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Evaluation of The Impact of Eco-Farm Project on Agricultural Productivity and Food Security In Kordofan, Sudan.

Idris Elnoman Elawad
MSc International Development Studies

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E-mail: klim0731@gmail.com

Noragric

Department of International Environment and Development Studies

The Faculty of Landscape and Society

P.O. Box 5003

N-1432 Ås

Norway

Tel.: +47 67 23 00 00

Internet: <https://www.nmbu.no/fakultet/landsam/institutt/noragric>

Declaration

I, Idris Elnoman Elawad, declare that this thesis is a result of my research investigations and findings. Sources of information other than my own have been acknowledged and a reference list has been appended. This work has not been previously submitted to any other university for award of any type of academic degree.

Signature.....

Date.....

Acknowledgement

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Dedication

I dedicate this thesis to my parents, Mr. Elnoman and Late Zeinab and my wife and son; Iman and Mohamed respectively.

Abstract

Traditional dry-land farming is a major production system and source of livelihood for over 75% of the population in North Kordofan, Sudan. However, due to the successive droughts, desertification and the decline in soil fertility, agricultural productivity within the region has been very poor which has rendered rural people vulnerable to food shortages and insecurity. To improve agricultural productivity, enrich the livelihoods of inhabitants and improve the food security situation in the region, “Eco-Farm Research Project” was introduced by the Drylands Coordination Group (DCG) to remedy the situation through the adoption of advanced technologies in agricultural production.

This thesis assesses the impact of eco-farm technologies on agricultural productivity in Kordofan, Sudan. A qualitative method of research was used for the study and data was collected from forty-five (45) purposively selected farmers and five (5) key informants from five (5) villages (Shaigiya, Faris, Tukmah, Angarko and Umalwan). The study adopted Rogers (1983) Adoption-Diffusion Theory as the theoretical framework to guide the study.

The study found out that a number of technologies have been disseminated in the region by several non-governmental organizations, but the most adopted technologies were the eco-farm technologies. The results of the study showed that seed priming, and improved seed were the most adopted technologies by farmers with 86.67% and 84.4% respectively while fertilizer micro-dosing and Saltlick (mineral) Blocks followed with 73.33% and 53.33% respectively. Again, the study revealed that the main reasons why farmers adopted the eco-farm technologies was because of the assurance of increased yield, simplicity of the technologies, its compatibility and trialability while major reason for non-adoption was due to culture and social systems as well as lack of financial resources.

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List of Acronyms

DCG	Drylands Coordination Group
FAO	Food and Agricultural Organization
SDG	Sustainable Development Goal
AREI	Agricultural Resources and Environmental Indicators

CHAPTER ONE

1.0 Introduction

Food security is increasingly receiving global attention and concern as it stands as one of the challenges the world faces today. With the rapid population increase worldwide, especially in developing countries with expectation of global population reaching 9 billion by the year 2050 coupled with long term climatic conditions, there is a global concern on how best the challenges of food security can be resolved to meet the world's growing population (Searchinger, Hanson, Ranganathan, Lipinski, Waite, Winterbottom & Dumas, 2014).

Traditional dry-land farming is the major production system and source of livelihood for over 75% of the population in North Kordofan, Sudan. However, in recent years, successive droughts, desertification and the decline in soil fertility has affected agricultural productivity within the region which has rendered rural people vulnerable to food shortages and insecurity. The region has gradually become fragile, unstable and have, highly resilient landscape prone to human and livestock problems.

According to FAO (1996), *“food security exists when all people at all times have both physical and economic access to sufficient, safe and nutritious food that meet their dietary requirements and food preferences for an active and healthy life”*. Thus, one's nutritional status expand to include his/her ability to have considerable access to food resources and how to translate the food obtained into satisfactory nutritional levels. Therefore, food security is a situation in which both food supply and effective demand are sufficient to cover nutritional requirements (Mittal, 2006, p. 16). In Sudan, just as it is with other Sub Saharan African countries, the level of agricultural production in most families are not enough to cater for the needs of the family, hence, there is high

levels of food insecurity among many households and families which makes it difficult for them to cover their basic food and nutritional needs. People, most especially those living in the rural areas of Sudan resort to various livelihood strategies to acquire food for their households while engaging in other activities to earn income to feed their family. Food insecurity negatively affects the physical, social, emotional and cognitive development of an individual and hence it is important to remedy the situation by ensuring sustainable food production and systems that enhances nutritional value for individuals and saves the environment.

Greater Kordofan lies within the Savanna zone of Central Sudan with low average yields from crops grown compared to international standards. This is due to a magnitude of natural and socio-economic constraints: rainfall variability, poor crop establishment, low soil fertility and poor crops genetic stocks are among the principal reasons for low productivity and food insecurity in the area (Abdalla, Osman, Maki, Nur, Ali & Aune, 2015). Sudan is the largest country in Africa covering an area of over 2.5 million square kilometers thus, it occupies 8% of the African continent which extends over 2000 kilometers from latitude of 3°35' N in the equatorial zone to latitude of 21°55' N in the Sahara Desert. The country is characterized by a wide range of rain fall zones from zero rain falls in the North to 1500 mm per annum in the South, associated with different ecological regions, from the desert in the North to high rain-fall woodlands savannas in the South (Ahmed, 1982). Sudan's vegetation was initially intended to follow an ecological term founded on a floristic composition. However, since the country's vegetation is highly dependent on rainfall and soil types, the divisions of the vegetation corresponds with the changes in rainfall and soil. The arid drylands have an average rainfall of 75mm annually whereas the semi-arid lands have between 75mm to 300mm annually covering approximately 60% of the country. The drylands are therefore faced with severe environmental and socio-economic problems such as drought, desertification,

deforestation, poverty, famine and migration (Harrison & Jackson, 1958). To increase productivity, enrich the livelihoods of inhabitants and improve the food security situation in the region “Eco-Farm Research Project” was introduced to remedy the situation through adaptation of advanced technologies in agricultural production. These technologies included; seed priming, early maturing and drought tolerant crop varieties, fertilizer micro-dosing on sorghum, millet, sesame, groundnut, and cowpea, Saltlick (mineral) blocks as source of mineral for lactating animals and introduction and distribution of Moringa seedling (Aune et. al, 2012, p. 9).

It is therefore critical to do an assessment of the technologies introduced by Eco-farm to see the impact it has had on agricultural production, food security and farmers livelihood in Kordofan through the adoption.

1.1 Problem Statement

There has been a steadily decline in agricultural productivity in North Kordofan, Sudan which has drawn international attention (Muneer & Musa, 1995). Between the years 1990 and 2005 Sudan lost about 8.8million hectares of forests, which represents 11%, of its forests mainly because of subsistence activities such as overgrazing, trees cutting and expansion of traditional agriculture (Rainforests, 2007). North Kordofan is a region which has a considerable contribution to Gum Arabic production in Sudan but characterized by a fragile ecosystem. A large portion of the area is semiarid with an annual rainfall ranging between 75-300mm. The region is highly sensitive to fluctuations in climate due to the intensive usage of their lands. Majority of the population are rural dwellers with nomadic life who engage in practices such as removal of vegetation, overgrazing by cattle and sheep, fire regimes and so on (Khiry, 2007). These practices have had severe impact on

agricultural productivity and food security which is affecting the livelihoods of its inhabitants. As the human population are increasing, demand for enlarged areas for traditional farming are equally on the rise leading to soil and vegetation deterioration. The trend of clearance of trees for growing annual cash crops coupled with the low and erratic rainfall are all factors contributing to poor agricultural productivity and food insecurity in the region (Mohammed, Hamad & Adam, 2016). To rescue the situation the government of Sudan, with assistance from the Drylands Coordination Group (DCG) and some donors implemented a project dubbed “Eco-farm Project” that aimed primarily at improving agricultural production, the environmental conditions, natural resource management, human nutrition and food security in Kordofan region.

This study seeks to evaluate and assess the impacts of the Eco-farm introduced technologies on agricultural productivity in North Kordofan, Sudan.

1.2 Research Objectives

The overall objective of this study is to assess if and how the eco-farm project has improved agricultural productivity and livelihoods of farmers in Kordofan.

1.2.1 Specific Objectives

- a) To assess the impact of Eco-farm technologies on agricultural productivity in Kordofan.
- b) To assess how farmers are adopting to the new technologies introduced by Eco-farm.
- c) To assess the reason for adoption and non-adoption of the Eco-fam technologies by farmers.

1.3 Research Questions

- a) How has the eco-farm project improved food security in North Kordofan?
- b) What is the level of farmers' participation in the adoption of eco-farm technologies in North Kordofan?
- c) What motivates farmers to adopt the Eco-farm technologies? What are the reasons for non-adoption?

1.4 Justification of the study

Mounting evidence suggests that advanced and integrated farming technologies has the potential of improving agricultural productivity and livelihoods of farmers especially those in rural areas. According to FAO (2011), modern agricultural technique such as zero tillage resulted in a 20 – 50% increase in yield in Brazil with a complementing decrease of 50 - 60% in input cost for machinery and energy especially fuel in the rural areas of the country. Furthermore, India is also a country that has achieved significant improvement in agricultural productivity through the adoption of integrated farming techniques. India through the conservation of rain water and prevention of soil erosion coupled with the sustainable production practices resulted in an expansion of irrigated area from 11% to 79% of cultivated area with overwhelming increase in yield (FAO,2011). Similar trends have been observed in other Sub-Saharan regions. For instance, in Burkina Faso, through the introduction of small-scale irrigation and improved crop and livestock production technologies the country had an increase in irrigated rice yields by 30% and lowland rice by 53% (FAO, 2011).

