vital for both immediate impact mitigation and long-term sustainability, as preventing slow decline hampers future development. Resilience enables proactive, sustainable actions (Moloney, 2021). Events like COVID-19 underscore the importance of managing physical, natural, social, and human capital collectively to build a resilient society, as focusing on one aspect can leave others vulnerable. Community resilience is assessed across ecological, engineering, and socio-economic aspects (Berkes et al., 2003).

The Vulnerability - Resilience Nexus

Vulnerability and resilience are crucial for mitigating risks and enhancing livelihoods in rural communities (Janssen and Ostrom, 2006; Cutter, 2010; Papathoma-Köhle, 2019). Although related, they have ambivalent attributes. Pachauri et al. (2014) define vulnerability to climate change as a system's susceptibility or inability to cope with the effects of climate change, including variability and extremes. Vulnerability depends on exposure, sensitivity, and adaptive capacity, linked to income and food access. It is context-specific, influenced by social and ecological changes (Eakin and Luers, 2006; Gunderson and Holling, 2002), with socio-economic factors such as ethnicity, class, and inequality affecting the vulnerability of farming households (Vásquez-León et al., 2003; Vermuelen et al., 2011).

Exposure, sensitivity, and response capacity shape vulnerability. Exposure refers to the extent of contact with a threat (Gallopín, 2006, p. 296), while sensitivity represents the degree to which a system is affected by disturbances (Gallopín, 2006, p. 295). Community vulnerability depends on resilience levels. Recurrent disasters hinder medium-term growth, resulting in significant social costs, including loss of life, worsened food insecurity, and damage to human capital, particularly affecting those experiencing poverty who lack resilience (IMF, 2019). Resilience, defined by Carreño et al. (2017), is a system's ability to adapt, respond, and recover from impacts. Reducing disaster risk requires preventive, mitigation, and adaptation measures (Hallegate, 2008; Epple et al., 2016). FAO (2021) emphasises the importance of investing in resilience and disaster risk reduction. Resilience and disaster management capacity determine preparedness and response to climate change and disasters (IOM, 2017).

Ecological and Engineering Resilience

Ecological resilience is the process of environmental reorganisation after a disturbance caused by internal and external forces affecting populations, communities, and ecosystems (Pickett and Roger, 1995). Developmentally, changes in environmental structure alter living conditions and economic opportunities (Walker and Willig, 1999). The severity and duration of disturbances affect communities differently, despite shared adaptive features. Ecological resilience is closely related to social resilience, which refers to a community's ability to cope with stresses arising from social, political, and environmental changes. For environmental disasters, it relates to the extent to which social and ecological processes can be disturbed without losing their complexity, rather than how quickly they recover (Windle, 2017).

Socio-economic Resilience

Adger (2006) describes social resilience as the capacity of social systems to handle and withstand shocks from environmental, economic, or political sources affecting their organisation and infrastructure. Socio-economic resilience emphasises climate-smart agricultural policies (Adger, 2000; Andah et al., 2003). A broader socio-ecological view includes learning, reorganisation, innovation, and transformability (Folke, 2006). Key measures of socio-economic resilience include household livelihoods, land tenure, labour, employment, and access to social services. Wily and Hammond (2001) highlight Ghana's lack of coherent land-use policy as a significant resilience barrier.

Strategies for Building Community Resilience

Generally, resilience has three features: coping capacities, which involve reacting quickly and flexibly to disruptions; adaptive capacities, which refer to proactive, long-term adjustments of structures, processes, or behaviours based on lessons from past crises and anticipating future risks. These adaptations aim to reduce harm rather than prevent crises outright. For natural disasters, this might mean emphasising citizen and private sector roles in crisis management, promoting civic participation and self-help, especially at the local level. Since disasters can't be fully predicted or prevented, and district capacities are limited, active community and private sector involvement is essential.

To effectively address complex global challenges, it is crucial to understand how to manage interconnected risks (McCarthy et al., 2001; Mastens and Obradovic, 2008). Today's climate decisions shape future risks, and ignoring them can lead to costly lock-ins, especially in infrastructure, housing, or community development that affects current and future generations (UNDRR and ACP, 2021). Once built, it is challenging to make changes, so neglecting future risks only leads to short-term gains. FAO (2019) and other organisations, such as UNDRR (2020), recommend an integrated approach to mitigate climate impacts and boost resilience.

