WOMEN AS AGENTS OF CHANGE: THE GENDER FACTOR TO CLIMATE CHANGE AND EDUCATION NEXUS FOR IMPROVED LIVELIHOODS IN GHANA

BY

AMMA BIRAGO KANTANKA GYIMAH (MRS.)

BSc. Planning (Kumasi), MSc. Development Policy and Planning (Kumasi)

Matriculation No.: 220294233

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AUTHOR: AMMA BIRAGO KANTANKA GYIMAH (MRS.)

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I certify that this work was carried out by Mrs. Amma Birago Kantanka Gyimah in the School of Agriculture and Environmental Science, The University of The Gambia

……..

Supervisor

P. Antwi – Agyei

B.Sc. (Kumasi), M.Sc. (Hull), Ph.D. (Leeds)

Associate Professor, Department of Environmental Science,

Kwame Nkrumah University of Science and Technology

……..

Co-Supervisor

G. Adom- Asamoah (Mrs.)

B.Sc. (Kumasi), M.Sc. (Bristol), Ph.D. (Kumasi)

Senior Lecturer, Department of Planning,

Kwame Nkrumah University of Science and Technology

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AEA	-	Agriculture Extension Agents
CC	-	Climate Change
CCC	-	Climate Change Communication
CCE	-	Climate Change Education
CCGAP	-	Climate Change and Gender Action Plan
CCLS	-	Climate Change Learning Strategy
CCVI	-	Climate Change Vulnerability Index
CIS	-	Climate Information Services
CSA	-	Climate Smart Agriculture
DE	-	Dormaa East
EEA	-	European Environment Agency
EG	-	East Gonja
EPA	-	Environmental Protection Agency
FAO	-	Food and Agriculture Organisation
FGD	-	Focus Group Discussion
GDP	-	Gross Domestic Product
GIPC	-	Ghana Investment Promotion Centre
GIS	-	Geographical Information Systems
GSS	-	Ghana Statistical Service
GTA	-	Gender Transformative Approach
ICT	-	Information and Communications Technology
IFAD	-	International Fund for Agricultural Development
IGGS	-	Institute of Green Growth Solutions
IPCC	-	Intergovernmental Panel on Climate Change
LINKS	-	Local and Indigenous Knowledge Systems
MESTI	-	Ministry of Environment Science, Technology and Innovation
MGCSP	-	Ministry of Gender, Children and Social Protection
MoF	-	Ministry of Finance
MoFA	-	Ministry of Food and Agriculture
MORB	-	Model of Responsible Behaviour
NDPC	-	National Development Planning Commission
NAPA	-	National Adaptation Plan of Action
NAMA	-	National Mitigation Plan of Action
NAPF	-	National Adaptation Plan Framework
NASA	-	National Aeronautics and Space Administration
NCCAS	-	National Climate Change Adaptation Strategy
NCCP	-	National Climate Change Policy
NDC	-	National Determined Contribution
NDPC	-	National Development Planning Commission
NGO	-	Non-Governmental Organisations
POS	-	Positive Organisational Scholarship
RII	-	Relative Importance Index

RWF - Rural Women Farmer
SAM - Situational Awareness Model
SDG - Sustainable Development Goal
SPSS - Statistical Package for Social Scientists
TPB - Theory of Planned Behaviour
TRA - Theory of Reasoned Action
UNDP - United Nations Development Programme
UNEP - United Nations Environmental Programme
UNESCO- United Nations Educational, Scientific and Cultural Organization
UNFCCC- United Nations Framework Convention on Climate Change
UNFPA- United Nations Fund for Population Activities
VA - Vulnerability Assessment
WASCAL - West African Science Services in Climate Change and Adapted Land Use
WED - Women Environment and Development
WHO - World Health Organisation
WMO - World Metrological Organisation
WIAD - Women in Agricultural Development

ABSTRACT

Global research on Climate Change Education (CCE) interventions has emphasized the school-based (formal) sector with little accent on the informal sector and negligible evidence from the global south. Notably, interventions targeting women, who are highly vulnerable to Climate Change (CC) impacts, are largely missing in the literature. This is particularly important for Ghana, where rural women rely on climate-sensitive sectors such as agriculture and forestry. This research assessed the critical factors in CCE that can enable rural women farmers build resilient livelihoods. Employing a mixed method approach, a formal questionnaire and a question schedule were used to collect data from a sample of 497 individual respondents and six focus group discussions consisting of Rural Women Farmers (RWF) from two agro-ecological zones. Thirteen expert interviews were also conducted with national and local stakeholders. Quantitative data were analysed using frequencies, percentages, Relative Importance Index, Adaptive Capacity Index, Chi-Square statistic and Binary Regression. Qualitative data were analysed through theme generation and synthesis. In assessing the situational awareness of RWFs, the study projected a disconnect between climate change knowledge and climate actions on the scale of perception (87.0%), comprehension (84.0%) and climate actions – [mitigation (31.0%) and adaptation (79.0%)]. Adaptation actions were found to be temporary and spontaneous rather than planned. Existing individual and systemic factors characterising RWFs, such as low literacy, workloads, high household size, unfavourable land ownership rights and limited access to expert knowledge, influenced the prevailing disconnect. Respondents were also challenged with timely (43.9%), reliable (51.1%), and particularly understandable (64.0%) CC information from various sources. The study found a moderate (0.405) adaptive capacity level for RWFs. It was also revealed that access to capitals by women farmers did not necessarily result in benefit from the capital assets. Access to different climate knowledge sources and climate actions predicted a significant drive on livelihood capitals, indicating appropriate climate knowledge's ability to influence adaptive capacity. Lessons from National and local stakeholders in CCC and CCE provided a guide to what strategies worked. Stakeholders subscribed to identifying personally relevant framing of CC knowledge considering women's unique backgrounds. Hands-on, interactive approaches were encouraged, including user-friendly and local-dialect-sensitive virtual platforms. The absence of proper operational structures and appropriate technical staff coupled with entrenched sociocultural norms limited respondents' ability to build resilience. The existing climate knowledge gaps and critical enablers to CCE from stakeholders were synthesised into a proposed framework for educating rural women farmers on climate change for livelihood resilience. The study concluded by highlighting the role of CCE in building the resilience of RWFs whose roles in reproduction, production and community make them important agents of change. However, systemic factors expressed through access, ownership and control rights of rural women limited their potential. It is therefore recommended that CCE and CCC should be framed taking into consideration the unique context of RWFs. A long-term benefit will be a progressive reconstruction of societal norms that disenfranchise women through multi-stakeholder engagements from the local to National levels.

Key Words

Climate literacy, Resilient women, Extension services, Sub-Saharan Africa

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The 21st century has been hit with the reality of changes in atmospheric conditions, affecting the livelihoods of many. In many parts of the world, the risks of extreme temperatures are expected to increase progressively at 1.5^{o}C, 2^{o}C and 3^{o}C; whiles human health and food security are adversely affected by heat stress and water deficit (Intergovernmental Panel on Climate Change [IPCC], 2022a). The IPCC has indicated that the persistent changes observed in climatic variables over a long period, mostly a decade and beyond, due to natural or anthropogenic factors, capture the essence of climate change (IPCC, 2014). Countries in the global south are adversely impacted by Climate Change (CC) due to limitations in the adaptation and mitigation of climate impacts (IPCC, 2018; Roy et al., 2018). The vulnerability of countries in the global south is heightened because their economies depend on climate-reliant sectors including agriculture and forestry (Ngoma et al., 2021; Antwi-Agyei et al., 2014). This is particularly critical for African countries, where agriculture remains one of the most important sectors, employing about 57.0% of the labour and serving as the primary source of income (Oxford Business Group, 2021; Food and Agriculture Organisation [FAO], 2019). The agricultural sector also provides a livelihood for most of Africa's poor residing in rural areas (FAO, 2019). CC has become a stress multiplier intensifying the already prevailing marginalisation, poverty risks and political instability (IPCC, 2022b; Rodenberg, 2009).

In Ghana, the agricultural sector is the engine of growth as it remains the most important sector for jobs and livelihoods, providing a base for raw materials for the

industrial sector and a value chain of enterprises for the service sector (World Bank, 2018). The agricultural sector, including forestry and fishing, is the highest employer in the Ghanaian economy (employing 3.3 million of those employed) and is predominantly rural (80.6%), employing 52.0% of rural women (Ghana Statistical Service [GSS], 2016). In recent times, however, the agricultural sector's contribution to Ghana's Gross Domestic Product (GDP) has reduced consistently from 22.7% in 2016 to 18.5% in 2019, lagging behind the industrial and service sectors of the economy (GSS, 2020). The decline in GDP is evidence of a reduction in the productivity of Ghana's agricultural sector, which is highly dependent on climatic and natural resources. Increased temperatures, rainfall variability, unexpected extreme weather events and sea-level rise recorded over prolonged periods are indications of climate change and variability in Ghana (Amoateng et al., 2018; Holtmaat, 2013; Ministry of Environment, Science, Technology and Innovation [MESTI], 2013).

The effects of climate change presented as a human and social issue is highly lop-sided on social actors. Alam et al. (2015, p.9) put it this way "climate change is a global challenge that burdens all of humanity but not equally". The most hard-hit are the poor and vulnerable with limited opportunities (IPCC, 2018; Roy et al., 2018). Women, who account for about 50.0% of people living in Africa, are more vulnerable to the adverse impacts of climate change that cut across a broad spectrum of their daily sustenance and livelihoods (Pons-Duran et al., 2019; World Health Organisation [WHO], 2012). Again, women are highly involved in primary agriculture and the agricultural value chain, thus increasing vulnerability to their livelihoods (Palacios-Lopez et al., 2017). Livelihood practices, such as energy use, water management, and waste management, have important implications for climate change adaptation and mitigation, for which women are primarily responsible.

Habitezion (2012) further indicated that men and women have different coping and adaptive capacities and different access and control over productive resources based on their unique roles and responsibilities at the community and household levels. The vulnerability of women has been partly linked to their high poverty levels, high illiteracy, and weak involvement in political and household decision-making processes that affect their lives (Habitezion, 2012; United Nations Environmental Programme [UNEP], 2011). Women's high involvement in the agricultural sector indicates their significant role in the Ghanaian economy. There, however, seems to be a gendered perspective on the adaptive capacity of smallholder farmers where males usually record a higher adaptive capacity than females in Ghana (Adzawla et al., 2019; Abdul-Razak & Kruse, 2017). For instance, Abdul-Razak & Kruse (2017) report that female smallholder farmers in northern Ghana score lower in knowledge and awareness, financial capital and technology regarding adaptive capacity. This situation heralds gender inequality and inequity, which requires specific and targeted policy efforts to address. One of such issues is the inclusion of gender analysis in development policy (Md et al., 2022; Denton, 2004).

Stern's report corroborates the value of climate change education as it indicates that behavioural change and transfer of technology, two (2) of the three (3) elements in climate response, are premised on climate change education (Stern, 2007). Therefore, an appropriate gender-sensitive, adult-centred educational approach is vital in upscaling women from mere victims of climate change to positive agents of change. An effective Climate Change Educational (CCE) approach, defined as education that aims to address and develop effective responses to climate change (United Nations Educational Scientific and Cultural Organisation [UNESCO], 2017), has the potential to challenge gender stereotypes and bridge the equity gap (Warth & Koparanova, 2012).

1.2 Statement of Research Problem

The Rio Declaration (Principle 20) in 1992, called for gender mainstreaming in climate change interventions, attesting to the indispensable role of women in environmental management and development (Fernandes, 2012). Historical trajectories in addressing societal challenges, such as population dynamics regarding child mortality and fertility, have been achieved by targeting women through education and awareness creation (Van Peer, 2000). According to Mani et al., (2018), education has a lot to offer regarding improvements required for addressing climate change. Article 6 of the United Nations Framework Convention on Climate Change (UNFCCC)'s report, the Doha Programme, further highlights the critical role of climate change education, training and awareness creation as essential pillars in the fight against climate change (UNFCCC, 2012).

There has been much interest in climate change education as a potential medium to drive positive change, harness effective climate response and drive positive change (Cordero et al., 2020; IPCC, 2018; Brown et al., 2012; Moser, 2010). However, there has been a marginal impact over 30 years after the Rio Declaration, expressed in a disconnect between what climate change means to people and their experiences (Cook & Overpeck, 2019; Hulme, 2018; Jasanoff, 2010). At the local level, women's knowledge base on climate change and environmental systems is based on lived experiences inherited from one generation to another (UNESCO, 2021; Crate, 2011). Dependence on indigenous knowledge highlights the inadequacy of climate change education for the informal sector, especially among females. Sociocultural barriers have often been blamed for limited access to climate information for females at the rural level (Antwi-Agyei et al., 2021; Chanana-Nag & Aggarwal, 2020; Lawson et al., 2019)

The challenge of limited impact concerning gender mainstreaming into climate education seems to resonate with the "add women and stir approach" concept. This concept occurs when women are merely included in climate change educational interventions without considering the unique historical and cultural context that hinders women. (Datzberger and Le Mat, 2018; Cavalcanti & Tavares, 2016). Monroe et al. (2019) conducted a systematic review that synthesised 49 articles on climate change educational interventions, revealing a disproportionate representation in geography, target audience and approach. All interventions reviewed by Monroe et al. (2019) were conducted in the global north, with over 90.0% from North America targeting mostly school-based formal audiences (primary to tertiary level students and trainers in the climate change subject area). The Sub-Saharan African picture in the climate change education space was missing. Yet, this region is considered as one of the most vulnerable regions to the adverse impacts of CC (IPCC, 2022).

In Ghana, efforts in this direction have mainly focused on adding to the school curriculum with limited focus on non-formal education and community awareness creation (MESTI, 2013). A Background Report shows that the National Development Planning Commission (NDPC) and the Environmental Protection Agency (EPA) have made efforts to integrate climate change and disaster risk reduction into District Medium Term Development Plans (Institute of Green Growth Solutions [IGGS], 2015). However, the extent to which the unique needs and considerations of rural women farmers who are critical stakeholders in the climate change discourse have been integrated, and the capacity of stakeholders involved in awareness creation at the grassroots have largely been lacking. This poses challenges in addressing the effects of CC on women in the country. The recent CC gender analysis, gender action plan and gender toolkits have been a significant leap in mainstreaming gender into the CC agenda

in Ghana (Antwi-Agyei et al., 2021b, 2021a, 2021c). However, research in Climate Change Education (CCE), especially among informal groups like farmers, has been highly limited to the perception of climate change without assessing how perception translates into comprehension and uptake of climate-smart interventions at the local level (Asare-Nuamah & Botchway, 2019; Amadou et al., 2015; Teye et al., 2015; Kemausuor et al., 2011). It also remains unclear specific approaches actors adopt in the CCE space for rural women farmers in Ghana (IGGS, 2015). The National Adaptation Plan Framework goes further to express the absence of a communication plan underpinned by gender-responsiveness, community and ecosystem-based approaches (Antwi-Agyei, 2019). Addressing these research gaps, this thesis seeks to assess how rural women farmers could be supported to address CC in Ghana. The identified research gaps drive the research questions.

1.3 Research Questions

1. How does the awareness of rural women farmers on CC influence their mitigation and adaptation actions?
2. What are the differential adaptive capacities of rural women farmers across different agroecological zones?
3. How does climate-related information drive the adaptive capacity of rural women farmers?
4. What specific strategies are utilised by actors in the CCE space for rural women farmers?
5. What framework will be suitable for enhancing CC literacy among informal rural women?

1.4 Objectives of the Study

The research aims to determine how women connect what they know in CC to climate action, assess the drivers to RWFs adaptive capacity and best practices in climate change education that can enable rural women farmers to build resilient livelihoods.

The research set the following specific objectives to achieve this aim;

1. Assess the situational awareness of rural women farmers from different agroecological zones on climate change in Ghana.
2. Measure the adaptive capacity of RWFs from different AEZs in Ghana
3. Determine the influence of climate information on the adaptive capacity of RWFs in Ghana.
4. Explore the state of CC awareness creation of RWFs in Ghana.
5. Propose and educational strategy for RWFs in Ghana

1.5 Scope of the Study

Geographically, the study focused on Dormaa East (DE) and East Gonja (EG) Districts representing the districts with the highest Climate Change Vulnerability Index (CCVI) within Ghana's two (2) largest agroecological zones, i.e. guinea savannah and deciduous forest zones (EPA, 2020). The CCVI was intended to draw on communities experiencing the impact of CC. The agroecological setting, in contrast, was designed to draw on communities with diverse ecological features for comparison purposes. Figure (3.2) highlights the selected agroecological zones and the selected districts.

Contextually, rural women farmers were considered a critical group for livelihood sustenance and as powerful agents of change in combating CC (Alam et al., 2015). Conceptually, CCE was explored as a tool for effective mitigation and adaptation for improved livelihood (IGGS, 2015; UNFCCC, 2012). Concerning time scope, the

research employed a cross-sectional time horizon as the phenomenon was studied in a snapshot and not over an extended timeframe.

1.6 Justification for this study

Findings from this research will enhance women's role as powerful agents of change by empowering rural women to be livelihood resilient through appropriate CCE techniques. In this regard, the research makes relevant contributions toward Sustainable Development Goal (SGD) five (5) on Gender Equality. Furthermore, this research makes a meaningful contribution toward the attainment of SDG eight (8) on decent work and economic growth as it seeks to enhance productivity in the agricultural sector, which is predominantly rural and dominated by rural women in the global south, particularly Ghana. Substantially, this research is relevant to urgent action on combating CC (SDG 13). The call to build capacity in climate management and planning among women in developing countries (SDG 13) is contributed to significantly as this research seeks to build the capacity of rural women farmers through CCE.

The National Adaptation Plan (NAP) framework, developed as an integrated document to coordinate all CC efforts, calls for gender-responsive, community-focused and ecosystem-based approaches (Antwi-agyei, 2019). Findings from this research contribute meaningfully to this call as it assesses a CCE trajectory based on gender, community and ecology. Additionally, the research results significantly contribute to achieving the most recent gender-based policies and plans for CC, intended to adequately mainstream gender into areas of CC through awareness creation. Again, the results of this research are highly relevant to the work of CC-related ministries, agencies and non-governmental organisations, especially in the climate change communication and education space. The MESTI, Ministry of Gender, Children and Social Protection

(MGCSP), Ministry of Food and Agriculture (MoFA), EPA and relevant Community-Based Organisations (CBOs) are target users of the results. Finally, the two study areas (DE and EG Districts) are beneficiaries of the findings of this research to enhance female-centred agricultural engagements for improved productivity in the agricultural sector while addressing gender inequality.

1.8 Definition of Key Terms

There are key variables that drive this research; climate change and variability, gender, climate change education, vulnerability, adaptive capacity, resilience and livelihood. The operational definitions of these variables for this research are thus defined.

Climate change and variability: change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable periods of ten years and above.

Gender: a social construction of the roles, responsibilities and power relations between men and women, boys and girls.

Vulnerability: the extent to which a system is prone to, or unable to adjust in the face of adverse effects of CC, including variability and extremes.

Adaptive capacity: the inherent qualities of a system that enable it to adjust or otherwise to CC.

Resilience: describes not just the ability to maintain essential function, identity and structure, but also the capacity for transformation

Adaptation: the process of adjustment to actual or expected climate change and its effects in order to moderate harm or exploit beneficial opportunities

Mitigation: actions that reduce the rate of CC by limiting or preventing greenhouse gas emissions and by enhancing activities that remove these gases from the atmosphere.

Livelihood: the ensemble of capabilities, assets, and activities that are required to make a living

CC Education: education that aims to address and develop effective responses to climate change

CHAPTER TWO

LITERATURE REVIEW

2.1 Conceptual Review

Although the concept of CC is well established in literature, various dimensions of CC need contextualisation for this research. As such, a conceptual review of CC and its relation to women and education for improved livelihood is critical. The key variables, gender - focusing on women, CC concept, CC education and resilient livelihoods are central to this Conceptual Review.

2.1.1 Climate, Climate Change and Variability

An appreciable understanding and awareness of the functioning of the Earth's systems and CC predate the IPCC by some decades. The UNEP and its counterpart World Metrological Organisation (WMO), set up the IPCC in 1988 to assess the scientific, technical and socioeconomic information associated with human involvement in CC. Since the first IPCC report in 1990, much deeper comprehension and advancements in climate modelling have been achieved (Le Treut et al., 2005). The work of the IPCC and UNFCC has, over the years, expanded knowledge on CC, contributing to well-established knowledge on the subject matter. In the light of this progress, discussions on CC have shifted from debates on its existence to the various dynamics and dimensions of CC; how climatic changes are occurring through its impacts and adaptations (IPCC, 2014; MacGregor, 2010). Key terminologies in climate change/variability research are therefore defined.

Climate is the average weather conditions of a place over a period equal to or over thirty (30) years (Koutsoyiannis, 2021). Atmospheric entities such as solar radiation, temperature, humidity, precipitation, pressure, cloud, and wind describe the existing weather conditions at any point in time. Climate is, however, more than the averages of the above elements, as it encompasses not only the averages but also the

variability and extremes(Koutsoyiannis, 2021; Le Treut et al., 2005). It is a significant component of the planet earth that profoundly influences humans and their activities. Climate change, however, refers to changes in the climate observed through various scientific measurements (IPCC, 2014). Changes are observed through differences in means and/or variability of the climatic variables, extended over a period typically decades or longer (Pagett, 2019; IPCC, 2014; Le Treut et al., 2005). The change may be due to natural internal processes, external forcings, or persistent anthropogenic changes in the composition of the atmosphere or land use (Koutsoyiannis, 2021; IPCC, 2014).

The UNFCCC thus distinguishes between CC attributable to human activities altering the atmospheric composition and climate variability attributable to natural causes. UNFCCC perceives climate change as a "change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable periods" (United Nations 1992, p.7). Climate variability refers to variations in the mean state and other statistics (e.g., standard deviations, extremes, and so on) of the climate on all temporal and spatial scales beyond those of individual weather events. CC and variability thus operate simultaneously and do not preclude variability or *vice versa*. Therefore, CC and variability are of the essence in this research, not only where there is evidence of CC. The evolution of CC and variability to date is thus of interest in order to establish where this research enters into the discussion.

2.1.2 Progression on Climate Change Discourse

The story of CC has evolved from detection to attribution, where anthropogenic forces have been the most relevant attribution in recent times (Koutsoyiannis, 2021; Le Treut et al., 2005). Since pre-industrial times, the Earth's climate system has experienced massive changes, much of which are attributable to human activities. The Paleo-technic

era between the 1750s and 1930s represents an enhancement in technological development and application with coal and iron as raw materials and energy. Dominance over the natural environment was launched with the development of infrastructures such as railroads, factories and bridges, facilitating mass production in agriculture and industries. The natural environment began to deteriorate due to the use of chemicals for mass crop production and factory emissions into the atmosphere (Bhandari, 2018). Meadows et al. (1972) authored "The Limits of Growth", a report that indicated that if current trends in the growth of people, food, pollution, and industrialization remain unchecked, the Earth's planet will reach its limits of growth in the next one hundred years. The concept of "limits of Growth" can be akin to Malthus's call for control in population growth, which he said, has the potential to result in self-corrective checks through war and famine (Malthus, 1798).

The 21st century has seen a realisation of the consequences of anthropogenic activities on the climate (Bhandari, 2018). The work of the IPCC, thus became heightened to guide policy and decision-making. The IPCC has, over the years, focused on the coalition of scientific research on CC for policy action by governments. The focus of their work has progressed from the physical science of CC to embrace its social science dimensions. Indeed, this is clear from the focus of IPCC assessment reports and how they have evolved over the years (IPCC, 2015). The first IPCC report highlighted CC scientific assessment, impacts and response, while the second assessment report expanded in addition to the science of CC to look at the impacts. The new addition in the second assessment was the introduction of adaptation, mitigation and socioeconomic dimensions. The third assessment report in 2001, in addition to existing concepts, introduced the vulnerability dimension, with much depth in adaptation and mitigation analysis (IPCC, 2001). The fourth and fifth assessment reports have highlighted the

same concepts and dimensions in greater depth (IPCC, 2014). The sixth assessment report focuses on consumption and behavioural patterns, technology and innovations and mitigation as the world transitions toward net zero emissions under the three main themes (IPCC, 2022b).

The work of the IPCC has been championed by three Working Groups; The first focuses on the physical science basis of CC, the second on impacts, vulnerability and adaptation and the third focuses on the mitigation of CC. As essential as the work of Working Group 1 is - espousing numerous physical sciences on CC; the assessment of the impacts, vulnerabilities and adaptation strategies cannot be overemphasised. The impacts, vulnerabilities and adaptation strategies touch base directly with the people impacted by CC. For instance, the IPCC has established facts on potential CC impacts over the years of research, among which are five key impacts as reported in its second assessment report (IPCC, 1995). These include shifts in the makeup and geographic dispersion of many ecosystems and food security challenges due to CC. On the global scale, impacts are expected to be small to moderate; however, the tropic and subtropics stand the risk of adverse food security challenges (IPCC, 2018; Pachauri & Meyer, 2014).

Furthermore, there is a decline in nutrition, an upsurge in a vast range of human diseases, including those associated with extreme weather events and the challenge to sustainable development in the face of loss of human habitat due to extreme events, sea level rise, reduction in quantity and quality of water. Finally, limited coverage of technologies that facilitate adaptation and mitigation options where the poorer regions are more at risk is a reality (IPCC, 2022a). The above prevailing impacts keep worsening as all the climatic indications (temperature, precipitation, sea level rise, accessibility to technologies necessary for adaptation and mitigation) keep skyrocketing (IPCC, 2022a;

IPCC, 2014). Therefore, this research seeks to enter into the discourse and the outcomes of the Working Group II of the IPCC to deepen understanding of impacts, vulnerability and adaptation in the light of rural women and CC education.

2.1.3 The Concept of Gender

The concept of gender has various variations; which must be established since they relate to this research. Gender has evolved from the binary separation between the male and female sexes to embrace other genders, such as lesbian, gay, bisexual, transgender and queer groups (Lopez, 2016). This research emphasises 'contextualising' the binary breakup of gender, representing male and female as the other introduced genders are not legally established concepts in the Global South where this research is premised. Data to extend the research into the other gender extensions are non-existent. Furthermore, the dynamics of the breakout genders are not context relevant in a study on rural women and CC education.

Various bodies and authors have defined gender with different emphasis (Momsen, 2019; UNDP, 2014; UNFPA, 2005; McDowell, 1999; Butler, 1990; West & Zimmerman, 1987). The UNDP defines gender as roles, responsibilities, rights, relationships and identities of men and women defined or ascribed to them within a given society and context (UNDP, 2014). West & Zimmerman (1987) put it this way; what we do, rather than something we are born with or something we have, is gender. Butler (1990), on the other hand, calls it something we perform. Momsen (2019) contributes to the concept by saying, gender is the socially acquired notion of masculinity and femininity by which women and men are identified. Momsen (2019) further states that embracing a gendered perspective requires a consideration of the social differences between men and women. The concept is a societal construction that

recognises the dynamic nature of gender based on beliefs, social practices, historical context, and political structures (McDowell, 1999).

All the various definitions have common grounds that highlight gender as a social construction of the roles, responsibilities and power relations between men and women, boys and girls, and this is adopted as a working definition for this work. In this regard, gender roles are location specific. As such, contextualisation is key to gender phenomena. There exist, therefore, dissimilarities between men's and women's access to facilities, resources, services, funds, benefits and decision-making due to existing norms and social construction in a particular location and time (Le Masson et al., 2015). Gender imbalances primarily exist in societies to the detriment of women and girls (Momsen, 2019). In this regard, a gender perspective that theoretically should not exclude men and masculinity (Le Masson et al., 2015; Carr & Thompson, 2014) is necessitated for gender equity – correcting historical imbalances in gender by placing a focus on women and girls. UNFPA (2005) defines gender equity as strategies that compensate for women's social and historical disadvantages, which prevent women and men from operating on a level playing field to ensure fairness. A necessary precondition and indicator for equality are equal opportunities, rights and responsibilities for all (UNDP, 2014). Hence in ensuring equity, equality is consequently achieved. Gender disparities manifest in diverse ways, and it is essential to highlight how these manifestations generally occur in the face of CC.

2.1.4 Manifestation of Gender Inequality

Gender disparities against women in various socioeconomic dimensions have been variously highlighted (FAO, 2018; Ortiz-Ospina & Roser, 2018; Blau & Kahn, 2017; World Bank, 2012). It is reported that women earn less than men on the same category of jobs with senior management positions highly underrepresented by women.

Low paying jobs are over-represented by women with only 18.0% female managers (Ortiz-Ospina & Roser, 2018). Ownership of land and productive resources are male dominated (FAO, 2018), whiles womens influence over important household decisions including decisions on their own incomes is limited (Blau & Kahn, 2017; World Bank, 2012). In the CC domain, Goodrich et al. (2019); Wrigley-Asante et al. (2019) and Aguilar (2009) set the tone by indicating that the coping mechanisms are different and harsher on women, deepening the inequality gap. A high number of fatalities are usually recorded among women and children. For example, the 2004 Asian tsunami had 70.0% of fatal cases being women and children, while the 2014 Solomon Island floods had 96.0% of fatalities being women (FAO, 2018). Women, especially small-scale women food producers, are most disadvantaged in the face of CC with unprecedented biodiversity loss and environmental degradation, which threaten food security and nutrition.

Women are mostly affected by the vagaries of local-scale effects of CC due to the high dependence on local production systems, which impact their food security, fuel and other products and services (FAO, 2017). Women's localised task has mainly been managing immediate resources such as providing food, water and energy, care and nutrition services to children and the elderly at home. Climatic stressors have triggered men's movement out in search of alternative incomes as their livelihoods in agriculture and livestock farming is hit. This situation puts a further load on women who care for the farms and livestock left behind (Rasul et al., 2016).

Discrimination is further faced in distributing assets, information and services such as land, employment, training, mobility, climate and market information services, technologies and inputs (Simelton & Ostwald, 2019; FAO, 2018; Ortiz-Ospina & Roser, 2018). The patriarchal stereotypes about women and men's rights, roles, traditional

cultures and values and prevailing economic models reinforce male-centred food and agriculture systems that stereotype women and undervalue their contribution to the economy (CARE et al., 2015). Existing gender-based disparities have evolved over various feminist and gender-based approaches, which are briefly exposed.

2.1.5 Women and Climate Change

The fact remains that women were largely ignored in early development encounters in the 1930s (Connelly et al., 2020). The linkage between gender equality and CC has become a challenge for many decision-making bodies involved in policy, programmes and initiatives (Aguilar, 2010). This was confirmed by a UN survey of environmental ministries, indicating a lack of incorporating gender dimensions into their activities. This view has improved over the years, where gender mainstreaming is being encouraged in all activities, especially in CC (UNFCCC, 2012). Aguilar (2009) asserts that the crucial role of women as agents of change has been noted, especially in the space of skills and knowledge related to mitigation and adaptation. However, to influence CC positively, it is imperative to ensure equal access to resources, knowledge and technology while ensuring that women actively participate in negotiations that shape the climate change regime. Entrenched social and power relations still limit women's empowerment and adaptation as competent change agents, thus limiting gender mainstreaming to 'add women and stir syndrome(Datzberger & Le Mat, 2018; Hillenbrand et al., 2015). Much effort is required to bridge the gender gap and catapult women to higher productivity and effectiveness. It is important to note that an effort to ensure gender equality does not mean that women and men have to become the same but that their rights, responsibilities and opportunities will not depend on whether they are born male or female (UNDP, 2014).

2.1.6 Concept of Vulnerability

The adverse effects of CC on communities, regions, social groups, economies, infrastructure and ecosystems are often called vulnerability and risk. Although both words have intuitive meanings, they can be misunderstood realistically (European Environment Agency, 2015). Vulnerability and risk are context-specific terms, and their conceptualisation must spell out their specifications and context to avoid ambiguity and misrepresentation (Giordano, 2020). Vulnerability is defined from three (3) essential perspectives: hazard, poverty, and CC. This research however focusses on the context of vulnerability in terms of CC. From the IPCC's perspective, vulnerability is the extent to which a system is prone to, or unable to adjust in the face of adverse effects of CC, including variability and extremes (IPCC, 2014). In the conceptualisation of vulnerability, five (5) key variables are highlighted for characterisation: livelihood strategies, hazards, resource endowment, social dynamics and coping strategies (Cardona et al., 2012). These variables interact at the community or livelihood zone, whereas the national/regional level presents social, political, economic and environmental conditions that are expected to create an enabling environment. These are essential factors for the characterisation of vulnerability.

Vulnerability relates to risk, and risk is a function of the existence of hazard (which in this context is CC) and the exposure level represents vulnerability. Risk can also be looked at as the potential impact based on existing exposure and sensitivity. It, therefore, presupposes that risk encapsulates the exposure and sensitivity of a target group to CC. According to IPCC (2022a), risk is defined as the potential for a human and ecological system to be affected by impacts of CC, the diverse values and objectives associated with the system and how different sectors, regions and population are impacted differently. According to IPCC (2001), vulnerability is risk minus adaptive capacity and is expressed as:

Vulnerability = Risk - Adaptive capacity

(where risk = exposure + sensitivity).

Therefore, the indicators for assessing vulnerability are exposure, sensitivity and adaptive capacity.

How natural systems and humans are sensitive to the impacts of CC requires identification and characterisation, which serves as an essential input for targeting and addressing vulnerability issues. Vulnerability Assessment (VA) is thus important for two (2) main reasons; management of current climatic risk and managing future climate risk (Giupponi & Shechter, 2003). These are very important, especially for developing countries that are presently undergoing rapid growth in the area of infrastructure. Thus, there is a need to incorporate current and future climate risks into urban settlements, transportation and irrigation systems design and planning. The essence of vulnerability assessment is its diversity, as different communities, sectors, nations, and regions have different levels of exposure. People who are intended to be protected from the adverse effects of CC remain the central focus of VA. People here refer to either individuals, livelihoods or populations which interact with institutions (organisations, firms or sectors) and can be geophysically found in places such as ecosystems, land, water and air (Giupponi & Shechter, 2003).