Traoré, Aune & Sidibé (2010), asserts that the level of production of millet and sorghum could be doubled or significantly increased with the application of 0.3gram of fertilizer to the pocket of crops. However, there are not much existing evidence and analytical work conducted to affirm such great impact of the technologies on the livelihoods of the people in Kordofan (Aune & Ousman, 2011). The Drylands Coordination Group (DCG) have introduced these technologies with the aim of contributing to improved food security of vulnerable households and sustainable natural resource management in the drylands of Africa and as a development programme it is expected that its beneficiaries are the exact group of persons meant to benefit.

This thesis hopes to contribute to the ideas and knowledge about the potential benefits of integrated farming technologies and systems on agricultural productivity, food security and livelihood of farmers in Kordofan. More so, considering the global concern of food insecurity and increasing population growth, this study is currently of great significance for Sudan, especially in the context of implementation of the second Sustainable Development Goal (SDGs) of achieving zero hunger globally by the year 2030. It is therefore important to advocating and introducing modern farming technologies and techniques that would help increase food production and security as well as individual livelihoods which is the basis for this study.

1.5 Overview of thesis

Chapter two of this thesis presents the conceptual framework for analysis of the impact of the Eco-farm project on agricultural productivity, food security and farmers livelihood. Chapter three will present the research methodology used for the study including the study population, sample size, procedure for data analysis and presentation. The chapter will also provide details of the study area such as location, background as well as demographic characteristics. Chapter four presents the

findings of the study from both the quantitative and qualitative data. Chapter five gives the discussions based on the findings. Chapter six provide conclusions and recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.0 Introduction

This chapter will introduce some concepts which guide the approach of the thesis and explore relevant scholarly literature in relation to the thesis. The chapter will further present and discuss the conceptual framework which guides the thesis and argue the relevance of the concepts and theories to the study.

2.1 Defining Eco-farming

Eco-farming is an agricultural development system, that allows farmers to efficiently use resources available to them to increase food production, household food security, preserve land from degradation and minimize fluctuations in crop yields (Kotschi, Waters-Bayer, Adelhalm & Hoesle, 1989). According to New World Agriculture and Ecology Group (2015), eco-farming serves as both a climate change mitigation and adaptation strategy, provides large-scale carbon sinks and offer many other options for mitigation of climate change.

The Eco-farm project in Sudan is primarily geared towards increasing crop yields without any harm to the environment through the adoption of the introduced eco-farm technologies such as seed priming and micro-fertilization. The Eco-farm project trains farmers on how to use fertilizers in a limited quantity or amount so it does not damage the soil but rather help to improve soil quality. Considering the various challenges facing drylands such as increasing population growth, climate change, poor yields, land degradation, low rainfall and inputs availability of which Sudan is no exception, adoption of technologies that mitigates these challenges is of great importance to small-scale farmers (Kotschi et al. 1989).

2.2 Micro-fertilization

According to Aune, Doumbia & Berthe (2007), micro-fertilization refers to the application of small or limited amount of fertilizer to increase crop yields. Aune et al. (2007), describes two types of micro-fertilizer technologies: one involving the application of phosphorus fertilizer of 0.3g per pocket in the ratio of 1:1 with seeds and the other type involves the application of 6g of fertilizer per pocket yield (Aune et al.2007). Results from these two types of micro-fertilization technology showed that the former application method was more efficient economically with very low demand for labour. Aune et al. (2007), suggests that the best starting point for farmers' to increasing their yields is through the adoption of the micro-fertilization technology as through these technologies they have shown that it is possible to increase yields by applying small amount of fertilizer. They further reiterate that micro-fertilization should be enhanced with alternative ways of maintaining soil fertility that can stimulate the natural processes of humification and mineralization and suggests that the recycling of crop residues which are transformed into organic matter and the fertilization of the soil, are useful components that sustains soil fertility (Aune et al., 2007).

2.3 Seed Priming

Seed priming refers to the means of controlling the hydration level within seeds so that the metabolic activity necessary for germination can occur while preventing the occurrence of radical emergence (Farooq, Basra & Ahmad, 2007). Priming is one of the seed improvement methods that has the potential of resulting in increased seed performance (germination and emergence) under stress conditions such as salinity, temperature and drought stress. Seed priming is a seed pretreatment where moisture is controlled, allowing the seed to be brought through the germination

process, just before root and shoot emergence (Binang, Shiyam & Ntia, 2012). Seed priming treatments can lead to better germination and establishment in many field crops, such as maize, wheat, and rice.

Several studies have shown that primed crop seeds germinate and grow faster, flowers, mature and gives more higher yields, which is a very effective technique for drought-prone areas (Mamun, Naher & Ali, 2018). There are different methods of seed priming; hydo-priming, liquid or osmotic priming, solid matrix priming and bio priming. Among these four (4) methods, the most commonly used one is the liquid or osmotic priming. One of the primary benefits of priming has been the extension of the temperature range at which a seed can germinate. A research conducted by Harris, Joshi, Khan, Gothkar & Sodhi (1999), revealed that on-farm seed priming significantly improved establishment and early vigor of seedlings which resulted in a faster development, earlier flowering and maturity and remarkably higher yields.

2.4 Importance of Adopting New Technologies

The growing problems associated with climate and environmental conditions has necessitated the need for the adoption of newly sustainable ways to agricultural production and practices. Climatic changes are a major threat to crop and livestock production worldwide as it has the potential of leading to a change in food and fiber consumption as well as prices of agricultural commodities and farm income (USDA, 2014).

According to the Agricultural Resources and Environmental Indicators (AREI) a lot of sustainable technologies have been introduced which has the potential of increasing agricultural productivity while protecting the environment (i.e land and water) from agricultural production. Investment in agricultural research plays a vital role in the development and sustainable supply of improved

agricultural technologies. It is thus encouraging to note a considerable expansion of international and national support to agricultural research in developing countries of which Sudan is no exception (Pardey, Roseboom & Bientema, 1997). A growing body of literature provides evidence that the adoption of new or modern technologies in agricultural production has a positive impact on soil fertility and yields. Yu & Nin Pratt (2011), using an improved nonparametric Malmquist index conducted a study on agricultural productivity and policy change in nine (9) Sub-Saharan African countries: Ghana, Angola, Nigeria, Cameroon, Mali, Zambia, Ethiopia, Mozambique and Guinea. Their study revealed that the adoption of new technologies in agricultural production through the implementation of the structural adjustment policies resulted in a remarkable increase in output per hectare.

Maredia & Minde (2002), examined the nexus between technology profitability and agricultural transformation and explored its adoption by farmers in Eastern Africa. They found out that farmers adopted profitable technologies such as the improved cassava varieties in Uganda and improved coffee varieties in Kenya. According to Maredia & Minde (2002), other technologies were not fully adopted while others were restricted to on-farm demonstration plots such as the wheat variety and hybrid maize in Ethiopia as well as the application of inorganic fertilizer on maize in Kenya. They further discovered that the low adoption rate was due to reasons far from technological limitations ranging from unfavorable climatic conditions, lack of infrastructure, government policies and access to factors of production, which reduced the profitability and adoption of new technologies. For example, a study conducted by Doss & Morris (2000), showed that female maize farmers in Ghana had adopted improved maize varieties and chemical inputs less extensively than male maize farmers not because the technology was inherently biased against women but because women have less access to land, labor and extensive access services than men.

Furthermore, a report by Guma Kunda Komey (2016), on the topic “Impact Evaluation of DCG Sudan's Former Eco-farm Projects” showed that there were some significant improvements in crop yields, after farmers had adopted the introduced technologies by Eco-farm. This indicated that the Dryland Coordination Group’s (DCG) introduced techniques had increased crop yield considerably, consequently improving food and livelihood security for the participating households and the community at large in each area and its surroundings which depicts the importance of adopting new technologies in agricultural production.

Aune & Ousman (2011), also studied the effects of seed priming and micro-dosing in sorghum and pearl millet in on-station and on-farm experiments for three seasons under rainfed conditions in the North Kordofan State, western Sudan. Their study revealed that seed priming increased sorghum grain yield in the on-station experiments across three seasons from 482 kg ha⁻¹ to 807 kg ha⁻¹. Also, micro-dosing of 0.3 g, 0.6 g and 0.9 g NPK fertilizer (17-17-17) per pocket increased sorghum grain yield by 50.4, 68.8 and 109.7% respectively compared to the control. Their results also showed that on-farm seed priming increased sorghum yields by 32.6% while seed priming plus 0.3 g fertilizer increased yields by 69.5%. With regards to millet, their study found out that the corresponding yields increased by 29.8% and 71% respectively while fertilizer use efficiency for both crops increased remarkably with seed priming, although this effect was more apparent in sorghum than in millet. According to Aune & Ousman (2011), these technologies are easy to apply, and they offer low financial cost and low risk and are affordable for resource-poor farmers which is an important reason for technology adoption.

