**UNIVERSITY OF GHANA**

**LEGON**

# PERCEPTIONS OF FARMERS ON CHANGING RAINFALL PATTERNS IN THE ZOSALI COMMUNITY

**BY**

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# DECLARATION

I, **Alhassan N. Sadat**, do hereby declare that, except for references to other people's work which have been duly cited in this research, the rest of the research is as a result of my own work carried out at the Centre for Climate change and Sustainability Studies (CCCSD) under the supervision of Dr. Abdulai Abdul- Gafaru of the Department of Public Administration and Health Services Management, University of Ghana, and that neither in whole or in part has this work been presented anywhere for the award of a degree.

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# DEDICATION

To God be the glory. I gladly and humbly dedicate this work to my family.

**ACKNOWLEDGMENT**

“Anyone who has done what Napoleon could not do needs to be uplifted”. The first and foremost recognition and appreciation goes to my supervisor, Dr. Abdulai Abdul-Gafaru for his exceptional guidance and tutelage

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# ABSTRACT

There is concern about the increase in temperature and reduction in rainfall in Ghana in recent times. Climate change together with the activities of humans could aggravate desertification in northern Ghana. This study examined the beliefs and experiences of farmers in the Zosali community in the Northern Region with regards to rainfall and how these things relate to the rainfall experience in the community. The studyemployed a survey design withmixed methods comprising a focused group discussion andadministration of questionnaires. The discussants were 10 leaders of various farmer groups whiles the questionnaires were completed by 140 farmers selected through convenience samplingin the Zosali community. The findings showed that five important factors, namely, traditional belief/superstition about rainfall, factual misconception of rainfall, bad land-use (bush burning, felling of trees, removal of vegetation cover, and charcoal burning), bad rainfall-experience (short rainfall episodes, flooding, and reduced soil water), and water scarcity are noteworthy the farmer's understanding of rainfall.Significantly, bad land-use was found to predict bad rainfall-experience. Traditional belief/superstition did not predict bad rainfall-experience. However, whereas this direct prediction was absent, there was an indirect predictive power of traditional belief/superstition on bad rainfall-experience because it significantly predicted bad land-use which in turn determined bad rainfall-experience. The study recommends that keen attention should be paid to land use by state agencies like the Environmental Protection Agency. Farmers in the hinterlands should be educated on climate change and causes of rainfall. Afforestation and sustenance of vegetation cover are aspects of improving rainfall experience. Also, proper disposal of waste is mentioned as a way to improve environmental conditions. Further studies should be done on the relationship between land and Green House Gases and their impact on climate change.

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# CHAPTER ONE

# INTRODUCTION

## 1.1 Background of the Study

Human species can be thought of as a special kind of creation because, given the space and time, we have learned a lot about the environment in which we live through scientifically proven methods and understanding. Still, we are discovering more through research and making knowledge more accessible. We have constantly been looking for ways to understand phenomena around us and encourage practicesthat promote a sustainable environment so that humans will not, ultimately, be wiped out of existence. Climate change, referred to as the increase or decrease in average precipitation caused by land use changes and the range of human activities which increase the concentration of greenhouse gases, is something that has occupied attention of researchers in the last few years (Intergovernmental Panel on Climate Change (IPCC) (2014). Because of that the Sustainable Development Goals (SDGs)captures in its thirteenth goal the essence of combating climate change and its impacts by year 2030 (UNDP, 2015).

Around the world, the concerns about climate change are evident and its impact on rainfall, or water supply, is a prominent feature in the discourse on climate change (IPCC, 2005). In Asia and the Pacific region, for example, there is vulnerability to the impacts of climate change. The Asian Development Bank (ADB) (2017) projects that unabated warming, deterioration of water sources, food insecurity, local sea level rise, and changes in rainfall patterns could significantly disrupt the ecosystem and lead to severe effects on human livelihood, health, potential conflicts, and migration. In Europe, the key risks of climate changeinclude, people affected by flooding, increasing sea levels, coastal erosion, peak river discharges, increased economic losses, extreme heat events and, of course, significant reduction in water availability. Also, these risks would have implications for health and well-being, labour productivity, crop production, air quality, and demand for water for irrigation, energy and industry, and domestic use (IPCC, 2014). In North America, the risks are associated with heat-related human mortality, urban floods inducing infrastructural damage, public health problems, impairment of water quality, extreme precipitations and cyclones (IPCC, 2014). No continent, and no country, has been exempted from the impact of climate change,and water appears to be a key ingredient affected by climate change.

In Africa, the facts available point to the idea that some severe impacts of climate changeare already being felt. Cline (2007) did a comprehensive analysis on the impacts of climate change on several countries in Africa, numbering twenty (20) including Ghana, Burkina Faso, Ivory Coast, Nigeria, Kenya, South Africa, and got estimates showing declines in agricultural output for all the countries in the sample.Consistent with the rainfall forecasts, the severest losses are in the northern Sahara region,followed by southern Africa, while the smallest losses are in tropical and eastern Africa. These losses were reduced to some extent in countries with a significant share of cropland under irrigation. Besides that, an assessment of the Intergovernmental Panel on Climate Change (IPCC) revealed high confidence that stress on water resources leading to increased water demand in the future, reduced crop productivity, heat and drought, food insecurity, water-borne diseases due to changes in the mean and variability of temperature and precipitation would be felt in Africa in coming years (IPCC, 2014).

In Ghana, studies have shown that three major physical impacts of climate change exist. These are; temperature change, change in rainfall, and sea level rise (Asante &Amuakwa-Mensah, 2015; World Bank, 2014; Owusu, Waylen& Qui, 2008). There is a shift in rainfall pattern in Ghana towards a longer dry season and diminishing wet season(Owusu et al., 2008). Rainfall has many implications, notably, for agricultural systems; it provides water for crops to grow, water to feed animal farms, including serving domestic purposes for humans.

Water and, therefore, rainfall is a sine qua non for human survival. However, while scientific methods are being employed toprove the causes of diminishing rainfall, there is the cultural and non-literate perspective in many of the agriculture-based communities in Ghana which suggest that spiritual (or unseen) forces, ancestral spirits, or any such beliefs, could explain the changing patterns of rainfall. This perspective of the changes in rainfall need to be studied to understand the orientation of the local peoplerelative to the changing rainfall pattern. The motive of this study will be to examine perceptions of farmersand its impact on the diminishing rainfall in the country.

Zosali is a rural community in the northern part of Ghana which is mainly agriculture-based. The northern part of Ghana experiences the strongest effect of the longer dry season currently being experienced in Ghana. The vegetation withers, humidity level drops and there is heat due to the sun's radiation in most of the dry season and part of the wet season (Friedrich Ebert Stiftung, 2012). This study aims to examine the perceptions of the farmers of the Zosali community about the causes of reduction of rainfall in the community.

## 1.2 Statement of the Problem

Everywhere in the world, climate change is a problem being tackled to reduce or expunge its wide negative effects on human existence (UNDP, 2015). The concerns about climate change are due to its adverse impact on the living conditions of mankind. Many countries, developed and developing, have been aiming at acting to countermand the negative impact of climate change (Climate Change Performance Index (CCPI), 2018).

Even though many countries in Africa have converged on the need to act toreduce the impact of climate change, not many have been able to achieve the desired targets. Climate change mitigation report by the OECD (2008) demonstrates a build-up of greenhouse gas concentrations with the ultimate effect being global warming. It is important to note that deforestation and forest degradation are estimated to cause17% of global emissions leading to climate change (OECD, 2008). This is a climate change burden caused by land use, and it implies that such practices that induce these emissions must be understood and stopped. Failure of climate change mitigation programmes would entail increases in the frequency and intensity of natural disasters and extreme whether events such as droughts, floods, and the deterioration of water sources and agricultural lands consequent to changes in rainfall patterns. Olessen, Chirinda and Adiku (2013) also note that changes in climate will mostly affect crop productivity negatively by reducing crop yields and, thus, requires effective adaptation to climate change in Ghana through technology application in agriculture, management of soil fertility, strong research and advisory services to develop, demonstrate and implement new technologies and effective implementation of agricultural climate change adaptations. This will reduce agricultural productivity in the most vulnerable regions in the world to climate change (IPCC, 1995).

If then in Ghana, as it is estimated, 70% of the population derives livelihood from agricultural activities, changes in climate must be an issue of great concern. The government of Ghana has taken a number of policy decisions towards mitigation of, and adaptation to climate change impacts (Mawunya&Adiku, 2013). The Environmental Protection Agency (EPA) is the primary state institution in charge of disseminating information on environmental issues in a way that provides relevant education to the masses on environmental sustainability issues. In addition, there has been some amount of research into climate change resulting in increased awareness of global warming and declining rainfall in Ghana as a major threat to agricultural production (MacCarthy, Adiku, Yangyuoru, 2013). Despite all these, has beenlimited research on how rainfall is conceived in traditional rural communities in Ghana leading to a weak appreciation of how local people resonate with climate change mitigation and adaptation policies.

Mawunya and Adiku (2013) have intimated that there is the possibility for lay persons not to easily understand the scientific relationships between climate and agriculture. When that happens, they would fail to appreciate or understand proven strategies to mitigate or adapt to climate change. For example, bush burning, indiscriminate felling of trees, depletion of forestlands, clearing of vegetation, among others, are ongoing in rural settings without recourse to environmental or atmospheric effects. This, therefore, leaves a gap in literature concerning how lay people have assimilated climate change and adaptation strategies. Still, effortshave not been gauged towards understanding the perspectives of the people of Zosali about rainfall taking into consideration their background, beliefs, factual conceptions, and so on, about rainfall.

The Northern part of Ghana is where the warming effect of climate change ishighly felt, rainfall is generally low (UNEP & UNDP, n.d.). The wettest area in Ghana is the extreme southwest where annual rainfall is about 2000 mm. However, the annual rainfall in extreme north of Ghana is less than 1100 mm. Further, the northern parts of Ghana experience higher temperatures than the southern (EPA, 2011; Asante &Amuakwa-Mensah, 2015).Climate change together with the activities of humans in relation to land use could aggravate desertification in northern Ghana. In view of this, the relevant question posed in this study regards how farmers in the Zosali community up north of Ghana apprehend rainfall issues and climate and the traditional beliefs that are accompanied by the reduction of rainfall. This study, therefore, to examines the perceptions of farmers on the reduction of rainfall in the Zosali community.

## 1.3 Purpose of the Study

The purpose of the studyis toexamine the perceptions of farmers on the reduced rainfall regime in the Zosali community. The study found out the beliefs of the traditional farmers regarding changes in the rainfall patterns in the Zosali community and the interpretations given to such patterns.

## 1.4 Objectives of the Study

The specific objectives of the study are follows:

1. To assess the experiences and beliefs of the farmers with respect to rainfall in the Zosali community;
2. To examine how the experiences and beliefs of the farmers are associated with rainfall experiences in the Zosali community;

3. Assess the relationship between the belief of the farmers and rainfall experiences in the Zosali community; and
4. To make policy recommendations for climate change mitigation based on the findings of the study.

## 1.5 Research Questions

Following from the objectives of the study, the following research questions are posed:

1. What are the experiences and beliefs of the traditional farmers withrainfallin the Zosali community?
2. What are the interpretations to rainfall in terms of the experiences and beliefs of the farmers in the Zosali community?
3. What is the relationship between belief system employed to interpret or explain the changes in rainfall in the Zosali community?

## 1.6 Significance of the Study

The study is significant in a number of ways. First, it is a known fact that climate change mitigation is a collective responsibility and requires a global effort for it to be successful. Ghana, like several other countries in the world, has been making policies and implementing them with respect to climate change mitigation. Decisions about how to implement those policies require information from the local or traditional settings in order to be successful with climate change mitigation policies. This study provides information about the beliefs and practices of farmers in the Zosali community which will contribute to policy decision making processes for the betterment of climate change mitigation practices in the Northern Region, and in particular, the Zosali community.

Second, the study offers the opportunity for the traditional community in Ghana to be aware of the impact of climate change and the practices and beliefs associated with it. It provides the avenue for local farmers to reconsider the impact of their activities on their lands as far as climate change is concerned. The results of the study will, therefore, create the awareness that is required in the Zosali community about climate change and the practices, in terms of land use, that exacerbate or, otherwise, reduce the impact of climate change.

Finally, the study will add to the existing body of literature on our understanding of rainfall and the changing pattern it is assuming as far as the Northern part of Ghana is concerned. It will provide insight on the practices and beliefs adopted by the local farmers to against the reduction of rainfall in the Zosali community. Other researchers can, therefore, rely on the information provided in the study.

### 1.7 Scope and Limitation of the Study

Climate change is, admittedly, a global issue that seems to require a global effort to mitigate it. The effect of human practices at one geographical location that destabilizes normal atmospheric conditions may be felt at a very different place. By the same token, changes in rainfall patterns at one place may be due to the human practices at another place. This implies that, to address the problem of rainfall, every human settlement must be involved. The small communities, farming settlements, non-literate and literate societies also need to be engaged in solving the problem.

This study is on the perceptions of the farmers about the changing rainfall pattern in the Zosali community in the Northern Region of Ghana. The Northern Region receives lesser amount of rainfall within a year than the southern part of Ghana. Further reduction in rainfall, as it is currently being experienced, attracts almost immediate attention. It is, therefore, important to understand the interpretations of local people as to how the changes in the rainfall pattern remains. In the Zosali community, farming is a prominent occupation of the local people, and their practices in terms of land use are directly connected with rainfall and availability of water in the land. The perceptions of the farmers in the area are also important to understand what the people conceive about the changing rainfall pattern in their environment.

