Farm households' adoption of Ecofarm integrated agricultural technologies and potential economic effects on livelihoods in Segou, Mopti and Koulikoro regions of Mali

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DECLARATION

I, Ernest Kwaku Amponsah, declare that this thesis is a result of my research investigation and finding. 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…………………………………..

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To Jehovah be the Glory!

ABSTRACT

Food production among the majority of agro-pastoral households in rural Mali are hampered by low rainfall, infertile soil, and extreme poverty. To improve productivity and enhance livelihood, the Drylands Coordination Group implemented the project Ecofarm on the farmers' field from the year 2004 to 2008 with technical assistance from the Department of International Environment and Development Studies (NORAGRIC) at Norwegian University of Life Sciences. The project tests the ability of low cost technologies to increase productivity and income in order to help poor farmers achieve a better livelihood. This study assessed the degree of Ecofarm technology adoption, identified the reasons for adoption, and investigated the impact of adoption on the livelihoods.

The study was carried out in the regions of Segou, Mopti and Koulikoro of Mali. Cross-sectional surveys were carried out in 12 randomly selected villages from the three regions in which 120 household heads were selected. A semi-structured questionnaire and interviews were applied to collect quantitative and qualitative data from household heads. Interviews with local and international NGOs were carried out using a Snowball sampling approach.

Results indicate that a wide range of technologies have been disseminated in the surveyed area by NGOs, but the Ecofarm technologies were the most adopted. The result shows that microdosin, the application of 0.3grams of fertilizer in the planting pocket simultaneously with sowing or 15 to 20 days after cultivation; is adopted by 68.1% of the household. While there are about 51.3% farmers adopting seed priming; the soaking of seed or grain in water before cultivation. The cross tabulation result indicates a variation in gender adoption of microdosing and seed priming. About 70.2% of men adopted microdosing while 61.1% women of women adopted microdsoing. Yet a chi square result shows no significant association between gender and adoption of microdosing technology. From the focus group discussion, it emerged that women adopt less of fertilizer microdosing technology as compared to seed priming because of the workload attached.

Results show increased crop yield with the application of fertilizer microdosing across regions. In Segou, average quantity of millet increased from 240 kg per hectare using traditional practices to 855 kg per hectare with microdosing technology. Sorghum yield

increased from 260 kg using traditional practices to 805 kg per hectare using microdosing technology in Segou. In Mopti millet and sorghum, yield increased from 125 kg and 155 kg per hectare using traditional practices, to 500 kg and 430 kg per hectare respectively with microdosing technology.

The gross output results show that the project has contributed to increasing farmers' income. In Koulikoro, microdosing of millet gave farmers a net benefit of 159508fcfa per hectare as compared to 1708fcfa using traditional practices. In Segou, microdosing of millet gave a net benefit of 144837fcfa as compared to 37974fcfa using traditional practices. While in Mopti, microdosing of millet gave farmers a net benefit of 81363 fcfa per hectare as compared to 21000fcfa using traditional practices. With sorghum, farmers who applied microdosing technology recorded an impressive net benefit of about 175087fcfa per hectare in Segou as compared to 54974fcfa using traditional practices. While those in Mopti and Koulikoro recorded a net benefit of 88863fcfa and 42259fcfa per hectare with microdosing technology, respectively as compared to 34750fcfa and 37708fcfa using traditional practices respectively.

Land size owned was one of the major determinants of the quantity of fertilizer use (adoption). The result indicates that the adoption of microdosing continues to increase with land size until it reaches a point where it starts decreasing. Similar trend was observed across regions. In Segou, average land owned by a framer was 18.1 hectares. Yet, just 1.1 hectares were used for microdosing as compared to Mopti and Koulikoro where average land size owned was 11.8 hectares and 4.9 hectares respectively, yet 4.8 hectares and 2.2 respectively were used for fertilizer microdosing technology.

Livestock fattening technology; tying of livestock to a tree or stick and feeding them with the leftover of cowpea and leaves, accelerated growth of livestock and increased income of the farmers. A sheep bought at a price of 23.000fcfa is sold for 55.000fcfa within 6 months in Segou if fattening technology is practiced. The same amount spent on the same livestock generates an average of about 60.000fcfa and 65.000fcfa in Mopti and Koulikoro, respectively. The number of trees planted on farmers field has dramatically increased. In Segou, each farmer has planted an average 122.2 trees, while those in Mopti and Koulikoro has planted an average of about 105,8 and 99.9 trees respectively in the surveyed areas.

The simple linear regressions result shows that a number of dependants' variable was positively and significantly related with adoption while variables such as distance to fertilizer, land size and prices of fertilizer used in the regression show a negative significant relationship with adoption. However, when all the above mentioned variables were put in a multiple regression, only distance to fertilizer showed a positive significant relationship with adoption.

Testimonies from the village of Dafara indicate that feeding on Moringa powder for a three month period increased the breast milk of a mother and contributed to an improvement in the health of a previously sick child. Moreover, adding Moringa powder to the diet improved the men potency. The survey and the common impression from farmers' testimonies is that those who adopted Ecofarm technologies experienced reduction in months of food insecurity, increased income, better health and nutrition and a general improvement in livelihood. Focus group discussion showed that the project has contributed to increased input outlets. Cross tabulation analyses of response from the 12 villages indicate that the Ecofarm technologies have been scaled up into about 51 villages.

The multiple regression result suggests a need for strengthening fertilizer outlet for a majority of farmers to adopt microdosing technology. Information dissemination by NGOs to farmers concerning seed preservation after soaking in water has also been indicated.

