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TOPIC:

RICE FARMERS’ ADAPTATION TO SALINE-WATER INTRUSION ON SWAMP RICE-GROWING FIELDS IN LOWER RIVER REGION OF THE GAMBIA

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ABSTRACT

Saline-water intrusion, one of the risks emanating from worsening climatic variations and climate change induced-sea-level rise poses serious threats to vulnerable peoples and livelihoods. Little information is available on how this specific climate hazard impacts people's livelihoods in lowlands located along River Gambia and how farmers adapt to it. This study aimed to investigate rice farmers' adaptation to saline-water intrusion on swamp rice-growing fields in Lower River Region of The Gambia. The research analyzed climate data and rice production of the region by employing trend analysis and correlation methods using Mann Kendall statistical test. The analysis confirmed that climate variability likely threatens swamp rice production in the region. To examine knowledge and farmers' adaptive strategies, 20 villages practicing swamp rice farming were randomly selected in the Region. Data were collected from 240 farmer household heads selected through a multi-stage sampling technique and 20 focus group discussions. Descriptive statistics in SPSS Software Version 23 were, therefore, used to analyse the data obtained from the selected households. The findings revealed that majority (96%) of the farmers were aware of saline-water intrusion and (>77.5%) perceived an increasing trend of salinity and its impacts on their yields over the last 5-year. A majority of 95.4% ascertained that saline-water intrusion reduced their rice yields and 85.8% affirmed its reduction impacts on their incomes. A majority of (76.70%) of respondents' rice farmers declared have employed adaptive measures which included on-farm and off-farm measures. Identified factors influencing the choice of adaption using a binary logistic regression model with the aid of STATA Software Version 13, revealed that non-educated farmers and small household size farmers were more likely to adapt to saline-water. Access to extension services significantly promotes adaptation. The FGD technic helped to identify most affected villages in the study area among which Kundung Numu Kunda, Karantaba, Kanikunda, Tembeto, and Marikoto. Challenges farmers faced in adapting to saline-water included basically poor access to adaptation information, low extension services, limited access to improved crop varieties, and high cost of farm inputs. The study recommends training for extension agents and farmers on saline-water intrusion adaptation and dissemination of climate and saline-water intrusion information through farmer to farmer, radio and extension services. Also, stakeholders and Government have to provide saline tolerant, early maturing and high yielding rice cultivars to the farmers and enhance water and soil conservation structures in the area. In addition, livelihood diversification programmes should be directed to the most affected communities by saline-water intrusion.

Keywords

Adaptation, Binary Logistic Model, Climate Variability, Lower River Region, Saline-water intrusion, Sea-level rise

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DEDICATION

To

- Almighty God
- My parents
- My sources of inspiration

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LIST OF ABBREVIATIONS

AfDB: Africa Development Bank

ANR: Agriculture and Natural Resources

asl: above sea-level

CBO: Community Based-Organization

FASDEP: Food and Agriculture Development Project

FGD: Focus Group Discussion

GALDEP: The Gambia Lowland Development Project

GBoS: Gambia Bureau of Statistics

GDP: Gross Domestic Product

GNAIP: Gambia National Agricultural Investment Plan

GTZ: German Organisation for Technical Cooperation

IFAD: International Fund for Agricultural Development

IPCC: Intergovernmental Panel on Climate Change

LADEP: Lowland Agricultural Development Programme

LGA: Local Government Authority

LRR: Lower River region

NAPA: National Adaptation Plan of Action

NEMA: National Agricultural Land and Water Management Development Project

NGO: Non-Governmental Organization

NRDS: National Rice Development Strategy

NWSRS: National Water Sector Reform Studies for The Gambia

PAGE: Programme for Accelerated Growth and Employment

PIWAMP: Participatory Integrated Watershed Management Project

SLR: Sea-Level Rise

SPCR: Gambia Strategic Programme on Climate Resilience

SSA: sub-Sahara Africa

SPSS: Statistical Package for Social Sciences

SWCP: Soil and Water Conservation Project

SWMP: Soil and Water Management Project

UNECA: United Nations Economic Commission for Africa

UNEP: United Nations Environment Programme

USAID: United States Agency for International Development

1. CHAPTER ONE: INTRODUCTION

1.1. Background of the study

Changes in the global climate comprise generally, variations in weather patterns over an extended period of times. Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer (IPCC, 2013). According to the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5), the global surface mean temperature has risen by 0.85˚C during the 1880-2012 periods, which is likely due to the observed increase in anthropogenic greenhouse gas concentrations (IPCC, 2013). Greenhouse gases contributed to the global mean surface warming (95% plus confidence) within the range of 0.5˚C - 1.3˚C over the 1951-2010 period with an increased risk of drought and an increased intensity of storms, such as tropical cyclones with higher wind speed, sea-level rise and floods in coastal areas (IPCC, 2013). Since the 1970s, droughts and SLR impacts on freshwater resources and ecosystems have become more common, especially in the tropics and sub-tropics, causing saline-water intrusion and altering the composition of ecosystems valuable to human survival (Alavian *et al.*, 2009). The severity of saline-water intrusion will vary significantly with location, being most problematic for small islands with limited areas of agriculturally productive land. In addition, sea-level rise is projected to extend areas of salinization of groundwater and estuaries, resulting in a decrease of freshwater availability for humans and ecosystems in coastal areas (Alavian *et al.*, 2009). The problem is expected to be more severe in Africa, where current information is the poorest, technological change the slowest, and the domestic economies depend heavily on agriculture (Mendelsohn *et al.*, 2000).

Agriculture is considered the most important sector in sub-Sahara Africa (SSA) and is projected to be hit the hardest by climate change and associated hazards. As the most significant environmental threat of the 21st century, climate change has been predicted to decrease agricultural productivity by as much 20% in Africa, Asia and Latin America (Adhikari, *et al*, 2015; Fargione *et al*, 2008; Komba & Muchapondwa, 2015). In most countries where agricultural productivity is already low and the means of coping with adverse events are limited, climate change and variability impacts are expected to reduce productivity to even lower levels and make production more erratic.

Most African countries are not well prepared to deal with the negative impacts to be expected as a result of climate change and are therefore most vulnerable to its consequences, and a country like The Gambia is of no exception. Gambia's HDI value for 2015 is 0.452—which put the country in the low human development category—positioning it at 173 out of 188 countries and territories. The economy of The Gambia is mainly dependent on rain-fed agriculture and on services; and exogenous factors such as climate change endanger economic stability in the country (UNECA, 2017). In addition, the geographical position of The Gambia predisposes it to drought, windstorms, coastal erosion and sea-level rise (FASDEP, 2013); owing to this fact, The Gambia is threatened by saline-water intrusion and a decrease in rainfalls.

River cities close to coasts tend to be influenced by coastal waterways and the tidal influence may extend for many kilometers upland, which is the case of River Gambia with a tidal excursion of 526 km (Tularam & Singh, 2009); the second highest tidal excursion in the world after the Amazon River in Brazil (735 km). Generally, saline-water intrusion makes the river water unfit for human consumption and affects adoption of irrigation practices (Abdullah, 2017; Al-tawash *et al.*, 2013).

Saline-water intrusion leads generally to soil salinization. Soil salinization is a common problem in areas with low rainfalls. When combined with poor irrigation and inappropriate drainage it can lead to permanent soil fertility loss. This type of salinity is a common factor of many drought-induced humanitarian crises (FAO, 2005.). In The Gambia's case, with projected climate change, the saline-water front (interface Atlantic Ocean/River Gambia) is expected to move upstream, thus reducing land availability and suitability for irrigation. Salinity is a major problem for rice production in The Gambia and it is affecting the farmers especially, those who are in lowland areas (Drammeh, 2015). Therefore, lowlands located in the middle reaches of River Gambia are at risk to saline-water intrusion, including flood or tidal plains well-known for rice farming (Webb, 1992). Additionally, the disappearance of freshwater swamps and soil salinization in lowland areas resulting from sea-level rise is likely to impact negatively rice production and the lives of women farmers in these areas (NAPA, 2007).

Rice is the staple food of the country and accounts for 25%-35% of total cereal production of the country (Fatajo, 2009) with agriculture accounting for 20% of GDP (GBoS, 2017) and 75% of the country's labor force (NPC, 2009). Rice is rated as an especially salt-sensitive crop (Mass and Hoffman, 1977; Shannon et al. 1998). Salinity is one of the major obstacles to increasing production in rice-growing areas worldwide (Zeng & Shannon, 1998) hence The Gambia's food security could be under threat.

Based on recent studies and model projections by the year 2100, a 1.2 meters rise in sea-level will mean the total flooding and loss of the capital city of Banjul (Jallow *et al.*, 1996). In addition, according to UNEP, The Gambia is among the top ten (10) most vulnerable countries to coastal erosion and sea-level rise due to its low lying nature. The problem, therefore, would become more severe and unpredictable in the future driven by extreme weather events, River Gambia's flow alteration, and sea-level rise (SPCR, 2017; Ervine *et al*, 2007; NAPA, 2007; Njie, 2002). In the face of these projections, more studies are needed for preventive and adaptive measures for an efficient resilience to climate change-associated risks such as saline-water intrusion which is already threatening food security and aggravating vulnerability of poor-resourced rice farmers. Consequently, the increased salinization exacerbated by unfavorable climatic conditions and projected sea-level rise will require farmers depending largely on the river for tidal rice irrigation production to improve their capacities to adopt improved climate change-induced saline-water intrusion adaptation measures.

The table 1 below illustrates projected sea-level rise for all the LGAs of the country with especially LRR, being among the vast rice swamping areas projected to be severely affected by SLR in the country (93 km^2, 154 km^2 and 197 km^2 under saline-water intrusion for projected SLR of 0 cm, 50 cm and 100 cm respectively).

Table 1: Area at or below SLR scenarios within LGA across the country

LGA	Total Area (km^2)	SLR 0 cm	SLR 50 cm	SLR 100 cm
Banjul	11	5.7	6.5	7
Kanifing	8000	34.2	35	36
Brikama**	1763	184	219	240
Manasakonko*	1561	93	154	197
Kerewan**	2200	254	365	385
Kuntaur	1495	41	55	71
Janjanbureh	1466	51	86	124
Basse	2046	9	10	10

Source: DEM and administrative boundary data- The Gambia 50000 GIS Database 2001. Department of States for Local Government and Lands *in* (NAPA, 2007)

*Headquarters of LRR (Rice is the major crop cultivated in LRR)

** swamp rice cultivation not the major crop cultivated in the region

1.2. Problem Statement

In The Gambia, frequent droughts result in significant loss to agriculture and allied sectors (Yaffa, 2013). Moreover, saline-water intrusion along the length of the river due to drought or sea-level rise could render most areas unproductive for rice irrigation (Fatajo, 2009). Consequently, many hectares of swamp rice farms have become unproductive or abandoned because of their high content in salinity resulting from low river flows and saline front moving into the middles reaches of the river (Webb, 1992), including Lower River Region. Any severe decline in the production of rice, the major basic food of the country (the auto-consumption of which is about 60-70%) will have a serious impact on the food security level of rural households and even those in the urban areas (Fatajo, 2009). Thus rice farmers' adaptive capacity may be affected by new circumstances of changes in rainfalls pattern and ecosystems that they were used to. In some cases, people might push into extreme poverty or fall back into poverty if they are not adequately prepared to face these impacts (Thi, 2016). Therefore, looking at the adaptive capacities of the rice farmers in this Region is essential in terms of adopting new technologies to combat saline-water intrusion in their rice-growing ecologies.

1.3. Justification of the study

The Gambia relies on its major surface freshwater, which is River Gambia, for agricultural irrigation. The decreasing trend of rainfalls associated with saline-water intrusion over the past years has led to a decrease in overall agricultural production (NAPA, 2007; NRDS, 2014). Owing to this fact, Lower River Region's rice-growing areas might be at risk of low production and food insecurity. According to Webb (1992), 1986 was the year where a decrease in rice production began to be felt in the Region. Moreover, from 2001 to 2010, the total national area under rice cultivation is increasing whilst the production is declining particularly in the lowlands (NRDS, 2014). Despite all these prejudicial facts, there is lack of empirical and social studies on risk related to saline-water intrusion which led to unproductive lands in the country.

Additionally, previous studies conducted have not fully investigated the relationship between low rainfalls induced saline-water intrusion and rice production in areas prone to saline-water intrusion phenomenon, mostly located in the lowest reaches of the middle zone of the river, including LRR. Furthermore, there appears to be limited information up to date in the literature on adaptation to saline-water intrusion. Siegele (2012) stated that as some of the potentially greatest loss and damage is expected to come from slow-onset hazards, there is an urgent need to identify effective approaches to manage them. For IPCC (2013) , climate-resilient pathways are the way forward in adapting to climate related risks and hazards. And to do so, it is essential to document how farmers adapt their farming practices in relation to the continuous and sudden changes in climatic events and identify what are the important socio-economic and institutional factors that contribute (or hinder) their adaptation (Uddin *et al*, 2014).

On the other hand, it is proven that increasing climate variability and change may increase saline-water intrusion in swamp rice-growing fields (FASDEP, 2013; Drammeh, 2013; Fatajo, 2009; Ervine et al, 2007) hence inducing low rice productivity, food insecurity and aggravates adaptive capacity of poor rural communities, dependent mostly on river provisions for livelihoods production. This situation has been already pointed out by Webb (1992). Analyses from 1943 to 1983 of climate parameters of the country depicted an increase of 1° C in the annual mean temperature and 20% to 25% reduction in the annual mean rainfall from 1943-2013 (AGRER, 2017). Therefore, under such conditions of climate variability and change, impacts on rain-fed and subsistence agriculture predominant in the country will cause detrimental consequences on crop production, including rice production, importantly swamp rice growing-fields threatened by increased salinity.

Cognizant of the fact that rice is the staple food in the country, the need arises to examine the phenomenon and provide pathways for solutions. Agricultural researchers, technicians, extension agents, and policymakers need to understand key factors such as trend of climate parameters and saline-water intrusion, information on current adaptive measures, possible disastrous effects of saline-water intrusion on agriculture in streaming or/and integrating mechanisms, and the implementation of programmes and projects at local scale to introduce and promote adoption of climate change adaptation measures to enhance resilience of rice farmers to the impacts of climate change associated hazards.

The proposed research may, therefore, go along in providing novel findings which will help to stir further investigation to gain deeper insights into related research in the future.

1.4. Purpose and Scope of the study

The study intends:

1. To fill specific knowledge gaps on rice farmers' adaptive responses to saline-water intrusion in the literature for The Gambia.
2. To inform policy and decision makers on rice farmers' adaptive responses and capacity to saline-water intrusion in the study area in the context of climate variability and change so as to know priority areas of action for adaptation, enhance smart policy design and implementation.
3. To contribute to enhancing rice farmers' resilience to the negative impacts of saline-water intrusion in Lower River Region and The Gambia as a whole and enhancing food security.

The study involves some analysis of climate impacts on rice production and rice farmers' adaptive responses, as well as factors influencing adaptation in the Lower River Region of The Gambia.

1.5. Objectives of the study

Specifically, the study will endeavor to achieve the following objectives:

1. To investigate temporal trends of and correlation between annual rainfall, temperature and rice production in the study area.
2. To understand the level of knowledge of rice farmers on saline-water intrusion.
3. To examine rice farmer's adaptive responses or strategies to saline-water intrusion and land use practices.
4. To examine factors affecting the adaptive responses of rice farmers to saline-water intrusion in the study area.
5. To identify most affected villages in the study area

1.6. Research Questions

The study in an attempt to assess rice farmers' responses to climate change induced saline-water intrusion will look at the following research questions:

1. How climate variability and change impact swamp rice production and land cover in the study area?
2. What is the awareness/knowledge of rice farmers of Lower River Region on saline-water intrusion?
3. How swamp rice farmers respond/adapt to the impacts of saline-water intrusion?
4. What factors influence rice farmers' adaptive responses to saline–water intrusion?
5. What are the most affected villages in the study area

1.7. Limitations of the study

The non-availability of data on soil and water salinity limits the study in quantifying salinity and depicting the real trend of salinity based on quantitative data in the study area. However, the study had the credit to rely on the literature and grassroots people to give detailed insights on the current status and trend of saline-water intrusion over past years in the study area based on their past and current experiences.

Furthermore, the language for communication was a barrier in conducting the research. However, the use of trained questionnaire enumerators, conversant with the language of their best understanding helped in minimizing such challenge. Moreover, tape-recording during FGDs was employed to counteract and mitigate biases in the interpretation of respondents' answers from the local languages to the English Language.

The Research Team had to replace farmers that were unavailable during data collection by their daughters involved in farming activities. This constraint could also limit in getting the full impacts and realities farmers lived with. Conversely, the use of the daughter (of 18 years and above) who used to farm with her mother helped in minimizing biases in the respondents' answers.

1.8. Structure of the study

This thesis report consists of four further parts. The second part provides a conceptual framework and literature review of the research concepts. The third part of the report highlights the methodology used to carry out the research. The fourth part provides results. Finally, the fifth part summarises the conclusions drawn from the research and provides recommendations. Additional information is presented in appendices.

2. CHAPTER TWO: LITERATURE REVIEW

2.1. Conceptual Framework

The Intergovernmental Panel on Climate Change (IPCC, 2013) defines climate change as a change in the state of the climate that can be identified, using statistical tests, by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It brings alterations in weather patterns (rainfalls, temperatures, etc.) that can have serious repercussions on biophysical and human systems by modifying seasonal cycles, harming ecosystems and water supply, impacting agricultural farming systems and food production, causing sea-levels to rise and its associated hazards, including saline-water intrusion. Saline-water intrusion is identified as a slow-onset hazard meaning it relates to incremental and cumulative environmental changes that emerge gradually over time, often based on a confluence of different events (Grasso & Singh, 2009; Adamo, 2011). Saline-water intrusion is defined as the migration of saltwater into freshwater aquifers (Baskaran *et al.*, 2016). Slow-onset events adversely affect agriculture by overall decrease in productivity, and loss of space (land, water, forest, etc.) for agricultural activities, which can drive out people who rely on it (FAO, 2016a, b).

Agriculture is extremely vulnerable to climate change (IPCC, 2001) and importantly its associated hazards. Adaptation is generally accepted as a key component of any strategy or policy response to climate change besides mitigation. Subsequently, it is a way of reducing vulnerability, increasing resilience, moderating the risk of climate impacts on lives and livelihoods, and taking advantage of opportunities posed by actual or expected climate change (Acquah-de Graft & Onumah, 2011). Thereupon, farmers have adapted to a certain amount of climate variability, but climate change may well force large regions of marginal agriculture out of production in Africa. This means that climate related hazards; particularly saline-water intrusion, for instance, will put more stress on agriculture in coastal and low-lying areas.

To cope with and to adapt to changes people usually establish coping/adaptation strategies that are ways in which local individuals, households, and communities have changed their mix of productive activities, and modified their community rules and institutions in response to vulnerabilities, in order to meet their livelihood needs (Rennie & Singh, 1996 *in* Schipper & Burton, 2009). It is noted that individual adaptation is different from government adaptation; however they are not independent of each other – they are embedded in governance processes that reflect the relationship between individuals, their capabilities and social capital, and the government (Adger & Vincent, 2005). That is why many authors conclude that an effective adaptation process would focus on the entire system rather than simply those components of the system, involve many aspects (physical, social, cultural, economic, and political environments) instead of single one (Turner *et al*., 2003; Brooks & Adger, 2004; Schipper, 2007). Therefore, Birkmann (2011) underscores that actual and potential limits of adaptation of different communities and groups need to be considered when dealing with adaptation strategies because the ability of various social groups and different coupled social-ecological systems to adapt successfully is socially differentiated.

The conceptual framework of this study is that agricultural technology adoption, climate change adaptation methods and other related models involve decisions on whether to adopt or not. Former studies have observed that agricultural technology adoption models are based on farmers' utility or profit maximizing behaviors (Norris & Batie, 1987; Pryanishnikov & Katarina, 2003). Probit and logit models are the most commonly used models in agricultural technology adoption research (Hausman & Wise, 1978; Wu & Babcock, 1998). Binary probit or logit models are employed when the number of choices available is two (whether to adopt or not). Extensions of these models, most often referred to as multivariate models are employed when the number of choices available is more than two. The most commonly cited multivariate choice models in unordered choices are multinomial logit (MNL) and multinomial probit (MNP) models. Multivariate choice models have advantages over their counterparts of binomial logit and probit models in two aspects (Wu and Babcock, 1998). First, they allow exploring both factors conditioning specific choices or combination of choices and second, they take care of self-selection and interactions between alternatives. These models have also been employed in climate change studies because of conceptual similarities with agricultural technology adoption studies. For example, Nhemachena and Hassan (2007) employed the multivariate probit model to analyze factors influencing the choice of climate change adaptation options in Southern Africa. Kurukulasuriya and Mendelsohn (2006) employed the multinomial logit model to see if crop choice by farmers is climate sensitive. Similarly, Seo and Mendelsohn (2006) used the multinomial logit model to analyse how livestock species choice is climate sensitive. Furthermore, Deressa et al. (2009) adopted the multinomial logit model to analyse factors affecting the choice of adaptation methods in the Nile basin of Ethiopia. In William and Stan (2003) study, the first stage is the analysis of factors affecting the awareness of new agricultural technologies and the second stage is the adoption of the new technologies. Similarly, Yirga (2007) and Kaliba et al. (2000) employed Heckman's selection model to analyse the two-step processes of agricultural technology adoption and the intensity of agricultural input use. The conceptual framework (Figure 1) on adaptation to saline-water intrusion have been linked to the independent variables of access to information, farmers' demographics, size of the farm, and farmers' level of education, although, other factors related to the study for example attitude, government policy and financial ability also may influence adaptation.