To the extent that the Zosali is a farming community and largely a non-literate one, communicating with the farmers in the formal English Language is going to be a limitation. Hence, extra effort is needed to bridge any communication gap because of that. Another limitation of the study is in respect of the fact that, there is extremely limited data or background information on the Zosali community as far as issues concerning rainfall are concerned. The lack of such information leaves us no choice than to rely on periodic visits to the community and primary data in this study to get well acquainted with the community.

### 1.8 Organization of Chapters

This study will be organized in five chapters. Chapter One will cover the introduction, and it will specifically address the background of the study, statement of the problem, purpose of the study, objectives of the study, research questions, significance of the study, scope and limitations of the study, and organization of chapters of the study. Chapter Two will deal with the review of pertinent literature and state of the conceptual framework of the study. Chapter Three will present the methodology, which will comprise the research design, study population, sampling procedure and sample size, data collection procedure, data collection instrument, reliability and validity, data analysis procedure, and ethical considerations. Chapter Four will present the analysis and discussions of data collected from the field of study, and Chapter Fiver will present the summary of findings conclusions and recommendations.

# CHAPTER TWO

# LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

## 2.1 Introduction

Extensive review of literature is undertakenon the erudition of rainfall. Theoretical underpinning of the cause of rainfall is reviewed. The review also gives cognizance to the essence of rainfall and discusses how it dovetails into the discourse on climate change.

Empirical literature reviewed on rainfall from selected literature also provides understanding of human experiences with rainfall.

## 2.2 Theoretical Underpinning of Rainfall

A very wide range of literature present an understanding of rainfall based on the hydrological cycle which is sometimes known as the water cycle or hydrological process (Shaw, Beven, Chappell & Lamb, 2011; Biswas, 1970; Gleick, 1996). The hydrological cycle gives the theoretical explanation of how rainfall occurs giving clear accounts of the soliterraneous mechanism that causes evaporation, condensation, precipitation, infiltration, percolation, runoff (surface and groundwater), storage (surface and groundwater), leading eventually to water use and demand. The hydrological cycle works in a continuum, but there is one component of it that is frequently not directly included in its descriptions, and that is, human activity (Pagano &Sorooshian, 2002). This is reviewed here too.

Climate change is associated with shifts in mean climatic conditions which is demonstrated by weather conditions (Easterling et al., 2000). The evidence from everywhere in the world and most oceans shows that the natural systems are changing due to climate changes, particularly, temperature increases (Singh, 2011). Rainfall and water availability are at the heart of these changes that are occurring. The use of hydrological models in explaining the water resources on earth facilitates our understanding of the effect of human practices on climate change and the impacts on water components (Wang, et al., 2011; Xiao et al., 2010; faramarzi et al., 2009; Abbaspoour et al., 2009).

In explaining the hydrological cycle, Shaw et al. (2011), Biswas (1970), and Gleick (1996) converge on the idea that, waters of the seas or ponds evaporate into the sky. Then, they come down to the land and in many forms, they are delayed, and return to the seas through the holes of the earth. This process is organized in a ceaseless cyclic, and it is called the Hydrological Cycle. According to the hydrological cycle, water is present everywhere in the world in whatever form it may be – hard, liquid or gaseous. Water circulates from the oceans to the atmosphere, from the atmosphere to the lithosphere and from the lithosphere to the oceans occurring through a complex and interdependent process. In other words, the hydrological cycle is the description term applied to thegeneral circulation of water from the sea to the atmosphere, to the ground and back to the seas again.

Since the hydrologic cycle describes the process of water movement it is essential to thoroughly understand the concepts of hydrology which provides a basis for the occurrence of rainfall.A brief explanation of the elements of the hydrologic cycle and how they influence the cycle is as follows:

**Evaporation:** The hydrologicalcycle begins with evaporation. The watery vapour is the reservoir of the hydrological cycle.By the rays of the sun, the waters of the ocean, rivers, canals, among others, evaporate and it ismixed with the atmosphere. The process by which water changes into watery vapour (gas) and rise through the atmosphere is calledevaporation. The water-vapours are lighter than often elements and so, they rise upward easily and speedily, and then, they get cooled and condensed and create thesprays of water. At present, with the rise of heat in the atmosphere the amount ofevaporation is getting increased (Biswas, 1970).

**Condensation:** After water vapour rises upward, it gets condensed turningultimately into drops of water or ice. This process occurs over an average period of 10 days (Shaw et al., 2011). This process is known as condensation. Again, theamount of the water vapour in the atmosphere and the warmth are closely relatedwith each other. How much water vapour resides in how much warmth determinesthe relative moisture of the air. When the relative moisture rises upto 100% it comesdown in the form of rain that means this time floating particles of vapour get biggerand assumes the form of rain and it is quite impossible for the atmosphere to carrythem and they fall down on earth as rain-drops (Biswas, 1970).

**Precipitation:** When the condensed water-vapour of the atmosphere turns hard or liquid, and falls to the ground by gravitation, it is called precipitation. The water-vapour of the atmosphere, fog or frost do not belong to precipitation. The rainwater, ice-fall and hail-storm do certainly belong to precipitation (Strangeways, 2007).

**Interception:** At the time of raining, the whole amount of rain does not reach the ground directly. Across vegetations, the atmosphere andsunraysevaporate some amount of rain. When it rains, anything that obstructs the raindrops from reaching the ground directly causes interception to occur. Therefore, interceptionshows that, though some amount of water gets evaporated, therest flows over the surface of the earth and augments the volume of external water level (Biswas, 1970).

**Absorption:** Absorption describes the amount of rainwater which enters underground and is absorbed to get the soil moist. This process sometimes fails to wet the earth completely. Very often, water level under-ground rises and wets the soil and as a result beyond the rainy season, the soil is found wet in other seasons too (Shaw, et al., 2011).

**Evapo-transpiration:** Plants suck salty minerals water from the earth through principal roots. After carbon assimilation, when the extra water is emitted through the pores of the leaves, it is called evapo-transpiration. This vapour is a form of additional vapour to the atmosphere and increases the moisture of the atmosphere. Therefore, in regions thick with trees and bushes, it rains more heavily than in other regions because the moisture is concentrated there (Gavillan, et a., 2009).

**Infiltration:** In some regions of the world, the water flowing over the earth and the ice-borne water control the deposit of water underground. The process through which meteoric water by capillary strength enters underground is regarded as infiltration. The infiltration of water underground depends on natural characteristics, for instance, the entrance of water into the deeprecesses of stones, the blowing of wind underground, the amount of rain, the change of seasons and the nature of plants (Beven, 2004).

**Ground Water:** The water deposited upon the impassable layers of the rocks underground is called ground water. This ground water is formed through the entrance of water inside the ground. Infiltration of water increases during the rainy seasons and the water level on the earth's surface rises. In the dry seasons, it decreases and the water level goes downwards. When the surface of the ground water remains above the surface of the river water, the supply of water happens in the riverbed and the river water increases. So, during the dry seasons, the flow of ground water helps in maintainingthe volume of river water. The flow of ground water happens in a very slow manner unlike river water and passing through rivers, ultimately falls into the seas (Sara, 2006).

**Soil-water:** When rainwater mixes with the particles of dust and the soil gets wet through capillary action, the water of the earth is formed. The main source of the soil water is the rains. Some amount of this rain-water is deposited in the ocean as it flows over the surface of the earth; some amount gets evaporated and the rest enters underground through percolation (Vander Leeden et al., 1990).

**Surface Water:** When the rainwater and other waters flow in the form of the steam of water, then we call it run-off water on the surface of the ground. Rivers, canals, seas, and oceans are the reservoirs of this surface water. Ninety seven percent (97%) of the total amount of water remains on the ground surface. And the rest three percent is present in the other elements of the world (Gernereaux, 2006).

From a global perspective, the world's supply of water is stored mainly in oceans (97.2%), while 2.15% is frozen water (ice caps) and 0.65% is fresh water on land. Of this fresh water component, only 2.5% makes up quantities in air, soil, lakes and rivers, while the remainder is groundwater, most of which is unavailable for human use (Vander Leeden et al, 1990).

The importance of the hydrological cycle in this study is that, it explains how rainfall takes place and gives insight into the conditions that are necessary for rain to fall, and for water to be available on the earthfor human consumption. There is, however, one element of the hydrological cycle that is often mentioned indirectly. That is, human activity that affect (often negatively) the rainfall cycle.

## 2.3 The Influence of Human Interventions on the Hydrological Cycle

Availability of water on earth is affected by many things. Haddeland et al. (2013) argue that terrestrial water fluxes are affected by both climate and direct human interventions, for instance, dam operations and water withdrawals. For the authors, Climate change is expected to alter the water cycle and will subsequently impact water availability and demand for water.

There is so much to show for how climate change is significantly changing the weather patterns across the world. But in the face of this development, Watts et al. (2015) have found that, even the climate factor affecting terrestrial water is caused by anthropogenic factors. They also argue that many of the most severe global impacts of anthropogenic climate change may be mediated by water (Stern, 2006), and that rivers may be among the ecosystems most sensitive to climate change (Kernan et al., 2010; Millennium Ecosystem Assessment, 2005; Ormerod, 2009). It is alsoanticipated that further warming will intensifythe hydrological cycle, leading globally to anincreased risk of floods and droughts (Bateset al., 2008; Giorgi et al., 2011; Rockstromet al., 2009) and increased exposure to water resources stress, even under the most stringent emissions mitigation scenarios (Arnell et al., 2011, 2013).

According to the United Kingdom's 2012 Climate Change Risk Assessment (CCRA), the major potential risk requiring early action is water-related. This may be due to flooding and coastal erosion risk management, but droughts in some regions too, calling for management of water resources (CCRA, 2012, p.8). Rainfall is the principal means by which water reaches the surface of the earth. This implies that there is the risk of having the rainfall patterns affected by climate change. The Intergovernmental Panel on Climate Change (IPCC) is 'virtually certain' that global precipitation will increase with increased global temperature, and has 'high confidence' that the contrast between wet and dry regions and wet and dry seasons will increase over most of the world (IPCC, 2013).

Regionally, the impact of anthropogenic climate change on the past and future water cycle is less clear. Projections of climate change at a regional level show considerable variability, with disagreement even about the sign of change in variables such as precipitation in some regions and seasons (Bates et al., 2008).

Evapotranspiration includes both direct evaporation to the atmosphere from soil and watersurfaces, and transpiration from trees and otherplants. Potential evapotranspiration (PE) is anestimate of the maximum volume of water thatcould pass to the atmosphere if there is no limit to supply. Actual evapotranspiration (AE) is constrained by water availability (usually soil moisture), and cannot be greater than PE. Evapotranspiration is a function of the energybalance, humidity and wind speed (Allen et al., 1998). Land use changes and their impacts are also important for water management and sustainable resource exploitation.

Several studies have assessed the impact of land use changes on hydrology for future climate change by using dynamic land use models(Wijesekara et al., 2012) or assumed future land use changes (Mango et al., 2011; Quilbe et al., 2007; van Roosmalen et al., 2009) combined with hydrological modelling. Large dams, reservoirs, and extensive canal systems are, perhaps, the most visible testimony to this. In several basins across the globe, surface water resources have been so intensively developed that major rivers periodically cease flowing to the ocean. The most pervasive change to the hydrologic cycle due to human activities is associated with land-use change. These changes are very important to consider since, according to van Dam (1999), the effects of climate variability and change on the hydrological cycle as a coincident with those of changes in land use leaves a lot to be fascinated about.

The various types of land-use changes have a lot to do with, inter alia, deforestation, agriculture, urbanization, draining swamplands. Pagano and Soroosh (2002) espouse the fact that afforestation causes increased interception in wet periods; delay in spring runoff; increased transpiration in dry periods through increased water availability to deep root systems. Deforestation on the other hand causes the converse effect. Table 2.1 gives the summary of the impacts of land use by humans on the hydrologic cycle.