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LIST OF ABBEVIATIONS

AMAPROS	Association Malienne pour la Promotion du Sahel
DCG	Drylands Coordination Group
FCFA	Currency unit in Mali
FAO	Food and Agriculture Organization
HA	Hectare
IER	Rural Economic Institute (Mali)
ICRAF	World Agroforestry Centre
KG	Kilogram
KILABO	Solidarity to neighborhood (Bambara, Language)
MSC	Most Significant Change
NGO	nongovernmental organization
NORAGRIC	Department of International Environment and Development Studies
NORAD	Norwegian Agency for Development Cooporation
SPSS	Statistical Package for the Social Sciences
SL	Sustainable livelihood
UMB	Norwegian University of Life Sciences
YAGTU	Yam Giriboro Tumo (NGO empowering women, Bandiagara Mali)
DFID	Department of International Development

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CHAPTER I: INTRODUCTION

1.1 Background

Farmers in Mali face many challenges as they grow crops to support their livelihood. Uncertain rainfall patterns, poor soil quality and limited access to inputs are some of the challenges contributing to the risk inherent in dryland farming in Mali (Samake, 2003). The country experience prolong dry season of about nine month period. Unpredictable rainfall is the main reason for poor food production and rural poverty in Mali. The farmers are so poor that they take everything they can out of the soil and are unwilling to invest in fertilizer since the growing season is risky. Failure to replenish soil induces a nutrient declining cycle. Until nutrients are replaced, soils are deteriorated and yields and crop quality decline, leading to widespread hunger and under nutrition (Van der Pol, 1992; Samake, 2003).

Previous evidences review that rural farm households basically rely on the traditional system of shifting cultivation to replenish soil fertility and increase crop production (Samake, 2003). The main problem using this system to increase crop production is that increasing population pressure has resulted in decrease in the length of fallow periods. This has continued to the point that the system is losing its effectiveness to increase productivity (Samake, 2003). Nutrient recovery through short fallow is not sufficient in restoring soil fertility and catering for the demand of crops (Van der Pol, 1992).

In addition to the use of fallow, the application of manure, household waste and mulch are ways to improve soil fertility and productivity in Mali (Samake, 2003). The main constraint to this practice is the supply of organic fertilizers. Small scale farm households do not own enough cattle to facilitate manure collection to support crop production on all fields (De Ridder and Van Keulen 1990). Mulching is used on a small scale because of competitive demand of crop residues for human needs (fuel and construction materials) and animal feed (Samake, 2003). According to Camara (1996), due to high human demands for crop residuals, less than 10% are buried to return nutrient removed from the soil profile in Mali (Camara, 1996). Evidence indicates that though farmers are aware of the uncertainties of the traditional production techniques, they are unable to invest in long-term technologies that will increase productivity and income due to reasons such as low investment capacity and the economic risk related to erratic rainfall (Dugue, 1993a). In addition, population increase is about 3% per year while increase in food production is about 2% per year. This elapses between population growth and food production results in famine and food insecurity, especially in rural areas of Mali (Buerkert et al, 2001).

To address the problems of soil fertility and food security affecting rural livelihood; and to enable rural households to increase productivity, NORAD financed the project Ecofarm in Mali through the DCG of Norway. The project lasted for four years and was initiated with technical assistance from Noragric and ICRAF. The project main objective was to test low cost traditional agricultural systems to increase productivity in selected villages. The technologies were to be taken to neighboring villages by NGOs dissemination (Traore et al. 2010).

The testing face of the project started in 2005 through two NGOs. The NGO AMAPROS intervened in the region of Segou while Kilabo intervened in the region of Koulikoro. The NGO Care International was later associated in the zone of Mopti in 2006 in a bid to diversify the agro-ecological technologies and extension of activities in the region. Before implementing the research activities, three strategic options were developed and tested. They are identification of farmers knowledge and expertise in the field of management of natural resources; the development of synergy among the different partners intervening in the project and a platform for exchange and discussions on the results (Traore et al 2010).

The technologies tested on the farmers field includes: i) crop technologies which consist of seed priming to facilitate seed germination and fertilizer microdose, ii) animal husbandry technology which includes feeding livestock with millet bran and cowpea hay, iii) human nutrition improvements technologies, the cultivation and feeding on modified Moringa oleifera and Baobab grown in the farmers home garden and iv) agroforestry technologies based on planting trees specifically improved Ziziphus Mauritiana, establishment of garden with Acacia niolitica and Acacia tumida. The technologies were presented to farmers as product of choice and as such, farmers had the right to modify the technologies to fit their socio-economic and environmental conditions. The project emphasized increasing the productivity of millet and sorghum which constitute the nutritional base not only in the Ecofarm sites but also the entire regions of Mali (Traore et al. (2010).

A report by Traore et al. (2010) shows positive outcome of the Ecofarm technologies on productivity. From Traore et al. (2010), the agriculture technology of seed priming recorded productivity increase of millet from 57% in 2007 to 122% in 2008 in the Mopti region of Mali (Traore, 2010). In the same region, farm households' net income has increased from 31490 CFA per hectare in 2008 for the traditional technology to 69189 CFA in the same year through the Ecoferme technology (Traore et al., 2010). The regions of Segou and Koulikoro have also observed a tremendous increase in household net income from about 51523 CFA/hectare to 68224 CFA/hectare in 2008 through the crop technologies (Traore, 2010). The report further depicts the agro forestry technologies as not only contributing to the improvement of the nutritional and health conditions of the surveyed households, but also increases revenue and contributes to environmental sustainability (Traore et al., 2010).

Further evidence from Traore et al. (2010), indicates that those practicing the agro-forestry technologies have good supplement of fresh leaves of Baobab and Moringa rich in vitamins A and C, giving households improved nutrition (Traore et al. 2010). In addition, Traore et al. (2010) reports that the agro- forestry technology of growing trees of Gliricidia Sepium, Acacia Colei, Acacia Tumida and Acacia Nilotica have improved the agro-forestry diversity and increase environmental sustainability. Besides, income of households has increased by the sale of big fruits of jujubier as a result of the cultivation of improved Ziziphus Mauritiana (Traore et al. 2010).

The report by Traore et al. (2010) shows that Ecofarm technologies could help improve small scale farm households' livelihood in Mali. More than 80% of the population is poor living in rural areas. The objective of this study is to undertake an in-depth analysis of the effects of the Ecofarm project on livelihood security. This study intends to analyze the degree of adoption, reasons for adoption and the impact of adoption of the project. This will show the effects of the crop technologies, agro-forestry, animal raising and human nutritional technologies that have been developed and introduced through the Ecofarm framework.