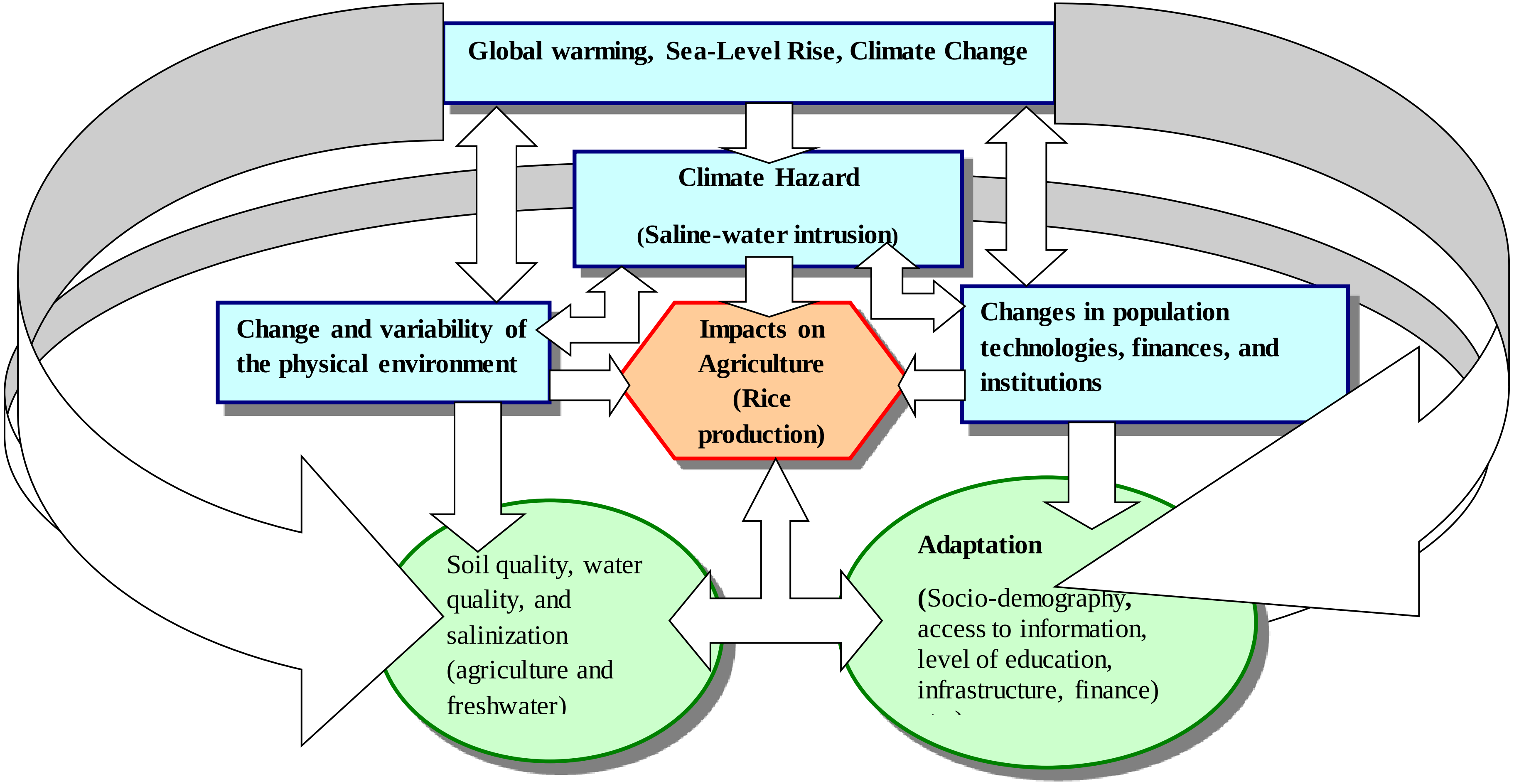

Figure 1: Conceptual framework for saline-water intrusion adaptation
Source: Adapted from Agnew and Clare Goodess (2017)

2.2. Literature Review

2.2.1. Overview of Global Climate Change, Sea-Level Rise and Saline-water Intrusion

Several scientific studies have confirmed that seas' levels are rising with climate change. Relationships between climate change and sea-level rise have been established by scientists and researchers' communities.

Global-mean sea-level rise is one of the most certain impacts of global warming and climate change which is projected to occur in many parts of the globe, especially in the coastal zones. The Intergovernmental Panel on Climate Change (IPCC) in its Fifth Assessment Report (2014) highlighted that the rate of Sea-Level Rise since the mid-19th century has been larger than the mean rate during the previous two millennia (high confidence). Over the period 1901-2010, global mean sea-level rose by 0.19 (0.17 to 0.21cm) (IPCC, 2014). The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea-level has risen and the concentrations of greenhouse gases have increased (IPCC, 2014). Ice sheets and glaciers are melting under a global warming climate and runoff into seas and oceans. Moreover, freshwater resources could be affected both qualitatively and quantitatively as a result of sea level rise, global warming and changes in rainfall patterns. Climate change as resulting from warmer temperatures affects water resources, including oceans by different processes. First, warmer oceans would expand; and secondly, melting ice sheets and glaciers would add to the total volume of water in the oceans (Theon, 1993). In addition, the rise in temperatures may lead to a series of depressions in atmospheric pressure that can cause a considerable rise in water levels in shallow ocean basins, according to Theon (1993). With a one millibar decrease in atmospheric pressure, the sea-level rises by 10 millimeters (Sherif & Singh, 1999).

Thereupon, several studies have also been conducted showing the evidence of the existing link between sea-level rise and saline-water Intrusion.

Anticipated impacts of climate-induced sea-level rise are: direct inundation (or submergence) of low-lying wetland and dryland areas, erosion of soft shores by increasing offshore loss of sediment, increasing salinity of estuaries and aquifers, raised water tables and exacerbated coastal flooding, storm intensity and storm damage (IPCC, 2007). Same results were found in Nicholls (2003) where sea-level rise is found to result in a range of impacts, including (1) increased flood risk and submergence, (2) salinization of surface and ground waters, and (3) morphological change, such as erosion and wetland loss. Furthermore, it has been indicated in the literature that many coastal areas in the world are threatened by or at risk of saline-water intrusion into freshwaters, groundwater, estuaries, and lowlands. Areas such as Atlantic Canada, Clyde in Glasgow, the Vietnamese Mekong Delta, Bangladesh, Malaysian estuaries, Brisbane in Australia, the Nile Delta, Senegal, and The Gambia (all these latters three in Africa) (Gisen, *et al*, 2015; Catto, 2010; Tularam *et al*., 2009, Ervine *et al*, 2007; Nicholls, 2003) are amongst areas of growing salinization in the world. On the basis of modeling studies, Sherif and Singh (1999) conclude that a 50 cm increase in sea-level in the Mediterranean will cause an additional intrusion of saline water of some 9 km in the Nile Delta, while a similar rise in the Bay of Bengal would cause an additional intrusion of 0.4 km.

The phenomenon of salinization of freshwaters has originated and being aggravated under the condition of low river water runoff and hot weather, intense evaporation (Mikhailov & Isupova, 2008). Moreover, Leatherman (1989) and Kana *et al*., (1984) *in* Neumann *et al*, (2000) indicated that one of the major physical impacts of sea-level rise includes an increased salinity in estuaries, marshes, coastal rivers, and coastal aquifers.

According to the Intergovernmental Panel on Climate Change report, the Mekong Delta of Vietnam, which produces nearly half of the country's rice, is forecasted to be one of three deltas that are most vulnerable to sea-level rise (Thi, 2016). According to IPCC, Bangladesh is slated to lose the largest amount of cultivated land globally due to rising sea-level. A 1 m rise in sea-level would inundate 20 per cent of the country’s landmass. In the country, prolonged inundation, increased drought, salinity and loss of land due to erosion are the enhanced risks that agriculture is facing due to climate change. With the sea water rise, as predicted by the researchers, Bangladesh may lose a major portion of her coastal areas to sea. This will definitely cause fresh lands under salinity as a result of tidal surge and salinity intrusion.

For the Gambia’s case, accelerated rates of sea-level could cause inundation of low-lying lands, saline-water intrusion into groundwater and streams, increased extent and severity of storm flooding, and coastal erosion (Drammeh, 2013). Additionally, the distance tidal salinity penetrates inland depends on the balance between freshwater flow and the tidal influence (NWSRS, 2014). Whenever the freshwater flow component is reduced by upstream extractions or by low flow conditions, saline-water front migrates upland potentially damaging useable land particularly, wetlands used for swamp rice farming in The Gambia.

2.2.2. Potential impacts of saline-water intrusion

SLR will have significant impacts on a number of marine and terrestrial ecosystems, many of which are already threatened by human activities (Jackson *et al.,* 2001 *in* Brooks *et al*, 2006). SLR may, therefore, compromise existing coastal lake ecosystems, including water, land, and people source of livelihoods (of which agriculture constitutes one of the majors) via increases in the frequency and severity of saline-water intrusion (Brooks *et al*, 2006).

2.2.2.1. Impacts on water resources

Previous studies have not yet established the extent of saline-water intrusion and its impacts on River Gambia. However, it is widely recognized that the extent of saline-water intrusion in River Gambia is mainly governed by the balance of outward advective transport by freshwater and inward dispersive salt transport from Atlantic side, extended with the rainfall rate, which accounts for the local rainfall and evaporation (Verkerk and Van Rens, 2005). The great degree of seasonality in the river flows also makes it vulnerable as a freshwater supply. Increasing vulnerability due to reducing rainfall-runoff is estimated at a 30% reduction in rainfall over the past 30 years (Ervine *et al.*, 2007). This is combined with a major vulnerability to rising sea levels and storm surges leaving the capital Banjul as one of the most climate-change threatened cities of the world (Njie, 2002)

Few studies on water quality have revealed an increase in the salinity of the river. In Healey (2014), it is indicated an alarming increase in values of river water conductivity during the dry season. Though the study did not give the status of the river in the wet season, these results confirmed that saline-water intrusion affects the water quality of the river. This could result in disturbance of the river ecological balance including fisheries with all micro-ecosystems depending on the river.

According to NWSRS (2014) during the rainy season, salts are leached down and thus may affect the groundwater quality, and soils remain saline during dry months. Therefore, from October to May salinity is at high peak with the fresh and saline-water interface at Kuntaur. Moreover, due to salinity, all along River Gambia valley, and around its tributaries, as far upstream as Janjangbureh, surface water cannot be used as a source for a sustainable water supply and irrigation as well (NWSRS, 2014). As an illustration, surface water samples taken from River Gambia indicated approximately 25-35‰ and 0.8-25 ‰ in West Coast

Region and North Bank, respectively. The high salt content in West Coast Region could be explained by its closeness to the Atlantic Ocean.

2.2.2.2. Impacts on Soil quality

Most of the soils have become more saline over the past years reducing, therefore, cultivable lands as a result of saline-water intrusion.

In Bangladesh, for instance, soil salinity is only observed along the coastal belt where tidal flooding during wet season (June-October), direct inundation by saline or brackish water and upward or lateral movement of saline groundwater during dry season (Nov-Jan.) are the causes of soil salinity development. Bangladesh has a coastal area of 2.5 million ha of which about 0.83 million ha, along the coastal belt, are under salinity of different magnitudes (Harun-ur-Rashid & Islam, 2007).

In The Gambia, a lot of lands ever affected in the mid-1900s have been abandoned by rice farmers (Webb, 1992). They are no longer utilized for crop production, mostly due to increased soil salinity. Increased soil salinity limits the growth of standing crops and affects overall crop production, and also makes the soil unsuitable for many potential crops (Haider & Hossain, 2014). Small island states are also particularly vulnerable to salinization due to their limited arable land, with implications for both export earnings and food security (Tompkins, 2005 *in* Brooks *et al*, 2006)).

Back to The Gambia, the intrusion of saline-water into River Gambia system and tidal flooding of the floodplains results in a gradually increasing salinity of the soils and the potential formation of acid sulfate conditions (NWSRS, 2014).

2.2.2.3. Impacts on Agricultural production and food security

Proofs exist that increased salinity has detrimental impacts on crops by limiting the productivity of agricultural crops. Generally known, most crops are sensitive to salinity caused by high concentration of salts in the water and the soil. Rice plants are relatively susceptible to soil salinity as abiotic stress, and sodium chloride (NaCl) is a major salt that causes this problem (Flowers, 2004; Gao *et al*., 2007). Salinity affects a broad range of metabolic processes in plants and induces changes in contents and activities of many enzymes (Amirjani, 2012).

Saline-water intrusion defined as slow-onset hazard has been reported to be one of the causes of loss and damage around the globe. For instance, in Bangladesh, salinity had induced loss and damage to farming households in coastal Bangladesh (Rabbani *et al*, 2013). A recent report shows that more than 1 million hectares of arable land in Bangladesh are affected by salinity intrusion caused by slow- and rapid-onset events (SRDI, 2010). The country is one of the critical saline-water intrusion prone areas in the world. Huq and Ayers (2008) in their work reported that the country may lose 0.2 million tons of crops to saline-water intrusion in a moderate climate scenario, but that this might be more than double in a severe climate scenario. This shows the negative impacts of saline-water intrusion on the rice production of the country.

Furthermore, saline-water intrusion as a result of sea-level rise impacts negatively agricultural land use and land cover of countries. The saline area in the world is three times larger than land used for agriculture (Binzel & Reuveni, 1994). Total of the saline area is about 953 million hectares covering about 8% of the land surface (Szabolcs, 1979; Singh, 2009). The global extent of primary salt-affected soils is about 955 M ha, while secondary salinization affected some 77 M ha, with 50% of these in irrigated areas (Metternichi &

Zinck, 2003). For instance, Rabbani *et al* (2013) in their work on coastal Bangladesh found that almost all saline-free and low-salinity farmland has turned into medium or high-salinity farmland, which has a severe impact on agricultural productivity.

Moreover, a high salt content of irrigation water can affect crops as salts accumulate near the roots (Colorado State University, 2014). Consequently, households lose their crops. In Rabbani *et al* (2013), it was found that households in the Ramjannagar Union (Tengrakhali and Patarakhola villages) experience slightly more food shortages.

According to The Gambia Department of Agriculture (2005), further temperature and rainfall changes will have significant effects on local people. The very fact that The Gambia is one of the top ten countries in the world with the uppermost share of the population living within lower elevation coastal zone (Bakurin *et al*., 2010) complexes this issue further.

Tidal action from the sea results in backwater along the estuarine reach of River Gambia and its tributaries, bringing saline-water up to Kuntaur (254 km from mouth of estuary) during the dry season (NWSRS, 2014). Rice crops, grown in the upper reaches of River Gambia, cannot grow in areas reached by saline-water (Carney, 1998). The high salt content in the farming environment increases the cost of production of poor farmers. Therefore, farmers are obliged to make more investments to control the salinity through the construction of anti-salt edifices with all the cost involved such as purchasing of materials, payment of labour force. Moreover, there are other serious impacts of salinity on people livelihoods and stability of communities. Thereupon, soil salinity has emerged as a problem which is not only reducing the agricultural productivity (Ali, 2006; Battacharya *et al*., 1999; Sarwar & Khan, 2007; Singh & Singh, 1995) but also putting far-reaching impacts on livelihood strategies of farmers.

According to Fatajo (2009), rice (*Oryza sativa, L*) accounts for 56 % of the cultivated land in The Gambia. The country's consumption requirement is 160,000 metric tonnes per year, of which only about 7,400 metric tonnes of clean rice is produced locally. Thus, the country only produces 4.6% of its annual requirements. It is proven that over 70% of the imported food stuff in the country can be produced locally with better planning and support services (PAGE, 2011).

Nevertheless, saline-water intrusion in the productive rice-growing areas along River Gambia and accompanying creeks are currently plummeting productivity or leading to the withdrawal of cultivation from affected areas. Thus saline-water intrusion tends to reduce the availability of land for rice cultivation by diminishing land fertility and suitability (Fatajo, 2009). Furthermore, it is established an increased drop in harvests over the past years.

Moreover, the estimated total cost of sea-level rise for The Gambia, joining costs of land loss, forced migration, salinization, sea floods and river floods are projected to be US$71.9 million per year for 2050 and US$313.4 million per year for 2100 (Brown *et al*. 2011). Interventions (and complementary actions such as the work through GNAIP) are in search of improving low-land rice growing by supporting the construction of water retention, anti-saline and flood protection dikes, installation of tidal gates and other flow control structures.

This has had huge implications on the amount of imported rice in the country. Prior to the 1970s, local production met the rural requirement and the market for imported rice was restricted mainly to the urban areas. However, the Sahelian droughts of the 1970-1980s disrupted this equilibrium by significantly affecting rice-growing fields in the lowlands, causing salinization and crop failure which resulted in a drastic decline in local rice production putting significant demand on imported rice (NRDS, 2014).

2.2.3. Adaptation to salinity and its determining factors in the world and The Gambia

2.2.3.1. Adaptation to salinity and its determining factors in the world

Climate change will mean additional huge impacts on the life support system and the livelihoods of rural poor living in developing nations. Therefore, adaptation has been identified by the Intergovernmental Panel on Climate Change (IPCC) as one of the formidable responses to climate change. In addition, Fussel (2007) argues that emphasis should focus on adaptation because human activities have already influenced vagaries in climate fluctuation. Climate variability and change's manifestations, mostly hard to predict are likely to occur with more intensity and frequency. Countries depending largely on rain-fed agriculture may found their economy threatened by new circumstances, all driven by climate change. These circumstances could be issues related to extreme events such as sea-level rise, flooding, storm surges, droughts, saline-water intrusion, etc. However, adaptation, both local and national is undertaken to lessen or to take advantage of climate change. In the agricultural sector for instance, at the local level, farmers introduce new practices which most of the times are influenced by many factors. On the other hand, government, NGOs or private institutions practices national and long-term adaptation strategies.

Many studies have shown that farmers do perceive that climate is changing and have developed coping strategies to adapt or reduce the negative impacts of climate change on their farming operations (Deressa & Rashid, 2010; Mertz *et al*., 2009; David *et al*., 2007). Recent progress in literature has also indicated that a number of socio-economic characteristics such as age, gender, educational status, household size and farm characteristics such as the size of farmland and soil fertility influences farmers' decisions to respond to climate change (Di Falco *et al*, 2011; Deressa *et al*., 2009). Some attempts have been made to analyze factors influencing the choice of adaptation measures to climate change and how farmers adapt to climate change in Africa (Apata, 2011; Hassan & Nhemachena, 2008; Deressa & Hassan, 2009; Admassie & Adenew, 2007; Deressa *et al*., 2009). The studies of Deressa and Hassan (2009) and Apata *et al*. (2011) employed the Ricardian approach to estimate the monetary impact of climate change on agriculture. Even though the applied Ricardian approach includes adaptation, it does not explicitly address factors influencing the choice of adaptation and what adaptation methods they employ. Studies that have examined factors influencing the choice of adaptation measures to climate change and adaptation strategies in Africa, although informative, did not address the extent to which different socio-economic and environmental factors affect perceptions and adaptation on saline-water intrusion (Akter & Bennet, 2009; Niggol & Mendelsohn, 2008 and Agrawala & Frankhauler, 2008).

The empirical literature on adoption of technologies by farmers shows the relationships and directionality of factors on adaptation choice of farmers.

Household size has mixed impacts on farmers' adoption of agricultural technologies. Larger family size is expected to enable farmers to take up labour intensive adaptation measures (Nyangena, 2007; Dolisca et al., 2006; Anley, 2007; Birungi, 2007). Alternatively, a large family might be forced to divert part of its labor force into non-farm activities to generate more income and reduce consumption demands (Tizale, 2007).

Age's influence on adaptation choices has been varied in the literature. Some studies found that age had no influence on a farmer's decision to participate in forest and soil and water management activities (Thacher et al., 1997; Anim, 1999; Zhang & Flick, 2001; Bekele & Drake, 2003). Others, however, found that age is significantly and negatively related to farmers' decisions to adopt (Gould et al., 1989; Featherstone & Goodwin, 1993; Lapar &

Pandely, 1999; Burton *et al*., 1999; Dolisca *et al*., 2006; Nyangena, 2007; Anley *et a*l., 2007). However, Okeye (1998) and Bayard et al. (2007) found that age is positively related to the adoption of conservation measures.

Gender is an important variable affecting adoption decision at the farm level. Female farmers have been found to be more likely to adopt natural resource management and conservation practices (Newmark *et al.,* 1993; Burton *et al*., 1999; Dolisca *et al.,* 2006; Bayard *et al*., 2007). However, some studies found that household gender was not a significant factor influencing farmers' decisions to adopt conservation measures (Bekele & Drake, 2003).

Education and farming experience were found in the literature as important factors influencing adoption decisions. Several studies have shown that improving education and disseminating knowledge is an important policy measure for stimulating local participation in various development and natural resource management initiatives (Bultena & Hoiberg, 1983; Anderson & Thampallai, 1990; Shields *et al*., 1993; Heinen, 1996; Traoré *et al*., 1998; Higman *et al*., 1999; Anim, 1999; Lapar & Pandely, 1999; Glendinning *et al*., 2001; Dolisca *et al*., 2006; Anley *et al*., 2007; Tizale 2007). Better education and more farming experience improve awareness of potential benefits and willingness to participate in local natural resource management and conservation activities. However, Clay et al. (1998) found that education was an insignificant determinant of adoption decisions, while Okeye (1998) and Gould et al. (1989) found that education was negatively correlated with such decisions.