Similarly, Muzari, Gatsi & Muvhunzi (2012), conducted a study on “The Impacts of Technology Adoption on Smallholder Agricultural Productivity in Sub-Saharan Africa” and espoused that agricultural technology development is an essential strategy for increasing agricultural

productivity, achieving food self-sufficiency and improving food security among smallholder farmers in sub-Saharan Africa. Their study further reiterated that the technologies farmers use plays a significant role in determining how fast agricultural productivity grows and how that growth affects the poor and the condition of natural resources. Hence, the development of agricultural technology for both food and non-food crops, rural financial markets, the dissemination of assets and information, developing agricultural research and extension facilities targeted towards the smallholder farmer all work together to prevent long-term famine through increased agricultural productivity.

2.5 Factors Affecting/Influencing Adoption

In assessing the performance of any agricultural research project, it is important to know the extent to which technologies generated by the project have spread throughout the target population and to understand the factors that have influenced and or affected the adoption process. To begin with this section, it is important to define or explain what technology adoption is. Technology adoption is the choice or decision made by an organization, an individual or group of persons to mentally accept, acquire, implement and use a new technology or innovation in their field of work. According to Meinzen-Dick, Knox, Place & Swallow (2002), assets, vulnerability and institutions are some major factors that affect technology adoption among farmers.

2.5.1 Assets

The asset factor of technology adoption deals with issues of whether a farmer has the required or needed material and technical knowhow relevant for a technology adoption without any form of discrimination. As espoused by Meinzen-Dick et al. (2004), the lack of requisite assets limits the adoption of a technology. Therefore, policy makers, researchers and development organizations and practitioners must emphasize or concentrate more on developing technologies that requires minimum or little assets and abstract possessions to ensure effective adoption and usage of a technology (Meinzen-Dick et al., 2004). This is because most farmers are poor, have restricted access to land and other resources to farming and also have little or no formal education which is a barrier to technology adoption. For example, Bisanda & Mwangi (1996), conducted a study on “Farmers’ Adoption of Improved Maize Varieties in Mbeya Region of the Southern Highlands of Tanzania”. The study results showed that male headed households had more access to asset resources such as land, education and information on new technologies and there was also a strong association between the gender of the household head and adoption of technological recommendations. Furthermore, their study revealed that female-headed households were discriminated against by credit institutions, and as such they are unable to finance yield-raising technologies, leading to low adoption rates. Hence, it is imperative that farmers are not discriminated against in terms of gender and as such credit packages must be designed in a way to meet the needs of specific target groups.

2.5.2 Vulnerability

The vulnerability factor is concerned with the extent to which farmers are exposed to economic, biophysical and social risks as a result of the technology adoption. Normally, a technology with

lower risk level would have a greater appeal to farmers who are naturally risk-averse (Meinzen-Dick et al., 2004). Most farmers are usually not willing to embrace technologies with high risk especially if it has not been tested which is quite rational for every individual. For instance, Mazonde (1993), argues that farmers are well informed that a sudden increase in the productivity of their fields is likely to deplete the soil nutrients, which could result in much lower returns in subsequent farming periods. Thus, farmers are reluctant to accepting new technologies because of the fear of being vulnerable to certain risks that comes with the adoption of a new technology. Therefore, agricultural training and extension programmes should be much more intense and effective to promote technology adoption by farmers but not limited only to improved yield-raising technologies, such as improved seeds, but also channel attention to fertility-restoring and conservation technologies (Nkonya, 2004).

2.5.3 Institutions

Institutional factors highlight the impacts that institutions have on technology adoption. Institutions in this context consists of all services to agricultural development ranging from finance, to insurance and information dissemination. Institutions further expands to include other aspects such as facilities and mechanisms that enhance farmers' access to productive inputs and product markets as well as the norms, behaviors and practices embedded in a given social setting or societal context (Meinzen-Dick et al., 2004). According to Meinzen-Dick et al. (2004), embedded norms, behaviors and practices in society can have a significant effect or influence on farmers decision to adopt or reject a technology. Therefore, it is prudent for institutions, researchers and development practitioners to design technologies that are in line with farmers acceptable norms and practices in society to boost their receptivity to adopting a technology. For

example, a study conducted in Sub-Saharan Africa showed that there is an existing societal practice where some crops are expected to be grown solely by men. With such practice, the adoption of a new technology which is associated with such crop can be limited as women may not be able to adopt it. It is therefore important to note that an understanding of local cultural practices and preferences is important when designing agricultural technologies so that the benefits from the technology are proportionally distributed among its target group.

2.6 Conceptual Framework

This thesis adopts the Adoption-Diffusion Theory developed by E.M. Rogers in 1962 as the theoretical framework to guide the study and evaluate the impact of Eco-farm introduced agricultural technologies on agricultural productivity and food security in Sudan, Kordofan.

2.6.1 The Adoption-Diffusion Theory

The Adoption-Diffusion Theory by E.M. Rogers is a theory which seeks to explain how, why and at what rate new ideas and technology spread among a population or targeted group of individuals. It offers a ready set of concepts and approaches that can be used to explain receptivity to new policies and practices by individuals and organizations. The adoption-diffusion principles can also be operationalized to accelerate the rate of adoption and broaden the reach of agricultural innovations. Professionals in several disciplines, ranging from agriculture to health, economics, marketing etc have used the innovation diffusion theory to increase the adoption of innovative policies, products and practices. The diffusion of innovations theory and adoption is a model based on an innovation which is communicated through certain channels over time among members of

a social system. Rogers adoption-diffusion model views the spread of an innovation as a social process, in which the social and economic, setting and personal characteristics of individuals influence their receptivity to innovations (Rogers & Shoemaker, 1971). The adoption-diffusion model can be used to mount the nexus or relationship between farmers' thoughts, perceptions and their adoption of improved technologies or techniques in farming.

The adoption-diffusion theory is fused with six (6) relevant concepts which are of critical importance to this thesis. To begin with, the theory highlights a farmer's decision to adopt or reject an innovation and identifies the innovation decision as a point at which barriers to adoption of an innovation or technique to farming and or any given social setting can occur. Secondly, the theory suggests that an individual's adoption decision is influenced by several other factors such as knowledge that the technology exists, development of an opinion about the innovation, a decision to adopt or reject it, implementing the technology and finally a re-evaluation of the decision (Rogers, 1983). Thirdly, the theory attempts to explain and predict the spread of an innovation or technology by studying the population of adopters and non-adopters. Fourthly, the theory espouses that personalities and socio-economic characteristics of individuals has a great influence on their technology adoption rates (Rogers, 1983). Last but not least, the theory suggests that innovations are communicated between individuals along different channels. Hence, the more personal the channel of communication is the more likely it is to diffuse (persuade and change). Thus, the process will also be enhanced if the source and recipients are of the same political, social and economic domains. Finally, the theory argues that people are naturally only receptive to innovations which tend to meet their needs and desires and are compatible with their values and beliefs (Solo, 1972).

The adoption-diffusion theory highlights that the study of adopting and non-adopting farmers serves as a means of identifying factors or influences of the diffusion of innovations. According to Rogers (1983), individuals who are likely to adopt a new technology or technique tend to evaluate such a technology based on the technology's attributes relative to the potential adopters' existing or current practices. Thus, how farmers perceive or conceive of the newly introduced farming techniques through the Eco-farm project relative to their existing or current farming practices greatly affects or influence their decision to adopt or not adopt Eco-farm introduced agricultural technologies. Hence, farmers' perception of the potential benefits or attributes of a new farming technique plays a vital role in their decision of adoption or non-adoption. For example, Murray (1986) surveyed the attitudes of high-country pastoral farmers in his study of the adoption of exotic forestry in the South Island and found out that farmers adoption was on a voluntary basis and their current economic conditions suggested that the farmers receptivity to the change was due to the profitability of the innovation as well as the external environmental benefits that were associated with the adoption decision.

2.6.2 Attributes of Innovations as Variables for Adoption

According Rogers (1983), there are five (5) key attributes that are used to evaluate an innovation or technology adoption and it is necessary to examine more closely the characteristics of the technologies, their diffusion patterns, and the factors associated with successful adoption. The five (5) attributes are relative advantage, compatibility, complexity, trialability and observability.

2.6.3 Relative Advantage

Relative advantage refers to the extent to which an innovation is seen or considered as better than the current or existing practice or technology. The relative advantage concept can be categorized

into economic factors, social status, comfort and time aspects, incentive payments and the duration or pay off times to serve as the basis for an innovation evaluation. In dealing with economic factors of innovation adoption, profitability, cost of production, adoption cost and rate of return on adoption are major factors considered by an individual in adopting a new technology or innovative ideas. Therefore, farmers adoption on Eco-farm farming techniques would be highly influenced by the potential benefits it would offer them. With regards to social status, farmers level of adoption is likely to increase when they are of the conviction that their social status would be improved and enhanced through the adoption of a technology. On comfort and time aspects, relative advantage on innovation evaluation suggests that farmers would be more receptive to adopting a new technology when the innovation proves to be comfortable and or takes less time relative to their current or existing farming practices and technique. Furthermore, incentive payment is an innovation evaluation criterion which influence farmers adoption by either decreasing the costs of adoption or increasing their income because of adoption. Lastly, the duration it takes for the benefits of adopting a new technology to be reaped or realized affects potential farmers perceptions of the innovation's relative advantage.