A major step to understand the importance and the effects of the Ecofarm project to improve the livelihood of benefitted communities is to identify the views of farmers who participated in the project (Traore et al., 2010). Some studies have been done on the average gains of each technology per crop. However, not much analytical work has been done on the degree of adoption, reasons for adoption and impact of adoption as compared to alternative, yet competitive technologies. The up-scaling of the technologies has also not yet been documented.

In a nutshell, there are limited evidences on the social and economic implications of adoption of Ecofarm technologies as well as the impacts on livelihood security before and after the implementation of the project in Mali. Such knowledge, if known, could offer important insight to development agencies and policy makers as to what sort of development project and agricultural intervention is relevant for improving livelihood security of agro-pastoralist households in Mali.

1.2 Research objectives and questions

The main objective of this research is to improve the understanding of reasons for adoption and scale up- of Ecofarm technologies which are further divided below:

Objective 1: To assess the degree of adoption of Ecofarm technologies

- ✓ How many farmers have adopted the different technologies?
- ✓ How do factors mainly age, household size and land size affect adoption?
- ✓ How does farmers access fertilizer and does distance has any influence on the quantity of fertilizer use?

Objective 2: To assess the reason for adoption of the Ecofam technologies

- ✓ What motivates farmers to adopt the Ecofarm technologies?
- ✓ How does the gross margin induce adoption?
- ✓ Why do farmer adopt more of some technologies than others?
- ✓ What are the reasons for non-adoption?

Objective 3: To assess the impacts of the Ecofarm technologies

- ✓ Does the adoption of the technologies have any impact on food security?
- ✓ What are the changes in productivity and income?
- ✓ What are the numbers of trees covered and the number of livestock own?
- ✓ What are the overall impacts of the Ecofarm technologies on the livelihood of rural households?

1.3 Justification of the study

Evidence shows that modern integrated farming techniques could improve the livelihoods of poor rural agricultural households. For instance, “non tillage” agriculture techniques accounted for yields increased by 20-50% and decreased input cost for machinery and energy particularly fuel by 50-60% in rural areas of Brazil (FAO,2011). In India, conservation of rain water and prevention of soil erosion followed by the introduction of sustainable production practices has accounted for irrigated area expanded from 11% to 79% of cultivated area and yield increased tenfold (FAO,2011). Country specific study in Sub-Saharan Africa also reveals a similar trend. In Burkina Faso, the introduction of small scale irrigation and improved crop and livestock production technologies recorded an increased in rice yields by 30% irrigated and 53% lowland rice (FAO, 2011).

Traore et al. (2010), reports that the application of 0.3gram of fertilizer to the pocket of crops could double productivity of millet and sorghum. However, not enough analytical work has been done at the household level to affirm such huge impact of the technologies on rural livelihoods in Mali. The government and the donor agencies are working on these technologies for improvements. This is particularly important; knowing that development is a social and political process and as such development programs are sustainable when it involves the people intended to better their lot.

The study thus contributes to knowledge about the implications of integrated farming technologies on the livelihood of rural farm households, as a basis for making policies and sustainable development relevant for the area. It also fits into current debates such as the United Nations Millennium Development Goal of halving extreme poverty and hunger by the year 2015 and the Norwegian government foreign policy of promoting research that enhance environmental friendly agriculture, yet sustainable and able to increase productivity. From FAO statistics, 98 percent of all 925 million hungry people are in developing countries (FAO, 2011). Three-quarters of all these hungry people live in villages and rural areas dependent mainly on agriculture for their food with no alternative source of income or employment making them vulnerable to crisis. Evidence shows that rural hunger is expected to rise. If it does, the vulnerable rural households, particularly women and children will be the most affected (FAO, 2011). It is therefore necessary to develop knowledge about technologies to increase rural farmers’ productivity and ensure food security; hence the reasons for this study.

An in-depth study of the Ecofarm project may help guide future negotiation and policy making. It could give an impetus for the comparison of the effects of the Ecofarm project on rural livelihoods with other competitive projects by comparing the risk related to the project with the alternative and the benefits of depending on the project to the alternative project. The study could also help visualize the cost-benefit technologies within the Ecofarm project, as a basis for making quick interventions on improving the livelihoods of the extreme poor households in rural communities.

1.4 Thesis organization

The thesis is sectioned into seven chapters. Chapter one is concerned with introduction to the thesis. This chapter presents the background, research objectives and justification of the study. Chapter two presents three livelihood frameworks of which one is selected as a conceptual framework for analysis of the impact of the project on livelihood. The third chapter dips into the research methods used for data collection and analysis. Followed by the research method is a presentation of results and discussion which falls on chapter four. The fifth chapter presents and combines the results and farmers testimonies to discuss the overall impact of the project on farmers' livelihood using Scoones (1998) livelihood framework of analysis. The six chapter presents testimonies and stories of significant changes the farmers have experienced with the project. The final chapter presents the conclusion of the thesis and some policy related recommendations.

CHAPTER II: CONCEPTUAL FRAMEWORK AND LITERARTURE REVIEW

In this chapter, livelihood frameworks are presented. First, definitions and different sustainable livelihood (SL) frameworks are presented and as such, one is chosen as a conceptual framework to discuss the overall impacts of the Ecofarm technologies on the livelihood of the surveyed rural households.

2.1 Conceptual framework

A livelihood framework (Figure 1) is used to deepen the understanding of the impact of the adoption of Ecofarm technologies at the rural household level in the different study areas.

2.1.2 The sustainable livelihood approach to poverty

The sustainable livelihood ideas was first introduced by the Brudtland Commission on Environment and Development as a way of linking socioeconomic and ecological in a cohesive, policy relevant structure. In 1992, the United Nations Conference on Environment and Development (UNCED) expanded the concept, advocating for the achievement of sustainable livelihood as a goal for poverty eradication (Krantz, 2001).

In the context of 1992 UNCED agenda 21, it was argued that sustainable livelihoods could serve as an integrating factor that allows policies to address development, sustainable resources management, and poverty eradication (Krantz, 2001). Since then, most of the discussion on sustainable livelihood has focused on rural areas and situations where people are farmers or make a living from some kind of primary self managed productions (Krantz, 2001).