Extension services are an important source of information on agronomic practices as well as on climate. Extension education was found to be an important factor motivating increased intensity of use of specific soil and water conservation practices (Anderson & Thampallai, 1990; Traoré *et al*., 1998; De Harrera & Sain, 1999; Baidu-Forson, 1999; Bekele & Drake, 2003; Tizale, 2007).

Idrisa et al (2010) in their study on farmers' socio-economic and technological characteristic on soybean technology adoption in southern Borno state in Nigeria, using 360 respondents selected through multistage, purposive and random sampling techniques and analyzing data by logit model established that age influenced use of adaptation measures, the younger respondents used more adaptation measures compared to their older counterparts. Oyekale (2009) in the study of climate variability and its impacts on agricultural income and households' welfare in southern and northern Nigeria postulated that younger farmers had greater tendencies to improvise and opt new technologies because they are relatively knowledgeable, more open to risk taking and have longer planning horizons than their older counterparts.

If several attempts had been made in rain-fed agriculture (for upland farming in particular), adaptation to climate change in Africa, yet still very little has been done on the most vulnerable continent in term of saline-water intrusion phenomenon which is also induced by climate change. This is one of the research gaps that this study would like to address. However, studies in the world on salinity exist and had examined adaptation strategies with few addressing factors determining such adaptation strategies employed by farmers.

A case study on saline-water intrusion in Bangladesh **(**Mitin, 2009**)** showed that, to adapt to climate change the government seeks long-term measures with dike construction for defense against sea-level rise and flooding. This research had the shortcoming for not revealing farmers' adaptive measures employed in the country. A study conducted in Mexico by Eakin (2005) argues that institutional change such as economic restructuring influences the adaptive capacity of farmers and plays a more important role in determining farmer livelihood strategies than climate risk. Rabbani *et al* (2013) show that farming households in coastal Bangladesh have adopted non-field and field-based adaptation strategies to deal with saline-water intrusion. Field-based adaptation strategies aimed at reducing saline-water intrusion impacts on rice production whereas non-field-based strategies regroup livelihoods diversification measures. Field-based strategies include mainly the use of saline-resistant cultivars, reducing salinity by washing rice fields, adjusting irrigation practices and repairing or reconstructing irrigation channels. Non-field strategies include, among others: temporary migration for work, changing eating habits and lifestyles, switching to non-agricultural income-generation activities. Further, the study pointed out the difference in the effectiveness of adaptation between various communities in their responses to adapt to saline-water intrusion. Factors like lack of knowledge about salinity effects, lack of access to saline-resistant cultivars, poverty, etc are susceptible to hinder effective adaptation. This study has, therefore, come up with certain factors which could hinder adaptive responses of rural rice farmers in a developing country.

Adaptation is first and foremost local even though, climate change is a global cross-cutting issue which does not have boundaries. Salinity into rice fields has detrimental impacts on rice farmers' livelihoods. The Gambia rice sector is an example. However, adaptation measures have been employed to reduce farmers' vulnerability, strengthen their adaptive capacity and increase their resilience.

2.2.4. Adaptation to saline-water intrusion in The Gambia

There appears a lack of empirical knowledge and study on swamp rice farmers' adaptation in The Gambia. Most of the studies that dealt with saline-water intrusion in the country entailed dynamic of saline-water intrusion in River Gambia (Ervine *et al.*, 2007; Healey, 2014; Njie, 2002). On the other hand, saline-water intrusion adaptive measures have been mostly contained in agricultural projects in the country. These projects have been implemented and are mostly made up of hard technologies provided to the rural Gambian farmers. However, adaptation has the particularity to be site-specific and local people have their ways of coping or adapting to climate hazards. Thus, farmers of LRR could have their own means of adapting to saline-water intrusion. This motivates in carrying out this research. In the literature, there have been described a wide variety of adaptation options that have the potential to reduce the vulnerability of agricultural systems to risks related to climate change (Smit & Skinner, 2002; Nzuma *et al*, 2010, Ngigi, 2009; Field *et al*, 2014). Following the typology developed by Smit and Skinner (2002), adaptation options in agriculture can be classified into four main categories:

i) Technological developments: focusing on crop development, weather and climate risk information systems and resource management innovations. Some examples of technological development are introduction of new crop varieties to increase the tolerance to climatic stressors (i.e. temperature, salinity etc.), early warning systems, water management innovations including soil and water control structures, farm-level resource management innovations to address risks associated with climate change.

ii) Government programs and insurance: it involves agricultural subsidy and support program, private insurance and resource management programs, policy and programs implementation to influence the use of land and water resource and management practices.

For The Gambia, soil and water conservation (SWC) infrastructures were constructed since the foundation of the Soil and Water Management Project in 1978 which later became Soil and Water Management Services (SWMS). SWMS has been active in addressing the problems of soil degradation in The Gambia (Trawally, 2015). Here, farmers provide the required labour force for soil conservation activities while SWMS offers materials and technical know-how. The drawbacks registered were generally the smallness of dikes and spillways which do not last long. Other projects came in to construct bigger dikes and spillways without any labour contribution of the beneficiary communities. These projects include: Soil and Water Management Project (SWMP) - Sponsored by USAID and The Gambia Government, Soil and Water Conservation Project (SWCP) - Sponsored by GTZ and The Gambia Government, Lowland Agricultural Development Programme (LADEP) - Sponsored by AfDB, IFAD and The Gambia Government, Participatory Integrated Watershed Management Project (PIWAMP) as a follow-up to LADEP - Sponsored by ADB, IFAD and The Gambia Government, The Gambia Lowland Development Project (GALDEP). GALDEP constructed a series of water retention and anti-saline-water intrusion dikes to retain fresh rainwater and prevent saline-water intrusion in the rice-growing areas, respectively. Also, spillways are constructed to regulate water volumes in the areas where dikes are constructed. Liming is practiced to counter excessive soil acidity in the rice fields. Recent projects like NEMA and FASDEP aiming at preventing saline-water into swamp rice ecologies are currently on-going in many of the agricultural regions of the country, including Lower River Region. These projects in the region have continued with anti-salt dykes and spillways construction for rural farmers. Moreover, they provided alternative sources of livelihoods to the farmers by establishing generally vegetable gardens for many villages in the region. This helped in adapting to saline-water intrusion issue. However, the projects intervention sites did not reach every part of the region under case study (LRR), and increasingly these infrastructures with time, became old vis-à-vis of the unceasing saline-water intrusion phenomenon in the region which is causing losses and damages to the poor rural farmers.

iii) Farm production practices: These include practices in farm production, land-use, and land-topography and timing operations. Some examples are: diversifying crop types and varieties, changing the intensification of production, changing the location of crop production, changing land and changing in timing of farm operations.

iv) Farm financial management: focusing on crop insurance, income stabilization programs, and household income.

It is, therefore, crucial to investigate adaptation to saline-water intrusion at farmers’ level to have more insights on adaptation to the issue in the study area.

3. CHAPTER THREE: METHODOLOGY

3.1. Study area

The Gambia is a tiny country in West Africa bordered on its three sides (north, east and south) by the Republic of Senegal and by the Atlantic Ocean on the west. With an area of approximately 11,300 km^2, the country lies between latitude 13 and 14°N and 17 and 1°W. The country sits within the Soudan-Sahel, the meridional transition zone between the semi-arid Sahel with the Sahara (SPCR, 2017), characterized by a long dry season (November to May) and a short wet season (June to October). The country receives from 850 to 1200 mm of rainfall ranges and the average temperature range is from 18 to 33°C. It stretches on about 400 km^2 of length and a width of 30 km^2 on both sides of the River Gambia. The river with over 1,130 kilometers of length (SPCR, 2017) is the dominant geographical feature of the country and a potentially significant freshwater resource, although the existence of extensive saline-water intrusion as far as Georgetown and Banseng further upstream, reduces its role as a feasible water resource. Originated from Fouta Djallon highlands in Guinea Conakry, it crosses the entire length of the country, with tributaries which are: Sandougou, Miniminyang, Baobolong, Sofanyama, and the Bintang Bolongs, that give existence to wetlands in the country. River Gambia is home to a rich ecological diversity of flora and fauna whose existence may be under threat from rising sea levels, reduced rainfall and run-off and increased salinization. Increasing vulnerability due to reducing rainfall-runoff is estimated at a 30% reduction in rainfall over the past 30 years for the whole country. Moreover, a major vulnerability to rising sea levels and storm surges is leaving the capital Banjul as one of the most climate-change threatened cities of the world (Njie, 2002). The average elevation of the capital Banjul above sea level is of the order of + 0.5 to 2.0 m asl. The soils are mostly ferralitic and ferruginous weathered tropical soils.

The country is subdivided into five (05) administrative regions, namely: West Coast Region, North Bank Region, Lower River Region, Central River Region and Upper River Region and six (06) agricultural areas, namely: (i) North Bank Region, (ii) Central River Region North, (iii) Upper River Region, (iv) Central River Region South, (v) Lower River Region, and (vi) West Coast Region.

The area of study is Lower River Region. With a total area of 1561.34 km^2, the region is located in the southern bank of River Gambia and stretches about ninety-five (95) kilometers from Brumen Bridge in the west to Sofanyama Bridge in the east (Government of The Gambia, 2007). The mean annual rainfall of the study area is around 700 mm and vegetation is mainly trees, shrubs, and seasonal grasses. The region is divided into two major areas called Kiangs and Jarras. Each area is made up of three districts making it a total of 6 districts, 12 wards, and 148 villages. Kiang West, Kiang Central, and Kiang East form the Kiangs' area while Jarra West, Jarra Central, and Jarra East make up the Jarras. The overall population occupying the region is approximately 81,042 inhabitants with 42,270 female and 38,772 male (GBoS, 2013). Over 80% of the population depends on agriculture and natural resources as their livelihood and household income (Government of The Gambia, 2007).

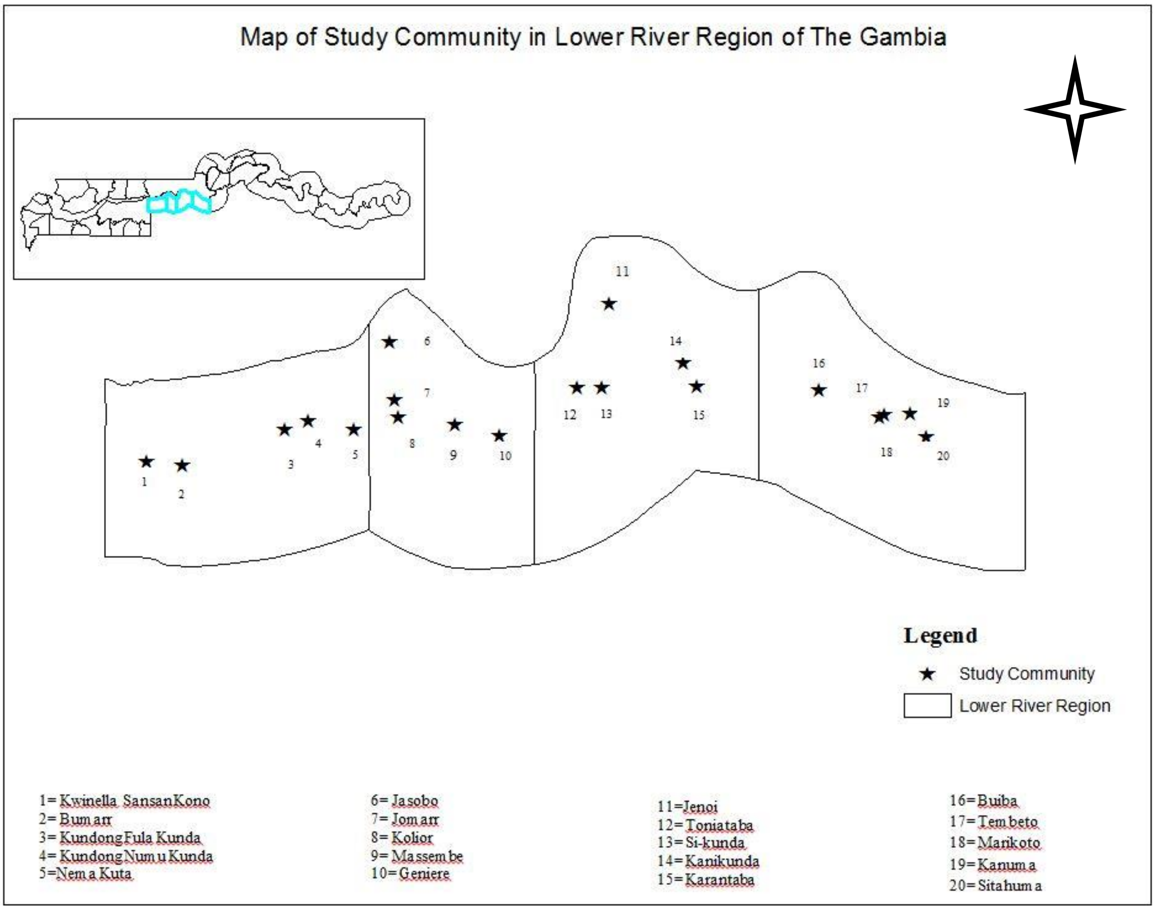

Figure 2: Map showing the study area
Source: Author, 2017

3.2. Sampling and Sample Size

A multistage sampling technique was employed to select respondents for the study. The first stage was the selection of one region in the country. The Gambia has six agricultural regions, but the Lower River Region was purposively selected because rice is the major crop cultivated in the region (MOA, 2013), therefore the predominant agricultural activity for thousands of poor rural households whose livelihoods depend on it. Moreover, LRR is being identified among the vast rice swamping areas expected to be severely affected by SLR in the country (93 km^2, 154 km^2 and 197 km^2 under saline-water intrusion for projected SLR of 0 cm, 50 cm and 100 cm respectively) (NAPA, 2007). Consequently, saline-water has negatively affected rice production of the region which constitutes the major source of subsistence for its peoples (Webb, 1992).

Simple random sampling technique was then used to select four districts from the six districts in the Lower River Region. Therefore, 2 districts were selected in each area. Kiang Central and Kiang East in the Kiangs and Jarra West and Jarra Central in the Jarras were randomly selected and five villages from each district for the data collection. Villages selected were identified earlier as having swamp ecology from the Agricultural Regional Directorate of the region. In the last stage, simple random sampling was used to select households from each village. Swamp rice cultivation is primarily done by women in The Gambia (Carney, 1998), a female adult of each selected household was interviewed but in the absence of the female adult, any of her daughters (more than 18 years) was considered for the interview. The following table (Table 2) outlines the selected villages for the study:

Table 2: Random Sampled Villages for the study

KIANG CENTRAL	KIANG EAST	JARRA WEST	JARRA CENTRAL
1. Kwinella SansanKono	1. Jasobo	1. Toniataba	1. Marikoto
2. Kundong Numu Kunda	2. Massembe	2. Kanikunda	2. Sitahuma
3. Bumarr	3. Geniere	3. Jenoi	3. Kanuma
4. Kundong Fula Kunda	4. Jomarr	4. Si-Kunda	4. Japineh
5. Nema Kuta	5. Kolior	5. Karantaba	5. Buiba

Krejcie & Morgan (1970) sample size formula below (Equation 1) was used in computing the sample size for the study. Hence 240 rice farmer-household heads were interviewed for the entire study.

Equation 1: Morgan & Krecje Sample Size determination formula

$$S = X^2NP(1-P)/d^2\,(N-1) + X^2P(1-P)$$

Where: S = required sample size

X^2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841) that is 1.96 *1.96 = 3.841

N = the population size.

P = the population proportion (assumed to be 0.50 since this would provide the maximum Sample size)

d= the degree of accuracy expressed as a proportion (0.05)

To obtain the number of respondents from each village, the total number of rice farmer-household heads in each village (obtained during the listing) was divided by the total number of rice farmers for the study area (638) and the value multiplied by 240. Table 3 indicates the sample size for each selected village.

Table 3: Determination of Sample Size

Region	Districts	Villages	Total households	Sampled households	Percentage (%)
Lower River Region	Kiang Central	Kwinella Sansan Kono	31	12	5
		Kundong Numu Kunda	38	14	6
		Bumarr	22	8	3.5
		Kundong Fula Kunda	47	18	7
		Nema Kuta	39	15	6
	Kiang East	Jasobo	43	16	7
		Massembeh	34	13	5
		Geniere	42	16	7
		Jomarr	32	12	5
		Kolior	50	19	8
	Jarra West	Toniataba	30	11	5
		Kanikunda	31	12	5
		Jenoi	30	11	5
		Si-kunda	32	12	5
		Karantaba	32	12	5
	Jarra Central	Marikoto	15	5	2
		Sitahuma	29	11	5
		Kanuma	14	5	2
		Tembeto	26	10	4
		Buiba	21	8	3.5
Total	**4 districts**	**20 villages**	**638**	**240**	**100**

3.3. Research Design

The research design of this study is comprised of quantitative and qualitative approaches. Survey, expert consultations, and desk review were used to conduct the study.

During the survey, interviews were conducted using questionnaires and focus group discussions (FGDs) to have clear and original information. Techniques such as interview and FGD allow the research participants to give very detailed and specific answers (Vanderstoep *et al.*, 2009). For the focus group, a recorder was used helping at capturing farmers' perceptions and knowledge about the issue.

3.4. Instruments

To attain the objective 1, the researcher used secondary data to examine the link between climatic parameters (rainfall and temperature) and rice production. For the objectives 2, 3, 4 and 5 (mentioned in Chapter 1), the researcher made use of questionnaires and FGDs. Questionnaires were administered and focus group discussions were held with farmers to seek information from the selected respondents. Demography and socio-economic characteristics, awareness of saline-water intrusion, adaptation measures undertaken by farmers and problems encountered during adaptation were the information asked during the survey.

The pre-testing of the instruments was conducted in Illiasa Community located in North Bank Region whose farmers shared the same characteristic with LRR respondents. The purpose of the pre-testing was to check the reliability of the instruments. The outcome informed on how to reframe the questions for more clarity. Therefore, necessary adjustments were made to suit the research questions, the respondents' level of literacy and the interpreter understanding' level. Further, the instruments were validated after experts' consultation. All these helped to ensure reliability and validity of the instruments

3.5. Data Collection

The data were collected during the fieldwork (September-October-November 2017) in the study area for the survey, meteorological data from the Department of Water Resources and rice production data from the Agriculture Regional Directorate based in Jenoi. In this study, a combination of quantitative and qualitative research methods was used because mixed approach provides a broader picture of the past and present situation of an issue.

Quantitative data were collected using semi-structured questionnaires. Face to face interviews was used by the research team during the questionnaire administration. This strategy was used because most of the respondents were not having a good command of English Language. Therefore, questionnaires were filled by the interviewers from the answers provided by the selected respondents.

The focus group discussions were conducted with a group of 9 to 12 farmers according to farmers' availability. The focus group discussion's role is to supplement the quantitative data for the in-depth understanding of the topic. It also served to triangulate and cross-check the information provided during the questionnaire's administration.

Moreover, a transect-walk was conducted after each focus group discussion in the selected rice farmers' fields to appreciate "in-situ" the status of the farms and realities on the phenomenon. This was done with the guidance of the farmers and the facilitation of the agriculture extension officer playing the role of translation from the local language to the English language.

3.5.1. Primary data

A research team for primary data collection was formed. This team consists of 4 peoples, all agriculture extension agents intervening in the selected areas with the author included. Before the survey, the team was informed about the research objectives and data collection purposes as well as trained on the instruments used for data collection. All members of the research team were familiar with the field survey methodology set up for the research. The tools for primary data collection included semi-structured questionnaire household survey (close-ended and open-ended questions).

Considering ethical issues that may arise in collecting data in the study area, the researcher was introduced to the selected communities by the district agriculture extension agents through the village heads. These meetings allowed the researcher to explain the purpose of the study and how it could benefit the Region. Moreover, the researcher assured the survey' respondents anonymity, that information given will be treated confidentially and solely for the purpose of the study. This made the informants comfortable in participating in the interview.

3.5.1.1. Household Survey

To embark on the survey, having the list of selected rice farmers, the extension agent intervening in each village served as an entry point to inform the village-head called "Alkalo" and the randomly selected farmers on the Research Team's visit for questionnaire administration. This had yielded in having farmers for questionnaire interviews according to their own schedule and free time, even though it was not the case in most of the cases.

The individual questionnaire was held at each farmer's compound at their convenient time despite the fact that farmers had other engagements like going for farming activities.

With the time frame for the research, the interviewers had to go and meet the interviewee on his farm to get in touch with him.

3.5.1.2. Focus Group Discussion (FGD)

After the individual farmer's questionnaire, FGDs followed with size starting from 9 farmers and above. Initial investigations revealed that Wednesday and Friday are days where most of the farmers do not carry out any farming activities except in the evening for vegetable gardening. In total, 20 FGDs were conducted. While the questionnaire technique helps to get an individual farmer point of view on the issue without being influenced by other farmers, the FGD had the beneficial advantage (after farmer's individual survey) to provide more detailed explanations obtained during farmers' individual interviews. It also served as mean to cross-check answers from the interview.