2.6.4 Compatibility

Another key attribute that affects innovation adoption is compatibility. According Rogers (1983), *“compatibility is the extent to which an innovation proves to be consistent with the values, experiences and needs of the potential adopters”*. Putting the compatibility attribute of innovation into context with this thesis, Pannel (2003), reiterates that a farmer's is more likely to adopt an innovation when the innovation is compatible with the farmer's objectives or motives. Since farmers objectives are reflective or a reflection of their values, experiences and needs there exist a clear nexus between their objectives and perceptions of innovations. For example, Cranfield,

Henson & Holliday (2010), using data from a survey of certified organic or in-transition to organic vegetable and dairy producers in Canada conducted a study to understand a farmer's decision to convert from conventional to organic production. Their study revealed that health and safety concerns and environmental issues were the predominant motives for farmers conversion to organic farming. Hence, farmers who held these values as motivations for converting to organic farming must have perceived organic farming as a means for achieving their objectives which implied a step toward meeting their financial, environmental, health, and animal welfare objectives. Thus, farmers values, past and present experiences and needs are important factors to be considered in innovation evaluation.

2.6.5 Complexity

To add to compatibility, complexity is another attribute suggested by Rogers (1983) as a factor of innovation adoption. Complexity basically refers to how difficult an innovation is to understand and or use. Thus, the adoption and diffusion of an innovation tend to be faster if the innovation is easier to use and understand. Generally, farmers reception to simplified farming techniques are higher than that of complex farming techniques because the latter requires more advanced management and usage skills than the former. It is therefore worthy to note that how farmers perceive the complexity of an innovation in terms of usage, application and or production affects their decisions of whether to accept or reject such a farming technique.

2.6.6 Trialability

According to Rogers (1983), "*trialability is the degree to which an innovation can be tested or experimented with before a commitment to adopt is made*". Generally, this factor of innovation adoption deals with the possibility of having an innovation tried severally to increase the likelihood

or possibility of adoption. As explained by Pannel (2003), running trials on an innovation offers potential adopters the opportunity to gather more information about the innovation which in most instances tend to reduce their uncertainty about the wholesome adoption and implementation of the innovation. Thus, with the adoption of Eco-farm techniques, a farmer may decide to experiment with just a single technique say seed priming before fully implementing it on a large scale or wholly on his or her farm.

2.6.7 Observability

Observability is the last attribute of innovation adoption described by Rogers (1983). According to Rogers, observability is the degree to which an innovation provides reliable, accurate and tangible results. He further states that the higher the observability levels the lower the perceived uncertainty about the innovation by its potential adopters. Just as trialability, observability also offers potential adopters' greater opportunity to gather information about an innovation which enables them to make a more informed decision on whether to adopt or reject an innovation. Hence, with regards to the Eco-farm techniques, potential adopters of the introduced farming techniques can observe the farming practices and results neighboring farmers who have already adopted some or all the Eco-farm techniques and make more informed decisions about whether to also adopt or not.

CHAPTER THREE

STUDY AREA AND RESEARCH METHODOLOGY

3.1 Study Area (Kordofan, Sudan)

The study was conducted in Kordofan, Sudan. This region has been selected for the study because it is one of the regions the Eco-farm agricultural technologies have been introduced by Drylands Corporation Group (DCG) and farmers have actively adopted the technologies.

3.1.1 About Kordofan, Sudan

Location and Size

Kordofan covers a total land area of 376,145 square kilometers with an approximated population of 3.8 million. The area is characterized by a large undulating plain with the Nuba Mountains in the southeast quarter. Kordofan is a former province of central Sudan which was divided into three (3) federal states in the year 1994 as North, South and West Kordofan respectively. As part of the process of implementing the Comprehensive Peace Agreement between the Government of Sudan and the Sudan People's Liberation Movement in August 2005, West Kordofan state was subsequently dissolved and its terrain was further shared between North and South Kordofan States (United Nations Mission in Sudan, 2007).

Population Dynamics

Sudan has a youthful society, with approximately 41 per cent of the population under the age of 15 as of 2017, 53.7 per cent between the ages of 15-64 and 5.5 per cent are 65 years and above. Sudan's population is young, with a life expectancy at birth of 61 years for men and 65 for women. Sudan has a population structure where male/female ratio at birth is 105 males to 100 females.

Sudan is a traditional society, in which the majority of households are headed by males. 28 per cent of households are headed by women, with this proportion being highest in rural areas. The average household size in Sudan is approximately seven persons.

Economic Activity

Agriculture is the most important and common economic sector in the country contributing 39 per cent of GDP, employs more than one third of the workforce, and used to produce 80 per cent of the country's exports until the late 1990s when oil and gold to lesser extent, took over as the main export products. Until 1999 when oil became Sudan's main export product, agricultural and animal products made up 75% of Sudan exports and had significant impacts on the country's economy.

Climate

Sudan is a warm country with the eastern and central parts having the highest mean annual temperatures ranging between 30 to 40 degrees Celsius while the northern and western part of the country have highest mean temperatures around 30 degrees Celsius. The highest temperatures within the country normally occur just before the rainy season with the mean minimum temperatures hovering around 20 degrees Celsius. The central and southern parts of Sudan have rainy seasons with their total lengths varying according to their latitude and most of the rain falls during winter whiles the climate along the Red Sea is alleviated by sea breezes.

3.2 Research Methodology

3.2.1 Introduction

According to Bryman (2016), research methodology refers to the process followed to conduct a study. However, the purpose of the study greatly influences the choice of research methodology used for a study (Berg & Lune, 2016). According to Creswell (2014), researchers have identified three basic methods of conducting a research and these are qualitative, quantitative and mixed methods research. This section is divided into sub-sections which discuss the research design, research population and sampling technique. The section further discusses issues on validity and reliability, limitations of the study as well as the ethical considerations.

3.2.2 Qualitative Approach – Why and How?

The main objective of this research is to evaluate the impact of Eco-farm technologies on agricultural production, food security and livelihoods of farmers in Kordofan, Sudan. This study will use a qualitative method approach; a research designed to familiarize a researcher about a particular topic while satisfying the researcher's curiosity and desire for a better understanding, as well as help test the feasibility of undertaking a more extensive study (Babbie, 2005). Qualitative research refers to meanings, concepts, definitions, characteristics and description of subjects. When using qualitative research, the quality is assessed through words, images and description. According to Creswell (2014), a research method is quantitative when it is an inquiry into a social or human problem based on testing a theory composed of variables, measured with numbers, and analyzed with statistical procedures in order to determine whether the predictive generalization of the theory hold true. This study has adopted a qualitative research method because it will enable the researcher to answer the research questions by examining several social settings, groups and/or

individuals who inhabit these settings (Berg & Lune, 2016). More so, by using a qualitative research method for this study, the researcher will be able to know the respondents' personal perceptions that otherwise couldn't be described or explained quantitatively.

3.3 Research Design

According to Gray, Williamson, Karp & Dalphin (2007), a research design is a process of using one's imagination coupled with scientific and strategy tactics to guide collection and analysis of data. A qualitative research design will be adopted for this study using a case study approach. A case study is defined by Bogdan & Biklen (1997) as an in-depth examination of a setting, subject or specific event. A case study approach will be used in this study because the study is specifically focused on evaluating the impact of Eco-farm technologies on agricultural production, food security and farmers livelihood in Kordofan, Sudan. Although case studies involve diverse stages, being a qualitative research, a spiraling approach will be employed. Because in the view of Berg & Lune (2016), this approach views the research process not as a linear progression but spiraling back and forth as the researcher continuously revisits and refine the different stages as the research progress.

3.4 Population Sample and Sampling Method

According to Cooper & Schindler (2003), a population is the total collection of elements or participants from which the researcher makes some inferences. Population is a complete set of events, people or things on which the focus of the research falls and in which the researcher has an interest about and wants to determine some characteristics. Therefore, in relation to this study,

my participants would be mainly small-scale farmers in Kordofan who have been actively engaged in and have adopted the Eco-farm technologies to their crop production.

For this study, a purposive sampling technique will be used to select participants for the research. As stated by Bryman (2016), a purposive sampling involves selecting people and organizations with the research study questions in mind. Thus, the research questions influence the selection process in terms of who and what to be selected in order to explore the research questions. That notwithstanding, it is critical that the researcher has a sizeable varied sample such that the selected participants have unique individual characteristics that would be essential to answering the research questions. There are different types of purposive sampling that can be used in a research study. These may include theoretical, generic and snow ball sampling technique. However, due to the nature of my research study and the preferred participants the researcher used a generic purposive sampling to select participants for my study. This is because, the generic sampling technique combines the other purposive sampling techniques which when used, offers the researcher good grounds to set criteria's that are relevant to answering the research questions guiding the study (Bryman, 2016).