The concept of Sustainable Livelihood is an attempt to go beyond the conventional definitions and approaches to poverty eradication as they were focusing only on certain aspect or manifestations of poverty, such as low income but did not consider other important aspect of poverty such as vulnerability

(Moser, 1998). Currently, it is recognized that more attention must be paid to the various factors and process that either enhance or constrain people's ability to make a living in an economically, ecologically and socially sustainable manner (Cohen, 2005). As every domain of human life continue to experience change, adaptation to highly sustainable and diverse portfolio in order to cope or adapt to new livelihood challenges, a thorough analysis of all aspect of vulnerability is a necessity, hence the need for the sustainable livelihood approach (Krantz, 2001).

2.1.3 Definition of Sustainable Livelihood

The definitions of sustainable livelihood are far and wide, and in some cases inconsistencies are apparent as actors interpret them for specific context (Krantz, 2001). In their 1992 paper title "Sustainable Rural livelihoods: Practical concepts for the 21 Century, Chambers and Conway proposed a definition of a sustainable rural livelihood:

"A livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living: a livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; which contributes net benefits to the other livelihood at the local and global levels and in short and the long term" Robert Chambers and Gordon Conway (1992)

The authors recognized variations in capabilities of individuals, extended families, the social group and the community towards achieving sustainable livelihood. Chambers and Conway (1992) argue that a livelihood is not sustainable unless it's able to enhance other capabilities well enough to increase the livelihood for the present and the future generation.

To Chambers and Conway (1992), interactions of portfolio of assets of which people construct their living are the most important component of a livelihood. These assets can be grouped as tangible (food stocks, stores of value such as gold, ceramics, cash savings) and resources (land, water, trees, livestock, farm equipment) as well as intangible assets such as claims (demands and appeals that can be made for material, moral or other practical support) that is influenced by access; the opportunity in practice to use a resources, store or service to obtain information, material, technology, employment, food or income (Chambers et al., 1992).

According to Chambers and Conway (1992), a combination of different assets with access are seen as fundamental for a livelihood construction process to be resilient; ability to withstanding and recovering from stress and shocks. By recovering from shocks and stress, Chambers and Conway (1992) argue that livelihoods should be robust in adapting and mitigating the changing socio-economic and environmental conditions (Chambers and Conway, 1992).

With somewhat a little modification on Chambers and Conway (1992) definition, Scoones (1998) and the Institute for Development Studies (IDS), also adopted by the British Department for International Development (DFID) defines sustainable livelihood:

"A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sutainable when it can cope with and recover from stress and shocks maintain or enhance its capabilities and assets, while not undermining the natural resources" Ian Scoones and the Institute for Development Studies (IDS) (1998).

Unlike Robert Chambers and Gordon Conway (1992) definition, Scoones (1998) refute the claim that a sustainable livelihood has to contribute net benefit to other livelihood. However, securing natural capital that has passed on from one generation to the other could be interpreted as a benefit to others.

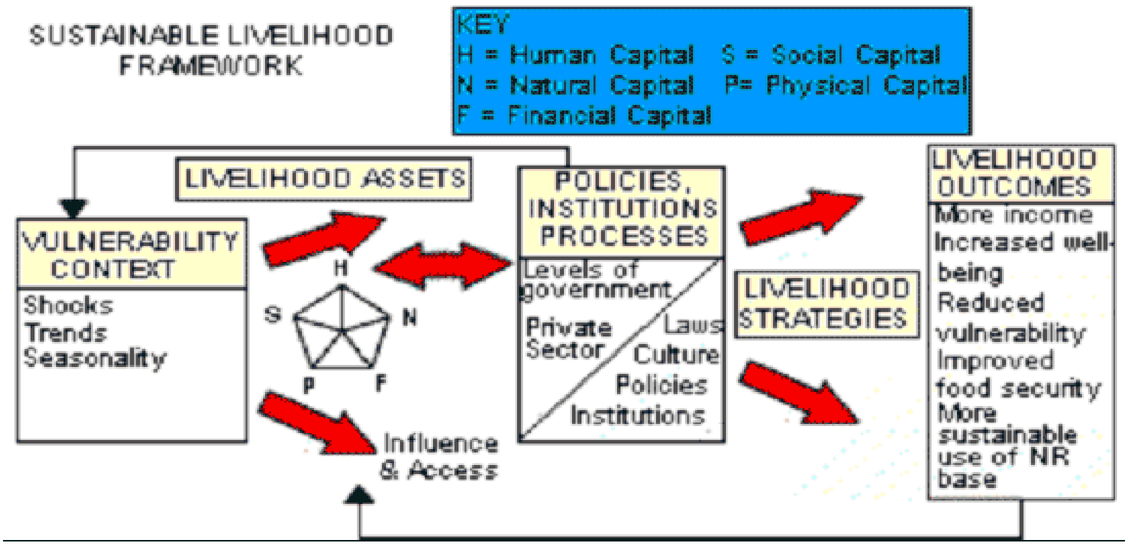


Figure 1: Sustainable Livelihood Framework (adapted: Scoones 1998)

The strength of Scoones (1998) framework is that it focuses on assets, what people are able to do with what they already have instead of poverty, what people don't have (Adato et al. 2002). These assets are depicted in Scoones (1998) framework (figure 1) as the opportunity each household has for resisting shocks and stress. The assets are further categorized into capitals in the form of; natural capital, human capital, Natural capital, physical capital, financial capital and social capital (DFID 1999; Ellis 2000; Scoones 1998). Natural and physical capital implies all the natural resources at the disposal of the poor households. Human capital on the other hand, refers to the skills, knowledge and efforts and health status which constitute the base assets of the poor. The social capital is how households relate to the other members of a community they derive their livelihood. While financial capital refers to savings, loan access, livestock and food stock. Such a well defined framework with strong emphasizing on policies and institutional process as the main factors that link livelihood assets and livelihood strategies is dynamic and fit well into our context; hence the reasons for adopting it in this study.

