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QUALITY SEED AND RICE PRODUCTION IN SIERRA LEONE: AN ASSESSMENT OF THE CHALLENGES FACED BY SMALL HOLDER RICE FARMERS

A Thesis Submitted to the Department of Agriculture and Rural Development, in Partial Fulfilment of the Requirements for the Award of a Master of Science (M.Sc) degree in Agriculture and Rural Development

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BUEA, APRIL 2015

CERTIFICATION

I hereby certify that this thesis entitled "**Quality Seed and Rice Production in Sierra Leone: an assessment of the Challenges faced by smallholder rice farmers**" was done by Bridget OyahKamara under my supervision.

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DECLARATION

I Bridget OyahKamarahereby certify that I am the sole author of this thesis done with the counseling of my supervisors and that no part of this thesis has been published or submitted for publication.

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I declare that this thesis has not been submitted for a degree to any other University or Institution of Higher Learning.

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Signature and Date

DEDICATION

To my late mother Mrs. Mary Stella Kamara.

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LIST OF ABBREVIATIONS AND ACRONYMS

ABCs Agricultural Business Centers
AESA Agro Ecological System Analysis
AESD Agricultural Extension Services Division
AfDB African Development Bank
AML African Mineral Limited
CAADP Comprehensive African Agriculture Development Programme
CARD Coalition for African Rice Development
CBs Community Banks
EU European Union
FAO Food and Agriculture Organization
FBOs Farmer Based Organizations
FEWs Frontline Extension Workers
FFS Farmer Field School
FGD Focus Group Discussion
FSAs Financial Services Associations
GAFSP Global Agriculture and Food Security Programme
GDP Gross Domestic Product
GoSL Government of Sierra Leone
HIV/AIDS Human Immune Deficiency Syndrome
ICAR Indian Council for Agricultural Development
ICARDA International center for Agricultural research in Dry Areas
IFAD International Fund for Agricultural Development
IPPC International Plant Protection Convention
IRAD Institute for Agricultural Research
IRRI International Rice Research Institute
ISTA International Seed Testing Association
IVS Inland Valley Swamp
JICA Japan International Cooperation Agency
MAFFS Ministry of Agriculture Forestry and Food Security
MDGs Millennium Development Goals
MFMR Ministry of Fisheries and Marine Resources
MOFA Ministry of Food and Agriculture

MNRDP Multi Nerica Rice Dissemination Project

MRU Mano River Union

NERICA New Rice for Africa

NGOs Non-governmental Organizations

NARS National Agricultural Research Systems

NASSP National Agriculture Support Services Programme

NMJD Network Movement for Justice and Development

NSB National Seed Board

NRSD National Rice Development Strategy

NSADP National Sustainable Agriculture Development Programme

NSS National Seed Secretariat

PAID-WA Pan African Institute for Development West Africa

PVS Participatory Varietal Selection

QDS Quality Declared Seed

RARC Rokupr Agricultural Research Center

RFCIP Rural Finance and Community Improvement Project

SADC Southern Africa Development Committee

SCP Smallholder Commercialization Programme

SLARI Sierra Leone Agricultural Research Institute

SLeSCA Sierra Leone Seed Certification Agency

SPSS Special Package for Social Sciences

SMP Seed Multiplication Project

SMU Seed Multiplication Unit

TandV Training and Visit

UAES Unified Agricultural Extension System

UPOVA Union for the Protection of Plant Varieties

VRC Varietal Release and Registration Committee

WAAP West African Agriculture Productivity Programme

WARDA West African Rice Development

WTO World Trade Organization

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ABSTRACT

Quality seed is considered one of the most vital inputs in crop production. This study was conducted in 2014, to assess the quality of seed rice and the challenges faced by smallholder rice farmers in Bombali and Kambia districts in Sierra Leone. The study used questionnaires, interviews, focus group discussions and an experimental design to collect data. Findings from the study revealed that thirty three different seed rice varieties were cultivated in Bombali and Kambia districts over the past three years (from 2011 to 2013). The distribution of seed varieties was related to ecological and cultural differences. A student t-test (at the 95 percent confidence interval) reveals that there was a significant difference between the mean germination percentages obtained in the laboratory and that of the greenhouse experiment ($t_{calculated}$ = -5.882, $t_{critical\ value}$ = ±3.182, at 95percent confident interval). On one hand, the results show that Pa Kiamp has the best quality (90percent and 59percent germination in laboratory and greenhouse conditions, respectively) compared to the other three seed rice varieties (Pa Chiam, Butter cup and ROK 24) though it has the lowest vigor (90percent and 32percent at 2 cm and 4 cm depth, respectively). On the other hand, the results show that ROK 24 has the worst quality (20percent and 5percent germination in laboratory and greenhouse conditions, respectively) compared to the other three seed rice varieties though it had the best vigor (100percent at 2 cm and 4 cm depth, respectively). Mindful of the fact that smallholder farmers struggle to improve on rice production in Bombali and Kambia districts, they are often challenged by: limited resources (financial, material and human); limited technical support and training from the government; threats from pest and diseases, land tenure and limited infrastructure for post-harvest handling. There is therefore the need for policy and research efforts to tackle the quest for quality seed rice in Bombali and Kambia districts in particular and in Sierra Leone at large.

Key words: Smallholder farmers, quality seed rice, rice varieties, challenges and Sierra Leone

Abstrait

La graine de qualité est considérée comme l'une des contribution les plus essentielles dans la production végétale. Cette étude a été menée en 2014, pour évaluer la qualité de semences de riz et les défis rencontré par les petit –proprietaire de rizière dans des zones de Bombali et de Kambia en Sierra Leone. L'étude a employé des questionnaires, des interviews, des discussions de groupe en foyer et une conception expérimentale pour rassembler des données. Les résultats de l'étude ont indiqué que trente trois variétés différentes de semences de riz ont été cultivées dans les zones de Bombali et de Kambia au cours des trois dernières années (de 2011 à 2013). La distribution des variétés de graine a été liée aux différences écologiques et culturelles. Un etude t-Test (à l'intervalle de confiance de 95 pour cent) indique qu'il y avait une différence significative entre les pourcentages moyens de germination obtenus en laboratoire et celui de que de l'expérience de serre chaude ($t_{calculé} = -5.882$, $_{valeur\ critique}$ de $t = \pm 3.182$, à l'intervalle confiant de 95percent). D'une part, les résultats prouvent que la PA Kiamp a la meilleure qualité (germination de 90percent et de 59percent en états de laboratoire et de serre chaude, respectivement) comparée aux autres trois variétés de semences de riz (tasse et ROK 24 de PA Chiam, de beurre) bien qu'il ait la plus basse vigueur (90percent et 32percent à la profondeur de 2 centimètres et de 4 centimètres, respectivement). D'autre part, les résultats prouvent que ROK 24 a la plus mauvaise qualité (germination de 20percent et de 5percent en états de laboratoire et de serre chaude, respectivement) comparée aux autres variétés de riz de trois graines bien qu'il ait eu la meilleure vigueur (100percent à la profondeur de 2 centimètres et de 4 centimètres, respectivement). Conscient du fait que les petit proprieretaire de rizière luttent pour une croissance dans la production de riz dans des zones de Bombali et de Kambia, ils sont souvent défiés par : ressources limitées (financières, matériel et humain) ; appui technique et formation limités du gouvernement ; menaces de parasite et maladies, tenure de terre et infrastructure limitée pour la manutention post-récolte. Il y a donc le besoin d'efforts politique, et dans le domaine de la recherché pour s'attaquer au problem semences de riz de qualité dans des zones de Bombali et de Kambia en particulier et en Sierra Leone dans son ensemble.

Mots clés : Petit propriétaire de rizière, semences de riz de qualité, variétés de riz, défis et la Sierra Leone

CHAPTER ONE

INTRODUCTION

1.1. BACKGROUND OF THE STUDY

Seed is considered the most important input in crop production (Ajeigbe*et al*., 2009). Seeds of high quality are obtained from a good crop variety of high yield. The additional effects of inputs like fertilizer, pesticides, insecticides irrigation and crop maintenance can be significantly realized with good quality seed that is why it is considered as a vital input in crop production (Maji, 2008).

Lack of quality seed is one of the many challenges faced by farmers in rice production in Sub-Saharan Africa. The growing population therefore continues to rely on importing rice from Asian countries to meet the demands of African countries (Africa Rice, 2010). Ghana for example has seen a decline of rice self-sufficiency from 38percentin 1999 to 24percent in 2006 (Ministry of Food and Agriculture MOFA, 2009).

Agriculture is a major sector that boosts the economy of Sierra Leone, providing about 75 percent of the GDP and employment for about 50 percent of the population (Ministry of Agriculture Forestry and Food Security MAFFS, 2009). The main actors in agricultural production are smallholder farmers who practice mostly subsistence farming.

Since the end of the civil war in 2002, it has been reported by Coalition for African Rice Development (CARD) that food crop production has increased considerably in the country. Estimates have also shown that households with adequate food consumption increased from 56 percent in 2005 to 71percent in 2007 and the level of rice self-sufficiency in the country increased from 57.4percent to 71percent between 2002 and 2007, yet there is still a 30percentimportation of rice which is the main staple food for Sierra Leoneans CARD, (2009).

As rice is the major staple food for Sierra Leoneans, there is a need to improve on rice production.

1.2 STATEMENT OF THE PROBLEM

The agricultural sector is one of the main drivers of the economy in Sierra Leone. The civil war that ended in 2002 disrupted seed and rice production in Sierra Leone and led to severe negative impacts within the country such as poverty and food insecurity (GTFS/SIL/028/ITA, 2007). Statistics have shown that about 1.3 million people or 26 per cent of the total population is food poor and farmers especially subsistence food crop farmers, are among the poorest in the country after the decade long civil war(GTFS/SIL/028/ITA, 2007). The government of Sierra Leone came out with a Poverty Reduction Strategy (SLPRS) which led to the establishment of the main reasons for food shortage in the country to include: (i) low capital investment (especially by the private sector), (ii) weak level of support for research technology generation and defunct extension services, (iii) weak or total absence of vital agricultural support services including the absence of viable technology-based inputs (GTFS/SIL/028/ITA, 2007).

Rice is the staple food in Sierra Leone, but the quantities produced are not enough to meet the demand (MAFFS, 2010). Much of rice production in the country is done by smallholder farmers, majority of whom practice subsistence farming. Rice yields over the years have been relatively low (1 metric ton per hectare) and distribution of the rice produced does not satisfy local demand due to cross border trade and other factors (MAFFS, 2010).

Including proper agronomic practices, one of the most important pre-requisite for a successful crop production is the availability of good quality seeds of high yielding varieties, adapted to the growing area and preferred by the farmers. MAFFS (2009) also considers the importance and availability of good seeds to farmers to contribute to about 40 percent of crop yields. Over the years, a large number of high yielding seeds of different varietieshave been developed and disseminated to a large number of farmers in Sierra Leone (MAFFS, 2009). These seeds were given to farmers in small quantities for further multiplication and use but presumably not adequate for extensive cultivation.

According to Food and Agriculture Organization (FAO, 2009), Sierra Leone annually requires about 500 000 tons of milled rice, which is the main staple, to feed its population. Domestic production covers around 70-75 percent, with imports making up the difference. FAO also reported that rice importation increased by 80 percent globally in 2004. This

situation saw African Countries doubled rice importation by 140 percent from 5 million tons in the early 1990s to 12 million tons in2004. West African countries including Sierra Leone which are mainly rice consuming countries are said to account for two-thirds of Africa's rice importation (JICA, 2007). According to FAO (2008) the cost of rice in Sierra Leone rose to over 50 percent in January to July in 2008.

In a bid to address the level of poverty and food insecurity, the present Government of the Republic of Sierra Leone has demonstrated its commitment to the agriculture sector by increasing the budgetary allocation from 1.6 percent inherited in 2007 to 10 percent of the national budget. Furthermore, the Government and its development partners tried to improve on small scale subsistence agriculture among others maintaining a sustainable seed production and supply system (MAFFS, 2009).

This was affirmed by the signing of the Comprehensive African Agricultural Development Programme (CAADP) in September, 2009 as a country which led to the design and implementation of the Smallholder Commercialization Programme (SCP). The SCP is one of the Government's priorities to fight against poverty and food insecurity in the country. The aim of this initiative was to increase the productivity of Sierra Leone's agricultural sector targeting the removal of over two and a half million people out of poverty, strengthening the national economy and putting the country on track to meet the Millennium Development Goals (MDGs).

In addition, a firm commitment was made byPresident Ernest Bai Koroma's Agenda for Prosperity in 2012 to prioritize agriculture. Tremendous efforts have further been made by various stakeholders including the German Government, the Food and Agriculture Organization of the United Nations, Africa Rice and the Ministry of Agriculture, Forestry and Food Security to increase food crop production. The seed multiplication unit and other Institutions within the seed industry were rehabilitated and operationalized to provide farmers with planting materials (seeds, cuttings and vines) at affordable prices to facilitate a steady increase in food crop production to attain food self-sufficiency. In spite of these endeavors by the government and her partners, smallholder farmers in Sierra Leone are still faced with challenges in achieving the said goal of the government. For example, some solely rely and use seeds mainly from the informal sector, complicating the efforts made by the government and its partners, hence the need for an in depth study to investigate the quality of the seed and

rice produced and to assess the challenges of smallholder farmers involved in the rice sector in Sierra Leone.

1.3 Research Questions

1. What are the rice varieties cultivated by farmers in Kambia and Bombali districts in Sierra Leone?
2. What is the quality of these seeds used by smallholder farmers in Kambia and Bombali districts inSierra Leone?
3. What are the challenges faced by smallholder farmers in quality seed and rice production?

1.4 Objectives of the Study

The main objective of the study is to assess the quality of seed rice and the challenges faced by smallholder rice farmers in Sierra Leone.

1.4.1 Specific Objectives

The specific objectives of the study are:

- To identify seed rice varieties commonly cultivated by smallholder farmers in Kambia and Bombali districts in Sierra Leone
- To assess the quality of these seeds used by smallholder farmers in Kambia and Bombali districts inSierra Leone.
- To identify the challenges faced by smallholder farmers in quality seed and riceproduction.

1.5 Significance and Justification of the Study

Farmers in Sierra Leone are perceived to obtain seed for rice production from many sources including the formal seed supply system (Research Institute , MAFFS and private seed and agro-dealers) and the informal seed supply system (farm saved seed, buying from market, exchange and gift from relatives, friends and neighbors). Rice varieties cultivated by these farmers range from local to improved types and from one locality to the other.

Farmers in Sierra Leone like other African countries often face difficulties in rice farming.It is therefore important to carry out a study to identify the rice varieties cultivated in the study area while assessing the quality of seed rice sown and the challenges faced by smallholder farmers.

The information generated from this research would be documented and disseminated amongst various stakeholders viz; researchers, students, farmers, development and extension workers by making copies of the report available in the documentation center of MAFFS and other Institutions upon expression of interest and request. It would be used by researchers for further research work and project planners to design possible seed production programs for smallholder farmers.

The findings of the research would be used by policy makers and the Ministry of Agriculture, Forestry and Food Security and related seed multiplication programmes for improvement or adjustment in order to meet the demands of farmers and consumers in Sierra Leone.

1.6Description of Study Area

Sierra Leone is located in West Africa between about 10° and 13° W and 7° to 10° N. The country's total area is 71 740 km^2 of which 5.4 million ha are arable with a North-South extent of about 340 km and a maximum East-West extent of about 300 km. Sierra Leone is bordered by Guinea in the North and East Liberia in the East and South. Atlantic Ocean is in the south and west is about 400 km long.

The population of Sierra Leone is estimated at 6 million. The 2004 census result revealed that the life expectancy at birth is 41.1 years and infant mortality rate of 165.4 out of 1000 live births. Projections by Statistics Sierra Leone put the population of Sierra Leone to reach 6.5 million by 2015. This may be proven after the proposed 2015 Population and Housing Census.

Administratively, the country is divided into four (4) regions: North, South, East and West. Each region is politically headed by a Resident Minister assisted by a Provincial Secretary. The three (3) regions (North, South and East) are divided into twelve (12) Districts which make up one hundred and forty nine (149) Chiefdoms.

Sierra Leone like many other countries in the sub-region has three (3) arms of Government, The Executive, Judiciary and the Legislature headed by the President of the Republic of Sierra Leone, the Chief Justice and the Speaker of Parliament respectively. There are altogether 124 Members of Parliament representing 112 Constituencies with the remaining 12 members representing Paramount Chiefs for the 12 Districts.

With the re-institution of the Local Government in 2004 by an Act of Parliament and under the Decentralization Secretariat, there are currently nineteen (19) City and District Councils and 336 Wards governed by Mayors, Chairmen and Councilors respectively.

The Mayors, Chairmen and Councilors of the Cities, District Councils and Wards represent the local administration. In addition there are District Officers (Dos) in all twelve (12) Districts. These DOs on the other hand represent the Central Government and are directly responsible to the Provincial Secretary.

The western district is divided into western area urban and western area rural. There are no chiefdoms within the western area but the villages and towns within the western area rural have headmen. Also there exists the position of tribal head for the major tribes within the Freetown Municipality.

Rice cultivation dominates the crop sub-sector due to the fact that it is the most important staple food in Sierra Leone and contributes about 75 percent of agricultural GDP.

The study area for the research included Bombali and Kambia Districts in the Northern Province of Sierra Leone.

1.6.1 Bombali District

Bombali District is in the Northern Region of Sierra Leone with Makeni as the Regional and District Headquarter Town. Makeni is 182 km away from the Nation's Capital Freetown.

The population in the District is estimated at 434, 319 with a land area of 7, 958km^2 (Sierra Leone Atlas, 2014). Bombali is the second largest District in the country next to Koinadugu District which is the largest. It borders with the Republic of Guinea to the North, Port Loko and Kambia Districts to the West, Tonkolili District to the South and Koinadugu District to the East. Annual rainfall in the District is estimated at 3000-3500mm.

The District has a City and District Council governed by a Mayor and Council Chairman respectively.There are thirteen (13) Chiefdoms in the District but only three out of these Chiefdoms (BombaliShebora, MakarieGbanti and SafrokoLimba) make up the study area. This is because these are the main Chiefdoms where the German Seed Project was implemented.

Bombali District is well known for agricultural activities with vast areas of bolil and and other ecologies which support extensive rice production (mechanized rice farming). Rice which is the staple food for Sierra Leoneans is the major crop produced in the District. It is also suitable for crops like cassava, sweet potatoes, sugar cane, cashew and groundnut and livestock production. Bombali is known for the trade of agricultural produce to travelers from both Eastern and Northern regions. Extensive ethanol production is done by ADDAX Bio-energy Company in the District. Also, the District, Makeni to be precise serves as the headquarters for the African Minerals Ltd (AML) Mining Company. These two companies (ADDAX and AML) provide huge employment for youths and other categories of Sierra Leoneans which helps to boost the country's economy by the payment for license and reduce unemployment rate.

1.6.2 Kambia District

Kambia District is also in the Northern Region of Sierra Leone with Kambia as the District headquarter town. Kambia Town is 172 km from the nation's capital Freetown. The District borders with the Republic of Guinea in the North, Port Loko District to the South and Bombali District to the East.

The population of Kambia District is estimated at 313,765 with a total land area of 3,108 km^2 (Sierra Leone Atlas, 2014). Kambia District is governed by a District Council Chairman who is the representative of the Local Administration and a District officer who represents the Central Government. There are seven (7) Chiefdoms in the District but only three out of the 7 chiefdoms in the District formed the study area. They are Mambolo, Magbema and Masungbala Chiefdoms. The District is one of the main rice bowls in the country. It has large agricultural zone for crops and livestock production. The south-West is dominated by large rivers and estuaries. Majority of the population are Muslims and farmers also make up the bulk of the people in the District.