Because my main objective is to evaluate the impact Eco-farm technologies have had on crop production, food security and farmers livelihoods, it is important that majority of the participants are beneficiaries of the Eco-farm project. Therefore, I will specifically engage farmers who fall in this sample size. Also, it is worth mentioning that due to the wide geographical scope of Kordofan, the researcher selected two (2) villages from North Kordofan (Shaigiya and Faris) and three (3) villages from South Kordofan (Tukmah, Angarko and Umalwan) to conduct the study and these villages are part of those villages where the Eco-farm technologies have been introduced.

3.5 Data Collection Method

The data for this study was collected in March 2019 from the five (5) villages (Shaigiya, Faris, Tukmah, Angarko and Umalwan). Since the initial interview guide was based on desktop research, it was necessary for the researcher to conduct a short pilot interview to test if there was clarity and relevance in the interview guide. Four (4) farmers who have adopted Eco-farm technologies were interviewed to know if there were questions that were difficult to understand so that the necessary adjustments could be made accordingly.

3.5.1 Qualitative Interviews

In conducting the interviews, a one to one semi structured interview guide was used for the depth interviews and same for key informants' interviews. A semi structured interview was used because semi-structured interviews are flexible and allows for the discovery and detailed information that are important to participants but may not have been considered as relevant by the researcher (May, 2001). In all, the researcher conducted forty-five (45) interviews with farmers from the five (5) villages and five (5) key informant interviews were also conducted which featured agrochemical dealers, the General Director of the ministry of agriculture and a representative of the Eco-farm project. All interviews were recorded with an audio recording device and transcribed word for word or literally into transcripts from Arabic to English.

3.5.2 Focus Group Discussions (FGD)

Two (2) focus group discussions were conducted, one each from North and South Kordofan with farmers who have adopted some of the Eco-farm technologies in their crop production. The participants for the focus group discussions were selected using purposive sampling technique and a guide with key topics was used for the focus group discussions. To ensure active participation

from the participants in the discussions and get them to freely share their views and opinions about how the adoption of the Eco-farm technologies have impacted on the crop productivity, food security and their livelihoods, the discussions were held in Arabic. Each focus group consisted of twelve (12) participants with each discussion lasting for about an hour and half. The focus group discussions were held in North Kordofan at the Farmers' Community Leader's residence. This location was chosen because almost all the participants knew the community leader's residence and it also happened to be a central point for the various participants. At the end of the focus group discussions each participant was given Sudanese Pound (SDG500) to cover their travel cost and to show appreciation for their participation in the discussion.

3.6 Data analysis methods

Berg & Lune (2016), defines data analysis as involving a “careful, detailed, systematic examination and interpretation” of collected data to “identify patterns, themes, biases and meanings”. The interviews were audio recorded and transcribed word for word into transcripts. The method of analysis for this study was thematic. Bryman (2016), defines a theme as a “*category identified by the analyst through his or her data; that relates to his or her focus; that builds on codes identified in transcripts and /or field notes; and that provides the researcher with the basis for a theoretical understanding of his or her data can make a theoretical contribution to the literature relating to the research focus*” (p. 580). The transcripts together with the field notes were grouped and organized in themes to help in answering the research questions of the study.

3.7 Ethical Considerations

It is mandatory for a researcher to have an ethical consideration for the population to be studied. In the view of Berg & Lune (2016), ethical issues are concerned with “issues of harm, consent,

privacy and data confidentiality”. In this study, the researcher ensured that all respondents were informed about the purpose of the research and sought for their informed consent before any information was collected from them. Again, respondents were made to understand that the research was purely for academic reasons and that there were no direct benefits to them to ensure unbiased responses from them. Furthermore, anonymity of respondents was adhered to when storing and processing data.

3.8 Reliability and Validity

Research quality is normally determined by the validity and reliability of the methodology and data. As espoused by Golafshani (2003), validity and reliability are two major aspects of a research study that every researcher must pay attention to when designing a study, analyzing results and determining the quality and credibility of a study. Reliability and validity are important concepts used in research and testing. Reliability is concerned with consistency of results. That is the degree to which same or similar results are attained for a particular study if the research is performed by another researcher within the same context as the previous ones or under the same conditions. Validity on the other hand is concerned with accuracy and credibility of results. Thus, it is the extent to which a test accurately measures what it is expected to measure. This study, would produce the same results given the same circumstance within which it was conducted; using a qualitative method both in data collection and analysis, hence the study is reliable and valid.

3.9 Limitations of the Study

The researcher encountered some problems in this study. To begin with, the study did not cover all towns and villages in North and South Kordofan where the Eco-farm technologies have been introduced due to time constraint hence the selection of only five (5) villages with two from North

and three from South Kordofan respectively. Also, it was difficult for the researcher to get to the very remote villages especially in South Kordofan due to bad roads that leads to these villages. Furthermore, there was a problem with getting fuel for the car for transportation from the capital city Obeid, North Kordofan because agricultural research in this capital has a limited quota for fuel and so I had to sometimes get fuel to the car from the black market which was quite expensive and I did not have enough resources to cater for the fuel such that I could include more villages in the study. In addition, most of the farmers were illiterates and could not communicate properly in English nor Arabic so communicating with them was a bit difficult had it not been the help of the community leaders in translating the responses for me. More so, it was difficult gathering farmers for the focus group discussion and for conducting the interviews as well because most farmers live outside the villages where they have their farms and I had to wait at the meeting point for any dialogue. Irrespective of these challenges, care was taken to ensure that there was gender balance, farmers with different crop production, different adopted Eco-farm technology and variance in age to make the findings of the as unbiased as possible.

CHAPTER FOUR
FINDINGS AND DISCUSSION

4.0 Introduction

This chapter presents data collected from the study and discusses the findings of the study.

4.1 Descriptive Statistics

Table 1 below shows the minimum, maximum and mean for the ages, land size and educational level of respondents (farmers who have adopted one or more of eco-farm technologies).

Table 1 Age, land size owned and educational level of farmers

	Minimum	Maximum	Mean
Age	26	82	46
Land Size (Acres)	3	262	17
Level of Education	No Formal Education	University	Basic/Primary Education

Total number of respondents = 45

Source: Own field survey, April 2019.

From table 1 above, the mean age of respondents (farmers) is 46 years while the minimum and maximum age of respondents (farmers) are 26 and 82 years respectively. With regards to land size owned or used for farming, the table shows that the mean land size owned or used for farming by respondents was 17 acres while the minimum was 3 acres and maximum was 262 acres. The table further shows that the mean level of education of respondents was basic or primary level of

education with maximum level of education being at the university level and the minimum level was little or no formal education.

Table 2 Eco-farm Technologies Being Adopted

Technology	Frequency	Percentage
Seed Priming	38	84.4%
Improved Seed	39	86.67%
Fertilizer Micro-dosing	33	73.33%
Saltlick (mineral) Blocks	24	53.33%
Agricultural Instructions	25	55.56%