Combining Scoones (1998) and Carney (1998), Ellis defined livelihood that take into consideration institutional roles. He defines livelihood as;

"a livelihood comprises the assets (natural, physical, human, financial and social capital), the activities, and the access to these (mediated by institutions and social relations) that together determine the living gained by the individual or household" (Ellis 2000).

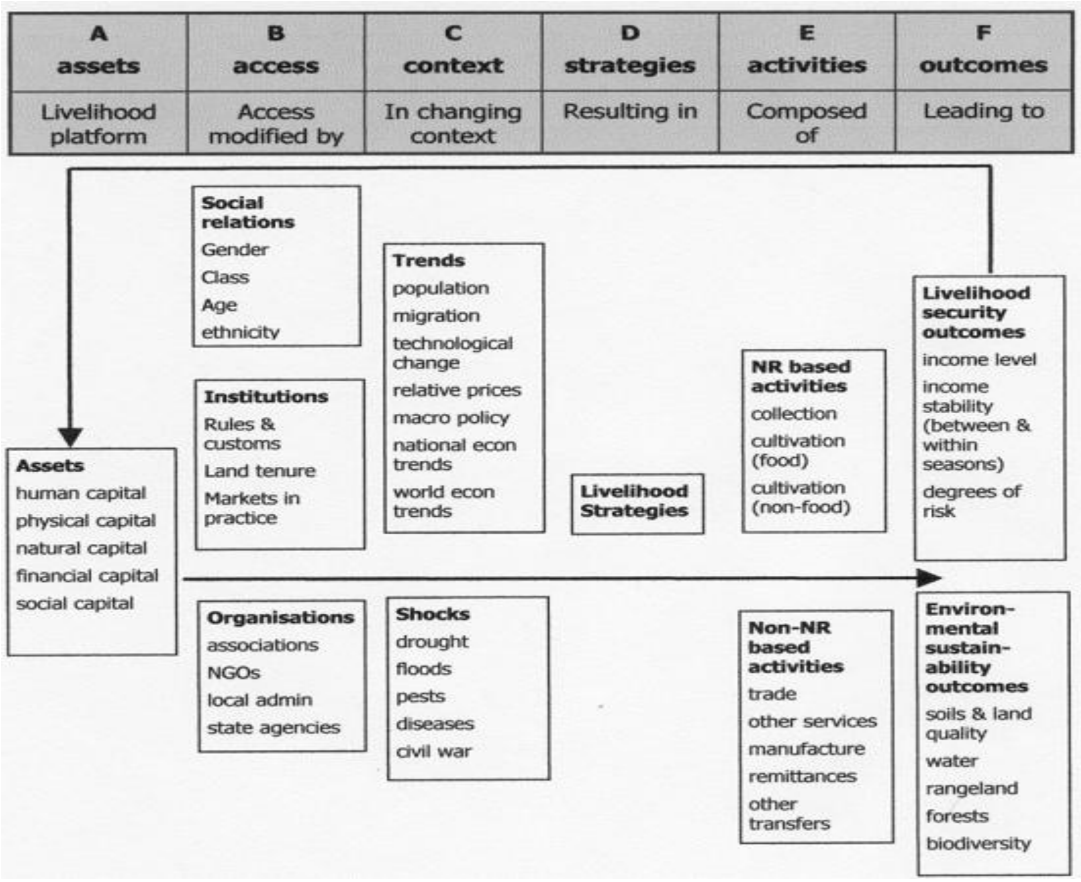


Figure 2: A livelihood framework for analysis (adopted: Ellis 2000)

From his framework of analysis, Ellis (2000) support chambers (1992), that in the midst of change and irregularity, livelihood constructions has to be seen as an evolution process. One of the strength of Ellis framework is its avoidance of Sen’s intuition of capability (Arun et al. 2004). Unlike Chambers and Conway (1991), Ellis explained the concept of capability into a different concept thereby, simplifying the definition of his framework. Differentiating the different forms of capital, Sccones (1998) argue that the relationship between the state and civil society that induce or restrain the pursuit of different livelihood strategies, may be referred to as political capital (Scoones 1998). However, this terminology was downgrade by Ellis who categorized institutions and broader political trends that affects access and livelihood process (Ellis 2000).

Though sustainable livelihood is an important approach to achieving a goal for poverty eradication, it should not be seen as the end to poverty eradication, but a means to understand the process and structures that aid in improving poverty (Krantz 2001). However, the way access, assets and institutions, interact in the process of achieving sustainable livelihood is relevant. These interactions are well highlighted in Chambers and

Conway (1991), Scoones (1998) and Ellis (2000) papers except a few infinitesimal variations in the implementation process; hence the relevance and inter-related nature of the different frameworks in explaining poverty.

CHAPTER III: RESEARCH METHODOLOGIES

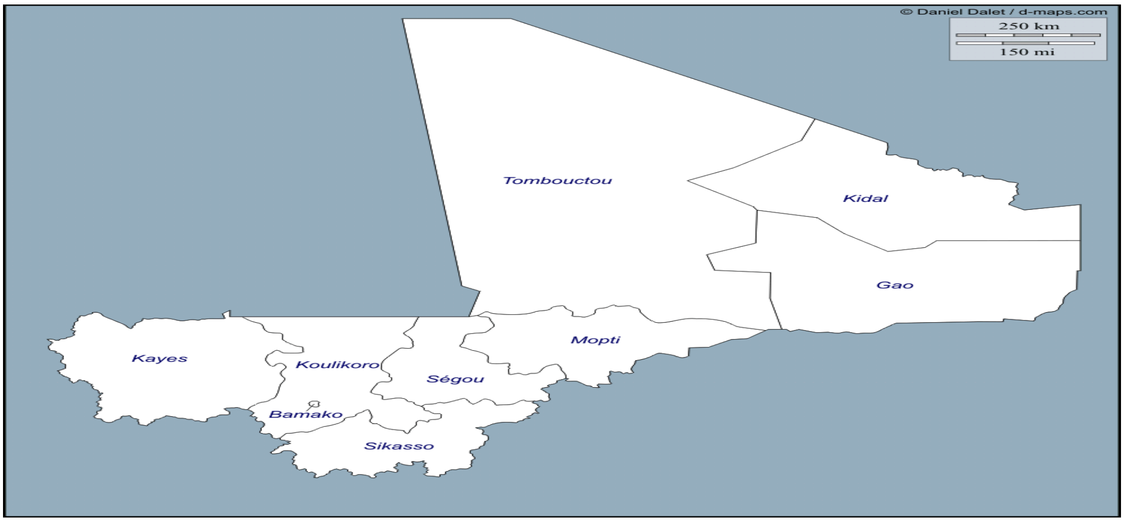
This section describes the survey and data collections methods used for this research. It starts with the description of the area study, the agriculture activities practiced in the study region and a presentation of the Ecofarm technologies tested in the study region. It continues with the description of the survey methods used. The section that follows looked into the sample methods relevant to this research and further dipped into the reliability and the validity of the research. The final part of the section presents models use in the analysis.