**Table 2.1: Summary of Impacts of Land Use on the Hydrologic Cycle**

| Land use change | Component affected | Principal hydrologic process involved | Geographic scale and likely magnitude of effect |
|---|---|---|---|
| Afforestation (deforestation has converse effect, except where disturbance caused by forest clearance may be of overriding importance | Annual flow | Increased interception in wet periods; delay in spring runoff; Increased transpiration in dry periods through increased water availability to deep root systems | Basin scale; magnitude proportional to forest cover. On average, conversion of 10% of watershed area to forest cover results in 34 mm year reduction in annual flow per unit area |
| | Seasonal flow | Increased interception and increased dry period transpiration will increase soil-moisture deficits and reduce dry season flow | Basin scale; can be of sufficient magnitude to stop dry season flows |
| | | Drainage activities associated with planting may increase dry season flows through initial dewatering and also through long term-effects of the drainage system | Basin scale; drainage activities will increase dry season flows |

| Land use change | Component affected | Principal hydrologic process involved | Geographic scale and likely magnitude of effect |
|---|---|---|---|
| | | Cloud water (mist or fog) deposition will augment dry season flows | High-altitude basins only; increased cloud water deposition may have significant effect on dry season flows |
| | Climate | Increased evaporation and reduced sensible heat fluxes from forests affect climate | Micro, meso, and global scale; forests generally cool and humidify the atmosphere |
| Agricultural intensification | Water quality | Altering of transpiration rates affects runoff | Basin scale; effect is marginal |
| | | Timing of storm runoff altered through land drainage | Basin scale; significant effect |
| Draining wetlands | Annual flow | Initial dewatering following drainage will increase annual flow | Basin scale; effect may last from one to two years to decades |
| | | Afforestation following drainage will reduce annual flow | Basin scale; effects as for afforestation |
| | Seasonal flow | Upland peat bogs, groundwater fends, and African dambos have little effect in maintaining dry season flows | Basin scale; drainage or removal of wetland will not reduce and may increase dry season flows |
| | | Lowering of the water table may induce soil-moisture stress, reduce transpiration, and increase dry season flows | Basin scale; a reduction of water-table depth to a minimum of 30cm below surface is required |
| | | Initial dewatering following drainage will increase dry season flows | Basin scale; effect may last from one to two years to decades |
| | | The deeper flow outlet of the drainage system will lead to increased dry season flows | Basin scale; effects will be long-term |
| Urbanization | Runoff volume | Impervious surfaces such as paved roads, roofs, and parking lots increase surface runoff during storm events and decrease groundwater recharge | Basin scale; magnitude of effect depends on extent of urbanization |

Table modified from Calder (1993) with additional data from Urbonas and Roesner (1993).

**Source: Pagano &Soroosh (2002, p.10).**

The impacts arise from changes in how the sun's rays reach the ground, surface roughness, surface permeability (the ability of water to pass through a surface, such as concrete), and the ability of the surface to intercept and evaporate moisture. Flohn (1973) suggested that the extent of landusechange in total has had a considerable impact over the last 8000 years, with approximately 11% of the land surface having been converted to arable land, and 31% of forests having been modified from their original condition. The consensus is that, crop production is affected by meteorological variables, including rising temperatures, changing precipitation regimes and increased atmospheric carbon dioxide levels (Adams et al., 1998).

## 2.4 Climate Change

Climate change refers to increase or decrease in the average precipitation caused by land use changes and the anthropogenic increase in the greenhouse gases, particularly, carbon dioxide ($CO_2$) in the earth's atmosphere. Climate change has been known as a great threat to the environmental conditions that fosters human survival and development. Climate change is responsible for droughts or floods across the world (IPCC, 2005). Lee (2009) points out that there is no single answer or solution to this problem.

Warming of the climate system is indisputable given the evidence from observed increases in, inter alia, global average air temperature and ocean temperatures (IPCC, 2005). With these conditions present, there is no gainsaying that the hydrologic cycle, which depends immensely on temperatures, will be affected.

Rainfall or availability of water is sine qua non in the overall discourse on climate change. There is a flurry of researches on the impact of climate change on water resources globally (Arnell & Lloyd-Hughes, 2014; Ashraf, Vaghefi, Mousavi, Abbaspour, Srinivasan, & Yang, 2014). Some of the studies highlighting these impacts, including instances from Ghana, have been reviewed.

### 2.4.1 Climate Change in Africa

A thorough search of literature reveals that, research on climate change scenarios in Africa is limited. Tyson (1991), Conway et al. (1996), and Zinyowera et al. (1998) are a few of the studies one is most likely to find. Otherwise, the IPPC and other international agencies are the major sources from which some facts about climate change in Africa can be obtained. However, the changes in climate, evidenced by temperature rise on the African continent, are indisputable, and the need to begin to do something to mitigate the impact of climate change is incontrovertible.

### 2.4.2 Climate Change in Ghana

Ghana has obviously not been spared in the current impacts of climate change. Climate change poses as a threat to livelihoods and nature. Nearly every year there is, at least, one incidence of massive flooding towards the northern part or in the southern part, particularly, Accra. This is accompanied by high temperatures, diseases and loss of human lives.

Amidst these impacts of climate change in Ghana is the challenge of low rate of farm productivity. Expects have attributed some of the problem of low farm productivity to the changes in climate. For instance, in the northern part of Ghana, wherefewer rainfalls during the rainy season and more dryness and withering during the dry season are experienced, drought is a major problem.

Given the large scale of the climate change impacts, the extent to which the area of climate change and its impacts on Ghana has been researched leaves a lot of gap in literature. Particularly, northern Ghana where, it seems, the impact of changes in climate is severely felt, there is every reason to research plentifully in the climate dynamics there, to contribute to the climate change adaptation and mitigation strategies over there. This study contributes in its own respect to fill this gap in literature.

## 2.5 Hydrological Drought

The term 'hydrological drought' can be seen in a number of studies in the literature. It refers to a lack of water in the hydrological system which is portrayed by abnormally low streamflow in rivers, lakes, reservoirs and ground water. Hydrological drought can be seen as a natural hazard (Wilhite &Glantz, 1985). It occurs in a number of places around the world – they are not confined to one place (Kundzewicz&Kaczmare, 2000). In some sense, it is like earthquake, volcanic eruptions, hurricanes, storms, floods, and others like that. (Nel et al., 2014). Though flooding appears to receive a lot more attention in the news and in literature, droughts develop slower and often unnoticed and have diverse indirect consequences (Van Loon, 2015). Hydrological droughts can, however, cover extensive areas and can last for months to years, with devastating impacts on the ecological system and many economic sectors (Tallaksen& Van Lanen, 2004; Sheffield & Wood, 2011). Examples of affected sectors are drinking water supply, crop production (irrigation), waterborne transportation, electricity production (hydropower or cooling water), and recreation (waterquality) (Van Loon, 2015). The impacts of drought differ from place to place, and that, we can have droughts influencing tree mortality and wild fires (Gudmundsson et al., 2014) and aquatic ecosystems, where they affect, population density (Lake, 2003) and food security (Ledger et al., 2013).

Currently, there is awareness of drought and related hazards (heat waves and wildfires). Also, effort is being made by researchers to inform policy makers, water managers, and the generalpublic via agencies concerned with the environment and water resource management elsewhere in the world, and the United Kingdom and United States are examples of places where this is happening (Van Loon, 2015).

In Ghana, the government has introduced a new development policy which is to health the northern part of Ghana in agriculture, popularly known as the "one village, one dam". This policy is obviously advised by the realization that water shortage is a great difficulty which farmers in the northern part have been contending with. The lack of rainfall, even though not the only cause of drought, is to a large extent responsible for drought. It is argued, however, there is an increased complexity of understanding drought including the hydrological processes (Van Loon, 2015). This suggests that there are still many uncertainties and gaps in our knowledge about hydrological drought.Mishra and Singh (2010),Cloke and Hannah, (2011) and Pozzi et al. (2013) argue that hydrological drought deserves more attention due to its crucial link with drought impacts. Also, the recent IPCC report on extremespoints out the need for more attention to the space-time development of hydrological drought (Pozzi et al., 2013).

Perhaps, there is a different dimension of drought which we might have to explore, and a great insight into this dimension might come from the understanding of the local people about rainfall and droughts – why do they occur? – in the places where they are experienced.

## 2.6 Classification of Droughts

Droughts, which is seen by many as the absence of rainfall and consequently water, seems to have complex dimensions and difficulty in defining. Therefore, how it is defined has a lot to do with the particular setting one is interested in, and for what purpose water is needed. However, it is incontrovertible that drought marks a deficit of water compared with normal conditions (Van Loon, 2015). But, whether it is normal or not, or how it occurs depends largely on the community or what one is interested in.

In this study, drought is seen something that happens when the rains cease and water becomes scarcer in relation to the demand for it. Generally, droughts are classified into four categories (Tallaksen& Van Lanen, 2004; Mishra & Singh, 2010; Sheffield & Wood, 2011):

**Meteorological drought:** This refers to a precipitation deficiency, possibly combined with increased potential evapotranspiration, extending over a large area and spanning an extensive period of time.

**Soil moisture drought**: This is a deficit of soil moisture (mostly in the root zone), reducing the supply of moisture to vegetation. Soil moisture drought is also called agricultural drought, because it isstrongly linked to crop failure. As soil moisturedeficits have additional impacts on, for example, natural ecosystems and infrastructure (Seneviratner et al., 2012; Corti et al., 2009).

**Hydrological drought:** This is also a broad term related to negative anomalies in surface and subsurface water. Examples are below-normal groundwater levels or water levels in lakes, declining wetland area, and decreased river discharge. Groundwater drought and streamflow drought are sometimes defined separately as below-normal groundwater levels (7, Peters, 2003; Hisda et al., 2004; Peters et al., 2006) and below-normalriver discharge, respectively (Fayen&Dankers, 2009).

**Socioeconomic drought:**This kind of drought is associated with the impacts of the three above-mentioned types. It can refer to a failure of water resources systems to meet water demands and to ecological or health-related impacts of drought.

It can be emphasized that many types of drought impacts are related to hydrological drought than to meteorological drought. The scarcity of water associated with drought is studied to be influenced also by anthropogenic factors on the water system. That is, water scarcity is caused either fully or partly by human activities (Senevirantne et al., 2012).

## 2.7 Conceptual Framework

From the extensive review of literature, having presented a theoretical understanding of rainfall with the hydrological cycle, we have shed light on the scientific processes by which water circulates from the earth to the atmosphere and back to the earth in a continuous cycle. We also showed how certain conditions favour these processes. But, we also show how human or anthropogenic activities influence the cycle and, inter alia, sometimes cause water scarcity. That is to show that, human activities can positively or negatively influence the water cycle which determines the availability of water for human use. Literature shows that water scarcity, though largely due to absence of rainfall, is a complex event that needs further studies to understand.

This study is to examine the perceptions of local farmers about the rainfall experience in the Zosali community in the Northern Region of Ghana. To examine the perceptions about rainfall,characteristics of farmers, their belief systems, and land usesare relevant to this study.

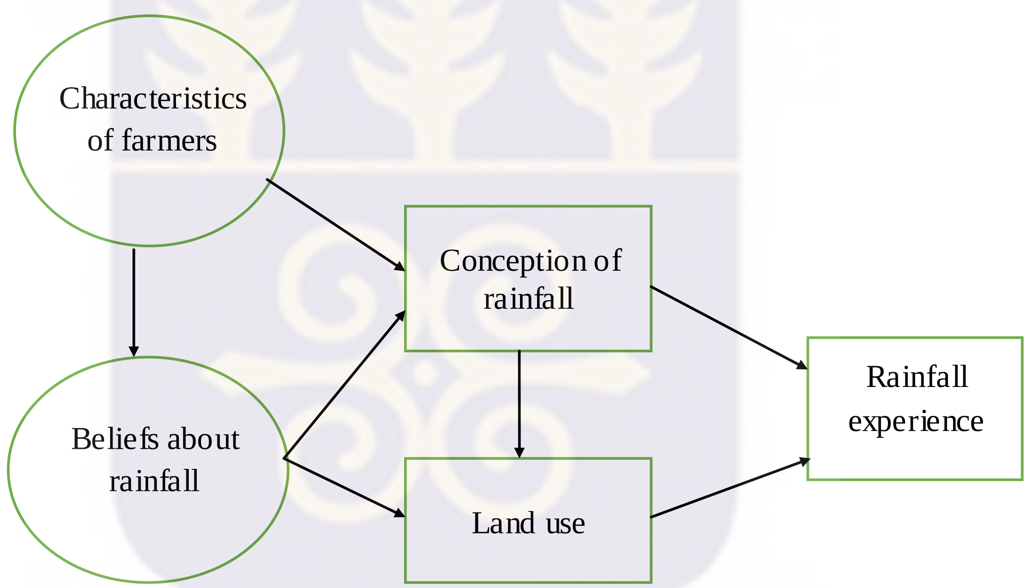
In a non-literate community like Zosali, the demographic characteristics of people are useful to understand how they know what they know. This is also important in the context of understanding what people believe as it is to what they perceive.

The belief of the farmers about how rainfall occurs is also vital in this study. In the African traditional settings, some people have local interpretations of events based on African traditional beliefs. How belief systems play out to inform local farmers' perceptions about rainfall in the Zosali community is vital for the study.

From the literature, it is emphasized that human activity influences the hydrological cycle. By extension, hydrologic drought or water scarcity will then depend on human activity. The practices of local farmers in terms of land use, is thus, vital to examine in this study. The land uses, however, are determined by the perceptions of farmers which then culminate into perceptions about rainfall.

The study, therefore, examines the perceptions of local farmers in the Zosali community in terms of rainfall experience in the community using the characteristics, beliefs, conceptions about rainfall, and land use as determinants. Figure 2.1 shows how the measures of beliefs, perceptions and land use of local farmers in the community are displayed in the study. The interrelationships between the measures are also captured by directional arrows. The model basically is that, the characteristics and the beliefs of local farmers inform their conception of rainfall. The conception of rainfall and beliefs in turn influence land use. Finally, rain experience is influenced by land use as well as conception of rainfall by the farmers.

**Figure 2.1: Conceptual Framework**




**Source: Author's construct of perceptions and practices about rainfall**

# CHAPTER THREE

# METHODOLOGY

## 3.1 Introduction

The study is community-based and it applied scientific and systematic procedures to undertake field data collection and data analysis. The methodology details the research design, study population, sampling procedure and sample size, data collection procedure, data collection instrument, reliability and validity concerns, data analysis procedure, and ethical considerations.