The focus group discussions were held in each village after the researcher is being introduced to the "Alkalo". The "Alkalo" announced the meeting to the selected farmers through the VCDs or in some cases farmers' network or the agriculture extension agents, and usually using mouth to mouth way of communication.

For availability reason, the quota of 12 members per FGD was not met for each village. Among the reasons, the absence of some farmers when the FGD was carried out can be singled out. Therefore, the researcher had to decide for each FGD a quorum of 8 farmers. According to Fern (1982), the ideal size for a focus group discussion is 8-12 members. The following table (Table 4) presents the number of farmers which participated in the focus group discussion session per village.

Table 4: Number of participants to FGDs per village

Districts	Villages	Number of participants of a focus group discussion
Kiang Central	Kwinella SansanKono	09
	Kundong Numu Kunda	12
	Bumar	09
	Kundong Fula Kunda	12
	Nema Kuta	12
Kiang East	Jasobo	10
	Massembeh	12
	Geniere	10
	Jomar	10
Jarra West	Kolior	09
	Toniataba	09
	Kanikunda	10
	Jenoi	09
	Si-kunda	12
Jarra Central	Karantaba	10
	Marikoto	10
	Sitahuma	10
	Kanuma	09
	Tembeto	09
	Buiba	09

3.5.2. Secondary data

Secondary data used for the study were gathered from different sources and organizations as follows:

- Data related to population, the contribution of agriculture to the national GDP were obtained from the Gambia Bureau of Statistics (GBoS).
- Total swamp rice production for the study area (LRR) was collected from the Planning Services Unit of the Department of Agriculture and the Regional Agriculture Directorate of the Region
- Climate data (Rainfall and Temperature) in the study areas were mainly obtained from the Department of Water Resources
- Documents for analysis obtained from both published and unpublished reports and documents from national and local government departments and journal articles.

3.6. Data Analysis

3.6.1. Temporal trends of and correlation between annual rainfall, temperature and rice production in the study area

The study used trend analysis and correlation methods to examine first, the trend of and second, the link between climate data (rainfall and temperature) and available data on swamp rice production for the study area over a period of time. The dataset used for this study is for the time period: 1974-2016 for rainfalls, 1987-2016 for the temperature and 1990-2004 for swamp rice production available for the region. Furthermore, farmers' insights on the lost cultivated area as a result of saline-water intrusion were reported to analyze quantitatively saline-water intrusion impacts.

3.6.1.1. Trend Analysis

To do so, data were plot in MS EXCEL 2010 to get figures using trend analysis and statistical tests. Statistical tests were run to check the significance of the results using Mann-Kendall non-parametric test. Mann Kendall test is a statistical test widely used for the analysis of trend in climatologic (Bera, 2017; Barry *et al*, 2017; Mavromatis & Stathis, 2011; Bhutiyani *et al*, 2010; Burn *et al*, 2004; Hirsch, *et al*, 1984) and in hydrologic time series (Yue & Wang, 2004; Hipel & McLeod, 1994). It has two advantages: 1) It is a non-parametric test and does not require the data to be normally distributed; 2) It has low sensitivity to abrupt breaks due to homogeneous time series (Tabari *et al*, 2011) thus any data reported as non-detects are included by assigning them a common value that is smaller than the smallest measured value in the dataset. For this test, the null hypothesis H_0 assumes that there is no trend (the data is independent and randomly ordered) and this is tested against the alternative hypothesis H_1, which assumes that there is a trend (Onoz & Bayazit, 2012).

The Mann-Kendall test is appropriate in cases when the data values xi of a time series can be assumed to follow the model:

$$Xi = f(ti) + \ \varepsilon i$$

Where $f(ti)$ is a continuous monotonic increasing or decreasing function of time and the residuals εi can supposed to be from the same distribution with zero mean. It is therefore assumes that the variance of the distribution is constant in time.

The Mann-Kendall S Statistic is computed as follows:

Equation 2: Mann-Kendall S Statistic formula

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sign\ (Tj - Ti)$$

$$Sign\ (Tj - Ti) = \begin{cases} 1\ if\ Tj - Ti > 0 \\ 0\ if\ Tj - Ti = 0 \\ -1\ if\ Tj - Ti < 0 \end{cases}$$

where Tj and Ti are the annual values in years j and i, j>i, respectively (Motiee & McBean, 2009).

If n < 10, the value of |S| is compared directly to the theoretical distribution of S derived by Mann and Kendall. The two-tailed test is used. At certain probability level H_0 is rejected in favor of H_1 if the absolute value of S equals or exceeds a specified value $S_{\alpha/2}$, where $S_{\alpha/2}$is the smallest S which has the probability less than α/2 to appear in case of no trend. A positive (negative) value of S indicates an upward (downward) trend (Drapela, Drapelova, 2011). For n ≥ 10, the statistic S is approximately normally distributed with the mean and variance as follows:

E(S) =0

The variance (σ^2) for the S-statistic is defined by:

$$(\sigma^2) = [n(n-1)(2n+5) - \sum ti(i)(i-1)(2i+5)] \times \frac{1}{18}$$

In which ti denotes the number of ties to extent i. The summation term in the numerator is used only if the data series contains tied values. The standard test statistic Z_s is calculated as follows:

$$\text{Zs} \begin{cases} \frac{s-1}{\sigma}\ for\ S > 0 \\ 0\ for\ S = 0 \\ \frac{S+1}{\sigma}\ for\ S < 0 \end{cases}$$

The test statistic Z_s is used to measure the significance of trends. In fact, this test statistic is used to test the null hypothesis, H_0. If $|Z_s|$ is greater than $Z_{\alpha/2}$, where α represents the chosen significance level (e.g.: 5% with $Z_{0.025} = 1.96$) then the null hypothesis is invalid implying that the trend is significant (Motiee & McBean, 2009).

3.6.1.2. Correlation test

Another statistic obtained on running the Mann-Kendall test is Kendall's tau, which is a measure of correlation and therefore measures the strength of the relationship between two variables (Karmeshu, 2012). Kendall's tau, like Spearman's rank correlation, is carried out on the ranks of the data. That is, for each variable separately, the values are put in order and numbered, 1 for the lowest value, 2 for the next lowest and so on. In common with other measures of correlation, Kendall's tau will take values between ±1 and +1, with a positive correlation indicating that the ranks of both variables increase together whilst a negative correlation indicates that as the rank of one variable increases, the other decreases (Blackwell Publishing,http://www.blackwellpublishing.com/specialarticles/jcn_10_715.pdf).

3.6.2. Level of knowledge of rice farmers on saline-water intrusion

Farmers' views on the causes and impacts of saline-water intrusion collected during the questionnaire administration helped in indicating the level of knowledge of rice farmers on the issue of saline-water intrusion. These data were entered into and analyzed with IBM Statistical Package for Social Sciences (SPSS) Statistics Software version 23. Descriptive statistics using frequencies were, therefore, computed to analyze data on farmers' level of knowledge or awareness and source of saline-water intrusion information.

3.6.3. Rice farmers' responses or strategies to saline-water intrusion

Farmers' responses on the adopted measures to respond to saline-water intrusion collected during the survey served to document the adaptive responses used by rice farmers in the study area in adapting to saline-water intrusion. For the analysis of the adaptive responses used by the farmers, SPSS Software version 23 was employed to analyze farmer's socio-demographic and adaptation to saline water intrusion.

3.6.4. Factors affecting the adaptive responses of rice farmers to saline-water intrusion in the study area

The study explores several adaptation choices, the suitable econometric model would, thus, be either a binary model or a multinomial model. The model estimates the effect of explanatory variables (socio-demographic and institutional factors based on the literature review) on a dependent variable (adaptation options) involving one choice with unordered response categories. Therefore, for this study, a binary logistic regression model (BLM) specification is adopted to model saline-water adaptation responses of farmers involving discrete dependent variables with only two choices (the farmer has adapted or not to saline-water intrusion). The key concern of this issue is to discuss the factors influencing the choice of adaptation measures if the farmers have adapted.

Adaptation is a dependent dummy-variable in the data. The dummy was determined by assigning a value of 1 for farmers who indicated that they had taken adaptive measures in response to negative effects of saline-water intrusion and a value of 0 for farmers who indicated they did not employ any adaptive measures at all in response to negative effects of saline-water intrusion. For instance, if a farmer uses at least one adaptive strategy to halt the negative consequences of saline-water then that farmer is considered to have "adapted" (1). During the enumeration of the survey, respondents were presented with a scripted explanation of practices vis-à-vis saline-water adaptation strategies, and then presented with a simple dichotomous (“yes/no” response) question about whether or not they had adopted any of these adaptive responses due to saline-water intrusion in their rice-growing fields, making results here self-reported.

The logit regression model was used with the aid of STATA software version 13. The model was, therefore, used to determine the extent to which selected variables influence (e.g. age, education, gender, household size, marital status, farming experience, access to capacity building, etc.) the decision of taking an adaptive measure. This model was chosen for its simplicity and its ability to take as many repressors. Mujeyi (2009) attested to the fact that parameter estimates of the logit model are asymptotically efficient and consistent in addition to variables not being necessarily normally distributed.

The simple form of the logistic model, according to Peng et al. (2002) is shown below:

Equation 3: Binary logistic model formula

$$Logit\ (Y) = natural\ log\ (odds) = ln\ (\pi/(1-\pi)) = \alpha + \beta xi$$

This equation helps us to predict the likelihood of the occurrence of the result of interest. This is using antilog in both sides of equation 2 as shown below:

$$\pi = probability\ (Y = outcome\ of\ interest/\ X = x) = \frac{e^{\alpha+\beta x}}{1+e^{\alpha+\beta x}}$$

Where;

π=probability outcome of interest

x= Y intercept

β= regression coefficient

e= 2.71828 (the base of natural logarithm)

x=binary or continuous variables

Table 5: Definition of the variables used in the binary logistic model

Variable	Coding	Category

Dependent variable		
Adaptation	1 if farmer uses at least one adaptive response, 0=otherwise	Dummy
Explanatory variables		
Age of farmer	Years	Continuous
Education level of farmer	1 if farmer is educated, 0=otherwise	Dummy
Gender of Household Head	1= male, 0= female	Dummy
Marital Status of the farmer	1= married; otherwise	Dummy
Household size	Number of members	Continuous
Farming Experience of the farmer	Years	Continuous
Access to Extension	1= access to extension, 0= no access	Dummy
Access to Saline-water information	1= access to saline water information 0= no access	Dummy

3.6.5. Identifying most affected villages by saline-water in the study area

To map out the most affected communities FGDs were used to get from the respondents their daily life experience, lost farmland as a result of saline-water intrusion and distance to access to their rice-growing fields were used (10-20 km) based on Below *et al*. (2011) similar study.

4. CHAPTER FOUR: `RESULTS AND DISCUSSIONS

4.1. Rainfall trend between 1974-2016

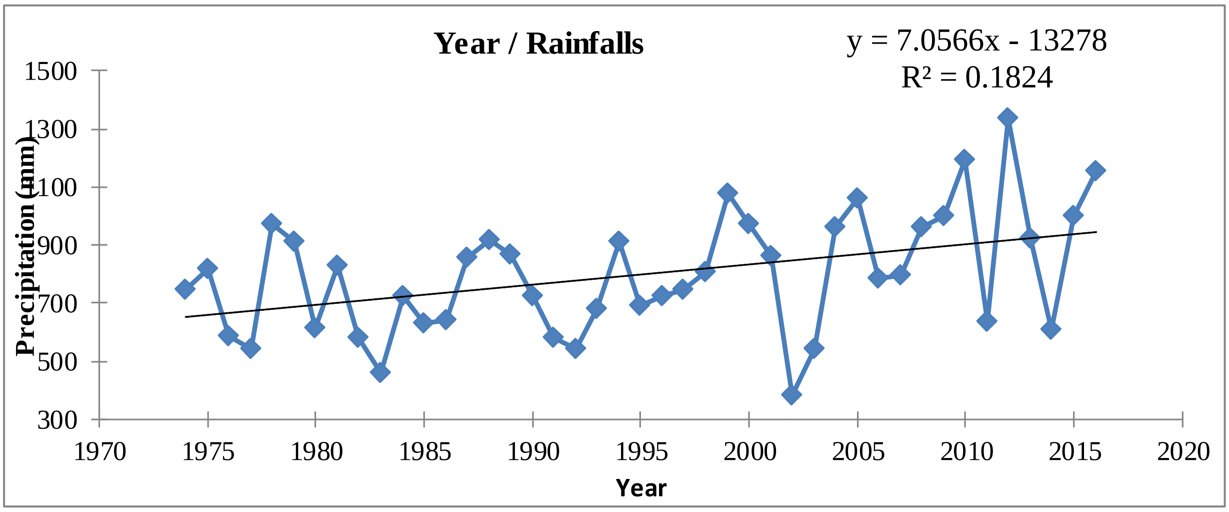

Figure 3: Annual rainfall in Jenoi (1974-2016)
Source: Author, 2017

Long-term annual rainfall data for Jenoi, the Regional Meteorological Station location for LRR is shown in Figure 3 (above). On running the Mann-Kendall test on rainfall data, the following results in Table 6 were obtained for the Region. If the p-value is less than the significance level α (alpha) = 0.05 (which is the case), H_0 is rejected. Rejecting H_0 indicates that there is a trend in the time series.

Table 6: Mann-Kendall statistical results for rainfall trend

Kendall's tau	0.2957
S	267.0000
Var(S)	0.0000
p-value (Two-tailed)	0.0049
Alpha	0.05

H_0: There is no trend in the series
H_a: There is a trend in the series

The Mann-Kendall (MK) Statistic test indicates that there is an increasing precipitation trend at 5% significance level despite some inter-annual variations in the rainfall amount over the period 1974-2016. These results are in contradiction with national rainfall trend for the country. The Gambia has registered 20% to 25% reduction in the annual mean rainfall from 1943-2013 (SPCR, 2017). Moreover, climate projections for the country showed a decreasing trend for rainfalls by 2050. This situation could be explained by the fact that with climate change, some areas are expected to receive more rainfalls while others less. Also, according to IPCC (2007), climate change is expected to increase the intensity and frequency of extreme events such as droughts, heat waves, heavy downpours, flooding, etc. However, these results corroborate with Koudahe et al (2017) findings which revealed a wet tendency in rainfall for Lomé and Tabligbo cities in Togo, located in West Africa. Also, similar results were found in Karmeshu (2012) for the states of New Jersey, Pennsylvania, New York, Connecticut, Massachusetts, Rhode Island, and Vermont in the Northeastern United States using MK test.

On the other hand, the study area experienced below-average rainfall (799.43±31mm) in 22 out of the 42 years between 1974 and 2016. Years with less than 700 mm rainfall which represents the value signifying good rainfalls for the region (DWR,2017) were 1974, 1976, 1977, 1980, 1982, 1983, 1984, 1985, 1986, 1990, 1991, 1992, 1993, 1995, 1996, 1997, 2002, 2003, 2006, 2007, 2011, 2014. These results showed a high variability in the amount of rainfalls in the region thus impacting the distribution of rainfalls across the region. The findings confirm those of Cessay et al (1989) who found an estimated 15 to 30 days decrease in the length of the rainy season across the country. Thereupon, such drop in rainfalls far below 700 mm in 15 (1976, 1977, 1980, 1982, 1983, 1985, 1986, 1991, 1992, 1993, 1995, 2002, 2003, 2011, 2014) out of the 42-year periods could be translated into an increase in the dry periods hence shortening the growing season and limiting required water for rice plants. Therefore, decrease in the production of rice is likely to occur. In addition, climate change in the form of higher temperature, reduced rainfall and increased rainfall variability is evidenced to reduce crop yield and threaten food security in low income and agriculture-based economies (Apata, 2011). According to Mkonda and He (2017), the identification of the number of dry and wet spells is particularly important, because they are good indicators of rainfall variability. Therefore, the study area is subjected to recurring interannual rainfall variability which is likely to reduce water flow in the river and thus threaten rice production.

4.2. Monthly Rainfall from 1987-2015

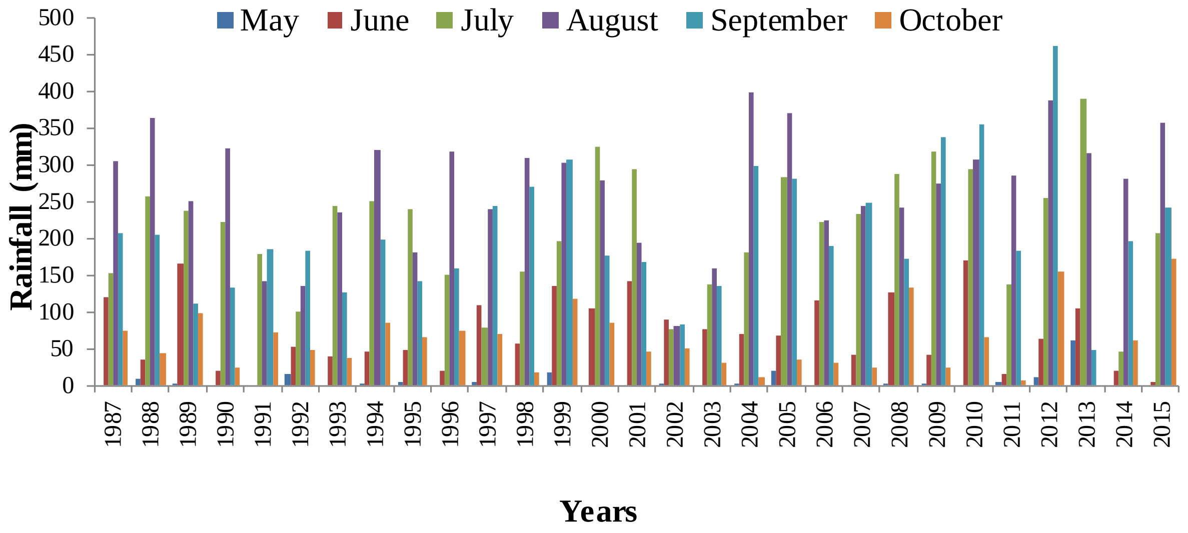

Figure 4: Monthly rainfall for Jenoi (1987-2015)
Source: Author, 2017

Figure 4 illustrates the monthly rainfall for Jenoi during the raining season from 1987-2015 with the month of August mostly receiving the highest amount of rainfall. This corroborates with the normal rainfall pattern during the raining season for the month of August for the country. This was true for most of the years except 1991, 1992, 1993, 1995, 1997, 2002, 2003, 2006, 2007, 2008, 2009, 2010, 2012, 2013 which received a low amount of rainfall. This will probably influence crop production in these years, especially rice cultivation in the swamps. A large amount of rainfalls help to push back the salt front far back to the Ocean (Webb, 1992), thus allowing the rice (not saline tolerant) to grow and mature before the end of the raining season. In cases of low rainfalls, high salt concentrations are present and could limit rice growth and production in these years. According to Miah et al (2004), most of the crops lose their yield capacity due to their intolerance to salinity in saline areas. This could probably lead to crop failure and put more burdens on subsistence rural poor-resource farmers in the region. FGDs held with farmers corroborate with these assertions who affirmed to have had a shift in their farming calendar which use to start in June but actually start in July.

4.3. Trend of Temperature from 1987 to 2016

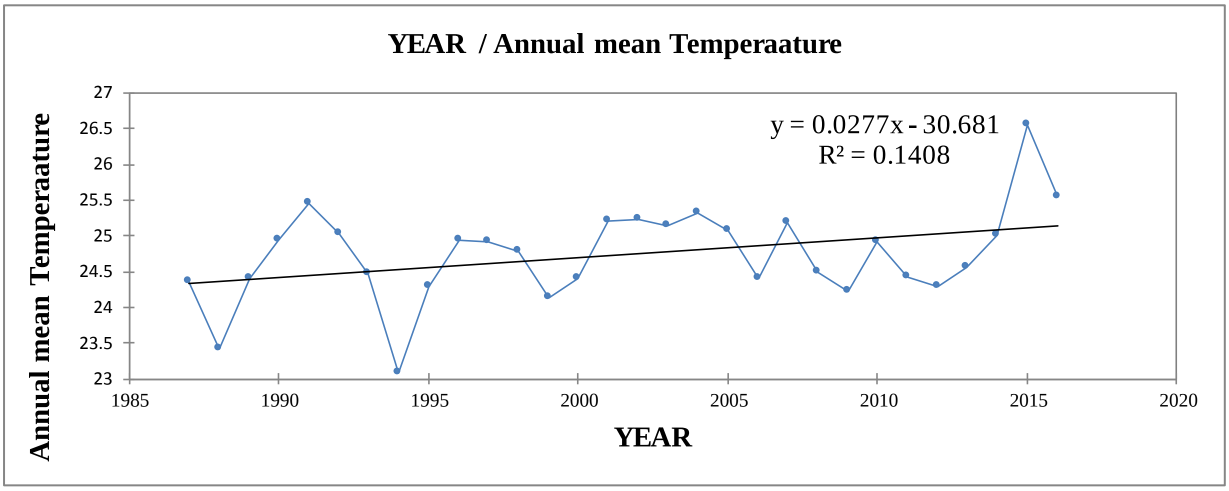

Figure 5: Annual mean Temperature (1987-2015)
Source: Author, 2017

Figure 5 shows the general increasing trend of the annual temperature in Jenoi, part of the study area. On running the Mann-Kendall test on temperature data, the following results in Table 7 were obtained for the region.