3.1 Description of the area of study

3.1.1 Location and Demographic characteristics

This study is conducted in 3 regions (Segou, Mopti and Koulikoro) of Mali. The survey took place in a total of 12 villages divided into 4 from each region. The region of Segou covers a surface area of about 64947 km2. It is boarded in the South by the region of Sikasso, in the east by the region of Mopti and in the west by the region of Koulikoro (See figure 3). The region of Segou is inhabited by a population of about 1.887,100 of which about 50% percent are younger than 15 years (DNSI, 2001).

Figure 3: Geographical regions of Mali, Google source, accessed on the 20th May, 2012



The Mopti region covers a surface area of about 79.000km2 representing about 6% of the national territory. The region has a population of about 1.500,000 which comprise mostly of the Bambara, Bozo, Dogon, Songhai and Fula ethnic group (DNSI, 2001). The region of Koulikoro on the other hand, covers a surface area of about 90120km2. It is the second largest administrative region of Mali with about 1.575.223 inhabitants (DNSI, 1990).

3.1.2 Climatic condition

The climatic condition of Mali ranges from tropical in the south to arid in the north. The country is relatively dry with a little amount of rainfall and drought. There are two seasonal variations in Mali: the wet and dry season. The wet season is in the late June to early December during which flooding is a common phenomena (Cisse et al. 1990).

The region of Segou experiences a semi-arid climate with average yearly precipitation of about 513mm. The region has two seasons: the wet and dry season. The rain season begins in June and last until September. The region experiences a cold and heat period during the dry season. The harmattan wind is dominant in the dry season and blows from the north to south, while the monsoon wind is frequent during the raining season and blows from south to north-west (Cisse 1990).

The region of Mopti experiences quiets a warm temperature with an annual rainfall of about 400mm. Mopti experiences enormous heat with average temperatures ranging from 36 to 40 degree Celsius (Cisse et al, 1990).

Koulikoro receives relatively a good amount of rainfall as compare to Mopti and Segou ranging from 600mm in the north to 1000 mm on the extreme in the south which has reduce considerable in the recent years (Traore et al. 2010).

3.1.3 Agricultural practices

The main economic activities of Segou region are agri-business and livestock. The agro-pastoral system of production is dominant in the region. The region produced about 30% of the total cereal production on an average of about 760 hectares of land (Brouwer et al., 1997). This land is about 31% of the total arable land of the region, estimated to be about 2.750,000 hectares (Brouwer et al., 1997). About 78% of the inhabitants living in Segou are sedentary farmers relying mainly on traditional farming methods.

In koulikoro, agri-business dominates all activities. The main agricultural activities are in cereals production. The region is also dip into animal husbandry as one of the major agricultural practices (Traore et al. 2010). Like Segou and Koulikoro, a greater part of Mopti is dominated by sedentary farming and livestock raising activities.

3.1.4 On the context of the Ecofarm project

The ecofarm project is one of the DCG and its development partners NGOs interventions meant to foster yields and production levels through experimenting on soil fertility and basic animal feeding technologies (Traore, 2010).

In 1999, Noragric and ICRAF started researching on soil microdosing through the project “integrated Plant Nutrient Management”. The project showed that application of 0.3 g mineral fertilizer per pocket give good results. In 2005 the Ecofarm project and the project “Plant Establishment” were initiated. This project worked on seed priming in combination with microdosing. The livestock component in the Ecofarm project was sheep fattening based on improved fodder ratios. The Ecofarm project also introduced a garden type of Moringa tree in the project area. This tree contributes to the food and nutritional need of farmers as it is rich in vitamin A (Traore, 2010).

This study is part of an effort to develop knowledge of the Ecofarm project. The previous study under this project provides information about the test that was put in place on the farmers’ field including the outcome on crops and livestock productivity. For this study, the effort is to capture the key changes that the project has brought to the livelihood of the local people through a thorough analysis of the local situation of the project area. The objective is to analyze the degree of adoption after the implementing period, the reasons of adoption and the impact of adoption.

3.2 Survey methods

A combination of quantitative and qualitative methods also known as "mixed methods research" is used in the household survey. The next section elaborates on the reasons for applying mixed methods research in this study.

3.2.1 Mixed methods research

To ensure reliability and credibility on the method used in data collection and analysis, both qualitative and quantitative research methods creating triangulation of methods also known as "mixed methods research" (Bryman, 2008) was used. My motive for selecting this method is not to make a division between quantitative and qualitative methods (Ellis, 2000), but to ensure that the biases using a single method is eliminated or reduced, making room for the weakness of one method to be compensated by the other method (Bryman, 2008).

As the research focused on a case specific study design, a mixed method is likely to produced better result in terms of scope and quality (Walliman, 2006). From the words of Walliman (2006), a case study design provides an in-depth opportunity to explore a social group, community or events (Walliman, 2006), and in this research, the study focused on agro-pastoralists communities in Mali, most likely adopted the Ecofarm Ecoferme technologies that were implemented as event within the broader integrated agriculture domain.

In their paper, Johnson et al., (2007) defines mixed method as a type of research process where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts and languages into a single study (Johnson et al., 2007).