Crops grown are rice, cassava, millet, sweet potatoes, and sorghum. Groundnut and maize are the major cash crops in the District. The District also favors livestock production but the rebellion in the country gave way to cattle rearers to cross over to the Republic of Guinea for

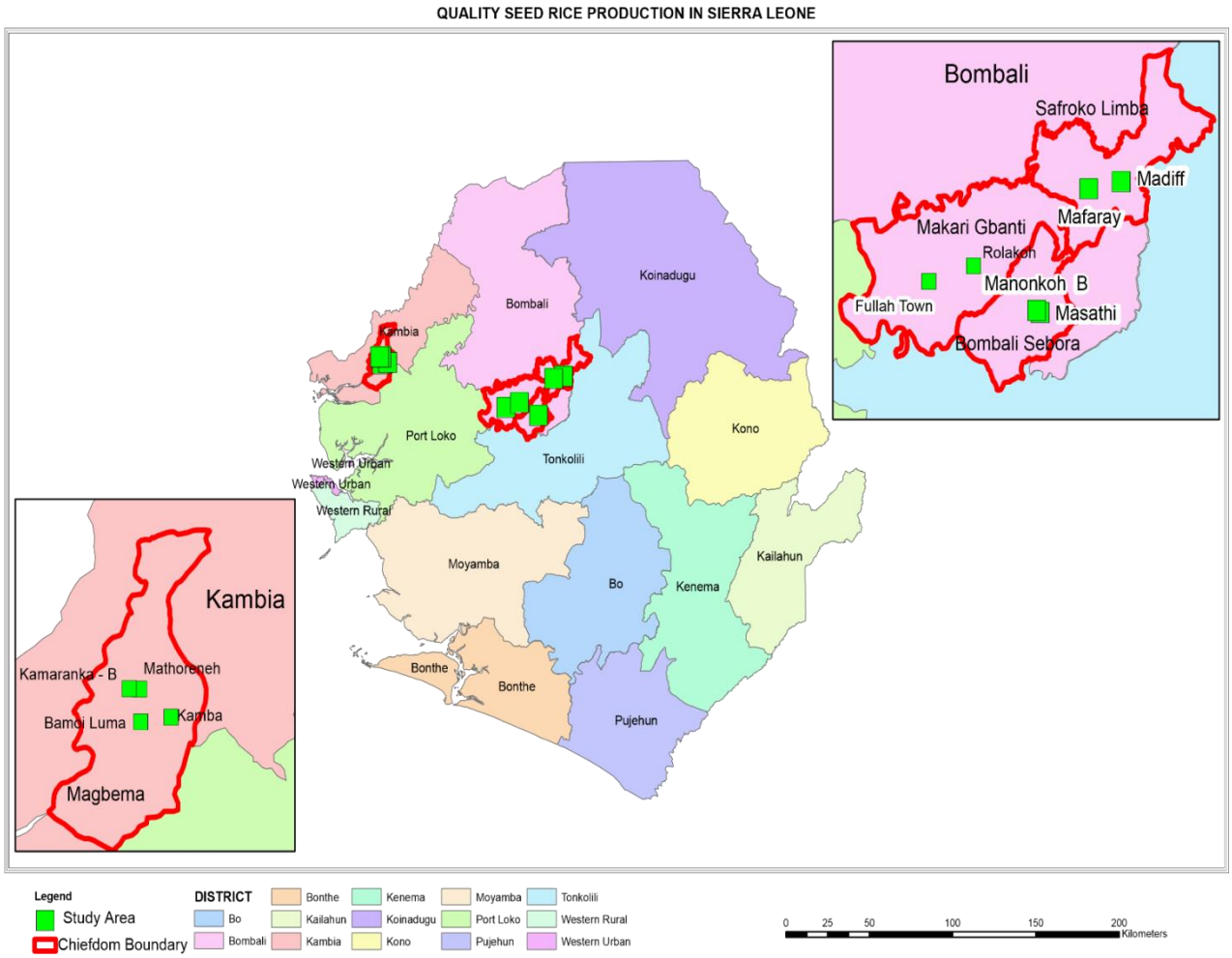


Figure1.1: Map of Sierra Leone showing Study Area (Kambia and Bombali Districts)

fear of their lives and the security of their animals. There is moreover cross border trade in the District housing a popular weekly periodic market known as “Loumah” which brings traders and buyers from across the Republic of Guinea and major parts of Sierra Leone together.

1.7Scope of the Study

The study was conducted in two Northern Districts (Bombali and Kambia) in Sierra Leone, West Africa from April to December 2014.

The study was concerned with identifying the common rice varieties cultivated; assessing the quality of seed and rice produced and the challenges faced by smallholder farmers in seed and rice production.

In trying to achieve this, two seed quality parameters (Physical and Physiological) of determining seed quality production were assessed. Purity analysis, Seed germination and vigor tests were done for four rice varieties (Pa Kiamp, ROK 24, Butter Cup and Pa Chaim). The study did not assess the genetic and phyto-sanitory quality aspects of the four rice varieties.

1.8Organization of the Study

The study is structured into five chapters. In Chapter one a brief a background of the study has been given as introduction stating the objectives of the research, the problem statement and information of the study area. Chapter two presents relevant literature on seed quality concepts; it illustrates the importance of rice as staple food in Sierra Leone; rice cultivation in Sierra Leone; the role of research in the development of new rice varieties; the function of agricultural extension services in the dissemination of rice varieties to farmers in Sierra Leone; seed supply systems and seed policy in Sierra Leone and concludes with the Possibilities and challenges in seed production. Chapter three gives a description of the methods and methodology used in the study, Sample size and selection. The chapter also highlights the research design and data collection methods and describes the administration of questionnaires and data processing and analysis methods used. In chapter four, the findings of the research are presented and discussed. Chapter five gives the summary, conclusions and recommendations of the study.

1.9 Definition of Terms

Seed: Seedis defined as "a fertilized ovule consisting of intact embryo, stored food and seed coat, which is viable and has got the capacity to germinate" Indian Council of Agricultural Research (2006). Seed can be classified into breeder seed, foundation seed, registered seed and certified seed as briefly described in figure 1.2.

Brreder seed: this is seed that comes directly from plant breeder.

Foundation seed: seed that is grown from breeder seed.

Registered seed: seed that is grown from foundation seed.

Certified seed: seed that is grown from either foundation or registered seed.

Seed Quality: Weltzien and Brocke, (2001) defined quality seed as "the ability of seed to germinate under favorable field conditions and establish a desired plant stand".

Smallholder Farmer: A smallholder farmer is one that has limited land for production, endowed with little resources, works at subsistence level and vulnerable to risk Abera (2009) and Hazell*et al*, (2007).

CHAPTER TWO

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 LITERATURE REVIEW

This Chapter serves to present relevant literature on seed quality concepts; the importance of rice as staple food in Sierra Leone; rice cultivation in Sierra Leone; the role of research in the development of new rice varieties; the function of agricultural extension services in the dissemination of rice varieties to farmers in Sierra Leone; seed supply systems, and seed policy in Sierra Leone.

2.1.1 Characteristics of Good Quality Seed

Quality seed is considered the most important prerequisite for good crop production. It is recognized to account for an increase in crop productivity of at least 15 percent (Ajeigbe and Ousmane, 2008). Quality seed contributes to about 12-20 percent total production depending on the crop (Dasgupta and Roy, 2011). One of FAO's strategies in attaining seed and food security during emergency operation is making available quality seeds of suitable crops and cultivars to farmers. This requires Project Managers to have an understanding of both technical and operational aspects of quality seed for this strategy to be achieved (FAO, 2011). Quality seed for planting have desired characteristics which include genetic purity, freedom from pests and diseases, high germination percentage and vigor. Seed quality results from genetic, physical, physiological and phyto-sanitary characteristics.

2.1.1.1Genetic Seed Quality

Genetic seed quality is determined by those plant characteristics that result from the genetic potential of the embryo which includes genetic variations within a seed lot and the multiplication of cultivars in breeding programmes without genetic alterations.

Quality control is critical in ensuring the realization of genetic quality of improved plant cultivars National Agriculture Support Services Programme (NASSP, 2005). Maintaining the genetic quality of seed is often cumbersome but if certain measures are applied, there is guarantee that the genetic quality of seeds could be preserved. The importance of quality seed in rice production cannot be overemphasized for example rice farmers in the North and Far North region of Cameroon are reported to obtain yields of up to 2-3t/ha with farmer-saved seed but with the use of certified seed and good farming practices up to 6.0-8.0t/ha could be achieved (Gueie*t al*., 2010).

Louwaars and Marrewiik (1994) considered the sowing of the right class of seeds, minimizing contamination with pollen from other crops through enough isolation distances between seed plots, avoiding mechanical admixture mostly during and after harvesting, rougeing of off-types during critical stages of crop development and eliminating volunteer plants to increase crop yields. In a similar way, Bradford (2006) suggested that potential crop yield largely depends on the quality of seed sown. Smallholder farmers mostly require seeds with uniform and high germination percentage of at least 90 percent. This is to ensure the achievement of proper genetic traits and appreciable yield.

2.1.1.2 Physical Seed Quality

Physical seed quality is the freedom of the seed from seeds of other crops, inert matter, diseased or insect damaged seeds and it is related to mechanical harvest, seed cleaning and transportation and storage without mechanical damage to maintain seed quality. All biological processes in seeds are regulated by moisture content. When seeds are without mechanical damage or injury, the physical quality is however maintained. Particle size, shape, volume, length, surface roughness, color, is also important characteristics to look out for when determining physical quality of seeds.

Thephysical quality of seeds can be determined by doing a physical purity analysis in which a sample is obtained from a seed lot. Pure seed, inert matter, weed seeds and seed from other crops are separated and weighed. Naked eye observation or a magnifying glass can also be used to determine physical seed quality.

The physical quality of seeds can be improved in the field by rougeing and elimination of volunteer plants and off-types. This quality of seed could also be obtained by proper cleaning and grading of seed lots before storage and sowing.

2.1.1.3 Physiological Seed Quality

This deals with viability and vigor and refers to the ability of the seed to germinate and produce a normal seed (Louwaars and Marrewijk, 1994). Seed vigor is the sum total of those properties that determine activity and performance of seed lots of acceptable germination in a wide range of environments (ISTA, 2008)

Seeds are considered by ICAR (2006) to have maximum quality at physiological maturity; moreover seed storage success depends on environmental, harvest and post-harvest and storage conditions.

Harrington (1963) suggested four major factors that affect the physiological quality of seed in storage: duration, temperature, moisture and biotic factors (especially fungi, insects and rodents).

The length of time for which the seed is stored will affect the quality of seed. Also for seeds to be properly stored while maintaining its viability and vigor, attention must be given to the right temperature, moisture content and freedom from insect pests and other disease causing agents. The latter can be achieved by cleaning stores, storage containers and pallets well and proper fumigation before storage of seeds.

2.1.1.4Phyto-sanitary Seed Quality

Phyto-sanitary quality means the presence or absence of disease-causing organisms such as fungi, bacteria, viruses and insects. It is believed that insects and fungi reduce the quality of seed.

The health of seeds is very important especially when considering importation and exportation. In order to avoid the spread of foreign injurious pests, diseases and noxious weeds, stringent plant introduction and phyto-sanitary procedures have to be put in place by all countries engaged in cross border seed trade. These procedures are based on International standards in line with International Plant Protection Convention (IPPC) and World Trade Organization (WTO) agreement on sanitary and phyto-sanitary regulations and guidelines (Waithaka*et al*., 2011)

2.1.2 The Importance of Rice as a Staple Food in Sierra Leone

Seed production in Sierra Leone is handled by both the public (Research and Seed Multiplication Unit) and private (commercial seed growers and smallholder farmers) sectors.

Sierra Leone has about 7.23 million hectares land area of which about 5.36 million hectares are arable, comprising upland and lowlands. Out of the 5.36 million hectares considered to be arable, only 600,000 to 660,000 hectares is cropped each year by about 400,000 farm families. (MAFFS, 2009)

The country is blessed with sufficient arable land and favorable climatic conditions, reasonable access to land; several agro-ecologies (Inland Valley Swamp, Mangrove, Riverain Grassland and Boliland) that are conducive for the cultivation of a wide variety of crops, abundant water resources and favorable political obligation for investment in the various sectors. This presents the country with a lot of opportunities for promoting small to large

scale holders for linkage to market economies. Agricultural products from Sierra Leone are highly demanded nationally and internationally. So Sierra Leone offers market opportunities for investors in the agriculture sector. (MAFFS, 2010)

Sierra Leone's climate is humid tropical with two distinct seasons. The rainy season starts in May and ends in October and the dry season run from November through April.

The country experiences an annual rainfall average of about 3,000mm per year ranging from a low of 2,000mm in the North to a high of 4,000mm in the south. Average temperature ranges from 23 degrees C to 29 degreesC, but can rise to an average maximum of 36 degrees C in the lowlands towards the end of the dry season while in the highlands the average monthly temperature could be as low as 15 degrees C at the beginning of the dry season.

Soils in Sierra Leone are ferralitic in nature and lack important mineral nutrient reserves (Coalition for African Rice Development, 2009). This is one of the factors that deter crop production in the country.

Rice (*Oryza sativa*), one of the three most important food crops in the world which forms the staple diet of 2.7 billion people and has become a commodity of strategic significance across much of Africa, (ICAR, 2006). It is also considered the second most important cereal in the world which provides 95 percent of food requirement of the world's population (Juliano, 1993; Boumas, 1985).

Rice is the main staple food in Sierra Leone and is grown in all ecological zones in the country with both local and improved varieties. It is documented by MAFFS (2010) to account for over 75percent of agricultural GDP. However, it is produced at subsistence levels and does not meet the food security needs of most households in Sierra Leone.

In Bangladesh and Eastern Asia, Hossain, (2012) proposed that the intake of micro nutrients from rice grain mainly depends on the processing and cooking methods and went further to state that a positive change in those methods of rice processing and cooking will help to maintain micro nutrients and reduce malnutrition.

In Sierra Leone, rice production in the year 2007 was estimated at 638,000 Mt which is 60 percent of total demand (MAFFS, 2007). In Ghana, rice is the second most important staple after maize and development partners therefore suggest that it is significant to increase and sustain domestic rice production by stakeholders in the agriculture (JICA, 2009).

Rice alone is said to account for 40percent protein and 32-59 percent of the dietary energy and therefore makes it a major source of carbohydrate and micro nutrients with 88 percent digestibility, high lysine content (4 percent) and relatively has better protein utilization, (ICAR, (2006). A typical Sierra Leonean will generally not hesitate to admit that he feels like he has not eaten at all if he has not had a rice meal at least once a day.

The first solid food for babies whose parents live below one dollar a day is rice with vegetables. This shows how important rice is as a staple food for different ages of Sierra Leoneans.Being the staple food for Sierra Leoneans, the country's national food security hinges on the growth and stability of its rice production.

2.1.3Rice Cultivation in Sierra Leone

Rice production was estimated at 4.4 million hectares in West Africa in 2008 (Somado*et al*., (2008; Tokpah, 2010). Rice cultivation dominates the crop sub-sector because it is the most important staple food in Sierra Leone and contributes about 75 percent of agricultural GDP. Annual per capita consumption of rice (104 kg) in Sierra Leone is amongst the highest in sub Saharan Africa. About 70 percent of Sierra Leone's 6 million people in 2004 were below the national poverty line, with 52 percentliving on less than US$1 per day, while 26 percent could not afford minimum daily calorific requirements**, (**CARD, 2009)

Sierra Leone usually export rice to other countries duringthe 1960s because of its expansion on land area which led to an increased rice production in the country, but since the late 1970s, rice production decreased and the demand for local consumption has not been met.

Domestic rice production as reported by FAO (2004) was stagnated and Sierra Leone couldmeet only 70 percent of its total requirements. As the country recovers from civil strife, sustainable rice production depends on greater support for input supply and output marketing and development of lowland rice production.

There was a shift in agricultural policy in the immediate post-independence period to direct interventions in agricultural production by the State. The Rice Cooperation which was established in 1961 imported tractors and equipment and established its own rice farms. These schemes were located in unsuitable areas and poorly staffed.

By 1967, the Rice Cooperation could not raise operating capital to pay farmers cash for produce. Government was compelled to close down the Rice Corporation in 1978 andmechan

ical cultivation Service fell back to the Ministry of Agriculture(Spencer, 2012). As a result of this, rice production declined to an average of just above 500,000 metric tons in the late eighties. The situation became worse in the mid-1990s with the emergence of the civil war in the country and production dropped to about 460,000 metric tons .Crop yields remained low at 0.72 and 1.23 metric tons for upland and lowland rice respectively.

In other words, Sierra Leone experienced self-sufficiency in rice in the early 60s and up to 1975. Over 600,000 metric tons of paddies were recorded to have been produced at the end of the 70s.

Although climatic conditions are generally favorable for crop production including rice, yet several factors such as diseases, pests, low soil fertility, in addition to the use of low yielding local varieties, poor extension services, and several socio-economic factors are considered to be limiting farmers' productivity. Post-harvest losses due to poor crop management, unsuitable storage and marketing facilities are greatly responsible for reducing small holder farmer's yield CARD, (2009).

Moreover, majority of Sierra Leonean smallholder farmers practice subsistence farming. This is because farmers lack adequate productive resources such as: fertilizers, insecticides, herbicides and basic farm machinery and lack knowledge and skills which could help enhance rice production (CARD 2009).

Rice is cultivated in the different ecologies in Sierra Leone depending on the location and topography for instance: Upland and Lowland ecologies such asInland Valley Swamps, Bolilands, Mangrove Swamps and Riverain Grasslands. In the lowland, rice is the only crop cultivated in the rainy season since other crops like groundnut, cassava and sweet potatoes do not tolerate much water.

Typically, rice is produced in upland systems, and account for about 64percent of total national rice area. Inland valley swamp system is the second major ecology, covering another 26percent. Only a small portion of less than 5 percent, of the inland valley swamp rice area has been developed, permitting partial water control, (FAO 2004).The main planting season for rice is April-July, with harvesting between September and January. Now with the introduction of NERICA varieties that are of early duration (90-110 days), rice can be grown 2-3 times per year depending on the available resources and the type of ecology. Upland rice is inter- cropped with other crops by direct sowing of seeds in slash-and-burn shifting cultivation. In other ecologies such as IVS and Mangrove, seeds are nursed and transplanted. Land preparation for rice cultivation in the different ecologies varies. For instance, in the

upland, land is prepared by slashing, burning, clearing, ploughing and harrowing whilst land preparation in the low land is done by brushing, clearing, ploughing and puddling using big hand hoes. However, it is important to keep in mind the locality, type of soil, rice variety, ecology and availability of inputs and labor in choosing a suitable planting method for rice, (IRRI, 2013).

Rice is directly broadcasted in the upland after proper land preparation methods as mentioned above with a seed rate of 63kg/ha and for lowland ecologies, rice must be nursed at a seed rate of 25kg/ha after preparation of a nursery bed or field and at a depth of 2 to 3cm. (JICA 2010). Another rice growing Institution like the International Rice Research Institute (IRRI) suggest the use of 60-80kg of seed rice per hectare for direct broadcasting and 40kg/ha at a transplanting rate of 2 plants per hill. At a three leaf stage, (2-3 weeks after sowing) when the fields are well prepared, the rice is gently uprooted with a ball of earth and transplanted. Transplanting in mangroves is normally done from late July to September after the salts have been washed out of the soil to reduce salt infiltration.

Yields obtained from lowland ecologies are generally higher than those from upland simply because soils in the lowland ecologies are rich in nutrients. .

Effective agricultural policies and strategies are crucial to augment agricultural production and also important for the dissemination and introduction of agricultural innovations, Abalu, (2009).The use of modern production inputs are uncommon and expensive and therefore cannot be afforded by smallholder farmers. This therefore reduces the average yield to as low as 1.3 tones/ha.Another factor responsible for decrease in rice production in the country is climate change and this challenge can be met by strengthening the capacities of research, extension, and the private sector in areas of development, dissemination and adoption of improved seeds and planting materials.

The National Rice Development Strategy (NRDS) suggests the following approaches for increasing rice production in the country:

(a) Increase in area cultivated, mainly in the lowlands where there is much underutilized capacity, and

(b) Increases in productivity per unit area in all ecosystems. Area expansion will mainly be in the IVS due to its existence in all parts of the country coupled with its potential for sustainable production.