Table 7: Mann-Kendall statistical results for mean temperature trend

Kendall's tau	0.2000
S	87.0000
Var(S)	0.0000
p-value (Two-tailed)	0.1261
Alpha	0.05

H_0: There is no trend in the series

H_a: There is a trend in the series

As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis H_0. Therefore, the Mann-Kendall (MK) test Statistic indicates a non-significant increasing trend in the temperature from 1987-2015. The results do not corroborate with SPCR (2017) which revealed significant increasing trend in temperature for the country for the period 1943-2013. Moreover, the results contradict many studies in Africa (Koudahe *et al.*, 2017, Barry *et al.*, 2017, Akinsanola *et al.*, 2014, Collins *et al.*, 2011) which all indicated an upward significant trend of temperature in many parts of Africa. Despite the non-significance upward trend for temperature, there is an increase in the temperature in the region. This was in agreement with swamp rice farmers' views who asserted that for the last 5-year there has been an increase in temperature. Moreover, the meteorological analyses revealed 1991, 2001, 2002, 2003, 2004, 2007, 2015, and 2016 as years of high temperatures, above 25°C (the normal annual mean temperature for the region). The implications of rise in the mercury for the region could be a high rate of evaporation from water bodies (River Gambia for instance) and evapotranspiration from the crops, including rice stalks. The Gambia estuary is vulnerable in the dry season, not only due to the advanced saline wedge but also with the danger of hypersalinity due to high evaporation combined with very low freshwater inflows from upstream (Ervine *et al.*, 2007).The increase of temperature and dry period is of great concern; it implies an increase of evapotranspiration which affects crop yields (Koudahe *et al,* 2017). Furthermore, as evaporation goes higher, the river's flow could decrease allowing saline-water to intrude farther on inlands, including flooding areas along the river, where swamp rice is mostly cultivated.

4.4. Swamp Rice Cultivated area of LRR (1990-2004)

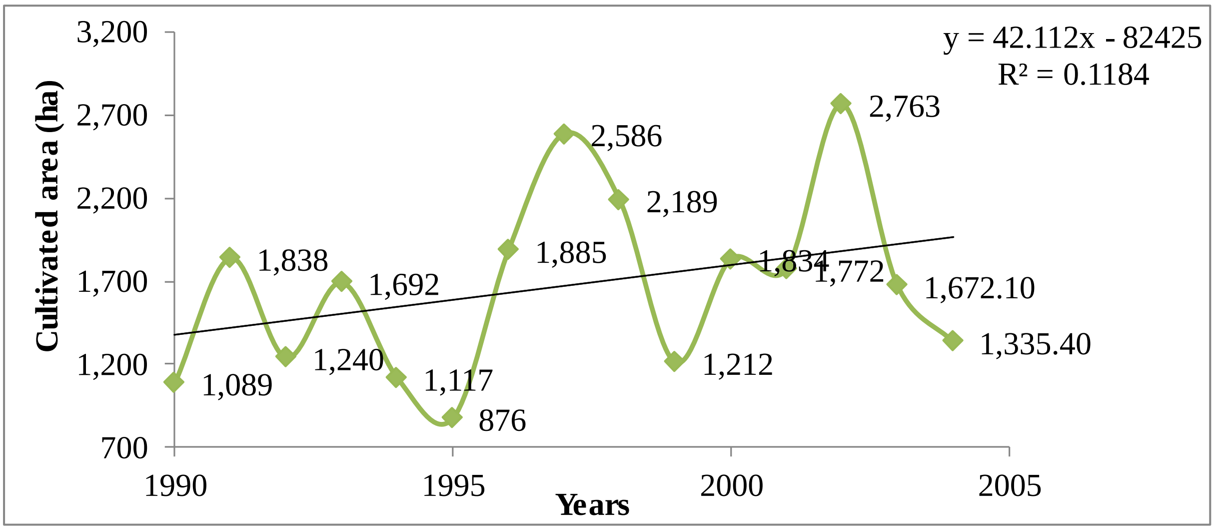

Figure 6: Annual mean Cultivated Area (1990-2004)
Source: Author, 2007

Swamp rice cultivated area for LRR during the period of 15 years (from 1990-2004) appears to be increasing over time. However, there appears a decreasing trend from 1990 to 1995 and 2000 to 2004. From 1990 to 1995 it has decreased from 1,089 ha to 876 ha representing 20% of decrease in cultivated area. From 1995 to 1997 an increase of cultivated area was registered from 876 ha to 2,586 ha accounting for 66.1% of increase. From 1997 to 1999, a decrease of 53% was observed. From 1999 to 2002 an increase of 56 % was registered with 2002 being the highest cultivated area so far (2,763 ha). From 2002 to 2004 a decrease in the area of rice cultivation in the swamp to 1,335.40 ha (2004) accounting for 52% of decrease. These decreasing trends observed almost every 2-5 years could be as a result of a decrease in fertile land all thank to climate change-induced impacts (sea-level rise, saline-water intrusion especially).

4.5. Swamp Rice Production (1990-2004)

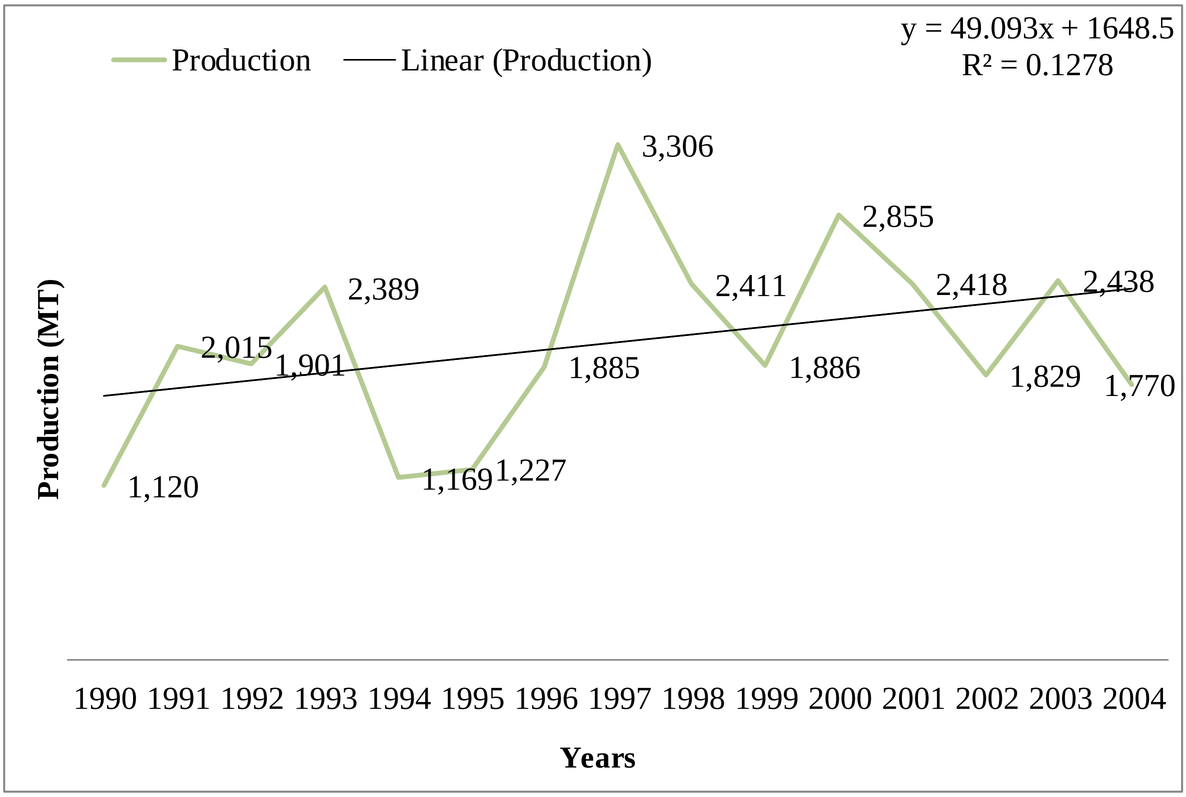

Figure 7: Swamp Rice Production (1990-2004)
Source: Author, 2017

An unstable production of rice, especially which showed 5 times a decrease in the production (1994, 1999, 2002 and 2004) illustrates the variation in rice production almost every 5 years for the study. The inter-annual rainfall variation could be a factor of rice production variation as per Figure 3 illustrated.

Years with mean annual rainfall below the normal annual mean (1991, 1992, 1994, 1995, 2002, and 2003) are more likely to register low crop production. However, only the years 1992, 1994, and 2002 with very low rainfalls registered low rice production. This corroborates with the fact that wet environment suits for rice cultivation. Therefore, lack of water in quantity and quality will affect the production of rice. These years of low rainfalls could also induce an increase of swamp rice-growing fields' salinity, hence undermining rice plants growth and development according to FAO (2005). Furthermore, findings in Webb

(1992) revealed that saline-water intrudes further with a low flow of the river, particularly in seasonally mangrove swamps located in LRR as a result of drought or sea-level rise. This also corroborates with Fatajo (2009) affirming that saline-water intrusion along the length of the river due to drought or sea-level rise could render most areas unproductive for rice irrigation hence reducing rice yields and production. On the other hand, years 1991, 1995, and 2003 found to have received below the normal rainfall did not register low rice production which might be hard to understand. This could be as a result of other factors for the rice sub-sector identified in ANR (2009) Sector Policy (2009-2015) such as improved farming practices and extensive swamp rice farming.

The year 2002 received the lowest amount of rainfall for the region. This could implicate huge crops' failure and worsen life of rural poor-resources persons, including rice subsistence farmers who heavily depend generally on rain-fed agriculture. Moreover, low rainfalls for the region could mean low river water flow hence a contributing factor to water shortage to supply swamp rice-growing fields located in the lowlands of River. The phenomenon of salinization of freshwaters originates and is aggravated under the condition of low river water runoff and hot weather, intense evaporation (Mikhailov & Isupova, 2008). The worst scenario could be a situation of food insecurity for the region during this year; which could be exacerbated if adaptive measures were not appropriate or insufficient.

4.6. Correlation Test

Table 8: Correlation test results

Variables	Rice Production	Rainfall	Temperature
Production	**1***	0.0436	0.2058
Rainfall	0.0436	**1***	-0.2815

Temperature	0.2058	-0.2815	**1***

p-values:

Variables	Production	Rainfall	Temperature
Production	**0***	0.8774	0.4618
Rainfall	0.8774	**0***	0.3095
Temperature	0.4618	0.3095	**0***

* Values in bold are different from 0 with a significance level alpha=0.05

The results from Table 8 revealed a positive weak correlation between rainfall and swamp rice production meaning the production increases as rainfall increases which is normal. However, there is no significant correlation (p-value>0.05) between rainfall and rice production for this time frame (1990-2004). This could be due to other factors among which saline-water intrusion is identified as limiting factor contributing to low yields, thus lowing rice production in the region. Fatajo (2009) and Webb (1992) in their respective works indicated that saline-water intrusion resulting from drought or sea-level rise is undermining rice production in The Gambia. Furthermore, any crop responds to a threshold temperature, above or below may affect the growth of the plant thus reducing the yield and production. Temperature correlates negatively with rainfalls (r<0) meaning when temperature increases, rainfall decreases which corroborate with farmers' views of observed increase in temperature when rainfalls decrease. Temperature correlates positively with rice production meaning when temperature increases crop production increases which are the result of the fact that the range of increases can be tolerated by the heat tolerant rice plant. Any crop responds to a threshold temperature, above or below this threshold may affect the growth of the plant thus reducing the yield and production.

4.7. Household Characteristics

From the 240 questionnaires issued all were successfully filled and returned. The response rate was therefore 100% which was deliberated as adequate for analysis and conclusion; according to Frankel and Wallen (2004) who affirmed that a response rate of above 95% of respondents adequately represent the study sample and offer adequate information for the study analysis.

Table 9: Socio-Demographic Profile of the Respondents (N=240)

Variable	Frequency	Percent
Gender of Household head		
Female	30	12.5
Male	210	87.5
Marital Status		
Single	2	0.8
Married	209	87.1
Divorced	2	0.8
Widowed	27	11.3
Age		
Less than 30 years	35	14.6
30 - 39 years	59	24.6
40 - 49 years	72	30
50 - 59 years	37	15.4
60 and above	37	15.4
Educational level		
Primary school	33	13.8
Secondary school	13	5.4
BSc.	1	0.4
Arabic	89	37.1
None	104	43.3
Household size		
1-5	34	14.2
6-10	118	49.2
11-15	49	20.4
16-20	24	10.0
21 and above	15	6.3

Source: Survey, 2017

Table 9 above shows that rice farming in the swamp ecology in The Gambia is primarily dominated by the women. This is the reason why from the research conducted all

(100%) the respondents are women. This corroborates with previous studies in the country where women are predominantly responsible for rain-fed and tidal swamp rice cultivation (Carney, 1998; NRDS, 2014). Such perpetuating mentality of the colonially imposed gender division of labor in the country still confines men into cash crop production at the uplands and thereby rendering little or no maintenance assistance to the women at the lowlands (Maddox, 1996). This bias in the gender in the study area largely affects the production of rice as well as the number of hectarages that can be put into production, and therefore increase rice production. On the other, it confirms Guard's findings which revealed that women produce most of the world's food (Gaard, 2015).

Table 9 also revealed that (87.1%) of the respondents (swamp rice farmers) were married whilst (11.3%) were widowed and the same percentage of respondents (0.8%) was single and divorced respectively. This can be explained by the land ownership structure of swamp rice-growing field in the area which allows primarily married women to own a farm. Furthermore, a positive implication of it could be more support in their farming activities from the spouse in terms of labor and help to acquire agricultural implements (materials and inputs). It also appeared in the findings that only a few (12.5%) of the population are female-household head meanwhile the majority of the households (87.5%) are male-headed.

In addition, results from the research indicated that the youngest and oldest ages of rice farmers were 22 and 80 years respectively with a mean age of 44 years. The majority of the population (54.6%) represents the active working group; aged between 30-49. 15.4 percent of the population is 60 years and above, 15.4% within the age group of (50-59) and 14.6% less than 30 years old. Rice farming generally requires people who are physically apt to conduct farming operations on the field. Farming systems prevailing in The Gambia are in general manually and consequently, labor intensive. This is why very old and very young people are not predominantly involved in this economic activity. Contrarily, having farmers predominant in the active working group could yield a positive effect on crop productivity since this age allows the farmer to undergo stress and carry out the required intensive labor. According to Otiloaiye et *al*. (2009), this could yield positive effect on crop productivity

Findings of the research also revealed that most of the farmers have not received formal education (43.3%). whiles 37.1% received Arabic (Quranic) education, 13.8% primary education, 5.4% secondary education and only 1 out of 240 making it 0.4% university first degree (Bsc.). The education level in The Gambia is still averagely low and particularly in the rural settings. This could explain these findings. Moreover, this situation of very low level of education can sometimes affect the aptitude of one person to perceive, understand and react positively to new technologies or strategies. For instance, Idrisa *et al*. (2012) reported that a minimum threshold in terms of educational qualification is necessary for understanding the scientific and technical nature of modern agriculture; which gradually tend to turn into climate smart agriculture (CSA) inclined to build resilience to climate risks and uncertainties.

The research also showed that majority (98.75%) of the respondents are Muslims and only (1.25%) of the respondents are Christians. This situation is typical for The Gambia where the majority of the population is Muslim.

Majority of the respondents (49.2%) had a household size between 6-10 member with the lowest and highest household size being 2 and 36 members respectively and averagely 11 members per household. The country's last census (GBOS, 2013) indicated an average household size of 9.2 for the region which is quite similar to the values obtained in this study area. This could imply that large-sized rural households would be capable of providing the labour needed in the farm.

Table 10: Farming Experience, Land ownership structure, Farm size and Farm Network of Respondents

Variable	Frequency	Percent
Farming Experience		
Less than 5 years	6	2.5
5 - 10 years	25	10.4
11 - 15 years	35	14.6
16 - 20 years	50	20.8
21 - 25 years	31	12.9
26 - 30 years	28	11.7
31 years and above	65	27.1
Land ownership structure		
Family/Privately owned	240	100
Size of Farmland (hectares)		
Small-sized <5	236	98.3
Medium-sized 5-20	4	1.7
Farm Network		
No	240	100
Yes	0	0

Source: Survey, 2017

Results from Table 10 indicated that the majority, representative of 27.1% of the farmers have a farming experience of 31 years and above with only 12.9% having the least years of experience in rice farming (less than 10 years). This shows that the majority of the rice farmers have been farming for a long period, hence, are experienced enough to make wise decisions and choices on their production which could help them increase their rice production and adapt well to many changes that may occur overtimes. In other terms, they might be in a better position to understand environmental variations and changes which will help them to avoid crop failure and adjust to the new circumstances. Maddison (2007) in his study also indicated that educated and experienced farmers are expected to have more knowledge and information about climate change and adaptation measures to use in response to climate risks and challenges.

The analysis of the land ownership structure showed that all the respondents work on their own farms. This implied that swamp rice farmers have the plain right on their farms.

This could be explained by the social organization prevailing within the study area and The Gambia at large where women are given land by their mother's spouse once they get married or part of the dowries or even borrowed from friends or neighbours. In the case, of borrowed land, the farmer-borrower cultivates the land and is still considered as the owner of the parcel. At the end, the land is not taken back from him because of the conviviality and sharing characters of the rural Gambians.

Moreover, the results of the research revealed that 98.3% of the respondents operate on small-sized farm (< 5 hectares), with 1.7% having a farm of medium size (5-20 hectares). This signposted that, farmers in the study area were generally subsistence farmers making them vulnerable to climate change as reported by Idrisa et *al*. (2012) in their study in Borno State, Nigeria.

Also, the study illustrated that all the respondents did not belong to any established farm network or organization in the study area. There is, therefore, possible high chance for farmers not to gain effective and efficient support from donors, organizations (governmental and non-governmental) which prefer to deal with them in organized structures or groups. Hence, rice farmers of the study area are likely to be not lucky to get their supports.

From the research, the majority of the respondents (81.3%) blame climate change and deforestation for the change in temperature observed in their region. This corroborates with their views on the change in the rainfall pattern and amount as illustrated in Figure 11 where the majority of the respondents (80.4%) attribute the change in rainfall patterns to the two causes that are climate change and deforestation. This has the implication that farmers of the study area are very aware of climate change, its manifestations and its causes. This shows a high level of awareness on climate change of rice farmers in the study area.

4.8. Farmers' Awareness and Knowledge of saline-water intrusion

Figure 8: Farmers' awareness of saline-water intrusion
Source: Survey, 2017

The majority of farmers (96%) said they are aware of saline-water intrusion phenomenon. They claimed that they heard of saline-water intrusion before the time they were interviewed.

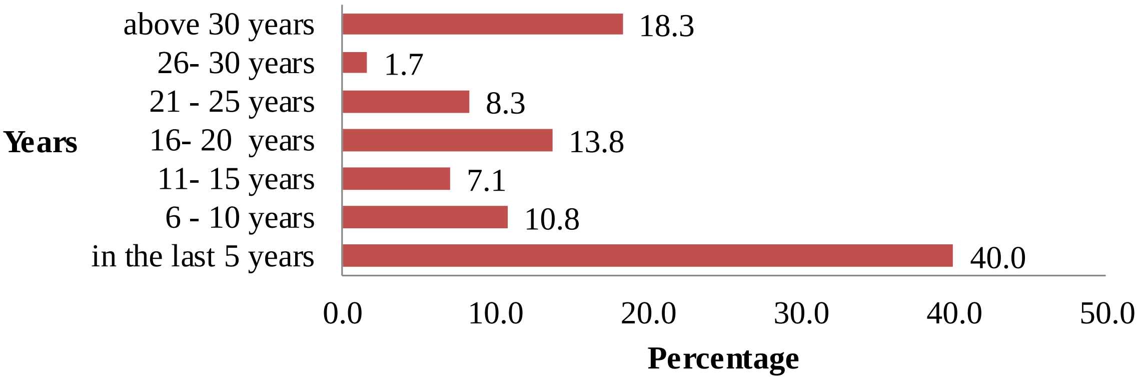

Figure 9: First-time saline-water intruded in the rice-growing fields
Source: Survey, 2017

Most of the respondents (40%) declared to have had their rice fields intruded for the first time in the last 5 years whilst 18.3% affirmed to have had saline-water intrusion on their rice fields for the first time 30-years and above. Virtually, it implies that saline-water intrusion over the last 30 years (1987-2016) is increasing according to swamp rice farmers interviewed. The fact that more people have seen for the first time saline-water intrusion in recent years can be attributed to the increasing saline-water intrusion in the study area resulting from the increasing change in the climate (low rainfalls associated with sea-level rise around Banjul).

According to Jallow et al (1996), the capital city Banjul is likely to be at high risk of inundation by 2100 as the result of sea-level rise).

Table 11: Time of the year saline-water is the most obvious

Time of the year saline-water is the most obvious	Percentage
End of the dry season	55.8
Onset of the raining season	44.2
During the raining season	10.4
Onset of the dry season	35
During the dry season	45.8
End of the raining season	52.5

Source**:** Survey, 2017

Table 11 revealed that for rice farmers in the study area, saline-water intrusion is the most obvious end of the dry season (55.8%) and end of the raining season (52.5%) which is supposed to be normal due to the absence of rainfalls. This suggests that in case of low rainfalls during the year, saline-water is present even further in the raining season in the water used (form River Gambia) to irrigate the swamp rice-growing fields. Also, these results suggest that salinity damages rice growth in particular during early and late periods of the rainy season, due to low rainfall and slow soil desalinization and/or salinity intrusion from estuaries. This in some cases could lead to change in livelihood strategies. For instance, rice farmers have the tendency to delay the time of farming activities among other strategies to avoid losses (Haider & Hossain, 2014).