## 3.2 Research Design

Basically, the study is a survey of local/traditional farmers in the Zosalicommunity in the Northern Region of Ghana. The perception of the local farmers about rainfall was vital in the study. The rainfall experience by the farmers was modeled as a function of their demographic characteristics, beliefs, conception of rainfall, and land use. Hence, the dependent variable is: rainfall experience and the independent variables are: demographic characteristics of farmers, beliefs, conception of rainfall and land use.

Mixed methods were adopted in the study in order to facilitate the collection of data from a large number of local farmers in the Zosali community, but also obtain some of the deepest insights into the understanding of rainfall from the farmers. To compliment quantitative data, focused group discussion was also employed to obtain qualitative data. In a survey research, such as this study, researchers advise that a collaboration of quantitative and qualitative data can provide a wide and deeper understanding of the facts central to the research. This study is, accordingly, advised to use this approach. The study primarily involves primary data which is the result of data collection from the Zosali community. Farmers within the Zosali community constituted the survey unit, but due to lack of relevant information about farmers in the community, as well as the community at large, basic information about the farmers and the community were obtained independently through a series of visits to the community. These visits played an important role in facilitating the familiarization process with farmer groups in the community. Farmers within the Zosali community constituted the survey unit. One of the important observations was that the farmers engaged in the Zosali community are members of identifiable farmer groups. The leadership of these farmer groups played important roles for the study to identify and contact farmers. Thus, a series of visits to the study field, and the organized farming groups in the community facilitated this survey.

### 3.3 Study Population

The study population refers to the farmers in the Zosali community. The community is a relatively small settlement of about 1,532 residents (GSS, 2014). In the larger Savelugu Municipality, which the Zosali community forms part of, there is 89.3% of the total households (14,669) engaged in agriculture.This percentage was used to gauge the proportion of people engaged in agriculture in the Zosali community.

### 3.4 Sampling Procedure and Sample Size

The farmers who participated in this study were selected from households in the Zosali community. It has already been stated that 89.3% of the households in the larger Savelugu Municipality in which the Zosali community is found engage in agriculture

(GSS, 2014). This can be interpreted in another way; nearly every four out of five people in the district are engaged in some form of agriculture. This study estimated the sample size based on the proportion of households engaged in agriculture in the district. In doing this, the sample size calculation formula below was employed.Rose, Spinks and Canhoto (2015) point out that to calculate the sample size based on the sample required to estimate proportion with an approximate 95% confidence level, this formula can be used

$$n = \frac{z^2 \times p\,q}{d^2}$$

Where n = the sample size;

$z$ = the standard normal deviation at 95% confidence interval = 1.96;

$p$ = proportion of the population having the required characteristics. This refers to the estimated proportion of households engaged in agriculture. This is found to be 89.3% (GSS, 2014). Therefore, $p$ = 0.893;

$q$= the proportion of households who do not engage in agriculture (that is, if $p$ is 0.893, then $q$ is given by 1 – $p$ = 1 – 0.893. Therefore $q$ = 0.107;

$d$ = the allowable margin of error = 0.05.

Substituting this information in the equation we have the following

$$n = \frac{1.96^2 \times (0.893)(0.107)}{0.05^2}$$

$$n = 147.517$$

Therefore, the sample size of the study is approximately 148 farmers from various households in the Zosali community.Beside this sample 10 leaders of the farmer groups were purposively selected based on their position as leaders in the farming groups and were involved in a focused group discussion. The convenience sampling approach was used to select the rest of the farmers.

### 3.5 Data collection and instrumentation

Data collection took place in the Zosali community and farmers werecontacted and selected according to their availability for the studyaside 10 leaders of the farmer groups who were purposively selected for focused group discussion. The instruments used for data collection wasa survey questionnaire and an interview guide. The questionnaire contained closed-ended questions with the majority of questions using a 5-point Likert scale response format wherein 1 stands for "Strongly Disagree", 2 means "Disagree", 3 represents "Neutral", 4 stands for "Agree", and 5 indicates "Strongly Agree"to elicit respondents' agreements on key issues of interest in this study. The questionnaire was designed with five major headings; the first elicited data on the background characteristics of the respondents. The second heading collected data about the beliefs of the farmers in terms of rainfall. The third was on the perceptions about the farmers about rainfall. The fourth elicited data on the land usefrom the farmers. The fifth heading elicited data on the rainfall experiences in the Zosali community (see Appendix A).

The interview guide contains major questions derived from the objectives of the study to guide the line of questioning in the focused groupdiscussion (see Appendix B). A meeting was arraigned for 10 leaders of the farmer groups in the community to converge under a traditional shed where community members rest after hard work. With all 10 members present a discussion ensued guided by the interview guide. The discussions were held in a combination of "broken English" and in the native language and recorded with a voice recorder for onward processing.

### 3.6 Data Analysis Procedures

Both quantitative and qualitative methods of data analysis were used to analyze the data collected in the study. The Statistical Package for Social Sciences (SPSS) version 21.0 was used to process and analyze the quantitative data. Specifically, a factorial analysis to extract the important constructs for modeling. Descriptive statistics using frequencies and percentages were employed to describe the demographic representations of the farmers in the study.

The first objective of the study which sought to understand the experiences and beliefs of the farmers in the Zosali community about rainfall was achieved by analyzing data using Principal Component Analysis to extract the essential factors that interpret what the farmers understanding or experience about rainfall.

The second objective which was to find out how the experiences and beliefs of the farmers about rainfallis associated with rainfall was achieved by testing relationships between the factors that describe the rainfall phenomena to the farmers. Chi Square test of Independence, Pearson's Correlation, and Hierarchical Multiple Regression were employed.

The third objective – to determine the relationship between the beliefs of the farmers and their rainfall experience – was achieved through a Linear Regression using the factors associated with belief and experience with rainfall.

The qualitative data from the focused group discussion were interpreted where necessary and transcribed from the voice recorder used for the purpose of recording the discussions. Thematic analysis was used by grouping related views under key themes and then searching for key views that highlight important themes. Inferences and deductions were made from the views to collaborate results from the quantitative data and deduce the findings therefrom.

The analysis is presented in detail in the next chapter, Chapter Four.

# CHAPTER FOUR

# DATA ANALYSIS

## 4.1 Introduction

This chapter presents the analyses of data obtained from the Zosali community; from farmers in the traditional setting of that community in the Northern Region of Ghana. The analysis is conducted with focus on the general objective of the study which is to examine the perceptions of the farmers on the reduction rainfall pattern the community. The experience and belief of the farmers regarding rainfall, the interpretations of the variations in rainfall patterns, and the relationship between belief and the rainfall patterns have been analyzed.Data was obtained from 140 farmers within the Zosali community. This represents a high response rate of 94.5% of 148 farmers engaged in the community. Beside this 10 leaders of farmer groups who participated in focused group discussions. Quantitative and qualitative analyses have been used collaboratively in the chapter. The assumption emerging from the conceptual framework of this study is that, the farmers' conception of rainfall influenced, of course, by the basic characteristics of the farmers and their beliefs on one hand, and on the other hand, their land uses, lead to the rainfall patterns in the Zosali community.

This chapter is organized into five parts to deal with the demographic characteristics of respondents, theexperiences and beliefs of the farmersregarding rainfall, and suggestions about how to improve upon the rainfall pattern of the Zosali community.

## 4.2 Demographic Characteristics of the Respondents

Gender, age, years of residence in the Zosali community, type of farming activity, household size, and level of education constitutes the demographic data solicited in the study. The distribution of the respondents in these respects (see Table 4.1) is discussed below.

### 4.2.1 Gender

About three in five of the farmers (60.7%) are males whereas females constitute 39.3%, that is, not more than two in five of the farmers. Considering that the proportion of males to females in the Zosali community is 49.1% to 50.9% respectively (Ghana Statistical Service, 2014), the predominance of male farmers in the study only evidences the fact that more males are engaged in farming activities in the community.

### 4.2.2 Age

Table 4.1 shows that farmers aged above 50 years form 36.4% of the total sample of farmers. This is followed by farmers aged from 30 – 34 years (18.6%). Those aged 35 – 39 and 45 – 49 years are next with 12.9% of the farmers apiece. At 18 – 24 and 25 – 29 years respectively, there are only 5.7% and 14.3% of the farmers. These results show that much of the young people aged below 30 years in the community are not into farming.

### 4.2.3 Years lived in the Zosali Community

Table 4.1 indicates that the greatest number of the respondents have resided in the Zosali community for more than 20% years (34.3%). Those who have resided in the community for 6 – 10 years followed (22.9%) and immediately afterward 11 to 20-year residents followed. Small proportions of the farmers, 10% and 21.4%, had lived in the community for less than one year and between 1 – 5 years respectively. This means that more of the farmers had lived in the Zosali community for relatively longer periods and would have experienced changing weather conditions of those periods.

### 4.2.4 Type of Farming Activities

From Table 4.1, crop farming happens to be the most practiced farming activity with (82.9%) of the farmers involved in it. There is 24.3% of the farmers who also do livestock rearing and 12.9% who are into tree planting (Note: some of the farmers are engaged in more than one farming activity).

### 4.2.5 Household Size

Majority of the farmers (87.9%) have 1 – 5 people in their household whereas 12.1% of them have 6 – 15 people in their household. This means that most of the farmers have 1 to 5 dependants (see Table 4.1).

### 4.2.6 Level of Education

Table 4.1 shows that majority (80%) of the farmers have no formal education. One in ten (10%) of the farmers has a Primary level of education whereas 7.9% of the farmers have a Middle/JSS/JHS level of education. A few (2.1%) of the farmers have a Secondary/Vocational/Technical education. The level of education among the respondents is, thus, low and reflective of many farming communities in Ghana.

**Table 4.1: Demographic Characteristics of the Farmers**

| Variables | | N | % |
|---|---|---|---|
| **Total** | | **140** | **100.0** |
| Gender | Male | 85 | 60.7 |
| | Female | 55 | 39.3 |
| Age | 18-24 | 8 | 5.7 |
| | 25-29 | 12 | 8.6 |
| | 30-34 | 26 | 18.6 |
| | 35-39 | 18 | 12.9 |
| | 40-44 | 7 | 5.0 |
| | 45-49 | 18 | 12.9 |
| | 50+ | 51 | 36.4 |
| Years of residence | Less than 1 year | 14 | 10.0 |
| | 1 – 5 years | 16 | 11.4 |
| | 6 – 10 years | 32 | 22.9 |
| | 6 – 10 years | 30 | 21.4 |
| | 20 + | 48 | 34.3 |
| Type of farming activity | Crop farming | 102 | 72.9 |
| | Tree planting | 18 | 12.9 |
| | Livestock rearing | 20 | 14.3 |
| Household size | 1 – 5 people | 123 | 87.9 |
| | 6 – 15 people | 17 | 12.1 |
| Level of education | No education | 112 | 80.0 |
| | Primary education | 14 | 10.0 |
| | Middle/JSS/JHS | 11 | 7.9 |
| | Secondary/Vocational/Technical | 3 | 2.1 |

**Source: Field Data (2018).**

## 4.3 Description of Discussants in Focus Group Discussion

The respondents in the focus group discussions also identified themselves as farmers; not only that but leaders of seven (4) farmer groups in the community. For the purpose of identification in this analysis, the respondents have been given pseudo names: Respondent 1, Respondent 2, Respondent 3… to Respondent 10. The respondents are resident in the Zosali community and are themselves farmers in crop farming and livestock rearing. The least in terms of age of the respondents was 44 years old. They were mainly non-literates with only two of them having received elementary education some long years ago. The respondents have had the benefit of long stay in the Zosali community, having resided in the community for at least 20 years. Generally, they appeared in this study to have the hindsight about rainfall patterns and experience in farming and land use practices, as well as belief systems which were vital in this study.

## 4.4 Experiences, Beliefs and Perceptions of the Respondents about Rainfall

In accordance with thefirst objective of this study to examine the beliefs and experiences of the farmers regarding rainfall in the Zosali community, there was, in addition to focused group discussion, data made up of 22 items or statements in the questionnaire administered to the farmers which had response formats anchored on a 5-point Likert scale. The respondents indicated whether they 'strongly disagree' (1), 'disagree' (2), felt 'neutral' of had no idea (3), 'agree' (4) or 'strongly agree' (5) with the items or statements put to them. The statements are a collection of facts and representations of rainfall phenomena as they apply to the northern part of Ghana. The respondents' approval ratings against the items reflected their beliefs, experiences, and understanding of rainfall. The data from the focused group discussion was analyzed in corroboration with the data from the farmers.

Based on the responses for the 22 statements obtained from the respondents, a Principal Component Analysis (PCA) was performed to extract and re-specify the beliefs, experiences, or perceptions of the farmers about rainfall. The PCA produced a Kaiser-Meyer-Olkin Measure of Sampling Adequacy of 0.626 with Bartlett's Test of Sphericity of $X^2(231) = 1152.654$ and $p < 0.01$. The sampling adequacy of 0.626 (greater than 0.5), and a Bartlett's Test of Sphericity significant at 99% ($p<0.01$) confidence level confirmed that the measures are fit for obtaining components that underlie the beliefs, experiences and perceptions of the farmers concerning rainfall.