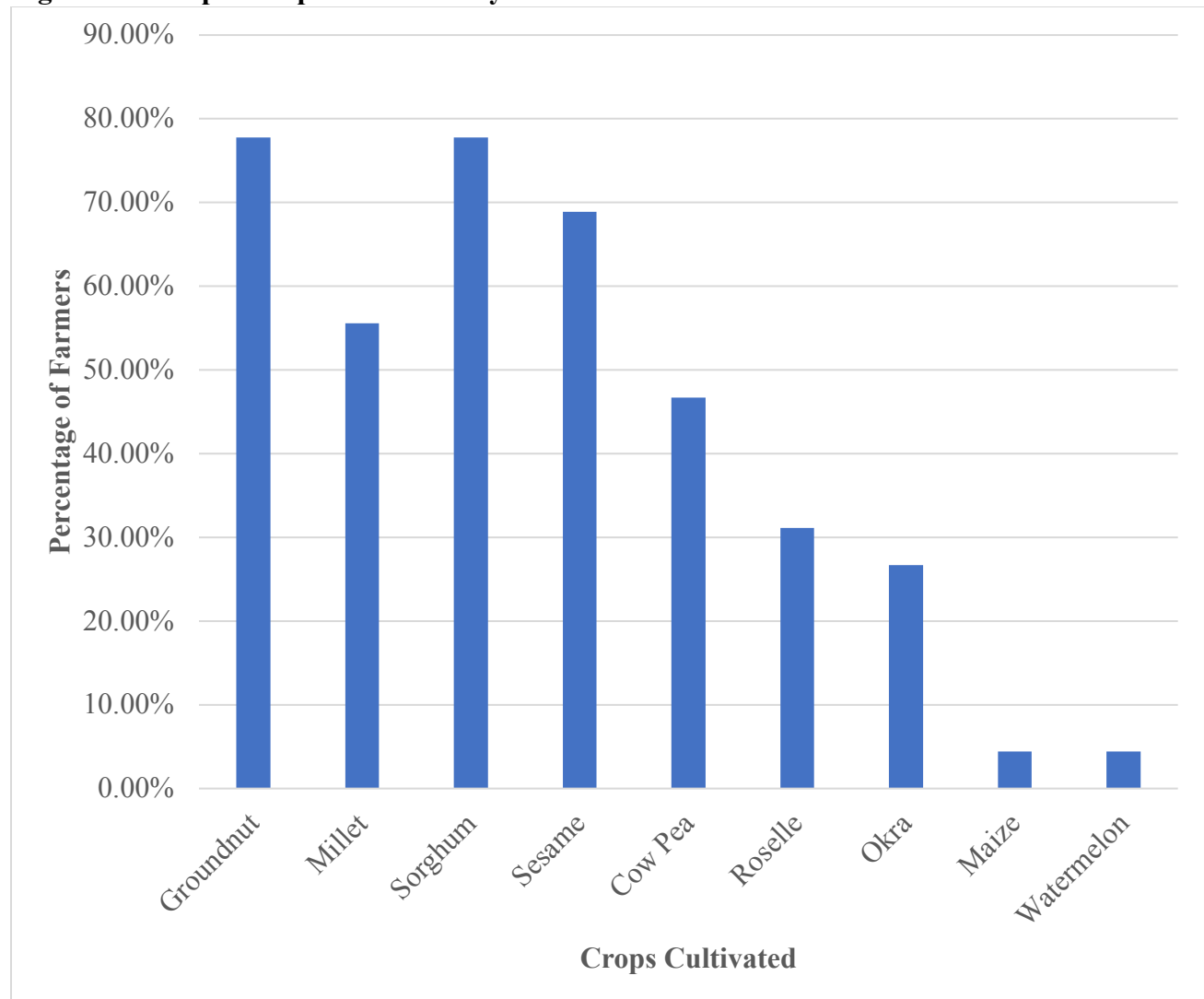
Source: Own field survey, April 2019

From the table, improved seed is the most adopted eco-farm technology with 39 respondents (farmers) representing 86.67% of the total respondents followed by seed priming which is adopted by 38 respondents (farmers) representing 84.4% of the total sample population. The table further shows that 73.33% of respondents adopted fertilizer micro-dosing technology while 55.56% and 53.33% of the respondents adopted saltlick and agricultural instructions respectively.

4.1.2 Principal Crops Cultivated by Farmers

Figure 1 below shows types of crops and percentage of farmers that cultivate the crops

Figure 1 Principal Crops Cultivated by Farmers



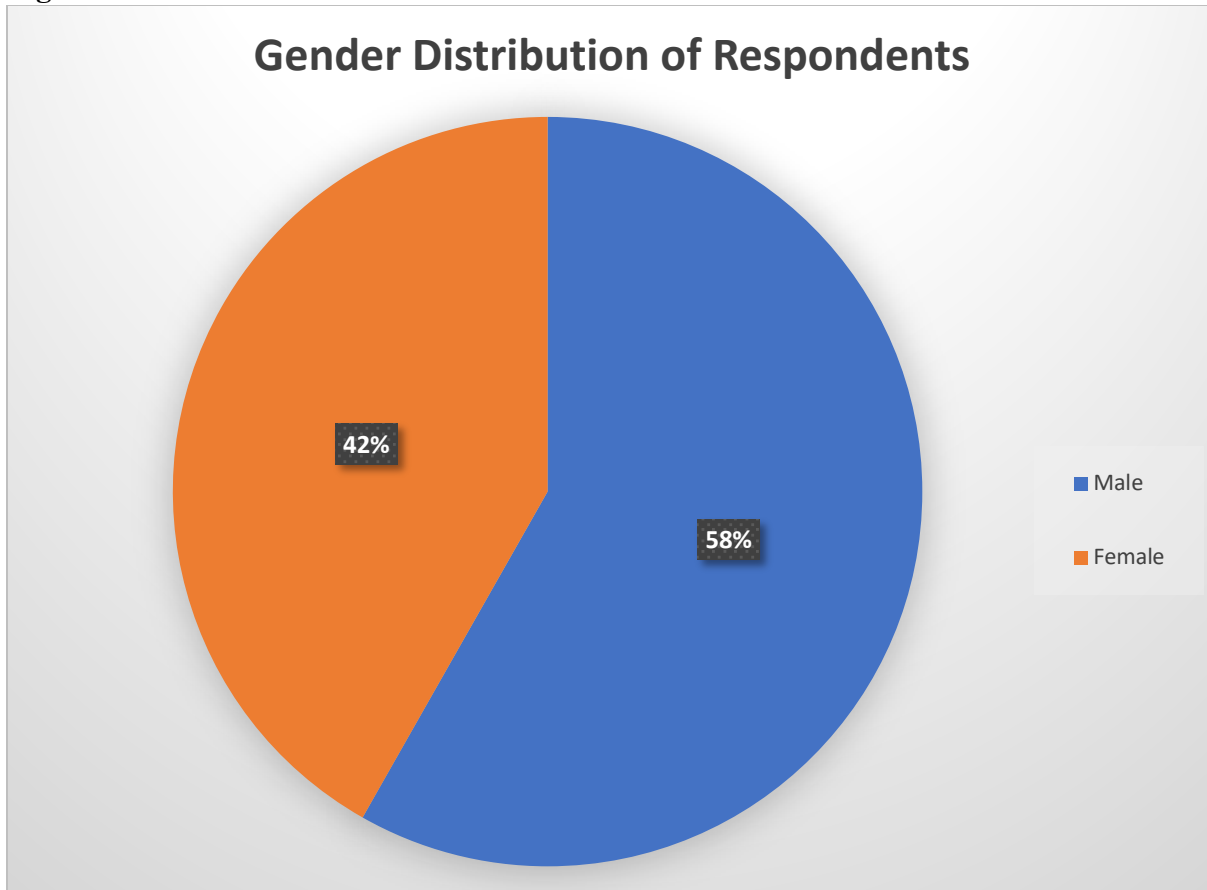
Source: Own field survey, April 2019

Figure 1 shows that 77.78% of respondents (farmers) cultivates both groundnut and sorghum while 4.44% of the respondents cultivates maize and watermelon respectively. The figure further shows that 68.89% of the respondents cultivates sesame whereas 55.56% cultivates millet. Out of the 45 respondents, 46.67%, 31.11% and 26.67% cultivates cow pea, roselle and okra respectively.

4.1.3 Gender Distribution of Respondents

Figure 2 below shows the gender distribution of the respondents for the study.

Figure 2 Gender Distribution of Household Heads



Source: Own field survey, April 2019

Figure 2 shows the gender distribution of the respondents (farmers). From the figure, out of the forty-five respondents, twenty-six (26) of them were males representing 57.8% whilst nineteen (19) of them representing 42.2% were females. This result shows that there were more male farmers than females from the study population.

4.2 Perception of Farmers about Eco-Farm Technologies and the Impact of Technologies on Agricultural Productivity

Generally, technologies are introduced with the sole aim of improving on the current or existing one or changing the way things are done for the better. The eco-farm technologies share the same ideology; introduced in Sudan to improve crops and livestock productivity and also enhance the food security and income of the inhabitants and reduce conflict over natural resources.

I started this discussion by asking respondents (farmers) of their opinion about the introduced technologies, how they got into the project and how beneficial it has been to them after participation. To be able to assess whether these objectives of the eco-farm project has been met or achieved, respondents were asked their opinions about the introduced technologies, how they got into the project and how beneficial it has been to them after participation (the impacts Eco-farm technologies have had on their yields after adopting one or more of the technologies). Most of the respondents gave a positive response and affirmed that they have had overwhelming yields after adopting one or more of the technologies. To know how intense this impact has been on farmers yields I probed further to ask them if they could be specific on how the technologies have improved their productivity and benefited them. Table 1 below captures some of the responses given by respondents on the impact of the eco-farm technologies on their yields.

Table 3: Participants Response on Impact of Eco-farm Technologies

<p>“I own 28 acres of land on which I produce sorghum on 9 acres, sesame on 4 acres, millet on 10 acres and the remaining 5 acres for groundnut production. My yields were very low prior to adopting eco-farm technologies. I am currently adopting seed priming and fertilizer micro-dosing on the sorghum and groundnut farm and the production has been impressive. Now per every 1.75</p>
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acres of land farmed I am able to produce 4 sacks of sorghum and 20 sacks of groundnut which is far better than I was producing prior to adopting the seed priming and fertilizer micro-dosing technology. So, for me I can confidently corroborate that these two technologies are good and have had a positive impact on my production”.

“I can say that I never regret adopting the eco-farm technology because it has been very good. After using the seed priming technique on my sorghum and sesame farm I have seen tremendous increase in my yields year after year. I am currently harvesting 6 sacks of sesame and 4 sacks of sorghum per 1.75 acres of land respectively which is a great improvement for me in terms of production”.

“I am 62 years old and I have been farming for more than 40 years. I must confess that my yields have never been this good as it is now since I started using the eco-farm technologies on my farm. I have 35 acres of land of which I use 9 acres for sesame production, 7 acres for groundnut, 6 for millet, 4 acres for sorghum and the rest are left for fallow. I also have cattle and goats. I have adopted three (3) technologies; fertilizer micro-dosing, improved seed and saltlick (mineral) blocks and so far, I am very happy with the results I am getting from my production, so I think the technologies are effective”.

“I do not think anyone who adopts any of the eco-farm technologies will have something negative to say about it. I did not want to use any of these technologies because I did not believe it would have any positive impact on my farm. But, after observing my neighbor in two farming seasons and comparing my yields to his, I realized I had done myself more harm than I could ever think off. My yields were not up to one third of that of my neighbors which was very disheartening for me. Since then, I have adopted the seed priming technique and it has worked marvelously for me. The impact, I genuinely can say cannot be quantified or underrated”.