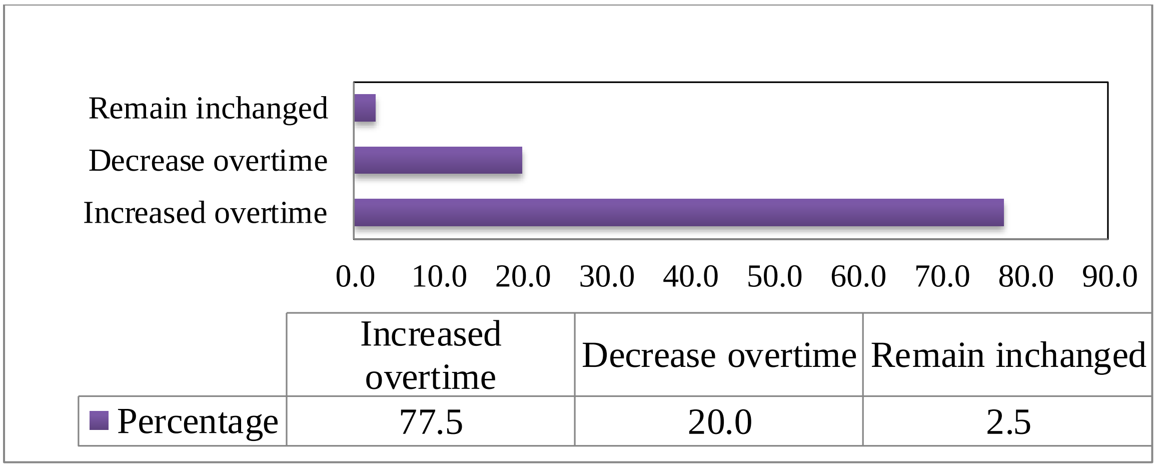

Figure 10: Perception of the respondents on the trend of saline-water intrusion over the last 5-year
Source: Survey, 2017

The findings from Figure 10 show that farmers had perceived an incremental trend in the river’s water salinity over the last five years. This signifies that River Gambia water’s salinity keeps increasing over years, which could induce severe impacts on the soil and therefore reduce rice production, rice being sensitive to the high concentration of salinity.

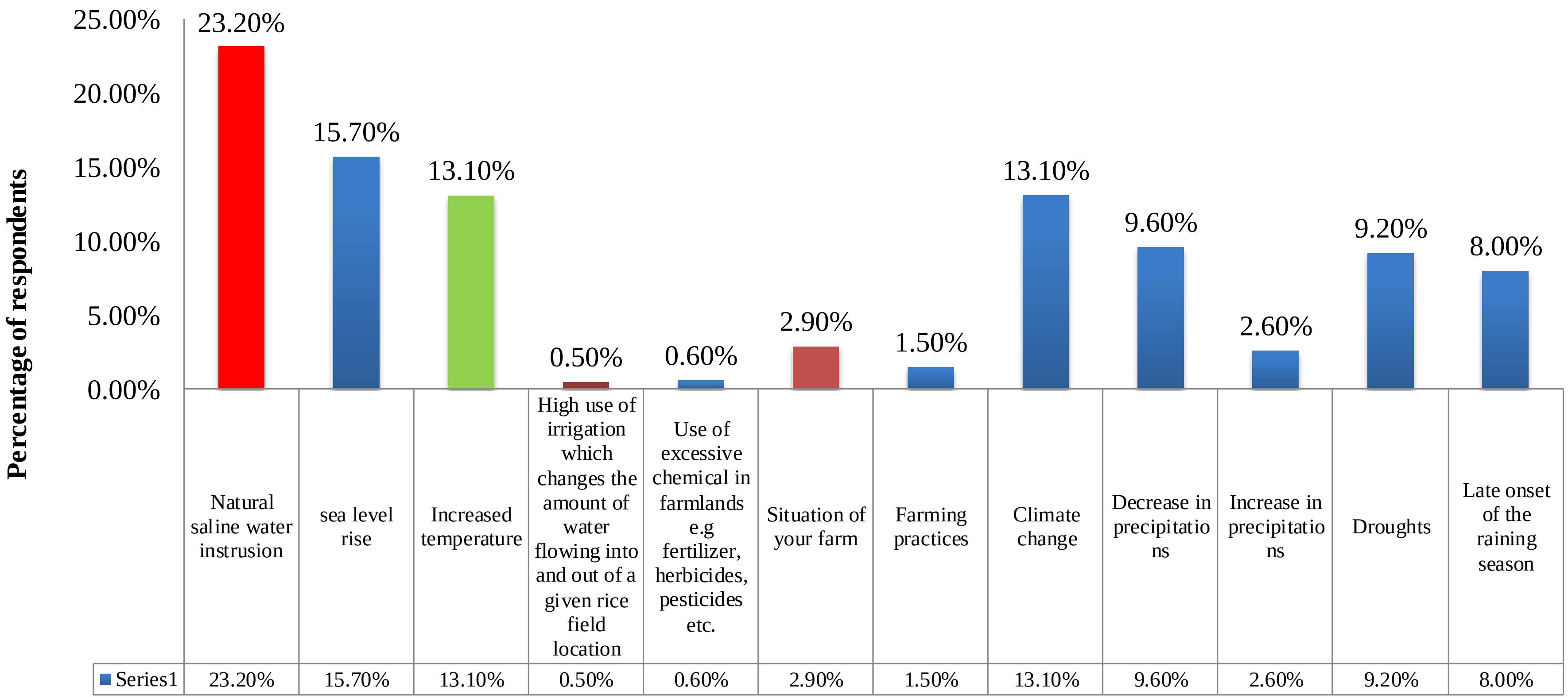

Figure 11: Farmers' Perception of the causes of saline-water intrusion
Source: Survey, 2017

Findings from the study indicated (Figure 11) that the majority of the respondents (23.20%) link saline-water phenomenon to a natural cause whiles 15.70% and 13.10% associated the issue with sea level rise and climate change. This revealed that most of the farmers consider saline-water intrusion phenomenon as a natural event meaning is God-made. Besides the fact that a very large majority of 96% (from Figure 8) of farmers are aware of the existence of saline-water intrusion, there is a divergent view of its causes as Figure 11 illustrated. This draws the attention on the fact that farmers are not able to associate some hazards to human factors, among which climate change is playing a key role. Saline-water intrusion, resulting from a combination of sea-level and erratic or low rainfalls could be technically more complex for the average farmer to understand and to relate it to climate change and variability. Therefore more education and training are needed for an increased understanding of the phenomenon in the study area. This could yield in having farmers well aware of the root causes of the issue as to be in a better position to address it and foresee adaptive strategies that may help them while responding sustainably to it to also increase their yields.

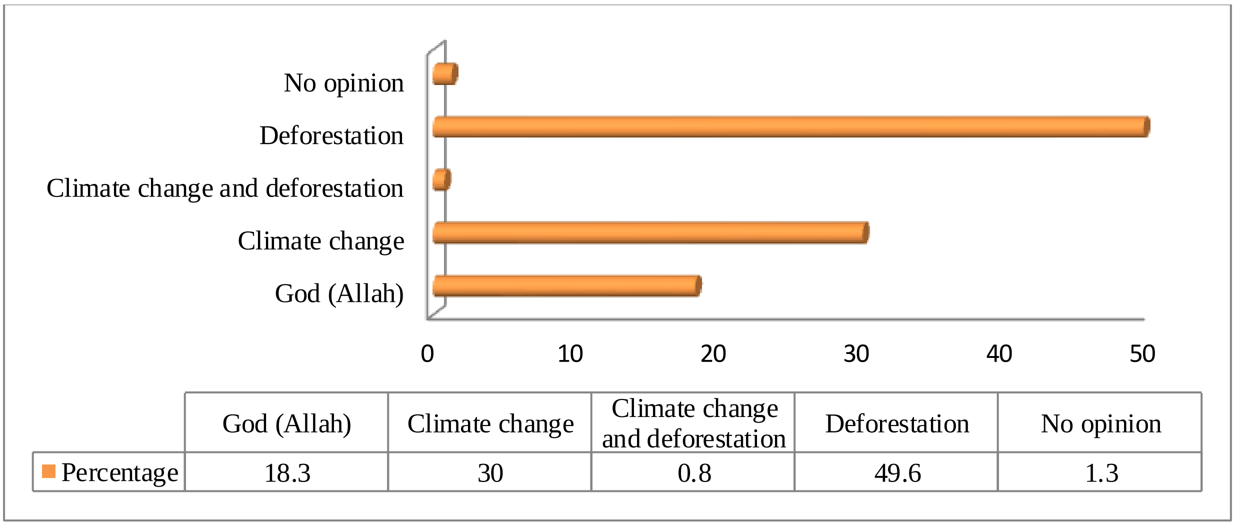

Figure 12: Perception of the respondents on the causes of change in rainfall patterns and amount in the study area
Source: Survey, 2017

From Figure 12 the majority of the respondents (80.4%) attributed the change in rainfall patterns and the amount in the study area to human activities (Deforestation and climate change) while 18.3% attributed its causes to nature (God-made) and 1.3% of the respondents did not have an opinion. The knowledge of the farmers on climate change could imply that farmers are very aware of the phenomenon and this thanks to various programs that have been carried out in the Gambia, especially in the study area on climate change training and workshops organized by various stakeholders (Government level, NGOs etc.)

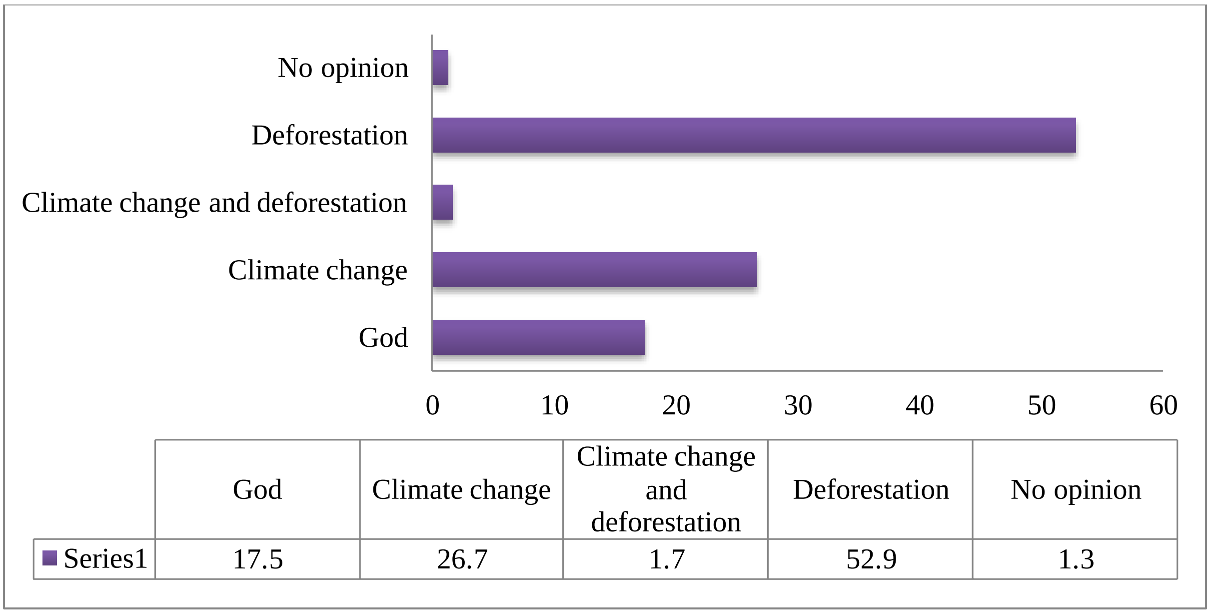

Figure 13: Perception of the respondents on the change in temperature observed in the study area
Source: Survey, 2017

From the research, the majority of the respondents (81.3%) blame climate change and deforestation for the change in temperature observed in their region. This corroborates with their views on the change in the rainfall pattern and amount as illustrated by Figure 13 where the majority of the respondents (80.4%) attribute the change in rainfall patterns to the two causes that are climate change and deforestation. This has the implication that farmers of the study area are very aware of climate change, its manifestations and its causes. This shows a high level of awareness on climate change of rice farmers in the study area.

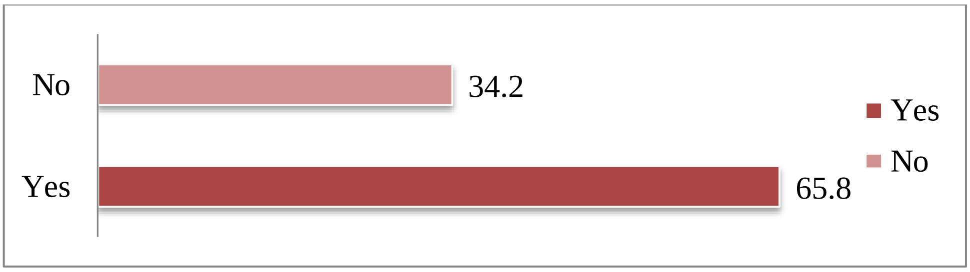

Figure 14: Farmers having and not having uncultivated land
Source: Survey, 2017

The results indicated that the majority of the farmers (65.8%) do not cultivate all their swamp land while 34.2% said they do not have. This explains the unexploited potential of farmlands in the study area; hence limiting rice production and productivity which could contribute to sustaining the well-known subsistence character of rice farming in the region particularly and The Gambia generally. Many reasons can act as constraints and lead to this situation which tends to hinder agricultural development.

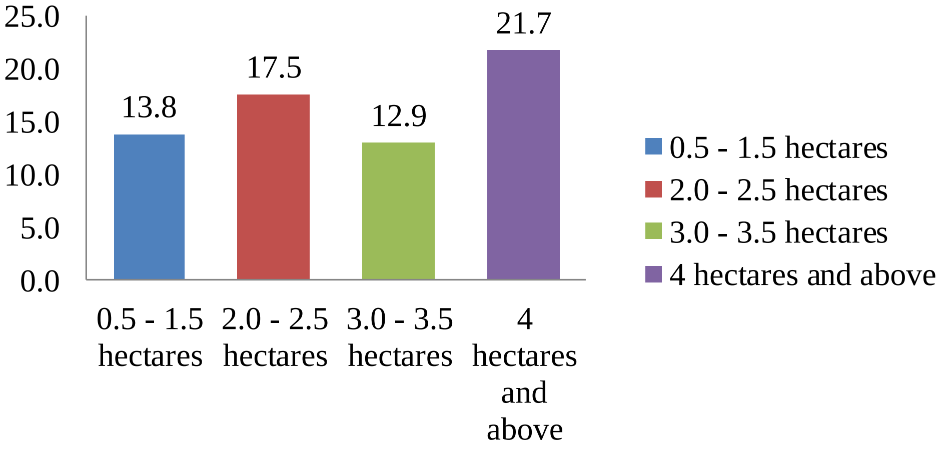

Figure 15: Proportion of farmers having uncultivated land and their size

Source: Survey, 2017

Out of the 65.8% respondents having uncultivated lands, the majority (21.7%) of them disposes of 4 hectares and above as uncultivated land. 17.5% of the farmers had 2-2.5 hectares of uncultivated farmland, 13.8% and 12.9% of them had 0.5-1.5 and 3-3.5 hectares of uncultivated land respectively.

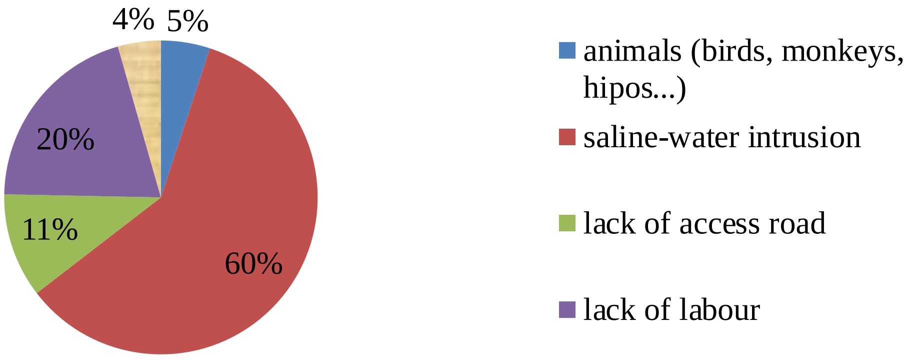

Figure 16: Causes of uncultivated lands in the study area
Source: Survey, 2017

As major reason of uncultivated land, 60 % of the respondents blamed saline-water intrusion as a push factor of leaving uncultivated their farmlands. In most of the cases, they abandoned saline-intruded farmlands where nothing can grow anymore. 20% of the respondents claimed that the lack of labor comes as the second cause. Although the large size for most of the households in the study area, there is lack of manpower because men are not traditionally involved in swamp activity, especially during land preparation which is a difficult task for the women. Because of the hard character of the swamp at the starting of the raining season, they declined to undertake farming operations on some of the available fertile lands. 11% of the respondents who had uncultivated land pointed out the lack of access roads to the swamps as a constraining factor to rice agricultural development in the study area, whilst 5% and 4% of them incriminated wild animals and the lack of farming implements respectively as causes of uncultivated farmlands in the study area.

Table 12: Total of uncultivated area as a result of saline-water intrusion from respondents

Units of farmland (hectare)	Frequency	Uncultivated area for the units of farmland (hectare)
0.5	**18**	8.5
1.50	**17**	25.5
1	**59**	59
2	**14**	7

2.5	**12**	30
3	**7**	21
Total of uncultivated area as a result of saline-water intrusion	**127**	**151.5 hectares**

Source: Survey, 2017

The 60% of farmers who do not cultivate their swampland as a result of saline-water intrusion had lost in total 151.5 hectares of land which could be used to increase rice production, reduce expenditures on food for the households and make savings. These findings show a direct implication of climate change related hazards on Land Use and Land Cover Change patterns which is an increase in unproductive salt land as the result of saline-water intrusion hazard. This is similar to a study undertaken by Barry et al. (2017) on Somone River Basin in Senegal where the barren salt area (Sabkha) has increased from 5.29% to 18.48%. The study showed that the main impact of climate change (fall in rainfall and an increase in temperature) is an enlargement of the salt pans. In such a case, food security and poverty alleviation goals are likely hard to be achieved for the region if alternatives are not made available for the farmers or farmers do not diversify their livelihood strategies.

Table 13: Impacts of saline-water intrusion on swamp rice-growing fields of the study area

Do you think saline-water intrusion impact your rice fields?	Frequency	Percentage
Yes	232	96.7
No	8	3.3
How does it impact your rice fields?		
Increased Production		
Yes	1	0.4
No	239	99.6
Reduced Production		
Yes	188	78.3
No	52	21.7
Increased labor		
Yes	103	42.9
No	137	57.1
Reduced labor		
Yes	19	7.9
No	221	92.1
Increased rice yields		
Yes	0	0
No	240	100
Reduced rice yields		
Yes	229	95.4
No	11	4.6
Reduced cultivated area		
Yes	187	77.9
No	53	22.1
Increased cultivated area		
Yes	3	1.3
No	237	98.7
Reduced income		
Yes	206	85.8
No	34	14.2

Increased income		
No	240	100
Yes	0	0
Saline-water intrusion a problem	237	98.8
Saline-water intrusion as both problem and opportunity	2	.8
No opinion on problem or opportunity of saline-water intrusion	1	.4
Impacts of saline-water intrusion on the soil		
Reduces soil fertility	121	50.4
Affects soil structure	118	49.2
Changes the soil color	1	.4

Source: Survey, 2017

Table 13 showed that the majority (98.8%) of the respondents viewed saline-water intrusion on their rice fields as a problem. 96.7% among them affirmed that saline-water intrusion impacts their rice-growing fields where 78.3% claimed that saline-water intrusion led to a reduction in rice production. Moreover, 77.9% see saline-water to reduce their cultivated 95.4% ascertains that saline-water intrusion reduced their rice yields and 85.8% affirmed that it causes a reduction in their incomes. The majority of the respondents affirmed that saline-water intrusion affects negatively the soil in terms of reduction of the soil fertility (50.4%) whilst (49.2%) affirmed that it affects the soil structure and 0.4% indicated that it led to changes in the soil color.

Table 14: Information and Assistance on saline-water intrusion

Type of information received by the farmers	Frequency	Percentage
Weather/Climate		
Yes	187	77.9
No	53	22.1
Saline-water information		
Yes	166	69.2
No	74	30.8
Sources of saline-water intrusion		
Radio	90	37.5
Television	6	2.5
Extension services	41	17.1
Farmers' Association	31	1.3
Farmer to Farmer	12	48.3
Local drama groups	24	10
Indigenous knowledge	69	28.7
Type of saline-water information received by farmers		
Sensitization/Awareness	79	47.6
Impacts of saline-water	66	39.8
Adaptive measures	21	12.7
Assistance from institutions		
Yes	38	15.8
No	202	84.2
Type of institutions		

Government	35	92.1
NGO/CBO	1	2.6
Community members	2	5.3
Nature of assistance		
Food provision/supply	5	13.5
Construction of soil and water conservation structures	30	81.1
Land donation from neighbors	2	5.4

Source: Survey, 2017

The results from Table 14 show that the majority of the respondents received climate/weather (77.9%) and saline-water intrusion information (69.2%). However, a comparison of the two type of information reveals that saline-water information is less received by the farmers than climate/weather information. This could imply the effective development of climate information delivery to the end-users that are employed in the country. Early warning project currently undergone could be a reason for this high percentage of people receiving climate and weather information in the country, including the study area.