However, the Government of Sierra Leone is currently pursuing a revised policy of mechanization and commercialization on rice farming in the country in which the MAFFS through the help of the Libyan Government distributed 244 farm tractors accompanied with 20 bushels of seed rice, 40 bags of fertilizer, 100 gallons of diesel fuel, 20 liters of herbicides and ten million Leones (Le 10,000,000) to each beneficiary for land preparation under a hire purchase scheme. Beneficiaries pay 60 percentof the cost of the tractors in which 20 percent payment was done off front and the remaining 40 percent stretched over a period of 7 years while Government pays the remaining 40 percent of the cost of the tractor as subsidy, (MAFFS,2011). This is done to give equal opportunity for farmers to acquire their own tractors in order to take agriculture as a business enterprise and be less dependent on direct Government support except for Technical services;increase rice production, improve yields and reduce the burden of hard labor. However, mostly middle income farmers who can afford to pay the cost for the tractors benefited leaving only a small proportion of peasant farmers to gain from the scheme or policy.

The Government's goal was to achieve rice self-sufficiency by 2013. This strategy targeted a land area of 830,000 ha and an increase in the average rice yield/ha to 2 mt/ha to comprehend the government's goal of rice self-sufficiency. Furthermore, an extension of the area to 1,100,000 ha over the following years, coupled with an increase in the average yield of rice to 4 mt/ha (ranging from 1.5 mt/ha in the uplands to 4.0 mt/ha in the IVS) is expected to result in the production of over 3 million tons of rice in 2018. Consequently, increasing productivity of rice and expanding the area under the crop in Sierra Leone with the aim of significantly increasing rice production in the country requires considerable improvement in the availability of quality seed supply to farmers coupled with improvement in other areas.

Informationon the national rice production and food sufficiency situation in Sierra Leone is given in Table 2.1. From the statistics below one could see that for the period 2001-2009 the national rice requirement was not met by the quantity produced but projections for the period 2010-2013 shows that the country's rice production is expected to exceed the requirement.

Table 2.1: National Rice Production and Self-Sufficiency for Period 2011 – 2013

Year	Area (Ha)	Yield (Mt/Ha)	Production (Mt)	Milled Equivalent (Mt)	Population	National Requirement (Mt Milled)	Self-Sufficiency (%)
2001	258,850	1.20	310,620	186,372	4,725,033	491,403	37.93
2002	343,142	1.23	422,065	253,239	4,814,808	500,740	50.57
2003	356,506	1.25	445,633	267,380	4,906,290	510,254	52.40
2004	426,772	1.27	542,000	325,200	4,999,509	519,949	62.54
2005	427,907	1.29	552,000	331,200	5,094,500	529,828	62.51
2006	422,556	1.33	562,000	337,200	5,216,890	542,557	62.15
2007	432,356	1.36	588,004	352,802	5,343,200	555,693	63.49
2008	475,592	1.43	680,097	408,058	5,473,530	569,247	71.68
2009	499,111	1.78	888,417	533,050	5,607,930	583,225	91.40
2010*	549,022	1.87	1,026,671	616,003	5,746,800	597,667	103.07
2011*	603,924	1.87	1,129,338	677,603	5,855,989	609,023	111.26
2012*	717,872	1.59	1,141,417	684,850	5,967,253	620,595	110.35
2013*	671,422	1.87	1,255,559	753,335	6,080,631	632,385	119.13

Source: PEMSD/MAFFS, 2014

- **Note:** Milled recovery = 60%
- Population growth rate at 1.9% using 2004 population as baseline
  Per caput consumption = 104 kg per person per annual

* Please note that 2010 to 2013 figures are projected figures.

2.1.4The Role of Research in the Development of Improved Rice Varieties in Sierra Leone

There have been tremendous efforts by the National and International Research and Development Institutions in generating high yielding improved varieties of crops and rice is no exception.

The decrease in rice yields is attributed to long time use of African rice (Oryzaglaberima), lodging and shattering of grains. The use of Asian rice (Oryza sativa) varieties was considered as an alternative to increasing rice yields in Africa but these varieties require abundant water and are not well adapted to African climatic and soil conditions. This necessitated the African Rice Center (WARDA) together with lead scientist and researchers to cross breed the two rice varieties (O.sativa and O. glaberima) to come out with the New Rice for Africa (NERICA) varieties. NERICA varieties possess a lot of characteristics apart from been suitable and adaptable to the African locality. It is worthy to note that the lead scientist in developing NERICA varieties, Dr. Monty Jones is a Sierra Leonean and currently one of the special advisers to the President of Sierra Leoneon agricultural matters.

In developing new crop varieties for farmers, it is important for Plant Breeders to select those that can better adapt to the farmers ecologies, local environment and production practices than the existing varieties they have and above all integrate the needs and priorities of Farmers.

The National Agricultural Research Stations (NARS) are encouraged to collaborate with the International Agricultural Research Centers such as International Institute for Tropical Agriculture (IITA), Africa Rice, and International Center for Agricultural Research in Dry Areas (ICARDA), in order to save costs and to minimize the period of variety development.

Furthermore, research fosters the cooperation of farmers in the context of participatory breeding, whereby experienced farmers are given the chance to contribute to the early identification of potential varieties as it is in the case of Sierra Leone.

The Sierra Leone Agricultural Research Institute (SLARI) has over the years developed and disseminated a large number of varieties that are high yielding. Currently, there are about 15 varieties of rice, 3 varieties of maize, 1 variety of groundnut, 4 varieties of cowpeas, 7 varieties of cassava and 6 varieties of sweet potatoes available for use by farmers. MAFFS, (2009)

Varieties used in Sierra Leone are locally developed in order to ensure conformity with the local agro-ecologies and meet the attributes desired by farmers, consumers and the agro-industry. Rokupr Agricultural Research Centre (RARC) of SLARI is responsible for developing new rice varieties, test and release those varieties with approval of the Varietal Release and Registration Committee (VRC). Over the years, RARC has developed thirty seven (37) rice varieties of which seventeen (17) and some varieties released in December 2014.

According to a research Officer at RARC, testing the newly developed cultivars is done for three (3) years with the full participation of Farmers and Researchers to present farmers with the opportunity to look out for desirable characteristics and identify suitable varieties for use. Proper linkages between seed producers and research/development organizations are said to enable farmers to access improved crop varieties.

In the first year, the trial is done together by the Farmers and Researchers. In the second and third years, new varieties are given to Farmers for self-trial with supervision by Research and Agricultural Extension. During this period, Farmers are required to look for characteristics such as: early maturity, high yielding, palatability, good grain quality, resistance to pest, diseases and climatic conditions etc.

Selection of the suitable varieties with desired characteristics is done by farmers for subsequent multiplication.

The breeding of new plant varieties can be effective if there are policies and regulations that support the production of new crop varieties. Such policies and regulations may need to provide a robust financial support to stakeholders and actors to fully partake in development (FAO, 2011).

The role of plant breeders, researchers and extension services in providing enough food to the world's population by making new crop varieties available is well acknowledged but it must be ensured that these newly developed varieties can create an impact, change yields and high quality seeds made available and affordable to farmers.

The Seed Multiplication Project (SMP) which was initiated in 1976 by the Government of Sierra Leone, with assistance from the Federal Republic of Germany and the Food and Agriculture Organization (FAO) has in the past been charged with the responsibility of the multiplication of varieties released by research. The SMP, currently named Seed Multiplication Unit (SMU), made considerable gains, particularly in seed rice multiplication

before the war broke out in the country. In essence, Research, SMP and Extension are collaborating in the breeding, multiplication and dissemination of rice varieties respectively.

As mentioned earlier, varieties used in Sierra Leone are as far as possible locally developed in order to ensure conformity with the local agro-ecological dictates and meet the attributes desired by farmers, consumers and agro-industry. Towards that end, Government strengthens the collection, utilization and conservation of indigenous plant genetic resources and support appropriate gene bank set up to enable optimum use and preservation of Sierra Leone's rich indigenous germplasm.

2.1.5The Role of Agricultural Extension Services in the Dissemination of Rice Varieties to Farmers

Agricultural extension services has been in existence for the past decades with the aim of helping farmers identify their problems and finding ways of solving them. Extension work is about maintaining an effective field level Organization and serving as a link between the Research Institution and the Farmer (Reda *et. al*, 2012). It is also considered by Anderson and Freda, 2007 as the "delivery of information inputs to farmers' and as a form of education that introduces new knowledge and technology to farmers". Moreover, Swanson (2008) suggests the role of the agriculture extension to include:

Provide technical advisory services to farmers; identify different needs of farmers based on their level of education; build effective human and social capacity of farmers; increase the technical and management skills of all types of farm households and educate farmers on how to use sustainable natural resource management practices. Agricultural extension services also offers opportunities to farmers to undertake farmer to farmer exchange visit in order for them to observe the methods of production and replicate best practices in their localities that will help them to increase the rate of adoption of new crop varieties for increased yield, income and eventually attain food security.

In Sierra Leone, several extension systems have been used to provide advisory services or technology transfer to Farmers. These include the Training and Visit (TandV), Unified Agricultural Extension System (UAES) and Farmer Field School (FFS) to name a few. Farmers in the past were as well encouraged to display their products during field days to motivate other farmers to learn and adopt new varieties and technologies. Presently, the Agriculture and Fisheries Trade Fair and World Food Day celebration are jointly organized annually by the Ministries of Agriculture, Forestry and Food Security (MAFFS) and Fisheries

and Marine Resources (MFMR) to allow farmers, fishermen, research institutions and NGOs to show case high yielding varieties and products of crops, fisheries products and improved breeds of livestock. Field days are also organized locally by Block Extension Supervisors (BES) and frontline extension workers (FEWs) in various Agricultural blocks and circles to provide an opportunity to Farmers who belong to Farmer Based Organizations (FBOs) to display and share experiences from field demonstrations, learning activities and group dynamics.

The T and V system was used in the early 1990s by over 40 developing countries and demands Extension workers to meet with a small group of "contact" farmers in their localities and farms to train them identify their problems and together find solutions to the problems and expected to disseminate information received to the members of their respective communities. This system is a top down approach and was effective in a way that contact farmers were trained. The major drawback of the system was that with limited funds available to developing countries, Frontline Extension Workers (FEWs) could not service all the farmers satisfactorily due to the farmer to FEW ratios (1:800).

The FFS is a system that was designed in Asia in the late 1980s to diffuse Integrated Pest Management (IPM) methods. The system has been very successful in Asia and Sub-Saharan Africa with Kenya and Sierra Leone having success stories. It is a non-formal education focused on field observations, season long research studies and hands on activities. (Ponniah*et al*, 2008).

FAO introduced FFS in Sierra Leone as a participatory approach to educate and empower farmers with the aim of building farmers' capacities to analyze their production techniques. At the introduction of FFS in Sierra Leone in 2003, a training of trainers was conducted by FAO in collaboration with MAFFS in which the Chief Trainer was an International Consultant from Uganda who has a wealth of experience in FFS methodologies and practices. A total of thirty one (31) people were trained. The trainees were drawn from MAFFS (27) and NGOs (4). This system is the most recent and widely used system by the MAFFS and Non-Governmental Organizations (NGOs) in the country to transfer technology to Farmers. A group of 25-30 farmers are brought together, trained on the cultivation and management practices of a particular crop starting from site selection to harvesting and marketing. In other words, it is a long season training in which emphasis is also placed on the effective management of pests and diseases since they serve as a major bottle neck in crop production. Pests are managed using the Agro Eco System Analysis (AESA) which is referred to as the

corner stone of FFS. AESA addresses the interactions between components of the ecosystem (e.g. plants, soil, water and the wider environment) and the functioning or performance of the system (FAO, 2013). Data on pests in the field is collected on a daily basis and decisions are made based on field observations.

FFS empowers farmers to be their own technical specialists on major aspects of crop and livestock production. The system offers the following advantages:

- A large number of farmers can be reached at the same time
- Farmers participate well in the training by using their fields as a classroom
- The extension worker is only a facilitator, this leaves the farmer with the a sense of belonging and recognition
- Both Farmers' and recommended practice are used to allow Farmers to compare and select the most suitable method for adoption
- Ensure proper records are kept to be able to determine the profitability of the farming enterprise

Discussions during an interview with the Director of Agricultural Extension Services Division (AESD) of MAFFS revealed that in terms of disseminating new rice varieties to farmers, the AESD served as a service provider for the implementation of the African Development Bank (ADB) funded Multi-NERICA Rice Dissemination Project.

In addition, the AESD through the West African Agriculture Productivity Program (WAAP) is establishing demonstration plots with and for farmers to promote NERICA rice varieties and other varieties of cassava which is the second most important food crop in the country.

Louwaars and Marrewiik (1994) concluded in a study conducted on informal seed system that the speed and effectiveness of the dissemination of new varieties depends largely on the variety to be diffused; affiliation; the existence of a particular culture in the locality; agricultural experimentation and economic stability of the farming enterprise.

According to the Director of the AESD, the Division is responsible for identification and selection of active Farmers; provide training and technical services, establish demonstration plots with recommended practices (line planting and timely cultural practices) and assist farmers in identifying and selection of suitable rice varieties provided by the Research Institution for further multiplication. As a strategy to arouse the interest of farmers to adopt a

particular variety of crop, the Participatory Varietal Selection (PVS) is used. Farmers are encouraged to join research and extension in the trial and selection of a new variety.

Despite the investment by government in building the capacities of extension workers, it is still difficult to reach farmers in remote areas because a good number of extension staff are aged, others look for better paid jobs since government salary is not enough to maintain one's family. The rest of the staff who afford to continue to render their services to the Ministry and cope with the low salary are often challenged with a wider area of coverage with limited or ineffective mobility support. Another challenge faced by the AESD is delay in getting market information for farmers and the provision of the technology by researchers without its full package.

As a way of fully involving the private sector in making planting materials available to farmers in Sierra Leone, SLARI/WAAP have invited persons active in buying and selling of agricultural inputs to express interest in becoming agro-dealers by applying and paying some amount of money as application fee. Seventeen agro-dealers were successful and have been selected through a competitive process. It is expected that these successive applicants will be given adequate training and later certified and recognized as registered agro-dealers who will partner with these organizations. The AESD of MAFFS is at the center of coordinating all these activities which manifests its role in making improved varieties of crops accessible and available to smallholder farmers at an affordable cost.

2.1.6 Seed Policy in Sierra Leone

The Government of Sierra Leone considers the achievement of food security as a priority and therefore the agriculture sector has a central position in the agenda for prosperity which is the government's working document for economic growth and development in the country.

The use of improved seeds/planting materials is considered as a major way for the realization of the national food security goals within the agriculture policy framework that was issued in 2002, MAFFS (2009)

Seed legislation varies from country to country. In India for instance, National seed cooperation (NSC) was established in 1963 under the Ministry of Agriculture. This was followed by putting together a seed Act in 1966 with amendments in 1972, 1973, 1974 and 1981. India got a new policy on seed development in 1988.

Having in mind the integration of different policies for a robust seed sub-sector, it is necessary for a national seed policy which normally makes room for a national seed board to streamline the policy making operations and organize various control structures.

The formulation of rules and regulations to govern the production and distribution of quality seed is dire in a country like Sierra Leone in which the farming community is dominated by illiterates and semi-illiterates.

Many countries that have attained food security had as a strategy to achieve this by establishing and maintaining a vibrant seed sub-sector with proper structures put in place backed by strong political will.To register high success to both the public and private sector plant breeding institutions for the production of new varieties, effective policies and regulations are needed by the responsible Governments, (FAO 2011). This was also affirmed by Sutton (1999) who holds the view that seed policy making is a roadmap to a problem solving process.This is because it has been reported for a number of countries that the Institutional framework that holds up variety development and release is weak. This may be due to lack of favorable policies and or inadequate financial and technical resources available to those institutions. Moreover, for seed quality control to be maintained there is need for seed law to be in place which specifies the requirements for variety release methods and rules regarding seed certification and standards for punishment for defaulters.

Louwaars (1990) suggests that a significant aspect of any seed policy is how well the seed chain is organized showing clear roles and responsibilities of each actor and institution. For a successful seed production program to be attained in any country there should be a link between policies from various components. Such policies could include research, agricultural and general business policies.

In line with the above the government of Sierra Leone through the MAFFS in 2009 formulated a National Seed Policy with the aim of rehabilitating the seed sub-sector and scale it up to match with international standards and maintain an efficient seed supply system making available to farmers high-quality seeds required by farmers and placing equal attention to true seeds and vegetative planting materials.The formulated policy has recently been reviewed and strongly recommends the setting up a National Seed Board (NSB) which will give support and advisory service to the Minister of Agriculture, Forestry and Food Security and other actors in the seed sub-sector.The NSB constitutes members from MAFFS, SLARI, Public and Private Seed sub-sectors and line Ministries. There is also a Varietal Release and Registration Committee (VRC) which is directly under the NSB and comprise of

members of the NSB, other relevant experts outside the NSB and researchers of various crops. The main objective of the NSB is to coordinate and facilitate the growth of seed industry activities for a faster development of the agriculture sector.

According to the seed policy, there will also be a National Seed Secretariat (NSS) which has already been established with the seed industry development and seed quality control units (SQCU). The seed development unit has the mandate to carry out seed industry studies; compile and manage seed industry data and train and develop the private sector among others while the SQCU is duly responsible for determining the quality of seed; provides secretariat and administrative support for the work of the VRC; monitor variety testing, evaluate and describe varieties and provide advice and assistance required to seed industry stakeholders; varietal registration and maintenance of official list of varieties to be released.

In all of this, with the good structures put in place to ensure the effectiveness and successful implementation of the National Seed Policy, it is hopeful that the seed industry could be revamped and smallholder farmers assured of quality seed supply at affordable prices for increase in food crop production.The Sierra Leone Seed Certification Agency (SLeSCA) is the Institution set up by Government to administer the Seed Act under the direct supervision of the Minister of MAFFS who is the Political head and National Seed Controller. According to the Interim Director of SLeSCA, a Seed Act 2012 has been drafted and presented by the Minister of MAFFS to Cabinet for discussion and has been approved by Cabinet.

The Seed Act 2012 is currently in the Office of the Attorney General and Minister of Justice for scrutiny and legal advice before tabled to the House of Parliament for debate and enactment as a law of Sierra Leone.

This Seed Bill when enacted will make it possible for the SLeSCA to get subventions from Government for administration of the Seed Act and implementation of its programs. The Bill will also facilitate the trade of quality seeds within and out of Sierra Leone thereby maintaining cross border trade within the sub-region.In ensuring an increase in the flow of seed across borders in the East and Central African Region, countries within this region had a rationalization and harmonization of seed policies, laws, regulations and procedures. The aim was to boost the choices of quality seeds available to farmers for increased productivity, income and food security. (Waithaka*et al* 2011).

2.2THEORETICAL FRAMEWORK

2.2.1 Seed Supply Systems

The "seed supply system" refers to the entire complex of organizations, individuals and institutions associated with the development, multiplication, processing, storage, distribution and marketing of seeds, Howard *et al*., (2001). Seed supply system as a whole is an interdisciplinary venture comprising of breeding of cultivars, testing, release, maintenance and marketing.

Basically, there are three main seed supply systems namely: Informal seed supply system, Formal supply seed supply system and Integrated seed supply system.

2.2.1.1 Local (Informal) Seed Supply System

The informal seed system is regarded as a low-cost source of seed and can be used as a vehicle to provide poor farmers with improved seed of modern varieties at affordable cost (Amelkinders*et al*,. 1994). The system is often associated with low quality seed by most people but Camargo andBragantini, (2004) suggests that both good and poor quality seed can be found in any of the seed systems. Large number of farmers is involved in producing both local and improved varieties sell their products and attend to their research needs by themselves. This system covers methods of local seed selection, production and diffusion. Cromwell (1992) describes this system as traditional, informal operating mainly at community level through exchange mechanisms and involving limited quantities per transaction. Informal seed supply system is also referred to as farmer-managed seed system. The informal seed supply systems in many African countries are normally not supported by the government Cromwell (1992). In most cases they are supported by NGOs and some big private seed companies. Few farmers involved in the study received support from MAFFS and SMP. The problem of inadequate funds for seed rice production is one of the main reasons for farmers not to embark on full scale seed rice production.