Assessment of vulnerability

There is no specific instrument for measuring vulnerability; however, indicators are utilised as the means of assessment, using its parameters of sensitivity, exposure and adaptive capacity (Giordano, 2020). The likelihood of a system being affected due to projected CC indicates how sensitive the system is. Giordano (2020) highlights some key factors that influence sensitivity to CC. The factors include the age, the physical and mental health of different socioeconomic groups, the effect of climate stimuli on

products and services, the effect of climate stimuli on physical structures and their services and the robustness of an ecosystem by its health and connectivity.

The potential impact of CC depends on the exposure and sensitivity levels of the system. It is important to note that the impacts of CC may be positive or negative (Giordano, 2020). If the impact of CC on a system is negative, then vulnerability ensues. In the case of a positive outcome, systems resilience based on a higher adaptive capacity is identified. Adaptive capacity is thus defined as the inherent qualities of a system that enable it to adjust or otherwise to CC (Ara Begum et al., 2022). Indicators of adaptive capacity include access and ability to translate and utilise information, resources for adaptation, ability to change in response to climate stimuli (flexibility), disposition to change and the potential of species to move or ecosystems to expand into new zones (IPCC, 2022b). Thus, to measure a community's vulnerability to CC, findings on the potential impact (which is a function of exposure and sensitivity) and adaptive capacity are measured (Figure 2.1). Cinner et al. (2015) indicate that the higher the adaptive capacity of a group of people, the lower their vulnerability and *vice versa*. Therefore, addressing vulnerability requires a critical assessment of a system's adaptive ability to withstand the threats posed by CC. Engle (2011) and Polsky & Eakin (2011) state that people's resilience to CC is fundamental and proportional to their adaptive capacity. Resilience as a concept is said to go beyond one's ability to maintain structure, function and identity to the potential to transform (Ara Begum et al., 2022). Adaptive capacity, which reflects the level of resilience, is therefore recognised as a critical quality in tackling CC, especially for resource-constrained farmers in undertaking adaptation and mitigation actions.

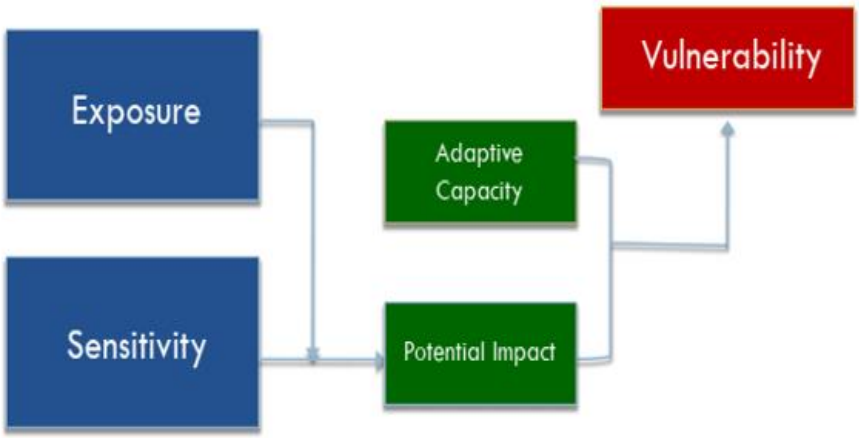

Figure 2.1 The components of Vulnerability

Source: Adopted from Midgley et al. (2011)

2.1.7 Interlinkages of Mitigation and Adaptation as Climate-Resilient Pathways

It has been pointed out that even the most stringent mitigation efforts cannot avoid further impacts of CC in the next few decades (IPCC, 2014). To ensure the society's safety, security, and sustainable development, it is essential to implement initiatives for the long-term mitigation of CC and policies to adapt to CC. The linkage and integration between mitigation and adaptation are critical, as well as the need to streamline mitigation and adaptation to sustainable development. Mitigation actions need to be achieved within a sufficient time frame that allows ecosystems to adapt naturally (Environmental / Ecology), to ensure secured food production (Social) and facilitate economic development (economic) for multiple benefits (Mensah, 2019; Shao et al., 2011). The multiple-benefit dimension highlights the numerous benefits and integration between the concepts of mitigation, adaptation and sustainable development, which ensures sustainable social, economic and environmental equity (IPCC, 2018; Pachauri & Meyer, 2014). This interaction, though complex, is the way to go in establishing climate-resilient pathways. In this regard, climate policies must go beyond mitigation and adaptation to broadly examine development trajectories. This calls for

"systems thinking", which looks at a holistic approach that considers the different parts of a system and how they interrelate and work in a larger system (Ollhoff & Walcheski, 2018). The principles of systems thinking establish that there are no perfect solutions but that the choices made will impact other parts of the system. By anticipating the impact of each trade-off, an absolute benefit can be generated by minimizing negative impacts (Ollhoff & Walcheski, 2018; Flood, 2010). CC calls for new approaches to sustainable development that considers complex interactions between climate, social and ecological systems (IPCC, 2022a; Pachauri & Meyer, 2014).

As highlighted, co-benefits or ancillary benefits in mitigation, adaptation and sustainable development pathways integration are critical and have been advocated. Still, their implementation is minimal and not widespread (Crumpler & Meybeck, 2020). Mitigation, adaptation and development measures are usually considered and handled as separate entities based on their definitions and concept, and they have been addressed in different plans and strategies. For example, nations have separately developed their National Mitigation Plans of Action (NAMA), National Adaptation Plans of Action (NAPA) and National Development Plans, which mainly highlight development measures. This in itself limits the effective integration of all three concepts as one system. This leads to duplication of actions and waste of funds, thus weaning the opportunity for co/multiple benefits.

Furthermore, different international expectations and incentives have made co/multiple benefits of the concepts a fallacy. For nations to benefit from international incentives, they must comply with set expectations that are mostly not in line with the concept of system thinking and are not designed for co/multiple benefits (Crumpler & Meybeck, 2020). Finally, the coordination of a system's project (i.e. integration of mitigation, adaptation and development measures) is complex and difficult, requiring

unique expertise to coordinate. Nations and sectors are further burdened where there is low technical expertise to handle this multi-task, making the implementation of such projects very rare. There is, therefore, a need to build capacities and integrate the concepts at the conceptualisation stage to make their implementation as a holistic system much smoother. Mitigation and adaptation action must therefore be considered as an integral part of local development.

2.1.8 Concept of Environmental Virtuousness

Sandler (2013) defines virtue as "the proper disposition or character traits of human beings regarding their interactions and relationships with the environment." Positive Organisational Scholarship (POS) view virtuousness as behaviour that surpasses "standards of adequacy" and "exceeds expectation", thus deviating from the norm. Virtuous behaviour is not considered extreme, excessive or obsessive (Bright et al., 2011). Virtuousness is a moral response to CC that results in positive action (Jamieson, 2014; Thompson, 2012). As defined by Sadler-Smith (2013), environmental virtuousness is a collective ethical disposition which habitually motivates, guides, and corrects moral behaviour in positively deviant ways that contribute to sustaining the whole Earth system's integrity and stability. Three (3) variables that interconnect environmental virtuousness are unconditional social betterment, human impact and moral goodness (Caza, 2015). Unconditional social betterment considers creating a social value that extends beyond self-interest, while human impact involves human flourishing, self-control, resilience and meaningful life purpose. Moral goodness also looks at guiding principles and ethical codes.

Different character traits of people cause them to respond differently to the same issue. An indifferent personality may take no steps or even negative steps when there is a need to alleviate a negative situation. In contrast, an emphatic personality may respond

positively to bring positive change. Thus, virtuousness thrives on the level of sensitivity of a person to take positive steps in bringing about positive change (Sandler, 2013). Aristotle puts it this way; a virtuous person is inclined to act right for the right reasons in the right way, with the right feeling and desires (Bartlett & Collins, 2011). The primary purpose of the concept of virtue is thus to constitute what is morally right. Several theories of virtue exist; however, the most prominent ones share features such as care of living things, appreciation of natural beauty, and moderation in using natural resources. These are referred to as environmentally justified virtues (Sandler, 2013).

Different virtues have different spheres of operation, but for this purpose, the emphasis is on environmentally responsive virtues whose field of operation is on the natural environment and in the domain of environmental advocacy, ecological sensitivity, perseverance and temperance regarding material goods that correspond to environmental productive virtues (Sandler, 2013). Another critical area of being environmentally virtuous is appreciating humans' dependency and vulnerability to the natural environment. This draws on environmental care, sensitivity and concern where human and environmental flourishing inter-twin and coincide (Cafaro, 2001). Much of the literature on virtuousness highlights organisational policies, processes and practices, whereas virtuousness emanates from individuals, communities, economies, cultures and societies (Arjoon et al., 2018). Sandler (2013) concludes his discussion on environmental virtue ethics by indicating that, environmental virtuousness is an indispensable component of preserving nature.

2.1.9 The Virtuousness and Vulnerability of Women in the Context of Climate Change

Vulnerability has many socioeconomic drivers and actors, making it a socially constructed phenomenon (Buhaug & von Uexkull, 2021; Simpson et al., 2021). Goodrich et al. (2019) describe vulnerability to CC as a phenomenon that presents itself

in a multi-faceted manner where different vulnerabilities are recorded for men and women based on their unique contexts, either biophysically or socioeconomic-wise. Vulnerability is shaped by gender-differentiated responsibilities and roles, access, rights, knowledge and priorities, which mostly result in a disproportionate impact on women due to inequalities and socioeconomic constraints (Goodrich et al., 2019). Thus, inequality in decision-making, gender division of roles and responsibilities, inequalities in access and control over assets and resources and work types and spaces of men and women represent four main conditions that determine gendered vulnerability (Goodrich et al., 2017). Arora-Jonsson, (2011) highlights the limited literature on gender and CC and further indicates that, in this limited literature, two themes dominate, i.e. the vulnerability or virtuousness of women concerning the environment.

The literature on women and CC highlights the subject of their vulnerability. The impact of CC on water availability, forest biomass and increased human risk to the health of children, women and the elderly are critical. This deepens the existing vulnerabilities of women, who are mainly responsible for providing and managing these resources (Arora-Jonsson, 2011). Three key issues are highlighted concerning women and climate change; women need more attention because they are the poorest of the poor, high mortality rate among women in the face of calamities from CC and women's higher environmental consciousness and responsiveness (Arora-Jonsson, 2011). Ro¨ hr (2006) and Denton (2002) have indicated that 70.0% of those living below the threshold of poverty in developing countries are women. Furthermore, Oldrup & Breengaard (2009) wrote that women's (real, not assumed) needs are mostly not considered, with minimal participation in CC debates and processes, especially at the national level. It has also been reported that women and children are likely to die fourteen times more than men in the face of CC calamities (Brody et al., 2008).

The flip side of women's vulnerability is their virtuousness which is not much trumpeted, especially in the global south (Arora-Jonsson, 2011). According to Brody et al. (2008), the sensitivity of women to CC risk is higher than their male counterparts. As such, they are more willing to make changes (behavioural) and are more aligned to accept and support the drastic measures on CC, making them more virtuous. This, therefore, qualifies women as powerful agents of change given the opportunity. Other authors have indicated that men are the principal polluters of the environment in their daily activities and choices (Oldrup & Breengaard, 2009; Johnsson-Latham, 2007; Sundblad et al., 2007). Taking the transport sector for example, the following observations were made; men travel more and for longer distances than women, using more sophisticated means of commuting, which has a bearing on the environment. Women travel less, using cheaper options such as walking, bicycling, and public transport (Johnsson-Latham, 2007). The arguments for women's vulnerability and virtuousness align with Women Environment and Development (WED) debates held in the 1980s, in which women were characterised as more environmentally conscious than their male counterparts. It is important to note that much of the literature focuses on women's vulnerability.

Arora-Jonsson (2011) calls for examining specific forms of vulnerability and virtuousness to respond appropriately. In other words, vulnerability or virtuousness should be context-specific for effective actions. Although research aligns with women's virtuousness, it is imperative to address the resource availability and capacity gaps to manage the environment (Leah, 2007). A report on how men and women respond to climate variability of drought in a village in Andhra Pradesh in India gave striking indications. It was reported that women who were disadvantaged in terms of access to extension services, were paid less than men for the same work done on National Rural

Employment Guarantee Projects, and information and services were directed more at men than women (Lambrou & Nelson, 2010). Arora-Jonsson, (2011) has opined that the main concern with the issue of gender in the light of virtuousness or vulnerability is power inequalities in decision-making in environmental management. Advocates for female rights have argued for more women to be involved in environmental decision-making, but the status quo has generally remained and existing inequalities have not been bridged. This is because the participation of women is hinged on rules and laws limiting women's say. Women, therefore, want to function in their groups where they feel confident and free, but this is often rejected by male-dominated village organisations as a case study in Sweden and India revealed (Arora-Jonsson, 2010).

The picture that emerges from this is that the entry of women into existing institutions without the necessary changes in structure and form is just a 'rubber stamp' on existing inequalities (Arora-Jonsson, 2010). Arora-Jonsson (2011) admits the importance of the gender dimension but highlights the need for contextualisation of the issue, as different contexts present different outcomes. Advocacy is therefore made for 'context-specific, comparative case studies that examine relationships and adaptations on the ground from different vantage points. Keeping discussions separately at the vulnerability and virtuousness level keeps women and gender on the climate change map, where their presence and relevance are quickly erased.

2.1.10 Resilient Livelihoods

As a concept, livelihood is defined as a means by which one makes a living. It entails the assets, capabilities, incomes, and activities needed to acquire the necessities of life (Sayer & Campbell, 2003). Ellis (2000), who has done extensive work on the subject, views livelihoods in terms of assets which are either natural, physical, human, financial, or social capital, coupled with the activities and access to institutions and

social networks. Scoones (1998) describes assets as the livelihood resources through which production is done. Thus, assets define livelihood strategy (Carney, 2003; Ellis, 2000). Resilient livelihoods do two (2) essential things. The first is to absorb stress and sustain function in the face of external stress. Secondly, resilient livelihoods adapt, reorganise and evolve into a more desirable state. (Nelson et al., 2007; Folke, 2006). Achieving sustainable livelihoods requires the combination of assets and diversification of a shared rural survival strategy (Baffoe et al., 2014; Ellis, 1998). The five capital assets, natural, human, physical, social and financial, are typical of rural economies, which are primarily agricultural (Clark & Carney, 2008; Ellis, 1998).

Natural capital is described as the natural resource stock (air, water, soil, genetic resource) and environmental services essential for farmers' livelihood (Kuang et al., 2019; Xu et al., 2019). Human capital also considers the skills, abilities of labour, knowledge, good health, and physical ability to accomplish a task (Fang et al., 2014; Nielsen et al., 2013; Sayer & Campbell, 2003). Yang et al. (2021) describes rural farmers' means of production that facilitate living as physical assets. These include infrastructural amenities and household assets such as radios, bicycles and irrigation pump ownership. Social capital refers to the networks, affiliations and associations people draw on to pursue their livelihood (Wang et al., 2021; Kuang et al., 2019). Networks and associations are functional safety nets and informal grassroots sources of insurance under challenging times, such as exposure to climate change hazards (Vincent, 2007, as cited by Antwi-Agyei et al., 2013). Su et al. (2019) and Liu et al. (2018) conceptualise financial capital as the capital base of farmers, including access to credit, remittances and items that may be translated into cash holding. A combination of these assets measures the resilience or otherwise of livelihoods, thus an essential measure of adaptive capacity (Cinner et al., 2015).

2.1.11 Climate Change, Women and Livelihood Sustenance Nexus

Socio-ecological processes worldwide are affected by CC, with Sub-Sahara Africa (SSA) experiencing the greatest adverse effects (IPCC, 2014). Shifts in rainfall patterns, warming trends, increased frequency of the incidence of extreme heat events, and droughts have recently characterised the region (IPCC, 2018). Thus, there are grievous impacts on the livelihood of many who depend on rain-fed agriculture for sustenance (Serdeczny et al., 2017; Asante & Amuakwa-Mensah, 2015). As a result, food production faces considerable threats in many SSA countries, including Ghana (Chemura et al., 2020; Kyei-Mensah et al., 2019; Asante & Amuakwa-Mensah, 2015). Agriculture employs a vast majority of low-income earners in SSA in general and Ghana in particular. Agriculture is, therefore, a significant livelihood option for many who require timely and accurate Climate Information Services (CIS) to make informed decisions on risks to their livelihoods (Antwi-Agyei et al., 2020). Most of the agricultural workforce in Africa are women farmers who are perpetually disadvantaged by unreliable and unpredictable precipitation and temperature patterns, causing drought and soil erosion (Ncube et al., 2011). These women are highly involved in primary agriculture and the agricultural value chain, thus subjecting them to increased vulnerability (Palacios-Lopez et al., 2017). In terms of rural employment in the agricultural sector of Ghana, 52.1% are women (GSS, 2016).

Forms of energy used, arresting deforestation, reforesting, and regenerative agriculture are the major drivers of mitigation, while CC adaptation promotes agriculture, food security and water management. Coincidentally, these livelihood drivers are predominantly women's tasks, especially in Africa, where 80.0% of food production is women-centred (Aguilar, 2009). Women farmers, therefore, play a crucial role in appropriate mitigation and adaptation to CC in SSA. Kaijser & Kronsell (2014) have said that social characteristics such as gender play a pivotal role in the appropriate

response to CC by groups and individuals calling for contextualised efforts to facilitate women's crucial role in securing the farming industry.

2.1.12 CC Awareness Creation / Education

Although CC as a global phenomenon is well documented and acknowledged, it is disconnected from what it means to the people and their experiences (Wibeck, 2014; Jasanoff, 2010). The disconnect between knowledge and the meaning of climate science is a major critique. At the local level, women's knowledge base of CC and environmental systems is based on lived experiences passed from one generation to another – local knowledge and not what is taught them (Latulippe & Klenk, 2020; Crate, 2011). Women's dependence on indigenous knowledge highlights the inadequacy of CC awareness creation/education for the informal sector. In recent years, however, there have been much interest and funding in CCE (Government of Alberta, 2017; Anderson, 2012; UNESCO, 2012). Efforts in CCE have mainly covered the addition to the curriculum on climate change, some form of awareness creation of unusual weather conditions as well as the possible environmental and socioeconomic changes due to climate change (Adger et al., 2013; Wheeler & von Braun, 2013; Bellard et al., 2012).

Due to the high impact of CC on development and security, several United Nations organisations are involved in developing Green and climate-resilient societies. Several international organisations met at COP 18 in 2012 in Doha to form a coalition to promote purposeful, results-oriented collaboration supporting CCE, training, awareness, public participation and access to information. Significant among the international organisations are the FAO, the UNEP, the UNESCO, the UNFCCC, and the WMO. The UN coalition/alliance have promoted CCE during COP meetings on themes such as "leaving no one behind in CCE" and "Climate Education as a driver of change" (UNESCO, 2012).

Despite the efforts at the apex of decision-making, there seems to be little impact at the grassroots regarding the trickling-down effect of CC awareness creation/education. Developing countries highly impacted by CC have poverty alleviation, well-being, and job creation challenges, while access to climate information remains low (Dodson et al., 2020; Froese & Schilling, 2019; Theisen, 2017; Scheffran et al., 2012). Low awareness about CC among developing countries impedes effective adaptation and mitigation of CC impacts (Antwi-Agyei & Stringer, 2021; Sharifi, 2021). Countries that are party to the UNFCCC have accepted commitments taking into account their common but differentiated responsibilities and other specific national and regional development priorities. Parties are required to promote and facilitate various education, training and awareness programmes at the national and regional levels (UNFCCC, 2012). The popular Stern's report corroborates this fact as it indicates that behavioural change and transfer of technology, two of the three elements in climate response, are premised on CCE (Stern, 2007). The indispensable role of CCE as a vital tool in facilitating effective climate response cannot be overemphasized.

2.2 Empirical Review

This literature section focuses on reviewing works that correspond to the objectives of this research. Thus, CC awareness interventions, their approaches, successes and challenges are discussed.

2.2.1 Approaches for CCE /Awareness Creation

Public communication on climate science has been argued to exist for more than three decades, reflecting public knowledge and awareness of the causes and effects of CC across countries (Sarfo et al., 2018). However, the proportional reflection of CC awareness in lifestyle and behavioural change leaves much to be desired. The lack of reflective action on climate knowledge is known as the 'attitude-behaviour divide' or the

'value-action gap' (Nicholson-Cole, 2005); in what is referred to as 'bigger-than-self problems' (Corner & Randall, 2011). Howell (2011) has argued that people can only do something about a situation when they believe they can and their contributions will be worth it.

Monroe et al. (2019) conducted a systematic review that synthesised 49 articles on CCE interventions, revealing a disproportionate representation in geography, target audience and approach. All interventions were conducted in the global north, with over 90.0% from North America targeting mostly school-based formal audiences (primary to tertiary level students and trainers in the CC subject area). The SSA picture in the CCE space was missing; however, this synthesis provides a valuable guide to tested approaches. In another review paper on enhancing learning and communication on CC, Wibeck (2014) suggests four complementary solutions, whiles Monroe et al. (2019) highlight tested educational interventions that have proven effective. A synthesis of critical points in empirical literature on CCE intervention are discussed as a benchmark for integration in this research.

Climate communication content

Feinberg & Willer (2011) report that climate communication contents that generate fear and gloom create a sense of hopelessness and apathy among the audience. On the contrary, messages of awareness creation that target essential issues to local actors and empower action are recommended by Norton et al. (2011). A promising road for climate communications, presented by Wibeck (2014), focuses on solutions rather than problems while highlighting the success stories of ordinary people in climate action. Positive feedback in the form of motivation for individual action on CC mitigation necessitates continuous action (Howell, 2011; Whitmarsh et al., 2011; Cooney, 2010).

Visualisation strategies

Using Geographical Information Systems (GIS), 3D imagery, and interactive Information Communication Technology (ICT) platforms is critical for the tangible, concrete visualisation of CC concepts (Neset et al., 2010). Kolb & Kolb (2009) highlight experiential learning by harnessing locally relevant impacts and actions as the reference point for thinking and reflections. Visualisation in linguistic metaphor and imagery in Climate Change Communication (CCC) is advocated by Wibeck (2014).

Content framing

CCC strategy and policy that connects with the deep values and beliefs of the audience facilitate positive responses. Wibeck (2014) suggests concepts that resonate with the framings of the audiences. For example, reframing CCC as a religious or moral issue, emphasising a moral obligation to protect the Earth and God's living things, is usually effective for audiences with strong traditional and religious beliefs (McNeal et al., 2014; Aguilar, 2009).

Audience segmentation

CCC audiences are unique and require appropriate segmentation to make the right impact. Target groups require different interpretative framing that resonates and makes sense in their context. The traditional segmentation of audiences into socio-demographic characteristics such as race, gender and age is inadequate. Brownlee et al. (2013) suggest that understanding the beliefs, values and attitudes of audiences on different issues of environmental education allows for effectiveness and is a good entry point to encourage a positive response. Wibeck (2014) suggests segmentation into sub-populations with a shared context.

Experimental learner-centred approaches

Demonstrative and practical approaches are effective interventions for CCE climate (Monroe et al., 2019). Engaging, learner-centred methods such as debates,

hands-on activities, group discussions and field trips were measured as successful interventions in implementing CCE (Karpudewan et al., 2015; Theobald et al., 2015 Reinfried et al., 2012). Learners who experienced these strategies were found to have gained more benefits in knowledge, attitude and behavioural change (Monroe et al., 2019). Holthuis et al. (2014) suggest that interaction rather than merely listening and reading as a learning approach produces much better results. Another useful criterion is starting with students' prior knowledge, simplifying complex processes into successional steps, reducing content, focusing on key ideas, and avoiding technical terms (Reinfried et al., 2012).

Monroe et al. (2019) further reveal four more themes of teaching strategies in the literature that may help learners acquire more depth of knowledge. These include deliberate discussion that allow learners to comprehend their views and that of others on CC better. The opportunity to interact with scientists and experience scientific processes first-hand has been found to be useful. Additionally, exposing and addressing misconceptions of CC and practical approaches in designing and implementation aspects of CC facilitate depth of knowledge in CC.

Visual imagery and ICT approaches (E-Games)

Many interventions have utilised visual imagery to capture their audience's interest (Cox et al., 2014; Mutlu & Tokcan, 2013; Reinfried et al., 2012; Vethanayagam & Hemalatha, 2010; Oluk & Özalp, 2007). Mutlu & Tokcan (2013) report an experiment where one group was allowed to watch a documentary while the control group did not. The results indicated that the experimental group demonstrated significant gains in knowledge compared to the control group. Other visual imagery interventions include animated videos (Vethanayagam & Hemalatha, 2010) and simple drawings or cartoons (Reinfried et al., 2012; Oluk & Özalp, 2007), which were proven to be more efficient in

terms of CC awareness creation/education. Innovation in ICT to address ecological and educational issues such as CC is apt.

Educational games have become practical tools for teaching and learning as it facilitates the acquisition of knowledge and interaction with learners in a playful, reality-grounded way, asserts Alves et al. (2021). In the age of ICT consciousness, using ICT mediums is an advantage. The use of technology such as remote sensing, GIS and satellite data technology has also proven to be very useful in knowledge acquisition in terms of awareness creation, understanding and confidence about CC issues (Cox et al., 2014).

Adult learner-centered approaches

Out of the total record of adult-centered interventions synthesised by Monroe et al. (2019), more than half represented adults in the formal school setting, such as college students, instructors or workers within the CC space, such as meteorologists. Regarding informal adult interventions, McNeal et al. (2014) indicated three (3) main factors as critical; respecting viewpoints, acquiring new information about CC and learning about others' perspectives on CC, especially faith-based views. Adults are, therefore, mostly seen to respond to CCE by protecting their identity and ways of life (Kahan, 2010). These remain valuable in conducting non-formal CC education/awareness creation.

Culturally-centered approaches

Culturally-centered approaches resonate with learning rooted in a group of people's unique culture, environment and history. The cultural context requires appreciating the uniqueness of the indigenous worldview as fundamental to learning (Roehrig et al., 2012). It enables instructors to discover traditional perspectives on climate education with the inspiration to improve educational outcomes (Monroe et al., 2019). Each culture has a fundamental being and understanding of nature, which existing CC awareness creation systems have failed to incorporate (Cajete, 1999, 1994).

Hewitt (2000) contrasts the western view with the indigenous view by highlighting that indigenous people accept that cooperation and coexistence with nature determine survival. The western view is mainly based on a reductionist view where there are attempts to harness and control nature. Ecology and environmental science are two bodies of science grounded in western science but viewed to provide more culturally compatible approaches to understanding the world and holistic to nature (Cajete, 1999).

The CYCLES approach is an innovation from NASA to enable instructors to discover traditional perspectives on climate education with the inspiration to improve educational outcomes (Roehrig et al., 2012). The CYCLES is a project targeted at American Indian students, and it was run as a programme to develop and implement culturally relevant approaches to teaching CC. CYCLES sought to strike the interconnections and similarities between native and scientific explanations of the natural world and climate (Roehrig et al., 2012). Therefore, culturally relevant approaches are of the essence in CCE.

Female-centred approaches

Scholarly works over the years have highlighted the critical role of women in the CC agenda vis-à-vis their disproportional vulnerability. As such, CC interventions were expected to highlight female-centred approaches to empower females to respond positively to the vagaries of CC, but this was negligible. Notwithstanding, Theobald et al. (2015) suggested that female students could better understand CC issues with local examples rather than global ones compared to their male counterparts. No key results were reported for females outside of the formal school setting in the systematic review conducted by Monroe et al. (2019).

Overall, Monroe et al. (2019) and Wibeck (2014) stress the importance of positive feedback on individual actions, locally and personally relevant framings of CC,

visibility and concretisation of CC-related issues and a focus on solutions rather than on catastrophic consequences of CC. Recurring approaches that serve as a valuable benchmark for this research are; experimental learner-centred, visual imagery and ICT-based, adult learners, female-centred and place-based approaches.

2.2.2 Constraints of Approaches to CCE /Awareness Creation

Constraints in cultural context, learners' age and opportunity to learn showed up in the programmes studied on CCE interventions. Additional barriers to CCE are that educators sometimes doubt their knowledge and skills to deliver it adequately, avoiding the topic altogether (Plutzer et al., 2016; Prokopy et al., 2015; Monroe et al., 2013). Some educators also reported being tagged with credibility issues at the community level as they embarked on CCE (Morris et al., 2014; Tyson, 2014). Credibility becomes a challenge because some of the factors that relate to the subject of climate and weather are subject to change. Forty-nine (49) studies on CCE strategies reviewed by Monroe et al. (2019) identified several themes for effective CCE. However, none of the reports used all of the themes integratively. Öhman & Öhman, (2013) suggest that a homogenous group may not necessarily represent the full range of alternative perceptions or views from the minority. Thus as much as what constitutes good education is known, the challenges of CC make it highly recommended to incorporate additional strategies in tackling such a politically nuanced system (Monroe et al., 2019). Considering the potential constraints, the outlined strategies guide the curriculum and teaching strategy choice.

2.2.3 Evidence of CCE /Awareness Creation in Ghana

The Ghanaian context to CC education/awareness creation has been limited to three (3) main approaches, namely, an addition to the curriculum, awareness creation of farmers by extension workers and through various media outlets (Odonkor et al., 2020;

Sarfo et al., 2018; Boateng, 2015; Codjoe et al., 2013). Ghana's Climate Change Policy further reveals the limited focus on non-formal education and community awareness creation, especially for actors within climate-sensitive sectors (MESTI, 2013). The Ghana National Adaptation Framework highlights the need for gender-responsiveness and community-based adaptation approaches as part of the six (6) adaptation approaches to guide CC adaptation in the country. In addition to the six approaches, there has been a call for a national communication strategy (Antwi-Agyei, 2019). The lack of a national climate change communication strategy has been ascribed to be responsible for the knowledge gap in the country. The need for a comprehensive National CCC Strategy has been equally stressed by MESTI (2013).

Within Ghana's microscopic community-level CCE and awareness creation, there is little indication of a specific gender and cultural context. The Ghana Climate Change Policy and the National Climate Change Adaptation Strategy highlight the gender dimension but have remained at a superficial level where male and female representations are used to check the box to represent gender considerations (UNEP & UNDP, 2016; MESTI, 2013). Indeed, most of these strategies incorporate women whom literature has established to be most vulnerable. The call for gender equality has been emphasised at all levels, especially with the development of the recent CC and gender policies and plans (Antwi-Agyei et al., 2021b, 2021a, 2021c). However, what remains unclear is the specific approaches used to target informal audiences and how awareness translates into effective climate action for resilience.

Additionally, broader socioeconomic and power relations that control access to economic, productive resources and information needed by households to tackle the risk associated with a changing climate are not readily available, especially for women (Djoudi et al., 2013). Thus, in Antwi-Agyei et al. (2020) study on predicators to access

and willingness to pay for climate information services in northern Ghana, it was revealed that men have greater access to radio devices which serves as key medium for CC awareness creation and information. The study further suggests that males have more access to the weekly and monthly weather forecast than their female counterparts (Antwi-Agyei et al., 2020). The disparities in access to climate information against women thus add to the need for intrinsic efforts at targeting women, especially rural women, in the area of CC awareness for resilient livelihoods.

2.2.4 Recommendations for Improving CC Awareness

UNESCO (2017) have stated that CCE outcomes should be looked at in a three-prong frame, i.e. cognitive, socio-emotional and behavioural. This coincides with the three stages of situational awareness of perception, comprehension and projection of the future, influencing decision-making and action (Endsley, 1995). Kagawa and Selby (2010) thinking on CCE, as presented by Reid (2019), is still relevant in structuring an effective communication strategy for CCE. This thinking is encapsulated in the following postulations;

1) Education is effective in allying with the horrendous conditions of CC by targeting the root causes

2) A multidisciplinary and interdisciplinary framework for CCE is essential

3) A global climate justice education is a prerequisite for an ethical and an appropriate response

4) The scope of an educational response should be both local and global

5) CCE must be a holistic learning process in a socially relevant context

6) There is a need for an urgent and radical rethink of the uncertainty and invisibility of CC by educators in the CC space.

To build capacity on CCE, the appropriateness of structures, models, programmes, and communications are critical points of call (Cantell et al., 2019). A primary resource for learning is the learner's local environment and community in the context of a place-based approach to learning. A place-based approach to CCE maintains a sense of place and culture in the land (Roehrig et al., 2012). Materials and programmes should be learner-centred, where learners create their understanding and learn new skills through hands-on, inquiry-based learning opportunities (NAAEE, 2004). The goal of CCE should be to provide scientific facts, build problem-solving skills, and build competence in climate action and advocacy (McNeal et al., 2014; Stevenson, 2007; Mappin & Edward, 2005). A mixture of all these goals is thus essential to combat CC aptly. Therefore, CCE (design and implementation) must consider balancing knowledge provision and integrating the cultural ideologies that influence perception and learning (Guy et al., 2014).

2.3 Theoretical Review

A theory is a tool for interpreting, criticising and unifying established laws, modifying them to fit data, and guiding the enterprise of discovering new and more powerful generalisations (Ornstein & Hunkins, 1993). This section, therefore, reviews theories that relate to key concepts in this research. Specifically, concepts relating to environmental awareness, adult education techniques, and women empowerment at the grassroots are reviewed. The study considers the following theories as relevant for review;

- The Situational Awareness Model (SAM) that is related to environmental awareness
- Andragogy related to adult learning
- Gender transformative theory related to women empowerment at the grassroots

2.3.1 Situational Awareness Model (SAM)

Numerous researchers have substantially researched CC awareness in the context of behavioural psychology and perception from an attitudinal point of view, drawing on behavioural response and subjective norms (Yuriev et al., 2020; Yandong Wang et al., 2019; Taufique & Vaithianathan, 2018; Masud et al., 2016). In light of the above, psychometric approaches have been utilised, drawing on theories such as the Theory of Reasoned Action (TRA), which was later developed into the Theory of Planned Behavior (TPB) and the Model of Responsible Behavior (MORB) (Ajzen, 2001; Ajzen & Fishbein, 1980).