From the 22 statements, Table 4.2 shows that 7 components or factors that bring about the essence of the beliefs, experiences and perceptions of the respondents emerged from the principal component analysis using the standard minimum Eigen value of 1.00 as the cut off point (Field, 2000; Reitveld & Van Hout, 1993). The 7 components jointly explain66.6% of the variance in the perceptions of the farmers regarding rainfall. The first component alone explains 20.4% of the variance in the perspectives on rainfall. The second explains 11%, whereas the third, fourth, fifth, sixth, and seventh components explain 9.7%, 8.3%, 6.5%, 6% and 4.7% respectively (see Table 4.2).

**Table 4.2: Analysis of the Essential Components in understanding Rainfall from the Perspective of the Farmers**

| Statements | Initial Eigen values | | |
|---|---|---|---|
| | Total | % of Variance | Cumulative % |
| 1. Rainfall is caused by a powerful supernatural being | 4.491 | 20.4 | 20.4 |
| 2. There can only be a spiritual explanation to how rainfall occurs | 2.411 | 11.0 | 31.4 |
| 3. God or gods need to be pacified for the rains to set in | 2.139 | 9.7 | 41.1 |
| 4. Except God (or gods), there can be no correct human explanation of rainfall | 1.817 | 8.3 | 49.4 |
| 5. If we obtain direction from spiritual people, it can cause rainfall | 1.431 | 6.5 | 55.9 |
| 6. We consult God (or the gods) to forestall drought | 1.322 | 6.0 | 61.9 |
| 7. The sun does not cause rainfall | 1.044 | 4.7 | 66.6 |
| 8. Rivers, plants and trees do not cause rainfall | 0.989 | | |
| 9. Human interventions cannot change the pattern of rainfall | 0.886 | | |
| 10. Climate change cannot be felt in this community | 0.869 | | |
| 11. There is more rainfall nowadays than before | 0.697 | | |
| 12. Bush burning | 0.595 | | |
| 13. Felling of trees | 0.561 | | |
| 14. Charcoal burning | 0.495 | | |
| 15. Removal of vegetation cover due to construction activities | 0.467 | | |
| 16. There is longer dry season than before | 0.407 | | |
| 17. The weather is often hotter than before | 0.383 | | |
| 18. There is shorter rainfall episodes than previous years | 0.268 | | |
| 19. There is increased risks of flooding during rainfall | 0.243 | | |
| 20. Crop productivity has reduced | 0.188 | | |
| 21. There is stress on water resources | 0.168 | | |
| 22. There is increased water demand for irrigation and domestic use | 0.127 | | |

Note: Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.626; Bartlett's Test of Sphericity: $X^2$= 1152.654; df = 231; and $p$ = 0.000

**Source: Field Data (2018).**

Table 4.3 reports the factor loadings, item-total correlations, and reliability test (Cronbach's alpha) for all the 7 components that were extracted.The factor loadings determine how much each of the 22 statements loads onto a specific component. Item-total correlation indicates how strongly a statement relates or adheres with the statements within a component whereas the Cronbach's alpha measures the overall reliability of the statements in each component.

By adopting factor loadings greater than 0.4, item-total correlations greater than 0.3, and Cronbach's alpha greater than 0.5 to interpret – as suggested by Field (2000) and Stevens (1992) – two (2) out of the 7 components were found to have failed to meet a minimum criteria of acceptability. These 2 components were, therefore, rejected. Thisresulted in the elimination of components and retention of 5 components (see Table 4.3). The first factor, Factor 1, has 5 items which were re-specified as "Traditional belief/superstition" because the belief that rainfall is a phenomenon that is explained by God and spirits was widespread. Factor 2 comprises 4 items which relate to "Factual misconceptions about rainfall"since this factor contains elements that show that correct facts about rainfall phenomena were denied by the farmers. Factor 3has 3 items and they reflect "Bad land-use". This factor is also expressed as such because of the bad land-use it connotes. Factor 4 is also made up of 3 items and is associated with "Bad rainfall-experience" expressed by little amount of rain, flooding, and reduced water supply to make crops productive. Finally, Factor 5, concerning "Water scarcity", is made up of 2 items depicting water shortage(see Table 4.3).

**Table 4.3: Re-specified Factors underpinning the Beliefs and Perceptions of the Farmers about Rainfall**

| Variables | Loadings | Item-Total Correlation | Cronbach |
|---|---|---|---|
| **Factor 1 – Traditional belief/superstition** | | | |
| There can only be a spiritual explanation to how rainfall occurs | 0.532 | 0.301 | |
| God or gods need to be pacified for the rains to set in | 0.871 | 0.756 | |
| Except God (or gods), there can be no correct human explanation of rainfall | 0.819 | 0.707 | 0.793 |
| If we obtained direction from spiritual people, it can cause rainfall | 0.723 | 0.671 | |
| We consult God (or gods) to forestall drought | 0.573 | 0.499 | |
| **Factor 2 - Factual misconceptions about rainfall** | | | |
| Rivers, plants and trees do not cause rainfall | 0.676 | 0.493 | |
| Human interventions cannot change the patterns of rainfall | 0.821 | 0.624 | 0.770 |
| Climate change cannot be felt in this community | 0.743 | 0.652 | |
| There is more rainfall nowadays than before | 0.736 | 0.531 | |
| **Factor 3 - Bad land-use** | | | |
| Bush burning | 0.694 | 0.558 | |
| Charcoal burning | 0.829 | 0.697 | 0.726 |
| Removal of vegetation cover due to construction activities | 0.640 | 0.422 | |
| **Factor 4 –Bad rainfall-experience** | | | |
| There is shorter rainfall episode than previous years | 0.746 | 0.576 | |
| There is increased risk of flooding during the rainfall | 0.823 | 0.625 | 0.762 |
| Crop productivity has reduced | 0.830 | 0.593 | |
| **Factor 5 - Water scarcity** | | | |
| There is stress on water resources | 0.780 | 0.412 | 0.578 |
| There is increased water demand for irrigation and domestic use | 0.827 | 0.412 | |
| **Factor 6** | | | |
| The sun does not cause rainfall[b] | 0.498 | 0.123[a] | 0.219[a] |
| There is shorter dry season than before[b] | 0.782 | 0.123[a] | |
| **Factor 7** | | | |
| Rainfall is caused by a powerful supernatural being[b] | 0.509 | 0.127[a] | |
| Felling of trees[b] | 0.612 | 0.133[a] | 0.157[a] |
| The weather is often hotter than before[b] | 0.362[a] | 0.138[a] | |

Note: [a]offending statistics; [b]rejected variables.

**Source: Field Data (2018).**

Therefore, the factors extrapolated from the beliefs, perceptions, and experiences of the farmers regarding rainfall were expressed in terms of the following:

1. Traditional belief/superstition,
2. Factual misconception about rainfall,
3. Bad land-use,
4. Bad rainfall-experience, and
5. Water scarcity.

Probing into the understanding of how rainfall occurs from the perspectives of the discussants in the focused group discussion, the respondents gave cognizance to the fundamental role the sun plays in the occurrence of rainfall. The idea was drummed home that the sun must evaporate the water from the land into the atmosphere for it to come down as rain. The salient views that addressed this issue are as follows:

> *"Rain is water in the sky. Before the water will get to the sky the sun has to heat the land and dry evaporate the water. So, when there is enough water in the sky it returns to the land in the form of rainfall"* (Respondent 4, Focused Group Discussion, 2018).

> *"Our fathers used to say that, when the sun shines fiercely, then it might rain. Today, we know that the sun must shine and the waters must dry, then after that, there will be rainfall. So, we know that the sun is important and it should shine on the land before there will be rainfall"* (Respondent 5, Focused Group Discussion, 2018).

One other element which was added to the sun was the wind. Apart from the sun, the wind and its direction, it was explained, sometimes determined rainfall occurrence.

> *"I think the wind and the sun all play their part in the occurrence of rainfall… The wind must be able to blow and move the clouds around until it reaches where it should rain"* (Respondent 10, Focused Group Discussion, 2018).

These submissions reflect laymen ideas of how rainfalls occurs which does not deviate widely from the scientific explanation of rainfall as expressed by the hydrological cycle in Shaw et al. (2011) and Biswas (1970). However, there was a subtle inability of the respondents to fundamentally describe what goes on to cause rainfall. The existence of spirits or gods behind the occurrence of rainfall was discussed. The comments from the respondents showed that, though there are natural mechanisms which determine rainfall, one cannot downplay the influence of certain spirits on the mechanisms that determine rainfall.

> *"…There are spirits which can control rainfall. There are spirits which can lock the rains and prevent them from coming. Sometimes, we have more rainfall here than usual and during such times we could only say that God has been good to us for bring down plenty of rain"* (Respondent 1, Focused Group Discussion, 2018).

> *"God controls rainfall because he causes it. If God says it should rain, it will surely rain. We do not see exactly what goes on before rainfall, and I believe that there are spirits that can control rainfall"* (Respondent 2, Focused Group Discussion, 2018).

> *"…Even in our locality, great men, traditionalists, and prophets have some level of eyesight to foretell that it will rain and it sometimes does. If they really saw in spirit that it was going to rain and it did, then there are some spirits behind rainfall occurrence which not everybody can see"* (Respondent 7, Focused Group Discussion, 2018)

The views above confirm the tendency in the Zosali community to perceive rainfall beyond the natural to a supernatural phenomenon which is caused by supernatural forces. Consistent with the above, the respondents shared a contrary opinion to the view that humans can do something to alter rainfall. Their common opinion is that humans cannot do anything to help the rains to come; that enterprise is just beyond the reach of humans. One respondent said, *"…Humans by ourselves cannot do anything to cause rainfall"* (Respondent 6, Focused Group Discussion, 2018). Another respondent succinctly put it, *"…Humans just do not have that influence on rainfall"* (Respondent 7, Focused Group Discussion, 2018).*"The mechanisms that cause rainfall are not in the realms of full human understanding. So it is difficult to understand how humans can alter rainfall"*said a respondent (Respondent 9, Focused Group Discussion, 2018). This position clearly contradicts the view that rainfall pattern and ultimately climate are affected or altered by anthropogenic factors (Haddeland et al., 2013; Watts et al., 2015; Kernan et al., 2010). The latter view is, nonetheless, more a scientifically proven position. The assumption, therefore, that humans cannot influence rainfall would be a factual misconception. Despite this, the discussion continued to show that it is more the job of the spiritually minded people and/or the spirits to determine what happens to rainfall. One of such responses is this:

> *"…I think that in matters that humans do not have control over, it may be reasonable to accept the interventions of those who have the power to do so. Humans cannot determine rainfall and so we can rely on spiritual people to determine what would happen to rainfall"* (Respondent 7, Focused Group Discussion, 2018).

From the above, it can be inferred there was not only the sense that rainfall cannot be altered by humans, but also that spiritual people or spiritual interpretations can help to determine what should happen to rainfall. Unfortunately, these views either solidify into traditional/superstitious belief or factual misconception about rainfall. Therefore, the interpretations and perceptions about rainfall among these respondents confirm that of the generality of the farmers in the study.

The respondents, however, indicated their awareness to the change in rainfall pattern over the years. Particularly, mention was made of the fact that rainfall in the community has reduced. Not only that, but it was perceived that the times during which rainfall used to be experienced has slightly changed.

> *"Rainfall has reduced a bit over the length of time I have been in this community. It used to be that the heavier rainscome about twice to thrice before the rainy season diminishes. In recent years, it is just one heavy rain and it then the dry season comes"* (Respondent 5, Focused Group Discussion, 2018).

> *"This days, the rainy season keeps long to set in and ends within a short time it gives way to the dry season for a long period"* (Respondent 7, Focused Group Discussion, 2018)

The findings above, therefore, coincide with the view from the larger group of farmers that there is bad rainfall experience in the Zosali community. Also, apart from the leaders of the farmer groups indicating that they have sometimes had to clear their land for cultivating crops by burning, they could not show that it had ramifications for rainfall. This also hints of bad land-use as the data from other farmers indicated.

The crux of this study, however, is to examine the causal connections between these factors. For emphasis, the study is to examine how the beliefs, perceptions, and experiencesof the farmers with rainfall are associated with the rainfall pattern in the Zosali community. Accordingly, staging the emerging factors in a model, bad rainfall-experience is expressed a dependent variable on traditional belief/superstition, factual misconception about rainfall, bad land-use, and water scarcity. The factor scores obtained for each of the factors were used in examiningthe relationships between the factors employing Chi Square, Pearson's Correlation, and Hierarchical Linear Regression and Simple Linear Regression at different stages of determining relationships.

First, the influence of the demographic characteristicsof the farmers on the emerging factors was examined. The data shows that traditional belief/superstition about rainfall (spiritual explanations of rainfall and attribution of rainfall to God or gods) is significantly attributed to the male farmers more than female farmers ($X^2(2) = 7.905$; $p < 0.05$). More of the male farmers (89.4%) agree or strongly agree with the traditional belief/superstition about rainfall than did 70.9% of their female counterparts (see Table 4.4).

Also, traditional belief/superstition about rainfall is significantly dependent on type of farming activity engage in by the farmers ($X^2(4) = 9.816$; $p< 0.05$). There was 87.2% of the total farmers involved in crop farming who agreed or strongly agreed with viewstraditional belief/superstition about rainfall whereas 72.2% and 65% of the farmers involved in tree planting and livestock rearing respectively held or held on tosame belief (see Table 4.4).