The system in addition includes methods of seed selection, production, and diffusion by farmers, and the exchange of seed. Farmers obtain seed and varieties through informal networks based on exchange with, or gifts from, relatives and neighbors, or through bartering with other farmers, farm own saved or purchasing from local markets. Farm own saved seed may be grain or grain selected for seed before or after harvest. Even though such seed is considered by farmers as the best option in terms of cost and confidence with a particular variety but the use of this kind of seed offers little or no opportunity for the use quality

planting materials and subsequently getting appreciable yield after harvest. Burg, (2004) observes that a better option of farmers to save seeds from their harvest is to cultivate a corner portion of their fields where plants will look healthy and strong to be harvested and reserved for seed.

The informal system is often marked with practices that result in the use of low quality planting materials and reduction in yields. The system is described by FAO (2004) to lack viable means of information for farmers about characteristics and production methods of new varieties in different environments. Farmers instead rely on observing the performance of crops in the fields of other farmers or neighbors. Little or no recognition is given to genetic or physical purity of seeds dealt with in this system. In other words, the issue of quality control is not compulsory with this system; in fact that is why seeds obtained from the informal or local seed supply system are often regarded as cheap, readily and widely available to farmers. Louwaars and de Boef (2012) described the main activities in the informal system to include seed selection, production and diffusion.

Local seed systems are also considered as risky ventures. Longley *et al*, 2001 documented the reasons for the failure of this system to achieve financial viability to include lack of marketing capacity and, lack of infrastructure for processing, storage of seed and lack of access to seed source.

However, the system can be strengthened in many ways by governments and stakeholders in the seed sub- sector. This could be in the form of providing easy access to foundation seeds, technical services on seed production, post-harvest activities and a legal framework that facilitate proper marketing of seeds. Moreover, the capacities of better resourced, skilled and committed farmers in the informal seed system can be built to become contract seed growers for seed companies. This will be a strategy to improve their income. Similarly, this strategy was employed by the Seed Multiplication Project in Sierra Leone during the late eighties to early nineties. Some smallholder farmers in the North West Region of Cameroon are also very active in the multiplication of seed for sale to other farmers and are members of the innovations platform set up by the Institute for Research and Agricultural Development (IRAD).

Informal seed supply system in the hands of the private sector with smallholder farmers as the main actors. Farm-saved seed is the most important source from which farmers obtain

seeds for planting. Reason being that farmers are familiar with the seed they grow themselves, know that the variety is adapted to local conditions and preferences and seed readily accessible when needed during the cropping season. (Bal and Douglas 1992)

During the Green Revolution period, genes from traditional varieties of crops were used to provide semi-dwarf characters of modern wheat and rice varieties as well as crops resistant to pests and diseases, (FAO 2011). This explains the important role played by farmers and the informal seed system in crop improvement programs.

Nevertheless, Camargo *et al*., (2004) holds a different view about the Green Revolution program in developing countries stating that local seed production schemes were looked upon by local authorities and technical and scientific community as being local and less important.

The informal seed system most times gets minimal support from NGOs and other development agencies. However, if smallholder farmers perceive seed production as a business enterprise, the sector can be improved and the supply of quality seed be ensured.

2.2.1.2 Formal Seed Supply System

The formal seed systeminvolves seed production and supply mechanisms that are ruled by defined methodologies and controlled multiplication backed by national legislation and international standardization of methodologies. Camargo *et al*., (1989) referred to this system as "the conventional seed sub-sector" whilst (ChopraandReusche, 1992) call it institutional seed sub-sector. The formal seed system is influenced or guided by a large number of policies from various sectors and international seed institutions. This includes agriculture, research, trade economics, International Seed Testing Association (ISTA) and Union for the Protection of Plant Varieties (UPOVA) that seek to maintain variety identity and purity and most importantly to guarantee physical, physiological and phyto-sanitory quality of seed.

Most formal seed supply systems are often managed by government as is the case in Sierra Leone. Significant investments have been made throughout the developing world to improve varieties and to produce and promote quality seed for some major food crops.

The establishment of the formal seed production systems in developing countries has been dated as far back as the sixties. Many programs and organizations have also been in the drive of establishing formal seed systems.Farmers normally are very much concerned and interested to sow the best quality seed. (Amelkinders et. al, 1994)

The research Institutions and the Seed Multiplication Unit in collaboration with the Ministry of Agriculture in Sierra Leone with support from various Donors and private sector Institutions are in charge of the Formal Seed System and technology generation, multiplication and dissemination respectively. There has been a significant demand for quality seed supply after breeding and testing of new varieties in developing countries over the years.

The main activities in the formal seed supply system include breeding, release of new varieties, multiplication, marketing and maintenance of genetic resources. (Louwaars and de Boef, 2011).The system is considered to be able to meet the demands of modern agriculture, adheres to seed industry requirement and distinguishes between grain and seed but also meets only about 10 percent of seed required by smallholder farmers for planting. Marketing of seeds from the formal seed system is normally done through specialized agro-seed dealers.This system is mainly designed for commercialized agriculture and for the use of improved varieties specifically for a market that puts premium to the application of new technologies. (FAO, 2004).The Formal seed system ensures that there is reliable seed source for the commercial seed growers and smallholder farmers who can afford to pay.

2.2.1.3 Integrated Seed Supply System

Integrated seed supply systems, in the context of this work, are mechanisms to supply seed of new varieties to farmers which combine methods from both the formal and informal sectors including local seed supply systems. The Informal Seed System is improved by 'borrowing' technologies and improvements from the formal sector and using informal channels Louwaars (1994a). This corresponds with the 'non-conventional system', introduced by Camargo *et al*., (1989) and incorporates 'integrated plant breeding', as introduced by Berg *et al*., (1991). Howard *et al*, (2001) also considers this system as market and non-market channels.

Furthermore, variety use and development, seed production and storage by farmers under local conditions, and seed exchange mechanisms are the three principal components of a dynamic system that forms the most important seed source of food crops for small farmers. In fact, the strengths and weaknesses of local seed systems indicate that local seed systems and the formal system are complementary.One of the fundamental principles of the integrated seed sub-sector development concept is the need to develop a two way approach where the effectiveness of both the informal and formal seed systems can be improved through a

combined effort ensuring that proper integration is considered at every stage in the seed value chain.Moreover, in the integrated seed supply system activities in both the Informal and Formal seed systems are done in a participatory manner with the goal of encouraging farmers to adopt improved varieties while also making them familiar with the full technology package. This system however is not yet fully practiced in Sierra Leone although there is some work ongoing by the West African Agriculture productivity programme (WAAP) to establish an innovations platform which will seek to bring together major stakeholders in the seed industry for effective collaboration in making available seeds demanded by farmers and adaptable to local environmental conditions.

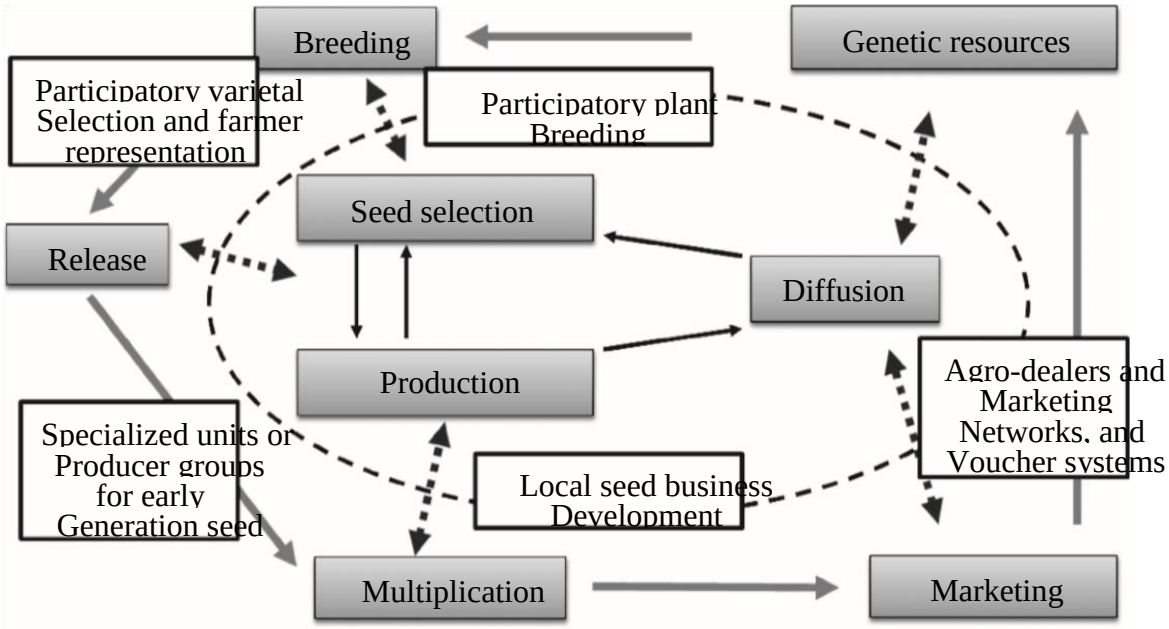


Figure2.1.Integration between Formal and Informal Seed Systems in an Integrated Setting Including Examples

Note: Dashed arrows visualize linkages between the formal and informal seed systems, each further elaborated by examples.

Source: Louwaars and de Boef 2012

CHAPTER THREE

METHODOLOGY OF THE STUDY

3.1.MODEL SPECIFICATION

The model used in this study was based on the quantification and qualification of two seed quality parameters (physical and physiological) used to measure four different rice varieties (Pa Kiamp, ROK 24, Butter Cup and Pa Chaim).

Quality seed = Physical (>77% purity) + Physiological (>80% germination +>80%vigor)

3.1.1. Description of Variables in the Model

The variables for measuring the physical parameters for quality of seeds were based on the test for purity (percentage of impurities (inert matter, weed seeds and seed from other crops) present in the sample). On the other hand, the variablesfor measuring the physiological parameters for quality of seeds were based on the test forgermination (percentage of seed emergence) and vigor (sowing depth; 2 cm and 4 cm). The parameters and variables are described in table 3.1.

Table 3.1: Parameters used to Measure Seed Quality

Parameters	**Variable**
Physical	Seed purity-presence of inert material Presence of weed seed Presence of seed of other crops -
Physiological	Vigor – sowing depth (2 cm and 4 cm) Germination test– percentage of seed emergence

Materials used for setting up and carrying out the germination tests in the green house included wooden boxes, substrate (loamy sandy soil), rice seeds, watering can, bucket and notebook. For the laboratory test, Petri dishes, filter paper, distilled water; rice seeds and assorted stationary were used. A digital camera was also used to capture pictures during the experiment. Table 3.2 gives details of the materials used for the greenhouse and laboratory germination experiments conducted:

Table 3.2.Materials used in Germination Experiments

Greenhouse germination test	Laboratory test
$1m^2$ wooden boxes (4)	Petri dishes (4)
Loamy sandy soil	Filter paper
Water and watering can	Distilled water
Rice Seeds (560)	Rice Seeds (40)
Bucket	Notebook, pencil, ruler, marker, simple camera
Notebook, pencil, ruler, marker, simple camera	

3.2STUDY DESIGN

This study made use of both exploratory and descriptive research design. A preliminary field visit was conducted to locate and observe thestudy area. Sampling was done to select Chiefdoms, Villages and respondents for data collection. Data was then collected through desk review, questionnaire administration, focus group discussion, semi-structured interviews and lastly the seed quality tests. The data were then analyzed and the results presented and discussed. Figure 3.1schematically represents the design used in the study.

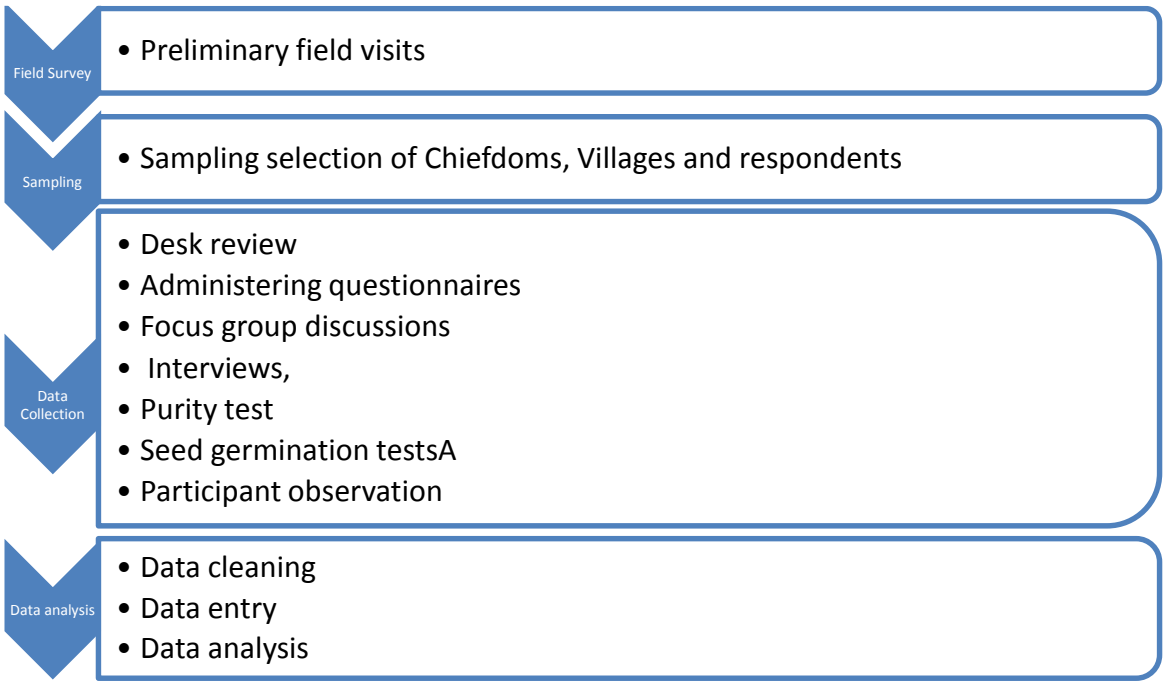


Figure3.1:Study design

3.2.1Sampling

Purposive sampling method was used to select the number of respondents needed for the study. This method was used purposely to target rice farmers that are direct beneficiariesof the German Seed Project.

3.2.2. Sample Size

Small holder Seed rice Farmers were identified and selected during a preliminary survey in the main planting season in the study area.

During the selection of respondents, emphasis was placed in identifying and selecting farmers that are direct beneficiaries of the German Seed Project in the two Districts. Rice (*Oryza sativa*), was targeted as a crop for the study.

TheDistrict Agricultural Extension Officers of MAFFS and Past Project and Program Staff of the Seed Multiplication Unit and FAOSL in both Districts were consulted in selecting Chiefdoms, Villages and respondents. A total of one hundred and twenty (120) Smallholder farmers were selected and interviewed in the two Districts using a structured household questionnaire.

3.2.3. DataCollection Instruments

The study employed a combination of data collection tools. Structured questionnaires and focus group discussions were used to get information that answered the first research question. Focus group discussions, germination, vigor and purity tests were used to assess the quality of seeds used by farmers. Key informant interviews were conducted to obtain information from stakeholders in the seed sub-sector. Both primary and secondary sources of data were obtained for the identification of rice varieties and assessment of the challenges of smallholder farmers in seed and rice production.

Primary data was collected using a detailed household survey. Secondary data was obtained through desk survey from the following sources:

- Available reports of MAFFS in Sierra Leone
- Review of related literature to the study
- Fact sheets and other publications on quality seed production and seed supply systems in the study area

3.2.3.1Administration of Questionnaires

A total of one hundred and twenty (120) questionnaires were administered to purposefully selected smallholder rice farmers in the two districts (sixty in each District). Each questionnaire had a total of forty three questions. The questions were categorized into three sections namely: Section A, B and C. Section A captured information on basic demographic data of farmers, section B sourced out information on seed rice production and quality aspects which included: rice varieties cultivated, methods and inputs employed in seed and rice production while section C generated data on harvest, post-harvest practices and challenges of farmers in seed and rice production. Participant observation complemented the questionnaire to validate answers from respondents.

A two days training program was organized for data collectors before the actual field work to better understand the use of the research instruments. The instruments were pre-tested to determine the time needed for administration and familiarity and to ensure reliability and validity of the data.Questionnaires were equally distributed amongst four (4) enumerators and were administered in July 2014. Due to other engagements of the enumerators and the respondents, the questionnaires were administered at their convenience and collected within fourteen (14) days. Two enumerators worked in each District and each administered thirty (30) questionnaires.

3.2.3.1.1 Quality and Fidelity Control

As a way of ensuring reliability of responses recorded in the questionnaires, cross referenced questions were introduced. In cases where answers are not the same, those questions were discarded. All questions in the questionnaire were analysed. Respondents were also convinced to give answers based on reality and experience.

3.2.3.2 Focus Group Discussions

Focus Group Discussions (FGDs) were held in the study area. The interactions and discussions with group members during the FGDs offered an opportunity for confidence building between the research team and the respondents while also validating and elaborating on challenges in seed and rice production. A stronger collaboration with stakeholders was also established and feasible suggestions in improving seed and rice production brought out by the farmers themselves. The FGD and the key informant interview were guided by a prepared check list. Two focus group discussions were held in each of the six chiefdoms

making a total of twelve FGDs in the study area. Separate groups of male and female farmers were formed for the FGD with group members limited to not more than twelve (12) persons.

3.2.3.3 Key Informant Interview

Key informant interviews were conducted to elicit information on seed policy, interaction and collaboration with stakeholders. Other issues discussed included available infrastructure for seed and rice production, technology generation and dissemination. Since there are many stakeholders (farmers, policy makers, extension staff, research, agro-dealers, marketers and transporters)in the seed industry in Sierra Leone, the interviews helped in identifying major challenges encountered and ways of strengthening quality seed rice production in the country.

The interviews were held in Freetown and both study Districts from July to September 2014. The discussants were drawn from the following Institutions:

- National Farmers Federation of Sierra Leone (Four persons),
- Seed dealers/suppliers /growers (Two persons)
- Seed Multiplication Program (SMP) (Two persons)
- MAFFS (six persons)
- Sierra Leone Seed Certification Agency (SLeSCA) (Three persons)
- Rokupr Agricultural Research Center (RARC) (One person)

3.2.4 Physical Quality Test

3.2.4.1 Purity Test

To determine the physical purity of sampled seed rice, a uniform container with a 100ml volume was used. Measured seeds of four different rice varieties (Pa Kiamp, ROK 24, Butter Cup and Pa Chaim) were weighed using an electronic balance to determine the weight of the seeds (plate 3.1.). The impurities (inert material weed seeds, and seeds of other crops) was removed and weighed separately to calculate its percentage within the sampled seed lot.

Plate 3.1: Measurement of seed impurities using an electronic balance

3.2.4.2 Physiological Quality Test

3.3.4.2.1 Germination test

An experiment to test for seed germination potential was carried out to determine the viability and quality of seedrice sown by sampled farmers. This test was done in a greenhouse. A similar experiment was done in Petri dishes under laboratory conditions.Four samples of four different rice seed varieties were obtained from both the formal and informal seed sub-sectors in Sierra Leone. The formal seed sub-sector provided two improved varieties called ROK 24and Pa Kiamp (ROK 34) while the informal sector provided two local varieties called Butter Cup and Pa Chaim.

3.2.4.2.1.1 Procedure for Greenhouse Germination Test

- Four woodenboxes (of sizes $1m^2$) were constructed and were placed in the green house. The boxes were then filled with loamy-sandy soil.
- One hundred and forty seeds of the four rice varieties were sowed in each of the four boxes. Amongst these, 100 seeds were sown at the surface of the soil, 20 were sowed at 2cm depth while the remaining 20 were sowed at 4cm depth. (plate 3.2)
- After sowing the seeds, watering was done using a watering can to provide moisture. This was done on a daily basis until after fourteen days
- Counting and recording of germinated seeds commenced on the fifth day of sowing the seeds until the fourteenth day.
- The number germinated seedlings were counted and recorded as total germination percentage for each variety.