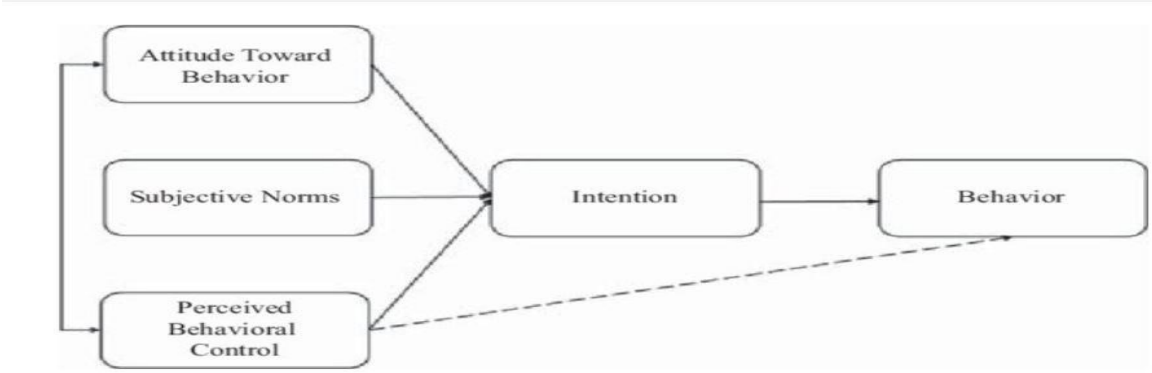

Figure 2.2 **Conceptual Framework of the Theory of Planned Behaviour**
Source: Adopted from Ajzen (2001)

TPB, the most commonly used theory, discusses the subject of perception from the intent to act stemming from three key variables; attitude, subjective norm and

behavioural control (Ajzen, 2001). Endsley (1995a) presents an alternative model – Situational Awareness (SA), that suggests that a person's decisions and actions (behaviour) are first influenced by their awareness. Awareness is presented at three (3) levels, i.e., perception of the current state of the environment, the comprehension of the meaning and significance of elements perceived, and then the conceptualisation of the future environment known as projection. Thus, whereas Endsley seeks to measure awareness and how it influences behavior and actions, Ajzen's TPB measures attitude and how it reflects behavior.

This research conjectures that a person's perception and understanding influence their behavior (action) and consequent attitudes and finds the situational awareness model most suited for the research. More so, this research aims to assess awareness, its effects and possible policy directions to enhance sustainable outcomes and not necessarily assess respondents' behavior and attitudes. The TBP over emphasized behavior and attitudes and subsequently became its limitation. Stern (2000) corroborates this limitation of the TPB by highlighting its over-emphasis on attitude, whiles CC-based actions are mostly knowledge and skills related. Additionally, Endsley's SAM is preferred over Ajzen's TPB as the former allows for continuous feedback for improvement, unlike the latter, which terminates at the behavior point of the target respondent (see Figures 2.2 and 2.3).

The SAM is a decision-making and performance model that suggests that for individuals to take positive action that brings about the required changes, environmental conditions are crucial (Nini, 2020). Endsley's model involves an appreciation of the components of the environment within the volume of time and space, what they mean in terms of their understanding, and a projection of its state in the near future. The SAM by Endsley (1995) breaks down awareness into perception, comprehension, projections

and resultant actions. The first level is perception which tells how an individual opines and discerns the elements in the environment. This feeds into the next level of comprehension, where a synthetization process takes place and the perceived environment is analysed and evaluated. The outcome of comprehension leads to the next level of projecting the future state of the environment, thus allowing one to make a decision and take action (Nini, 2020; Endsley, 1995). For behavioural change and transfer of technology to be successful, within a measure of time and space, the perception of the elements in the environment, the comprehension of their meaning and the projection of their status in the near future must exist (Flin et al., 2017; Koskinen-Kannisto, 2013; Stanton et al., 2001; Endsley, 1995). Various authors have applied this model in CC and environmental studies in assessing effective communication, comprehension and uptake of commensurate actions (Laurila-Pant et al., 2023; Ogunbode et al., 2019; Onencan & Van de Walle, 2018).

Farmers' major decision-making and action points in the CC space are to either mitigate or adapt to the vagaries of CC. The Situational Awareness Model, however, details that such decision actions are premised on what farmers perceive via sensory stimuli and what is taught to them, i.e. knowledge base. Perception is then transferred to the level of comprehension, which conceptualises what is perceived. Comprehension thus moves from perceiving the existence of CC to appreciating its impact on related activities such as crop production, biodiversity and forest resources and socioeconomic and cultural issues. With this depth of comprehension, farmers thus project their concept of the environment. It is when all three levels of awareness are settled that farmers decide on what actions to take concerning their livelihood in terms of mitigating the effects of CC and adapting to the current condition

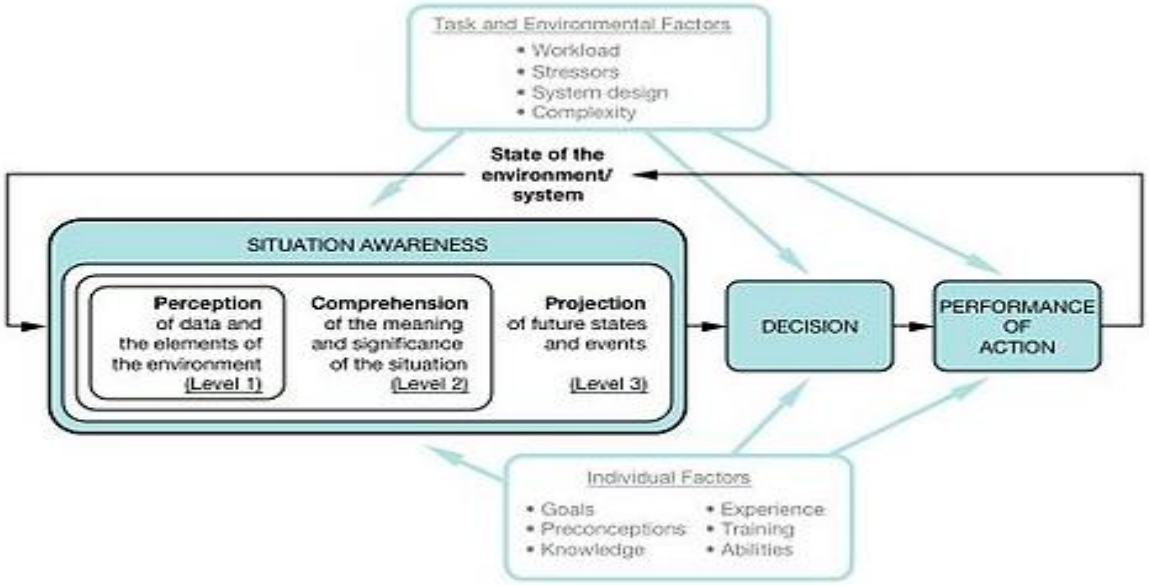

Figure 2.3 **Situational Awareness Model (SAM)**

Source: Endsley (1995)

As a cyclical model, the actions taken determine the state of the environment and feed into the three levels of awareness for continuous enhancement in awareness levels. The model further suggests individual and external factors influencing situational awareness, such as stressors, workload, knowledge, experience and training. These are important because they serve as an enabling environment for developing optimum awareness. The Situational Awareness Model has been identified as useful in conceptualising CC awareness (Ogunbode et al., 2019; Onencan & Van de Walle, 2018).

2.3.2 Andragogy –Adult Learning Theory

In 1980, Malcolm Shepherd Knowles introduced the term andragogy, synonymous with adult learning in the spirit that adults learn differently from children (Knowles, 1984). He defined andragogy as the art and science of helping adults learn as opposed to pedagogy which is the art and science of helping children learn. According to Houle (1996), the most learner-centred approach to adult learning is andragogy, a valuable

guide for facilitating non-formal education. Knowles's theory of adult learning operates by the following assumptions;

- Self-concept – adults are at a mature developmental stage, which gives them a more secure self-concept than children. The self-concept of adults allows them to take part in directing their learning.
- Past learning experience – adults have a vast array of experiences that must be drawn on as they learn, unlike children who are now gaining new experiences.
- Readiness to learn – many adults have reached a point where they see the value of education and are ready to be serious about and focused on learning.
- Practical reasons to learn – adults are looking for practical, problem-centred approaches to learning. Awareness creation approaches must, therefore, be practical.
- Internal motivation – innate self-motivation of adults should be tapped.

The five critical assumptions of andragogy must be critically assessed in a context-specific way as they remain assumptions and may not remain valid for all adults. Furthermore, Knowles (1984) expressed the importance of four key principles that must underpin the above-stated assumptions;

- Since adults are self-directed, they should have a say in the content and process of their learning.
- Due to adults' wealth of experience, adult learning should focus on adding to previous knowledge and drawing on their experiences for collective learning.
- Since adults seek practical learning, content should focus on work or personal life issues.

- Additionally, learning should be centred on solving problems instead of memorising content, as adults are relevance and goal oriented.

In practice, andragogy requires a focus on the process and much less on the content being taught. Teaching strategies such as role-playing, case studies, self-evaluation and simulations are most helpful. The teacher or instructor here is a facilitator or resource person rather than a lecturer or grader (Culatta, 2021). This theory is useful in designing any adult-centred learning approach, especially in the non-formal setting to achieve maximum results (Kearsley, 2010).

2.3.3 Gender Transformative Approach

The positive impact of gender equality, where women generally have much greater access to work, income, education, better health and enhanced mortality, has been highlighted (Majid & Siegmann, 2021; Kabeer & Natali, 2013). However, in the face of gender-based violence and inequalities, lower labour productivity, lower child health and nutrition, poorer educational outcomes, and poorer economic growth from household to community and national levels exist (Kabeer & Natali, 2013; Morrison & Orlando, 2004). Kabeer & Natali (2013) further argue that more significant gender equality measures promote sustainable development. However, the flip side of the equation, which suggests that economic growth automatically fosters gender equality, does not hold (Kabeer, 2016).

In light of this, UN Women (2013) has called for a particular lens on supporting women's rights and gender equality by paying attention to how different gender groups are affected by developmental efforts. Mainstream approaches to women's economic empowerment have been criticised for not targeting the social, political and market systems that are not neutral but structured to deepen the social inequalities that shape them (Cornwall, 2014; Razavi & Miller, 1995). The issue of 'add women and stir'

without transforming the entrenched social, political and structural dimension of gender inequality tends to deepen gender injustice which intensifies poverty and prohibits social development, as asserted by Cavalcanti & Tavares (2016), Kabeer & Natali (2013) and UN Women, (2013).

A gender-transformative approach challenges gender inequalities by targeting the transformation of structures and power dynamics that entrench the inequalities, thus allowing for women's social improvement (Hillenbrand et al., 2015). A Gender Transformative Approach (GTA) goes beyond the mere symptoms of gender inequality to address the root causes embedded in social norms, behaviours, attitudes and social systems (CGIAR Research Programme on Aquatic AgriculturalSystems, 2012). Rottach et al. (2009) put it this way; a GTA engages groups to examine critically, question, and challenge existing gender norms and power relations perpetuating gender gaps, the root causes embedded in social norms, behaviours, attitudes and social systems. Hillenbrand et al. (2015) and Morgan (2014) support the GTA by presenting three broad domains of empowerment that are important to measure transformative change. They are listed hereunder;

- Agency: individual and collective capacities (knowledge and skills), attitudes, critical reflection, assets, actions, and access to services
- Relations: the expectations and cooperative or negotiation dynamics embedded within relationships between people in the home, market, community, and groups and organisations
- Structures: the informal and formal institutional rules, individual and institutional practices, such as environment, social norms, recognition and status.

Other authors have reverberated that to achieve effectiveness; approaches have to focus on individuals as the catalyst for empowerment; thus unleashing the potential of

women as drivers of economic growth and superior investors in savings, health and education (Cornwall, 2014; Razavi & Miller, 1995). Hillenbrand et al., (2015, p.5) highlights four dimensions of power in GTA;

- "Power over", defined as control over people, resources and others' lives - the most commonly addressed form of power.
- "Power to" seen as power to act and realise one's aspirations, which are measured in terms of individual skill, capabilities and self-confidence.
- "Power within", which refers to a person's self-awareness, Self-worth, Self-knowledge and aspirations shaped by social norms and gendered institutions.
- "Power with", which is collective and collaborative power with others through mutual support, collaboration and recognition and respect of differences.

Therefore, the kind of change GTA aims at is context-specific, highly ambitious, hardly progresses linearly, and takes a long time to envision. It, therefore, calls for a perspective shift in what is ascribed to as a success. Measurement procedures are best conducted with outcome mapping and progress makers that assess incremental progress instead of endpoint or final product (Guijt, 2008). Batliwala & Pittman (2010) have highlighted the need for robust monitoring, evaluation and system learning tools. They further indicate the need for gender expertise that can measure and monitor risks, backlash against unanticipated changes and pushbacks associated with GTA and women's rights work. Participatory system learning is also essential in unpacking stakeholder experiences beyond initial plans and proposals, facilitating an active response to challenges (Tapella & Rodríguez-Bilella, 2014). Thus, GTA seeks to correct entrenched gender inequalities, which will not self-correct via business as usual (Hillenbrand et al., 2015).

2.4 Existing Gap in Literature

The literature review in the area of CC and education nexus for improved livelihood of women has brought very key highlights;

- The issue of CC as a concept is well documented in all its scientific and socioeconomic dimensions and impacts.
- The concept of vulnerability expressed as a function of exposure, sensitivity and adaptive capacity is measured qualitatively or quantitatively.
- Virtuousness, a moral response to CC, ensures environmental sustainability. Virtuousness falls within a continuum where the more environmentally virtuous one is, the more sustainability-conscious the person becomes.
- Women have been highlighted as more environmentally and climate virtuous and vulnerable than their male counterparts. There is a call to contextualise the vulnerability or virtuousness of the genders by identifying their unique context.
- The key tenants of resilient livelihoods are its assets and ability to absorb stress and maintain function while adapting, reorganising and evolving to better respond in the future.
- Again, most livelihood drivers, such as water and food, are women task dominated, which makes women important agents for livelihood sustenance, especially at the local levels.
- Many international bodies have attested to the indispensable role of CCE in harnessing behavioural change and its corresponding action to combat CC. Despite the above reality, the knowledge and awareness level of CC remains low, calling for much more extensive and intentional work in the area.
- Three key theories were reviewed relevant to the concepts being studied; i.e. Situational Awareness, Andragogy and Gender Transformative Approach.

- Situational awareness brings to bare a system's thinking approach where key environmental factors influence one's perception, comprehension and projection of the future, eventually leading to a decision-making point followed by an informed action. This theory is an essential guide to assessing the awareness of rural women on CC, as the process of measuring awareness is progressive and holistic.
- To embark on an educational approach, the target group is relevant in guiding the approach to be utilised. Indeed, pedagogical approaches have been highlighted regarding education/awareness creation. However, andragogy is an educational approach that primarily targets adults based on their unique characteristics of being practical, experienced, self-directed and goal-oriented, unlike children.
- The research's focus on women, especially rural women, draws on the Gender Transformative Approach, which primarily emphasises a need to address the power relations that hinder gender progression and empowerment.
- Empirically, approaches to CCE and awareness creation exposed numerous approaches with pros and cons. These approaches include experimental learner-centred, visual imagery and ICT (e-games), adult learners-centred, female-centred and place-based approaches.
- The localised context on approaches to CCE and awareness creation in Ghana has mainly focussed on additions to the curriculum, awareness creation through extension officers and the work of the media, especially the radio stations at the local level. The addition to the curriculum is limited by inadequate knowledge transfer or communication strategies. Context-specific approaches for women

farmers are also challenging due to capacity gaps among stakeholders in the CCE space, especially Agricultural Extension Agents.

2.4.1 Entry Points of the Research

1) A major gap is a lack of a communication strategy that serves as a roadmap in reaching the different stakeholders in the CC discourse namely, women, CC educators (including media groups), men, youth, etc. Thus, a suited framework for CC awareness creation at the grassroots level for women would be an essential contribution to knowledge and an indispensable gap bridger.

2) Much research on gender dimensions has focused on women's vulnerability, with almost negligible information on women's virtuousness, CC awareness and livelihood nexus. This research contributes to a holistic knowledge of the nexus between CCE, women's potential virtuousness and vulnerability for resilient livelihoods.

3) Geographically, the global south perspective on critical enablers and barriers to CCC and education is almost missing in the existing literature. This research, therefore, presents the global south perspective in the context of rural women farmers in Ghana. Specifically, a comparative approach is used to conclude similarities and differences between rural women from different agroecological zones.

2.5 Theoretical Framework

The literature review has revealed various concepts and theories that drive this research, coupled with insights from the empirical review. The key findings have been synthesized into a theoretical framework highlighting the interrelationship between various variables (Figure 2.5). Holistically, the research seeks to enhance the resilience of rural women farmers by introducing a context-specific CCE which takes into cognisance the culture and the ecosystem context (i.e. crop farming) whiles being gender

sensitive (rural women). This context-specific intervention should thrive on the pillars of andragogy, an adult-learner-centred approach. This context-specific intervention is intended to influence existing approaches in CC awareness creation.

This will further enhance the situational awareness of the target group on the scale of perception and comprehension of CC and the resultant climate actions taken. Ultimately, the power dynamics that influence societal norms and characterise rural women require transformation to enable women realise their potential as agents of change. The transformation of the power dynamics is also expected to influence women's access, ownership and control over capital assets, thus enhancing their adaptive capacity and resulting in resilient women farmers. Failure to transform the power dynamics in the face of existing CC hazard, will deepen the vulnerability of rural women farmers, which will require the application of the intervention.

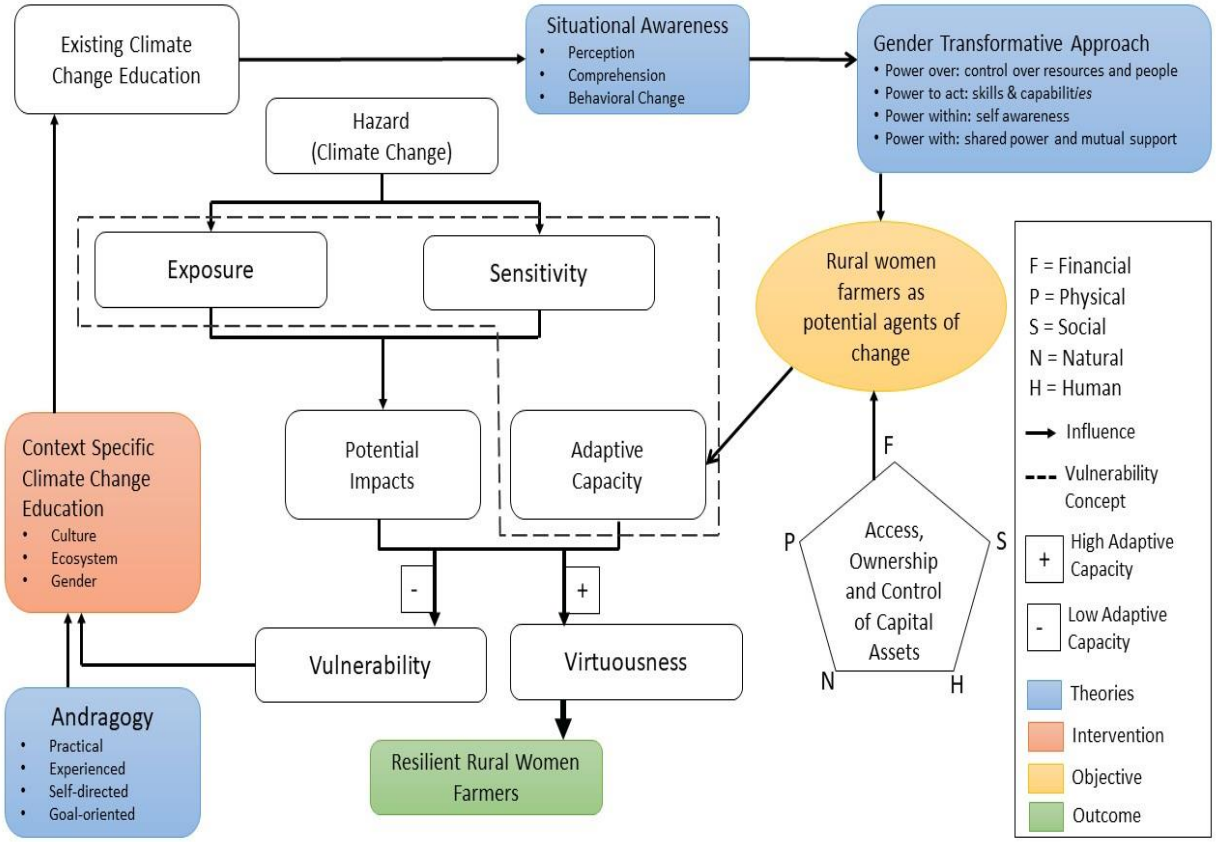

Figure 2.4 **Theoretical Framework**

Source: Adapted from Hillenbrand et al. (2015); Endsley (1995); Knowles (1984)

CHAPTER THREE

METHODOLOGY

3.1 Research Design

A pragmatic philosophy was employed for this research based on the assumption that reality can be studied through multiple approaches. The pragmatic view maintains that reality may be viewed from various angles, allowing researchers to choose the method that best addresses the issue they are studying (Creswell & Creswell, 2018). Therefore, multiple approaches were used to achieve the objectives of the study. The pathway for achieving the research outcomes is expressed in an onion-like diagram where each ring highlights the procedure for engaging in the research [Figure 3.1] (Saunders et al., 2019). Multiple approaches benefit CC research due to their complex and multifaceted nature. The use of multiple approaches to data collection curtails the limitations associated with singular methods, such as limited details, low response rate, and expertise with proper tool usage (Easterby-Smith et al., 2015). There is a greater diversity of views, triangulation of data and enhanced confidence in findings from a mixed method. Both quantitative and qualitative methods were harnessed to draw data for the objectives set to strengthen the resilience of rural women farmers through effective CCE pathways.

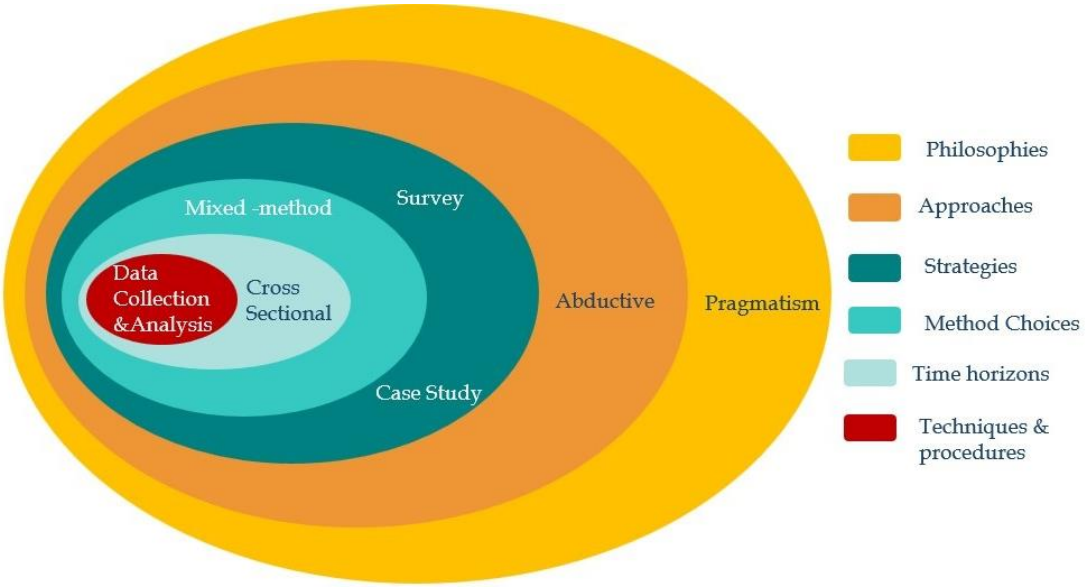

Figure 3.1: The Research Onion

Source: Adapted from Saunders et al. (2019)

The research onion in Figure 3.5 is adapted from Saunders et al. (2019) to reflect the specific details engaged in this research.

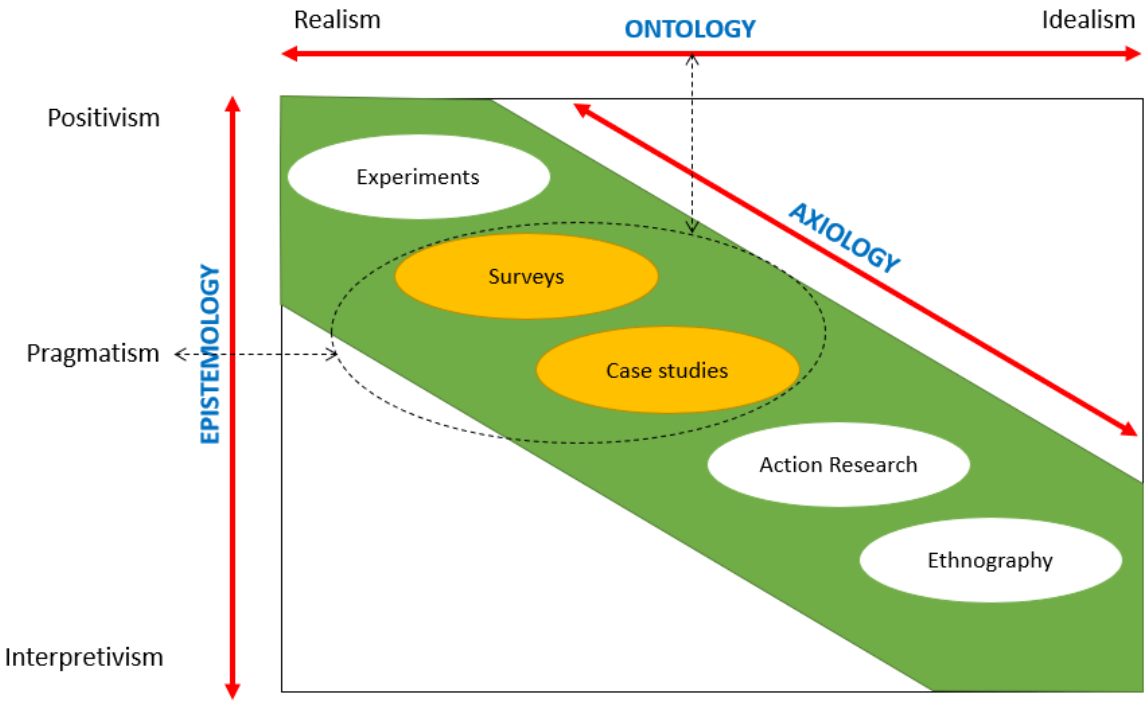

Figure 3.2: Continuum of Research Strategies

Source: Adapted from Sexton (2003)

With a focus on pragmatism, survey and case study strategies were used in this research (Figure 3.2). The survey and case study strategies align with the study's epistemology (knowledge accessed through multiple means) and ontology (functions from an objective and subjective point where both approaches complement each other). Within the axiological continuum, survey and case study strategies allow for both quantitative and qualitative data collection approaches, most suited for a mixed method. A case study approach considers many methodologies and aids in learning in-depth information and is most appropriate when the distinction between the phenomenon under study and the context is not apparent (Yin, 2018). In this regard, the impact of CC on the livelihoods of rural women farmers and their knowledge of the phenomenon is a lived reality whose boundaries cannot be distinguished. However, Yin (2018) has noted flaws such as generalization issues, a lack of rigour, and biases in case studies. This research selected two cases from Ghana with diverse AEZs. The choice of multiple cases augments the advantages of numerous sources of proof and replication of outcomes (Saunders et al., 2019; Yin, 2018). The time horizon for the study is cross-sectional, as the survey was conducted within a specific timeframe and not over an extended period. A cross-sectional study was conducted because the research seeks to assess the nature of the present state of CCE among rural women farmers and the impact on their livelihoods.

3.2 Area of Study

Ghana is classified as a low-middle-income country on the West African Atlantic Coast. Geographically, Ghana is located between latitudes 4.5^{o}N and 11.5^{o}N and longitudes 3.5^{o}W and 1.3^{o} E, bordered to the West by Cote d'Ivoire, Togo to the East, and the North by Burkina Faso. Ghana is governed through sixteen administrative

regions (Figure 3.3) and categorized into seven (7) AEZs characterized by unique vegetation cover, climatic and soil types as shown in Figure 3.4. The AEZs are Sudan Savannah, Guinea Savana, Transitional, Deciduous Forest, Moist Evergreen, Wet Evergreen and Coastal Savannah (Bessah et al., 2022; Ghana Statistical Service, 2021; FAO, 2005)

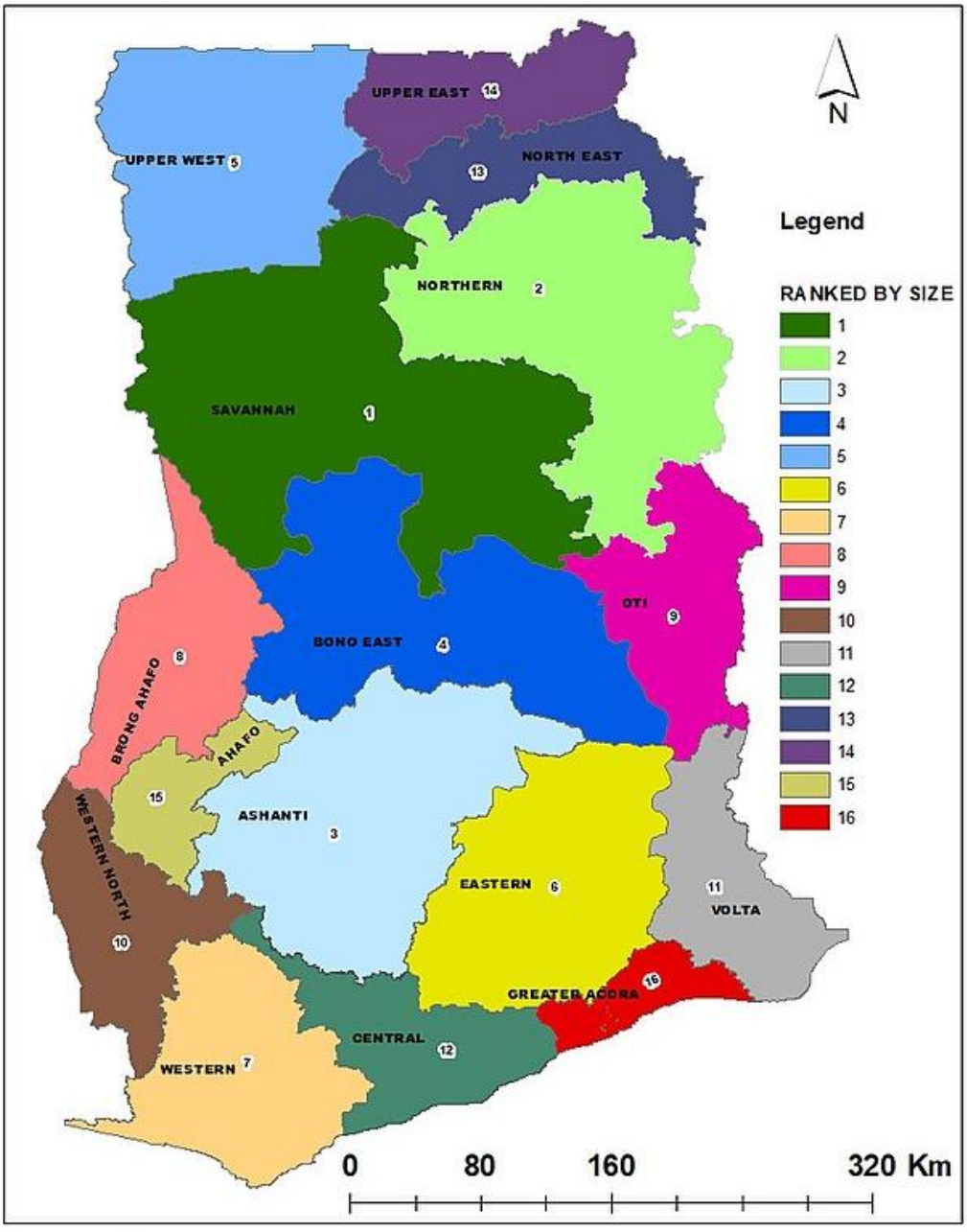

Figure 3.3: Administrative Regions of Ghana

Source: Sako.com (n.d)

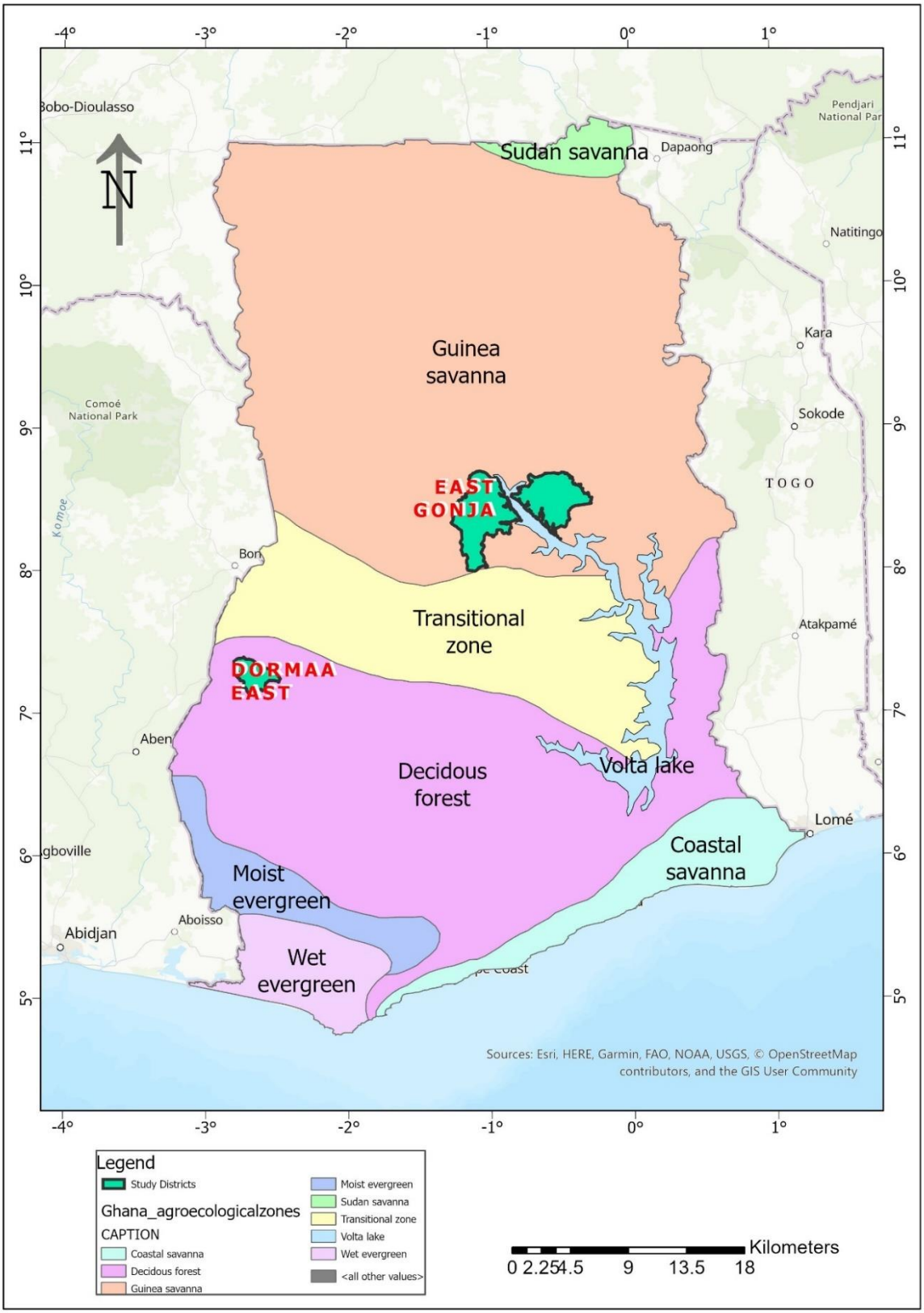

Figure 3.4: Map of Ghana showing AEZs

Source: Author's construct (2022)

Ghana has an estimated 13.5 million hectares of agricultural land, with approximately half of this land under cultivation and 222,978 hectares of agricultural land under irrigation. The agricultural sector in Ghana is divided into four main sectors - crops, livestock, fisheries and forestry (Ghana Investment Promotion Centre [GIPC], 2021). Ghana is located within the tropical climatic zone with an average annual temperature range from 26.1ºC within the coastal region to 28.9 ºC closer to the extreme North. On scorching days, temperature could rise to 40ºC in the North. The weather in the southwest corner is usually hot and humid, while it is hot and dry in the North (GIPC, 2021). Ghana's agriculture largely depends on rainfall's volume, intensity and distribution. There are two main rainfall seasons in the southern part, while the northern part of Ghana has one primary rainy season. The rainfall patterns in the country shape the planting season (major and minor seasons). Ghana has a total land area of 238,533 square metres and an average household size of 3.6 persons. The household size in rural Ghana is slightly larger than the national average (4.0). Ghana's population has increased from 24,658,823 in 2010 to 30,832,019 in 2021with a 2.1% annual intercensal growth rate (GSS, 2016).