The magnitude of factual misconception about rainfall (example, that rivers, plants and trees do not cause rainfall, humans interventions cannot change the patterns of rainfall, climate change cannot be felt in the community, and there is more rainfall nowadays) among the farmers depends significantly on level of education of the farmers ($X^2(6) = 28.120$; $p < 0.01$). The greatest proportion (96.4%) of the farmers who have no education held or strongly held on to factual misconceptions about rainfall. Among the farmers who have a Primary level of education, 92.9% held or strongly heldon to factual misconceptions about rainfall. The farmers who have Middle/JSS/JHS and Secondary level of education had smaller proportions, 63.6% and 66.7%, of them respectively subscribed or strongly subscribed to factual misconceptions about rainfall (see Table 4.4). Of course, education and literacy is an important avenue by which scientific knowledge can be obtained. It provides people with both the content and the ability to decipher scientific information. Much of the scientific explanations and facts surrounding rainfall and understanding of weather are in books and literary documents. As a non-literate one, this community will fall short of such scientific information, especially, if there has been no intervention to relay scientific information in terms that they may understand.

Consequently, a large number of the farmers with little or no education have the highest factual misconception about rainfall.

**Table 4.4: Connections between Characteristics of the Farmers and Factors attributed to Rainfall**

| Factors | Farmers' Characteristics | Disagree % | Moderate % | Agree % | Total % |
|---|---|---|---|---|---|
| **Traditional belief/superstition** | Male | 4.7 | 5.9 | 89.4 | 100.0 |
| (Chi Sq. = 7.905; df=2; *p*=0.019) | Female | 10.9 | 18.2 | 70.9 | 100.0 |
| (Chi Sq. = 9.816; df=24 p=0.044) | Crop farming | 6.9 | 5.9 | 87.2 | 100.0 |
| | Tree planting | 5.6 | 22.2 | 72.2 | 100.0 |
| | Livestock rearing | 10.0 | 25.0 | 65.0 | 100.0 |
| **Factual misconceptions** | No education | 0.9 | 2.7 | 96.4 | 100.0 |
| (Chi Sq. = 28.120; df=6; p=0.000) | Primary | 0.0 | 7.1 | 92.9 | 100.0 |
| | Middle/JSS/JHS | 18.2 | 18.2 | 63.6 | 100.0 |
| | Sec/Voc/Tech | 33.3 | 0.0 | 66.7 | 100.0 |

**Source: Field Data (2018).**

## 4.4 Interpretations to Rainfall based on Beliefs and Perceptions of the Farmers

Having drawn out five factors associated with rainfall from the perspectives of the farmers, effort is made in this section to examine how the factors are associated with rainfall experiencedin the community. First, the correlations between the factors areexamined. Second, the causal connections between the factors and the farmers' experience with rainfall were examined.

Table 4.5 shows the Pearson's Correlation statistics obtained among the five factors as analyzed in Table 4.3, that is,(1) traditional belief/superstition(2) factual misconception about rainfall, (3) bad land-use, (4) bad rainfall-experience, and (5) water scarcity. The mean value (above 4.00 on the scale of 1 to 5)obtained for each of the factors shows that, in general, the views of the farmers affirmed the factors. There were significant correlations between a number of the factors (at least $p<0.05$). Traditional belief/superstition was positively correlated with factual misconceptions about rainfall (r = 0.291; $p< 0.01$) as doesbad land-use (r = 0.363; $p < 0.05$). This implies that as tradition belief/superstition increases, misconception about the facts surrounding rainfall also increases. This is not a surprise because many traditional and superstitious beliefs are not founded on scientific understanding and so they lack reasonable support to make them sustainable unless they are labeled as traditional or superstitious beliefs. For example, if it is believed by the local farmers that God or gods need to be pacified for the rains to set in they would be under a factual misconception about how rainfall occurs. The fact about the cause of rainfall is lucidly explained by the hydrologic cycle which shows the sun and the earth working together to cause rainfall.

Bad rainfall-experiencerecorded positive correlation with traditional belief/superstition (r = 0.197; $p < 0.05$).This means that bad experiences with rainfall increase as traditional beliefs or superstition about rainfall increases. Bad land-use was also positively correlated with factual misconception about rainfall (r = 0.211; $p < 0.05$) and bad rainfall-experience (r = 0.220; $p < 0.01$).From these results, it appears that bad rainfall-experienceis what the traditional belief/superstition about rainfall leaves behind. The belief that God (or the gods) should be pacified to bring down the rains, for instance,does not agree withfactual conception of rainfall. This kind of beliefs,apparently, limits the chances of using land in manners that promote the atmospheric conditions favourable for normal rainfall.It must be emphasized that out of these correlations, traditional belief/superstition and bad land-use had a better positive correlation. Nonetheless, bad rainfall-experiencepositively correlates with traditional belief/superstition and bad land-use (see Table 4.5).

**Table 4.5: Correlations among Estimated Factors attributed to Rainfall**

| Factors | Tradition/superstition | Factual misconceptions | Bad land-use | Bad rainfall-experience | Water scarcity |
|---|---|---|---|---|---|
| Tradition/superstition | **4.23 (0.88)** | | | | |
| Factual misconceptions | 0.291** | **4.43 (0.67)** | | | |
| Bad land-use | 0.363** | 0.211* | **4.43 (0.65)** | | |
| Bad rainfall-experience | 0.197* | 0.138 | 0.220** | **4.4 (0.78)** | |
| Water scarcity | 0.045 | 0.057 | 0.083 | 0.083 | **4.34 (0.87)** |

Note: Mean value and parenthesized Standard Deviation are in bold.
** Correlation is significant at 0.01.
* Correlation is significant at 0.05.

**Source: Field Data (2018).**

It must be stated however that, the interconnections between the beliefs, perceptions about rainfall, land use, and rainfall experience were not things that the farmers readily considered. The leaders of the farmer groups could not make out the relationship between land use and rainfall experience with the dominant idea that, *"…there are things which go on for rainfall to occur which humans cannot fully understand"* (Respondent 7, Focused Group Discussion, 2018), and that, *"…humans cannot alter the rainfall pattern"* (Respondent 1, Focused Group Discussion, 2018).

In dealing with the fundamental question, "What are the interpretations to rainfall in terms of the experiences and beliefs of the farmers in the Zosali community?" the causal connections between the estimated factors surrounding rainfall were examined. The main object here was to determine how rainfall experiences, as observed by the farmers, is explained by other factors known from the farmers' perspectives in respect of rainfall.

By the conceptual framework of this study, two paths by which rainfall in the Zosali community might be predicted were examined. The first regarded how the farmers' conception of rainfall predictsthe rainfall experience in the Zosali community. The second explored how land use by farmers predicts rainfall experience in the community.

It is conceived from literature that rainfall is capable of being altered by land uses (Wijesekara et al., 2012; Mango et al., 2011; Pagano & Soroosh (2002). In this study, it has been found that'bad land-use' (unsound uses of land, such as bush burning, felling of trees, poorly planned removal of vegetation cover, and so on)is positively correlated with traditional belief/superstition, factual misconception about rainfall and bad rainfall-experience.Hierarchical multiple regression modelwas conducted to further determine how all the factors in this study predict the bad rainfall-experienceof the farmers. Thus, the dependent factor here was bad rainfall-experience (see Table 4.6).

**Table 4.6: The Effect of Land Use, Perception and Beliefs about Rainfall on Rainfall Experience**

| Model | | B | Std. Error | Beta | T |
|---|---|---|---|---|---|
| 1 | (Constant) | 3.22 | 0.45 | | 7.156** |
| | Bad land-use | 0.267 | 0.101 | 0.22 | 2.65** |
| | F (Prob.) = 7.022** | | | | |
| | Adjusted R = 0.042 | | | | |
| | SE of Estimate = 0.766 | | | | |
| 2 | (Constant) | 2.976 | 0.476 | | 6.252 |
| | Bad land-use | 0.207 | 0.107 | 0.171 | 1.93 |
| | Traditional belief/superstition | 0.12 | 0.079 | 0.134 | 1.516 |
| | F (Prob.) = 4.693* | | | | |
| | Adjusted R = 0.050 | | | | |
| | SE of Estimate = 0.763 | | | | |
| 3 | (Constant) | 2.728 | 0.57 | | 4.789 |
| | Bad land-use | 0.197 | 0.108 | 0.163 | 1.82 |
| | Traditional/superstition beliefs | 0.105 | 0.081 | 0.117 | 1.285 |
| | Factual misconceptions about rainfall | 0.081 | 0.101 | 0.069 | 0.795 |
| | F (Prob.) = 3.331* | | | | |
| | Adjusted R = 0.048 | | | | |
| | SE of Estimate = 0.764 | | | | |
| 4 | (Constant) | 2.314 | 0.629 | | 3.678 |
| | Bad land-use | 0.186 | 0.108 | 0.154 | 1.723 |
| | Traditional/superstition beliefs | 0.104 | 0.081 | 0.116 | 1.281 |

| | | | | |
|---|---|---|---|---|
| Factual misconceptions about rainfall | 0.075 | 0.101 | 0.064 | 0.74 |
| Water scarcity | 0.113 | 0.075 | 0.125 | 1.516 |
| F (Prob.) = 3.097* | | | | |
| Adjusted R = 0.057 | | | | |
| SE of Estimate = 0.760 | | | | |

** Correlation is significant at 0.01.

* Correlation is significant at 0.05.

**Source: Field Data, 2018.**

Results from Table 4.6 show that bad land-use significantly predicts bad rainfall-experience (F=7.022; *p*<0.01). Bad land-use alone explains 4.2% of the variance in bad rainfall-experience. An increase in bad land-use by a unit will predict an increase in bad rainfall-experience. By limiting the influence of bad land-use, the other factors, that is, traditional belief/superstition, factual misconception about rainfall, and water scarcity did not add any significant predictive value to bad rainfall-experience.

These results demonstrate that bad land-use has a significant predictive power over bad rainfall-experience. Adding traditional belief/superstition, factual misconception about rainfall, and water scarcity to bad land-use renders the model insignificant in predicting bad rainfall-experience. In other words, the model which treats bad rainfall-experienceto be dependent on bad land-use, traditional belief/superstition, factual misconception about rainfall, and water scarcity is not sustainable. But maintainingbad land-use and eliminating other factors in this model, one is able to significantly predictbad rainfall-experience. This means that if measures for land use are known, the nature of rainfall experience can be predicted. Effectively, a unit increase in bad land-use will intensifybad rainfall-experience.

This finding echoes the position of several researchers that land use is an important factor in the discourse on climate change, water management and sustainable resource exploitation (Wijesekara et al., 2012; Pagano & Soroosh, 2002; Flohn, 1973). Deforestation, agriculture, urbanization and draining of swampy lands are some types of land uses highlighted in research which impact negatively on water availability. However, it cannot be gainsaid that afforestation forestalls negative effects attributed to land use in that, it prolongs wet season by increasing interception of water, delay runoff, increase transpiration in dry season to retain soil water (Pagano & Soroosh, 2002). Therefore, land-use changes are found to have impact on hydrological cycle (Wijesekara et al., 2012). In evidence to this, it has been argued that over the last 8,000 years or so, approximately 11% of the land surface has been converted into arable land and 31% of forests have been modified from their original states. The changes in how land is used affect temperature, rainfall, and atmospheric carbon dioxide (Adams et al., 1998). Therefore, variations in land use ought to be favourably tuned to meteorological variables that support life (Flohn, 1973).

## 4.5 Relationship between Traditional Belief regarding the Rainfall pattern in the Zosali Community

In typical non-literate and semi-literate Ghanaian societies, it is not surprising to hear people demanding for the rains to come, especially, towards the end of the dry season. Evokingthe supernatural, like God, to bring down the rains is not novel. Still, some people, particularly in the rural hinterlands, show tendencies of traditional belief or superstitious practices being something that can be relied on to ask for the rains to fall. Such beliefs as pacifying God or gods to bring the rains, relying on spiritual explanations and causes of rainfall or droughts are expressed in this study as "Traditional belief/superstition.

In previous sections, it emerged that traditional belief/superstition and bad rainfall-experience of the farmers in the Zosali community are positively but weakly correlated($r=0.197$; $p<0.05$) (see Table 4.5). This implies thatenhancements in traditional belief/superstition would, somewhat, correspond with an increasedbad rainfall-experience. If this were so, then traditional belief/superstition might predictbad rainfall-experience observed by the farmers in the Zosali community. However, in predicting bad rainfall-experience, it was subsequently established that apart from land uses, adding traditional belief/superstition, among other factors, results in an insignificant way to predict bad rainfall-experience (refer to Table 4.6). Therefore, traditional belief/superstition has no direct significant effect on bad rainfall-experience observed by the farmers.

However, to be sure of what the relationship or causal connection between traditional belief/superstition and bad rainfall-experience is, indirect relationships between the two were explored. Bad land-use has already been established as a significant direct predictor of bad rainfall-experience. Giventhat bad land-use is the only probable factor that significantly predicts bad rainfall-experience, traditional belief/superstition could indirectly predict bad rainfall-experience if it directly determinedbad land-use. A simple linear regression was performed to examine the relationship between traditional belief/superstition and bad land-use.