(a)Setting up experiment *(b) Sowing of rice seeds* *(c) Irrigating seeds*

Plate 3.2: Setting up and managing the greenhouse germination experiment

3.2.4.2.1.2: Procedure for Laboratory Germination Test

- Four Petri dishes were cleaned with distilled water several times
- Filter papers were lined in the dishes
- Ten seeds from the four rice varieties were each placed in the Petri dishes
- Tap water was added on as when required to keep the seeds moist
- The dishes were kept in a dark corner in the laboratory
- Counting of the germinated seeds started on the fifth day and ended on the fourteenth day
- The number germinated seedlings were counted and recorded as total germination percentage for each variety.

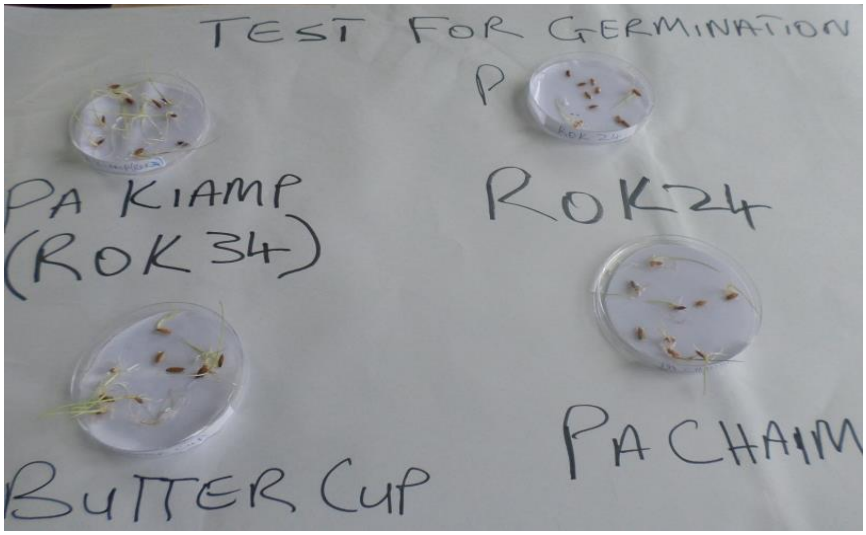


Plate 3.3: Laboratory germination test using Petri dishes

3.2.4.2.2 Vigor Test

Thepotential of seeds to maintain uniform growth and development into normal seedlings under a wide range of field conditions can be determined by carrying out vigor test.

Forty seeds from the four different varieties tested for germination were each sown in separate seed boxes.

Twenty seeds were each sown at a depth of 4 and 2 cm. This was done to know how seedlings can emerge at various planting depths. The emerged seedlings were carefully observed for a period of fourteen days to get the percent of those that were vigorous and non vigorous after germination.

3.3 Data Analysis

Analysis was restricted to the relevant information available on the selected indicators. Primary and secondary data were analyzed qualitatively and quantitatively. Descriptive statistics was also used in analyzing data. The Statistical Package for Social Sciences (SPSS) was used to analyze data with the help of Excel spreadsheet to present results in tables and charts.

3.4 Validation of the Results

The challenge arising from data gaps (quantitative and qualitative) was complemented with visual observations and field experience of the seed production processes. This study was limited to the two districts in which the German Seed Project took place. Thus the results hold for these two districts and cannot be fully generalized to the other districts that did not make up the study population due to the absence of the German Seed Project in those districts.

CHAPTER FOUR

PRESENTATION AND DISCUSSION OF RESULTS

Thischapter presents and discuses key finding of the study. It begins with findings of the demographic characteristics of respondents such as gender, religion and education. It further discuses results of different rice varieties cultivated by farmers.In addition, quality aspects of seed and rice produced by farmers with respect to farmers' source of planting materials and their perception about seed quality and certification, issues of land accessibility with regards to method of land acquisition; size of land cultivated and ecology; characteristics and management for seed and rice production are also presented and discussed. Lastly, the challenges of smallholder farmers in seed production are presented.

4.1 DEMOGRAPHIC CHARACTERISTICS OF THE RESPONDENTS

The results indicated that demographic characteristics of smallholder rice farmers in Sierra Leone vary considerably (Table 4.1). From the study, 67 percent of the respondents were men while 33 percent were women. This shows that rice cultivation in Sierra Leone is dominantly a male activity. The high level of involvement of men in rice production could be ascribed to the fact that rice cultivation is an intensive activity requiring enormous inputs. Land has to be cleared followed by construction of mounds, sowing of seeds sometimes by broadcasting, weeding, etc. to worsen the situation, rice cultivation requires a lot of labor to capital investments which most women could not afford. In addition land is a pre-requisite for the cultivation of rice, however most traditions in Sierra Leone do not give women equal chances just as men the right to own land which presumably has an influence on the level of women's involvement. Sierra Leone is a country with two major religions viz Muslims and Christians. From the study, 85 percent of the respondents are Muslims while 15 percent are Christians.

Thestudy showed that 65.0 percentof farmershave had any formal education, 20.0 percenthad primary education, 10.8 percent secondary education and 4.2 percent with tertiary education. This neither shows that most farmers in Sierra Leone could not basically read nor write. The implication of this high illiteracy rate amongst the farming community is that it would be difficult to effectively execute any training program in seed production or improved farming practices. It will therefore require the government's enormous investments in order to meet up her food desire if considerable efforts are not placed in the educational sector. according to the SCP in Sierra Leone's motto 'Farm for business', for farmers to consider farming as a business enterprise, farmers need to have at least minimal numeracy skills in order to be able

to keep records of daily expenditure and income on the farm which are unfortunately lagging in Sierra Leone. From field experience, record keeping can assist one to determine the profitability of the enterprise. Worldwide researchers have applauded the participatory contributions of farmers in the development of new crop varieties, which is more appreciated by the literacy of farmers (Delimini, 2012). Recording of dates of event during a plant breeding exercise or multiplication of varieties is an important factor for results to be obtained for further replication to other farmers or localities.

Table 1.1: Socio-demographic characteristics of respondents

Characteristics	Count	Percent	Characteristics	Count	Percent
District			**Educational Level**		
Bombali	60	50	No formal education	78	65.0
Kambia	60	50	Primary education	24	20.0
			Secondary education	13	10.8
Chiefdoms			Tertiary institution	5	4.2
BombaliShebora	20	16.7			
MakarieGbanti	20	16.7	**Marital Status**		
SafrokoLimba	20	16.7	Married	106	88.3
Magbema	20	16.7	Single	8	6.7
Mambolo	20	16.7	Divorced	2	1.7
Masongbala	20	16.7	Widowed	4	3.3
Gender			**Religion**		
Male	80	66.7	Christian	16	13.3
Female	40	33.7	Muslim	102	85.0
			Others	2	1.7
Head of Household					
Yes	85	70.8			
No	35	29.2			

4.2. Rice varieties Cultivated by Respondents in the Study Area (Research question 1)

The choice of variety of seed rice to cultivate is relevant in seed and rice productionRickman *et al*., (2006). Clean healthy seeds with uniform variety must be selected for sowing. One should be able to know if seed (meant for multiplication purpose) is produced separately from grains (produced mainly for human and animal consumption).

In most African countries, seed used by farmers for sowing are perceived to be certified seeds but the issue of treatment of these seeds before storage and carrying out germination test isnot often considered by farmers. Evidence from the study reveals that majority of the respondents in study districts (78 percent) do not produce seed on a separately from grains. Instead seeds are selected before, during or after harvest. Similar results have been reported by Louwaars and Marrewiik (1994) that farmers select seed from their own crop and consider this as the best way. In some cases, vigorous tillers are carefully identified by the farmer for seed before harvesting. Sometimes these tillers are harvested and processed separately to get seed for the subsequent planting season. Alternatively, a portion of the grain is reserved after threshing and winnowing. The implication in using this method to select seeds for planting is that seeds selected may not be of good quality.

The small scale farmers and key informants affirmed that little or no idea in seed production; inadequate production resources (certified seed, fertilizers, farm land, labor, chemicals) expensive method to practice because of inputs needed and required procedures (isolation, field inspection and rougeing of off-types); requires a lot of energy, time and technical skills were some of the factors that hindered them not to produce seed separately from grains. This implies that if Sierra Leone is of dire need to vulgarize her seed rice production, she needs to improve on the mentioned areas.

Thirty three (33) rice varieties were cultivated in the study area as shown in table 4.2Thetop four (4) varieties cultivated by respondents are Pa Kiamp, ROK 10, ROK 5 and NERICA L19.Rice farmers in Sierra Leone often cultivate more than two varieties.The choice of seed rice varieties by farmers is in line with their needs and priorities coupled with other factors such as available resources (land, labor, capital and inputs); reliable market demand; land or soil suitability and cultural norms and traditions. Similar observations have been reported in other parts of the world on rice (Delimini, 2012) and vegetables (Asongwe*et al*., 2014).

In Kambia District, only 15 percent of respondents cultivate Pa Kiamp (ROK 34). The high proportion of farmers' involvement in the cultivation of Pa Kiamp (ROK 34) in Bombali could be ascribed to the fact that in Bombali, both inland valley swamps and boliland are cultivated. Also, at the time of data collection in July 2014, Pa Kiamp was a local variety but by December 2014, this variety which was undergoing improvement from the rice research institute was released and became an improved variety. On the other hand, farmers in Kambia are scarcely involved in boliland rice cultivation.

In Kambia,ROK 5, ROK 10 and Culma are mostly cultivated. The first two are improved varieties released to farmers by the research institution while the third is a local variety. A total of 30 percent and 28.3 percentof respondents cultivate ROK 5 and 10 respectively. The high involvement of farmers in the cultivation of these varieties in Kambia district more than in Bombali (5 percent and 23.3 percent respectively) could be due to the fact that ROK 5 and 10 are improved varieties which need intensive cultural practices. The Rokupr Rice Research Centre is situated in Kambia District, providing technical support to farmers involved in rice production in this area. Fifty three percent of farmers in this area acknowledged receiving support from extension staff which must have contributed to their involvement in the cultivation of ROK 5than any other variety.

Sampled farmers in Kambia district cultivate a total of 19 varieties whereas 17 rice varieties are cultivated by respondents in Bombali district. A ranking of varieties cultivated indicates that in Bombali, Pa Kiamp (ROK34) tops farmers preference. 70 percent of respondents in Bombali district cultivated ROK 34. In general, 42.2 percentof respondents cultivated this variety in the study area.

The use of the NERICA L19 variety could be linked to the implementation of the Multi-NERICA Rice Dissemination and German Seed Projects' support to farmers in Kambia District. It is worth noting that Culma which is a local rice variety is only cultivated in Kambia. It is the most unique and cultivated variety in Mambolo Chiefdom which could probably be linked to mangrove ecology in the area. This shows the variety could thrive best in mangrove ecology.In Bombali, there are three top varieties cultivated. These are: Pa Kiamp, ROK 10 and Pa Limba. Rice varieties such as: Pa Biaka, Pa Janet, Pa Matches, Pa Limba, Pa Koroma, and ROK 14 arealso varieties cultivated in Bombali but not in Kambia District.

In general, whether in Bombali or Kambia, different chiefdoms often show appreciation to the cultivation of one or two varieties unique to them. This could be an indication that there is an ethnic pattern in the cultivation and consumption of rice varieties. According to Louwaars and Marrewiik (1994) identification of indigenous varieties of crops is of utmost importance as it would lead to the conservation of valued genes which would have been lost if not identified.

Table 4.2: A rank of rice seed varieties cultivated in Bombali and Kambia districts in Sierra Leone

Bombali District		Kambia District	
Rice Variety	**Total**	**Rice Variety**	**Total**
Pa Kiamp	42	ROK 5	18
ROK 10	14	ROK 10	17
Pa Limba	7	Culma	14
ROK 3	3	NERICA L 19	11
ROK 5	3	Pa Kiamp	9
NERICA L 19	3	Pa Chaim	9
Pa Yaka	2	Butter cup	8
Pa Biaka	2	Yan Gbessay	8
Pa Chaim	2	ROK 3	5
ROK 24	2	Mayeani	4
NERICA 4	2	Compound	3
Pa Janet	1	YealiFoday	3
Pa Matches	1	YealiBombor	3
CP4	1	NERICA 4	2
ROK 14	1	Blostic	2
Pa Sheka	1	NERICA 4	2
Pa Koroma	1	Salim	2
Butter cup	0	Pa Kandeh	2
Compound	0	ROK 24	1
Culma	0	CP4	1
YealiFoday	0	Pa Kambia	1
Pa Kambia	0	KoliSaidu	1
YealiBombor	0	KoliSafie	1
Mayeani	0	Pa Osman	1
KoliSaidu	0	Kortum	1
KoliSafie	0	Pa Yaka	0
Yan Gbessay	0	Pa Biaka	0
Pa Osman	0	Pa Janet	0
Blostic	0	Pa Matches	0
NERICA 4	0	ROK 14	0
Kortum	0	Pa Limba	0
Salim	0	Pa Sheka	0
Pa Kandeh	0	Pa Koroma	0

4.3 Quality of Seed Produced by Smallholder Farmers in the Study Area (Research question 2)

4.3.1 Perception of Farmers about Seed Quality

Farmers were interviewed on how they determine quality seed andtheir perception about seed quality differs in various ways. Some understand quality seed to be seed that is free from inert materials, disease-free. Some think quality seed is one with uniform variety and that which is tolerant to pest, diseases and adverse climatic conditions others think quality seed is one with high germination percentage. The responses are indicated in Figure.4.1.Sixty percent of farmers interviewed during the focus group discussions were of the fact that they use color after pounding (milling) with a mortar and pestle to determine seed for sowing. If the grains are white in color then it is considered as quality seed with high germination potential. If on the other hand the grains color is dark then the seed is regarded as low quality seed with low germination potential. This indigenous knowledge is vital, given that most of the areas where rice is cultivated are remote areas, and the poor farmers will need a lot of money to reach areas of certified options.

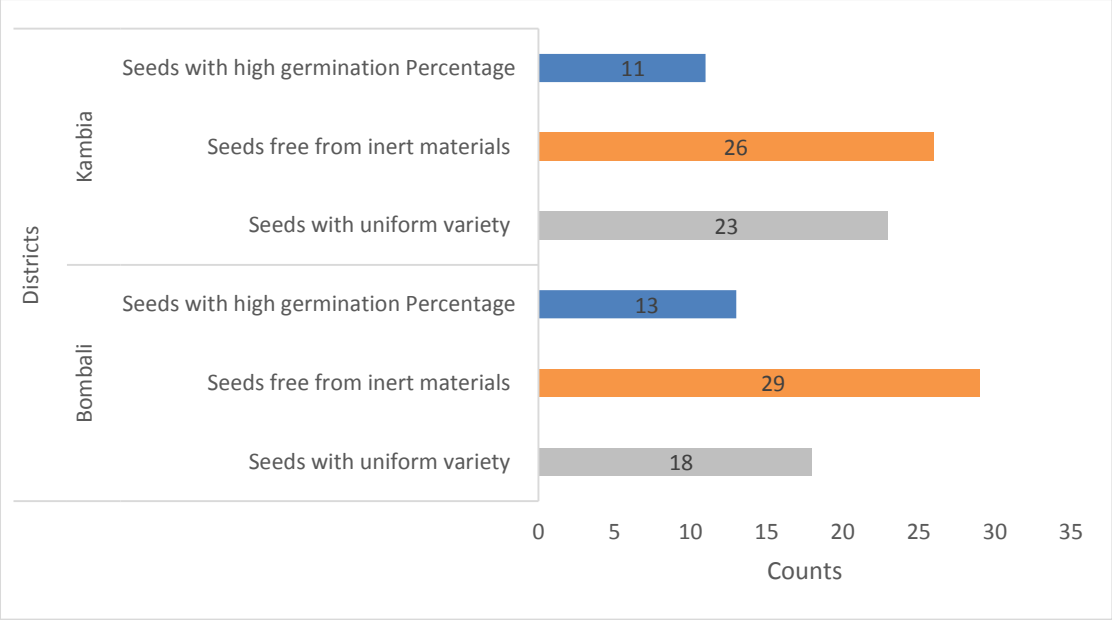


Figure4.1.Perception of farmers about Seed Quality

4.3.2. PurityAnalysis

Tokpah (2010) reported that the use of quality seed for production gives the advantage of increasing production and productivity whilst aiding the production of uniform crops free from admixtures (mixture of other varieties in the seed lot).

Figures 4.2 gives the percentages of pure seed and contaminants calculated from weighed samples of the four different rice varieties. Although all the rice varieties had at least some amount of impurities, Butter cup had the highest percentage (8.72)percentof contaminants (inert material, seeds of other crops and weed seeds) while Pa Kiamp (ROK 34) had the lowest (3.38 percent) contaminants. The lowest percentages of contaminants in ROK 34 could be associated to the recent improvement of the variety so as to revitalize the loss of quality formerly witnessed, so as to boost the quantity of rice produced in Sierra Leone, while Butter cup on the other hand is presumably associated with poor handling given that t is a local variety which is in circulation and predominantly used by farmers in Kambia district.

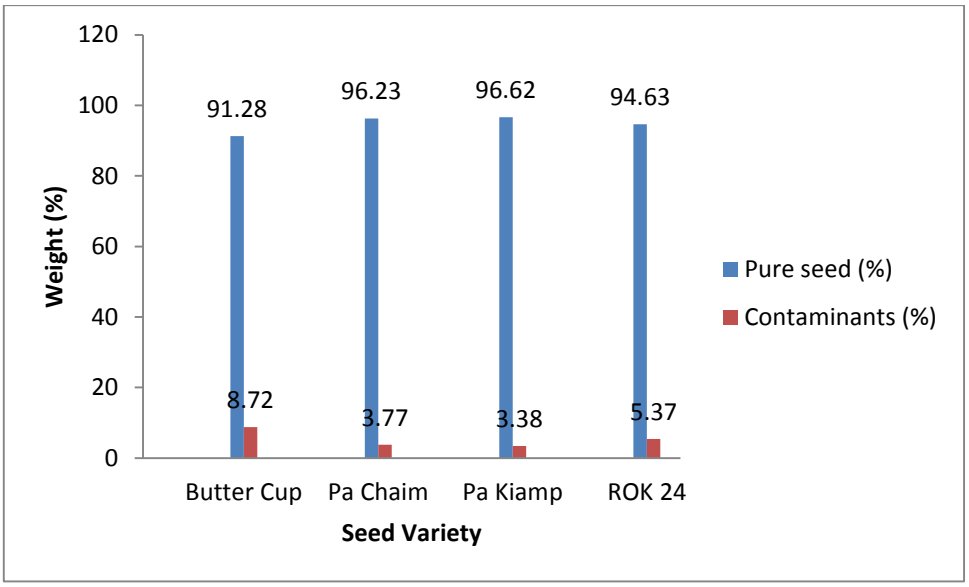


Figure 4.2: Percentage composition of pure seeds and contaminant of four rice varieties grown by farmers in Sierra Leone

4.3.3 Physiological Quality of Seed

4.3.3.1 Seed GerminationTest

According to ISTA (2007) the only test farmers can do to determine the suitability of seeds for planting is germination test. ISTA further stated that it is only by getting the germination percentage that farmers will be able to get the required plant population in the field. Results from the germination test conducted for four varieties (figure 4.3) reveals that Pa Kiamp(ROK 34) an improved seed rice variety in Sierra Leone has 59 percent in the greenhouse experiment and 90 percent germination in the laboratory (Petri dish) experiment.

During the time of field data collection in July 2014, Pa Kiamp was a local variety but upon research improvements, it was later released as an improved variety and bears the name ROK 34, given by SLARI and SLeSCA in December (2014).