Coping and Adaptive Capacity

Many writers distinguish 'adaptive capacity' and 'coping capacity' as long-term and short-term adjustments to socio-ecological systems (Smit and Wandel, 2006; Gallopín, 2006; Abdul-Razak & Kruse, 2017). Strengthening community resilience is a key transformational strategy for future risk management and reducing rural vulnerability (Keating et al., 2017; Carreño et al., 2017; ACP, 2021). Coping and adaptation strategies form a holistic approach that communities and organisations use to lower vulnerability and sustainably improve livelihoods. Adaptation strategies can be either short-term or long-term (IOM, 2017). Coping strategies include self-help, household solidarity, and informal networks based on neighbourhood, kinship, religion, and social ties. Local communities' knowledge of disaster prediction and preparedness is often profound, enabling more effective interventions. A system's adaptive capacity depends on a range of interconnected factors (McCarthy et al., 2001).

Adaptive capacity is linked to the vulnerability of socio-ecological systems (Pretari, 2019). The IPCC defines it as ''the ability of systems, institutions, humans, and other organisms to adjust, take advantage of opportunities, or respond to damage" (Pachauri et al., 2014, p.118). It reflects a community's ability to demand, access, and utilise climate and other information to identify, assess, and select adaptation options, innovate, and make informed decisions to adapt to climate change. Community resilience varies from place-based resilience in socio-ecological thinking to people-based resilience that's enhanced through nurturing a sense of place. Assets available to communities for improving livelihoods and managing risks are crucial for strengthening adaptive capacity (Dazé, 2013). Governance and entitlements influence capacity by either supporting or constraining reactions to disasters, particularly considering gender differences, as men and women have distinct societal roles (Akter et al., 2011). This results in unequal access to information, resources, and decision-making power (Dazé, 2013).

Adger et al. (2007) identify two main dimensions of adaptive capacity: generic and impact-specific. The former addresses general responses to climate change, while the latter pertains to specific stimuli. Schneiderbauer et al. (2013) added a sector-specific dimension, evaluating the capacity of economic sectors within regions to adapt. Key determinants include economic development, education, technology, infrastructure, institutions, equity, and social capital, which influence capacity both internally and externally (Adger et al., 2007; Jones et al., 2010; Kruse et al., 2013; Brooks and Adger, 2005). Locally, adaptation capacity is affected by managerial ability, resources, infrastructure, institutional environment, political influence, and networks (Smit and Wandel, 2006). Community-based strategies are crucial for strengthening rural resilience to climate risks (Berkes and Ross, 2013; Ross and Berkes, 2014), involving stakeholders such as youth, women, farmers, and community leaders. These programmes should align with regional and national efforts —a practice known as community-based disaster risk management (CBDRM) by UNDRR (2020). Building resilience requires addressing social exclusion, poverty, and vulnerability, which influence susceptibility to shocks. Poverty reduction, technology, and policies promoting climate-smart agriculture and adaptive governance are essential for mitigating climate-related disasters (Sabates-Wheeler et al., 2008; Folke, 2006; Boyd, 2008; Alexandratos and Bruinsma, 2012).

Social protection programmes aimed at reducing climate-induced disasters like droughts and floods must include policies that target: a) decreasing poverty and reliance on negative coping strategies; b) creating climate-resilient livelihoods; and c) supporting inclusive disaster responses. Victims should be involved in decision-making to reduce their vulnerability, enhance their capacity to handle climate shocks, and promote climate-resilient, sustainable livelihoods through incentives, training, and access to resources.

Disaster risk reduction strategies must consider local development challenges and adapt to national contexts (IOM, 2017). A holistic approach prevents silo thinking, essential for natural disaster resilience. Effective climate change adaptation requires an understanding of local scientific knowledge, which can be integrated into modern agricultural policies, such as the use of innovative technologies (Boakye-Danquah et al., 2014). Ignoring local vulnerabilities overlooks indigenous knowledge that helps respond to climate and non-climatic disaster drivers. Combining indigenous knowledge with modern communication tools can enhance disaster response and management. Since disasters often stem from vulnerable livelihoods, disaster management should focus on addressing these vulnerabilities to lessen disaster impacts (Dovie, 2010).