The results in Table 4.7 show that traditional belief/superstition is significantly associated with bad land-usein the Zosali community (F=7.863; *p*<0.01). Traditional belief/superstition singularly explains12.6% of the variance in bad land-use. A unit increase in traditional belief/superstition produces an increase in bad land-use (t=4.577; *p*<0.01; B=0.267). Therefore, traditional/superstition belief significantly predicts bad land-use. This can be interpreted in another way; to the extent that traditional belief/superstition gives no account of scientific explanation of rainfall, people would rely on what those beliefs would do and not the understanding of their responsibility to ensure that they use land in a manner that does not destabilize climate. If this happened, then tradition belief/superstition would lead to uncontrolled land use, much of which use would turn out to be inimical to climate.

**Table 4.7: Relationship between Traditional belief/Superstition and Bad land-use**

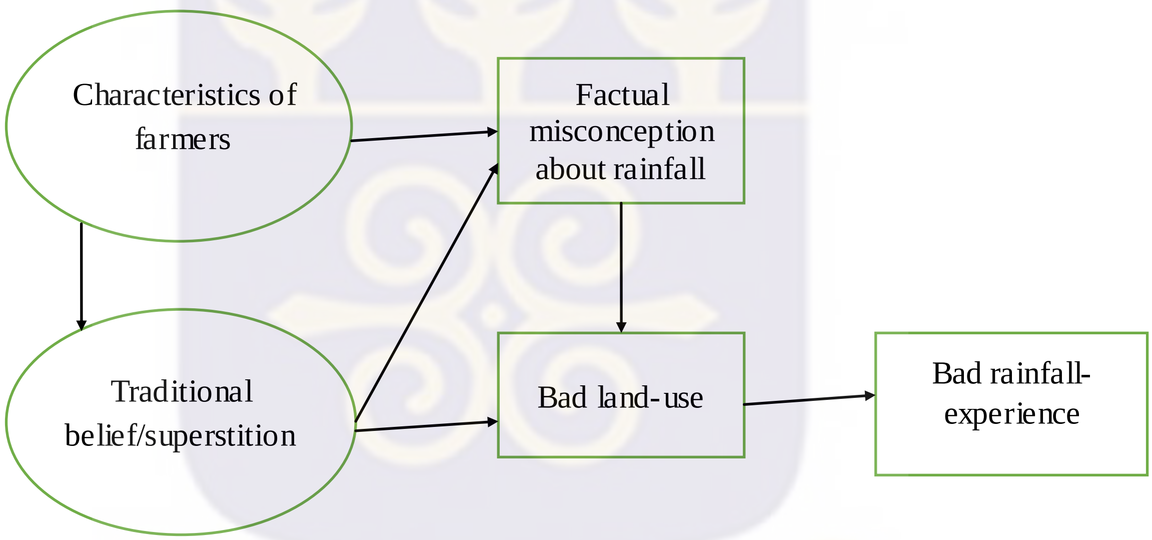
| Variables | B | S.E. | Beta | t |
|---|---|---|---|---|
| (Constant) | 3.299 | 0.252 | | 13.113** |
| Traditional/superstition belief | 0.267 | 0.058 | 0.363 | 4.577** |
| Adjusted $R^2$ = 0.126   F (Prob.) = 20.950** | | | | |
| S.E of Estimate = 0.604 | | | | |

** Correlation is significant at 0.01

**Source: Field Data (2018).**

Following from the relationships thus far established, Figure 4.5represents the factors involved in the model and how they are interrelated based on significant relationships found in the analysis. Each significant relationship is represented by an arrow showing the direction of the relationship.

**Figure 4.1: Re-specified Model for Interpretation of Bad Rainfall-Experience**

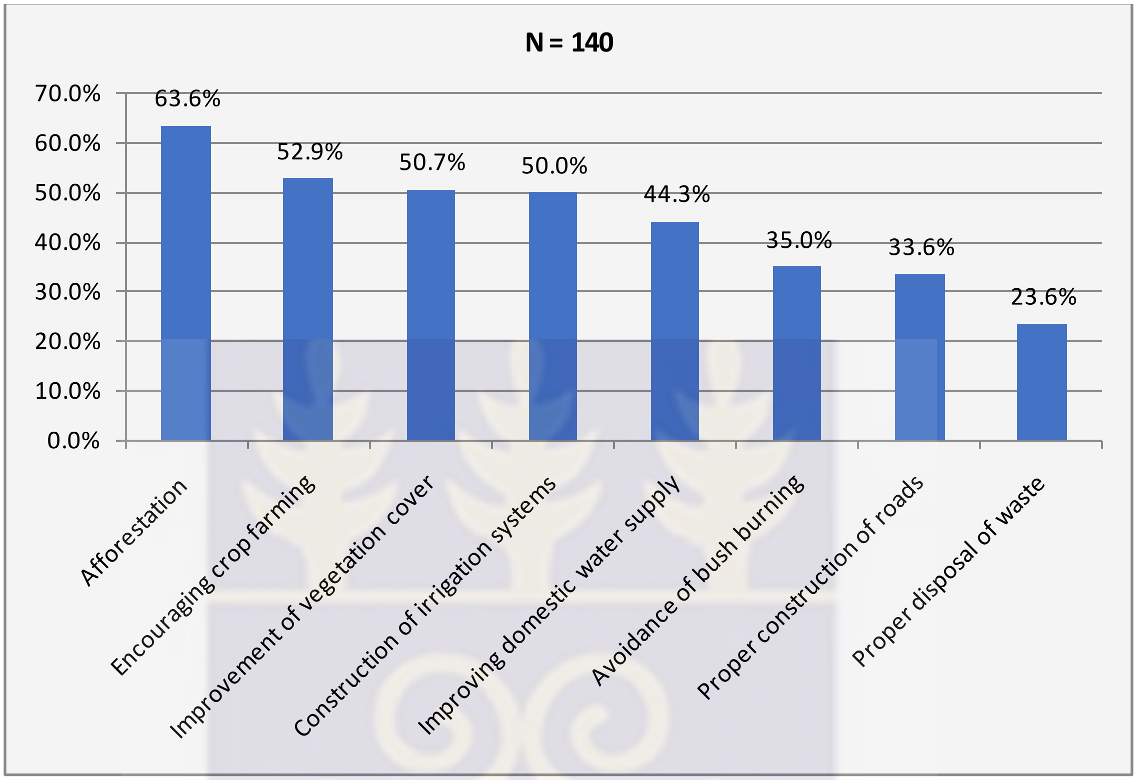



Effectively, the analysis showed that traditional belief/superstition was associated with bad land-use. Meanwhile, traditional belief/superstition attributed to the farmers depended on demographic characteristics of the farmers. More males than females were associated with traditional belief/superstition regarding rainfall. Also, factual misconception about rainfall was dependent on level of education of the farmers. Farmers with a low education or no education were associated with factual misconceptions about rainfall. Factual misconception about rainfall in turn correlated positively with bad land-use. The main effect, however, was that bad land-use was a direct significant predictor of bad rainfall-experience observed by the farmers.

## 4.6 Suggestions from the Farmers to improve Rainfall Experience

The study elicited the views and suggestions of the respondents fundamentally on what could be done to improve the average weather condition of the Zosali community. The question, "Suggest ways in which the rainfall pattern can be tamed or adopted for the benefit of the local people" was posed in the questionnaire. Several varied views and suggestions emerged from the responses, and same were categorized into themes. Through this process, eight (8) themes showing how the average weather condition in the Zosali community can be improved emerged. The themes also pay regards to some environmental conditions conducive for human survival. The percentage representations of the themes across the responses are as shown in Figure 4.2. From Figure 4.2, afforestation is the dominant view that was expressed by about three in five (63.6%) of the respondents.

**Figure 4.2: Suggestions for improving Average Weather Condition and promoting an Environment conducive for Life**




Note: The sum of percentages exceeds 100% because of several instances of multiple views from one respondent.

**Source: Field Data (2018).**

One of the responses that highlight the view that afforestation would improve rainfall experience was expressed as follows:

> *"...we need to plant trees and make our environment green. Because the weather becomes hot in many parts of the year, we need the trees to provide shade and some cool air."*

Another respondent also said,

> *"if we have trees in our environment the weather would be a bit cool especially during the dry season. We have to make sure that we have trees in our environment because it can improve upon the weather in this community".*

The finding above echoes Pagano and Soroosh (2002) who espoused that afforestation causes increased interception in wet periods; delay in spring runoff; increased transpiration in dry periods through increased water availability to deep root systems. Deforestation on the other hand causes the opposite effect.

About half (52.9%) of the respondentsasserted that farming, specifically, crop farming, needs to be improved as a way to promote good weather conditions. Improved crop farming would then imply that people employ better ways of cultivating the land as more people are called to engage in crop farming. This also ties in with the suggestion that improvement of vegetation cover would impact positively on the weather condition for the community as was indicated by half (50.7%) of the respondents. Again, half (50.0%) of the respondents believe that construction of irrigation systems would impact on their environment. This view tends to emphasize provision of irrigation as a good way to improve upon sustainability of water to crops or plants to promote a green environment. Improving domestic water supply was shown by 44.3% of the respondents. In support of that, one respondent stated that there should be*"provision of borehole"* as a means to improve domestic water supply. Enhanced domestic water supply comes forth as a remedy to water scarcity that some members of the community may be enduring. Fewer respondents (about three in ten) intimated that 'avoidance of bush burning' and 'construction of proper roads'were ways to improve the weather and environmental condition in the community. The fewest (23.6%) of the respondents emphasized that 'proper disposal of waste' will help to improve the environmental condition of the community. It is important to emphasize that the respondents, in suggesting how to improve the weather condition in their community, were also focused on those elements that would improve environmental conditions such as waste management and construction of roads.

## 4.7 Conclusions

The chapter has provided a systematic analysis of the data obtained in relation to the objectives of the study. The background of the farmers showed that they were predominantly males, had spent long years in the Zosali community, and were generally involved in crop farming. In assessing the experiences and beliefs of the farmers with respect to rainfall in the Zosali community, Principal Component Analysis (PCA) revealed five essential factors, namely: (1) traditional belief/superstition which measures the extent to which people's traditional belief and superstition shroud their understanding of rainfall phenomenon; (2) factual misconception about rainfall which measures people's lack of knowledge concerning rainfall; (3) bad land-use which measures the degree of use of land in a way that is inimical to the atmosphere; (4) bad rainfall-experience which is the observed extent of unproductive rainfall; and (5) water scarcity which measures the availability of water. Focused group discussion with 10 leaders of farmer groups in the community confirmed that the cause of rainfall was considerably associated with beliefs in spiritual things. However, there was limited idea about how their beliefs and perceptions about rainfallrelate with their experiences with rainfall. The analysis revealed some significant inter-factor correlations and interdependencies among the factors observed. Demographic characteristics of the farmers influenced their traditional belief/superstition and factual misconception about rainfall which in turns influenced bad land-use. The analysis showed that only bad land-use significantly predictsbad rainfall-experience. Traditional belief/superstition possessed an indirect effect on bad rainfall-experience. The respondents, in suggesting how weather conditions can be improved in the community, emphasized both elements that impact on weather, like afforestation and promotion of green environment, and the immediate environment, like construction of proper roads and proper waste disposal.

The next chapter integrates the study by summarizing of key findings, drawing conclusions and making recommendations from the study.

# CHAPTER FIVE

# SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

## 5.1 Introduction

The northern part of Ghana has continued to experience some of the devastating effects of the changing atmospheric conditions in Ghana as compared to the southern part. Zosali is a small agrarian community in the Northern Region of Ghana which experiences reduced rainfall. How the beliefs, experiences and practices of members of this community affectrainfallwas the concern of this study. More so, the limitedness of water supply in that part of Ghana makes it important to examine the factors that affect the rainfall from the Zosali community. In accordance with the objectives of this study, therefore, the experiences, practices and beliefs in respect of rainfall were assessed, and the interconnections between them were interpreted. In doing that, the study employed a survey design with mixed methods comprising a focused group discussion and administration of questionnaires. The discussants were 10 leaders of various farmer groups whiles the questionnaires were completed by 140 farmers selected through convenience samplingin the Zosali community.These farmers were predominantly males, had stayed in the community for relatively long periods of more than five years, had very low levels of education with some having no education at all, and they were involved mostly in crop farming.

## 5.2 Summary of Findings

Using Principal Component Analysis, five essential factors that describe the experiences, practices and beliefs of the farmers in relation to their understanding of rainfall in the Zosali community were found in the study. These five factors include:

1. Traditional belief/superstition
2. Factual misconception about rainfall
3. Bad land-use
4. Bad rainfall-experience
5. Water scarcity

The study found that these factors were associated with the rainfall phenomena in the Zosali community. Thus, the factors reflect the experiences, practices and beliefs of the farmers in the community. Traditional belief/superstition was a factor because it expressed important traditional beliefs regarding rainfall. Factual misconception was a factor because it measured the misconceptions held by the farmers which were important to indicate how the farmers interpret rainfall phenomena. Bad land-use was a factor that was on how bad the farmers use the land to incur the deficit or gaps in the advantages of rainfall.Bad rainfall-experience expressed the limitedness of rainfall and the bad consequences, like flooding, that follow rainfall episodes whenit rained. The study found that water scarcity is also a factor or measure that highlights the nature of rainfall and water availability in the Zosali community.