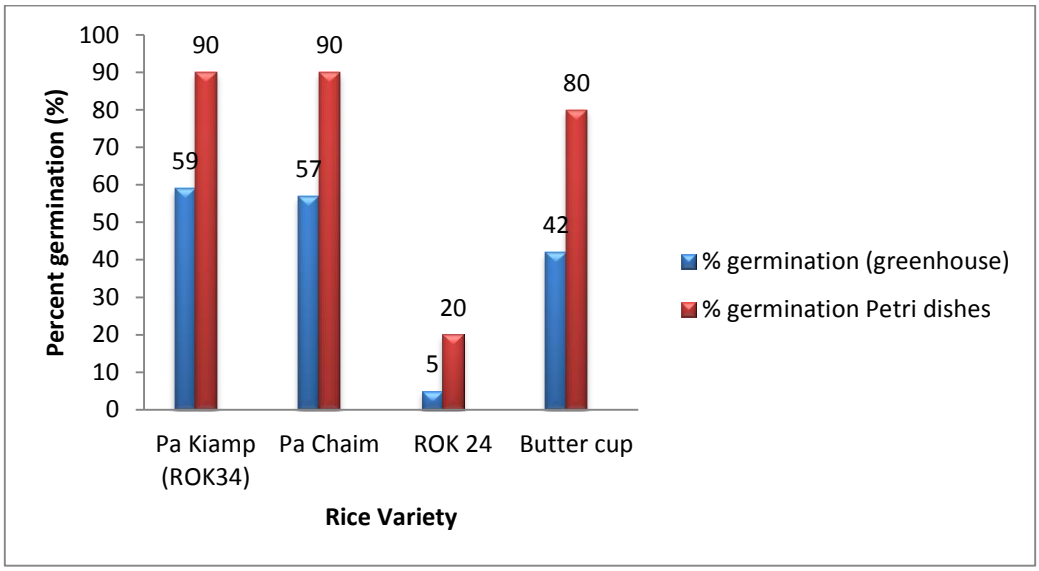
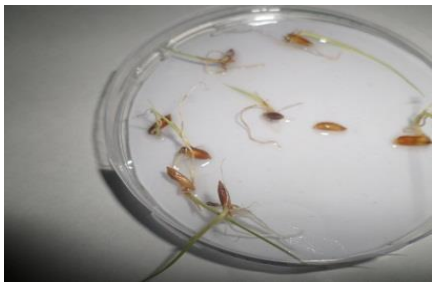


Figure 4.3: Percentage germination test (greenhouse and laboratory) for some seed rice varieties collected in the Bombali and Kambia districts in Sierra Leone.

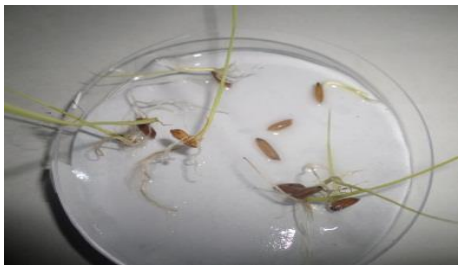
ROK 24 which is an improved rice variety released by SLARI in the 80s had only 5 percent and 20 percent germination in the greenhouse laboratory experiments, respectively (plate 1 and 2). This had the lowest germination percentage amongst the four rice varieties tested for germination. This result conforms to that of the respondents to questionnaires which reveals that only 2.5 percent of small scale rice farmers cultivate this rice variety. The low level of farmers involved in the cultivation of this variety further justifies its selection for a germination test.The low level of usage of this variety could also be linked to the fact that it has been recycled many times over the years, thereby losing both its quantity and viability and probably the taste preferences of consumers. Because our calculated student t-testvalue is outside the t-critical value, (at the 95 percent confidence interval), it reveals that there is a significant difference between the mean germination percentages obtained in the laboratory and that of the greenhouse experiment ($t_{calculated}$ = -5.882, $t_{critical\ value}$ = ±3.182) (appendix IV), with higher percentages from the laboratory experiment. This suggests that the environmental conditions were different under the two media. In the same light, experimental conditions will differ from the farm condition which farmers often face. Therefore, a policy implication can suggest that farmers should increase their sowing density in order to meet up with the

demand. The conventional acceptable minimum percentage for certified seed is based on laboratory experiment which measures a germination percentage of 80 percent and above to meet the physiological requirement that qualifies a seed to be of high quality (ISTA, 2007 and IRRI, 2013).

Pa KiampRok 24



Pa Chaim



Butter cup

Plate 4.1: Germination Results for Laboratory Experiment using Petri Dishes

(a) Day 1. Before germination

(b). 14 days after sowing

Plate 4.2: Greenhouse germination experiment using soil boxes,

4.3.3.2 Vigor Test

Establishing the vigor of seeds is essential in determining duration of storage. Vigor is influenced by environmental conditions during seed maturity (Perry, 1981). The results (figure 4.4) show that ROk 24 had the highest vigor although it had the lowest germination percentage. This implies that when seeds of ROK 24 succeed to germinate in the field, they

would grow to maturity, thereby showing high resistance to most poor soil conditions. Contrarily, Pa Kiamp, which had the highest germination percentage, had the lowest vigor at greater depths. This means that for the cultivation of this variety, absolute precautions should be taken with regard to depth. This result confirms why Pa Kiamp is nursed and transplanted in low lands while it is simply broadcasted in the uplands in the two districts.

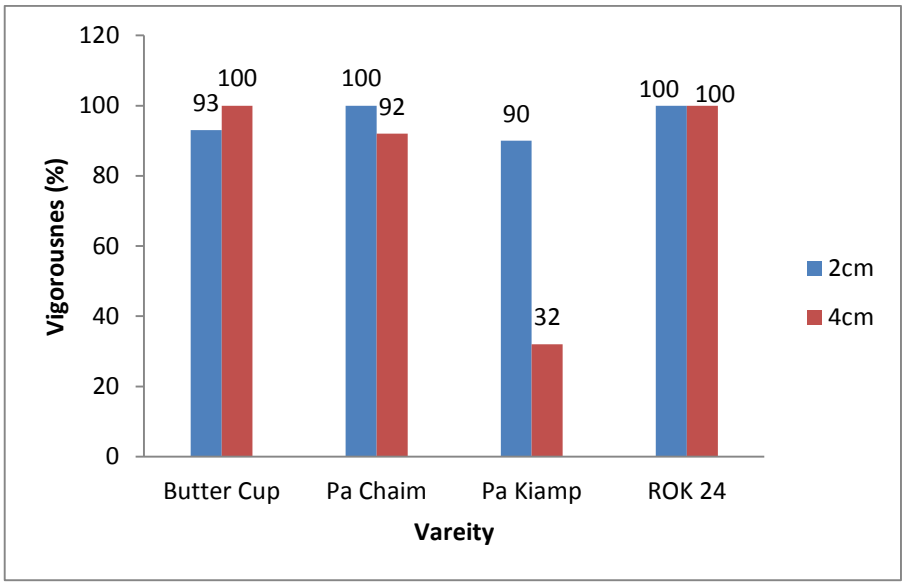


Figure 4.4: Effects of vigour four rice varieties sown at different depths in percentage

4.4 Seed Accessibility and Management

4.4.1Method of Acquiring Seed

The method of acquiring seed by farmers is important in assessing the quality of seed produced (Burg (2004). Farmers in Sierra Leone obtain their seeds for planting from different sources but the informal seed system is the main source of their planting materials. This system includes farm saved seed, farmer to farmer exchange and buying from the local market. Although this system is popular and cheap, however it is not the best because farmers do not produce seed separately from grains. Seed rice production cannot be successful without selecting the best varieties (Burg (2004).Normally, farmers in Sierra Leonehave one farm cultivated in which after harvest a portion is reserved as seed for the next planting season whilst the remaining is used for home consumption and sold to solve problems or provide other needs (medicines, clothes, school fees for children etc) in the home. The right choice of these varieties makes an impact on their characteristics on the yearly performance (Burg (2004). These results are in concordance with those of Tokpah (2010) who reported that about 95 percent of seeds used by smallholder farmers are got from their communities,

friends and neighbors. The latter noted that the formal seed system supplies only 10 percent of seed requirements in Asia. Similar results have been reported by Dasgupta and Roy (2011) for Sierra Leone. As such, this type of cultivation for rice and seeds does not conform to the rules and standards set by seed regulatory bodies for formal seed production, processing and storage. The non-conformity of these farmers to the standards set for quality seed production either as a result of ignorance or lack of education and training and productive resources (land and inputs) greatly contributes to inadequate supply of quality seed rice for maximum production.

Although 35 percent of farmers get seeds from multiple sources including the formal seed system (Research institutions, certified seed growers and private seed dealers) as gift or credit yet the informal seed system takes the lead in seed acquisition for planting. Results from this study show that respondents in the two study Districts obtained seed from the following sources: own saved seed from previous harvest 47 percent, credit 26.7 percent, buying 17.5 percent seeds, gift 5.0 percent and other sources 3.3 percent. Respondents of the study perceived that the use of their own saved seeds from previous cropping season was the cheapest means of acquiring seed apart from being readily available and thus the reason the use was common.

Even though the use of own saved seed by farmers is the cheapest and readily available means yet results obtained from the germination test proves that the quality of the seed used is questionable. This could be associated to the fact that as much as farmers have firsthand experience in managing their seeds nevertheless they sometimes pay little or no attention to certain parameters like cleaning seed, observing right moisture content (12 percent) and proper storage in maintaining the quality of seed before, during and after harvest. This implies that the quality of seed is first reduced if care is not taken in the processing methods used for threshing, cleaning and storage. It is during this process that mechanical admixture of varieties occurs. Moreover, proper storage conditions and practices most times do not make up to the recommended standards for storage of seed.

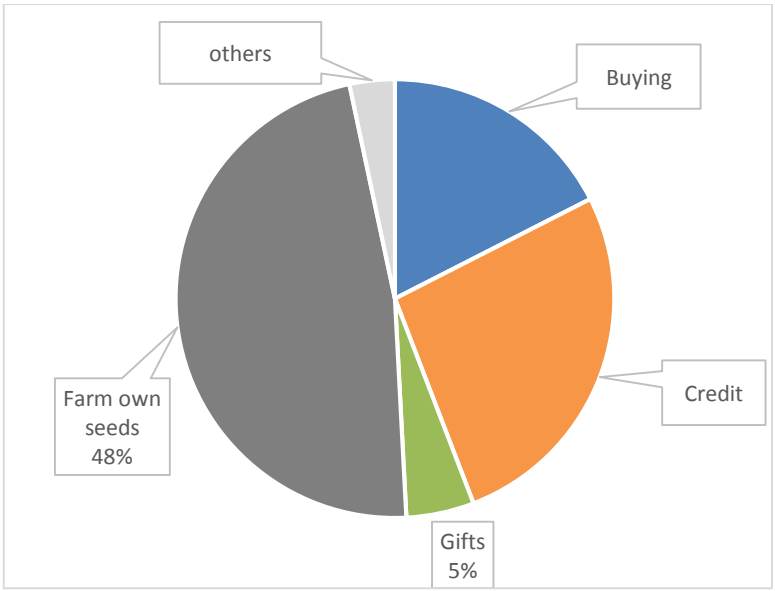


Figure 4.5: Sources of Seed

4.4.2Treatment of Seed Rice

To ensure that the quality of seeds is preserved during storage and before sowing, it is advisable for seeds to be treated or stores well fumigated against weevils and other storage pests. The issue of treating seeds before storage or sowing was investigated and results show that in Bombali District only 28.3 percent of the respondents treat seeds before planting, 71.7 percent do not treat seeds before planting. In Kambia District, the situation on treatment of seeds before sowing is different. Majority of the respondents (96.7 percent) treat seeds whilst 3.3 percent do not treat seeds. Table 4.3 gives details on treatment of seeds in the two study Districts. The variance in the treatment of seeds before planting in the two districts is because in Kambia District the respondents are closer to the Rokupr Agricultural Research Center (RARC) responsible for rice improvement and got support (seed loan and extension services) from Institutions (MAFFS and SMP) whilst in Bombali District farmers do not have easy access to a research Institution and received very little support from other Institutions. Some of the respondents reported that they treat their seeds locally with neem tree leaves against insect and pest attack.

Table 4.3: Treatment of seeds before sowing

District * Do you treat Seeds before sowing? Crosstabulation				
		Do you treat Seeds before sowing?		
		Yes	No	Total
District	**Bombali**	17	43	60
	Kambia	58	2	60
Total		75	45	120

4.5 Land Acquisition for Seed Production

The quality of seed rice produced by smallholder farmers can also be successfully assessed by the kind of production method used by farmers. The very first aspect of ensuring quality seed production rests on the selection of land on which the seed could be produced. It is good to select land free from weeds for the production of certified seed. Asea *et. al*., (2010) noted that the choice of land for seed production contributes greatly to success in seed production.

Land for agricultural use in Sierra Leone is abundant but the problem often faced by farmers is acquisition. According to Baloyi (2010), smallholder farmers in developing countries face major challenges in production and key among these challenges is poor access to land. Results from the study showed that 76.67 percent and 80 percent of the respondents in Bombali and Kambia districts respectively acquired land for agricultural production through inheritance (Figure 4.6). Similarly, 18.33 percent and 15 percent acquired land by renting, 3.3percent and 1.67 percent acquired land by buying while1.67 percent and 3.33 percent acquired land by leasing. Land was inherited either from parents, family clans or by marriage. Access to land for agricultural production and ownership of land are different. In the former, a farmer can arrange to have access to a piece of land for a particular planting season with no written agreements. In most village settings, owners of land are sometimes not reliable in land use agreements within their localities. If for example a farmer has farmed on a piece of land in one season and succeeded to get a bumper harvest, the owner of the land may become jealous and may request the return of that piece of land for the next cropping season.

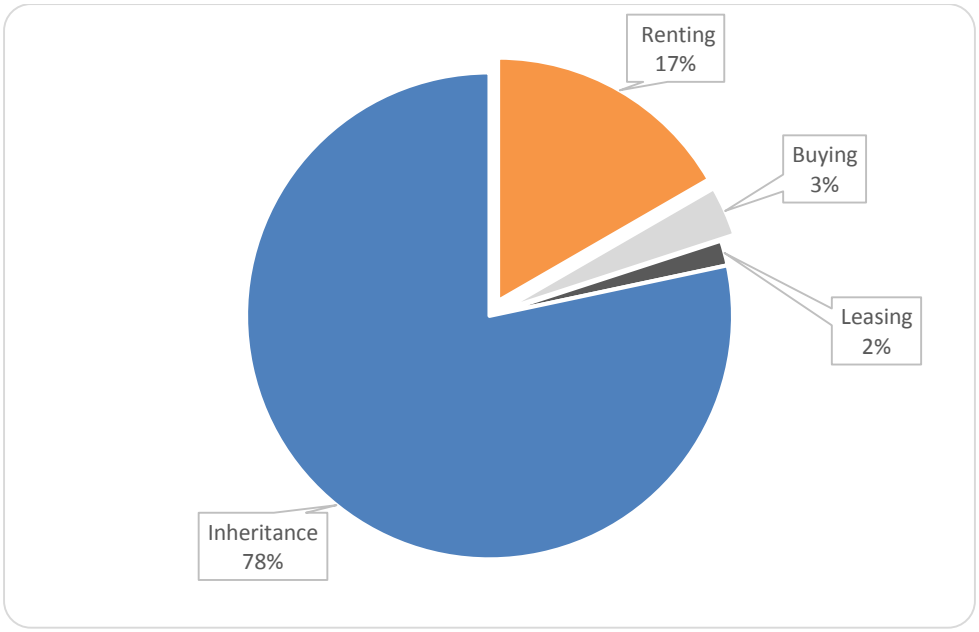


Figure 4.6: Acquisition of Land for Rice Cultivation by Respondents

4.6. Ecologies and Method used in Seed Rice Production

In Sierra Leone like many other countries, rice can be cultivated on a variety of ecologies. Data from the study proved that three major ecologies are used by respondents for rice production (table 4.4). In both Bombali (54 percent) and Kambia (45 percent) Districts the inland valley swamp (IVS) is more used in the cultivation of rice. The situation is different with Boliland and Mangrove ecologies. In Bombali, IVS and Boliland are used for rice production while Kambia utilizes Mangrove and IVS for rice production. There is virtually no mangrove ecology in Bombali District. These ecologies are used for seed and rice cultivation under rain fed conditions and in developed IVS with proper water control structures in the dry season. Farmers produce rice under rain fed conditions. Information gathered from farmers on the ecologies used in producing rice show that majority (49 percent) of the respondents in the study area utilize the IVS ecology with the main planting season in rainy season and a second cropping at the start of the dry season for farmers with access to developed IVS. For IVS cultivation, seeds are raised in a well prepared nursery bed which is normally located close to the planting site. During the growth of rice in the nursery, the fields are well prepared for transplanting. It is recommended for the mature seedlings to be transplanted at a three leaf stage with ball of earth. Preferably, the duration of the rice in the nursery should be 21 days depending on the variety. Once the seedlings have been transplanted, the farmer carries out the normal agronomic practices (weeding, fertilizer application, insect and pest control, bird scaring etc). Farmers engaged in seed production

follow recommended practices from research or extension services and those in general production practice their own methods.

Rice production in the mangrove ecology is similar to that of IVS though the date for transplanting is delayed a bit in the mangrove. Farmers experience shows that this is done to allow seedlings to be strong enough to stand salt water intrusion. In Sierra Leone this was the case witness in the various ecologies. Land preparation for upland rice cultivation on the other hand is slightly different from that in the IVS ecology. Here, after a thorough land preparation which involves brushing, felling, burning, stumping (discretional) clearing, and plowing seed are broadcast evenly. These are normal practices recommended and encouraged as they assist for suppression of weeds and for effective growth of the plant.For proper seed production, it is expected that the farmer takes into consideration the following procedures as given by Asea and Onaga (2010): land selection having in mind cropping history; selection of seeds free from diseases; maintaining an appropriate isolation distance from other crops to prevent mixture of varieties; and rouging of off-types and volunteer plants. Unfortunately, only a few of sampled respondents do consider these procedures. Majority of the respondents produce rice generally and reserve some portion after harvest without carrying out standard procedures in seed production. The issue of field inspection from a seed certifying agency is only possible for the few farmers who solely produce seed separately from grains. Farmers who produce seed separately have received support in the form of provision of seed, training and extension services either from Government (MAFFS), SMP or other Institutions. Other farmers are even not aware of any seed certifying agency.

Table 4.4: Distribution of seed rice production across various ecologies in the Bombali and Kambia districts in Sierra Leone

District	Ecology				Total
	IVS	Upland	Boliland	Mangrove	
Bombali	31	10	19	0	**60**
	51.70%	16.70%	31.70%	0%	100%
Kambia	27	12	3	18	60
	45%	20%	5%	30%	100%
Total	58	22	22	18	120
	97%	37%	37%	30%	100%

Asea and Onaga (2010) suggests the selection of fertile land with good drainage and good water holding capacity and soils rich in clay and organic matter content to be suitable for seed production. According to Abdelrasoul *et al*., (2013), proper land selection for rice production is critical in obtaining high yields in any out grower scheme. Farmers in the study area pay little or no attention to this aspect as they make use of farm land available to them. However, for them to ensure that the land on which they cultivate is fertile they allow it to fallow for some years and go back to it later. This is mostly the case for upland rice production. For IVS, boliland and mangrove ecologies, they are relatively fertile because most nutrients that are washed away by erosion from the upland are deposited in these ecologies. The soil fertility of these ecologies can also be maintained by the use of organic and inorganic types of fertilizer.

4.7Challenges faced by Smallholder Farmers in Seed Rice Production (Research question 3)

Challenges faced by farmers in seed and rice production were highlighted in the questionnaires and fully discussed during the focus group discussions.

4.7.1 Production Challenges

The production challenges that make it difficult for farmers to embark on quality seed production include farm land ownership; untimely access to quality seed; high cost inputs (seeds, fertilizer, labor, and chemicals); labor drudgery due to manual labor; pests and diseases problem, flooding and high weed infestation. Evidence from the study reveals that majority (98 percent) of the respondents in study Districts do not produce seed separately

from grains. Instead seeds are selected before, during or after harvest. Vigorous tillers are carefully identified by the farmer for seed before harvesting. Sometimes these tillers are harvested and processed separately to get seed for the subsequent planting season. Alternatively, a portion of the grain is reserved as seed after threshing and winnowing.