The Centrality of the Five Capitals

Real resilience requires a strategy that encompasses five types of capital: social, human, technological, physical, and economic, with additional types such as financial, environmental, natural, and political also being important. A system's resilience depends on its sensitivity and capacity to adapt, requiring active involvement from all community and organisation members. Resilience involves radical transformation, especially in social resilience, where societies undergo profound and rapid change due to threats such as climate change and pandemics like COVID-19. Climate change can lead to population shifts and environmental refugees (Boon and Le Tra, 2007). Adopting a resilience mindset and providing post-disaster support helps reduce vulnerability to natural disasters, such as floods and droughts, in Ghana. Communities need both short-term emergency and long-term strategies to build resilience against climate-related disasters.

RESULTS AND DISCUSSION

Socio-demographic Characteristics of Survey Respondents

One hundred fifty (150) respondents participated in the field survey, with 61% of them being male and 39% being female (Figure 4). The majority (60%) of the survey respondents were middle-aged adults, followed by adults

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aged 35 and below. This indicates that middle-aged and older adults predominantly practise smallholder farming. A small number (3%) of the respondents were widowed, 6% were divorced or separated, and 10% had never married. The majority of the respondents (81%) were married, and 60% had at least a basic education, while 30% had no formal education (see Figure 4).

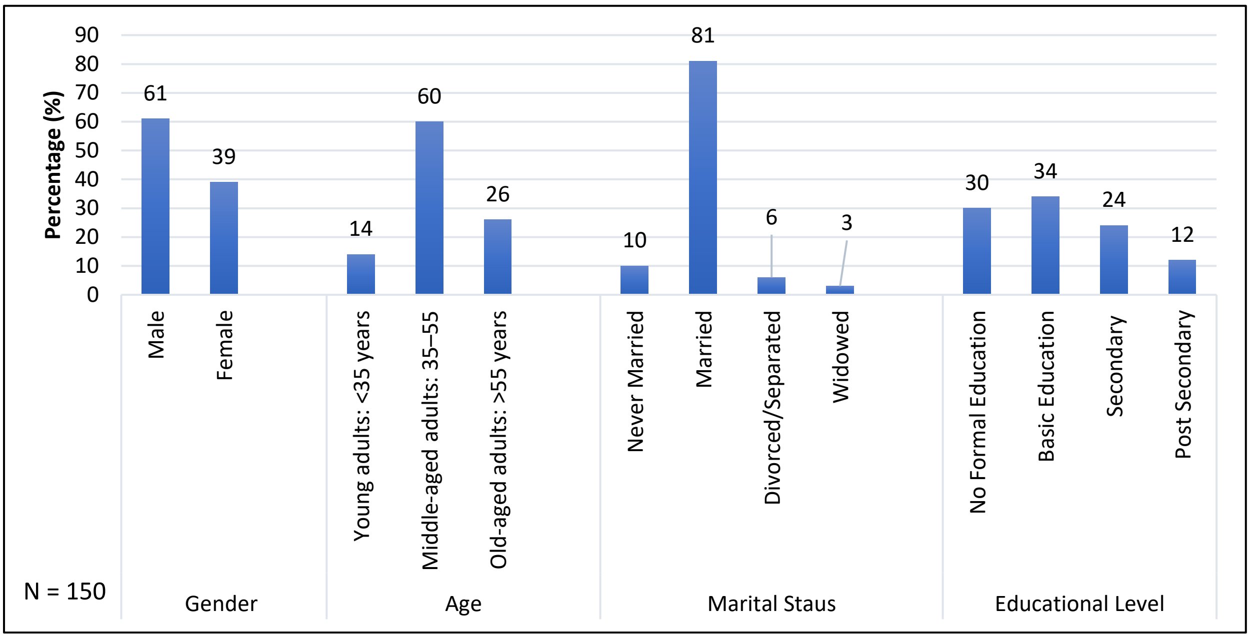

Figure 4. Sociodemographic characteristics of survey respondents

Perceptions of Climate Change-Induced Disasters

The significant climate change-related disasters experienced in the four surveyed communities were a primary target of the investigation. Drought was viewed as a major climate change-driven disaster by 99% of respondents from the Lambussie District and 94% from Jomoro (Figure 5). Most of the respondents (61%) agreed that the green spaces in their neighbourhood were of good quality. Wildfires were viewed by 72% of the respondents in Lambussie as a major climate-related disaster. However, the majority (97%) of the respondents in Jomoro did not consider this phenomenon to be a major climate change-induced disaster in their communities. Regarding windstorms, only 42% of respondents from Lambussie considered them a major climate change-related disaster. Less than 10% of the respondents from both Lambussie and Jomoro districts viewed flooding as a major climate change-related disaster in their communities (see Figure 5).