“I am 38 years old and I have 12 acres of farm land. I was not around when the officials came to introduce the technology but when I returned my neighbor who had participated coached me on the fertilizer micro-dosing technology and I am proud to say there has been a change in my yields after using it”.

“Before I joined the eco-farm project, I could hardly have enough food for my family and no money to take care of my children. But since eco-farm project was introduced and I participated, now I am able to produce enough to feed my family and also sell some of my produce to earn some income. Because of that, now my children can go to school because I can afford. I thank the eco-farm project leaders for such an opportunity. I use seed priming and fertilizer micro-dosing technologies. I recently got two cattle and three sheep and will soon adopt the saltlick (mineral) blocks technology to improve production on my livestock.”.

“As you know, we have problem with rainfall in our region and to have good yield we need to use irrigation but I cannot afford because it is expensive for me. I am happy the eco-farm project was introduced because the seed soaking technology is an effective method of increasing yield yet it is very cheap and easy to adopt as compared to irrigation. When I soak my seed, I am more of the conviction that with a little amount of rainfall my seeds would germinate and yield good produce. The eco-farm project has helped me a lot and I am grateful to those who initiated the project”.

“Before the eco-farm project came, I did not know that I can have an alternative technology to irrigation. Because of drought and poor rainfall, I used to borrow money from friends and family to use irrigation system on my farm to improve my production but ever since I got training from the eco-farm project on seed priming, I have saved a lot of money. Seed priming is cheap to use, and it equally gives me good yield and I am satisfied. I really hope this project continues in our community”.

“Now, hunger is a thing of the past in my household. Thanks to eco-farm project my family have food in abundance all year round. I got training on seed priming and fertilizer micro-dosing on my farm and these technologies have lived to my expectations. The yields from my farm have been super good and it is all by the help of eco-farm project. If there are any other technologies I will be happy to adopt too because the eco-farm technologies are effective.

“The training I received by participating in this eco-farm project was very useful. I received training on seed priming, improved seed and fertilizer micro-dosing. As a farmer it is necessary to have or adopt new technologies and ideas to improve your production and this is exactly what I have experienced with eco-farm technologies after adopting them in my farming operations. If I only relied on traditional farming I don't think I would have achieved this level of food security for my household and increase my revenue as much as I have now. I believe it is good to be dynamic and be ready to learn new things because the world is growing and the way we do things keep changing. I hope that this eco-farm project is maintained to keep us learning and improving our farming skills and knowledge”.

4.3 Reasons for Adoption

The objectives underpinning the introduction of Eco-farm technologies has been to increase yields and improve food security in Kordofan. From the responses given above, this objective has undeniably been successful. Almost all of the respondents concurred that the adoption of the technologies have significantly increased their yields and their household food security. In spite of all the benefits gained from the technologies as identified by respondents, some of the technologies were adopted while others were ignored. Hence, as part of the objectives of this study, respondents

(farmers) were engaged to understand the main reasons for adoption and non-adoption of the technologies.

It is important to note that technology adoption is not a one-time decision made by targeted groups/individuals which leads to a continuous use of the technology. Several factors come into play before a technology is accepted and subsequently yields a continuous usage. Relatively, the timing and willingness to adopt a technology may differ from farmer to farmer even if there are considerable evidence to show that adoption of the technology will be profitable to them. During the interview and focus group discussion sections I was keen to understand farmers reasons for adoption and non-adoption of some of the technologies. They listed quite a number of reasons for both adoption and non-adoption and also elaborated on some challenges they face. The main reason for adoption of eco-farm technologies as mentioned by farmers were the expected increased yields although they admitted that rainfall timing and levels were also factors that could make the increased yields materialize. To kick start this discussion, I asked farmers how they got to know about the eco-farm technologies, followed by their reasons for adopting the technologies. One farmer stated that *“I am using improved seed, fertilizer micro-dosing and the seed soaking technology. I heard about these technologies through the officials of the eco-farm project and I decided to participate and adopt the technologies because I wanted to increase my production so I can make enough income from my harvest and also have enough food to feed my family”*. Clearly, this farmer’s response tell that he considered adopting the technology due to the benefits that he would gain from it. A 32-year-old female farmer also said that she got to know about the technologies through her older brother who had participated and adopted some of the eco-farm technologies and she herself had witnessed how effective and productive his brother’s produce have been. *“I decided to learn the seed priming and fertilizer micro-dosing technologies from my*

brother, in order to increase my production of millet and sesame, increase my income and also have some of the produce to store for my family, she added'. As Rogers (1983) describes, most people decision to adopt a technology is highly influenced by the benefits they intend to gain from the adoption. Hence, the study found out that potential benefits to be gained from the adoption of eco-farm technologies played a major role in farmers' decisions to participate and adopt the eco-farm technology.

Apart from the benefits of having increased yields or productivity, the study also found out that some farmers had chosen to adopt the eco-farm technology due to their experiences with other farming techniques they had previously used. One farmer from Shaygia, said *"I have tried some new technologies which improved my yields a little but as a farmer, I wish to have more bags of sesame and groundnut after harvesting so I chose to use the eco-farm seed priming technique because I was informed by the officials that it will greatly improve my production compared to the current technique I am using and comparatively I have seen a great change in yield after adopting this technology. Also, there is a big difference between traditional agriculture and the use of agriculture, he added"*. Similarly, one farmer from Um-alwan at the focus group discussion also shared her experience. She said, *"I have been farming for 10years and every time we get people from development organizations coming to help us with new ideas to increase our farm produce which is good. The last technique I was using was ok because it improved my production by 3 bags compared to before but I joined this eco-farm project because I noticed that my neighbor was having excess bags than I was so I also wanted to have excess bags after harvesting and that is why I am using the eco-farm seed priming and improved seed techniques on my farm"*. Judging from these two farmers responses, I noted that they had adopted eco-farm technology due to the relative advantage they will have over their existing farming technique which is a rational behavior

of every human. As posited by Rogers (1983), a person's decision or willingness to adopt a technology is greatly dependent on the relative advantage the new technology has over the current or existing practice or technology.

With the main goal or objective of the eco-farm project in mind, the study also discovered that most farmers adopted the eco-farm technologies because it was compatible with their own objectives as farmers. According Rogers (1983) and Pannel (2003), a farmer is more likely to adopt an innovation when the innovation is compatible with the farmer's objectives or motives. The focus group discussion confirmed this reason as most of the participants explained that the information they got from the eco-farm project officials were aligned to their personal motives and expectations as farmers. One farmer stated that *"I rear sheep and goats, produce and sell sorghum and millet and it is always my wish to have more production to be able to sell more, so when the officials explained to me that adopting the eco-farm saltlick (mineral) blocks, seed priming, fertilizer micro-dosing technology would help to increase my current yield on sorghum and millet as well as my livestock production, I believed it was in line with my desire and ambition as a farmer so I had no objection to it but gave it a try and these technologies have actually been good so far"*. Therefore, farmers receptivity and willingness to adopting a technology is dependent on how well the technology reflects in their values, experiences and needs (Rogers, 1983).

Generally, it is widely known that the adoption of a technology to a large extent depends on how friendly the technology is to its users. Some farmers mentioned during the interview and focus group discussion sections that they considered to adopt the eco-farm technologies because after the initial meeting or dialogue with the officials of the eco-farm project on the technologies available, the technologies did not seem too complex to adopt. A farmer from Angarko said *"I was very happy after the officials introduced seed priming and fertilizer micro-dosing technology to*

me. I did not think I would be able to adopt this technology until they trained me and I must say that it is not difficult as many other farmers think. It is very easy to use, he added". Another farmer also stated that *"we have tried different techniques, some easily adaptable others a bit complex but for eco-farm seed soaking and improved seed technology, I think it is very simple to comprehend and use on your farm"*. Consequently, farmers reception to simplified farming techniques are higher than that of complex farming techniques because the latter requires more advanced management and usage skills than the former (Rogers, 1983). Furthermore, some farmers also stated that they adopted the eco-farm technologies because they were given an option to try the technology on a section of their lands to see its effectiveness before adopting them wholly on their farms. According to Rogers (1983), an innovation which offers its target group the opportunity to test or experiment with before a commitment to adopt is made has a greater potential of having mass adoption. The study found out that, the eco-farm project was introduced to the farmers on this same strategy which gave farmers room to explore and experiment the technologies on a portion of their farm lands before committing to full adoption. Most of the farmers commended the officials of the eco-farm project for such initiative.

4.4 Reasons for Non-Adoption

According to the Adoption-Diffusion Theory by Rogers (1983), agricultural innovations varies significantly across time and space and social and economic setting as well as personal characteristics of individuals influence their receptivity to innovations. It is quite difficult to comprehend why extremely effective and efficient technologies that could improve agricultural productivity and farmers' incomes are sometimes rejected or ignored. Therefore, this study also focused on finding out reasons why other farmers had rejected and or discontinued adopting the eco-farm technologies in order to properly understand the adoption and diffusion technology

process to help improve the spread of new technologies among targeted groups or population (farmers).