3.3 Population of the Study

The target population of the research is rural women farmers who play instrumental roles in food security and livelihood sustenance in Ghana's local economy (Ghana Statistical Service, 2020). Again due to the triple roles of women (reproduction, production and community management), their activities cover a broad spectrum of CC-related sectors such as energy, food, water, forest cover and biodiversity (Tantoh & McKay, 2020). Furthermore, the gender roles and norms in society limit women's access to crucial livelihood capital such as land and climate-smart information, deepening

women's vulnerability to CC and its attendant socio-economic challenges (Abdul-Razak & Kruse, 2017; Bessah et al., 2021).

Women account for 50.7% of Ghana's population, while 49.9% dwell in rural Ghana. Women account for about 39.0% of the farm labour force in Ghana (GSS, 2021). This research targeted rural women farmers within the economically active age group of 15 to 65 years. The study focused on Ghana's two largest AEZs; the Guinea Savanna and Deciduous Forest. The districts with the highest CCVI within the AEZs, East Gonja (n = 0.35) and Dormaa East (n = 0.05), were selected (EPA, 2020). Two cases were studied for comparison, where cases were explicitly contrasted against each other for parallels or differences in outcomes, as explained by Azarian (2011), who highlighted the value of comparative studies.

3.3.1 East Gonja District

East Gonja (EG) District is situated in the north-eastern part of Ghana, bordered to the North by Yendi and Tamale Districts, west by Central Gonja District, east by Nanumba-North and Nanumba-South and south by Volta and Brong Ahafo Regions. EG District is located in the Savannah region, with Salaga as its administrative capital. The EG District is found within the geographical coordinates between longitude 0.29^{o}E & 1.26^{o}W and latitude 8^{o}N & 9.29^{o}N. It has a land area of 10,787 square kilometres, representing about 15.3% of the total landmass of the Northern Region (MoFA, 2022). It records an annual rainfall of 1,100 mm with a uni-modal planting season between 180 to 200 days. Its primary land use system is annual food and cash crops, mainly maize, sorghum, yam and livestock. It practices a patrilineal cultural system, with approximately 49.0% of the population being women (GSS, 2014a). The population of the Municipality is 117,755, disaggregated into 60,199 males and 57,556 females (GSS, 2021). Additional characteristics of the District is presented in Table 3.1.

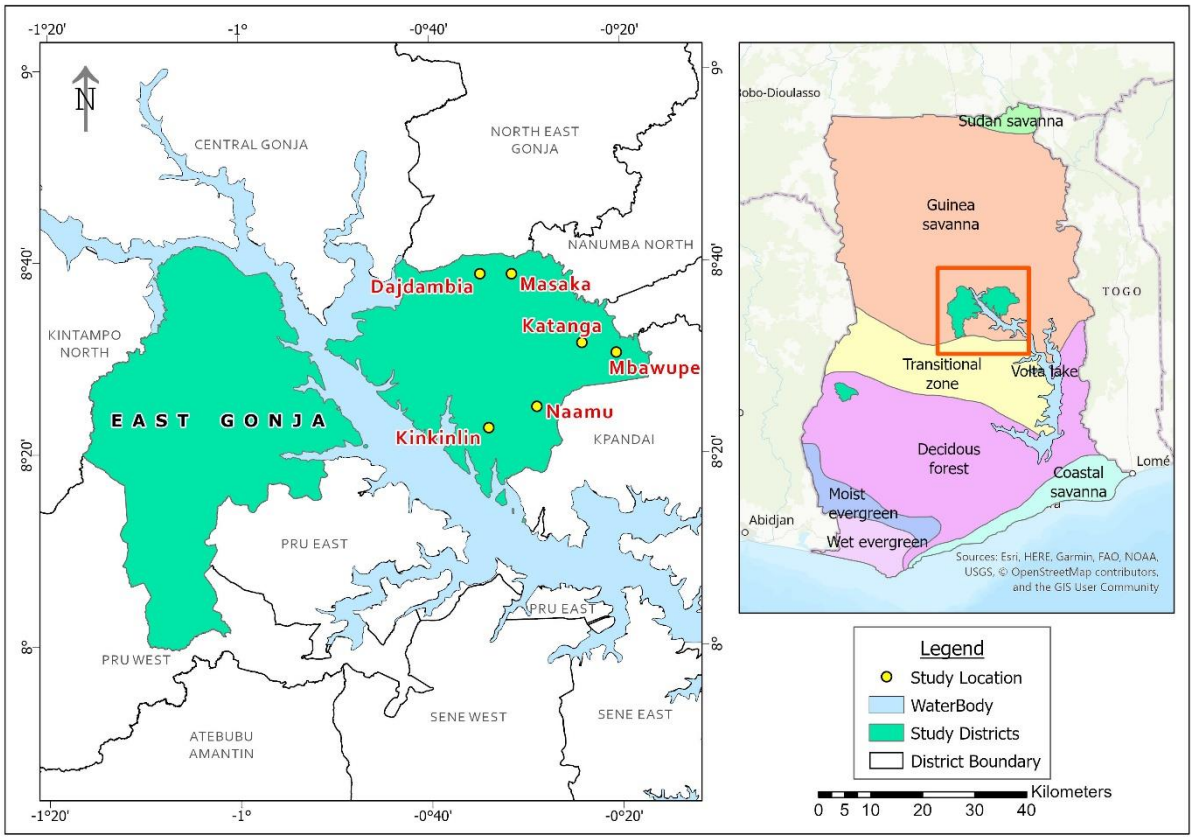

Figure 3.5: District Map of East Gonja showing Study Locations

Source: Author's construct (2022)

3.3.2 Dormaa East District

Dormaa East (DE) District is one of the 29 administrative districts in the Bono Region, with Wamfie as its district capital. DE District is located in the South-Eastern part of Ghana, bordered to the North by Berekum Municipal, West by Dormaa Municipality, East by Sunyani West and South by Asunafo North and Asutifi Districts. DE is situated between longitudes 2.35^0 West and 2.48^0 West and latitude 7.80^0 North and 7.25^0 North, with a land area of 541 square kilometres (MoFA, 2022). The total land area of the DE District is 456 Square Kilometres representing about 1.18 percent of the total land area of the Brong Ahafo Region. The District has a bi-modal planting season; the primary planting season is between 150 and 160 days, and the minor season has 90 days. There is, however, a pronounced dry season from the latter parts of November to

the end of February. The dry season is accompanied by a relative humidity between 75 - 80 and 70 - 72 percent for remaining months of the year (MoFA, 2022).

The GSS report suggests that 80.0% of households are involved in agriculture, with 90.0% residing in rural areas(GSS, 2021). Crop farming is the predominant livelihood for 60.0% of the population, accounting for 30.0% of internally generated funds in the District. The central land use systems are forests and plantations, with roots and plantain being the main food crops. Regarding vegetation, extensive cultivation is transforming the forest into grassland. The primary occupation in the District is agriculture, forestry and fishery sector (67.2%), contributing to food crops, livestock and cash crops (MoFA, 2022). The population of women in the district is 53.0%, with a matrilineal cultural system (GSS, 2014b). DE has a population of 67,899, with 33,336 males and 34,563 females. Additional characteristics of the District is presented in Table 3.1.

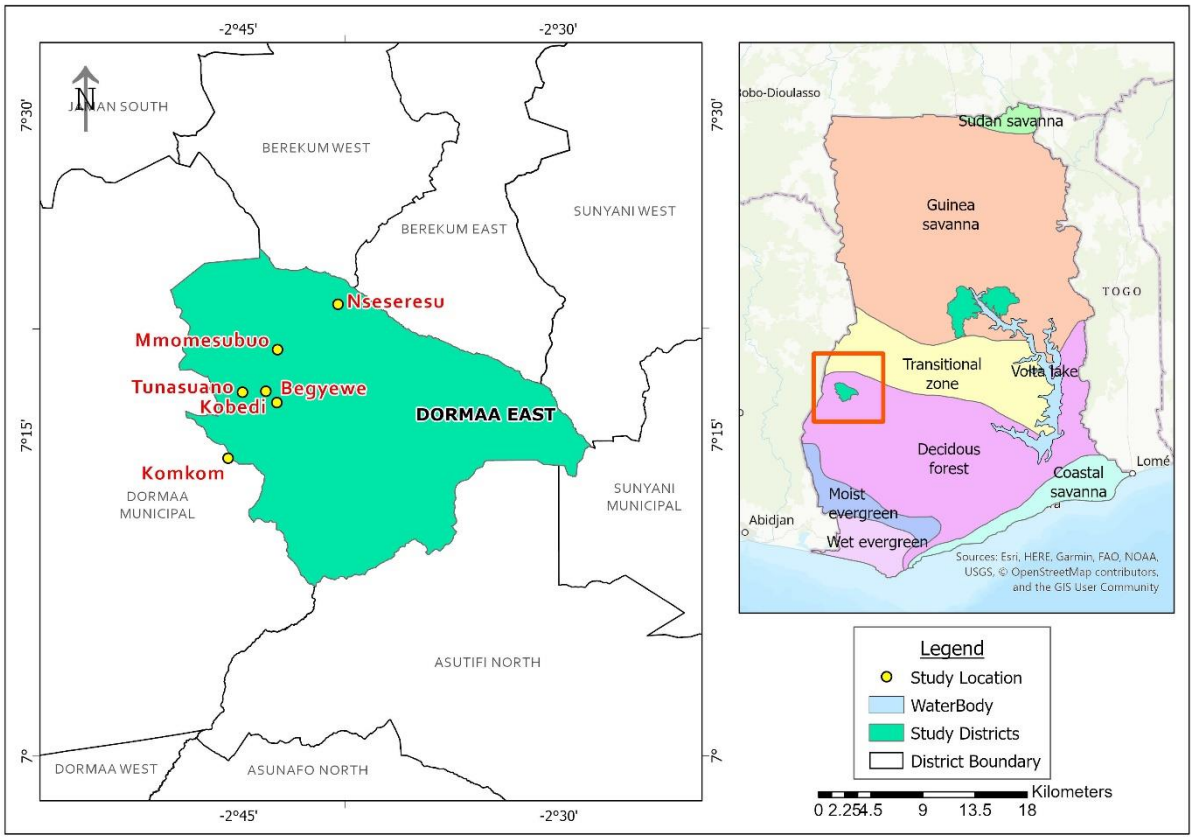

Figure 3.6: District map of Dormaa East with Study Locations

Source: Author's construct (2022)

Table 3.1 Characteristics of the Study Area

Item	Guinea savannah	Deciduous forest
Agroecological land size	Largest	2nd Largest
Selected district	East Gonja	Dormaa East
CCVI per district	0.37 (highest in the AEZ)	0.05 (highest in the AEZ)
Climatic region	East semi equatorial	Tropical continental
Average temperature (^{0}C)	29 -40	26 -30
Rainfall (mm/yr)	1,100	1,500
Planting season	Uni-modal (180 – 200 days)	Bi-modal (Major 150 -160 days; Minor 90 days)
Main food crops	Annual food and cash crops, livestock, sorghum, maize	Forest, plantation, roots, plantain
Major livelihood activity	Agriculture (crop farming)	Agriculture (crop farming)
Cultural system	Patrilineal	Matrilineal
Proportion of women	49.0%	53.0%
Average rural household size	5.1	4.1

Source: Environmental Protection Agency (2020); Ghana Statistical Services (2014a); Ghana Statistical Service (2014b)

3.4 Sampling Technique and Sample Size

A multi-stage sampling approach with probability and non-probability methods at different stages was used for the study. The different stages of sampling are subsequently discussed.

3.4.1 Selecting the Study Communities

The MoFA directorates at the selected districts are divided into four zones; three rural and one urban for operational efficiency. The study, therefore, purposively selected the three rural zones due to the focus on rural women farmers and for a representative sample. In consultation with Agriculture Extension Agents (AEAs), who work closely with farmers, two communities were selected from each rural agricultural zone. Key factors considered in determining the communities were accessibility to the communities, availability of AEAs to facilitate community entry and its related protocols, time and budget limitations. Twelve rural communities, six per district, were sampled for data collection. In the EG District, Mbawupe, Kinkinlin, Naamu, Dadjambia, Masaka and Katanga were selected, and in the DE District, Komkom, Tunasuano, Nseseresu, Kobedi, Begyewe, Mmomesubo were chosen as the study communities (Figure 3.5 and 3.6).

3.4.2 Sample Size Determination

In the absence of a sampling frame for this target population, the proportion of women in the two selected districts was used as a proxy for calculating the sample size, as suggested by the Cochran formula for sample size calculation (Cochran, 1977). The Cochran sample size calculator is considered the most helpful for an unknown population. Utilizing the Cochran equation for calculating sample size, a total sample size of three hundred and eighty-five (385) was determined for each district (Appendix 2):

$$n_0 = \frac{Z^2 pq}{e^2}$$ Equation (1)

Where n_0 = sample size for unknown population

Z = z score. It is determined based on the confidence level. With a confidence level of 95%, the z score was = 1.96 (z score table)

P = percentage of population probability (estimated to be 50% = 0.5 for both districts)

q = q is 1 – p (1 – 0.5)

e = Margin of Error (MoE). With a confidence level of 95%, MoE will be 5% = 0.05

3.4.3 Selection of Respondents

A total sample size of 497 was interviewed from the field using purposive sampling. A purposive sampling was most suitable for this research as it focuses on a particular subgroup with similar characteristics – rural women crop farmers. Thus, at the community level, only women farmers were interviewed. With a more than fifty percent response rate from both districts (EG, 77.1%; DE, 56.6%), a total sample of 279 was interviewed from EG and 218 from DE. The response rate was higher in EG as women farmers would gather and wait for their turn to be interviewed upon receiving information on the study. The close connection between the AEAs and women farmers in EG facilitated the high response rate. The distribution of responses obtained from each community is presented in Table 3.2.

Table 3.2 Sample Size Distribution at the Community Level

District	Zone	Communities	Number of respondents
Dormaa East	Wamanafo	Kobedi	26
		Begyewe	18
	Asuotiano	Nsesereso	47
		Tunasuano	39
	Kyeremasu	Mmomesobo	48
		Komkom	40
Total			**218**
East Gonja	Kafaba	Dajdambia	25
		Masaka	28
	Kpembi	Mbawupe	45
		Katanga	85
	Makango	Kinkilin	74
		Naamu	22
Total			**279**
Grand Total			**497**

Source: Author's construct from Fieldwork (2022)

3.5 Types and Sources of Data Collection

For each objective, a mixed method was used to collect data; however, the extent of qualitative and quantitative methods varied from objective to objective. Objectives 1 and 2 emphasised quantitative data collection, while objective three focused mainly on qualitative data collection. Specifically, three main techniques were used to collect data, being a mixture of questionnaire-based surveys targeting women crop farmers, Focus Group Discussions (FGDs) and Key Informant Interviews (KII). Data collection procedures covering reconnaissance survey, training of research assistants, administration of questionnaires, FGDs and KIIs are subsequently discussed.

3.5.1 Reconnaissance Survey

In October 2021, a reconnaissance survey was conducted to facilitate entry into the study communities, contact key stakeholders, and pre-test the survey instrument for clarity, consistency and validity. Key stakeholders included the District Development Planning Officers, Directors of Agriculture, some key extension officers and Directors of Women in Agriculture. The district development planning officers of DE and EG were initially contacted and introduced to the aim of the research, who referred the team to the district MoFA office as the appropriate quarter for further interaction. Upon

further interactions, the director at MoFA handed the team to the director of extension services, who was briefed on the research coverage and requested to facilitate contact with the target population. An AEA who is very conversant with the communities was called upon to assist the team with community entry to familiarise and notify community leaders of the impending study.

In consultation with the director of extension and guided by the research aim, the AEA helped select the communities for surveying based on accessibility, time and budget constraints. Ten (10) survey questionnaires for rural women farmers, five (5) for each district, were deployed for the reconnaissance survey. The survey questionnaire was deployed on the kobo collect app for a more efficient and accurate enumeration of questionnaires and to allow for real-time data validation. This exercise facilitated fine-tuning some questions for clarity and consistency and was beneficial for the actual data collection exercise.

3.5.2 Training of Research Assistants

Four data collection assistants were recruited for the exercise to facilitate timely data collection (Appendix 4.1). The data collection assistants (all undergraduates) were trained for two days to ensure clarity and shared interpretation of all survey questions. The assistants were first taken through the research aim and the study's rationale. Again, survey questions were individually discussed on the meaning and how the questions are to be asked to avoid losing meaning when translated from English to the local dialect. The recruited data collection assistants had prior experience in data collection, with effective communication and writing skills. Irrespective of the experience of the data collection assistance, they familiarized themselves with the kobo collect app by interviewing each other through role-play. The principal investigator keenly monitored this process to identify errors or miscommunication. In EG District, however, three

additional assistants were engaged for translation due to the language barrier. Translators were people who understood the local dialect (Gonja) and English.

3.5.3 Administration of Questionnaire in the Study Area

This study's primary quantitative data collection method was through survey which relied on the use of copies of a questionnaire deployed on the Kobo Collect App. The Survey questionnaire was used to gather data from sample (n = 497). Although the questions asked were close-ended, provision was made for the 'other (specify)' option in some cases to make room for unlikely but possible options to be provided by respondents. Averagely, an hour 15 minutes was used to administer a survey questionnaire in the face-to-face level process in the selected communities. The field data collection took place in November 2021. Pictures of the data collection exercise are presented in Appendix 4.2.

All filled and submitted copies of the questionnaire on the app were deployed to the principal investigator instantly to accept or otherwise. This process allowed the principal investigator to review all copies of the completed questionnaire sent in for any errors before final acceptance. The two-step verification process served as a quality assurance mechanism for the data. In EG District, data collection assistants asked the question to the interpreter, who in turn asked the respondents in the local dialect. Feedback was then given to the research assistant in English to record. If feedback was out of place, it was interrogated by the research assistant to ensure clarity and appropriate interpretation of questions and answers.

3.5.4 Ethical Considerations

The standards of behaviour that guide a [researcher's] conduct concerning the rights of those who become the subject of [the researcher's] work or are affected by it are referred to as ethics (Saunders et al., 2019: p.252). Therefore, several procedures were taken to ensure that the standards of behaviour were not breached. The rights of

access were the first ethical consideration, ensuring that the appropriate quarters were contacted and the proper procedures of community entry were followed at all stages of the study. An official introductory letter from the University of The Gambia was sent to the District Assemblies and the MoFA offices to secure access to engage persons and institutions in the districts (Appendix 3). Facilitated by district AEAs, community members were well-informed about the study and were not surprised by the presence of the research team.

Again, because the target population were women farmers, who, in addition to their farming engagements, have other household duties, the data collection activity was undertaken at proposed hours convenient to the women to offer appropriate answers. Data collection was primarily conducted between 7 am to 9 am and evenings from 3 pm to 6 pm. The data collection team ensured they were present at the stipulated time so respondents could fully participate in the exercise. Additionally, consent was sought from the husbands to engage their wives in an interview where applicable. Face-to-face interviews were conducted in the respondents' communities in an open space accessible by others as a safeguard to both data collectors and respondents. The purpose of the survey (being purely academic) was re-echoed to all participants to avoid participant bias, where participants were tempted to give false answers for fear of being exposed or to attract some benefits.

Again, respondents were assured of absolute anonymity, whiles the provision of names was kept optional. Additionally, respondents were assured that they could withdraw from the interview at any time if it became necessary. Additional consent was sought from participants when audio recordings and photographs were taken, and any participant who felt uncomfortable was allowed to withdraw from these activities.

Finally, direct quotes used to enrich the study's results were kept anonymous, as was affirmed to participants.

3.6 Definition and Measurement of Variables

The choice of appropriate data requirements, indicating the operationalized variables, their corresponding indicators of measurement and data collection techniques are discussed in this section. Table 3.3. presents an objective specific definition of variables and their measurement.

Table 3.3 Objective-based Variables and Measurement

Research Objective	Variables	Indicators	Data collection method
1. Assess the situational awareness of rural women farmers from different AEZ on CC in Ghana	Perception	Knowledge of changes in climatic dimensions	A questionnaire-based survey targeting women farmers
	Comprehension	Understanding of the impact of climate change on crop production; biodiversity and forest resources; socio-economic and cultural factors	FGD
	Climate action	Mitigation actions Adaptation actions	
2. Measure the adaptive capacity of RWFs from different AEZs in Ghana	Adaptive capacity	Access to livelihood capitals (Human, Physical, Social, Financial, Natural)	A questionnaire-based survey targeting women farmers KII
3. Determine the impact of climate information on the adaptive capacity of RWFs in Ghana	CC information medium	Access to CC information medium	A questionnaire-based survey targeting women farmers
	Influence of climate information on access to livelihood capitals	Impact of climate information mediums on access to livelihood capitals	KII

4. Explore the state of CC awareness creation for RWFs in Ghana	Quality of CCE for RWFs	Reliability, Timeliness and Understandable information. Mandate, Achievements and Set-backs	A questionnaire-based survey targeting women farmers
	CCE institutional stakeholder analysis	Coproduction of Knowledge, Place-Based Engagements, Visual Imagery Techniques, Gender-Sensitive and Adult-Learner Friendly approaches	KII (institutions)
	Effectiveness of CCE approaches	Critical Enablers and Barriers to CCE for RWFs	
5. Propose an educational strategy for RWFs	Context-specific educational strategies for RWFs	Synthesis of critical enablers and barriers to CCE	A questionnaire-based survey targeting women farmers KII (institutions)

Source: Author's construct, (2022)

3.6.1 Instruments for Data Collection

<u>Survey questionnaire</u>

The survey questionnaire was divided into four sections, and the first was on the general background of rural women farmers. The general background was followed by the section on rural women farmers' awareness of CC and how it translates into effective climate action. Data were collected on the socio-economic status of women farmers, the perception of rural women farmers on CC and variability, the comprehension of the impact of CC and variability, and mitigation and adaptation actions a respondent undertook. A Likert scale ranging from one least association to five highest association was used to rate the situational awareness (perception, comprehension and climate action) of respondents. The third section of the survey questionnaire captured the capital assets available to rural women farmers for livelihood sustenance. Indicators for assessing capital assets, as used in other studies, are presented in Table 3.4.

Table 3.4 Indicators for Assessing Capital Assets in Literature

Livelihood capital	Capital asset indicator	Evidenced in literature
Natural capital	Access to land Land size Access to water Nativity	Kuang et al. (2019); Xu et al. (2019); Lax & Krug (2013)
Human capital	Marriage Household size Literacy Farm Labour Skill/knowledge upgrade Physical fitness	Sayer & Campbell (2003); Lax & Krug (2013); Fang et al. (2014); Nielsen et al. (2013)
Social capital	Membership of social groups Family support	Wang et al. (2021); Kuang et al. (2019); Lax & Krug, (2013); Vincent (2007)
Physical capital	Road network Electricity Market Potable water Health facility	Yang et al. (2021); Lax & Krug (2013) Zhang et al. (2007)
Financial capital	Credit Remittances Savings Financial control	Su et al. (2019) Liu et al. (2018) Lax & Krug, (2013)

Source: Author's compilation (2022)

The fourth and final section of the questionnaire focused on the access to CC and variability information, channels of access to CC information and quality of climate change and variability information received regarding timeliness, reliability and understandability.

Focus Group Discussion

The FGDs were conducted to draw depth and meaning from the quantitative data collected during the questionnaire-based survey. FGDs helped provide in-depth information on the subject and allowed participants to share opinions in a tolerant, open environment and reach a consensus (Krueger & Casey, 2015). FGDs were conducted with participants from the same agricultural zone. Thus six FGDs were done in all.

The FGDs were facilitated with a checklist (Appendix 1) which covered the general perception and comprehension of CC in terms of what it means and how it

impacts their livelihoods. Again, barriers to access to information and critical livelihood assets were also interrogated for discussion. The most appropriate mediums for accessing CC information were also discussed. Although a checklist was provided as a guide for discussions, participants could expand and draw in other relevant issues not necessarily provided by the checklist. There was, however, a keen effort to ensure that the discussion did not stray from the main objective. In cases where digression occurred, the moderator respectfully drew participants back on course by indicating that the issue would be a subject for discussion on another day. Participants for the FGDs were purposively sampled from the questionnaire-based survey respondents who showed maximum cooperation, depth of understanding during the survey and were willing to participate. A session of the FGD was made up of between 8 to 10 participants and was undertaken within approximately an hour.

FGDs were done outside the community at a centralized location in Kyeremasu in DE District and the District MoFA office in EG. FGDs were conducted outside the communities to avoid distractions and interruptions from respondents who were not selected for the FGD. Meeting participants outside their communities was essential to prevent crowding, which would affect the effectiveness of the FGD. FGDs were facilitated by the principal investigator and moderated to encourage participation by all and to avoid dominance by a few participants. In this regard, every participant was allowed to share a thought on the topic for discussion. Particularly pointing to specific participants to share their thoughts on what others have expressed was also valuable for encouraging participation. As in every group dynamics, one or two dominant members always attempted to overshadow the discussion. Practically such individuals were sometimes requested to hold on to their suggestions for a while so others could express themselves. Participants were accompanied by their zonal AEAs, who helped facilitate

commuting to the venue for the FGDs. Data collection through FGDs was also conducted in November 2021 after the survey data was collected in the respective districts. Pictures of FGDs are presented in Appendix 4.3.

Key Informant Interviews

KIIs were also conducted for key stakeholders in CCC and CCE from local to national levels, including Civil Society Organisations (CSOs). At the national level, representatives were contacted from the MESTI / EPA and MoFA. MoFA and EPA were targeted due to their instrumental role in policy formulation, coordination, training and providing support to the farmers on CC adaptation and mitigation. At the local level, district directors of MoFA, the directors of extension at the districts, zonal AEAs, and directors of Women in Agricultural Development (WIAD) for the two selected districts were consulted for interactions. SEND Ghana in the EG District was identified as a resident CSO engaged in gender, agriculture and CC dynamics.

Data were collected using a semi-structured interview guide (Appendix 1). Data requirements were on the mandate of stakeholders regarding CCC and CCE, strategies adopted in targeting women farmers on the score of co-production of knowledge, visual imagery and ICT (E-Games), adult learner-centred, place-based and gender-sensitive approaches; availability of a curriculum for climate change training and education; significant challenges in their operations and recommendations for improving climate change communication and training for better uptake of climate-smart technologies for women farmers.

Interviews were conducted by the principal investigator supported by a research assistant who took care of notes taking in addition to an audio recording. Interviews with experts lasted forty-five (45) minutes to one and a half hours. Pictures of expert interviews are presented in Appendix 4.4.

3.7 Validity and Reliability of Research Instrument

Essentially, a reliability test was conducted using the SPSS for internal consistency. A Cronbach Alpha coefficient of 0.774 (Figure 3.7), within the documented threshold of 0.7 and above, validates the data collection instrument's internal validity (Pallant, 2020). The research supervisors further peer-reviewed the data collection instrument, and a reconnaissance survey was conducted to validate the instrument further. The methodological rigour and accuracy of data collection tools and analysis were also considered to ensure the validity and reliability of the data collected and the results attained (Saunders et al., 2019). Thus, methodological processes have been explicitly outlined to facilitate replicability while rigorous instruments and suited analytical procedures were utilized. Specifically, the kobo collect app was used for real-time data validation by ensuring all questions were answered before data collectors could move on to the next question.

Again, a filled form moved through two validation stages before they were finalized, allowing errors to be corrected before questionnaires were finally accepted. Additionally, built into the analytical tools (SPSS and Microsoft Excel) are self-correcting systems that expose errors and validate results by highlighting invalid data values and missing data. Lastly, to avoid participant and researcher bias, the data collection team was trained to ensure that the aim and meaning of the questions were not different. Overall, selecting a representative sample size and ensuring quality control in measurement instruments was essential to validity and reliability, thus enhancing the generalizability of the results.

Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	494	99.4
	Excluded[a]	3	.6
	Total	497	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.774	27

Figure 3.7: Reliability Test for the Questionnaire-based Survey Instrument

Source: Fieldwork (2022)

3.8 Methods of Data Analysis

Data collected were analysed using various descriptive and inferential statistics with the help of Special Package for Social Scientists (SPSS) version 22 and Microsoft Excel 2018. Tables, charts and narrations were used to present the results of the analysed data. The different quantitative and qualitative analyses used in the research are discussed in this section.

3.8.1 Quantitative Analysis

Survey data, mainly quantitative, were extracted from kobo collect and coded into SPSS for various forms of descriptive and inferential statistics. Descriptive statistics were presented in frequencies and percentages. The descriptive statistics (percentages and frequencies) were used to show results on the demographic characteristics of rural

women farmers, the perception and comprehension of respondents on CC, mitigation and adaptation actions taken by rural women farmers, access of women to various livelihood capitals, access to CC information through multiple mediums, quality of access to information and practical approaches used by stakeholders to educate rural women on CC. Bar charts and tables were used to present results from the percentages and frequencies.

The Relative Importance Index (hereafter RII) was also employed to rank rural women farmers' awareness of CC and how it impacts their farming activities and other social-cultural issues. Microsoft Excel 2018 with XLXS plug-in was used for calculating the RII. The formula for calculating RII is shown in Equation (2);

$$RII = \sum \frac{W}{AxN} \qquad \text{Equation (2)}$$

Where *W* is the weight given to a variable between one and five rated by respondents; *A* characterizes the highest scale (5), and *N* is the total number of respondents. Appendix 3 shows the calculation of the RII for the various categories of awareness. The adaptive capacity index was also calculated with the help of Microsoft Excel, where indexed indicators for capital assets were standardized. This approach was vital as it converts different measurement units into a non-dimensional unit and indicators normalised to a relative position between 0 and 1 (Antwi-Agyei, 2013; Hahn et al., 2009). As was done by UNDP (2007) to standardise life expectancy index indicators, all indicators of adaptive capacity were also standardised. Studies in the past, including Mazhar et al. (2021) and Antwi-Agyei et al. (2013), also have normalised research data by following a similar approach. Equation (3) presents the index standardisation method.

$$\textit{Index value (standardized value)} = \frac{(actual\ value)-(minimum\ value)}{(Maximum\ value)-(minimum\ value)} \qquad \text{Equation (3)}$$

With five indexed capital assets, an equal weight of 0.20 was allotted to each standardized capital asset value. The use of equal weights is an objective approach that limits subjectivity to selecting indicators. The subjectivity in selecting indicators is also covered by the standardization of asset indicators (Sharpe & Salzman, 2003). The Adaptive Capacity Index formula is presented in Equation (4).