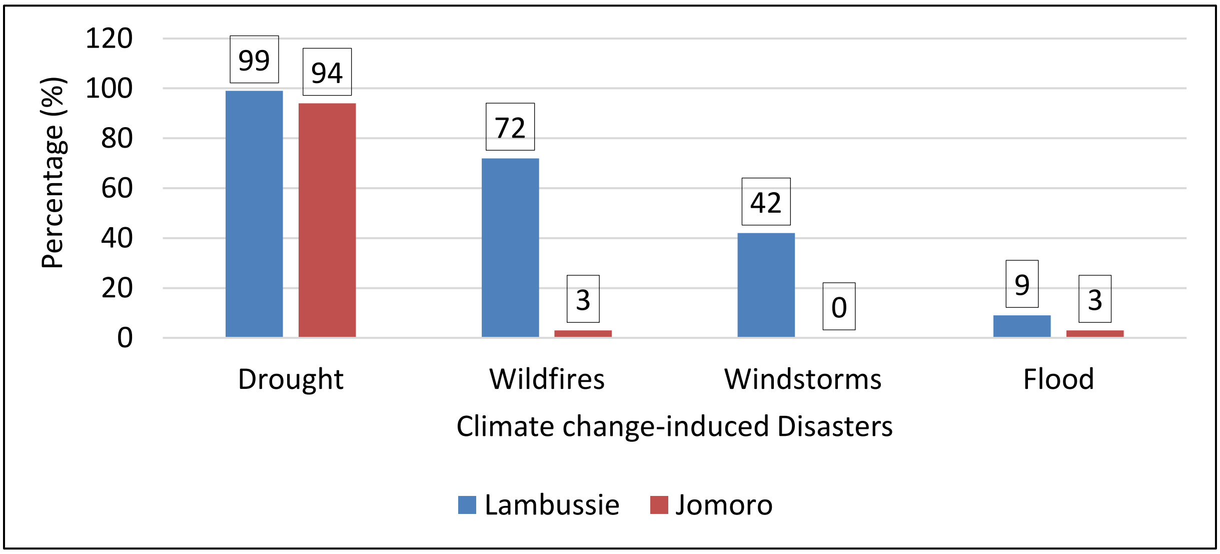

Figure 5: Major climate Change-Driven Disasters Experienced in Lambussie and Jomoro districts

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Regarding the question of whether drought is one of the most extreme climate-related disasters in their communities, over 90% of respondents in both Jomoro and Lambussie districts agreed (Table 1). The majority of the respondents from Lambussie (91%) and Karni (67%) further indicated that wildfires constitute the most extreme climate-related events in their communities. Unlike the occurrence of floods and windstorms, the majority of respondents from the Egbazo and Metika communities in the Jomoro district did not consider wildfires to be a significant climate change-related event (see Table 1). Windstorms were regarded as one of the extreme climate change disasters by 97% of the respondents from Lambussie. Like Egbazo and Metika, the majority of the respondents from Lambussie (62%) did not agree that floods are the most threatened extreme climate change event in their communities. Regarding exposure to floods, while respondents from the Jomoro district affirmed that their communities are more exposed, those from the Lambussie district considered exposure to drought, wildfires, and windstorms more destructive in their communities.