Reasons advanced by respondents during the focus group discussions and from the structured questionnaire for not producing seed separately from grains were: Little or no idea in seed production; inadequate production resources (certified seed, fertilizer, farm land, labor, chemicals); expensive method to practice because of inputs needed and required procedures

4.7.1.2 Size of Land Cultivated

Even though there is no clear cut definition of a smallholder farmer yet smallholder is defined as "*one with limited land availability, poor resource endowments, subsistence-oriented and highly vulnerable to risk*" (Abera, 2009.)

With this regards, smallholder farmers cultivate small area of land mainly for subsistence purpose. Table 4.5 gives details of the size of land cultivated. About 32.8 percent of the respondents cultivated 0.4 of a hectare, 22.7 percent cultivated 0.8 ha and 1 ha respectively while 21 percent cultivated 2 and 5 hectares of land respectively. Investigations during focus group discussions as to why a limited land area was cultivated yielded similar responses. Responses from members of the group in the two Districts were almost the same. Farmers complained of inadequate agricultural inputs such as quality seed, labor and fertilizers and chemicals for insect, pest and weed control. Farmers that cultivated up to 5hectares of land are considered as middle income farmers and do not only rely on farming as a source of livelihood. They are engaged in off-farm activities and other income generating activities which make it easy for them to access seed on time and hire the services of a farm tractor for land preparation. Farmers with small area of land cultivated are constrained with limited productive resources such as inadequate finances to hire labor or a tractor, purchase quality seed of high yielding varieties and agro-chemicals (fertilizers, fungicides, herbicides, and insecticides). These farmers are resourced-poor and produce mainly for subsistence purposes.

Table 4.5: Distribution of sizes of land cultivated

Size (ha)	Count	Percent	Cumulative %
0.4	39	32.5	32.5
0.8	27	22.5	55
1	27	22.5	77.5
2	25	20.8	98.3
5	2	1.7	100

4.7.1.3Difficulty in Owning Farm Land

Even though results from the study reveals that 78.3 percent of respondents acquire land for production from inheritance, yet issues surrounding small farm holdings came up during the focus group discussions. This kind of ownership of land in the rural areas is associated with communal land tenure ownership in which the laws of Sierra Leone makes provision for such lands to be owned or managed by families, NMJD (2013). Due to the large family sizes (15 members) and family members having access to family land, farmers are restricted to only cultivate a small area of land entitled to them. The desire is there to embark on medium to large scale farm sizes but is confronted with this challenge of ownership.

4.7.1.4Untimely Access to Quality Seed

Smallholder farmers have multiple channels of obtaining seed for planting but the informal seed supply system is the major source of getting seeds. This has been confirmed in this study as more of the respondents (47 percent) use own-saved seeds from previous harvest for planting. The use of farm own saved seeds is not always guaranteed because when unexpected shocks and weather fluctuations occur, yields are low or there is crop failure and therefore during the lean season even seed that is saved for sowing is either consumed or sold to meet other household expenditure. Moreover, the dependence of the farmer on his or her own seed saved seed becomes a risk in case of disaster or crop failure. Despite the intervention of government in establishing 392 Agricultural Business Centers in all 149 Chiefdoms in the country through the Smallholder Commercialization Programme (SCP) yet farmers find it difficult to get access to quality seed for buying. Their trust is solely in their own seeds. One major disadvantage of using own saved seeds by farmers is that if farmers used hybrid seeds in the last planting season and reserve seeds for subsequent season, they

will result to non-productivity or crop failure because the hybrid seeds are meant for single production. Farmers would then rely on credit, neighbors and friends for seeds. Sometimes the seeds are not readily available. For farmers who get credit from lenders and other Institutions complain of high interest rate. A cross section of the executive of the NaFFSL contacted during the study expressed concern about the late supply of seeds and planting materials from various Institutions to farmers but also commended the efforts of other institutions like MAFFS, SLeSCA, the West African Agricultural Productivity Programme(WAAP) for their intervention in making improved seeds and planting materials available to farmers and to remedy the problem of late supply of inputs to farmers.

4.7.1.5High Cost of Inputs

The cost of agricultural inputs is one of the major challenges presented by farmers across the study area during the administration of questionnaires and focus group discussions. Farmers reported that they are constrained with limited financial resources for seed production. The size of farm land cultivated each season largely depends on the available finances. The cost of inputs such as quality seed rice, fertilizers, chemicals and labor is unbearable by most farmers which restrict them to small farm holdings. The problem of high cost involved in hiring labor to work in farms from land preparation to harvest and post-harvest was outstanding during the study. Before now, labor was provided by family members. This situation has changed because according to members of the various focus group discussions, there is an increase in the school enrolment in rural areas. Moreover, youths who were actively involved in farming operations at village level are now engaged in motor bike transportation services as a strategy to self-employment. Others who cannot afford to own or ride a motor bike have gained employment with the multi-national companies (ADDAX Bio-energy Company and Africa Minerals Ltd.) within Bombali District. In Kambia District, youths are engaged in Motor bike transportation; trading and a few migrate to neighboring and other Districts to seek jobs from the iron ore mining company (African Minerals). Farmers therefore no longer rely on family labor for carrying out farm operations but have to hire. This is a contributing factor to increase the cost of production.

4.7.1.6Labor Drudgery due to Manual Labor

The realization of appreciable yields by farmers for their area of cultivation per season is difficult to achieve with the method of production and kind of labor used. It was observed during the research that smallholder farmers still depend on manual labor as source of farm

power. Despite the intervention of the Government of Sierra Leone's numerous programmes in the agriculture sector to move from subsistence to commercial agriculture by making tractors available on a hire purchase scheme, yet the use of farm machinery in rice production is still at a low level. Better-off farmers who can afford to buy or hire a tractor for example can utilize it for land preparation and seed harrowing.

During the existence of the work oxen programme in Bombali District in the late eighties to nineties, farmers in the District made use of oxen with implements attached for land preparation. Today, peasant farmers still use rudimentary tools in rice cultivation for rice cultivation activities. This reduces the efficiency of farmers and size of land cultivated.

The condition is even worst with women farmers who struggle to adapt to using the available farm tools available though they are not woman-friendly.

This kind of labor used by smallholder farmers is partly responsible for small scale production and poor quality seed produced by farmers. The health of farmers especially women is also affected due to manual work on the farm.

Quality seed production and processing requires the availability and use of modern infrastructure and farm machinery for land preparation, harvesting and cleaning of seeds.

4.7.1.7Pests and Diseases Problem

Information gathered during the focus group discussions reveals that farmers are challenged by pest and disease attack. The presence of pests and diseases in a rice field and during storage is a potential threat to the farmers yield and quality of grains for that cropping season and also increases the cost of production. Seventy percent of respondents of the study indicated that the problem of incidence of pests and diseases is prominent across the two study districts. It was ascertained that the quality of grains is reduced when attacked by diseases during the growth of the plant. Some of the most notorious diseases reported by farmers include damping off, leaf spot and rice blast. Farmers described the nature of infestation and appearance of the plant after the infestation. Pests like cane rats, grass cutters and birds have been reported by farmers to be destroying crops in the field and during storage. Other pests which cause great loss to rice fields are blood worms which attack plants from 3 weeks to 5 weeks old. Water snails noted by farmers are some of the common pests found mostly in Kambia District. The destruction reduces the quantity and quality of grains. Pest attacks of rice are difficult and expensive to control and the loss is worst during storage and if not urgently controlled will cause the loss of a whole seed lot. Similarly diseases can

be easily spread in the field and during storage if the right temperature, moisture content and relative humidity are not maintained.

For seed to be certified there are international standards that need to be met. One of these standards is seed health. Healthy seed is one attribute of quality seed Bradford (2006). The outbreak of pests and diseases in rice fields and during storage as reported by sampled farmers is therefore a major constraint limiting smallholder farmers in producing and maintaining quality seed for rice production.

4.7.1.8Flooding

Over the years, Sierra Leone as a country has witnessed indiscriminate deforestation and unsustainable agricultural practices (slash and burn, high use of chemicals, tillage practices etc).MAFFS (2010) The change in rainfall patterns as a result of climate change together with deforestation and unsustainable agricultural practices has led to negative impact in the agriculture sector. Flooding is one of the effects of climate change in some areas in the country. Fifteen percent of respondents in Kambia District during the study expressed that flooding of their rice fields in the last cropping season was a major challenge. This was attributed due to heavy rains and absence of water controlled structures in the lowlands which affected rice yield. The effect of flooding goes beyond reduction of yields in rice cultivation. It also has a negative impact on the environment.

4.7.1.9High Weed Infestation

Weeds infestation in rice fields during crop growth can cause disaster to the farmer a whole season. Weeds compete with crops for sunlight, nutrients, water and space in the whole seed lot if allowed to infest fields. Apart from this, some weeds which have seeds can be mixed with rice varieties if not controlled on time and will reduce the quality of seed and render the seeds unsuitable to be certified. The presence of weeds in a rice farm also increases the incidence of pests and diseases as the weeds serve as host for pests.

Moreover, 70 percentof respondents to questionnaires indicated that if weeds are not properly controlled on time, harvesting becomes a difficult and time consuming operation leading to increase in cost for the farmer. However, they indicated that controlling weeds manually is labor intensive and time consuming especially the use of herbicides to control them which is an expensive that increases the cost of production. Flooding of fields immediately after land preparation has been reported to be effective in controlling weedsIRRI (2013). Also regular

and timely weeding can help to control weeds. Farmers reported that the high rate of weeds infestation is due to late and/or poor land preparation. This could be due to the fact that most of the farmers are Poor and poor farmers do not get easy access or can afford the cost of a tractor or power tiller for ploughing harrowing, or puddling and therefore depend mainly on manual labor. Those with high capital have easy access and priority to the use of tractor (s) for timely and proper land preparation and were thus minimally affected by weeds per the survey. Minimum weed percentage based on international seed testing standards is one of the basic requirements for seeds to be considered as quality declared seeds (QDS) Delimini, (2012). This is why it is a pre-requisite for field inspectors to visit any seed production farm at least three times during production. Plate 4.3 shows a weed infested rice field in Bombali District.

Plate 4.3: A Rice Field infested by Weeds in Bombali District

4.7.2 Post-harvest Practices

4.7.2.1Harvesting

Post-harvest losses occur during harvesting. According to Somado and Berhe (2006), the appropriate time to harvest rice is when the grains have formed dough, is hard and turn yellow/brown or when 80 percentof the upper proportion of the panicles is straw-colored at a moisture content of 20-22 percent. For lowland cultivation, it is good to drain water from the field at least one week before harvesting. All (100 percent) respondents in the study area harvest rice manually using panicle and sickle harvesting method. Farmers who cultivate

large areas of land especially in the boliland ecology are most times unable to harvest the entire rice field because of manual harvesting method used.

The use of this method result to high percentage of loss in the field especially when rice is not harvested on time and shattering occurs. The use of a mechanical harvester can reduces cost, saves time, minimizes loss and improves quality for the farmer while ensuring minimum mechanical damage to grains.

4.7.2.2 Threshing

Majority (98.3 percent) of the respondents thresh their rice by beating with sticks and 1.7 percent use mechanical thresher. This is because farmers have little or no access to mechanical threshers. Panicles harvested are packed in piles and beaten with sticks to remove the grains from the straws with tarpaulins or mats spread underneath. The use of sticks for threshing of rice is time consuming and offers a lot of opportunities for a mixture of varieties, impurities and inert matter.

According to Somado and Berhe (2006), post-harvest losses incurred by farmers have been reported to be as high as 35 percent due to manual threshing. For any seed production system to be efficient there is need to make available and use of labor saving devices to minimize the rate of contamination of seeds or grains as the case may be.

4.7.2.3 Cleaning/Winnowing

The normal practice in rice processing after harvesting and threshing is to clean the grains immediately before storage. Cleaning is done to remove bulky straws, chaff, weed seeds and other particles. This is followed by winnowing which is traditionally done by the use of a local winnower to blow off the chaff from the grains. This is exactly the situation with respondents in the study area. From the discussions held with farmers during the focus group discussions, the activity is solely carried out by the women. The task was reported to be time consuming, laborious and energy demanding.

4.7.2.4 Drying

Drying is a very important aspect of rice processing. Well dried seeds are said to be stored for a longer period. The extent to which varieties are mixed lies also in the drying method used. Only 12 respondents out of 60 (20 percent)in Kambia and 27 respondents out of 60 (45 percent) in Bombali Districts dried their grains on a drying floor (figure 4.7). The rest that do not have access to drying floors are left with the alternative of drying their grains on mats or

tarpaulins. Drying of the grains on mats is not a sound practice as it exposes grains to the risk of birds and chickens. These animals would not only eat the grains but could also deposit their droppings which will lead to reduction of quality of grains. In the process of preventing birds, chickens and animals from eating grains, stones can be thrown at them. These stones if not collected can form part of the impurities especially if grains have already been cleaned before drying. The utilization of tarpaulins for drying of grains if not properly checked can cause the grains to be wet and get damp during storage. Farmers who have the opportunity of cultivating both seasons have difficulty in drying grains in the rainy season. The grains therefore could be discolored, infested by fungus and sprout before or during storage.

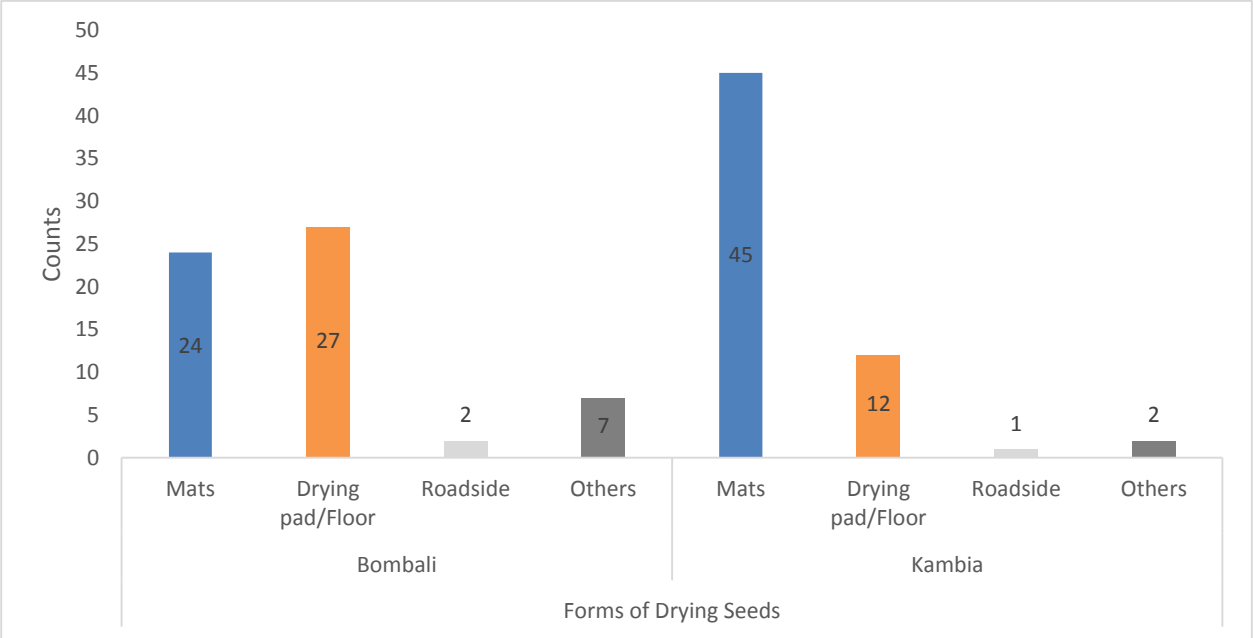


Figure 4.7.Distribution of forms of seed drying across districts.

4.7.2.5 Storage Facilities

The amount of post-harvest losses that occur during storage of grains is high. Hence this is a cause for concern for both farmers and stakeholders in the agriculture and seed sub- sectors.

It is difficult to assess post-harvest losses in quality of stored grains. This is why safe storage of rice seed or other grains need careful attention for all storage requirements which include right moisture content (12 percent), relative humidity (75 percent), temperature (32 ^{0}c) and adequate ventilation. Seed longevity is reduced without controlling the relative humidity. Groot and Liesbethde, (2008). Before seeds are stored, the store should be cleaned and fumigated to prevent the multiplication and spread of storage pests which cause damage, loss

and reduction of stored products. Gwinner*et.al*., (1996). The provision of pallets for stacking of bags plays a significant role in reducing losses and maintaining the quality of seed during storage. However, the storage method greatly depends on the quantity of produce to store and the facility that is available. Cleaned seeds have small volume and can be easy to store. Most of the selected farmers do not have access to community store in their localities and therefore store their grains in bags in their houses paying little or no attention to treatment of seeds and proper ventilation. This method though is trusted by farmers is not the best.

Some selected communities in Bombali Shebora Chiefdom in Bombali district have been provided by development projects with stores but their uses are not effective. Reasons advanced by respondents during the study for this were, storing of grains in a community store will reveal to others how much is owned and saved by an individual farmer which will reduce yields in the next planting season. This thought is based on the assumption of witchcraft activities taking place in the local setting.

4.7.2.6 Lack of Proper Infrastructure for Processing Seed rice

Lack of basic farm infrastructure such as post-harvest processing and storage facilities pose a serious barrier in the production and marketing of agricultural commodities Bienabe*et al*., (2004). It was discovered during the field survey and preliminary visits that seed processing rooms and stores were available in the two study districts during the Seed Multiplication Project and were accessed by farmers who were selected as contact seed growers for the project. However, these facilities are now dilapidated and no longer in use for processing or storing seed. This is a major setback in the seed production and multiplication programme. The availability of irrigation and seed processing infrastructures would facilitate 2 to 3 cropping a year and reduce post-harvest losses while improving the quality of rice seed for storage and sowing respectively.

4.7.3 Other Challenges in Seed Production

4.7.3.1 Inadequate Finances to Support Seed Rice Production

In any business enterprise, a startup capital is needed at the initial stage to properly establish it. This is the same with farming or seed production. Whether the farmer aims at producing seed for self or for sale to other farmers and Institutions, funds are needed to procure inputs and hire labor for various farm activities and post-harvest operations.

During the focus group discussions in the study area, FGD members were asked to list other challenges that they face in seed rice production by order of priority. The problem of insufficient funds to finance the activities involved in seed rice production was first on the list. With the availability of adequate funds, it is easier for the farmer to acquire a bigger farm land, procure quality seeds, essential fertilizers for nutrient management, appropriate chemicals for the control of pests and diseases, motorized threshers and other locally fabricated post-harvest equipment and observe seed certification procedures (seed testing, isolation, field inspection and rougeing).

4.7.3.2 Absence of Effective Seed Policy/Seed Certification Agency

In quality seed rice production, apart from the various tests carried out before sowing, the expertise of a seed certifying agency is required throughout the stages of production. Field inspectors are sent to inspect the fields at least three times in a production season. This is a kind of supervision exercise from a certified agency in line with defined standards set for quality seed production. The first time being for the purpose of checking for the suitability of the land for production paying kin attention to the history of cultivated crops and varieties on the proposed farm land and also for the presence and percentage of weeds. These are very fundamental issues to consider as they greatly influence the quality of seed produced. The second visit is done during the vegetative stage of the plant to look for the percentage of weeds, growth of the crop, and presence or absence of diseases and pests. The last visit is normally done at the pre-harvest stage in which the inspectors check for off-types (plants from other varieties).

Even though a seed policy has been drafted by Sierra Leone's Ministry of Agriculture which is currently in the Office of the Attorney General and Minister of Justice for scrutiny and legal advice before tabled to the House of Parliament for debate and enactment as a law of Sierra Leone, yet results from the study shows that 90 percent of the respondents are not aware of any seed policy or seed certification agency. Apart from Sampled smallholder farmers not been aware of the seed policy and seed certification agency, they are also not well informed about the standard procedures in quality seed production. Seed production involves a chain of actors starting from plant breeding to multiplication and dissemination of seeds.