Adaptive capacity index = $(Ssvi\ X\ Wi) + (Nsvi\ X\ Wi) + (Fsvi\ X\ Wi) + (Psvi\ X\ Wi) + (Hsvi\ X\ Wi)$ Equation (4)

Where:

Ssvi = standardised value of social capital

Nsvi = standardized value of natural capital

Fsvi = standardized value of financial capital

Psvi = standardised value of physical capital

Hsvi = standardised value of human capital

Wi = equal weights = 0.20

Results of the adaptive capacity index for the various capitals were presented using the spider graph. The spider graph gives an immediate impression of the capitals with the strongest and weakest adaptive capacity comparatively and across districts. The Chi-square statistic and the Binary logistic regression were inferentially used to draw additional statistical implications from the descriptive statistics. Pearson's Chi-square was used to measure the differences between the two unique districts selected regarding their situational awareness and adaptive capacities. Differences were considered statistically significant at a 95% confidence interval. Microsoft Excel was used to undertake the chi-square analysis. The formula for calculating the chi-square statistic (x^2) is

$$x^2c = \sum \frac{(0i-Ei)x^2}{Ei}$$ Equation (5)

Where *c* is the degree of freedom, 0*i* is the observed value, and E*i* is the expected value. The Binary Logistic Regression model was utilised to measure how climate-related knowledge and actions drive the livelihood of rural women farmers. For the Binary logit model, the dependent binary variable considers the relationship between a set of binary or continuous independent variables presented by Greene (2011) as;

$$log\left(\frac{p_i}{1-p_i}\right) = log(p_i) = B_0 + B_i xi... \quad \text{Equation (6)}$$

Pi is the probability of access to livelihood assets, and Xi is an independent variable. The parameter βi gives the dependent variable's log odds, where β0 represents a constant. The odds ratio indicates the likelihood of an event occurring relative to not occurring. The Odds ratio is also given by Greene (2011) as follows;

$$\frac{p_i}{1-p_i} = exp(B_0 + B_i + x_i \ldots) \quad \text{Equation (7)}$$

The logit model is considered most significant for this analysis as both dependent, and independent variables are dichotomous, i.e. presence or absence (Pallant, 2016; Tabachnick & Fidell, 2013). The predictor variables for the model were; mediums of access to climate information, mitigation and adaptation actions taken by rural women farmers. The presence or absence of key livelihood asset indicators was the dependent variable as the research conceptualises that access to livelihood capitals is a predeterminant of adaptive capacity or otherwise.

Access to climate-related information through various mediums, respondents' engagement in adaption and mitigation actions were selected as the predictor or independent variable while keeping access to livelihood capital assets as the dependent variable. A climate information medium and action were considered to have a

significant impact on livelihood capitals at a p-values less than or equal to 0.01, 0.05, 0.10 or at a 99%, 95%, 90% Confidence Interval. The Odds Ratio (OR) represented by Exp (B) indicates the possibility of an independent variable impacting a dependent variable. However, an OR < 1 less than 1 reflects a negative relationship depicted by a negative Beta (B) figure. A negative Beta value implies a decrease rather than an increase in the dependent variable relative to the predictor variable. Each independent variable (climate-related information medium and action) is pitched against each livelihood capital assets (dependent variable) to determine the degree and direction of impact.

3.8.2 Qualitative Analysis

Qualitative data gathered through FGDs and KIIs were analysed by transcribing data collected through notes and audio recordings. Data were further developed into themes guided by the checklist that informed the process of FGDs and expert interviews (Appendix 1). The use of themes facilitated the segregation of data into common categories whiles divergent ideas were noted. Thematic analysis was used purely for analysing results from the FGDs. In contrast, some form of content analysis was infused (in addition to thematic analysis) into the analysis of results from expert interviews. Results were mainly presented using discussions and narrations on various themes and charts for content analysis. Quotes from FGDs and expert interviews were used to enrich the discussion of results.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND DISCUSSIONS

4.1 Socio-Demographic Characteristics of Respondents

The socio-demographic characteristics of study respondents are presented in Table 4.1. Respondents of the study present with an adult population with majority (53.5%, n = 266) falling within the age category 36 to 64 years. Reflectively, 69.8% (n = 347) of respondents across both Districts were married with 23.3% (n = 81) in polygamous marriages. EG District had a higher proportion of respondents being married (77.4%; n = 216) and polygamous (34.3%; n = 74). Access to land for farming was mostly through family ownership (66.2%; n = 329). District-wise, EG presented with a higher household size where 87.9% (n = 245) of respondents had household members of four and above, while DE had 76.1% (n = 166) of respondents in the same category. Majority of respondents (56.7%) presented with a land size of an acre or less. DE however, had relatively higher land sizes, about 56.0% (n = 122) between 2 and 5 acres, compared to about 29.0% (n = 81) of the same land size represented by EG. Majority of respondents had never been to school (67.4%; n =335) and even in the local languages, literacy levels were generally very low at 4.4% (n = 22) across both districts.

With an adult population, agricultural work becomes more tedious, especially, among smallholder farmers who are characterized by limited access to agricultural inputs. Rufai et al. (2018) has indicated that apart from physical strength (i.e., own labour), most women do not have access to agricultural inputs, making youthfulness an essential asset. Kuivanen et al. (2016) has also indicated that youthfulness is of the essence as agriculture is rain-fed and rudimentary for smallholder farmers.

Table 4.1 Demographic Characteristics of Respondents

Variable	EG n = 279	DE n = 218	Total n = 497
Age			
18-35	129(46.2)	53(24.3)	182 (36.6)
36-64	133(47.7)	133(61.0)	266 (53.5)
65+	17(6.1)	32(14.7)	49 (9.9)
Marital status			
Married	216(77.4)	131(60.1)	347 (69.8)
Single	6(2.2)	12(5.5)	18 (3.6)
Separated	2(0.7)	8(3.7)	10 (2.0)
Divorced	8(2.9)	20(9.2)	28 (5.6)
Cohabitation	24(8.6)	21(9.6)	45 (9.1)
Widowed	23(8.2)	26(11.9)	49 (9.9)
Marriage type			
Monogamy	142(65.7)	124(94.7)	266 (76.7)
Polygamy	74(34.3)	7(5.3)	81 (23.3)
Educational level			
None	237(84.9)	98(45.0)	335 (67.4)
Primary	26(9.3)	112(51.4)	138 (27.8)
Secondary	16(5.7)	8(3.7)	24 (4.8)
Literacy in local language			
Yes	5(1.8)	17(7.8)	22 (4.4)
Partial (can either read or write)	8(2.9)	42(19.3)	50 (10.1)
No	266(95.3)	159(72.9)	425 (85.5)
Household size			
Below 4	34(12.2)	52(23.9)	86 (17.3)
5-10	175(62.8)	145(66.5)	320 (64.4)
10+	70(25.1)	21(9.6)	91 (18.3)
Type of farming			
Cash crop	0(0.0)	80(36.7)	80 (16.1)
Mixed cropping	58(20.8)	89(40.8)	147 (29.6)
Vegetables	4(1.4)	9(4.1)	13 (2.6)
Roots and tuber	204(73.1)	38(17.4)	242 (48.7)
Legumes and cereals	13(4.7)	2(0.9)	15 (3.0)
Acreage of farm			
Less than 1 acre	8(2.9)	20(9.2)	28 (5.6)
1 acre	175(62.7)	74(33.9)	249 (50.1)
2-5 acres	81(29.0)	122(56.0)	203 (40.8)
5-10 acres	15(5.4)	2(0.9)	17 (3.4)
Years into farming			
Less than 1 year	3(1.1)	0(0.0)	3 (0.6)
1-5 years	86(30.8)	19(8.7)	105 (21.1)
6-10 years	59(21.1)	67(30.7)	126 (25.4)
10 years+	131(47.0)	132(60.5)	263 (52.9)
Ownership of land			
Lease	60(21.5)	105(48.2)	165 (33.2)
Family	218(78.1)	111(50.9)	329 (66.2)
Hirer on contract	1(0.4)	2(0.9)	3 (0.6)
Challenges in farming			
Access to assets and resources	258(92.5)	201(92.2)	459 (92.4)
Control over assets and resources	19(6.8)	5(2.3)	24 (4.8)
Ownership of assets and resources	2(0.7)	12(5.5)	14 (2.8)

Source: Author's Construct from Fieldwork, (2021). The numbers in parentheses are percentages and numbers outside parentheses are frequencies

With respect to marital status, Van Aelst & Holvoet (2016) has indicated that, especially for rural women, being married facilitates access to key household capital assets such as land. The role of the cultural system reflects in land ownership where women in DE with a matrilineal cultural system, had higher land holding rights, compared to their counterparts in the EG District within a patrilineal cultural system. Additionally, land size *inter alia* reflects the type of farming done, as some farming practices, such as cash crop farming, require larger land sizes (Asante et al., 2018). With majority of respondents have an acre of land of less, it is clear their enterprise is highly at subsistence level.

The influence of sociocultural practices on access to essential livelihood assets resonates with the issues of system design presented in the situational awareness model (Endsley, 1995b). In the situational awareness model, the awareness level and resultant actions taken on any phenomenon are impacted by existing system designs, such as sociocultural practices that perpetuate gender inequalities (Hillenbrand et al., 2015). Meinzen-Dick et al. (2019) and Antwi-Agyei et al. (2015) have also said that land tenure systems that are against women limit their access to extension services, a significant source of climate information, technology, and adaptive capacity. A study by Bhadwal et al. (2019) in the Himalayan Region of India affirms that lack of access to natural capital, of which land is central, is a driver of gender vulnerabilities.

Household size is a crucial determinant of the dependency ratio of a given population which has implications for livelihood sustainability. Household sizes were relatively larger in the EG District primarily due to higher polygamous marriages than DE District. A high dependency ratio can potentially become a stressor that negatively impacts awareness levels. When there is an excessive overload of women with many household responsibilities, their ability to participate effectively in knowledge and skill-

building activities that enhance their awareness and resultant actions becomes limited(Hillenbrand et al., 2015; Jones & Endsley, 1996). Thus stressors, workload and system design cannot be overlooked in awareness creation strategies in the context of rural women farmers.

Literacy levels are vital individual factors that influence situational awareness levels as it affects knowledge, training and experience gaining (Endsley, 1995a). The literacy background of respondents has important implications for the approach of awareness creation on climate change which will eventually influence perceptions, comprehension and decision-making actions. Therefore, Lovett et al. (2015) suggest that CCE or awareness creation approaches be tailored and structured in more practical, visual imagery ways for effectiveness.

4.2 Data Presentation on Research Issues

4.2.1 Objective 1 - Situational Awareness of RWFs from Different AEZs in Ghana

Perception of CC

The SAM suggests three levels of awareness: perception, comprehension and decision-making. For level 1 - perception, results indicated that respondents in both EG and DE ranked observed changes in the climate and increase in temperature as the two most important climatic changes in their communities (Table 4.2). The other climatic variables equally received high RII ranging from 0.96 to 0.86 except for the increase in floods, which is ranked least with RII of 0.49 and 0.52 in EG and DE, respectively.

Table 4.2 RII of Respondents' Perception on Changes in Climatic Variables

Variable	Frequency of climate change Perception in EG **Certainly not**	**Perhaps not**	**Probably not**	**Perhaps yes**	**Most certainly**	**RII**	**Rank**
Observed changes	2(0.7)	1(0.4)	2(0.7)	22(7.9)	252(90.3)	0.97	1
Increase in temperature	2(0.7)	0 (0.0)	0(0.0)	28(10.0)	249(89.2)	0.97	1
Unpredictable rainfall pattern	12(4.3)	29(10.4)	10(3.6)	73(26.2)	155(55.6)	0.84	6
Worsening of harmattan	2(0.7)	1(0.4)	2(0.7)	37(13.3)	237(84.9)	0.96	3
Increase in flood	157(56.3)	4(1.4)	19(6.8)	31(11.1)	68(24.4)	0.49	7
Frequency of dry spells	3(1.1)	4(1.4)	0(0.0)	104(37.3)	168(60.2)	0.91	5
Increase in droughts	2(0.7)	5(1.8)	2(0.7)	90(32.3)	180(64.5)	0.92	4
Overall RII						**0.87**	
	Frequency of climate change perception in DE					RII	Rank
Observed change	0(0.0)	0(0.0)	0(0.0)	10(4.6)	208(95.4)	0.99	1
Increase in temperature	0(0.0)	4(1.8)	0(0.0)	31(14.2)	183(83.9)	0.96	2
Unpredictable rainfall pattern	2(0.9)	9(4.1)	2(0.9)	57(26.1)	148(67.9)	0.91	4
Worsening of harmattan	2(0.9)	4(1.8)	0(0.0)	26(11.9)	186(85.3)	0.96	3
Increase in flood	91(41.7)	19(8.7)	33(15.1)	38(17.4)	37(17.0)	0.52	7
Frequency of dry spells	6(2.8)	22(10.1)	9(4.1)	63(28.9)	118(54.1)	0.84	6
Increase in droughts	10(4.6)	16(7.3)	4(1.8)	55(25.2)	133(61.0)	0.86	5
Overall RII						**0.86**	
Average RII across districts						**0.87**	

Source: Author's Construct from Fieldwork (2021). Numbers in parentheses are percentages

Comprehension of impacts of CC

Level 2 of the SAM - comprehension, was measured by assessing respondents' understanding of the impact of CC on key farming sectors. On crop production, low crop yield and an increase in crop diseases were ranked as the two most important by respondents in both districts (Table 4.3). Discussions at the FGDs supported this claim as many participants enumerated the losses incurred from wrongly estimating the onset/cessation of rain and from increased drought and harmattan. "*At times, we incur so many losses as the information we rely on to take decisions fails us. You may want to plant earlier expecting a certain volume of rain, and it fails you woefully. All the same, we have no options, so we still trying and hope for the best*" (FGD Tunasuano DE, November 2021).

Table 4.3 RII of Respondents' Comprehension on the Impact of CC on Crop Production

Variable	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree	RII	Rank
	Frequency of impact of CC on crop production in EG						
Low crop yield	18(6.5)	30(10.8)	6(2.2)	16(5.7)	209(74.9)	0.86	2
Increase in crop diseases	3(1.1)	21(7.5)	32(11.5)	47(16.8)	176(63.1)	0.87	1
Increase in insects	4(1.4)	23(8.2)	25(9.0)	97(34.8)	130(46.6)	0.83	6
Reduction in size of cropping area	16(5.7)	13(4.7)	19(6.8)	90(32.3)	141(50.5)	0.83	5
Increase in production cost	14(5.0)	21(7.5)	15(5.4)	96(34.4)	133(47.7)	0.82	7
Reduction in water quality	7(2.5)	7(2.5)	24(8.6)	123(44.1)	118(42.3)	0.84	3
Hardening of seedbed and reduction of soil fertility	7(2.5)	19(6.8)	35(12.2)	75(26.9)	144(51.6)	0.84	4
Overall RII						**0.84**	
	Frequency of impact of CC on crop production in DE						
Low crop yield	0(0.0)	2(0.9)	2(0.9)	15(6.9)	199(91.3)	0.98	1
Increase in crop diseases	0(0.0)	0(0.0)	4(1.8)	32(14.7)	182(83.5)	0.96	2
Increase in insects	2(0.9)	0(0.0)	5(2.3)	38(17.4)	173(79.4)	0.95	3
Reduction in size of cropping area	8(3.7)	3(1.4)	34(15.6)	54(24.8)	119(54.6)	0.85	6
Increase in production cost	2(0.9)	2(0.9)	12(5.5)	44(20.2)	158(72.5)	0.92	4
Reduction in water quality	26(11.9)	25(11.5)	61(28.0)	39(17.9)	67(30.7)	0.69	7
Hardening of seedbed and reduction of soil fertility	2(0.9)	0(0.0)	19(8.7)	56(25.7)	141(64.7)	0.91	5
Overall RII						**0.89**	
Average RII across districts						**0.87**	

Source: Author's Construct from Fieldwork (2021). Numbers in parentheses are percentages

For biodiversity and forest resources, the extinction of certain plants and forest species is ranked by respondents as the most important in EG, while for DE, it was a reduction in plant and forest species (Table 4.4). Decrease in forest area was ranked as the least important impact of CC on biodiversity and forest resources across both Districts with an RII of 0.81 for EG and 0.88 for DE.

Table 4.4 RII of Respondents' Comprehension on the Impact of CC on Biodiversity and Forest Resources

Variable	Frequency of impact of CC on biodiversity and forest resources in EG **Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**RII**	**Rank**
Reduction in plant and forest species	4(1.4)	1(0.4)	21(7.5)	67(24.0)	186(66.7)	0.91	2
Reduction in bird and animal species	4(1.4)	1(0.4)	19(6.8)	85(30.5)	170(60.9)	0.90	3
Decrease in forest area	3(1.1)	19(6.8)	54(19.4)	88(31.5)	115(41.2)	0.81	5
Extinction of certain plants and forest species	4(1.4)	4(1.4)	14(5.0)	71(25.4)	186(66.7)	0.91	1
Extinction of certain bird and animal species	2(0.7)	0(0.0)	33(11.8)	76(27.2)	168(60.2)	0.89	4
Overall RII						**0.88**	
	Frequency of impact of CC on biodiversity and forest resources in DE						
Reduction in plant and forest species	4(1.8)	2(0.9)	6(2.8)	36(16.5)	170(78.0)	0.94	1
Reduction in bird and animal species	6(2.8)	0(0.0)	17(7.8)	55(25.2)	140(64.2)	0.90	4
Decrease in forest area	5(2.3)	3(1.4)	13(6.0)	78(35.8)	119(54.6)	0.88	5
Extinction of certain plants and forest species	0(0.0)	2(0.9)	13(6.0)	66(30.3)	137(62.8)	0.91	3
Extinction of certain bird and animal species	0(0.0)	2(0.9)	11(5.0)	65(29.8)	140(64.2)	0.91	2
Overall RII						**0.91**	
Average RII across districts						**0.90**	

Source: Author's Construct from Fieldwork (2021). Numbers in parentheses are percentages

Respondents demonstrated a low comprehension of sociocultural impact as the variables provided were rated lower than variables under crop production, biodiversity and forest resources. Results were much lower in the EG District, where RII spanned from 0.36 to 0.95 while corresponding values for DE was from 0.64 to 0.95. Reduction in household incomes was ranked first and second in EG and DE, respectively. Respondents thus understood loss of income as a significant impact of CC on their livelihoods.

Table 4.5 RII of Respondents' Comprehension on the Impact of CC on Socio-Economic and Cultural Factors

Variable	Frequency of impact of CC on socio-economic and cultural factors in EG **Very unlikely**	**Unlikely**	**Not certain**	**Likely**	**Very Likely**	**RII**	**Rank**
Increase in disease infection	4(1.4)	20(7.2)	43(15.4)	86(30.8)	126(45.2)	0.83	3
Increase in mortality	35(12.5)	43(15.4)	57(20.4)	52(18.6)	92(33.0)	0.69	5
Reduction in household incomes	2(0.7)	2(0.7)	5(1.8)	46(16.5)	224(80.3)	0.95	1
Increase in migration in search of greener pastures	82(29.4)	32(11.5)	14(5.0)	45(16.1)	106(38.0)	0.64	6
Increase in belief in God	29(10.4)	39(14.0)	47(16.8)	50(17.9)	114(40.9)	0.73	4
Decrease in belief in God	182(65.2)	26(9.3)	36(12.9)	18(6.5)	17(6.1)	0.36	7
Widening of the gap between rich and poor	12(4.3)	2(0.7)	59(21.1)	50(17.9)	156(55.9)	0.84	2
Overall RII						**0.72**	
	Frequency of impact of CC on socio-economic and cultural factors in DE						
Increase in disease infection	4(1.8)	20(9.2)	21(9.6)	25(11.5)	148(67.9)	0.87	3
Increase in mortality	49(22.5)	23(10.6)	16(7.3)	37(17.0)	93(42.7)	0.69	5
Reduction in household incomes	4(1.8)	6(2.8)	5(2.3)	32(14.7)	171(78.4)	0.93	2
Increase in migration in search of greener pastures	6(2.8)	0(0.0)	2(0.9)	27(12.4)	183(83.9)	0.95	1
Increase in belief in God	69(31.7)	11(5.0)	7(3.2)	37(17.0)	94(43.1)	0.67	6
Decrease in belief in God	49(22.5)	20(9.2)	53(24.3)	31(14.2)	65(29.8)	0.64	7
Widening of the gap between rich and poor	15(6.9)	6(2.8)	39(17.9)	30(13.8)	128(58.7)	0.83	4
Overall RII						**0.80**	
Average RII across districts						**0.76**	

Source: Author's Construct from Fieldwork (2021). Numbers in parentheses are percentages

Climate actions by rural women farmers

Results showed that most respondents (74.9% in EG and 62.8% in DE) did not undertake any mitigation action in the face of CC (Table 4.6). Only a small proportion of respondents (EG 19.7% and DE 20.6%) took to tree planting. Anonymous rhetoric during the FGD in EG affirms this; "*Madam (referring to the facilitator), we all burn wood (charcoal producers) and use the proceeds to support our livelihoods. However, we merely do this on a small scale using mostly dried wood, so we are not responsible for forest destruction. Big-time charcoal producers are responsible for forest destruction, not us. On the advice of the Agric people (referring to AEAs), we sometimes plant trees to replace the trees we use for charcoal production."* (FGD in EG, November 2021). A switch from non-organic to organic materials mainly in the area of fertilizer use was very minimal especially among respondents from EG District (EG 4.7%; DE 16.5%).

Table 4.6 Proportion of Mitigation Actions by Respondents

Type of farming	Mitigation actions by respondents in EG (Frequency)			
	Nothing	**Plant trees**	**Switch from non-organic to organic materials**	**Total**
Roots and tubers	165 (59.1)	28 (10.0)	11 (3.9)	204 (73.1)
Vegetables	4 (1.4)	0 (0)	0 (0)	4 (1.4)
Legumes and cereals	5 (1.8)	6 (2.2)	2 (0.7)	13 (4.7)
Mixed cropping	35 (12.5)	21 (7.5)	2 (0.7)	58 (20.8)
Total	**209 (74.9)**	**55 (19.7)**	**13 (4.7)**	**279 (100)**
	Mitigation actions by respondents in DE (Frequency)			
Roots and tubers	24 (11.0)	14 (5.0)	0 (0.0)	38 (17.4)
Vegetables	5 (2.3)	4 (1.8)	0 (0.0)	9 (4.1)
Legumes and cereals	0 (0.0)	2 (0.9)	0 (0.0)	2 (0.9)
Mixed cropping	73 (33.5)	0 (0.0)	16 (7.3)	89 (40.8)
Cash crop	35 (16.1)	25 (11.5)	20 (9.2)	80 (36.7)
Total	**137 (62.8)**	**45 (20.6)**	**36 (16.5)**	**218 (100)**

Source: Author's Construct from Fieldwork (2021). Numbers in parentheses are percentages

Results further revealed that most respondents practised varied adaptation actions (EG 79.1% and DE 78.5%). The adaption measures taken by smallholder women

farmers were in crop diversification and farm management practices, including change in planting time, mulching, intercropping and crop rotation. Concerning adaptation measures, respondents highlighted the following during some of the FGDs; "*When the weather fails us, we do the usual, nothing special, which sometimes yields results and other times does not work out*" (FGD Dajdambia EG, November 2021). Another feedback from DE District indicated; "*Although most of the actions we take are not new to us, the Agric people give us some tips that give us better results. For instance, I would previously slash and burn, but now I see the benefits of mulching, especially during harmattan and droughts*" (FGD Tunasuano DE, November 2021).

A small proportion of respondents switched to another enterprise (EG 2.8% and DE 8.3%), revealing the short-term unplanned nature of adaptation among respondents (Table 4.7). WIAD officers in charge of entrepreneurship training and supporting women with alternative livelihoods were challenged with funds to undertake this all-important assignment. While women in EG had been trained in processing fortified groundnut paste and gari, their operations were too subsistent a level to be effectively considered a full-fledged business enterprise. Alternatively, women in DE had received training in soap making but had challenges with start-up capital to engage in this enterprise, as revealed during FGDs and expert interviews. A significant proportion of respondents (EG 20.8% and DE 21.6%) took no adaptative action.

Table 4.7 Proportion of Adaptation Actions by Respondents

Type of farming	Adaptation actions taken by respondents in EG (Frequency)				
	Do Nothing	Crop diversification	FMP	Switch to another enterprise	Total
Root and tubers	29 (10.4)	103 (36.9)	65 (23.3)	7 (2.5)	204 (73.1)
Vegetables	0 (0)	4 (1.4)	0 (0)	0 (0)	4 (1.4)
Legumes and cereals	9 (3.2)	2 (0.7)	2 (0.7)	0 (0)	13 (4.7)
Mixed cropping	20 (7.2)	32 (11.5)	5 (1.8)	1 (0.4)	58 (20.8)
Total	**58 (20.8)**	**141 (50.5)**	**72 (25.8)**	**8 (2.8)**	**279 (100)**
Type of farming	Adaptation actions taken by respondents in DE (Frequency)				
	Do Nothing	Crop diversification	FMP	Switch to another enterprise	Total
Roots and tubers	12 (5.5)	10 (4.6)	12 (5.5)	4 (1.8)	38 (17.4)
Vegetables	3 (1.4)	2 (0.9)	4 (1.8)	0 (0.0)	9 (4.1)
Legumes and cereals	0 (0.0)	2 (0.9)	0 (0.0)	0 (0.0)	2 (0.9)
Mixed cropping	15 (6.9)	39 (17.9)	33 (15.1)	2 (0.9)	89 (40.8)
Cash crop	17 (7.8)	25 (11.5)	26 (11.9)	12 (5.5)	80 (36.7)
Total	**47 (21.6)**	**78 (35.8)**	**75 (34.4)**	**18 (8.3)**	**218 (100)**

Source: Author's Construct from Fieldwork (2021). Numbers in parentheses are percentages. Farm Management Practices (FMP)

Association between sociocultural characteristics and situational awareness of RWFs

Results showed observable differences in the sociocultural characteristics between study respondents in the two districts. Differences were found regarding the percentage of married against divorced, separated and cohabiting; polygamous and monogamous marriages; educational attainment and literacy; household size; ownership of land and experience in the number of years into farming (Table 4.1). The statistical significance of the observed differences at a 95.0% confidence interval was assessed using Chi-square analysis. A chi-square value of 0 was obtained at two significant decimals and a p-value ranging from 0.95 to 1 across the different parameters of situational awareness (Table 4.8).

Table 4.8 Pearson Chi-square Statistic Across Situational Awareness Parameters

Parameter	Value	df	Asymptotic significance
Perception of changes in climatic variable	0.000	1	0.991
Comprehension of the impact of CC on crop production	0.001	1	0.970
Comprehension of the impact of CC on forest resources and biodiversity	0.000	1	0.982
Comprehension of the impact of CC on socioeconomic and cultural factors	0.004	1	0.948
Mitigation action	0.026	1	0.871
Adaptation action	0.000	1	0.100

Source: Author's Construct from Fieldwork (2021)

4.2.2 Objective 2 – Measure the Adaptive Capacity of RWFs from Different AEZs in Ghana

The adaptive capacities of respondents from the different districts were calculated, highlighting each capital asset's sub and major components with their corresponding frequencies and adaptive capacity indices (Table 4.9). Based on the dispersion of indices as suggested by Defiesta & Rapera (2014) and a similar study conducted by Chepkoech et al. (2020), the adaptive capacity index was rated low, moderate and high on a scale of 0.000 to 0.339, 0.340 to 0.669 and 0.670 to 1.000, respectively.

Table 4.9 Adaptive Capacities of Districts showing Frequencies, Indexed Sub & Major Components of Livelihood Capital Assets

Capital Asset / Indicator	DE (n=218)		EG (n=279)		Total (n=497)	
	Frequency Variable	AC index	Frequency	AC index	Frequency	AC index
Natural capital	142(65.1)	**0.464**	119(42.7)	**0.366**	261(52.5)	**0.415**
Access to land	207(95)	**0.190**	236(84.6)	**0.169**	443(89.1)	**0.180**
Land size	124(56.9)	**0.100**	96(34.4)	**0.091**	220(44.2)	**0.096**
Access to water	88(40.4)	**0.081**	28(10.0)	**0.020**	116(23.3)	**0.051**
Nativity	101(46.3)	**0.093**	120(43.0)	**0.086**	221(44.5)	**0.090**
Human capital	160(73.4)	**0.595**	242(86.7)	**0.680**	402(80.9)	**0.638**
Physical fitness	140(64.2)	**0.128**	256(91.8)	**0.184**	396(79.7)	**0.156**
Household size (>/3.5)	28(12.8)	**0.085**	24(8.6)	**0.116**	52(10.5)	**0.101**
Literacy	43(19.7)	**0.039**	8(2.9)	**0.006**	51(10.3)	**0.023**
Farm Labour	19(8.7)	**0.017**	28(10.0)	**0.020**	47(9.5)	**0.019**
Skill/knowledge upgrade	195(89.4)	**0.179**	253(90.7)	**0.181**	497(90.1)	**0.180**
Married	160(73.4)	**0.147**	242(86.7)	**0.173**	402(80.9)	**0.160**

Social capital	59(27.1)	**0.139**	206(73.8)	**0.233**	265(53.3)	**0.186**
Family support	93(42.7)	**0.085**	119(42.7)	**0.085**	212(42.7)	**0.085**
Membership in a social group	59(27.1)	**0.054**	206(73.8)	**0.148**	265(53.3)	**0.101**
Physical capital	189(86.7)	**0.587**	219(78.5)	**0.388**	408(82.1)	**0.488**
Market	63(28.9)	**0.058**	13(4.7)	**0.009**	76(15.3)	**0.034**
Electricity	196(89.9)	**0.180**	268(96.1)	**0.192**	464(93.4)	**0.186**
Road network	189(86.7)	**0.173**	219(78.5)	**0.157**	408(82.1)	**0.165**
Potable water	173(79.4)	**0.159**	26(9.3)	**0.019**	199(40.0)	**0.089**
Health facility	18(8.3)	**0.017**	15(5.4)	**0.011**	33(6.6)	**0.014**
Financial capital	49(22.5)	**0.325**	64(22.9)	**0.272**	113(22.7)	**0.299**
Credit	16(7.3)	**0.013**	58(20.8)	**0.034**	74(14.9)	**0.024**
Remittances	46(21.1)	**0.042**	29(10.4)	**0.021**	75(15.1)	**0.032**
Savings	207(95.0)	**0.190**	258(92.5)	**0.185**	465(93.6)	**0.188**
Financial control	131(60.1)	**0.080**	234(83.9)	**0.032**	365(73.4)	**0.056**
Overall Adaptive Capacity		**0.422**		**0.388**		**0.405**

Source: Fieldwork, (2021). Figures in parentheses are percentages, figures in bold are Adaptive Capacity (AC) index.

Natural capital

Access to natural capital is relatively higher in DE (65.1%) as compared to EG (42.7%), reflected in the respective adaptive capacity thereof (DE = 0.464, EG = 0.366) (Table 4.9). With an overall index of 0.415, RWF's adaptive capacity to natural capital is scaled moderate. It is however, essential to note that access to land does not equate to ownership and control over land as was corroborated during FGDs. Consensus on the hardships faced by the women farmers regarding land access, control and ownership are indicated;

"Our situation here is sad. Our husbands give us portions of land to farm on, usually the rocky non-fertile grounds. When these lands are given to us, we are expected to feed the household daily without any additional support" (FGD Mbawupe EG, November 2021). *"Whatever the marriage situation is, circumstances force us to stay in it to have access to land to feed ourselves and our children."* (FGD Dajdambia EG, November 2021). The situation seems worse for divorced women; *"When your husband is no more interested in marrying you, you lose rights to the land you previously owned.*

You are therefore compelled to work on someone's land as a hirer with its attendant challenges" (FGD Participant, Tunasuano DE, November 2021).

Human capital

Respondents highly represented human capital (DE, 73.4%; EG, 86.7; Total, 80.9%); with a major component adaptive capacity index of 0.638 – Table 4.9. Human capital was therefore rated at a moderate-level adaptive capacity, recording the highest index among all capital assets. The highest contributing indicators to this capital asset are marital status, access to knowledge upgrade services and physical fitness [0.160 (80.9%), 0.180 (90.1%), 0.156 (79.7%) respectively – Table 4.9]. Lower literacy levels across districts (0.023, 10.3%) and high household size with only a small proportion having a household size less than 3.5 people (0.101, 10.5%), negatively contributed to human capital.

Physical capital

Respondents across districts indicated greater access to physical capital DE (86.7%), EG (78.5%) – Table 4.9. Although there was a high representation of access to physical capital, some asset indicators were ill-represented, not to mention the quality of the physical assets. Access to healthcare facilities and markets is a significant challenge for respondents across ecological zones (6.6% and 15.3% access, respectively - Table 4.9). Access to potable water is a unique challenge in EG alone, with only 9.3% (Table 4.9). Overall, the quality of physical assets was rated low, as only a few respondents (DE, 25.9%; EG, 18.6%) rated all asset indicators as good in quality (Table 4.10). Overall, the major component adaptive capacity index for physical capital is rated moderate level at 0.488 (Table 4.9).