Table 1: Respondent Perceptions of the most exposed climate-related event in their community

Variable	**Flood is the most threatened extreme climate-related event**		
	% Agree	% Neither Agree nor Disagree	% Disagree
Community			
Egbazo	13	0	87
Metika	36	0	64
Lambussie	35	3	62
Karni	47	6	47
	Drought is the most threatened extreme climate-related event.		
	% Agree	% Neither Agree nor Disagree	% Disagree
Community			
Egbazo	94	0	6
Metika	96	0	4
Lambussie	100	0	0
Karni	95	0	5
	Wildfire is the most threatened extreme climate-related event.		
	% Agree	% Neither Agree nor Disagree	% Disagree
Community			
Egbazo	0	0	100
Metika	11	0	89
Lambussie	91	6	3
Karni	67	3	30
	Windstorms are the most threatened extreme climate-related events.		
	% Agree	% Neither Agree nor Disagree	% Disagree
Community			
Egbazo	6	0	94
Metika	4	0	96
Lambussie	97	3	0
Karni	47	19	34

Perceived Impacts of Climate Change-Related Disasters

The impacts of climate-related disasters experienced by the four surveyed communities in Jomoro and Lambussie districts over the past 15 to 30 years were a key aspect of the investigation (see Table 2). The results of the data analysis clearly indicate that most respondents (85%) from Lambussie identified psychological stress as a problem. In comparison, only 9% of the respondents from Jomoro reported that this had not been experienced in

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their communities over the past 15 to 30 years. More than 80% of respondents from both Jomoro and Lambussie districts reported that climate change-induced disasters had occurred in their communities, resulting in a reduction in farm yields over the past 15–30 years. A similar trend of responses was observed for the impact of climate change-induced disasters on household income during the period (Table 2). In terms of the impact of climate change-induced disasters on respondents' dwelling units, 57% of respondents from the Lambussie district reported that their houses had been severely damaged over the last 15-30 years. In the case of the Jomoro district, only 31% of the respondents reported that the occurrence of climate-related disasters has impacted their dwelling units.

The occurrence of heat spells in recent times, compared to 15-30 years ago, was another element of the research; 98% and 93% of the respondents from Jomoro and Lambussie districts, respectively, affirmed the occurrence of this phenomenon. While chronic diseases attributed to climate change were regarded by the majority (75%) of respondents from the Lambussie district, as indicated by their occurrence, 91% of respondents from Jomoro did not experience this phenomenon. In Jomoro district, the majority (75%) of the respondents estimated that they have lost less than GHC1,000.00 (US$100.00) due to climate change-induced disasters during the past 15-30 years whiles about 56% of the respondents from Lambussie district estimated that they have lost more than GHC1,000.00 (US$100.00) as a result of climate change-induced disasters during the past 15-30 years (Table 2). We also explored the impacts of climate change-related disasters on livestock owned by the respondents; 97% of the respondents from Jomoro and 72% from Lambussie reported that fewer than 11 livestock were lost due to these disasters. Only one respondent from the Lambussie district mentioned the demise of a family member during the last 15 to 30 years because of the occurrence of climate change-induced disasters.

Table 2: Impacts of Climate Change-Related Disasters Experienced during the last 15-30 years by the Surveyed Districts

Variable		Study Districts	
	Level of Agreement	Jomoro	Lambussie
I have suffered from psychological stress due to climate change-induced disasters experienced in this community during the last 15-30 years	% Agree	9	85
	% Neither agree nor disagree	0	0
	% Disagree	91	15
	Level of Agreement		
Climate change-induced disasters experienced in this community have resulted in a reduction of my farm yields in the last 15-30 years	% Agree	88	89
	% Neither agree nor disagree	2	1
	% Disagree	10	10
	Level of Agreement		
Climate change-induced disasters experienced in this community during the last 15-30 years have led to a significant reduction in my household income	% Agree	82	98
	% Neither agree nor disagree	0	1
	% Disagree	18	1

	Level of Agreement		
Your house has been severely damaged by the occurrence of climate change-induced disasters over the last 15-30 years	% Agree	31	57
	% Neither agree nor disagree	0	4
	% Disagree	69	39
You experience more heat spells due to the occurrence of climate change-induced disasters in recent times compared to 15-30 years ago.	Level of Agreement		
	% Agree	98	93
	% Neither agree nor disagree	0	0
	% Disagree	2	7
You experience chronic disease due to the occurrence of climate change-induced disasters in recent times, compared to 15-30 years ago.	Level of Agreement		
	% Agree	9	75
	% Neither agree nor disagree	0	6
	% Disagree	91	19
The estimated amount of money (in GHC) lost because of Climate change-induced disasters experienced by your community during the last 15-30 years.	Estimated Amount of Money Lost		
	Less than GHC 1001	78	34
	Between GHC 1001-2000	6	22
	Between GHC 2001-3000	2	6
	Between GHC 3001-4000	3	6
	More than GHC 4000	11	32
The estimated number of livestock lost because of climate change-induced disasters experienced during the last 15-30 years.	Estimated Number of Livestock Lost		
	Less than 11	97	72
	Between 11-20	0	13
	Between 21-30	0	4
	Between 31-40	0	4
	More than 40	3	7