The advantages, according to the article of Creswell et al. (2004) is that mixed methods research does not only increase the research vacuum, but also ensure quality that could have otherwise been apparent if single method was used. As further noticed by Creswell et al. (2004), "This form of research is more than simply collecting both quantitative and qualitative data; it indicates that data will be integrated, related, or mixed at some stage of the research process." This integration and mixing of data provide valuable opportunity for data triangulation design (Creswell et al., 2004).

3.3 Data collection methods

The data for this research analysis come from a cross-sectional agro-pastoralists households and communities survey conducted from June, 2011 to August 2011 as discussed below.

3.3.1 Semi-structured household questionnaires

Household survey using a semi-structured questionnaire was administered for data collection. To improve the quality of the questionnaire, a pre-test was applied on about 5 respondents in the village of Ntogosso in Segou. A modification was vehemently made on the number of questions and the time used to answer before starting the actual data collection. The usefulness of this approach is to determine the credibility of the survey in terms of ethics, wordings and the clarity of the questions. In the region of Segou, two enumerators were hired from the village, one who is the leader of the farmers union in Ntogosso and speaks Bambara with basic French and one that translates from Bambara to French. While just one enumerator (project coordinators) conversant with the villages and the project was used in Mopti and Koulikoro respectively. The intention is to ensure validity and reliability and cross checking of the response given by the respondents. The questionnaire data includes in-depth information on household location, demography, assets including production line, production technologies et cetera (See appendix I).

3.3.2 Semi-structured interviews

About 10 households' heads were drawn in each village for interviews. In the villages of Segou, the interviews took place mostly at night from 07pm to 12pm when farmers were back from their farm work. However, the interviews in the villages in Mopti and Koulikoro where farmers were less busy took place mostly in the day in a form of small groups of about two to ten members in a group. The key informants were mostly researchers and NGO coordinators working around the ecofarm project.

The key informants' interviews were administered in person but sometimes in the presence of DCG representative in Bamako who aid in clarifying unclear sentences and local French words. Tape recorder was used but only at the consent of interviewees for ethical reasons. I decided to use semi-structured interview because according to Bryman (2008), it permits flexibility in data collection, it decreases the complexities involved in adaptability of formulations of question and wordings to fit the respondents educational and social background (Bryman, 2008).

Flexible interview guide was also used (Walliman, 2006), since it leaves room for following up on matters raised during the interview that could be of particular interest to this research. In the research period, I often moved back and forth trying to grasp the view of the researchers, the coordinators and the farmers on similar topics. After an interview with farmers, I often return to the researchers and project coordinators to get their views on related matters. This was possible since all the key informants, specifically NGO coordinators and researchers working around the project were interviewed first before the one at the farmers' level took place.

3.3.3 Participatory Observations

I lived three months in rural villages in Mopti, Segou and Koulikoro. Through this period, I spend time learning the people surveyed culture and engaging in their daily activities. The aim of this participatory observation method is to gather information and images of purported technologies adopted and their effects on income, livelihoods and productivity. I paid special attention to factors such as infrastructure, access to input, land preparation, types of harvested crops and markets while walking as they may have effects on the kind of technology adopted and a possible modification of the technologies. I also took part in village gatherings where I talked to women, men and children of various ages to find out the extend the technologies are used in their communities. While in Bamako, I spend my evenings watching television for the diffusion of the ecofarm technologies. The few days they did, I asked my host for the reasons for the diffusion and the target group. From the first day I entered into villages in Mali, I developed the habit of eating bare handed in the same bowl and also drinking tea from the same cup with the farmers. Through eating and drinking together, the farmers were opening up to me and share their experiences in a friendly manner. Most village heads sat with me for several hours while eating and sharing their views on the ecofarm technology without reservations.

3.3.4 Secondary data sources

As this research seeks to avoid biased result, relying on only questionnaires, interviews and observations is not comprehensive enough to give a valid outcome. I collected all sorts of secondary documents relevant to intgrated agriculture technologies and livelihood security issues among agro-pastoralists households in Mali. In addition, I collected information from the web sites of DCG and other prominent development organizations working on improving food security and related issues across the globe. The reason for collecting wide range of information is to develop a solid understanding of the nature of the agriculture challenges faced by farmers as a result of social and ecological constraints.

Due to the broad nature of adoption of improve technologies and impacts on livelihood insecurity, all sorts of literatures addressing technology adoption and impact on livelihood is used. Literatures based on the work of agriculture technology adoption specialists, Negatu and Parik (1999) and Scoones (1998) sustainable livelihood framework and some steps in Davies and Darts “Most Significant Changes Techniques”, form the basis for the discussion in this paper. Relevant images and statistical data is used when deem necessary to address factors that influence household decision for adoption of new technology. Since this paper seeks to address a development issue, the literatures used is interdisciplinary and multidisciplinary; well connected to the theme in this paper

3.3.5 Sampling

A total of 120 household heads were randomly selected from the 3 study regions of Segou, Mopti and Koulikoro. However, the point worth mentioning is that due to poor and absence of well established statistical data kept of households in some of the regions, different procedurals were administered to randomly select the household heads in some village and regions. In Segou, all the villages had a leader who is like an intermediary between the village chief and the people. This person, popularly call “president” kept a list of all the household heads of the village. Upon arrival at the entire villages in Segou, the president hand over the list of household heads. With the help of my interpreter, we copy the list on pieces of paper, mix them together and select the names of 10 heads each from the villages. A message is sent to each of the farmer to make room for the administration of the questionnaires.

However, different procedures were applied in Mopti and Koulikoro, where I discovered before hand, from the NGOs coordinators who worked on the project of the absence of a list of household. In this case upon arrival, I ask the village chief to randomly give a list of 20 household heads to be interviewed on general farming practices. We make sure not to mention the project Ecofarm as this may influence the list. The 20 names given by the household heads are again mixed together and 10 are selected for questionnaires administration. The same procedure was administered for focus group discussions in villages which did not have the list of household heads beforehand. However, the criteria for selecting focus groups interviewees was based on gender, age and household status as these may influence adoption decisions and line of production. Though, there is no doubt that asking the village king for a list of names may influence the selection procedure, this was the best option available to us at that time. Other option could have been to go from one household to the other and jot down the names of all the household heads personally before randomly selecting. But this would have required enormous time and resources, yet some of households' heads would have still not had the chance to be selected as there could have been the error of double counting or problems with accessing their house.