Social capital

Social capital was more predominant in EG (73.8%, 0.227) than in DE (27.1%, 0.109) -Table 4.9. During interactions with key informants (AEAs), it was found that various farmer groups facilitated by Non-Governmental Organisation (NGO) interventions were present in EG but only lasted as long as the intervention remained. Overall, adaptive capacity to social capital was rated low (0.186, 53.3%) within the low range (0.000 to 0.339). Results show that although 73.8% indicated access to social capital (Table 4.9), as many as 29.4% indicated no form of social ties and interaction from social networks (Table 4.10). In comparison, only 4.3% indicated high-level ties and interaction from social groups. On the flip side, 57.3% of respondents in DE indicated no form of social interaction, with only 5.5% affirming good ties and interaction with social networks (Table 4.10).

Financial capital

Significantly, access to financial capital was deficient across districts (DE, 22.5%; EG, 22.9%) - Table 4.9. With an overall adaptive capacity index of 0.299, it is rated low and only comes second to social capital as the weakest capital asset for the livelihood formation of rural women farmers in the study areas.

Table 4.10 Reliability and Usefulness of Assets

Physical	**Quality of assets (%) DE (Frequency)**				**Quality of assets (%) EG (Frequency)**			
Assets	**Not at all**	**Poor**	**Moderate**	**Good**	**Not at all**	**Poor**	**Moderate**	**Good**
Road	4(1.8)	55(25.2)	66(30.3)	93(42.7)	46(16.5)	118(42.3)	2(0.7)	113(40.5)
Electricity	16(7.3)	46(21.1)	60(27.5)	96(44.0)	4(1.4)	29(10.4)	112(40.1)	134(48.0)
Market	145(66.5)	11(5.0)	42(19.3)	20(9.2)	266(95.3)	5(1.8)	0(0)	8(2.9)
Potable water	2(0.9)	79(36.2)	73(33.5)	64(29.4)	185(63.3)	92(33.0)	2(0.7)	0(0)
Health	188(86.2)	12(5.5)	9(4.1)	9(4.1)	245(87.8)	3(1.1)	27(9.7)	4(1.4)
Social capital	125(57.3)	17(7.8)	64(29.4)	12(5.5)	82(29.4)	74(26.5)	111(39.8)	12(4.3)

Source: Fieldwork, (2021). Figures in parentheses are percentages

Differential adaptive capacities between RWFs from different AEZs

Women farmers in DE were characterised by comparatively higher natural capital, physical capital and financial capital, while women farmers in EG had higher human capital and social capital (Figure 4.1). Overall, DE had a higher adaptive capacity (0.422) over EG (0.388), which fits into the moderate adaptive capacity category. In addition, the major components that contributed most to the adaptive capacities of the two districts were human, physical and natural capital assets (Figure 4.1). The adaptive capacities of rural women farmers across different agroecological zones were statistically insignificant at a P-value > 0.5 (0.969) and had a chi-square of 0.001.

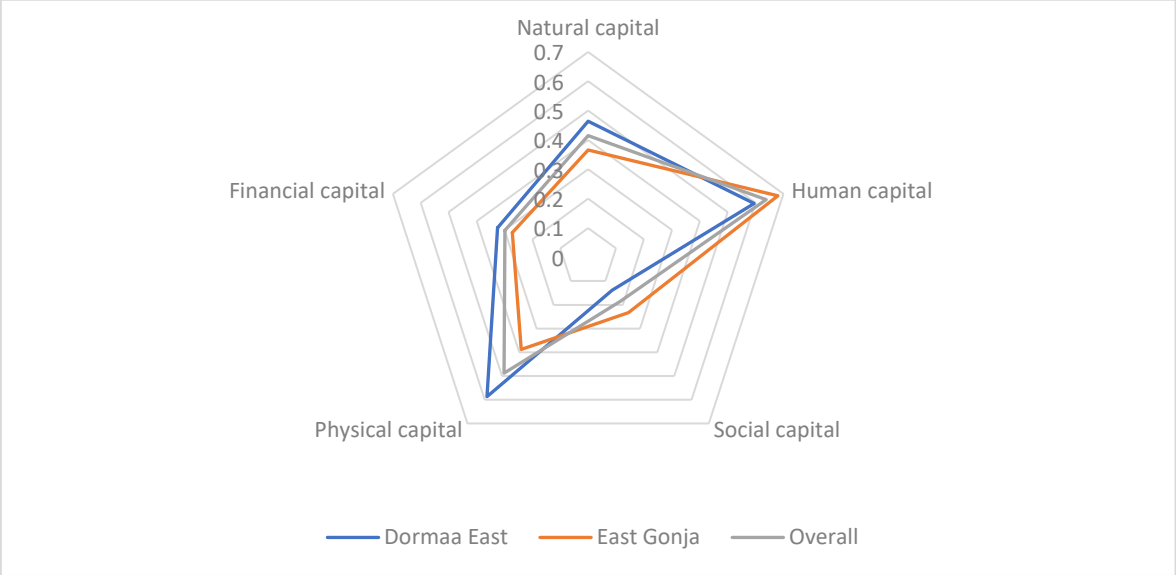

Figure 4.1 Spider Diagram Depicting Adaptive Capacity across Districts

Source: Fieldwork (2021)

4.2.3 Determine the Impact of Climate Information on the Adaptive Capacity of RWFs in Ghana

The character of climate action and information mediums of respondents

Respondents indicated access to various sources of CC information (radio, TV, extension officers, farmer groups and self-generated indigenous knowledge).

Indigenous knowledge was the highest contributor to CC knowledge among respondents, with only 19.5% not utilising this medium (Table 4.11). Additionally, there was limited interaction with extension officers on climate-related knowledge acquisition (12.9%), the least recorded among the mediums of knowledge acquisition. Radio is another vital medium of CC information (68.0%, Table 4.11). Key informant interactions revealed that RWF commonly uses mobile phones to access radio information. For instance, in the EG district, RWFs were found to tag mobile phones in their headscarves near their ears to listen to the radio while they work. Also, respondents engaged in various forms of adaptation (78.9%, see Table 4.7), mainly as a coping strategy to the vagaries of CC and a need to sustain their livelihood. Mitigation actions were also low (30.0%, see Table 4.6) as it is not considered an essential survival option.

Table 4.11 Proportion of Climate-related Information Mediums used by Respondents

Climate information Medium & Actions	**DE n=218**	**EG n=279**	**Total n=497**
	Frequency	Frequency	Frequency
Via radio	189(86.7)	149(53.4)	338(68.0)
Via TV	57(26.1)	91(32.6)	148(29.8)
Via farmer groups	20(9.2)	80(28.7)	100(20.1)
Via extension officers	8(3.7)	56(20.1)	64(12.9)
Via indigenous knowledge	145(66.5)	255(91.4)	400(80.5)
Mitigation action(s)	81(37.2)	68(24.4)	149(30.0)
Adaptation action(s)	171(78.4)	221(79.2)	392(78.8)
No. of mediums available to a respondent			
One	71(32.6)	35(12.5)	106(21.3)
Two	98(45.0)	147(52.7)	245(49.3)
Three	44(20.2)	86(30.8)	130(26.2)
Four	5(2.3)	11(3.9)	16(3.2)

Source: Fieldwork, (2021). Numbers in parentheses are percentages

Impact of climate action and information mediums on adaptive capacity

All independent variables (radio, extension agents, farmers groups, indigenous knowledge, adaptation and mitigation actions) had a significant impact on access to a capital asset except the TV medium for climate change information (Table 4.12). This implies that the TV medium did not enhance access to livelihood assets. The other independent variables have differing impact on the various livelihood assets (either a positively or negatively relationship). Natural capital was positively impacted by access to climate information through the radio medium ($p < 0.10$, $OR > 1$) - Table 4.12. Human capital was also significant to adaptation action ($p < 0.01$, $OR > 1$) and radio medium ($p < 0.10$, $OR < 1$). Social capital, on the other hand, had a positive impact on climate information through farmer groups ($p < 0.05$, $OR > 1$) and indigenous knowledge ($p < 0.01$, $OR > 1$) but a negative relationship with adaptation action and radio medium ($p < 0.05$, $OR < 1$ and $p < 0.001$. $OR < 1$ respectively) – Table 4.12.

Adaptation action and access to climate information through farmer groups positively impacted physical capital at 99% and 95% confidence intervals (0.000, 0.029) with an OR of 5.215 and 2.655, respectively. Although mitigation action and access to climate information through extension agents and indigenous knowledge had an impact on physical capital (p-value < 0.01, 0.01 and 0.10 respectively), it was negatively related ($OR < 1$) – Table 4.12. Financial capital, a poorly represented asset among respondents, was impacted by access to climate information through extension agents (p-value < 0.01); however, the relationship was a negative one ($OR = 0.197$).

Table 4.12 Binary Regression of Climate Action and Climate Information Mediums on Livelihood Capital Assets

CAPITAL	Natural			Human			Social			Physical			Financial		
DRIVER	**B**	**Sig**	**Exp (B)**	**B**	**Sig**	**Exp (B)**	**B**	**Sig**	**Exp (B)**	**B**	**Sig**	**Exp (B)**	**B**	**Sig**	**Exp (B)**
Adaptation	-0.300	0.152	0.741	0.881	**0.000 *** **	2.414	-0.449	**0.040****	0.638	1.652	**0.000*****	5.215	0.100	0.692	1.105
Mitigation	-0.089	0.700	0.915	0.060	0.839	1.062	0.176	0.462	1.193	-1.303	**0.000*****	0.272	-0.247	0.380	0.781
Radio medium	0.383	**0.075***	1.466	-0.478	**0.097***	0.620	-0.666	**0.003*****	0.514	-0.033	0.918	0.967	0.107	0.685	1.113
TV medium	-0.028	0.889	0.972	-0.039	0.882	0.962	-0.241	0.249	0.786	0.490	0.132	1.633	-0.174	0.475	0.840
Farmer group	0.375	0.131	1.456	-0.006	0.986	0.994	0.568	**0.029****	1.765	0.977	**0.037****	2.655	-0.166	0.571	0.847
Extension officer	-0.457	0.108	0.633	0.306	0.427	1.357	0.519	0.084	1.680	-1.023	**0.003*****	0.360	-1.625	**0.002*****	0.197
Indigenous knowledge	0.031	0.893	1.032	-0.258	0.399	0.772	0.782	**0.001*****	2.186	-0.680	**0.065***	0.507	-0.308	0.241	0.735

Represents statistical significance (@ 0.10, @ 0.05**, @ 0.01***)

Overall, drivers with a greater significance to adaptive capacity measured by access to livelihood capitals were adaptation action and access to climate information through the radio medium. These two drivers influenced a total of three capital assets each.

4.2.4 Objective 4 - Explore the state of CC Awareness of RWFs in Ghana

Quality of CC information available to RWFs

The quality of CC information accessible to women farmers was assessed on timeliness, reliability and understandability. Fifty-six percent of respondents reported access to timely information, while 48.9% indicated the reliability of the information received. Understandability was poorly represented, as only 35.9% stated the ability to understand the information received (Figure 4.2).

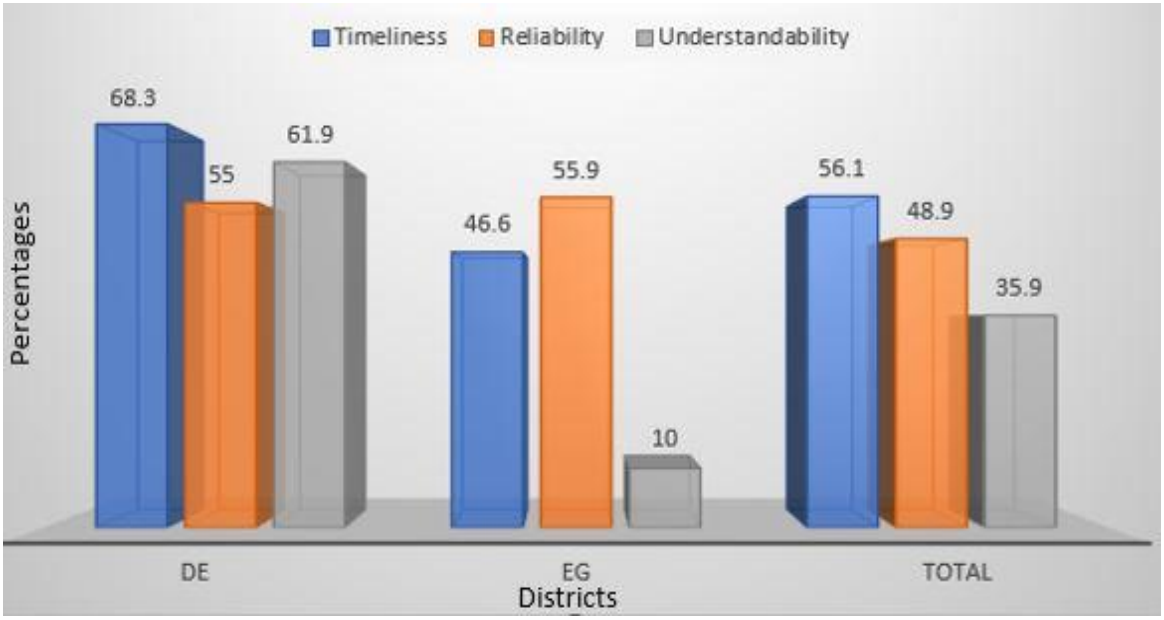

Figure 4.2: Quality of CC information to Women Farmers

Stakeholder analysis of actors within the CCC and CCE space in Ghana

Key stakeholders sampled from national to local levels have unique roles, responsibilities and challenges in undertaking their mandate in the climate change discourse. A stakeholder analysis is vital for effective coordination and cohesion. The functioning of selected stakeholders in CCC and CCE are outlined in Table 4.13. Stakeholders present with unique contributions to the CCE agenda for farmers whiles encountering some challenges. For MESTI/EPA, the lack of a streamlined strategy in

area of CCC/CCE happens to be the major challenge reflecting in the overreliance on donor funds and poor coordination of parallel actors for continuity.

MoFA at the national level responsible for the coordination and dissemination of CSA is setback with the ability to unpack technicalities in the simplest form for users. Logistical and technical support gaps are a common feature for District level MoFA stakeholders. The CSO however finds gaps with technical personal for collaboration and the difficulty in transforming behavior which is the goal of CC and gender-based interventions as a major setback. The key challenges of stakeholders at the grassroot where implementation occurs, need to be critically considered for enhancing the uptake of climate smart interventions through effective awareness creation. Essentially, the CSO (SEND Ghana) was found to utilize a holistic approach in engaging women by targeting the power dynamics in society, coupled with various capacity building and empowerment tactics.

Table 4.13 Stakeholder Analysis of Selected Actors in CCC and CCE

Name of organisation	Mandate in CC	Major achievements	Major setbacks
MESTI/EPA	Sector ministry in charge of CC. The host institution for UNFCC. Responsible for coordinating all actors in the CC space.	Coordinated the development of various CC policies. Coordinated the recent gender-focused documents on climate change; gender analysis, gender action plan and gender toolkits on CC. Training capacity and awareness creation on CC. Coordinated CC negotiations for the country	Piecemeal engagements which are difficult to aggregate. Projectized engagements motivated by funders' interest. Overreliance on donor funding with a limited national budget to function in a coordinated, continuous fashion. Numerous parallel actors in the sector whose activities are difficult to monitor, evaluate and coordinate.

MoFA National	Communicating CC and its impact on agriculture. Dissemination of CSA technologies to actors in the agricultural sector.	Awareness creation on the CC phenomenon and its associated impact on agricultural-based livelihood. Improved uptake of climate-smart interventions among farmers.	Interpreting CSA technologies into local languages. Capacity for technical backstopping on CSA practices
MoFA Dormaa East District	Facilitate the uptake of CSA interventions among farmers at the district level. . Provide technical backstopping for farmers. Awareness creation of CC	Skills training on basic processing in fortified gari and soap making. One million cashew trees planted through the planting for exports and development (PERD) programme. Ranked 2nd best District in afforestation in Ghana under the Ghana Productivity Safety Net Project (GPSNP). Enhanced uptake of zero-tillage farm management and reduced bush burning.	Logistic support to undertake the mandate. The technical capacity of AEAs requires frequent upgrade. Project-based budgeting affects the continuity of interventions. Radio engagement with farmers is limited due to the lack of an FM station in the District. Start-up capital for groups trained in basic processing. Coordination of market outlets for farmers products.
MoFA East Gonja District	Facilitate the uptake of CSA interventions among farmers at the district level. Provide technical backstopping for farmers. Awareness creation of CC	Nutrition improvement programmes for women farmers using legumes and cereals, e.g. groundnut. Encouraged the formulation of female farmer-based groups. Linking farmer groups to market avenues. Frequent sensitisation on radio platforms.	Limited personnel and logistics for engagement. Start-up capital after nutrition improvement training for farmers. Limited budgetary allocation toward climate change sensitization. Technical aptitude for engaging with women farmers.
SEND Ghana (CSO)	Ensure equitable living between men and women.	Enhanced the livelihood of female farmers	Climate change and gender are embedded in

		through village savings and loans (VSL).	lifestyle changes that are difficult to achieve.
Enhance livelihoods through agriculture, and gender.	CC	Addressed gender stereotyping through gender family model. Encouraged the up-take of CSA interventions through demonstration farms. Women mentored to take up local leadership positions. Women are supported with subsidies to acquire inputs and equipment for their livelihood.	Limited personnel to collaborate with in targeting women farmers.

Source: Author's Compilation from Fieldwork (2022)

Pathways to CCE by stakeholders

The effectiveness of stakeholders in their CCE engagement with women farmers was assessed on a scale of one (1) to three (3), where one is ineffective and three is highly effective. The benchmarked pillars of educational engagement were co-production, place-based, gender-sensitive, adult learner-centred, and visual imagery (ICT) approaches. Results revealed that adult learner-centred approaches were the most significant considerations by stakeholders, where the approaches used were more demonstrative than instructive. Indeed, stakeholders affirmed their desire for more demonstration farms and logistics to engage farmers, especially female farmers, as the coverage of demonstrative engagements with farmers was low.

Visual imagery (ICT) approaches were the least effective approaches used by stakeholders, requiring much more exploration, especially with a high extension officer-

farmer ratio. National-level government stakeholders scored better than district-level bodies on all five approaches.

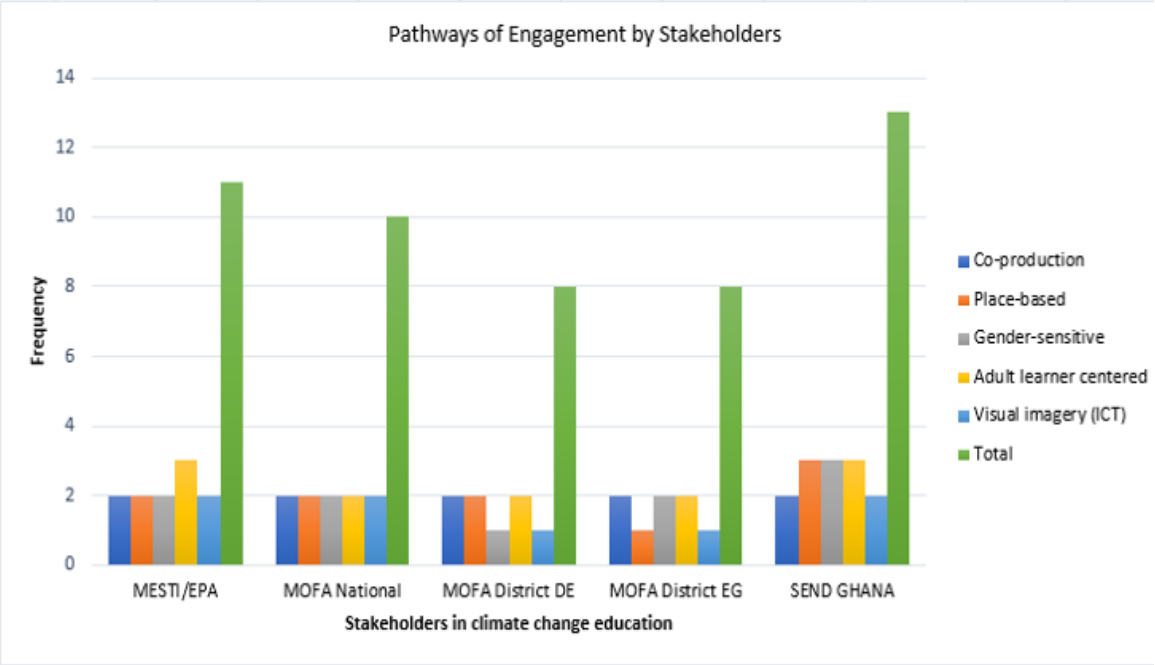

Figure 4.3 Pathways of Engagement by Stakeholders

4.2.5 Objective 5 - Propose an Educational Strategy for RWFs

Enablers to effective climate change education for rural women farmers

Stakeholders expressed vital factors facilitating their engagement with farmers under five broad concepts, subsequently exposed.

A gender transformative approach (gender model family)

SEND Ghana used this approach to correct sociocultural gender stereotyping that deepens the vulnerability of women. It did this by engaging both husbands and wives at the family level. With this approach, gender roles are redistributed among household members intended to ease stress and workload on a few members of the family, especially females. According to SEND Ghana, beneficiaries of this model attest to holistic benefits to the family where productivity levels of family members have improved, especially that of women who were previously loaded with household chores.

Context-specific engagements

Stakeholders advocate for context-specific engagements, facilitating appropriate framing and audience segmentation for effectiveness. AEAs affirmed that farmers are more agreeable to engagement that start within the confines of their indigenous knowledge before branching into additional scientific knowledge. As an Agric officer puts it, "*disregarding the belief system of adult learners has proven to repeal rather than encourage integration*" (Expert interview, 2021). Again, an Agric Officer in Dormaa East indicated: "*Whenever interventions are organised at a centralised location due to logistical limitations, the representation of women farmers is especially very low*" (Expert interview, 2022). It was further stressed that the timing of interventions must be constructed to favour women farmers before they can participate effectively.

Hands-on demonstrative engagements

Stakeholders at policy and coordination of CC (EPA/MESTI) advocated for practical approaches whiles all other stakeholders highlight demonstration farms as a critical success factor. SEND Ghana, which collaborates with MoFA in East Gonja, said; "*The use of the demonstration farms is helping to influence farmers' appreciation of climate change and adoption. Farmers are allowed to apply their old practices on one side of the demonstration fields alongside the new and improved practices introduced by AEAs. With this, they observe the differences in yield and are more convinced to adopt the new practice*" (Expert interview, 2022).

Interactive ICT platforms

The ability of the rural woman farmer to use ICT mediums should not be underrated. As indicated by a stakeholder, "*Most women have mobile phones from which they access information on the radio without using a box radio that belongs to a husband*"(Key informant interview, 2022). SEND Ghana is exploring the use of audio gadgets where dramatised pieces of training are recorded for use during FBO meetings.

Farmers can then discuss among themselves and challenging issues forwarded for addressing at a convenient time by AEAs.

Selection of role models

Farmers who successfully used CSA interventions and other practices were selected as models for communities to encourage climate change adaptation. As models, their pictures were sometimes put on flyers and further allowed to participate on platforms outside the domains of their communities. They were further supported with inputs to facilitate their enterprises. SEND Ghana notably used the model approach and indicated that it inspired positive involvement from community members to participate.

Barriers to effective climate change education for rural women farmers

Stakeholders expressed factors that have limited their operations with farmers in the face of CC. These barriers were synthesised under four (4) broad themes.

Non-existent operational structure

Although the EPA is mandated to coordinate all activities under CC, limited personnel at the grassroots level coupled with systems that limit control is a major setback. The focal person at EPA used a German example to stress his point. He said, "*The Federal Ministry of Education and Research (BMBF), a cabinet-level ministry, coordinates all funding in education and research and has information on all educational investments. This is because they receive reports on all agencies that source funds from them to operate. MESTI/EPA neither controls the budget of non-governmental organisations nor receives reports on their operations*"(Key informant interview, 2022).

Lack of gender-focal persons

Personnel challenge is a resounding issue across all stakeholders, especially at the grassroots. Local stakeholders report very few female AEAs (absent in some places)

available to interact with women who live in communities with prohibited male-to-female interactions. Overall, AEAs with up-to-date knowledge of CSA interventions are limited.

Boxing of vulnerable groups

The general practice is to ensure a percentage representation of women during engagements without a critical analysis of which category of women is being represented. The deputy director of Agricultural Extensions at the national level highlighted the need to unpack the different categories of women in terms of vulnerability. She said "*Distinctions exist between rural women farmers, i.e., disabled farmers, those with social safety nets and those without safety nets. Thus, different strategies should be utilized to target different women*".

Gender stereotyping

A crucial concern is the sociocultural norms that limit women's land ownership, especially in patrilineal cultural systems. Decisions on farming practices mostly come from landowners who may not have knowledge to CSA strategies or its benefits, especially when farmers are not land owners. An Agric officer described his frustration when a farmer he had been working with for almost ten (10) years would always appreciate methods taught to him but will not implement them. Upon further probing, he found out that the actual owner of the land was not in favour of these practices and threatened to reclaim his land if the CSAs were practised.

Framework for educating informal rural women for climate resilience

A synthesis of results from stakeholders reveals a context-specific CCE that should consider the individual and systemic factors that define rural women. As indicated by Endsley (1995b), individual and external (also referred to as system) factors are basic conditions that influence situational awareness (perception, comprehension

and resultant actions) of a system. Thus, applying the situational awareness model in the context of Climate Change Education (CCE) for RWFs, the individual factors refer to the characteristics of rural women identified by the demographic characteristics discussed in section 4.2 (Table 4.1). Essentially, they reflect the educational level, literacy, marital status, experiences (in this context, experience in farming), and household size, among others.

The external/system factor looks at the societal norms, cultural/ inheritance practices, and institutional arrangements that govern the functioning of rural women. The system factors may also be referred to as external factors as they do not emanate from the women themselves but are generated externally to influence the functioning of women (Endsley & Jones, 2012). Therefore, it is evident that there is a direct relationship between the individual and systemic factors, where the system factors shape the characterization of RWFs. The characterization of RWFs further shapes how they perceive and understand the concept of climate change and how they can translate this knowledge into appropriate decisions and actions. Figure 4.4 highlights a proposed framework for streamlining RWFs engagement in CCE for resilience.

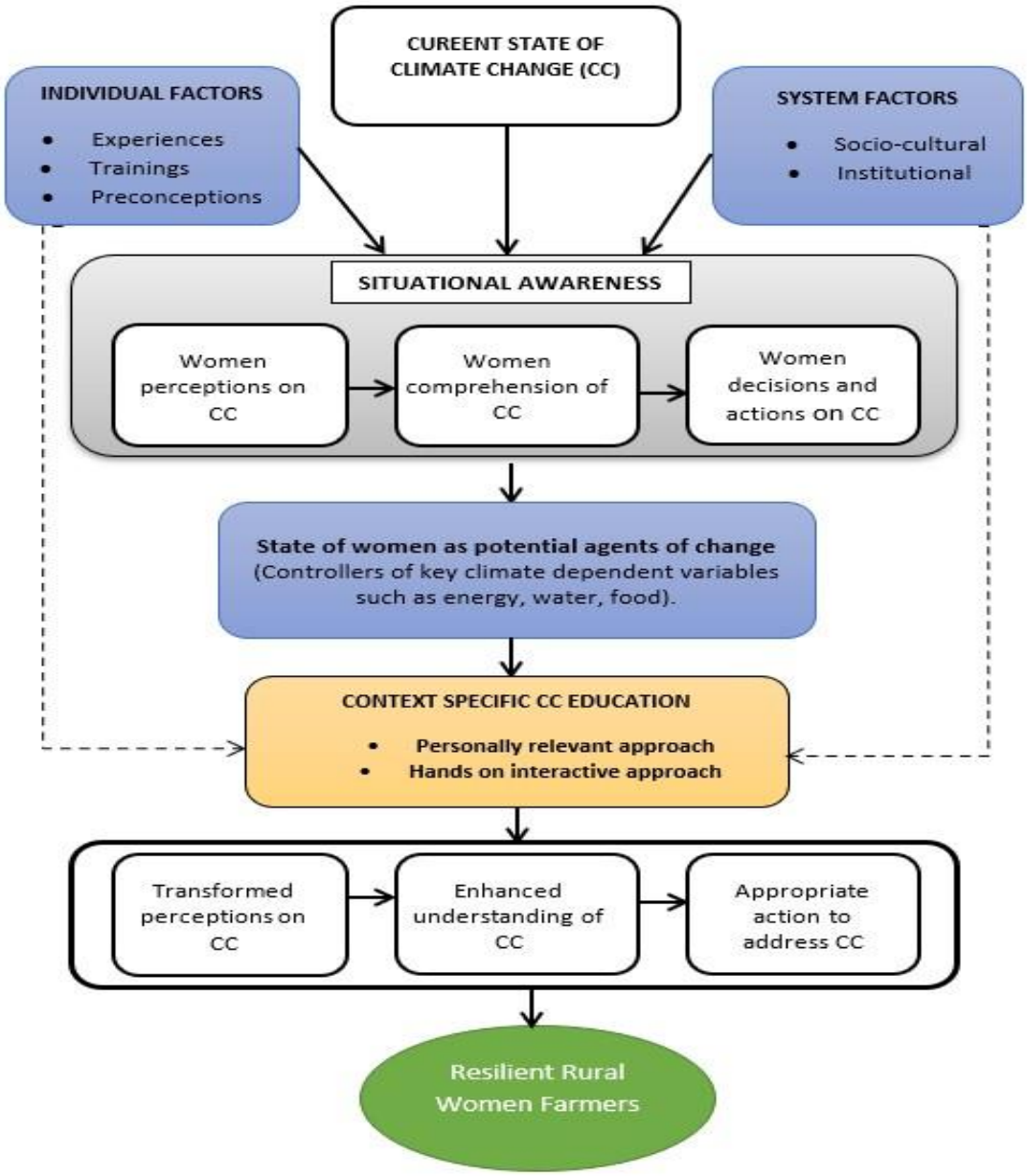

Figure 4.4: Framework for Educating Informal Rural Women for Climate Resilience

Source: Author's Construct from Fieldwork (2022)

4.3 Discussion of Findings

4.3.1 Objective 1: Situational Awareness of RWFs from Different AEZs in Ghana

Perception

Respondents' high perception with CC (Table 4.2) affirms climate variability in the selected districts as they represent the districts with the highest CCVI in their respective AEZ (EPA, 2020). The association with CC further indicated high levels of respondents' perception of climatic changes in the respective Districts, which affirms the findings of Asante et al. (2021), suggesting high levels of perception among rural farmers on CC and variability in northern Ghana. The high levels of perception may be attributed to sensitization drives that have intensified on various mediums on CCs. Most significantly, high levels of perception of rural women farmers in the changes in climatic variables can be attributed to the need to monitor the changes in climatic variables on which their livelihoods depend.

Antwi-Agyei et al. (2014) and Vermeulen et al. (2012) have indicated the high dependence of smallholder farmers in the global south on climatic variables such as on set and cessation of rainfall, the intensity of temperature and wind, making it a compelling interest area. Asrat & Simane (2017) and Deressa et al. (2009) allude to a positive correlation between high perceptions of CC and livelihood adaptation. Antwi-Agyei et al. (2015a) highlight financial, sociocultural, technical and information issues that hinder effective CC adaptation in their systematic review of barriers to adaptation irrespective of high perception.

Comprehension on impact of CC

The high understanding of respondents on the impact of CC on crop production, yield and diseases (Table 4.3) is not surprising due to the high dependence of agriculture on natural and climatic variables. The occurrence of losses on in crop yields have been attested to by Asante et al. (2021) and Amisah et al. (2009) who recount of loss of whole

maize farms due to flooding and decreased crop output in the Offin Basin of Ghana due to erratic rainfall patterns. Changes in climatic conditions have also proven to initiate the onslaught of pest and crop diseases such as fall armyworm and stem borer disease (Asante et al., 2021; Amisah et al., 2009).

The differences in the degree of association in understanding of CC impact on biodiversity and forest resources (Table 4.4), seem related to the extent of CC in the District in question. For EG, extinction was very significant as the impacts of CC dimensions are harsher with a higher CCVI of 0.37 than DE with CCVI of 0.05 according to EPA (2020). Issues that directly relate to the livelihood of respondents, such as the impact on crop production and incomes seemed to have carried greater importance to them. This confirms the findings by Monroe et al. (2019), indicating that adult learners are self-motivated and have underlining interests; hence learning becomes effective when situated in issues surrounding their lives, such as their livelihoods.

Climate actions of RWFs

Mitigation actions were poorly represented among respondents across Districts (Table 4.6). This is not surprising as rural farmers are known to be livelihood conscious; therefore, CC mitigation may not be the first point of call in their decisions except it is seen as a co-benefit enterprise (Smith et al., 2022; Gosnell et al., 2020; Tschora & Cherubini, 2020). Additionally, in both districts, it was realised that the majority had engaged in tree planting exercises due to District-led initiatives where they were provided with trees to plant. Tree planting was the commonest mitigation feature among smallholder farmers, which has been found to contribute to above and below-ground carbon sequestration and other co-benefits. However, with only about 20.1% of respondents participating in tree planting, there is a need to deepen awareness in this

area to attract and sustain maximum patronage and benefits in tree planting to women farmers. Alternative innovative mitigation measures should be explored for RWFs.

Adaptation action by RWFs

Almost all the adaptation actions taken by respondents were temporary and seemed spontaneous rather than planned; which are considered as coping strategies. As Holzkämper (2017) and Vincent et al. (2013) suggest, the adaptation options selected by respondents are survival inclined rather than yielding towards a behavioural and a practice shift which is more sustainable and accrues to resilience building. Such categories of adaptation actions are referred to as coping strategies (Holzkämper, 2017; Vincent et al., 2013). A small proportion of respondents switched to another enterprise (EG 2.8% and DE 8.3%), revealing the short-term unplanned nature of adaptation among respondents (Table 4.7). Fedele et al. (2019) have highlighted the efforts required in pursuing an enterprise change by indicating the need for strategic planning and alteration of the fundamental attribute of production, which stakeholders should note.