Vulnerability and Resilience Levels

The results of the analysis on climate change vulnerability and resilience at the district and community levels are presented in Figures 6-8. As Figure 6 indicates, 63% of the respondents from the vulnerable and highly vulnerable groups in the Lambussie district were slightly higher than those from the Jomoro district (60%). This was reflected in the level of resilience as a higher proportion (64%) of the respondents from Jomoro were either resilient or more resilient to the impacts of climate change-related disasters than those from the Lambussie district (51%) (See Figure 6b). A nonparametric Pearson chi-square test of independence showed a significant difference in the distribution of vulnerability (X^2= 7.164, p-value = 0.028, Cramer's V = 0.231) and resilience levels (X^2= 12.328, p-value = 0.002, Cramer's V = 0.303) across the two study districts.

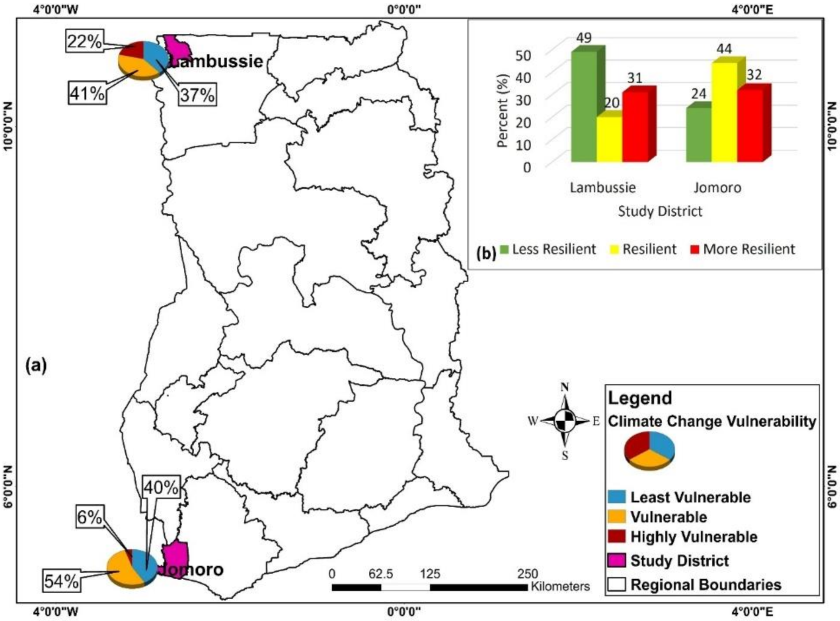

Figure 6: Map showing the distribution of (a) climate change vulnerability and (b) climate change resilience across study areas (Lambussie and Jomoro)

Community differences in climate change vulnerability (X^2= 14.108, p-value = 0.028, Cramer's V = 0.229) and resilience (X^2= 24.380; p-value = 0.000; Cramer's V = 0.302) were also observed. As shown in Figure 7a, 50% of the respondents from Lambussie were either vulnerable or highly vulnerable to the impacts of climate change-related disasters. In comparison, 78% of the respondents from Karni were either vulnerable or highly vulnerable. In the case of the two communities surveyed in the Jomoro district, 54% of the respondents from Metika were either vulnerable or highly vulnerable to the impacts of climate-related disasters. In contrast, 64% of the respondents from Egbazo were either vulnerable or highly vulnerable (Figure 8a). Figure 7b and 8b show the resilience levels of the respondents from the communities in the Lambussie district and Jomoro districts, respectively.