Altogether, these were the dimensions that were measured to give an understanding of rainfall from the perspective of the farmers in the Zosali community. Summarily, the aggregated facts leading to these dimensions showed that negative aspects of rainfall are in the community. This, therefore, provided direct response to the first objective of the study which was to assess the beliefs, and experiences of the farmers with respect to rainfall.

Next, the study found that the five factors underpinning the understanding of rainfall to the farmers of the Zosali community were mostly positively correlated. Specifically, the study found that traditional belief/superstition associated with rainfall was factual misconception about rainfall increases as the traditional belief/superstition associated with rainfall becomes more widespread.

Meanwhile, the traditional belief/superstition held about rainfall depended on the demographic characteristics of the farmers. The males held such beliefs and traditions more than their female counterparts. Also, the factual misconception about rainfall by the farmers depended on their level of education. Those with little or no education held greater misconceptions about rainfall.

Furthermore, the study found that traditional belief/superstition is positively correlated with bad land-use. The higher the traditional belief/superstition, the higher the bad land-use scenario gets. The findings also showed that, factual misconception about rainfall is positively correlated with bad land-use. Here also, the more the factual misconception, the greater the bad land-use situation. In turn, the bad land-use factor was found to be positively correlated with bad rainfall-experience.

Despite the interconnections between the factors underpinning rainfall obtained from the farmers, the single most important factor found in this study was that bad land-use is a significant predictor of bad rainfall-experience. Bad land-use measured the extent to which land was utilized in ways that are inimical to precipitation and the consequences thereof. Bad land-use singularly explained a significant 4.2% of the variance in bad rainfall-experience. The study found that the contribution of the other factors, that is, traditional belief/superstition, factual misconception about rainfall, and even water scarcity were insignificant in predicting bad rainfall-experience. Thus, only bad land use was found in this study to significantly predict bad rainfall-experience. However, factual misconception about rainfall indirectly predicts bad rainfall-experience since it was found to have a significant predictive effect on bad land-use which in turn predicts bad rainfall-experience.

The study supported the claim that bad land-use is a significant predictor of bad rainfall-experience. The finding provided response to the research objective two, which was to examine how the beliefs, practices and experiences of the farmers affect rainfall as experienced by the farmers. Apart from factual misconception about rainfall, the findings showed that bad land-use is dependent on traditional belief/superstition among the farmers. This dovetails into the findings in respect of the third objective of the study.

The third objective of the study was to find out the relationship between traditional beliefs about rainfall and rainfall experiences. The study found that, traditional belief/superstition among the farmers has an insignificant predictive power over bad rainfall-experience. However, traditional belief/superstition has an indirect effect on rainfall experience which is manifested through its influence on bad land-use. In other words, traditional belief/superstition has an indirect effect on bad rainfall-experience because it predicts bad land-use which in turn predicts bad rainfall-experience.

The study found suggestions on how rainfall experience can be improved in the Zosali communityfrom the farmers. The findings in this regard emphasized the farmers' desire to improve the weather condition in their community through practices like afforestation, and also those elements that would improve environmental conditions such as waste management and construction of roads.

## 5.3 Conclusion

This study has highlighted pertinent information about the understanding of rainfall by the farmers in the Zosali community in the Northern Region of Ghana. Although, the understanding of rainfall is seemingly complex, dominant literature has succeeded in breaking it down and classifying the knowledge of the elements of rainfall under the broad concept called the hydrological cycle. This study shows by examining the understanding of farmers in the Zosali community about rainfall under the lenses of scientific knowledge about rainfall, the factors, namely, traditional belief/superstition about rainfall, factual misconception of rainfall, bad land-use, bad rainfall-experience, and water scarcity emerges. Traditional belief/superstitionincreases the factual misconception of rainfall and encourages bad land-use (practices inimical to rainfall or water availability). Of course, being a rural agrarian society characterized by very low levels of education, the limited education plays a pivotal role in the traditional belief/superstition about rainfall and the factual misconception of rainfall held by the farmers. Traditional belief/superstition and factual misconception of rainfall correspond with bad land-use. The most emphatic claim from this study is that bad land-use is a significant determinant of bad rainfall-experience. It must be noted that traditional belief/superstition about rainfall and factual misconception of rainfall contribute to bad land-use since the pay very little regard to any scientific explanation to the phenomenon of rainfall. The implication of this study is that land use has major influence on rainfall experience. To make any positive impact on rainfall experience, traditional belief/superstition and factual misconceptions about rainfall must be dispelled in any climate change mitigation programme, particularly, in the Zosali community.

### 5.4 Recommendations

Based on the findings of this study the following recommendations have been proffered:

First, land use must be given a keen attention in the rural communities, particularly, the Zosali community. Land must be put to use but for the good reasons which enhance good atmospheric conditions. The promotion of green environment in which there is a deliberate effort to make plants and trees grow is important to maintain a balanced or normal atmospheric condition. At present, there is a plan in Ghana to promote a green economy by mitigating Green House Gas emissions and increasing resilience to the impact of climate change. While some actions in this plan are being implemented, it is important that appropriate state agencies, like the Environmental Protection Agency (EPA), should encourage the sustenance of vegetation and forest,by promoting good agricultural and forest conservation practices in rural agrarian communities such as the Zosali community. More importantly, setting up a national or statutory agency which will be robust and spread out in communities to plant trees and preserve vegetation needs a critical consideration to mitigate the effects of climate change. The function of this body could be augmented by such civil society organizations as the Friends of the Environment movement and so on.

Second, farmers, especially traditional or local farmers with characteristically low levels of education need to be factored into the comprehensive programme to create a clean environment and avoid practices that speed up the deterioration of climatic conditions. Education of farmers about climate and atmospheric conditions, particularly, what causes changes in rainfall and brings about bad rainfall-experiences should be readily provided to the farmers to inform their decision to adjust their negative practices and wrong beliefs. Again, the Environmental Protection Agency needs to play a significant role in this regard. Agriculture extension services by the Ministry of Agriculture should be facilitated to provide further education to farmers about farming practices that deplete the normal atmospheric condition.

Third, action needs to be taken in some specific areas as far as promotion of rainfall and good weather conditions is concerned. The specific areas emerging from this study include afforestation, crop farming, improvement of vegetation cover, construction of irrigation systems, and avoidance of bush burning. These require contemplating appropriate technologies that would help push forward these activities that are friendly to the environment. For example, bush burning ought to be replaced by some other methods of bush control. The appropriate technologies to use should be provided by technical experts in the Ministry of Agriculture.

Finally, some of the specific actions which emerged from the study for improving rainfall experience also include improving domestic water supply, proper disposal of waste, and construction of proper roads. This requires that the Ministry of Minerals and Water Resources and the local government institutions should be facilitated to collaborate in ensuring that these environmental systems are done in consistence with the effort to promote a friendly environment devoid of pollution and land degradation.

## 5.5 Suggestion for further Studies

This study alone may not have addressed all the issues within the communities in Ghana with which weather conditions and rainfall are interpreted. Therefore, it is recommended that further studies be undertaken to provide information on the relationship between land and Green House Gases and their impact on climate change by comparing empirical data from urban communities and rural communities.

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# APPENDIX A

## SURVEY QUESTIONNAIRE

## UNIVERSITY OF GHANA, LEGON
## CENTRE FOR CLIMATE CHANGE….

*My name is Alhassan N Sadat, a post-graduate student at the Centre for climate change and sustainability studies at the University of Ghana, Legon. I am undertaking a research for my thesis as part of the requirements for Master's degree in climate change and sustainable development. The thesis aims to understand the interpretations of traditional farmers in the Zosali community and to examine the impact of that understanding on rainfall patterns in the community. Whatever information you will give will be handled confidentially, and will be solely for use according to the purpose of this study. Your completion of the questions will improve our understanding of rainfall and farmers can act or strategize to prevent unfavourable weather conditions from negatively impacting on their productivity.*

**Demographic Information**

1. Gender: Male [ ] Female [ ]

2. Age:
(a) 18 – 24 [ ]
(b) 25 – 29 [ ]
(c) 30 – 34 [ ]
(d) 35 – 39 [ ]
(e) 40 – 44 [ ]
(f) 45 – 49 [ ]
(g) 50 + [ ]

3. Years of residence in the Zosali community:
(a) Less than 1 year [ ]
(b) 1 – 5 years [ ]
(c) 6 – 10 years [ ]
(d) 11 – 20 years [ ]
(e) 20 + [ ]

4. Type of farming activity: *You may choose multiple responses.*
(a) Crop Farming [ ]
(b) Tree Planting [ ]
(c) Livestock Rearing [ ]
(d) Fish Farming [ ]

5. Household size: ……………………………………………….

6. Level of education:
(a) No education [ ]
(b) Primary education [ ]
(c) Middle/JSS/JHS [ ]

(d) Secondary/Vocational/Technical [ ]
(e) Tertiary/University [ ]

*Choose one of the alternatives 1 to 5 by circling to indicate how you agree with the statements concerning rainfall, beliefs about rainfall and land use practices in your community.*

| **Beliefs concerning Rainfall** | **Strongly Disagree** | **Disagree** | **Neutral** | **Agree** | **Strongly Agree** |
|---|---|---|---|---|---|
| 1. Rainfall is caused by a powerful supernatural being | 1 | 2 | 3 | 4 | 5 |
| 2. There can only be a spiritual explanation to how rainfall occurs | 1 | 2 | 3 | 4 | 5 |
| 3. God or gods need to be pacified for the rains to set in | 1 | 2 | 3 | 4 | 5 |
| 4. Except God (or gods), there can be no correct human explanation of rainfall | 1 | 2 | 3 | 4 | 5 |
| 5. If we obtained direction from spiritual people, it can cause rainfall | 1 | 2 | 3 | 4 | 5 |
| 6. We consult God (or the gods) to forestall drought | 1 | 2 | 3 | 4 | 5 |
| | | | | | |
| **Perceptions about Rainfall** | 1 | 2 | 3 | 4 | 5 |
| 1. The sun does not cause rainfall | 1 | 2 | 3 | 4 | 5 |
| 2. Rivers, plants and trees do not cause rainfall | 1 | 2 | 3 | 4 | 5 |
| 3. Human interventions cannot change the pattern of rainfall | 1 | 2 | 3 | 4 | 5 |
| 4. Climate change cannot be felt in this community | 1 | 2 | 3 | 4 | 5 |
| 5. There is more rainfall nowadays than before | 1 | 2 | 3 | 4 | 5 |
| | | | | | |
| **Land Use Practices** | | | | | |
| 1. Bush burning | 1 | 2 | 3 | 4 | 5 |
| 2. Felling of trees | 1 | 2 | 3 | 4 | 5 |
| 3. Charcoal burning | 1 | 2 | 3 | 4 | 5 |

| | | | | | |
|---|---|---|---|---|---|
| 4. Removal of vegetation cover due to construction activities | 1 | 2 | 3 | 4 | 5 |
| **Rainfall Patterns** | **Strongly Disagree** | **Disagree** | **Neutral** | **Agree** | **Strongly Agree** |
| 5. There is longer dry season than before | 1 | 2 | 3 | 4 | 5 |
| 6. The weather is often hotter than before | 1 | 2 | 3 | 4 | 5 |
| 7. There is shorter rainfall episode than previous years | 1 | 2 | 3 | 4 | 5 |
| 8. There is increased risk of flooding during rainfall | 1 | 2 | 3 | 4 | 5 |
| 9. Crop productivity has reduced | 1 | 2 | 3 | 4 | 5 |
| 10. There is stress on water resources | 1 | 2 | 3 | 4 | 5 |
| 11. There is increased water demand for irrigation and domestic use | 1 | 2 | 3 | 4 | 5 |

**Suggest ways in which the rainfall pattern can be tamed or adopted for the benefit of the local people.**

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Thank you for your co-operation.

# APPENDIX B

## INTERVIEW GUIDE

This interview guide is to elicit information from leaders of farming groups in the Zosali community on the research topic, **"Perceptions of farmers on the changing rainfall pattern in the zosali community".** The views expressed by participants in this in-depth interview are solely for the purpose of this study.

### Background information

1. What role do you play as a leader and a farmer in this community?
2. How long have you been in this community?
3. What type of farming do you do?
4. What type of farmers do you represent?

### Perceptions and beliefs of farmers with respect to rainfall

5. Please, tell me what you understand about how rainfall occurs.
6. Do you think that there are some spirits or gods behind what happens before rain falls? Please explain why you think so.
7. If there is no rain, do you think humans can do something to help for the rains to come? Please tell me why or why not.
8. Do you think we can obtain direction from spiritual people to cause the rains to come? Please explain how.
9. Do you think that human interventions can change the pattern of rainfall? Please explain how. Use examples such as bush burning, felling of trees, removal of vegetation cover, etc.
10. How do you think the rainfall pattern has changed over the long period you have been in this community?
11. What methods are often used in preparing your land for cultivation in this community?

### Relationship between beliefs and rainfall experience

12. How would you describe the pattern of rainfall in this community? Does it rain often nowadays? Is it very intense?
13. How would you describe the weather condition in recent times? Is it getting colder or hotter?
14. How has the rainfall pattern impacted on your farming activities in the community?
15. Would you say that your experience with rainfall depends on how you have believed in the spirits or gods (supernatural) to cause rainfall? Why do you say that?

**Suggestions for improved rainfall experience in the community**

16. What do you think can be done to improve upon rainfall experience in the community?