To begin with some farmers explained that their culture somehow restricted their decision to accept the eco-farm technologies. One farmer stated that *“in our culture, it is not easy to own up to accept an innovation most especially when it comes from people who do not hail from our land. All other persons would look at you like an outcast and I personally, I do care about personal relationship with fellow farmers and so what they think or perceive of me matters a lot to me as well as the Shaygia community as a whole. This is why I did not participate in the eco-farm project. I have not adopted any of the technologies on my farm, he added”*. Ordinarily, technology spreads through social systems and therefore a person’s decision to adopt an innovation would be largely influenced by the opinions of people within his/her social networks (Rogers, 1983). In addition, some farmers also explained that they had discontinued the usage of the eco-farm technologies due to lack of financial resources. Some farmers from Angarko, said that they have stopped using the eco-farm technologies because although the technologies have helped them to increase their yields they are unable to get financial support to be able to manage the farm produce in terms of storage and transporting them to neighboring towns to sell so most of their produce go waste at the end of the day which is not favorable for them. In addition, some farmers from Um-alwan also stated that they had stopped using eco-farm technologies as a result of the war and political instability in the country while others too said they would have loved to participate but they could not due to the uprising. More so, the study discovered that some farmers had discontinued the use of eco-farm technologies because although they admit that the technologies are beneficial to them, they still had some setbacks with its usage or application. Some farmers also cited that they were not adopting some of the technologies due to lack of information and proper training on its

application. As Rogers (1983) explains, individuals who have wide access to communication and information on an innovation are more likely to adopt an innovation than those who do not have that level of access to information. Also, the study noted that fertilizer micro-dosing technology was adopted by only few female farmers and out of the few a lot of them had discontinued using the technology. When asked why they had stopped using fertilizer micro-dosing most of them said that the application requires a lot of physical energy and the workload in adopting the technology was too much for them to bear so they prefer to use technologies that is easy to adopt and one which do not take too much physical strength.

Furthermore, the study found out that most farmers were so much dependent on the financial support given to them through the eco-farm project and so instead of developing themselves and finding ways of maintaining the technologies on their farm and keep it running they were just relying on the funding they were receiving from the project officials and since the project stopped offering financial support to them they have consequently discontinued using the technologies claiming they do not have the financial capabilities to continue adopting the technologies on their farms.

CHAPTER FIVE

CONCLUSION AND RECOMENDATIONS

5.0 Conclusion

The main objectives of this thesis have been; to assess the impact of eco-farm technologies on agricultural production in Kordofan, the degree of adoption of eco-farm technologies and the reasons for adoption and non-adoption of the eco-farm technologies.

Most of the farmers shared their experience after using the eco-farm technologies and confirmed that they have been impressed with the results after adopting the technologies. All respondents gave a positive feedback on the technologies and stated affirmatively that they have had their yields increase overtime since they started adopting eco-farm technologies. This feedback from farmers showed that the eco-farm project has contributed immensely to farmers wellbeing and welfare which is the main objective behind the eco-farm project.

The results of this study showed that improved seed technique was the technology that was adopted most by the farmers with 86.67% adoption rate while the least adopted technology was Saltlick (mineral) Blocks with 53.33% adoption rate. Seed priming was the second highest technology being adopted by farmers with 84.4% adoption rate followed by Fertilizer Micro-dosing with an adoption rate of 73.33%.

The study found out that the main reason for adopting eco-farm technologies was the idea of increased yield or production. Other reasons for adoption included simplicity of the technologies, the relative advantage the eco-farm technologies had over previous farming techniques, how compatible the technologies are with regards to its alignment with farmers values, experiences and needs and the fact that farmers had the opportunity to test the technologies on a section of their

farm to experience how effective they were before adopting it wholly. With regards to why others rejected and or have discontinued using the technologies the study found out that culture and social systems played a major in farmers decision of not accepting the eco-farm technologies. Also, other farmers cited that they had stopped adopting the technologies because of lack of financial resources.

Overall, evidence from the study and encounters with farmers indicates that the eco-farm project has undoubtedly been beneficial to farmers of Kordofan. The testimonies given by farmers who adopted the technologies shows that adoption of the technologies have greatly improved their livelihoods and income as well as household food security which is very commendable.

5.1 Recommendations

Based on the findings of the study and following the interpretation of the field data, the following recommendations and suggestions are made for the attention of the government and eco-farm officials.

- Credit facilities should be made available to all farmers such that the very poor households can have access to reasonable amount of credit to help them in their farming operations.
- Officials of the eco-farm project should liaise with the agricultural ministry so that the agricultural extension officers can help with intense education and training of farmers on the technologies so that farmers can apply the technologies on their farm with ease.
- Also, farmers must have access to all vital information regarding technology adoption so that they can have an informed decision about the technology.

- Furthermore, farmers should be supported with some essential farming equipment and machineries to smoothing their farming operations because in the focus group discussions most farmers complained that they do not get the necessary farming tools and equipment and sometimes they get them too late.
- If possible, officials of the eco-farm project should try and develop an alternative or easy way to adopt the fertilizer micro-dosing technology such that it is more user friendly for women. This will enable a lot of women to adopt the technology to improve their livelihood and that of their entire family or household.

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Appendix

Interview Guide

Informed Consent & Cover Page

Hello. My name is Idris Elawad. I am a student of Norwegian University of Life Sciences working on my master thesis on the topic “**Evaluation of The Impact of Ecofarm Project On Agricultural Production and Food Security In Kordofan, Sudan**. In order to get more information about improvement in agricultural production, household food security and quality of life of individuals in Kordofan, I am conducting a survey in this area. Your household has been selected and I would like to ask you some questions related to the eco-farm technologies and how your livelihood has improved as a result of adopting the technologies.

The information you provide will be useful in assessing the impact of the eco-farm technologies on agricultural production in this region and will be used to plan future development programs in this area and also in the country.

Participation in the survey is voluntary. All the information you give will be confidential. The information will be used to prepare general reports for my thesis but will not include any specific names. There will be no way to identify that you are the one who gave this information.

Thank you.

Signature of Interviewer:

Date:

Respondent Agreed to be
Interviewed

1. YES

2. NO

EVALUATION OF THE IMPACT OF ECOFARM PROJECT ON AGRICULTURAL PRODUCTION AND FOOD SECURITY IN KORDOFAN, SUDAN.

INTERVIEW GUIDE FOR FARMERS

Farmer's Details:

Name of the Farmer: _____

Age: _____

Education: _____

Land owned: _____ Acres

Crops grown:

1. Who influenced you to participate in the eco-farm project?

- a) On your own ()
- b) Friends/relatives/ neighbors ()
- c) Representatives of the project ()
- d) Other

2. Why did you participate in the eco-farm project?

.....

3. What factors affect your yield?

- a) Natural calamities ()
- b) Lack of proper farming practices or knowledge ()
- c) Lack of financial resources ()
- d) Other.....

4. How has yield changed during the last 10 year?

.....

5. Has your cultivated area changed?

.....

6. Was it enough to feed you and your household year-round?

- a) Yes
- b) No

7. Could you make a living from your yields?

- a) Yes
- b) No

8. Which of the eco-farm technologies did you adopt?

- a) Seed priming ()
- b) Fertilizer micro-dosing ()
- c) Saltlick (mineral) blocks ()
- d) Agricultural instruction ()

9. How much of your land is used for these new technologies?

.....

10. What is your assessment or opinion after the adoption? Has it been beneficial to you?

.....

11. Has your productivity improved after the adoption of the techniques? Explain with details.

- a) Yes
- b) No

12. What is your average yield now after applying the technologies?

.....

13. Has the techniques improved your livelihood and earnings?

.....

14. Are you still applying the technologies? Explain why you are still or no more applying.

- a) Yes
- b) No

15. Are there other non-participant farmers adopting the technologies you or other participants have applied? If yes which method? If no what is or are their reasons for not adopting the techniques?
- a) Yes
 - b) No
16. Has the adoption of any of the technologies had a negative effect on your crop production? If Yes explain how.
- a) Yes
 - b) No
17. Can you afford to use fertilize?
18. Is there any credit for fertilizer?
19. What has been the most significant impact of the new technologies in your household? (the most significant change method)
20. For how many months do your household have enough food to eat?
- a) 1 – 3 months
 - b) 3 – 6 months
 - c) 6 – 9 months
 - d) 9 – 12 months
21. How many years does your own food production last you?
22. How many animals do you have in your household?
23. How much of the household income is used on purchasing food?
24. Has there been any change in number of meals per day as result of adopting the new technologies?
25. Has there been any change in migration as a result of improved income?
26. How have you used the increased income?
- a) Purchase food
 - b) Cloths
 - c) Taxes
 - d) Marriages
 - e) Education
 - f) Health

g) Agricultural input

27. Are you purchasing more agricultural input now compared to 10 years ago?
28. How has access to fertilizer changed in the last 10 years?
29. Are there any subsidies on fertilizers?
30. What has been the changes in the fertilizer market over the last 10 years?



Norges miljø- og biovitenskapelige universitet
Noregs miljø- og biovitenskapelige universitet
Norwegian University of Life Sciences

Postboks 5003
NO-1432 Ås
Norway