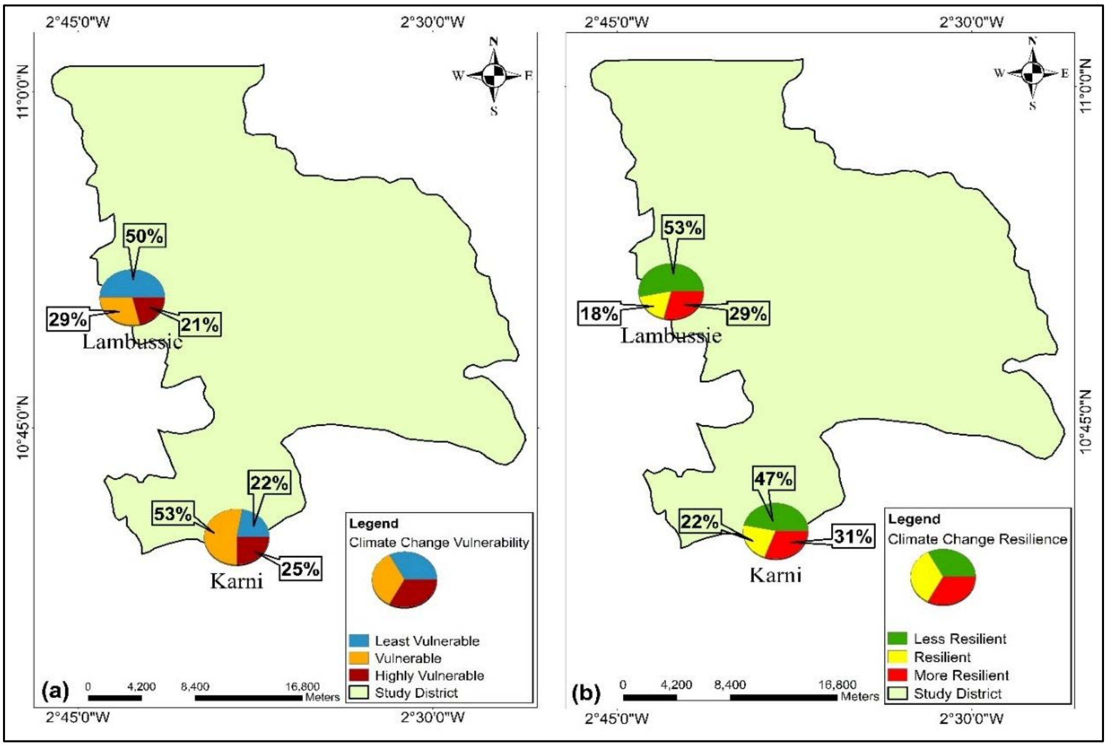

Figure 7: Map showing the distribution of (a) climate change vulnerability and (b) climate change resilience across study communities in the Lambussie District

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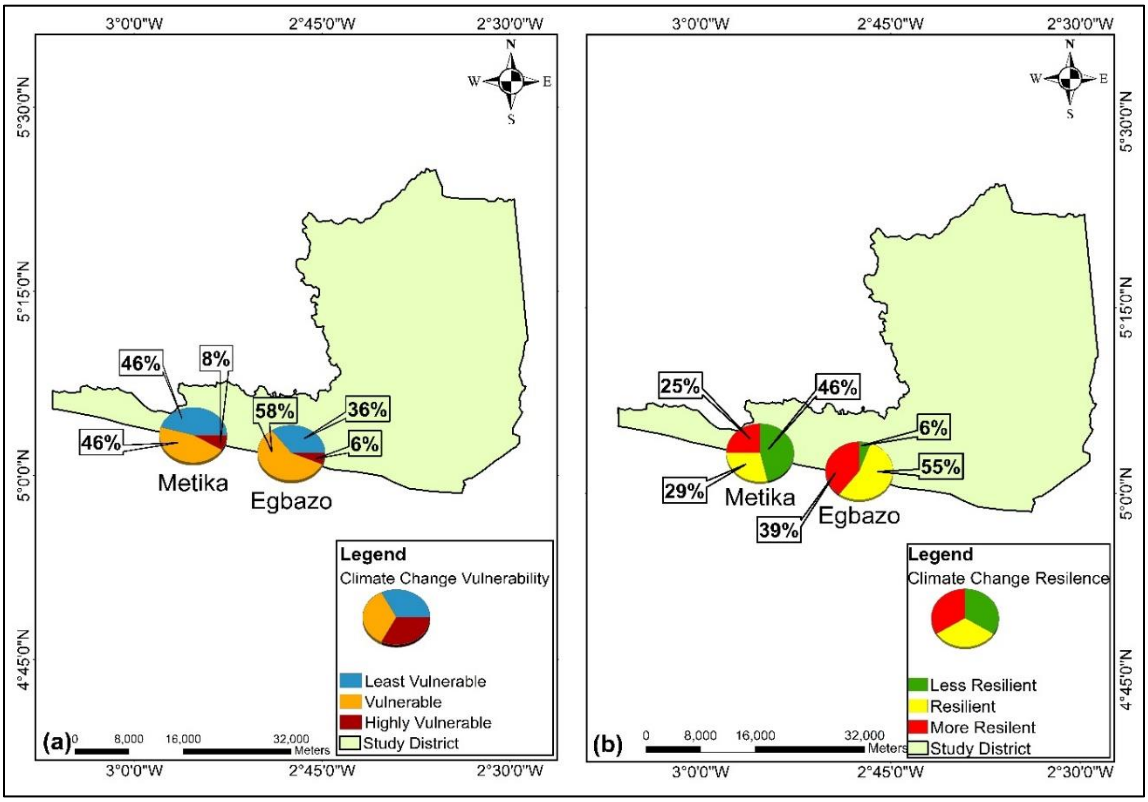