A major setback for the livelihoods of rural women who play a crucial role in sustaining the national food basket is the significant proportion of respondents who do not take any adaptation action (Table 4.7). The high incidence of CC perception and comprehension compared to the high incidence of no action in mitigation and the unplanned nature of adaptation actions suggest a disconnect between CC awareness and climate response. Financial, technical, sociocultural and information barriers are highly attributed to this disconnect, as Antwi-Agyei et al. (2015a) found as barriers to effective climate response. Mulwa et al. (2017) indicated in a study on response to climate risk among smallholder farmers in Malawi that addressing information barriers is a critical motivating factor for farmers to adapt to CC even in the face of other limitations such

as finance. As such, gaps in climate change awareness creation must be addressed while creating the enabling environment for effective, sustained climate response.

Association between sociocultural characteristics and situational awareness of RWFs

The results indicate that although there are some observable differences in the demographic character and situational awareness of respondents from the two unique districts, they are not statistically significant. The statistical insignificance of differences between the situational awareness of the two districts indicates that the similarity of rural women farmers supersedes the differences in sociocultural characteristics. Thus, there is no association between sociocultural characteristics and rural women farmers' situational awareness of climate change.

4.3.2 Objective 2 - Measure the Adaptive Capacity of RWFs from Different AEZs in Ghana

Natural capital

The adaptive capacity of RWF is hinged on this capital as farming is highly dependent on access to land and its related attributes like access to water for irrigation purposes, land size and the influence of nativity. The place of RWFs is even more critical as they are further disenfranchised due to the customs of land ownership which is highly unfavourable to women.

The rhetoric from the FGDs affirm the burden on women farmers, further deepening their vulnerabilities. There is a need to rethink and reconstruct societal norms influencing women's access to natural capital for livelihood effectiveness. Bhadwal et al. (2019), Meinzen-Dick et al. (2019), and Antwi-Agyei et al. (2015) scholarly works sit with the finding that attests to a high association between limited access to natural capital, especially land and gender-based vulnerabilities – mostly against women.

Human capital

Human capital is found to be the highest representing capital among RWFs highly influenced by marital status, knowledge upgrade services and physical fitness. However, lower literacy and high household size potentially negate human capital's positive impact. For instance, low literacy levels can affect the benefits of knowledge and skills upgrade services. The low access to farm labour may be facilitated by the respondent's physical fitness and high household size, which substitutes for farm labour. Rufai et al. (2018) confirmed the benefit of physical fitness and stated that physical strength is the key (and in most cases only) input available to women in agriculture.

Physical capital

Although RWFs indicated an appreciable access to physical capital (Table 4.9), most of these asset indicators were challenged on the scale of its quality and benefit (Table 4.10). It is therefore critical that the quality of physical assets in terms of functionality and reliability are taken into consideration in assessing adaptive capacity. Lax & Krug (2013) regarded the quality of physical assets as a relevant indicator in their scholarly work on livelihood assessment tools for natural resource communities. The research however avoided ownership of household assets due to the potential of social desirability bias whiles focusing on road networks, markets, health facilities, electricity and potable water. As a measure of physical capital, Llanto (2012) and Zhang et al. (2007) have indicated the capacity of infrastructure to facilitate the functionality of the other key assets holdings and production at the farm level.

Social capital

Low social capital (Table 4.9) has a telling on access to financial capital as safety nets often facilitate access to financial resources. Membership in social groups, although important, is considered beneficial based on the depth of interaction and strength of ties among members (Antwi-Agyei et al., 2013). Respondents hence ranked the support they

receive from social networks which showed weak support in times of hardship although the networks were available. Results on access to capital assets (Table 4.9), in contrast to the quality of assets, i.e., reliability and usefulness (Table 4.10), further affirm that access to a capital asset may not necessarily reflect capacity, especially for vulnerable groups.

Financial capital

Inadequate financial capital (Table 4.9), exposed the fragility of the livelihoods of respondents, as many local economies have now been monetised. Financial capital is, therefore, essential for the survival and acquisition of various farming inputs (Lax & Krug, 2013). Fosu-Mensah et al. (2012) further indicated the importance of financial capital in facilitating adaptation to climate change, especially in acquiring inputs such as improved crop varieties. Livelihood diversification, extensification and intensification is likely to be seriously challenged affecting livelihood security. Incomes and asset holdings that could be translated into finance were not considered, as farmers find it difficult to determine their real incomes and profits. Again, people are not easily comfortable with sharing personal financial information. Antwi-Agyei et al. (2013) affirmed this by citing record-keeping challenges and memory lapses in acquiring data on income levels.

Differential adaptive capacities between RWFs from different AEZ

RWFs coming from distinct AEZs present with differential capacities in terms of livelihood capital assets (Figure 4.1). The observed differences, were found to be statistically insignificant. Thus, although Guinea Savannah agro-ecological zone seems prone to harsher climate variability and different cultural norms compared with the Deciduous Forest zone, the differences do not significantly tell on the adaptive capacity of rural women farmers. The gender roles, coupled with similar geographical setting (rural) and livelihood strategy (farming), seems to put them in a much identical category

of adaptive capacity. However, agroecological zone-specific interventions should not overlook unique differences in adaptive capacity. Overall, a moderate-scale adaptive capacity (a figure that could slip into low-scale - 0.405) which has grave implications for vulnerability was recorded. A high adaptive capacity is critically required, especially for a group exposed to the vagaries of climate variability and whose livelihoods are hinged on natural and climate-sensitive variables.

4.3.3 Objective 3 - Determine the Impact of Climate Information on the Adaptive Capacity of RWFs in Ghana

The character of climate action and information mediums of respondents

Local and Indigenous Knowledge Systems (LINKS) are an essential and effective medium for everyday decision-making among local people with low literacy levels (UNESCO, 2021). LINKS which was the most predominant medium of information to respondents (Table 4.11) should therefore be unearthed, documented and integrated with scientific knowledge for greater effectiveness. Face-to-face interaction between women farmers and extension officers was very poor (Table 4.11). Gender roles and cultural practices may contribute to the poor interaction between women farmers and extension officers. Males are the first point of call, especially for RWFs who work on a parcel of land with their spouses and also due to land ownership rights. Quisumbing & Pandolfelli (2010) indicated, among other things, that women are usually not considered agricultural decision-makers in their review of promising approaches to addressing the needs of poor female farmers.

Cultural norms that restrict male-female interactions with a limited and in some cases, no involvement of female extension officers in Ghana, Ethiopia and India are also reported by Quisumbing & Pandolfelli (2010) as a cause for limited extension officer interaction with women. Extension officers must therefore seek constructive ways to

engage marginalised groups, as Business-As-Usual (BAU) will not reach this vital audience – rural women farmers. Efforts should be made to attract and retain female extensionists while training male AEAs on techniques tailored for engaging female farmers. Again, AEAs should consider engaging women at periods that do not conflict with gender roles such as homecare responsibilities in addition to providing incentives to AEAs who report high outreach of female farmers. Mekonnen et al. (2021); Amfo & Ali (2020); Diouf et al. (2019) have in their research on sources of climate information, indicated the radio as a highly effective medium for women farmers relative to men, affirming the results of this work (Table 4.11). Again, it was noted that District AEA reps mainly handle radio-based climate information engagements, a reasonable effort at augmenting mainstream face-to-face interactions between farmers and extension officers.

Traditional (radio, TVs) and modern (mobile telephones for calls, Short Messaging Services, Multimedia Messaging Services, social media) ICT mediums must be explored and integrated as alternatives. The World Bank Group advocates for the inclusion of traditional and modern ICT mediums with the benefits of cost-cutting in extension service delivery (World Bank, 2017). ICT mediums have also been found to facilitate timeliness and service quality in Short Messaging Services (SMS) in Kenya (Wright et al., 2016) while serving Caribbean farmers effectively (Narine et al., 2019). Additionally, multiple sources of climate information (Table 4.11) allow for rich, augmented and in-depth knowledge. However, there is a need for proper coordination to avoid conflicting and ambiguous information. Finally, co-benefit practices for both adaptation and mitigation should be encouraged among farmers.

Impact of climate action and information mediums on adaptive capacity

Adaptation action's influence on capital assets

Adaptation actions by woman farmers build their skills, experience and capacity, therefore, accruing to human capital enhancement. Women farmers who adapt will likely have secure livelihoods reflected in improved yields and productivity, indicating a positive synergy between adaptation and resilience (Naqvi et al., 2020; Kansiime, 2012). However, a decrease in social capital, influenced by adaptation, was probable because the more a RWF adapts to the vagaries of climate change and variability, the more resilient and self-reliant she becomes. Resilient RWFs may reduce participation in social networks and ties when not viewed as a critical need.

RWF's engagement in social groups should be constructed to facilitate their involvement despite excessive household responsibilities and workloads. Mudege et al. (2016) and Quisumbing & Pandolfelli (2010) have highlighted gender norms that limit women's participation in and access to social support. Mudege et al. (2016) indicated scenarios in a study where men were presented as family representatives and would represent at all forms of meetings without the participation of women. Underneath this assertion was the view of women's inability to understand issues presented during the meeting, so they were not allowed to participate. Quisumbing & Pandolfelli (2010) have indicated the need to bring social engagements closer to women by scheduling activities when women are not engaged in household responsibilities. These are essential considerations to deepen the social capital of RWFs situated within entrenched sociocultural norms.

Radio medium's influence on capital assets

Although the radio medium is a significant source of climate information to RWFs, its influence on human and social capital was negative. A decreasing

relationship between radio medium to climate information and social capital may be because the more radio becomes a reliable source of climate-related knowledge, the less likely it is for a female farmer to engage social ties and networks for a similar purpose. Gender roles and norms that do not encourage women's effective participation in social groups and associations limiting social capital require addressing (Mudege et al., 2015b).

TV medium's influence on capital assets

The TV medium does not record significance to any livelihood capital. Statistical insignificant is most likely recorded for TV against all livelihood capitals because the TV medium is not highly preferred for RWFs (only 30% utilising the medium – Table 4.11). Again, the limited mobility of the TV medium compared to the radio medium makes it an unfavourable medium.

Farmer group medium's influence on capital assets

Access to climate information through farmer groups positively correlates with social and physical capital. Farmer groups offer a social network base where farmers interact and leverage other forms of support. Regarding physical capital, the network base and interaction created through farmer groups will likely generate advocacy for local development, including infrastructure provision. Mudege & Kwangwari (2013) and Penunia (2011), for instance, have indicated the benefit of farmer groups in advocating and influencing policy while strengthening women's voices to be heard.

Extension officer medium on capital assets

The Extension officer medium provides face-to-face interaction and support for farmers regarding knowledge and input capacity; however, it is significant to physical and financial capital in a decreasing dimension. Dunne et al. (2019) have highlighted the critical role extension officers play in assisting farmers in building resilience through technology transfer and innovative practices. Reliance on women farmers' physical and

financial capital may reduce for those who benefit from face-to-face interaction with AEAs due to improved adaptive capacity and resilience.

Indigenous knowledge medium on capital assets

Indigenous knowledge, also known as LINKS, has a positive relationship with social capital. The odds of increased social capital by 2.186 times was probable as LINKS is embedded in societal knowledge transferred from person to person and from generation to generation. Recent research by Jha & Gupta (2021) in rural India highlighted farmers' reliance on previous experiences and knowledge from fellow farmers as a premium source of climate knowledge. Indigenous knowledge sits in the confines of social ties and networks. As such, the more indigenous knowledge is available to a RWF, the more likely she is to possess an increase in social capital.

4.3.4 Objective 4 - Explore the State of CC Awareness of RWFs in Ghana

Quality of CC information available to RWFs

On all fronts of the quality of the information received (reliability, timeliness and understandability), it is evident, that more work is required to make climate information and communication more helpful to women farmers. The effectiveness of CCC and CCE for women farmers is therefore questionable as the personal relevance and interactive component attested to by Karpudewan et al. (2015), Theobald et al. (2015), and Wibeck (2014) seems missing. A reorientation and restructuring of existing CCC and CCE mediums will be a step in the right direction.

Stakeholder analysis of actors within the CCC and CCE space in Ghana

Generally, gaps in skilled capacity especially at the grassroot, limited financial resources coupled with donor regulated funding and collaborative challenges between actors were some of the challenges expressed by stakeholders within the CCC and CCE

space in Ghana. Empirical research on Government-based institutions in Ghana present with similar findings (Adu-Baffour et al., 2021; Appiah, 2016; Arthur, 2016). Rasul et al. (2021) and Arthur (2016) highlight human capacity challenges for the effective implementation of policies at the grassroot. Rasul et al. (2021) reports a positive correlation between management efficiency and completion of task whiles Arthur (2016) scholarly work emphasizes the need for skills that facilitate the management of multiplicity of task at the local level.

The lack of such technical staff has been said to be fueled by the increasing exodus of experienced personnel into other private sector well-paying jobs and the recruitment of staff on the lines of personal affiliations such as political rather than on competence. Appiah (2016) also reports of the overreliance on external funding with weak ability for generating funds internally as a major limitation to the effective functions of government institutions. Bottlenecks in effective collaboration between stakeholders is emphasized by Adu-Baffour et al. (2021). For effective functioning of critical stakeholders in the CCE and CCC space, highlighted bottlenecks require addressing.

Pathways to climate change education by stakeholders

The use of adult-learner centered approaches which are more demonstrative in nature as the most effective approach by stakeholders affirm the scholarly works of Monroe et al. (2019) and Wibeck's (2014) who asserts the effectiveness of demonstrative and practical approaches in CCE. The inculcation of a more practical, user-friendly virtual techniques will be a helpful addition to engaging farmers, as visual imagery (ICT) techniques are the weakest approaches used by stakeholders. Rolnick et al. (2023); Ramadhan et al. (2019); Cox et al. (2014); Mutlu & Tokcan (2013) have all

recommended the use of different visual imagery and ICT techniques including the use of Artificial Intelligence (AI) in enhancing conceptualization and CC learning.

Better performance of national-level stakeholders indicates capacity issues at the grassroots. Apex bodies may have the capacity to implement some of the critical considerations in the approaches. However, local-level stakeholders are challenged with logistics, funds and personnel gaps indicated in the stakeholder analysis (Table 4.14). Non-Governmental Organisations (NGOs), on the other hand, can perform better due to autonomy, availability of funds and personnel to function. NGOs are project-focused and usually have the full complement of resources before engaging. It is, therefore, not surprising that SEND Ghana had the highest score with all five approaches (Figure 4.3).

4.3.5 Objective 5 - Propose an Educational Strategy for RWFs

Enablers to effective climate change education for rural women farmers

According to Hillenbrand et al. (2015), there exist structures that disenfranchise women that require transforming rather than a mere empowerment of women. This goes to support the efforts of SEND Ghana championing the gender model family – a gender transformative approach. The gender model family approach addresses the sociocultural barriers that inhibit rural women's access to climate information by equally engaging the men who are usually the heads of the home for livelihood enhancement. Furthermore, framing CCE approaches within the context of sociocultural and religious beliefs as entry points have proven more successful in contextual engagements. Rubbishing what farmers know as useless always leaves them indifferent to the information presented. Wezel et al. (2020) validates this assertion by highlighting the benefit of co-creation and knowledge sharing in transforming agriculture into a sustainable enterprise.

Additionally, findings suggested that the closer and more practical interventions are to women, the better placed they are to participate and adopt CSA practices. In support to this assertion, Ainscow (2020) has indicated the need for organizational flexibility that encourages dialoguing on what strategies work best for learners. As indicated by Quisumbing et al. (2014), women will easily opt out of any engagement interrupting their gender role as homemakers and caregivers. The practicalities involved in engaging women farmers have also been said to be critical to success in CCC and CCE. Vincent & Balasubramani (2021) and Thinda et al. (2020) have corroborated the potency of demonstration farms as a CCE strategy in upscaling the adoption of CSA interventions. Results of demonstration activities which are practical and hands-on are vivid within farmers own setting, thus facilitating a quick acceptance and adoption.

Highly interactive, user-friendly and local dialect-sensitive ICT platforms are further suggested for effective CCE, affirmed by the scholarly work of Thinda et al. (2020). Selection of farmer role models as a feedback mechanism and motivation to farmers has been encouraged by Wibeck (2014). Giving feedback to local people on their climate action and acknowledging their efforts through various motivations is a productive climate learning strategy asserts Wibeck (2014).

Barriers to effective climate change education for rural women farmers

The presence of multiple actors without a centralised coordination unit has resulted in duplication of efforts and lack of continuity. Progress in literacy building becomes challenging, and different actors use different non-monitored approaches that may erode existing advances. Adu-Baffour et al. (2021) has also highlighted challenges of effective collaboration between state and non-state actors in his research work, validating this finding. Again, gaps in technical expertise, especially with gender-focal persons who coordinate all gender issues for mainstreaming at the sector and national

levels has also been reported by Antwi-Agyei et al. (2021b), in the Gender Analysis of NDCs Sectors in Ghana. Rasul et al. (2021) and Arthur (2016) have equally exposed human capacity challenges at the grassroot.

Furthermore, to address the barrier of boxing vulnerable groups together, Chanana-Nag & Aggarwal (2020) and Lawson et al. (2019) have indicated the need for further synthesis of female-based interventions to reach the most vulnerable. Finally, interventions that do not address the underlining power relations and sociocultural norms keep women entangled, irrespective of the capacities and support they receive (Ravera et al., 2016; Hillenbrand et al., 2015). A crucial concern is the sociocultural norms that limit women's land ownership, especially in patrilineal cultural systems. Lawson et al. (2019) affirms this barrier by indicating that access and ownership of land is a critical setback to climate change adaptation among women farmers.

Framework for educating informal rural women for climate resilience

A primary concern for CC adaptation is a functional communication strategy highlighting unique needs and strategies for engaging different audiences (Antwi-Agyei et al., 2018). Rural women farmers have been identified as an exclusive audience in CCC due to their role in controlling vital climate-related sectors such as food, water and energy (Arora-Jonsson, 2011). It is, therefore, essential to enhance the perception and comprehension of rural women farmers for effective CC decisions and action. The research has already established that the situational awareness of RWFs is flawed by a disconnect between adequate perception, comprehension and poor actions (section 4.3). Additionally, it has been established that approaches that are not particularly rural women contextualized affect appropriate comprehension that fuels commensurate climate actions. Contextualizing knowledge on what works with a particular audience and the co-creation of knowledge has be validated by Ainscow, (2020) and Wezel et al.

(2020). Thus, rural women farmers' characterization gives an indication of the kind(s) of approaches that can be useful in terms of CCE.

Low literacy, in even local dialect, a character of RWFs, highlights the need for framing CCC and CCE more visually, inclusive of demonstrative techniques. Vincent & Balasubramani (2021) and Thinda et al. (2020) also affirm the potency of using practical and demonstrative engagements. Additionally, workloads expressed in household size and ownership of livelihood assets such as land reveal a need for a more intentional and appropriate selection, timing and location of climate change training to ensure effective participation from RWFs. For instance, the choice of trainees in reference to land owners will cut off many women due to land ownership issues (Chanana-Nag & Aggarwal, 2020; Lawson et al., 2019). The ability to tackle societal gender stereotyping that conditions women will be a long-term gain for women-centred interventions (Hillenbrand et al., 2015).

To translate rural women farmers from mere victims to powerful agents of change, the application of the lessons, best practices and experiences of various stakeholders, in addition to the individual and system factors that characterise RWFs, have been essential considerations. Overall, personally relevant and interactive hands-on approaches contextualized for RWFs are highlighted as instrumental in this research (Monroe et al., 2019; Wibeck, 2014). By personal relevance, CCE interventions and approaches that merely call for female representation without particularly considering the characterization of rural women farmers will become counterproductive. Hand-on interactive approaches suggest using practical rather than theorized approaches and platforms. Context-specific CCE, expressed as personally relevant and hands-on interactive approaches, is a summary of the critical enablers highlighted by stakeholders in CCE while considering the personal views of respondents expressed in the study.

4.4 Problems Encountered in the Field

As with any research, this research came with its methodological setbacks; however, efforts were made to ensure that the limitations encountered did not affect the quality of the research work. The sample size selection was setback with a lack of a sample frame of rural women farmers across the districts. Thus to determine the sample size, the projected proportion of women was used as a proxy to calculate the sample size facilitated by the Cochran sample size calculator for unknown populations (Nanjundeswaraswamy & Divakar, 2021). Also, the western part of East Gonja District could not be sampled due to resource and access limitations. This was because the white volta separated the western part, which required special arrangements and additional financial resources the research could not cover. However, selecting respondents to cover every rural zone proved sufficient for sample representation.

Additionally, the study could have sampled from each agroecological zone for an extensive representation of Ghana. However, selecting the Guinea Savanna and Deciduous Forest agroecological zones proved adequate for two reasons. The selected agroecological zones represent Ghana's primary cultural practices (patrilinear and matrilinear) and the main planting seasons (uni-modal and bi-modal). Again, the language barrier in the East Gonja District was catered for with the help of interpreters who were conversant with the local dialect and the English language. The Kobocollect app, used to collect survey data, needed internet connectivity to upload completed questionnaires for validation and finalization. However, the lack of internet connectivity in the communities limited field assistants' ability to submit completed questionnaires on time. Questionnaires were uploaded and validated upon return to the main town where field assistants were lodged. In the event of a need for editing, audio-recorded interviews were referred to for the necessary adjustments.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATION

5.1 Summary

5.1.1 Situational Awareness of RWFs from Different AEZs in Ghana

Results indicated that women had a high rate of perception of the changes occurring among climatic variables and high comprehension of the impact of climate change on crop production, biodiversity and sociocultural factors. However, the climate actions represented by mitigation and adaptation were lower in contrast to perception and comprehension. Adaptation actions were unplanned but undertaken as a reactive measure towards prevailing climatic stresses, categorised as coping strategies. Therefore, climate change knowledge, expressed through perception and comprehension, had not effectively translated into climate response (mitigation and adaptation).

The gap between perception and comprehension of climate change, as against climate action, suggests a need for awareness creation efforts to emphasise the value and multiple benefits of appropriate, well-planned and sustained adaptive measures. Results further highlighted that the homogeneity of rural women farmers supersedes the differences in their agroecological backgrounds. Thus, interventions for enhancing CC awareness among rural women farmers may cross-carpet different localities with minimum considerations.

5.1.2 Measure the Adaptive Capacity of RWFs from Different AEZs in Ghana

Results show that the core capitals that contribute to the adaptive capacity of RWFs are human, physical and natural. Although RWFs indicated access to these three

capital assets, the holistic benefit and control over these assets are questionable in terms of usefulness and reliability. Thus, focusing on a major component of adaptive capacity without a critical focus on the subcomponent indicator presents a bleak picture. An overall adaptive capacity of 0.409 (DE=0.405, EG=0.388) which is weak has implications for the livelihood resilience of RWFs. Observable differences in adaptive capacity between RWFs in the two agroecological zones proved statistically insignificant and affirmed the commonality among rural women within the agricultural space, specifically crop farmers.

5.1.3 Determine the Influence of Climate Information on the Adaptive Capacity of RWFs

All climate information mediums and actions used as independent or predictor variables proved to have a significant drive on livelihood capital assets (Natural, Physical, Financial, Human and Social) except for the TV medium. However, there was an Odds of a decrease in some livelihood capital relative to access to a climate information medium and engagement in climate action. This result was found to be situated in existing social norm and gender roles that exacerbate the plight of women. Thus, as long as system designs that stereotype and limit women remain, access to climate information mediums, mitigation and adaptation are not sufficient in enhancing the adaptive capacity of women.

5.1.4 Explore the State of CC Awareness Creation in RWFs

Results showed that the most effective technique used by stakeholders in engaging farmers was demonstrative rather than instructive methods, most suited for adult learners. Visual imagery (ICT) platforms were the weakest approaches used by national and local stakeholders. It was found that individual (training, experiences, knowledge and abilities) and external factors (stressors, workload and system design) play a crucial role in shaping the awareness of rural women farmers. The individual and

external factors together form the unique context of RWFs. The research findings highlight the setbacks RWFs face in accessing appropriate CCE due to sociocultural norms, capacity gaps and limited budgetary allocations.

5.1.5 Propose an Educational Strategy for RWFs

Efforts at self-correcting entrenched gender stereotyping by targeting the family unit proved as a significant enabler, although a snail-paced process. Additionally, context-specific, hands-on demonstrative, interactive ICT and model selection approaches facilitate effective CCC and CCE. On the contrary, significant barriers have been the lack of operational structures, capacity gaps with gender focal persons, boxing of vulnerable women and gender stereotyping approaches. A proposed framework for engaging informal rural women through a synthesis of key lessons from stakeholder in the CCC and CCE space, including the perspective of RWFs. The framework is developed as an entry point into the development of a holistic National CCC and CCE strategy.

5.2 Conclusion

Climate change and variability are stress multipliers that worsen rural women farmers' plight. The predicament of rural women farmers is exacerbated due to their dependence on climate-related sectors and limited access to livelihood capitals for building resilience. Appropriate CCC and CCE strategies that encourage the uptake of climate-smart interventions are effective strategies for enhancing the resilience of rural women farmers. Existing societal norms and gender stereotyping, however, further disenfranchise rural women farmers. This research proposes an educational framework for advancing climate change knowledge and action, considering the unique context of RWFs. A context that requires intentional and tailored approaches to reach this all-important group – RWFs. The educational framework for educating RWFs on climate

change, coupled with the key enablers and barriers, is a significant contribution towards developing a national climate change communication strategy advocated for by numerous policy documents.

A gender transformative lens that challenges societal structures and power dynamics is recommended to address entrenched gender inequalities which will not self-correct on a business-as-usual ticket. There is, therefore, a need for the progressive transformation of societal norms that deepen inequalities. In sum, a critical arm in addressing climate change lies in building the capacity of rural women farmers whose triple roles (reproduction, production and community) make them potential positive change agents. Systemic factors expressed in power relations and rights that significantly setback women require reconstruction through various stakeholder consultations.

5.3 Recommendations

Policy recommendations relevant to specific research findings, policy documents, policymakers, and actors are presented in Table 5.1. It is believed that the policy recommendations, when implemented, will contribute immensely towards effective CCE for rural women farmers and women in the informal sector as a whole. The overall objective is to ensure multiple benefits through enhanced CC awareness, resulting in the effective uptake of CSA interventions whiles addressing existing sociocultural barriers that limit women. The policy recommendations are categorised into short, medium and long-term, depending on the time required to implement a recommendation. Short-term recommendations require a few months to a year to implement, and medium-terms require a year to five years, while long-term recommendations consider five years and above.

Table 5.1 Research Recommendations for Policymakers

Research finding	Policy recommendation	Responsible actors	Related policy document	Recommended time frame
Disconnect between climate change knowledge and climate actions	Awareness creation efforts for RWFs must emphasize the value and multiple benefits of appropriate, well-planned and sustained adaptation measures	EPA, MoFA (Agricultural Extension Agents)	NCCAS, NCCP, NAP Framework, CCLS, CC&GAP	Short term
Non-existent operational structures in the CCE space.	A functional CCC strategy that highlights educational approaches that suit particular audiences and guide the activities of actors in the space will be an excellent tool	MESTI/EPA	NAP Framework, CCLS	Short to medium term
Non-existent operational structures in the CCE space.	Mainstream critical enablers and barriers expressed by existing stakeholders in CCE into a holistic and effective CCC strategy	MESTI/EPA	NAP Framework, CCLS, CC&GAP	Short to medium term
Overreliance on external funding with a limited national budget to function in a coordinated and continuous fashion.	Make statutory budgetary allocations for implementing the CC and gender action plan as a national developmental concern.	GoG, NDPC, MoF, MESTI/EPA	CC&GAP	Short to medium term
Individual and systemic factors such as extremely low literacy, workloads, high household size and land ownership rights that characterise RWFs limit their access to appropriate CCE	Progressive transformation of entrenched societal norms that will not self-correct and deepen gender inequalities.	MGCSP, CSOs	CC&GAP	Medium to long term

Source: Author's construct, 2022

5.4 Contribution to Knowledge

The research makes various contributions to knowledge underpinned by its implications to theory, practice and policy at both global and national levels. Research contribution at various levels are thus highlighted.

5.4.1 Research Contribution to Theory

The research results affirm that limitations in educating the RWF that translate into effective climate response are embedded in various societal and cultural practices that hinder women. Again, weak adaptive capacity, which is symmetrical to high vulnerability, is fueled by stereotyping in the roles, access and use of resources by RWFs. This situation sits in the corridors of the gender transformative theory, which suggests that societal structures and power dynamics that inhibit marginalised groups such as women require transformation to facilitate optimum returns on interventions. A gender transformative theory, which goes beyond the symptoms of gender inequality to address the root causes embedded in social norms, behaviours, attitudes and social systems, is a more sustainable approach to addressing gender inequality.

5.4.2 Research Contribution to Policy

As a nation that is a member state of the UNFCCC and has ratified the Paris Agreement, Ghana has myriad policies guiding its engagement in mainstreaming climate change issues. These policies run from the National Climate Change Policy (NCCP), the National Climate Change Adaptation Strategy (NCCAS), Climate Change Learning Strategy (CCLS), The National Adaptation Plan Framework and the Climate Change and Gender Action Plan, among others. These policies are relevant to this research in climate change education and awareness creation for building resilience with a gender lens. Additionally, the study is equally relevant to the United Nations Sustainable Development Goals (SDGs), especially for goals related to climate change,

gender and livelihood development. The research implications of various national and global policies are discussed in this section.

Contribution to National policy

In the climate change, gender and agricultural space, major actors in terms of policy are the Ministry of Environment, Science, Technology and Innovation (MESTI); National Development Planning Commission (NDPC); Ministry of Finance (MoF); the Ministry of Gender, Children and Social Protection (MGCSP) and the Ministry of Food and Agriculture (MoFA). These actors have oversight responsibilities over various climate change and gender-related documents and will find the results of this research interesting to their work.

Contribution to the National Climate Change Policy (NCCP)

The central policy for climate change action in Ghana is the National Climate Change Policy (NCCP) which highlights the need for capacity building and training for effective response to climate change across formal and informal scales. This research zooms into this agenda by the NCCP by targeting the informal sector for capacity building and training for effective climate response.

Contribution to the Climate Change Learning Strategy (CCLS)

Additionally, the Climate Change Learning Strategy (CCLS) reveals efforts towards climate change learning and capacity building in Ghana and calls for a national communication strategy for a systematic, country-driven, sustainable planning of CCE. The proposed framework for educating informal women contributes significantly to the national climate change communication strategy.

Contribution to the National Climate Change Adaptation Strategy (NCCAS)

This research aims to improve the resilience of rural women farmers through the effective uptake of climate-smart interventions fuelled by appropriate and contextualised CCE. This overall aim coincides with the primary goal of the National

Climate Change Adaptation Strategy (NCCAS), which seeks to build capacity in infrastructure and knowledge to deal with climate change among vulnerable groups.

Contribution to the National Adaptation Plan Framework

The National Adaptation Plan Framework, which synthesised the various policy documents on climate change in Ghana, has further expressed the absence of a communication plan underpinned by gender-responsiveness, community and ecosystem-based approaches (Antwi-Agyei, 2019). This research synthesises the central themes of gender, community and ecosystem by investigating the dynamic of climate change communication for rural women farmers within different agroecological zones of Ghana.

Contribution to the Climate Change and Gender Action Plan (CC&GAP)

In collaboration with all relevant sector ministries, MESTI and MGCSP have produced the Climate Change and Gender Action Plan, which provides a framework to advance the integration of climate change and gender dynamics. The Climate Change and Gender Action Plan highlights various action steps within the agricultural sector as one of the focal areas of Ghana's NDCs. Specifically, issues on raising awareness of women farmers through improved extension services and ICT platforms are discussed in the Gender Action plan. This research contributes explicitly to best practices that can enhance extension services, including using basic, user-friendly ICT platforms.

This research also reveals strategies that can encourage the participation of women in agric initiatives also considered in the Gender Action Plan. Additionally, the plan calls for developing training protocols for gender and climate change which is contributed to by this research through the proposed framework for engaging informal women in CCE. The study concludes with best practices for climate change and gender engagement, specifically for RWFs, an essential point of call in the Climate Change and Gender Action Plan.

Contribution to Global policy (SDGs)

The work of national ministries is to ensure national development and ultimately work toward achieving the United Nations SDGs. The ultimate aim of the SDGs is to make meaningful contributions to ending poverty, protecting the climate and earth's environment, and securing peace and prosperity for all people. Precisely, the work of MESTI, MGCSP, and MoFA aligns toward the achievement of SDG 5 on Gender Equality, SDG 8 on Decent Work and Economic Growth and SDG 13 on Climate Action. The findings of this research have direct implications towards the achievement of SDGs 5,8 and 13 which are subsequently discussed;

Contribution to Gender Equality (SDG 5)

Regarding gender equality, the research findings highlight the need to further integrate into policy issues addressing discrimination against women regarding access to effective climate change education for resilient livelihoods. The research focuses on the unpaid workloads and stressors on rural women farmers that limit their access to climate change information and effective climate action. The call to promote locally relevant shared responsibilities within the households and families as a gender transformational approach is highlighted in this research as a critical enabler to effective CCE. The study further voices challenges with access, control and ownership of land for productive engagements, especially for rural women farmers. The global targets for SDG 5 also speak to key issues in this research to ensure gender equality. Addressing these prevailing challenges in CCE for RWFs will facilitate the achievement of SDG 5 in Ghana.