4.7.3.3 Inadequate Training and Technical Skills on Seed Rice Production

The cultivation of crops has been in existence for ages. Farmers use to cultivate local varieties which are adaptable to their environments. Cultural practices carried out during production of rice are based on indigenous knowledge of farmers and the purpose of production which is mainly for grains. This kind of production requires little or no technical skills.

For smallholders to be successful in seed rice production programme, they should be equipped with the right training and technical skills JICA (2010) which was unfortunately lacking amongst rice farmers in Sierra Leone. Sixty seven percent of the respondents to questionnaires among other issues indicated that they do not produce seeds on a separate farm nor practice isolation because of lack of technical and trainings. According to SLeSCA in Sierra Leone, quality seed rice production may be similar to the production of grains for consumption. They differ in the sense that in the former, attention is paid on practices such as proper selection of land free from weeds or where rice has previously been planted; perform seed testing to verify the quality of seed that will be sown; observing isolation distances to prevent mixing of varieties from other fields; and carry out field inspections from a seed certification agency at various stages of production to ensure that quality standards are maintained. The inability of the farmers to produce seeds for production separately is further constrained by the fact that, management practices for grain and seed production though may be similar entails more technical knowledge especially in terms of nutrient management, control of pests and diseases and record keeping on daily field activities. Given the illiteracy rate amongst the farming populace where few farmers can read simple instructions on fertilizer or chemical usage, it is difficult for them to successfully adhere to the international standards prescribed for certified seed production.

4.7.3 4Ineffective Agricultural Extension Support Services

According to the Director of Extension in MAFFS, new rice varieties released by research to farmers are normally accompanied by a full package which explains in details what is required to cultivate that variety. The services of the extension workers are very essential in the trial and use of these varieties.

However, 71 percent of farmers in the study mentioned the problem of ineffective agricultural extension services in the cultivation of rice as another obstacle to seed and rice production. Even though farmers have their experiences in rice production and general

farming practices, yet quality seed rice production needs technical skills and supervision in order to produce seeds that meet international seed testing and quality standards.

Despite efforts put in place by various stakeholders in rice production in Sierra Leone, farmers are generally challenged by diverse issues. Farmers need to be guided at every stage of multiplication and cultivation of new rice varieties.

4.7.3.5Low Yields

In this study, it was discovered that yields obtained by farmers in rice production are low. This could be to the fact that smallholder farmers are resourced poor and make use of re-cycled seed rice varieties and usually apply little or no fertilizers to maintain soil fertility. Soils in Sierra Leone have been categorized as ferralitic which need to be replenished with the essential nutrients for plant growth (MAFFS, 2009) which is unfortunately not done by small scale farmers. Late planting, weed infestation, pest and disease attack were also mentioned as reasons for low yield. The problem of low yields is responsible for some farmers not able to sell seed to other farmers. What is produced is barely enough to feed their families, reserve seed for the next planting season. Table 4.6 below gives details of yield obtained by respondents in the 2013 cropping season.

Table 4.6: Distribution of last year yields (ha) across chiefdoms

Chiefdoms	Yields (ha)				Total
	250 ha	500 ha	750 ah	Above 750 ha	
BombaliShebora	13	3	2	2	20
MakarieGbanti	14	2	1	2	19
SafrokoLimba	12	6	0	2	20
Magbema	5	14	0	0	19
Mambolo	1	2	3	14	20
Masongbala	2	8	6	4	20
Total	47	35	12	25	119

4.7.3.6Farmer Health

Farmers in the study area during the group discussions highlighted few health problems restricting them from going into large scale rice production or even maintaining the little area under cultivation each season. Diseases such as malaria, anemia, hernia, diarrhea and pneumonia were the most common diseases mentioned. Farmers are also aware of HIV/AIDS

as a disease but ascertained that they have received training from MAFFS and other partners on the prevention of disease. The current outbreak of the Ebola pandemic in Sierra Leone is also a very serious problem which has killed a good number of farmers across the country (statistics of infected or deceased farmers not yet available). The farming season is badly affected and crop yields are expected to be low. Many farmers have abandoned their farms because there is insufficient manpower to work as they used to. With the present situation on the state of public emergency which is intended to break the chain of transmission, gatherings are forbidden and so it is difficult for farmers to hire work gangs to work on their farms. Farmers who fall sick as a result of other diseases also find it difficult and impossible to get medical attention. This is due to the fact that all medical cases are considered to be Ebola suspected cases until proven otherwise. The stigma attached to the disease also makes it impossible for sick people to present themselves at health facilities for treatment.

It is envisaged by some donor partners (FAO and IFAD) in the agriculture sector that the Ebola outbreak in the country will cause a negative impact even after the disease would have been contained or eradicated. There is even a possibility that farmers who are used to getting seed s for sowing from their previous harvest will not be able to save seeds for the next planting season. This implies that there is little guarantee for the availability of seeds in the informal seed system if modalities are not put in place by relevant authorities.

4.7.3.7Socio-cultural Issues

Issues like gender inequalities in the access to and control of productive resources are of grave concern in seed rice production. Even though many researchers have found out that women contribute to about 60-80 percent of labor on the farm Lodin (2012) yet they are limited in terms of owning a farm land all by themselves, accessing loans from financial institutions without collateral and controlling both financial and material resources in the home. During a separate FGD, women reported that they spend most time in caring for the family and performing daily domestic chores while working on the farm or home garden to provide the needed services and needs of their families. These inequalities coupled with cultural beliefs and norms are therefore restricting women from participating fully in rice cultivation but rather engage on small scale production of vegetables and back yard poultry.

4.8 Limitations of the Study

This study was limited by time and financial constraints. Another serious limitation of the study is the outbreak of the Ebola Virus Disease in the study area. Despite these limitations, it is believed that findings may contribute to the improvement of seed and rice production by smallholder farmers in these Districts.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 SUMMARY OF FINDINGS

5.1.1 Findings of Objective 1

Findings from the study revealed that thirty three different seed rice varieties were cultivated in Bombali and Kambia districts in Sierra Leone over the past three years (form 2011 to 2013). Out of the 33 rice varieties cultivated by farmers in the study area, only 9 are improved varieties. The remaining 24 are local varieties. Pa Kiamp is the most widely cultivated rice variety (cultivated by forty two percent of the total respondents). This variety is one of the recently released varieties by the research institute and seed certification agency in Sierra Leone. In Kambia district ROK 5, ROK 10 (improved varieties) and Culma (local variety) ranked the first three rice varieties cultivated by respondents while in Bombali district, Pa Kiamp, ROK 10 (improved varieties) and Pa Limba (local variety) are the most commonly cultivated varieties. Sampled farmers in Kambia district cultivated a total of 19 varieties whereas 17 rice varieties are cultivated by respondents in Bombali district. There are irregularities in the naming of rice varieties in the Bombali and Kambia districts in Sierra Leone. Furthermore, rice cultivation in Sierra Leone show an ethnical choice of pattern.

5.1.2 Findings of Objective 2

Amongst the 33 rice varieties cultivated by respondents, four commonly cultivated varieties (Pa Kiamp, Pa Chiam, Butter cup and ROK 24) were identified and tested for seed quality (based on physiological and physical parameters). Pa Kiamp had the highest germination ability in both the laboratory (90 percent) and in the greenhouse (59 percent) experiments, but its vigor was lowest at depths of 2 cm (90 percent) and 4 cm (32 percent). Contrarily, ROK 24 had the lowest germination ability in the greenhouse (5 percent) and in the laboratory (20 percent) experiments but had the highest vigor (100 percent).Butter cup had the highest percentage (8. percent of contaminants (inert material, seeds of other crops and weed seeds) while Pa Kiamp (ROK 34) had the lowest (3.38 percent) contaminants. In Bombali District only 28.3 percent of the respondents treat seeds before sowing, 71.7 percent do not treat seeds before planting. In Kambia District, majority of the respondents (96.7 percent) treat seeds whilst 3.3 percent do not treat seeds.

5.1.3 Findings of Objective 3

Farmer's challenges in seed and rice production in the Kambia and Bombali Districts in Sierra Leone amongst others include: Limited resources (financial, material and human) to support seed rice production; very few farmers handling large farms sizes. About 32.8 percent of the farmers cultivated only 0.4 hectare of land, 22.7 percent cultivated 0.8 ha and 1 ha, respectively while 21 percent and 0.8 percent cultivated 2 and 5 hectares of land respectively. Moreso, the farmers have limited technical support and training from the government, face severe crop failure due to pests and diseases. In the districts, there are limited infrastructures for post-harvest handling of rice. Worst still, many socio-cultural practices in the Kambia and Bombali Districts of Sierra Leone limits women getting into rice cultivation. A good number of farmers in the area are often challenged by health issues. Despite these, the numbers of agricultural extension staff in Sierra Leone are very limited for effective sensitization.

5.2 CONCLUSION

Findings from the study reveal that thirty three different seed rice varieties were cultivated in Bombali and Kambia districts in Sierra Leone over the past three years (form 2011 to 2013). The distribution of seed varieties was related to ecological and cultural differences. On one hand, the results show that Pa Kiamp(ROK 34) has the best quality(90 percent and 59 percent germination in laboratory and greenhouse conditions, respectively) compared to the other three seed rice varieties (Pa Chiam, Butter cup and ROK 24) though it has the lowest vigor (90 percent and 32 percent at 2 cm and 4 cm depth, respectively).On the other hand, the results show that ROK 24 has the worst quality (20 percent and 5 percent germination in laboratory and greenhouse conditions, respectively) compared to the other three seed rice varieties though it had the bestvigor (100 percent at 2 cm and 4 cm depth, respectively). Unfortunately, although small scale farmers struggle to improve on rice production in Bombali and Kambia districts, they face challenges such as: limited resources (financial, material and human), limited technical support and training from the government, threats from pest and diseases, land tenure and limited infrastructure for post-harvest handling. Therefore, it can be concluded that there is need for policy and research efforts to tackle the quest for quality seed rice in Bombali and Kambia districts in particular and in Sierra Leone at large.

5.3 RECOMMENDATIONS

From the findings of the study, the following recommendations are made:

- A complementary research should be conducted on the genetic and phyto-sanitary aspects of the Pa Khiam, ROK24, Pa Chiam and Butter Cup so as to complete knowledge on their quality.
- SLeSCA to harmonize names of seed rice in different localities in the country as confusions sometimes arise even within households.
- Farmers' organizations should be strengthened in terms of finance, technical competence and capacity building programmes in seed and rice production to match their development efforts in quality seed and rice productionin order to minimize the challenges they frequently face.
- The extension division in the MAFFS to increase the number of extension staff, and make effective extension services to rice farmers
- MAFFS and Donor partners should rehabilitate the available seed rice processing infrastructures of the former German supported Seed Multiplication Project in Kobia and Thakobulor in Kambia and Bombali Districts, respectively
- The crops and extension divisions in the MAFFS should encourage more women farmers to embark on rice production so as to promote gender equity.

5.4SUGGESTED AREAS FOR FURTHER RESEARCH

Similar study should be carried out in other districts in Sierra Leone so as to produce a comprehensive list of various rice varieties cultivated, their qualities, and the challenges faced by farmers.Indigenous knowledge on rice pest and diseasemanagement is also proposed for study.

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APPENDICES

Appendix I: Questionnaire

Questionnaire

Quality Seed and Rice Production in Sierra Leone: an assessment of the Challenges faced by Smallholder Rice Farmers

I am Bridget OyahKamara, a Master of Science Student at the Pan-African institute for Development West Africa (PAID-WA) Buea, South West Region Cameroon.

The purpose of this research is to assess the challenges and Opportunities of smallholder farmers as potential seed producers. The information generated in the research will be used for its intended purpose. Thank you for your valued time and cooperation.

Instruction: **Please fill in or tick appropriate answer**

Section A: General information

1. Questionnaire No ……..

2.**District**:Bombali……Kambia ……

3. **Chiefdom**

Bombali

(i) BombaliShebora□

(ii) MakarieGbanti□

(iii) SafrokoLimba□

Kambia

(i) Magbema

(ii) Mambolo

(iii) Masungbala

Village (s)……

4. Gender

(a) Male□ (b) Female □

5. **Religion**

(a) Christian □ (b) Muslim □(c) Other (specify)……

6. **Educational level**

(a) Primary School □ (b) Secondary School □ (c) Tertiary Institution□(d) No formal education □

7. **Marital status**

(a) Married □(b) Single (c) Divorced □ (d) Widow □ (e) Widower□

8. Are you the head of the household?

(a) Yes □ (b) No □

Section B: Seed rice production and quality aspects

1. How do you acquire land for production?

(a) Renting □(b) Buying □(c) Leasing □ (d) Inheritance □

2. What is the size of land cultivated each season?

(a) ≤ 5 ha□ (b) 6-10 ha (c) 11-15 ha (d)≥15 ha

3. What agro-ecologies do you use for seed rice production?

(a) Inland valley swamp □ (b) Upland □ (c) Boli land □ (d) River rain grassland □ (e) Mangrove □

4. When do you normally produce seed?

(a) Dry season □ (b) Rainy season □ (c) Both seasons □

5. List the varieties of seed rice you cultivate

…….

……..

…….

6. What is the growth duration of the variety (ies) planted?

……..

……

7. What kind of labor do you use on the farm?

(a) Hired □ (b) Communal □ (c) Family □

8. How do you get seeds and other productive inputs?

(a) Buying □ (b) Credit □ (c) Gift □ (d) Farm own saved □ (e) other …….

9. Do you get support from any public or private institution?

(a) Yes □ (b) No □ (If yes answer questions 10and 11)

10. Name the Institution (s)

…….

…….

……

11. What kind of support do you get? (Tick appropriate options)

(a) Seed □ (b) Fertilizer □ (c) Agro- chemicals □ (d) Extension services □ (e) Training □

12. What was the yield obtained in last season's production?

(a) 250kg □ (b) 500kg □ (c) 750 kg □ (d)≥ 750 kg

13. How do you determine seed quality?

(a) Seed with uniform variety □
(b) Seed free from inert materials □
(c) Seed with high germination percentage □
(d) Seed that is disease-free □
(e) Seed tolerant to pest and diseases □

(f) Other (specify) ……

14. Do you treat your seeds before sowing?

(a) Yes □ (b) No □

15. Do you produce seed on a separate farm?

(a) Yes □ (b) No □

16. If yes do you observe isolation?

(a) Yes □ (b) No □

17. What is the isolation distance used?

(a) 1-5m □ (b) 6-10m □ (c) 11-15m □ (d) 15-20m□

18. If no in 16 state your reasons

……

……

……..

……..

19. Do field inspectors visit your farm?

(a) Yes □ (b) No □

20. If yes how often do they visit during the production season?

(a) Once □ (b) Twice □ (c) Thrice □ (d) Four times □

21. Are the seeds you produce certified by a seed certifying agency?

(a) Yes □ (b) No □

22. If no state your reason (s)

……

….

……

….

……

…

23. Are you aware of any seed certifying agency in the country?

(a) Yes □ (b) No □

Section C: Post Harvest practices in seed production

1. What harvesting method do you use?
   (a) Manual □ (b) mechanical □
2. How do you thresh your rice:
   (a) Beating with sticks □ (b) Mechanical thresher □ (c) Foot threshing or trampling □
   (d) Beating against a thresh rack □
3. Where do you dry your seed?
   (a) Mats □ (b) Drying pad/floor □ (c) Roadside □ (d) other …….
4. How do you store your seed?
   (a) Bags □ (b) Boxes □ (c) Store □ (d) Roof top □ (e) other ……..
   (b) Do you sell your seed? (a) Yes □ (b) No □
5. How do you sell your seed?
   (a) Wholesale □ (b) Retail □ (c) Exchange □ (d) Other …….
6. Where do you sell your seed?
   (a) Market □ (b) Farm gate □ (c) Institutions □ (d) other ……
7. What is the distance from the production area to where you sell your seed?
   (a) 1-5 km □ (b) 6-10 km □ (c) 11-15 km □ (d) Above 15 km □
8. What means of transport do you use for transporting seed?
(a) Vehicle □ (b) Tractor □ (c) Motor bike □ (d) other ……..
9. Is there a fixed price or measure for your produce?
   (a) Yes □ (b) No □
10. Are you able to sell all the seed meant for sale each production season?
(a) Yes □ (b) No □
11. If no state reasons

    .....

    ……

    …….
12. What challenges do you face in producing quality seed?

    ……

    ……...

Thank you for your time and cooperation

Appendix II

Check list for Focus Group Discussions and Interviews

Group one – Smallholder Farmers &Farmers Federation (8-12 members per group and disaggregated by gender)

- Types and methods of production
- Ecology (ies)
- Constraints/challenges
  - land issues
  - Sources of seed and other inputs
  - Management practices
  - Pest and disease problems
  - Policy issues
  - Post harvest issues (harvesting, processing, packaging, labeling, storage and marketing)
  - Collaboration with MAFFS and other key stakeholders
- Opportunities
- Suggestions to improve on seed production for rice cultivation

Group two- Agro-dealers/SMP/MAFFS (one to one interview)

- Role in the supply of quality seed to farmers in Sierra Leone
- Level of cooperation and interaction with farmers, NGOs, line ministries and other relevant stakeholders
- Challenges in the seed sector
- Issues of seed policy in the country
- Available infrastructure and management of the seed sector

Group 3: SLARI (interview)

- Technology generation
- Varietal development, testing and release
- Total number of rice varieties released
- Role in the dissemination of high yielding varieties to farmers

Appendix III:

List of rice varieties cultivated by smallholder farmers in Bombali and Kambia districts in Sierra Leone

Rice Variety	Bombali District			Total	Kambia District			Total	Grand total
	Bombali Shebora Chiefdom	MakarieGbanti Chiefdom	SafrokoLimba Chiefdom		Magbema Chiefdom	Mambolo Chiefdom	Masungbala Chiefdom		
Pa Kiamp	15	15	12	42	7	-	2	9	51
ROK 3	3	-	-	3	1	-	4	5	8
Pa Yaka	2	-	-	2	-	-	-	0	2
ROK 5	1	-	2	3	3	14	1	18	21
Pa Biaka	2	-	-	2	-	-	-	0	2
Pa Janet	1	-	-	1	-	-	-	0	1
Pa Matches	1	-	-	1	-	-	-	0	1
Pa Chaim	-	1	1	2	5	-	4	9	11
ROK 10	-	6	8	14	2	15	-	17	31
ROK 24	-	-	2	2	-	1	-	1	3
CP4	-	-	1	1	-	1	-	1	2
NERICA L 19	-	2	1	3	2	1	8	11	14
NERICA 4	-	-	2	2	-	-	2	2	4
ROK 14	-	-	1	1	-	-	-	0	1
Pa Limba	-	7	-	7	-	-	-	0	7
Pa Sheka	-	1	-	1	-	-	-	0	1
Pa Koroma	-	1	-	1	-	-	-	0	1
Butter cup	-	-	-	0	2	3	3	8	8
Compound	-	-	-	0	-	3	-	3	3
Culma	-	-	-	0	1	13	-	14	14
YealiFoday	-	-	-	0	3	-	-	3	3
Pa Kambia	-	-	-	0	1	-	-	1	1
YealiBombor	-	-	-	0	3	-	-	3	3
Mayeani	-	-	-	0	1	-	3	4	4
KoliSaidu	-	-	-	0	1	-	-	1	1
KoliSafie	-	-	-		1	-	-	1	1
Yan Gbessay	-	-	-	0	3	-	5	8	8
Pa Osman	-	-	-	0	1	-	-	1	1
Blostic	-	-	-	0	-	-	2	2	2
NERICA 4	-	-	-	0	-	-	2	2	2
Kortum	-	-	-	0	-	-	1	1	1
Salim	-	-	-	0	-	-	2	2	2
Pa Kandeh	-	-	-	0	-	-	2	2	2

***Appendix IV**: Student t-test for mean germination tests of four rice varieties collect in the Kambia and Bombali Districts in Sierra Leone.*

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	% germination (greenhouse) - % germination Petri dishes	-29.250	9.946	4.973	-45.076	-13.424	-5.882	3	.010