Figure 8: Map showing the distribution of (a) climate change vulnerability and (b) climate change resilience across study communities in Jomoro District

CONCLUSION AND RECOMMENDATIONS

The findings of this study identified several climate change-related factors that exacerbate vulnerability and reduce the resilience of rural communities in the two case-study districts. Many interrelated climatic and non-climatic stressors determine livelihood vulnerability in the two communities. For example, the low level of education and understanding of climate change impacts, as well as the lack of effective management strategies, are significant factors contributing to the vulnerability and low resilience of the surveyed communities. In addition, the considerable fall in agricultural productivity and food and nutrition security is another principal cause of the vulnerable conditions in the communities. In addition, more than 80% of the respondents from both Jomoro and Lambussie districts indicated that climate change-induced disasters experienced in their communities over the past 15–30 years have resulted in a reduction of farm yields. Furthermore, the occurrence of heat spells in recent times and related disasters, such as wild bushfires, pose human and environmental health risks, including psychological stress, which are other determinants of the vulnerability and low resilience of communities in the two districts.

To effectively combat these fundamental challenges calls for the implementation of comprehensive strategies and concrete actions. Firstly, an effective way to address the challenges of climate change-induced disasters and the vulnerability of local communities is to simultaneously adopt climate risk-sensitive solutions and build adequate resilience capacity tailored to their specific regional contexts, such as geography and access to the five capitals. The assets available to communities for improving their livelihoods and effective risk management constitute a crucial foundation for strengthening their adaptive capacity. Access to information, control over resources and influence in household and community decision-making are vital. It is also essential to integrate indigenous knowledge systems and modern communication technology to catalyse effective community adaptive response to disasters. Secondly, it is necessary to address existing and potential economic, social, and environmental barriers and pave the way for promoting productive livelihoods. An effective simultaneous deployment of both adaptation and mitigation measures is vital. However, achieving this strategy requires significant investments in disaster risk reduction preparedness and coping capacity. It also requires effective poverty reduction strategies to enable local communities to strengthen their level of economic, social and ecological resilience.

Building a high level of economic, social, and ecological resilience in local communities is a third appropriate action to consider. Community-based strategies constitute an effective tool for enhancing the adaptive and coping capacities of rural communities, thereby strengthening their resilience to vulnerability risks. The effective deployment of socio-economic resilience concepts, which focus on place-based and community resilience (people-based resilience), is critical for success. It is equally important that the relationship between social processes, such as informal networks within civil society and the private sector, and ecological dynamics should not be disturbed. Furthermore, it is essential that individuals, organisations and communities deploy both short-term and long-term emergency strategies. Social protection programmes should be designed to specifically target the reduction of climate change-induced disasters, such as droughts and floods, in rural communities and to enhance their adaptive capacity. These programmes should target: a) reducing vulnerability to poverty and reliance on negative coping strategies; b) providing a stepping stone towards climate-resilient livelihoods; and c) supporting inclusive disaster preparedness and response.

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