It is also observed from Table 14 that the preferred sources of saline-water information by the farmers are farmer-to-farmer (which comes as the major source of saline-information in the study area 48.3%), followed by radio (37.5%), indigenous knowledge (28.7%) and extension services (17.1%). Farmer to farmer communication is the predominant source of information for rice swamp farmers of the study area since the Gambian's society, especially in its rural settings socialization through sharing and chatting under "Barnabas" is typical to the Gambians. Moreover, farmers justify this situation by affirming that few of them who have gotten saline-water intrusion information from the extension services (which coverage is still low in The Gambia) are compelled to inform and educate other farmers on the issue. Others declared that during their visits in some of the neighbouring villages, or even in Senegal (neighbouring country which also is threatened by saline-water intrusion), where they have seen some improved ways of dealing with salinity on the rice fields. Therefore, they start to apply them once back on their fields. In such cases, the farmer educates his colleagues back home to improve upon their farms' situation of increased salinization and reduce crop failure.

It is found that television and farmer's associations are not the preferred sources of information on saline-water intrusion for the respondents. This is as the result of few rural farmers having TVs in their homes and the majority does not have a source of energy to supply their TVs even if they have. Radio is easily affordable by poor rural communities as compared to TV because it is cheaper. In almost every household in The Gambia, there is a radio where members of the family access information and all the information the government or departments are communicated to the general public through radio (Bojang, 2015). The justification for radio being the second source of information to the farmers is its capacity to reach uneducated farmers in comprehensible language. Also, the study showed earlier (Table 14) that very few respondents' farms are part of a group or network or association. This could explain their least source of information on saline-water intrusion being Farmers' Association. Indigenous knowledge comes in the third position of sources of saline-water intrusion. This confirms that saline-water information dissemination is predominantly done among the farmers by the farmers themselves at their community level. This implies the high use of indigenous knowledge in the study area on saline-water related matters. Also, women farmers in the study area have this way of transferring swamp knowledge and skills to their daughters or daughters-in-law so as to sustain rice cultivation which is a tradition in the rural Gambian. Moreover, rice being the major crop that is cultivated in the region, farmers make sure to pass on their knowledge to next generations so as to sustain the tradition and continuing to feed their families. The low percentage of 17.1% as a source of information from extension services illustrates that saline-water intrusion information is poorly addressed by the extension services in the region as some of the farmers responded. This could be seen in the table below where at the question: do extensions agents pay you visit? The majority of the respondents (52.1%) affirmed by the negative. This corroborates with Bojang (2015)' findings for the same study area where it is reported a high percentage of vegetable farmers without access to extension services. Similar results from Oduniyi (2013) in Mpumalanga province of South Africa also revealed poor access of rural farmers to extension services. This could adversely affect farmer's adaptation to saline-water intrusion as extension officers are responsible for educating and training farmers on agricultural issues. As a result of lack of extension services, farmers stay powerless or in use of their own technologies which might not necessarily be adequate to sustainably face issues that are more complex, namely climate change-induced hazards.

The local drama groups commonly called locally "kajelengo" have been associated with educational programs in The Gambia, especially in climate information through the early warning programme currently run in the country. These local groups are constituted by farmers themselves who after being trained give back to their communities the information received. According to the farmers, for saline-water information, these constituted groups have not participated to any training on the issue, but they sensitize on the matter based on their own experience and indigenous knowledge, since most of their members are generally active elderly persons.

Table 15: Access to Extension Services on Saline-water intrusion

Access to Extension Services	Frequency	Percentage
Yes	115	47.9%
No	125	52.1%

Source: Survey, 2017

Furthermore, the results from Table 15 indicate that awareness on saline-water intrusion is the major type of information that most of the respondents (47.6%) received in the study area. Adaptation to saline-water information's content is only at 12.7% present in the delivery of saline-water information from the preferred sources of information used by the farmers in the study area. This could be explained by the fact that expertise is lacking in the field of mitigation or adapting to climate-related hazards in Africa generally and the Gambia particularly. To illustrate it, very few farmers who received extension services visits on their rice fields undergoing saline-water intrusion, for instance, declared that extension agents came just to see the fields and go back.

Regarding the assistance received by farmers to respond to saline-water information, only 15.8% of the 96.7% (in Table 14) of the respondents who affirmed that saline-water intrusion impacts their rice-growing fields and 84.2% declared not had received any type of assistance when their fields got intruded by saline-water intrusion. This gives current assistance coverage of 15.8% in the study area on saline-water intrusion and related matters. This could involve huge lost and poor yields for the farmers. The largest part of the assistance received by the respondents came from the Government (92.1%) while community members (5.3%) and NGO/CBO (2.6%). The assistance entailed construction of soil and water conservation structures (81.1%), food provision/supply (13.5%) and land donation (5.4%) to the affected households. The construction of water and soil conservation structures has been reported by farmers to be projects run by the government. This is true because, a large number of lowland development projects have taken place in the region (from GALDEP, LADEP, RADEP, NEMA to FASDEP to mention few). These projects constructed causeways, bridges and anti-salt dikes within the region. However, it is not actually enough according to farmers of the region whose in most of the discussions called for government assistance.

Most of the respondents who received assistance from NGOs or CBOs affirmed that these aids were in term of coping and adaptive strategies which are shifting into animal rearing and vegetable gardening for livelihood diversification.

Community members come into support to saline-water affected peoples by donating swamp land to the individuals who since then become the owners of the land. However, the new owners in compensation donate one part of their bumper harvests to the donors over a relative period of 5 years. Some affected communities identified to have had most of these cases of assistance from neighbouring villages are Kanikunda and Karantaba which have been given free swamp land by Jenoi, Toniataba, and Si-Kunda Villages in Jarra West District. This could be explained by the presence of vast swamping areas in these three villages. Therefore, there is available land for their relatives. On the other hand, affected farmers had to walk from one village to the other to continue practicing their farming activities which is time-consuming and tiring. These are some of the challenges that many of the affected farmers have reported.

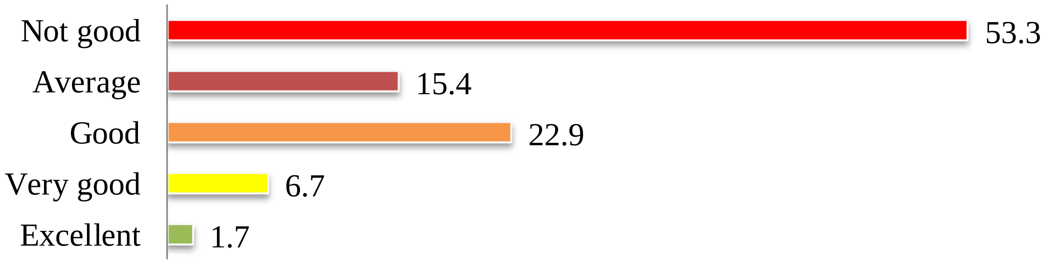

Figure 17: Perception of the respondents on their farm's ability to adapt to saline-water intrusion
Source: Survey, 2017

From Figure 17, the majority of the farmers (53.3%) have rated their farm's ability to adapt to saline-water intrusion as not good whilst 15.4% said it is average, (22.9%) rated their farm's ability to be good, 6.7% to be very good and 1.7% to be excellent. This means that more than half of the study sample size affirmed to be not able to face or adapt to the impacts of saline-water intrusion. For instance, in many cases, farmers declared not being able to rely on their harvests as they used to do in the past where the harvested rice from their swamp fields can sustain the feeding of their families up to the next growing season without buying imported rice. However, it is no longer the case, with the drastic drop in the yields; they can no more fully rely on their farms. The reason why some of them ate once a day or made extra expenditure on the family's feeding. In other cases, they go in for other activities like charcoal mining, vegetable gardening to be able to meet the household food consumption. Farmers reported cases of malnutrition, pregnancy failure, and other related hardships.

4.9. Adaptation Responses to saline-water intrusion used by farmers in the study area

An overwhelming majority (76.70%) of respondents rice farmers declared have employed at least one adaptive measure in response to saline-water intrusion in the region while 23.30% indicated no adoption of any adaptive strategies. This stands as evidence supporting a conclusion that farmers of this area were taking actionable steps and changing practices to tackle saline-water intrusion.

The field survey revealed adaptive responses employed by the farmers in the study area (Figure 14). The majority of farmers (59.60%) used change in the planting date as major adaptive responses to saline-water intrusion. Other adaptive responses to saline-water are: increased use of fertilizers and seeds (56.30%), intensive manure application (55.20%), moving to a different site (48.60%), use of early maturing varieties (35.50%), practicing zero-minimum tillage (32.20%), use of weather forecast (18.60%), use of chemicals: herbicides, pesticides etc. (14.20%), ashes (11.30%), expansion of cultivated area (9.30%), change from crop production to animal rearing (7.70%), change from crop production to marketing of agricultural products (7.70%), change from farming to other occupations (2.20%), sawdust+

groundnuts shells (3.30%), gardening (2.90%), drainage of saline-water out of the field (2.50%), out migration from climate risk zones (1.60%), group approach to climate risk zones (1.10%), construction of local dykes (0.80%), construction of contours (0.80%), construction of dam within the river (0.5%), use of gypsum (0.80%), use of lime (0.4%), and commerce (0.4%) are also used by farmers of the study area to adapt to the negative impacts of saline-water intrusion on their swamp rice-growing fields.

The above farmers' self-reported adaptive responses to saline-water intrusion corroborate with results found in the study conducted by Miah et al (2004) where most of the rice farmers in Pakistan followed different farming practices to reduce salinity effect on the lands and increase crop production. Amongst these responses were the use of ashes, gypsum, fertilizers like urea, and compost. The same results were found in Haider and Hossain (2013) study in Bangladesh where farmers prefer to apply gypsum, lime, urea and phosphate amendments.

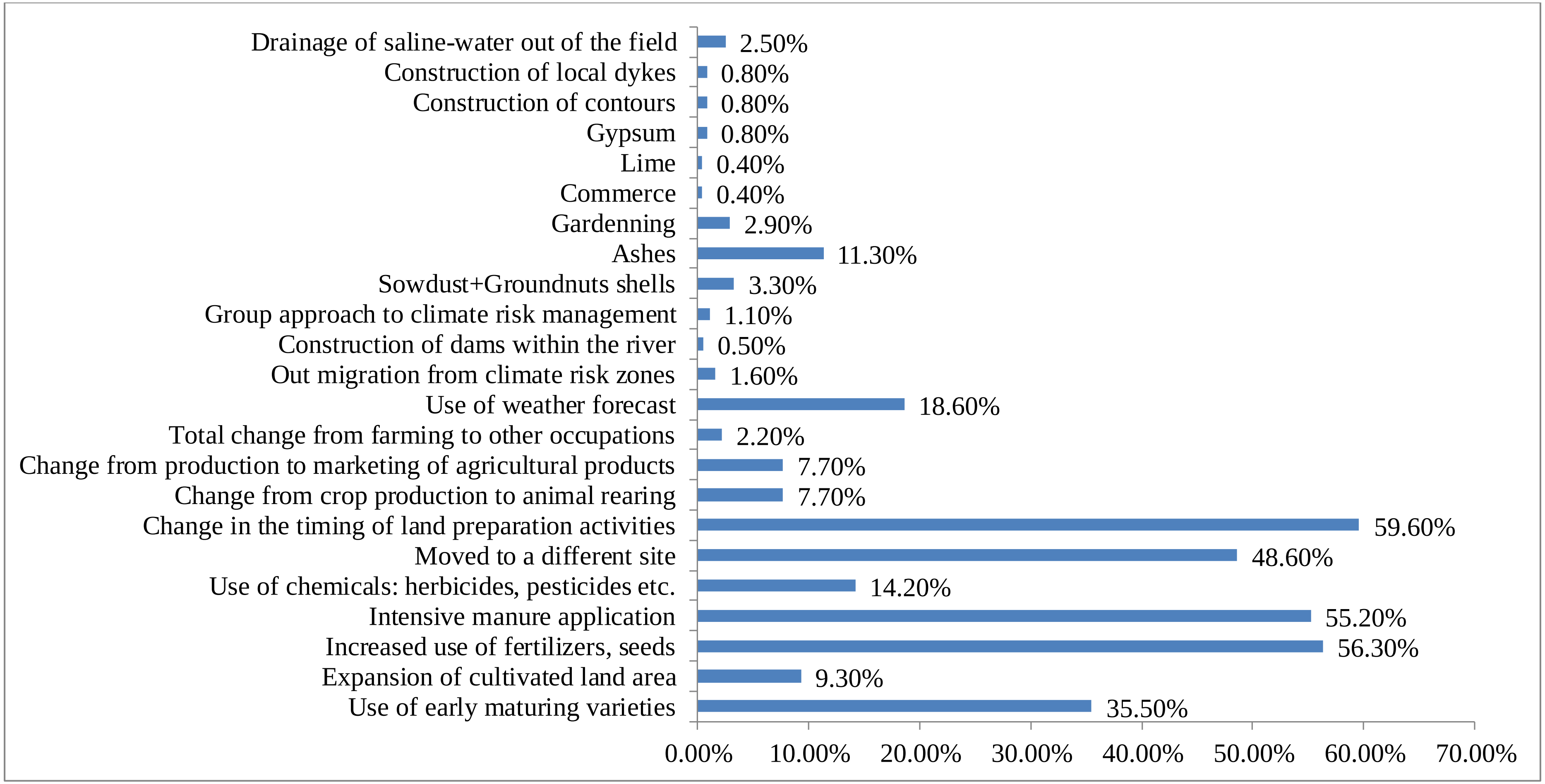

Figure 18: Adaptation Responses practiced by the farmers in the study area
Source: Multiple Responses from Survey, 2017

These adaptive responses can be categorized into two different groups: on-farm adaptation and off-farm adaptation (Table 16).

Table 16: Categorization of adaptive responses used by farmers

On-farm Adaptive Responses	Off-farm Adaptive Responses
1. Change in the planting date	1. Change from crop production to animal rearing
2. Increased use of fertilizers, seeds	2. Change from crop production to marketing of agricultural products
3. Intensive manure application	3. Change from farming to other occupations
4. Moving to a different site	
5. Use of early maturing crops	
6. Use of weather forecast	
7. Use of chemicals: pesticides, herbicides	
8. Use of ashes	
9. Expansion of cultivated area	
10. Sawdust+ Groundnuts shells	
11. Gardening	
12. Drainage of saline-water out of the field	
13. Construction of local dikes	
14. Construction of contours	
15. Gypsum	
16. Construction of dam within the river	
17. Use of lime	

Source: Survey, 2017

Explanations given by farmers on their choices of the above mentioned adaptive responses were to limit saline-water intrusion effects on their rice production or avoid it totally. The majority of farmers adapted by shifting the season calendar to early July as compared to formerly period of June or mid-June. This is a consequence of the late onset of the raining season which was pointed out during the survey as one of the causes of more saline-water in their rice-growing fields.

Moreover, many farmers adopted an increased use of chemical fertilizers and seeds as well as intensive manure application. An explanation given by farmers was that with reduced hectarage (because of lost fields due to salinity), increasing productivity of their farms is the only option left to have good production on fields or areas not intruded by saline-water. Farmers claimed to have learned these techniques from training and importantly from services rendered by extension services in the study area.

The use of early maturing varieties of rice responds to the reduction in the length of the raining season in the study area thus of the growing season from 4 months in the past to currently 3 or 2 months of good rains. This helped farmers to save their harvests despite the vagaries of the climate, especially the inter-annual variations in the climate (revealed by the monthly rainfall over 30-year in the study area). This was confirmed by the farmers during the survey who had observed abnormalities in the pattern and amount of rainfall. On the other hand, harvesting after two months provides women rice farmers the benefits of fewer expenses on imported rice to feed their families.

Farmers applied lime, gypsum, ashes, and sawdust + groundnuts shells on their rice-growing fields to neutralize the salinity of the water and the soil. Gypsum improves soil structural stability by providing a mildly saline soil solution which is not strong enough to adversely affect water uptake by most crops, but which restricts the movement of water molecules into the space between clay particles. Gypsum also contains calcium, which displaces sodium and magnesium from the exchange sites between clay particles thus impoverishes the soil (McKenzie & Orange, 2003). Moreover, the use of gypsum, lime and urea has been revealed by farmers during FGDs as economically unsustainable due to their high costs. As a result, higher saline area's farmers have to incur more expenditure than lower saline area's farmers for dealing with the salinity problem. This is in agreement with Haider and Hossain (2013) whose study also pointed out the economically and environmentally unsustainable character of gypsum and urea application among other adaptive strategies used by rice farmers in four villages from two unions in Asasuni upazila of Satkhira district in Bangladesh. The same study indicated that farmers seem not having any systematic understanding about the probable side effects of gypsum application on their soil, such as an increase in pH level, negative effects on seedling and survival, contaminating nearby watersheds and deficiency of iron, manganese and magnesium.

Some farmers went in for alternative sources of livelihoods like animal rearing, commerce, vegetable gardening to diversify their sources of livelihoods hence to offset the reduced yields encountered as a result of saline-water intrusion.

Besides these major adaptive responses employed by the farmers (mentioned above), farmers reported having adopted coping measures in years where saline-water intrusion was very severe. They reported during the FGDs the following measures:

- Rely on support from other people
- Rely on support from organizations
- Earn extra income to buy food
- Sell assets (e.g., livestock) to buy food
- Reduce food consumption

The above measures helped most of the farmers to cope with a period of low yields resulting from important loss and damage caused by saline-water intrusion, generally in years where saline-water was more pronounced. Most of the FGDs held in the study area revealed an established link between low rainfalls and high salinity of the river. Farmers said they started realizing saline-water intrusion when monthly rainfalls started to decrease over the years and thus low river flow. In fact, they reported the time period of 1970-1980; which coincides with the Sahelian drought to be the worst period where they encountered the most severe saline-water intrusion as a result of low rainfalls. Households found themselves in a difficult period where they had to struggle to survive. Most respondents reported that support in the form of aids came from the government during this period of no farming activity in the swamps because of permanent saline-water in the river as a result of the severe drought.

4.10. Problems encountered in adapting to saline-water intrusion

Table 17: Problems encountered in adapting to saline-water intrusion

Problems encountered by farmers in adopting to saline-water intrusion	Percentage
Poor access to information source relevant to adaptation	76.3
Type of land tenure system practiced in my area	14.2
Ineffectiveness of indigenous strategies	61.3
Traditional beliefs do not allow me to use the adaptive strategies	35
Lack of financial resources	77.9
Poor/Low extension services	78.8
lack of access to saline-water information forecasts	64.6
Limited access to improved crop varieties	74.6
High cost of improved crop varieties	73.8
Absence of government policy on adaptation to saline-water	73.8
Non-availability of credit facilities	74.2
Limited knowledge of adaptation measures	74.2
Poor response to saline-water intrusion by the government agencies	75
Risk of adaptation	72.1
High cost of fertilizers and other inputs	74.2
High cost of irrigation facilities	72.9
Nonavailability of farm inputs	73.8
Inadequate knowledge on how to cope	75.8
Non-availability of farm labor	69.6

Source: Multiple Responses from Survey, 2017

Table 17 describes the challenges faced by farmers in applying adaptive strategies to saline-water intrusion in the study area. These above-mentioned challenges faced by swamp rice farmers tend to exacerbate the burdens caused by saline-water intrusion on the lives and livelihoods of farmers. It clearly depicts areas where improvements need to be done.

These findings revealed signs of failing of adaptive strategies employed by the farmers of the study area. 76.3% of the surveyed households affirmed to have poor access to information source relevant to adaptation, 61.3% revealed that the ineffectiveness of indigenous strategies led to the failing of their adaptive measures. 73.8% affirmed the absence of government policy on adaptation to saline-water, 74.2% declared the limited knowledge on adaptation measures, 75% acknowledged poor response to saline-water intrusion by the government agencies and 75.8% revealed their inadequate knowledge on how to cope. Based on these results, it literally means that the current adaptive responses employed by more than half of the farmers were not enough to offset the negative impacts of saline-water intrusion in the study area.

4.11. Factors influencing adaptation to saline-water intrusion

Table 18: Results of Logit Regression on factors influencing farmers' adaptive responses to saline-water intrusion

Adaptive Responses	**Coef.**	**Std. Err.**	**Z**	**P>|z|**	**[95% Conf. Interval]**	
Age	.0427977	0.21139	0.39	0.695	-0.0331513	0.049712
Education	-0.9604682	0.4292801	-2.24	0.025**	-1.801042	-0.1190946
Farming experience	-0.262785	0.195769	-1.34	0.179	-0.646485	0.120916
Household size	-0.711876	0.356973	-1.99	0.046**	-0.141153	-0.0012222
Gender of Household	-0.8143119	0.8853898	-0.92	0.358	-2.549644	0.9210203
Access Extension	1.816112	0.4322575	4.20	0.000***	0.9689025	2.663321
Access saline-water Information	-0.5903793	0.4021102	-1.47	0.142	-1.378501	0.1977423
Marital Status	-0.9758703	0.5961067	-1.64	0.102	-2.144218	0.1924773
Constance	4.312138	1.245112	3.46	0.001	1.871763	6.752513

Number of obs = 240 LR chi2 (8) = 55.63

Prob > chi2 = 0.0000

Log likelihood = -100.1456 Pseudo R2 = 0.5874

*** and ** means statistically significant at 1% and 5% respectively.

The logit regression analysis indicated (Table 18) that at 5% significance level, two factors are statistically significant in influencing the choice of adaptation of swamp rice farmers to saline-water intrusion in the region. The factors are education and household size. Both factors (with their respective coefficients all negative z=-2.24 for education and z=-1.99 for household size; z<0) influence negatively swamp rice farmers' choice for adaptation. In other words, it means that the low educational level of rice farmers in the study area did not prevent them to adapt to saline-water intrusion on their rice-growing fields and farmers with small household size are most likely to undertake adaptive measures to saline-water intrusion in the region.