Contribution to Decent Work and Economic Growth (SDG 8)

The National Development and Planning Commission (NDPC), in collaboration with MoFA, coordinates policies that facilitate productivity in the agricultural sector through the upscale of climate-smart technologies and innovation. Practical strategies

for disseminating information on climate change and awareness creation necessary for the uptake of climate-smart agricultural interventions among rural women farmers provide valuable additions to policy. These contribute to enhanced productivity in the agricultural sector by acquiring knowledge to adopt appropriate technologies and innovations for sustainable development.

Contribution to Climate Action (SDG 13)

Climate action has become a cross-cutting developmental issue in most parts of the world, particularly Ghana. However, the ministry directly responsible for coordinating activities in this sector is the MESTI, with EPA as its implementing arm. The research has highlighted the instrumental role of appropriate climate change education and communication in building resilience and adaptive capacity among rural women farmers challenged by climate-related hazards. Essentially, the call to enhance human and institutional capacity for adaptation and mitigation through improved awareness creation and education has been the core of the research.

5.4.3 Contribution to Practice

The research draws attention to what works for rural women farmers in an informal setting and the challenges of stakeholders concerning CCE and awareness creation. The study revealed that national-level stakeholders are more effective than local-level stakeholders, who are mostly limited with the necessary logistical, budgetary and technical personnel. For effectiveness at the local level where policies and plans are implemented, the local level stakeholders, especially AEAs and WIAD officers, should be targeted with the commensurate human and material resources for effective implementation. Additionally, the research has affirmed that wholesale approaches targeting rural farmers usually miss female farmers. Due to high illiteracy levels, visual imagery and demonstrative hands-on approaches to learning are encouraged. The use of simple, user-friendly ICT platforms, such as simple phones commonly used by RWFs

could be harnessed for visual and dramatised audio training to address the challenge of a high farmer AEA ratio.

Again, the triple roles of women compounded with existing sociocultural norms make it difficult for RWFs to pursue pieces of training organised outside of their communities and at certain times of the day. Therefore, the timing and location of training should be critically considered to facilitate the effective participation of RWFs. The use of indigenous knowledge and belief systems as the entry point to additional scientific knowledge by AEAs orders well for the coproduction of knowledge.

5.5 Suggestions for Further Studies

Research is a never-ending cycle that continues to build on existing knowledge. For future research, phenomenological studies such as ethnography that reveal intricate details among vulnerable groups should be explored to better understand the dynamics of access, ownership and control over capital assets for livelihood resilience. Future research can also explore an experimental research design with a control and an experimental group to validate the functionality of the proposed framework for educating informal women. Results from the experimental research will validate the existing framework or introduce modifications for necessary improvement.

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APPENDICES

APPENDIX 1

Questionnaires

INSTITUTIONAL QUESTIONNAIRE

Questionnaire on the PhD Research Topic "Women as Agents of Change; The Gendered Factor to the Climate Change and Education Nexus for Improved Livelihood in Rural Ghana".

This questionnaire is purely for educational purposes and information provided will be used purely for this purpose.

Name of institution ----------

Name of officer responding----------

Positon of officer----------

1) In order of severity, what are the major issues facing women farmers in the district?
   a) Access to timely information (on weather changes, new technologies) b) Access to funds c) Access to Market d) Access to land e) Access to farm inputs f) Others (specify)
2) Which of these issues has a direct relationship with CC

   ---
3) Is climate change a major issue in the district?
   a) Yes b) No
4) If **YES** why do you say so? ----------

   ---
5) If **NO** why do you say so? ----------

   ---

6) On a scale of 1 to 5 (with 1 being the highest) how often does CC issues feature in your activities?
   a) Always (1) b) Frequent (2) c) Sometimes (3) d) scarcely (4) e) Never (5)

7) What is your direct role in relation to climate change awareness creation?

   ---

8) what logistics are required to carry out your role? (You may select more than 1 option)
   a) A communication plan b) qualified personnel c) recurring budget d) means of transport e) Other (Specify) ---

9) Is your office equipped in terms of staff capacity to handle CC awareness creation?
   a) Yes b) No

10) What logistics are available to your office in undertaking CC awareness creation?

   ---

11) Do you have a curriculum or content for CC awareness creation?
   a) Yes b) No

12) What goes into the content of CC awareness creation?

   ---

13) Which government institutions do you collaborate with in information dissemination and awareness creation of CC? ---
   ---
   ---

14) Any special reason for the selected institutions? ---

---

15) Who are your target group(s) in your climate change awareness creation effort?
    a) Men b) Women c) Youth d) School Children e) All f) Other (Specify)
16) What specific activities do you do to create awareness?

---

17) Are there activities targeted at facilitating comprehension of CC issues? --------

---

---

18) If **YES** what are they? ----------

---

19) Are there activities targeted at mitigation and adaption to CC?
20) If **YES** what are they? ----------

---

21) How will you describe the approach used to educate women on CC if any? a) Non-existent b) Productive / Effective c) Haphazard
22) Are there any specific programmes targeted at women? a) Yes b) No
23) If **YES**, what are they and which group of women benefit?

---

24) What avenue(s) or medium(s) is (are) used in information dissemination and awareness creation activities? a) Radio b) Television c) Extension Worker d) Farmer group networks e) NGOs

25) Is there a budget allocated to CC awareness creation? a) Yes b) No

26) If **YES,** what is the percentage distribution between formal and informal education/ awareness creation activities? Formal ----------Informal ----------

27) Do you consider the budget adequate? a) Yes b) No

28) How will you describe the release of funds for CC awareness activities?

a) Regular and substantial b) Regular and Insufficient c) Irregular but substantial d) Irregular and inadequate

29) Are there any NGO's operating in the district in relation to CC awareness creation?

a) Yes b) No

30) If yes, name them and their roles

Name of NGO	Communities of operation	Specific specialization

31) How do you think this subject area can be improved for effectiveness? ----------

---

---

32) Resource Endowment in your community

Human capital	Natural capital	Social capital	Financial capital	Physical capital

Officers to be interviewed

DA - Planning officer, MOFA – District Extension officer, Director for women in Agricultural Development.

CHECKLIST FOR NON-GOVERNMENTAL ORGANIZATIONS OPERATING IN THE DISTRICT ON CC AWARENESS CREATION

Questionnaire on the PhD Research Topic "Women as Agents of Change; The Gendered Factor to the Climate Change and Education Nexus for Improved Livelihood in Rural Ghana".

This questionnaire is purely for educational purposes and information provided will be used purely for this purpose.

1) Name of Organization ----------
2) How long has the organization been in operation in this area? ----------
3) What has been the approach(es) in undertaking your mandate?----------
   ---

   ---
4) How do you assess the approaches used so far? a) effective [ ]
   b) Ineffective [ ] c) Moderately effective [ ]
5) How many women has the organization been able to influence since your operations?
6) How many of these women are farmers?
7) What factors drive CC vulnerability among rural women farmers in this community? ----------
   ---
   ---
8) What are the broad areas that make up the content of awareness creation or education? ----------
   ---

   ---
9) How are you able to influence perceptions of CC, ensure comprehension and behavioral change? ----------
   ---

---

10) How do you collaborate with other NGOs and Governmental organizations also operating in this area? ----------

---

---

11) In what ways do you think CC awareness creation can be improved among rural women farmers? ----------

---

CHECKLIST FOR FOCUS GROUP DISCUSSION FOR RURAL WOMEN FARMER GROUPS

Interview guide on the PhD Research Topic "Women as Agents of Change; The Gendered Factor to the Climate Change and Education Nexus for Improved Livelihood in Rural Ghana".

This interview is purely for educational purposes and information provided will be used purely for this purpose.

1) What is your understanding of Climate change?
2) What do you consider to be the causes of CC?
3) Who do you think are responsible for CC?
4) Do you think CC has anything to do with you?
5) What practical things do you do to secure and preserve your environment?
6) How does CC affect your work in the home and as farmers?
7) What factors do you think deepen your vulnerability to CC?
8) How do you get information on weather changes and farming techniques to adapt to CC?
9) Do you feel disadvantaged compared to your male counterparts in assessing CC information?
10) Are you willing and able to pay for CC information?
11) If **YES** why?
12) If **NO** why not?
13) Which medium and approach do you think can help you in acquiring CC information?
14) What are your key areas of need when it comes to CC and your farming activities?
15) Resource Endowment in your community

Human capital	Natural capital	Social capital	Financial capital	Physical capital

16) Are there societal structures that discriminate in distribution of assets, information services, technology and inputs? a) Yes b) No

17) If yes, explain ----------

SURVEY QUESTIONNAIRE FOR RURAL WOMEN FARMERS

Instructions:

The objective of the survey should be explicitly exposed to all interviewees and their approval sought before the commencement of the interview. Interviewees should be given an idea of the duration for the administration of the questionnaire to have an idea of the time required of them to complete the instrument.

This questionnaire must be answered by only a woman who is a farmer in the selected community and is 18 years and above who are the target for this research work. Permission must be sought from the household head where required.

Where options are provided, please enter the appropriate responses as provided and where there are no options, there must be clarity of expression.

How you may introduce yourself:

I am ……, a research assistant. I am helping to collect data on information needs and awareness of women on climate change and how it is impacting their farming activities. This is to enable the researcher to propose strategies for embarking on CC awareness creation for rural women farmers to improve their livelihoods.

You are assured of the highest level of confidentiality with the information being provided as the principle of anonymity guides the exercise. Personal information being taken in the form of names and addresses are meant only to assist in the case of data gaps and a need for follow-up. This part of the information collected will not be utilized in the analysis being done.

Thank you.

SECTION A

General Background Information

1. Name of District? ----------

2. Name of Community? ----------

3. Name of Respondent (Not required)? ----------

4. Age of respondent? 18 -35 [ ] 1 36 – 50 [ ] 2 51 – 65 [ ] 3 65+ [ ] 4

5. What is your marital status? Married [ ] 1 Single [ ] 2 Separated [ ] 3 Divorced [ ] 4 Co-habitation [ ] 5

6. If married, what type of marriage is it? Monogamy [ ] 1 Polygamy [ ] 2

7. If polygamy, how many other women are married to your husband? One [ ] 1 Two [ ] 2 Three [ ]3 Four [ ] 4

8. Can you read and write with understanding (Literacy)? Yes [ ]1 Partially (can do either one of them [ ]2 No [ ]3

9. What is the highest educational level attained? None [ ] 1 Primary [ ]2 Secondary [ ]3 Tertiary [ ]4 Higher [ ]5

10. How many people are in your household (Household size)? 1-3 [ ] 1 4-6 [ ] 2 7-9 [ ]3 10+ [ ]4

11. What is your religion? Christianity [ ]1 Islam [ ]2 Traditionalist [ ]3 Other(Specify) [----------] 4

12. Are you a native of the community? Yes [ ]1 No [ ]2

13. If yes which ethnic group do you belong to?

14. If no, where do you come from/ethnic group? [----------] 1

15. What is your farm size (acres)? > 1 acre [ ] 1 1 acre [ ] 2 2 - 4 acres [ ] 3 5 – 7 acres [ ] 4 8+ acres [ ] 5

16. How many years have you been into farming? > 1 year [ ] 1 1 – 3 years [ ] 2 4 – 6 years [ ] 3 7 – 10 years [ ] 4 10+ [ ] 5

17. What is the ownership type of your farm? Self [ ] 1 Family [ ] 2 Hirer on contract [ ]3lease [ ]4 Other (Specify) [ ]5

18. Is farming your primary occupation? Yes [ ]1 No [ ]2

19. If NO, what other activity are you engaged in? Handicraft [ ]1 Poultry [ ]2 Livestock [ ]3 Extraction [ ]4 Service and sales [ ] 5 Other (Specify) [ ]6

20. Occupation (Type of farmer) Food crop [ ]1 Vegetables [ ]2 Legumes and cereals [ ]3 Mixed [ ]4 Cash crop [ ]5 Other (specify)[----------]6

21. What are the major challenges you face in your farming activities? Access to assets and resources [ ]1 Control over assets and resources [ ]2 Ownership over assets and resources [ ]3 Other (specify) [ ]4

Section B

Situational Awareness on CC (Perception, Comprehension, Projection of future climatic variable)

Awareness of changes in climatic variables

Kindly score this section from question number 21 to 27 on the scale of 1 – 5; where Certainly not [1], Probably not [2], Perhaps not [3], Perhaps yes [4], Most certainly [5].

No.	Indicator	Weight
22.	I have noticed changes in the climatic variables in the community	
23.	Temperature in the area has been rising	
24.	Rainfall patterns are unpredictable	
25.	Harmattan conditions are worsening	
26.	There are increases in floods	
27.	There are frequent dry spells unlike previously	
28.	There are increases in drought	

29. How long have you noticed these changes in weather (precipitation and temperature)? With in a year [ ]1 Less than 5 years [ ]2 About 10 years [ ]3 More than 10 years [ ]4 No changes seen [ ]5

30. What do you consider to be responsible for the changes occurring in the climatic variables?

Climate change [ ]1 Punishment from God [ ]2 Human induced causes [ ]3 A curse [ ]4 Other (specify) [ ]5

Impact on crop production

Kindly score this section from numbers 31 to 36 on the scale of 1 – 5; where strongly disagree [1], Disagree [2], Neutral [3], Agree [4], Strongly Agree [5].

No.	Indicator	Weight	Total
31.	Changes in the climate are a cause of low crop yield		
32.	Crop disease increase can be attributed to climatic variations and changes		
33.	Weather changes are a cause of pest and insects increases		
34.	Reduction in size of cropping area has something to do with climatic variation nd changes		
35.	Increase in production cost is as a result of changes in the weather patterns		
36.	Water quality has reduced as a result of climate variability and change.		
37.	Climate change is a contributory factor to the hardening of seedbed and reduction in soil fertility		

Impact on Biodiversity and forest resources

To what extent do you agree that Climate change and climate variability are responsible for the following using the scale of 1 – 5; where strongly disagree [1], Disagree [2], Neutral [3], Agree [4], Strongly Agree [5];

No.	Indicator	Weight	Total
38.	Reduction in plant and forest species		
39.	Reduction in bird and animal species		
40.	Decrease in forest area		

41.	Extinction of certain plant and forest species		
42.	Extinction of certain bird and animal species		

Socio-economic and cultural impacts

Which of the following socio-economic and cultural factors do you consider to be a likely cause of climate variability and change? Answer using the scale 1 -5; where Very unlikely [1], Unlikely [2], Not certain [3], Likely [4] and Very Likely [5];

No.	Indicator	Weight	Total
43.	Increase in disease infection		
44.	Increase in mortality		
45.	Increase in poverty		
46.	Reduction in household incomes		
47.	Increase in migration in search of greener pastures		
48.	Increase or decrease in belief in God		
49.	Widening of gap between rich and poor		

50. What personal actions have you taken in order to protect and secure your environment and natural resources around you in the wake weather changes/ climate change? Nothing [ ]1 Plant trees [ ]2 Switch from the use of non-renewable natural resources [ ]3Reduce, Reuse, Recycle [ ] 4 Other (specify) [ ]5

51. What are your immediate and initial steps in the face of weather changes and crop failure? Switch to another crop [ ]1 Use a technique to avert the situation (specify) [----------]2 Switch to another enterprise [ ]3 Do Nothing [ ]4

Other (Specify) [----------]5

Section C

Drivers of livelihood vulnerability - natural, human, physical, financial and social assets – access, control, ownership

52. What factors deepen your livelihood vulnerability in the light of CC? Order of priority a) Prevailing hazards b) low/ limited resource endowment c) existing social structures d) limited/no coping strategies

53. What assets do you have in the community?

Human capital [ ] 1 Natural capital [ ]2 Social capital [ ]3 Financial capital [ ]4 Physical capital [ ] 5

Natural asset – access, control, ownership

54. Do you have access to fertile land for farming? Yes [ ] 1 No [ ]2

55. During the last planting season, who worked physically on the land? Self [ ]1 Self and Spouse [ ]2 Spouse [ ]3 Other house members [ ]4 Hired labour [ ]5

56. During the last season, who made the general decisions about which crop/s to plant on the land? Self [ ]1 Self and Spouse [ ]2 Spouse [ ]3 Other house members [ ]4 Hired labour [ ]5

57. Who was responsible for taking the produce to the market and negotiated the sales in the last planting season? Self [ ]1 Self and Spouse [ ]2 Spouse [ ]3 Other house members [ ]4 Hired labour [ ]5

58. Who had the right to take decisions on the revenue generated from the produce sold on the land? Self [ ]1 Self and Spouse [ ]2 Spouse [ ]3 Other house members [ ]4 Hired labour [ ]5

59. Do you have access to a water body for irrigation purposes during the dry season? Yes [ ]1 No [ ] 2

60. Are you able to access the water body at any point of need? Yes [ ] 1 No [ ] 2

61. If no what is (are) the regulations governing the use of the water body? ----------
---

Human assets – access, control, ownership

62. Do you have access to experts/centres who give you skill and knowledge to upgrade yourself in farming? Yes [ ]1 No [ ]2

63. Who has the decision-making right in choosing the skill, knowledge and labour you participate in? Self [ ]1 Self and Spouse [ ]2 Spouse [ ]3 Other house member [ ]4 Other (Specify) [ ]5

64. Are you physically fit to carry out your dialy livelihood activities? Yes [ ]1 No [ ]2

65. What skill have you acquired to carry out your livelihood activities? None [ ]1 Farming technology [ ]2 Harvesting [ ]3 Processing [ ]4 Marketing [ ]5

Social assets – access, control, ownership

66. Are you part of any social group? Yes [ ]1 No [ ]2

67. If yes, please name the social group? ----------

---

68. Who is responsible for taking decisions on your participation in the selected social group? Self [ ]1 Self and Spouse [ ]2 Spouse [ ]3 Other house member [ ]4 Other (Specify) [ ]5 ----------

69. How will you rate the level of support you receive from your social connections, including family? Not at all [ ]1 low [ ]2 moderate [ ]3 High [ ]4

Physical Assets – access, control, ownership

70. Do you have access to the following physical assets; Road network(a) Yes [ ]1 No [ ]2, Electricity (b) Yes [ ]1No [ ]2, Market (c) Yes [ ]1 No [ ]2, Potable water(d) Yes[ ]1 No [ ]2, Health facility(e) Yes [ ]1 No [ ]2

71. What is the quality of access to infrastructure (a) Not at all [ ]1 poor [ ]2 Moderate [ ]3 good [ ]4

72. What is the quality of access to infrastructure (b) Not at all [ ]1 poor [ ]2 Moderate [ ]3 good [ ]4

73. What is the quality of access to infrastructure (c) Not at all [ ]1 poor [ ]2 Moderate [ ]3 good [ ]4

74. What is the quality of access to infrastructure (d) Not at all [ ]1 poor [ ]2 Moderate [ ]3 good [ ]4

75. What is the quality of access to infrastructure (e) Not at all [ ]1 poor [ ]2 Moderate [ ]3 good [ ]4

76. Are there any cultural norms that limit your use of the infrastructure? Yes [ ]1 No [ ]2

77. If yes give details ----------

Financial assets – access, control, ownership

78. What are the sources of finance available to you? Credit facility [ ] 1 Remittances [ ]2 Savings [ ]3 Other specify [ ]4

79. Are you allowed to access these financial products by yourself? Yes [ ] 1No [ ]2

80. Are there any norms that limit your access to financial products? Yes [ ]1 No [ ]2

81. Who has the decision making right over the financial asset available to you? Self [ ]1 Self and Spouse [ ]2 Spouse [ ]3 Other house member [ ]4 Other (Specify) [ ]5

Section D

Mediums for shaping climate change awareness

82. How do you access information in the event of extreme weather changes and/or training on adaption? Radio stations [ ]1 TV stations [ ]2 Through farmer groups [ ]3 Extension officers[ ]4 Other (Specify) [----------]5

83. Are you able to get timely information? (a) Not at all [ ]1 poor [ ]2 Moderate [ ]3 good [ ]4

84. Are you able to get reliable information? (a) Not at all [ ]1 poor [ ]2 Moderate [ ]3 good [ ]4

85. Do you get information in easily understandable ways? (a) Not at all [ ]1 poor [ ]2 Moderate [ ]3 good [ ]4

86. How do you think accessibility to CC information can be improved? ----------
---
---

87. How does inadequate or lack of CC information affect your farming activity? a) loss of crop b) loss of livelihood c) loss of capital or investment d) other (specify)? ----------

88. Which hazards are prevalent in your community? a) floods b) drought c) temperature extremes d) pest infestation e) pollution f) environmental degradation g) natural resource depletion h) other (specify) ----------

89. Are you willing and able to pay for CC information?

90. If YES why? ----------

---

91. If NO why not? ----------

---

92. Which medium and approach do you think can help you in acquiring CC information?

93. Are there societal structures that discriminate the distribution of assets, information services, technology and inputs? a) Yes b) No

94. If yes, explain ----------

QUESTIONNAIRE ON THE PHD RESEARCH TOPIC "WOMEN AS AGENTS OF CHANGE; THE GENDERED FACTOR TO THE CLIMATE CHANGE AND EDUCATION NEXUS FOR IMPROVED LIVELIHOOD IN RURAL GHANA".

This questionnaire is purely for educational purposes and information provided will be used purely for this purpose.

NATIONAL BODY RESPONSIBLE FOR CC AWARENESS CREATION (EPA, MESTI, MoFA)

1) Name of Institution ----------
2) Designation of officer responding ----------
3) What is your specific role/mandate in CC awareness creation ----------
   ---

   ---
4) Which approaches are used in undertaking your mandate of awareness creation
   ---

   ---
5) Is there a designated communication strategy in embarking on CC awareness creation for the country? a) Yes b) No
6) If yes, how is it accessed at the local level for implementation? (request for copy) ----------
   ---
   ---
7) If no, how are awareness creation efforts guided at the different levels of operation? ----------
   ---

   ---
8) What strategies are used in contextualizing the needs of women in order to reach them with information on CC? ----------
   ---

9) Are women targeted generically or different women groups are targeted?
   a) generic b) targeted
10) What have been your major successes so far in CC awareness creation at the informal local level? ----------
    ---

    ---
11) What are your major challenges in embarking on your mandate? ----------
    ---

    ---
12) Rate the effectiveness of your organization in relation to the parameters outlined in the table below; where 3 is highly effective, 2 moderately effective and 1 Ineffective

	Highly effective	Moderately Effective	Ineffective
Co-production			
Place-based approach			
Gender Sensitivity			
Learner Centered			
Adult learner sensitive			
Visual Imagery/ICT sensitive			

13) Recommendations for improving CC awareness creation targeted at women at the local level? ----------
    ---

APPENDIX 2

Sample Size Calculation

Sample Size Calculation (https://www.socscistatistics.com/tests/samplesize/default.aspx)

This calculator allows you to determine an appropriate sample size for your study, given different combinations of confidence, precision and variability.

For large populations, it uses Cochran's equation to perform the calculation.

$$x = \frac{Z^2 pq}{e^2}$$

For small populations of a known size, it uses Cochran's equation together with a population correction to calculate the sample size.

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}}$$

Instructions

The default values we provide below will work well for many scenarios.

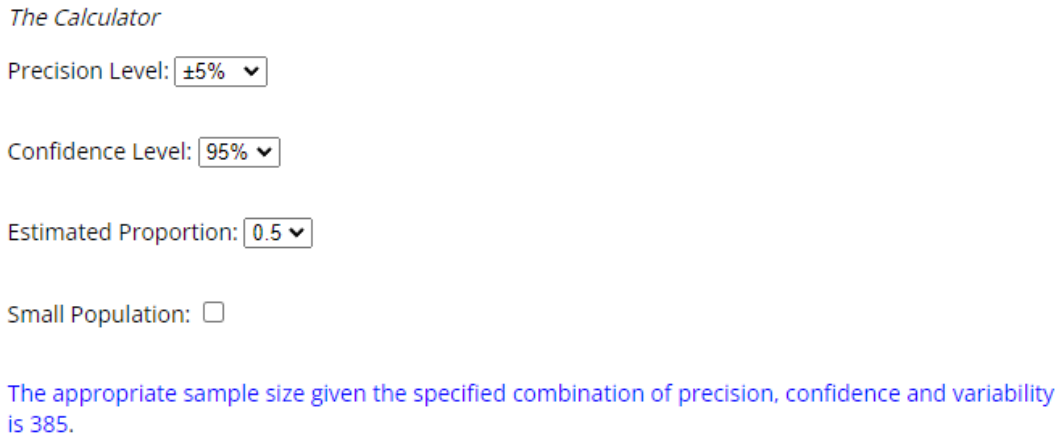
Precision Level is the margin of error you're prepared to tolerate - e.g., 5% means a result that is within 5 percentage points of the true population value.

Confidence Level is a measure of confidence in the precision of the result. For example, selecting 5% as the level of precision, and 95% as the confidence level, indicates a result that is within 5% of the real population value 95% of the time.

Estimated Proportion is a measure of variability. We suggest you leave this at 0.5 - maximum variability - unless you have prior knowledge about the population from which you are drawing your sample. For both districts of study (Dormaa East – DE, East Gonja – EG), the percentage of women was approximately 50% and thus proportion was entered at 0.5

The final thing to note is that if you know the size of the population from which you wish to take a sample, you can select the Small Population option, and specify population size. This will result in a smaller sample.

The Calculator



The proportion of sample collected

	Dormaa East District	**East Gonja District**	**Total of 2 Districts**
Total Sample Needed using Cochran	385	385	770
Total Data Collected	218	279	497
Percentage of sample realized	57%	72%	64%

APPENDIX 3

Introductory Letter for Data Collection

University of The Gambia

Doctoral Research Program on Climate Change and Education

Farafenni Campus, North Bank Region

The Gambia

22nd December, 2020.

TO WHOM IT MAY CONCERN

Please assist the bearer of this letter, **Mrs. Amma Birago Kantanka Gyimah,** to help her with information pertaining to his/her data collection exercise for his/her research leading to the award of Doctorate in Climate Change and Education degree at the University of The Gambia.

For further questions or clarifications, please don't hesitate to contact me. Thank you.

Professor Sidat Yaffa

Dean, School of Agriculture & Environmental Sciences

Director, UTG/WASCAL Doctoral Research Program on Climate Change and Education.

Tel: +2203650028; Email: syaffa@utg.edu.gm, ksidat@netscape.net

APPENDIX 4

Pictures on Data Collection

4.1 Data Collection Team

4.2 Data collection (rural women)


NYC

4.3 Data Collection (Focus Groups) - DE

4.4 Data Collection (Focus Groups) – EG

4.5 Data Collection (Institutional)


Co-operative Development
Foundation of Canada
FERTILIZER CANADA
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: 0546915196
: 0248543873

APPENDIX 5

Table of Relative Importance Index on Situational Awareness

	Perceptions at East Gonja								
Variables	**Certainly not (1)**	**Perhaps not (2)**	**Probably not (3)**	**Perhaps yes (4)**	**Most certainly (5)**	**Total**	**A*N**	**RII**	**Rank**
Notice of change	2	1	2	22	252	1358	1395	0.97	2
Increase in temperature	2	0	0	28	249	1359	1395	0.97	1
Unpredictable rainfall pattern	12	29	10	73	155	1167	1395	0.84	6
Worsening of harmattan	2	1	2	37	237	1343	1395	0.96	3
Increase in flood	157	4	19	31	68	686	1395	0.49	7
Frequency of dry spells	3	4	0	104	168	1267	1395	0.91	5
Increase in droughts	2	5	2	90	180	1278	1395	0.92	4
								0.87	#N/A
		Perceptions at Dormaa East							
Variables	**Certainly not (1)**	**Perhaps not (2)**	**Probably not (3)**	**Perhaps yes (4)**	**Most certainly (5)**	**Total**	**A*N**	**RII**	**Rank**
Notice of change	0	0	0	10	208	1080	1090	0.99	1
Increase in temperature	0	4	0	31	183	1047	1090	0.96	2
Unpredictable rainfall pattern	2	9	2	57	148	994	1090	0.91	4
Worsening of harmattan	2	4	0	26	186	1044	1090	0.96	3
Increase in flood	91	19	33	38	37	565	1090	0.52	7
Frequency of dry spells	6	22	9	63	118	919	1090	0.84	6
Increase in droughts	10	16	4	55	133	939	1090	0.86	5
								0.86	#N/A

		Understanding of crop production East Gonja							
Variables	**Strongly disagree(1)**	**Disagree(2)**	**Neutral (3)**	**Agree (4)**	**Strongly agree (5)**	**Total**	**A*N**	**RII**	**Rank**
Low crop yield	18	30	6	16	209	1205	1395	0.86	2
Increase in crop disease	3	21	32	47	176	1209	1395	0.87	1
Increase in pest and insects	4	23	25	97	130	1163	1395	0.83	6
Reduction in size of cropping area	16	13	19	90	141	1164	1395	0.83	5
Increase in production cost	14	21	15	96	133	1150	1395	0.82	7
Reduction in water quality	7	7	24	123	118	1175	1395	0.84	3
Hardeining of seedbed and reduction of soil fertility	7	19	35	75	144	1170	1395	0.84	4
								0.84	#N/A
		Understanding of crop production Dormaa East							
Variables	**Strongly disagree(1)**	**Disagree(2)**	**Neutral (3)**	**Agree (4)**	**Strongly agree (5)**	**Total**	**A*N**	**RII**	**Rank**
Low crop yield	0	2	2	15	199	1065	1090	0.98	1
Increase in crop disease	0	0	4	32	182	1050	1090	0.96	2
Increase in pest and insects	2	0	5	38	173	1034	1090	0.95	3
Reduction in size of cropping area	8	3	34	54	119	927	1090	0.85	6
Increase in production cost	2	2	12	44	158	1008	1090	0.92	4
Reduction in water quality	26	25	61	39	67	750	1090	0.69	7
Hardeining of seedbed and reduction of soil fertility	2	0	19	56	141	988	1090	0.91	5
								0.89	#N/A

		Understanding on impact on biodiversity and forest resources in East Gonja							
Variables	**Strongly disagree(1)**	**Disagree(2)**	**Neutral (3)**	**Agree (4)**	**Strongly agree (5)**	**Total**	**A*N**	**RII**	**Rank**
Reduction in plant and forest species	4	1	21	67	186	1267	1395	0.91	2
Reduction in bird and animal species	4	1	19	85	170	1253	1395	0.90	3
Decrease in forest area	3	19	54	88	115	1130	1395	0.81	5
Extinction of certain plants and forest species	4	4	14	71	186	1268	1395	0.91	1
Extinction of certain animal species	2	0	33	76	168	1245	1395	0.89	4
								0.88	#N/A
		Understanding on impact on biodiversity and forest resources in Dormaa East							
Variables	**Strongly disagree(1)**	**Disagree(2)**	**Neutral (3)**	**Agree (4)**	**Strongly agree (5)**	**Total**	**A*N**	**RII**	**Rank**
Reduction in plant and forest species	4	2	6	36	170	1020	1090	0.94	1
Reduction in bird and animal species	6	0	17	55	140	977	1090	0.90	4
Decrease in forest area	5	3	13	78	119	957	1090	0.88	5
Extinction of certain plants and forest species	0	2	13	66	137	992	1090	0.91	3
Extinction of certain animal species	0	2	11	65	140	997	1090	0.91	2
								0.91	#N/A

		Understanding on impact of climate change on socio-economic and culture in EG							
Variables	**Very unlikely**	**Unlikely**	**Not certain**	**Likely**	**Very likely**	**Total**	**A*N**	**RII**	**Rank**
Increase in disease infection	4	20	43	86	129	1162	1395	0.83	3
Increase in mortality	35	43	57	52	92	960	1395	0.69	5
Reduction in household incomes	2	2	5	46	224	1325	1395	0.95	1
Increase in migration in search of greener pastures	82	32	14	45	106	898	1395	0.64	6
Increase in belief in God	29	39	47	50	114	1018	1395	0.73	4
Decrease in belief in God	182	26	36	18	17	499	1395	0.36	7
Widening of gap between rich and poor	12	2	59	50	156	1173	1395	0.84	2
								0.72	#N/A
		Understanding on impact of CC on socio-economic and culture in DE							
Variables	**Very unlikely**	**Unlikely**	**Not certain**	**Likely**	**Very likely**	**Total**	**A*N**	**RII**	**Rank**
Increase in disease infection	4	20	21	25	148	947	1090	0.87	3
Increase in mortality	49	23	16	37	93	756	1090	0.69	5
Reduction in household incomes	4	6	5	32	171	1014	1090	0.93	2
Increase in migration in search of greener pastures	6	0	2	27	183	1035	1090	0.95	1
Increase in belief in God	69	11	7	37	94	730	1090	0.67	6
Decrease in belief in God	49	20	53	31	65	697	1090	0.64	7
Widening of gap between rich and poor	15	6	39	30	128	904	1090	0.83	4
								0.80	#N/A

APPENDIX 6

Calculation of Chi square for Situational Awareness and Adaptive Capacity

	THE ADAPTIVE CAPACITY OF WOMEN FARMERS					
Category	Hypothesized proportion	Observed	Expected			
Dormaa East	0.5	0.422	0.405		0.00071358	
East Gonja	0.5	0.388	0.405		0.00071358	
		0.81			0.00142716	Chi-square value
p-value	0.969864862					
test statistic	0.00142716					
	MITIGATION PERCENTAGE					
category	Hypothesized proportion	Observed	Expected			
East Gonja	0.5	0.244	0.3075		0.013113008	
Dormaa East	0.5	0.371	0.3075		0.013113008	
		0.615			0.026226016	Chi-Square value
p-value	0.871349571					
test statistic	0.026226016		F3256			
	ADAPTATION PERCENTAGE					
Category	Hypothesized proportion	Observed	Expected			
Dormaa East	0.5	0.785	0.788		0.0000114213	
East Gonja	0.5	0.791	0.788		0.0000114213	
		1.576			0.0000228426	Chi-Square value
p-value	0.996186607					
test statistic	0.0000228426					