Education negatively and significantly (at 5%) affects farmers' adaptation strategies choice to saline-water effects. This implies that the probability of adaptation to saline-water intrusion is greater for those who have lower educational attainment compared to highly-educated or literate farmers. This could be perceived as in contradiction with the logic being that educated people have more knowledge and greater ability to understand and respond to anticipated changes than non-educated ones. Previous studies on agriculture adaptation to climate change found that education positively and significantly affects adoption of technology (Acquah, 2011; Deressa et al, 2011; Quayum *et al*, 2012; Adeogun et al, 2008; Maddison, 2006; Jaim and Mizanur, 1999; Alam, 1995; Asaduzzaman, 1988; Bhuiyan, 1981) but particularly for upland farming that are threatened mostly by dry spells and droughts. For this study, in particular, this result could be explained by the fact that majority (80.4%) of the farmers did not have formal education (Quranic included) thus they were not having other options than to autonomously adapt to the changes in their environment to survive based on human behavioral system of reaction and adaptation to changes (behavioral theory). Moreover, since the majority of farmers rely heavily on swamp rice farming as main source of livelihoods for their family in the country (NRDS, 2014; Carney, 1998) and increasingly because of the fact that rice is the major crop cultivated in the region (DOA, 2013), farmers did not have any choice than to adapt. Moreover, it is evidenced that rice is the staple food of the country (Fatajo, 2009). However, these results corroborate with Okeye (1998) and Gould et al. (1989) who found that education was negatively correlated with decisions to adopt natural resource management initiatives.

Household size is negative and significantly (at 5% level) related to farmers' adaptation strategies to saline-water intrusion. However, the negative sign of this relationship is contradictory to our initial hypothesis. This negative sign indicates that with increasing size of the family, the probability of farmers' adoption of an adaptive strategy decreases. Prior to this study, it was expected that the sign of the variable family size would have a positive sign, the logic being that large family size makes available more labour which can actively engage in work hence facilitating the adoption of adaptive measures to saline-water intrusion. This guess was in line with the results of analogous works on climate change adaptation strategies done by Deressa *et al.* (2008, 2009), as well as the large body of literature on technology adoption such as Mignouna *et al.*(2011), Tiamiyu *et al.* (2009) and many others. Given this negative results, a profounder look at the literature and the survey's results on labour availability within the household and its impact on the tendency to adopt new technologies or farming strategies was required. A variety of potential explanations for the negative sign found in the work emerged which tends to lead to a flight to quality of a household's labour endowments and a reduction in actual internal labor availability: (1) Farmers revealed to have low labour resulting from the fact that swamp rice farming in the country is traditionally the domain of women (Carney, 1998) thus male in the study area do not have interest in swamp rice farming by even helping women, (2) Farmers also pointed out the unavailability of children busy with school. Other studies, such as that of Quayum and Ali (2012) have shown that family size was negatively and significantly related to adoption of technologies, but there is no definitive causation shown in the literature reviewed for preparing this work.

Findings from the model also unveiled that access to extension services statistically influence positively at 1% the choice of swamp rice farmers to adapt to saline-water intrusion. This means that the more access to extension services the higher is the probability for farmers to adopt adaptation measures to combat saline-water intrusion in the area. Extension services are essential in dissemination of information, knowledge and new technologies among farming communities. Therefore, farmers who have significant extension contacts have better chances to adapt.

4.12. Identifying most affected villages

4.12.1. Data gathered as reported from the FGDS

From the FGDs, saline-water intrusion in this region started as far back as 60 years and is as a result of combined effects of low amount of rainfalls, deforestation, late onset of raining season, early cessation of rainfalls, rise in temperatures and sea-level rise from the majority of the respondents in the study area. However, few of them attributed the phenomenon to nature or God.

As impacts, all of the respondents acknowledged a decrease in their production as saline-water intrusion spoils the soil and diminishes its fertility (reduction in productive lands). Thus it led to reduction of number of meals per day thus aggravating food insecurity condition in some households. It induced loss of forest cover along the river banks. The saline-water penetrates in some cases into uplands and gardens serving as an alternative source of livelihoods for the farmers. It led to groundwater contamination as farmers indicated saline-water presence in their wells. Roofs on top of houses easily got rusted because of saline-water into the river. The month of August well known in The Gambia for its highest record in rainfall amount can no more help in pushing back the saline-water front towards the ocean due to a decrease in rainfall amount over years.

As part of the challenges encountered by the farmers, it is identified no resources to fight saline-water intrusion, lack of adequate knowledge on saline-water intrusion adaptation and lack of support from the government. Nonetheless, in the face of such impacts and challenges, some farmers are taking advantage of the situation by extracting salt from the river even though at a very small scale and used it for household consumption and sale.

To counter and adapt to the issue, farmers evidenced a wide range of forms of coping and adaptive strategies (responses) which are out-migration from risk zones to other villages to farm, making of contours on the farm, switching from swamp to the uplands, planting of mangroves by some communities, using of early-maturing varieties, drainage of saline-water out from the farm, construction of manually and locally-made dykes and dams (made with clay and small stones), using of chemical fertilizer and intensive manure application to increase farm's productivity and to make rice ripe early before shortage of rainfall and saline-water intrusion occurrence, using prayers asking for God's intervention, use of acid from old batteries and sow dust to neutralize the salt, diversification of livelihood activities through gardening, charcoal burning and tree logging. Few mentioned assistance from government and NGOs through support in food and construction of soil and water conservation structures (anti-salt dykes, bridges, causeways and spillways) which according to them is few.

Finally, as solutions, farmers identified a broad series of actions to the devastating effects of saline-water intrusion. Identified solutions were: government assistance for irrigation facilities helping to flush the saline-water by diluting the salt content in the river water, construction of anti-salt dykes, causeways, bridges, and dams. Furthermore, they advocated for support in farming implements, tree planting activities along the river banks to restore the depleting mangroves which have a huge ecological benefice to many species and can also serve as buffer to saline-water intrusion, assistance in salt tolerant varieties and early-maturing varieties and maintenance of water and soil conservation structures.

4.12.2. Identified most affected villages from the FGDs

Based on views of farmers during the FGDs sessions held in each sampled village, farmers recognized some villages which are severely affected by saline-water intrusion and where most of the farmers had lost their farms. These villages were: Kundong Numu Kunda in Kiang Central whose farmers got new farmlands in Mandina because of being severely impacted by saline-water intrusion, Karantaba and Kanikunda farmers in Jarra West used to walk far distance to farm in Pakalinding, Toniataba and Jenoi. Tembeto and Marikoto villages' farmers in Jarra Central used to go as far as Soma to continue farming and provide food for their various families.

5. CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

The study came up with five major findings:

1. There is no statistical evidence on the link between rainfalls and rice production in the study area. However, it came to conclude that saline-water intrusion in swamp-rice growing fields in Lower River Region comes from the combined effects of climate variability and sea-level rise which both impact negatively rice production as monthly rainfall data revealed and backed up by respondents who confirmed abnormal distribution in rainfall patterns. In addition, rice farmers pointed out climate change and importantly sea-level rise as precursors of saline-water intrusion. More than half of the surveyed farmers have abandoned in total 151.5 hectares of land because of salinization of their farmlands, thus a reduction of their rice production.
2. The awareness level on saline-water intrusion in the study area is very high (96%) and denotes that farmers were aware of the root causes of the phenomenon. Droughts, low rainfall, late onset of the raining season, sea-level rise and climate change were recognized by the farmers as the root causes of saline-water intrusion in the study area.
3. Farmers have adapted to saline-water intrusion to minimize its impacts on their livelihoods through a wide variety of on-farm and off-farm activities. Nonetheless, the adaptation responses are still poor performing regarding the loss in term of cultivable lands. This has been due to a combination of many factors that constitute the challenges for adequate adaptation; amongst which lack of adequate knowledge and technology, poor assistance, lack of finances and capacity building.
4. Adaptation to saline-water intrusion in the study area was revealed to be influenced by factors which were education, household size and extension service.

5. Some communities have been identified to be most affected by saline-water intrusion based on the FGDs sessions where these farmers affirmed to have gotten most of their fields become permanently saline and had to go to farm in other villages and districts at far.

5.2. Recommendations

At the end of the study, a series of recommendations arise from the findings mentioned in this report. Therefore, the study recommends the following:

1. Training and capacity building on a regular basis for farmers and agricultural extension agents on saline-water intrusion-related matters, especially in the area of adaptation technologies to saline-water intrusion.
2. Dissemination of climate and saline-water information and knowledge should be carried out through mediums such as farmer to farmer and extension services in the study area. It is highly recommended that farmers should organize themselves into groups or associations thus enabling them to get support from donors or NGOs.
3. Research and development activities need to be carried out to provide farmers with salinity resistant, early-maturing and high yielding crop varieties suitable for the local conditions. For this purpose, the genetic potential of local crop species must be investigated and specimens stored in seed banks.
4. Government, donors and other stakeholders are recommended to extend the construction of soil and water conservation structures (anti-salt dikes, bridges, causeways, spillways, etc.).

5. Government, donors, and other stakeholders should intensify Agriculture Support programs and organize training on livelihood diversification to swamp rice farmers in the most affected communities.

5.3. Suggestions for further Research

To mention few, further areas of investigation could be made as per the following:

- Assessment of the documented adaptation options found in the study area to effectively address saline water intrusion
- Assessment the impacts of saline-water intrusion on land cover/use change of the region
- Examining the level of salinity on rice-growing fields in the growing season

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APPENDICES

Farmers' Questionnaire

We invite you to take a few minutes to complete this questionnaire. This is a questionnaire for Master's Research Thesis to collect primary data so as to help in assessing Rice Farmers' Adaptive Responses to Saline-water Intrusion in Lower River Region, The Gambia.

Section A: DEMOGRAPHICS

Name of Interviewer ____

Date of interview___________ Questionnaire number______________

District ___________________

Village ________________________

Phone.No.__________________________________

1. Age of Farmer? _______________________
2. Years of farming experience_____________________
3. Gender of the household head? (1) male (0) female
4. Marital Status? 1. Single ( ) 2. Married ( ) 3. Divorced ( ) 4. Widowed ( )
5. Number of people in the household ___________________________________

SECTION B: SOCIO-ECONOMIC LEVEL

6. What is the ownership structure of your farm?

Family / privately owned	(100 %)	☐	
Foreign owned	(100 %)	☐	
Government leased	(100 %)	☐	
Joint venture		☐ →	Local private equity ______%
			1. Foreign equity ______%
			2. Government ______%

7. Is your farm part of a larger group e.g. national organization, network, association, consortium or corporation? 1.Yes ☐ 2.No ☐
8. If yes, specify ____
9. What are the main rice cultivars grown in your area? (Please tick relevant themes)

(a) Local rice ☐

(b) NERICA Rice ☐

(c) ITA 306 or IET 3137 ☐
(d) Others ☐

10. Size of farm (Please tick one):
(1) Small - sized< 5 ha ☐ Specify size……… (2) Medium -sized 5 – 20 ha ☐ Specify size…….
(3) Large – Commercial > 20 ha ☐ Specify size…….. (4) Other (specify) ………………

11. Uncultivated land and Why? ……………………………………………..

12. What is your highest academic level attained?
(1) Primary school ☐ (2) Secondary school ☐ (3) Certificate Course ☐ (4) Diploma☐
(5) B.Sc. ☐ (6) None ☐ (7) Others (specify) __________

SECTION C: SALINE-WATER INTRUSION

C1: Awareness and Knowledge of saline-water intrusion Phenomenon

13. Have you heard of saline-water intrusion before now? (1) Yes ☐ (2) No ☐
If YES, what did you hear about saline-water intrusion in rice field(s)?

____

If NO, why not?

____

14. When was the first time that you had saline-water intrusion in your rice fields?

____

15. What are the causes of saline-water intrusion in your rice-growing fields?

Natural saline water intrusion (1) Yes ☐ (2) No☐
Sea level rise (1) Yes ☐ (2) No☐
Increased temperature (1) Yes ☐ (2) No☐
High use of irrigation which changes the amount of water flowing into and out of a given rice field location (1) Yes ☐ (2) No☐
Use of excessive chemical in farmlands e.g. fertilizer, herbicides, pesticide etc. (1) Yes ☐ (2) No☐
Situation of your farm (1) Yes ☐ (2) No☐
Swamp land reclamation (1) Yes ☐ (2) No☐
Farming practices (1) Yes ☐ (2) No☐
Climate Change (1) Yes ☐ (2) No☐
Decrease in precipitations (1) Yes ☐ (2) No☐
Increase in precipitations and/or flood (1) Yes ☐ (2) No☐
Droughts (1) Yes ☐ (2) No☐
Late onset of the raining season (1) Yes ☐ (2) No☐
Others (specify) ____

16. Do you think that saline-water intrusion impacts your crop rice fields? (1) Yes ☐ (2) No☐ ____

17. If YES, how does saline-water intrusion impact your rice fields?

1. Increased production ☐ 3. Increased labour 5. Increased rice yields☐ 7. Reduced cultivated area☐

2. Reduced production☐ 4. Reduced labour☐ 6. Reduced rice yields☐ 8. Increased cultivated area☐ 9. Reduced income ☐ 10. Increased income ☐

18. Do you see saline-water intrusion in your rice field as?

1. Opportunity ☐ 2. Problem ☐ 3. Both Opportunity and Problem ☐

19. Explain why you view saline-water intrusion as an opportunity or a problem or both?

____

20. When during the year is saline-water intrusion the most obvious? Please tick

1. Onset of the rainy season 2. Onset of the dry season 3. During the raining season

4. During the dry season 5. End of the dry season 6. End of the raining season

Others (Specify):____

21. How has the salinity level in the water in your rice fields changed in last past five the years?

1. Increased overtime ☐

2. Decrease overtime ☐

3. Remain unchanged ☐

24. What are the effect(s) and/or impact(s) of saline-water intrusion on the soil or cultivated land? Please tick

1. Reduces soil fertility

2. Affects soil structure

3. Change soil colour

____

26. In your opinion, what is the cause of the change in rainfall pattern and amount?

____

27. In your opinion what is the cause of change in temperature?

____

C3: Adaptation measures used by Farmers

30. Which of the following measures have you used in your rice farming practice in the past 5 years? Please indicate by ticking (√)

Adaptation Measures	**1. Yes**	**2. No**
Planting of trees		
Use of resistant varieties		
Expansion of cultivated land area		
Increased use of fertilizers, seeds		
Intensive manure application		
Increased weeding		
Use of chemicals: herbicides, pesticides etc.		
Moved to a different site		
Change in the timing of land preparation activities		
Changes in planting dates		
Practicing zero / minimum tillage		
Changes in harvesting dates		
Change from crop production to animal rearing		
Change from production to marketing of agricultural products		
Total change from farming to other occupations		
Prayers for God’s intervention		
Planting of early maturing crops		
Use of weather forecast		
Out migration from climate risk zones		
Construction of dams within the river		
Group approach to climate risk management		
Migration		

C4: Problems Encountered by Farmers in Adapting to the Impacts of saline-water intrusion

32. Tick the appropriate options, problems encountered in adapting to the impacts of saline-water intrusion.

S/N	**PROBLEMS**	**1. Yes**	**2. No**
1.	Poor access to information source relevant to adaptation		
2	Type of land tenure system practiced in my area		
3	Ineffectiveness of indigenous strategies		
4	Traditional beliefs/ practices does not allow me to use the adaptive strategies		
5	Lack of financial resources		
6	Poor/low extension services		
7	Lack of access to weather forecasts		
8	Limited access to improved crop varieties		
9	High cost of improved crop varieties		
10	Absence of government policy on adaptation		
11	Non-availability of credit facilities		
12	Limited knowledge on adaptation measures		
13	Poor response to crises related to saline intrusion by the		

	governments agencies and interest groups		
14	Risk of adaptation		
15	High cost of fertilizers and other inputs		
16	High cost of irrigation facilities		
17	Non-availability of farm inputs		
18	Non-availability of processing facilities		
19	Inadequate knowledge of how to cope		
20	Non-availability of farm labour		
21	High cost of farm labour		

C5: Services provided by the Department of Agriculture

33. Do the extensions agents pay you visit? (1) Yes ( ) (2) No ( )

If yes, how many times have they visited you in the last 12 months?

____

34. Please tick the appropriate options the activities of the extension service in your locality as it applies to saline-water intrusion

S/N	**Extension activities available**	**1. Yes**	**2. No**
1)	Demonstration / training on the use of adaptive measures (e.g. mulching) to cushion the effects of saline-water intrusion		
2)	Visiting sites that are undergoing changes due to saline-water intrusion		
3)	Advisory services on how to manage farm to reduce the effect of saline-water intrusion		
4)	Awareness creation on the effects/consequences of saline-water intrusion		
5)	Organizing public shows on saline-water intrusion		
6)	Excursion showing varying climate situations		
7)	Field days where discussions on effect of saline-water intrusion is discussed		
8)	Others specify --		

35. Please rate your farm’s ability to adapt to saline-water intrusion. **Circle** as appropriate
(1) Excellent (2) very good (3) good (4) average (5) not good.

C6: Network collaboration

36. Have you ever received weather/climate information? 1. Yes ( ) 2. No ( )
37. Have you ever received saline-water information? 1. Yes ( ) 2. No ( )

38. If yes, what type of information? 1. ---

2. ---

If NO, why?

....

39. What is (are) the source (s) of the information? Please tick

1. Radio 3. Extension services 5. Farmers' Association 7. GSM companies

2. Television 4. NGOs 6. Farmer to farmer 8. Local drama groups

9. Indigenous knowledge
10. Others
(Specify)……………………………………………………………………………………
…………………………………………………………………………………………………
…...

40. Has any Institution assisted you with ways to respond to saline-water intrusion risks in your locality / farming activities? 1. Yes ( ) 2. No ( )

41. If YES, what type of Institution? 1) Government agency -----------------------------
2) NGO/CBO ( ) 3) Private Organization ( ) 4) Community members ( )

5) Others specify ---
If NO, why?
....

42. What was the nature of assistance rendered?
1 ---

2 ---

Focus Group Discussion

A. Part of holding the focus group

Country: The Gambia	
Region: LRR	
District:	
Village:	
Name of the leader :	
Date of discussion realization :	
Starting hour	
Ending hour	
Language used in discussion	

Participants' characteristics

N°	1. Sex	2. Age Bracket	3. Education Level	4. Matrimonial situation	5. Ethnic group	6. Occupation	7. Religion
01							
02							
03							
04							
05							
06							
07							
08							
09							
10							
11							
12							

1 = Male, 2 = Female

1 = 18-24 years, 2 = 25-34 years, 3= 35-44years, 4= 45-54 years, 5 = 55-64 years, 6 = 65 and plus

1 = Non educated, 2 = Primary school, 3 = Secondary school, 4 = University, 5 = other

1 = single, 2 = Married, 3-Divorcee, 4- Widow or widower

B. INTRODUCTION

Hello, you are all welcomed to this focus group discussion. My name is …………………………………...My colleagues here with me are called …………………………………...I am a student who wants to know more about the adaptive responses to saline-water intrusion in your community. Thank you for agreeing to participate in this meeting despite your busy schedule.

Thus we shall discuss about farmers’ adaptive responses to saline-water intrusion. You are invited to discuss freely, but please one after another. There is no right or wrong answers, all answers are welcome. The information you provide is very important. That is why we ask you to answer honestly and truthfully to questions. My colleague present here will serve as an interpreter and I will be taking notes.

Because I might not be able to log everything and as we do not want to lose any of your ideas, we would like to record our discussion with permission. I want you to know that anything said will remain confidential and will be treated anonymously. Thank you.

C. Perception and Attitudes regarding saline-water intrusion and climate change

Themes	Questions	Responses
1- Historical aspect of saline water intrusion in the area	1.1 Since when have you been experiencing the negative impacts of saline-water intrusion and the types of associated problems in your community?	
	1.2 Have you lost farmland? And to what extent (size)?	
	1.3 What is the distance between your village and farmlands (Km)?	
	1.4 According to you what are the causes?	
2. Perception on climate change	2.1 Have you ever heard the word climate change?	
	2.2 Is there a link between climate change and saline-water intrusion?	
	2.3 What is the link between climate change and saline-water intrusion?	
3. How they cope with saline-water intrusion/ adaptation	3.1 What do you do to face and cope with saline-water intrusion?	

	3.2 Are you equipped to face saline-water intrusion? Have you some propositions or solutions?	
4-The perception of saline-water intrusion	4.1 Do you think that saline water affects household assets? If yes how? (list the effect or impacts)	
	4.2 Do you think saline-water affects food and nutrition security of the household? If so, how? (list and describe the effects or impacts)	
	4.3 Do you think saline-water worsens poverty and living conditions of the household? If so, how? (list and describe the effects or impacts)	

Questionnaire administration in the study area

Focus Group Discussion Sessions in the study area