Key informants mainly NGOs and the government departments interview was administered in a form of snowball sampling procedure as I assumed that they have some sort of network within the study domain and their network could even help to identify new contacts that are not known to them. The snowball sampling method gave a positive outcome since through one DCG coordinator; I was able to reach out to a local NGO AMAPROS. Through AMAPROS, I had the opportunity to meet a key researcher of the Ecofarm project who worked with the then ICRAF. I was then sent to another important researcher at IER who introduced me to several other researchers and field coordinators who were on the field with farmers during the testing face of the Ecofarm project. This method was relevant because not only was I linked with knowledgeable people on the Ecofarm project but also I discovered their operating channels and the collaboration between NGOs and researchers operating in Mali.

3.4 Validity and Reliability

Data obtained on the field were cross-checked with NGOs field coordinators, researchers and well informed participating farmers (See section 3.3.1). The farmers' knowledge of technologies was compared with researchers at IER for clarifications. Measuring of a sack of millet, groundnut, sorghum, and cowpea with traditional scales were crosschecked with modern scale to ensure validity and reliability of figures.

However, "to err is human" especially when farmers do not keep record of their productivity. In this situation, information given may have been influenced by biases which could affect the outcome of the results and discussions. This could also explain the reason for several outliers in the regression. The sample size and the selection method used (See section 3.3.5) may have also influenced the outcome or making generalization about the regions. However, in most cases the 10 samples selected were the entire population. My personal interpretation of things observed on the field may have also influenced the outcome, though immense effort is made to avoid errors.

3.5 Models used for data analysis

Qualitative and quantitative data were collected, coded and then a univariate and bivariate analysis were performed for descriptive statistic such as means, frequencies and percentages with the help of Statistical Package for Social Sciences (SPSS). Household characteristics and socio-economic status mainly age, gender, land size, fertilizer prices and distance to fertilizer were analyzed for descriptive statistic such as means, frequencies and percentages using bar charts, cross tabulations and simple tables. The relationship between household characteristics, socio-economic status and the degree of adoption is investigated using simple and multiple linear regressions. In the simple and multiple linear regressions, sex, age, number of children, other dependants, distance to fertilizer, land size and prices of fertilizer were all used as independent variables while quantity of fertilizer (adoption) was set as dependent variable (Y). Gender effect on adoption is assessed using a chi square goodness of fit test. Cross tabulations are used to compare reasons of adoption, impacts of adoption and scaling up of the Ecofarm technologies. The MSC technique was partially used to collect farmers own stories and testimonies to deepen the understanding on reasons of adoption and the overall impacts of adoption on livelihood.

CHAPTER IV: RESULTS AND DISCUSSION

This part of the paper presents and discusses the main findings of the research.

4.1.1 Households characteristics in the surveyed region

The average household size in the Ecofarm site is 19, 15 members. This size consists of a male household head, a wife and an average of about 6.64 children and 10.51 other dependents respectively. The average land size owned per households head in the survey region is 11.54 hectares. In the focus group discussion, it emerged that household used about 2 labors to clear and prepare one hectare of land.

Table 1: Characteristic of household heads in the surveyed regions (N=120)

Variable	Frequencies	Percent
Age (years)		
≤ 30	4	3.3
31-40	23	19.2
41-50	58	48.3
51-60	27	22.5
>60	8	6.7
Mean ±SD	47.4± 8.9	
Sex		
Male	84	70.0
Female	36	30.0
Marital Status		
Married	118	98.3
Widow	2	1.7
Land/Hectare Owned		
≤1-10	69	57.5
11-20	37	30.8
21-30	9	7.5
31-40	5	4.2
Mean ±SD	11.54±9.7	

Children per Household		
≤1-5	44	36.7
6-10	64	53.3
11-15	11	9.2
≥16-20	1	0.8
Mean±SD	6.64±3.1	
Number of Other dependent		
≤1-5	48	40.0
6-10	15	12.5
11-15	17	14.2
16-20	4	3.3
21-30	36	30.0
Mean±SD	10.5±12.1	
Householdsheads Level of Education		
Primary Education	20	16.7
University Education	1	0.8
Studied Coran	8	6.7
Alphabets	15	12.5
No Education	76	63.3

Age and sex are other relevant households characteristic in the study area. Most of the household heads in the Ecofarm sites are mostly men with a median age of 47 (See table 1), indicating strong and active members. In focus group discussion, it emerged that large size households, generally sell their labor to increase livelihood resources. Working on other farms to generate income to boost the household livelihood resources are some of the ways households combines capitals to make a living.

In addition to effort from labor, the level of education may influence a kind of decision to make and which livelihood strategy to adapt. On average, just a few households on the Ecofarm site have had former education. A majority of the farmers have no former education but depend on their local knowledge to make decisions about when to sow and a type of crop to be sown.

Social network is a major component of social capital and it serves as a means of spreading livelihood improving information among farmers. Most of the sampled households in the ecofarm site are members of an association. Gender and interest are the main determinants of a choice of associations to join. A majority of women in Ntogosso belong to women association. Through the association, the women are able to make huge gardens where they grow garden crops and fruit. The income generated is either used on community development or share among the women contributing to the household wealth. A similar association can be found in Wousare in the Mopti region. Most women in the village of Wousare belong to an association. The association aim is to teach women new farming and animals raising techniques. In Djafala, a group of women, well known as Moringa women group grow and sell Moringa not only to improve household income but also strengthen women networking.

The men also benefit from farmers association where they can save their extra money and crops and have access to credit. This association also assists member households who have difficulty to purchase inputs by giving out credit or input to farmers to be paid back after harvest. In addition, through the association, farmers spread information about a new technology as well as evaluating the pros and cons of a new technology. Some of the men associations, specifically in the village of Songora and Niengue Coula have been able to secure a fertilizer supplying sites within the villages and as such, has connected with other nearby villages bridging the gap between distance and fertilizer.

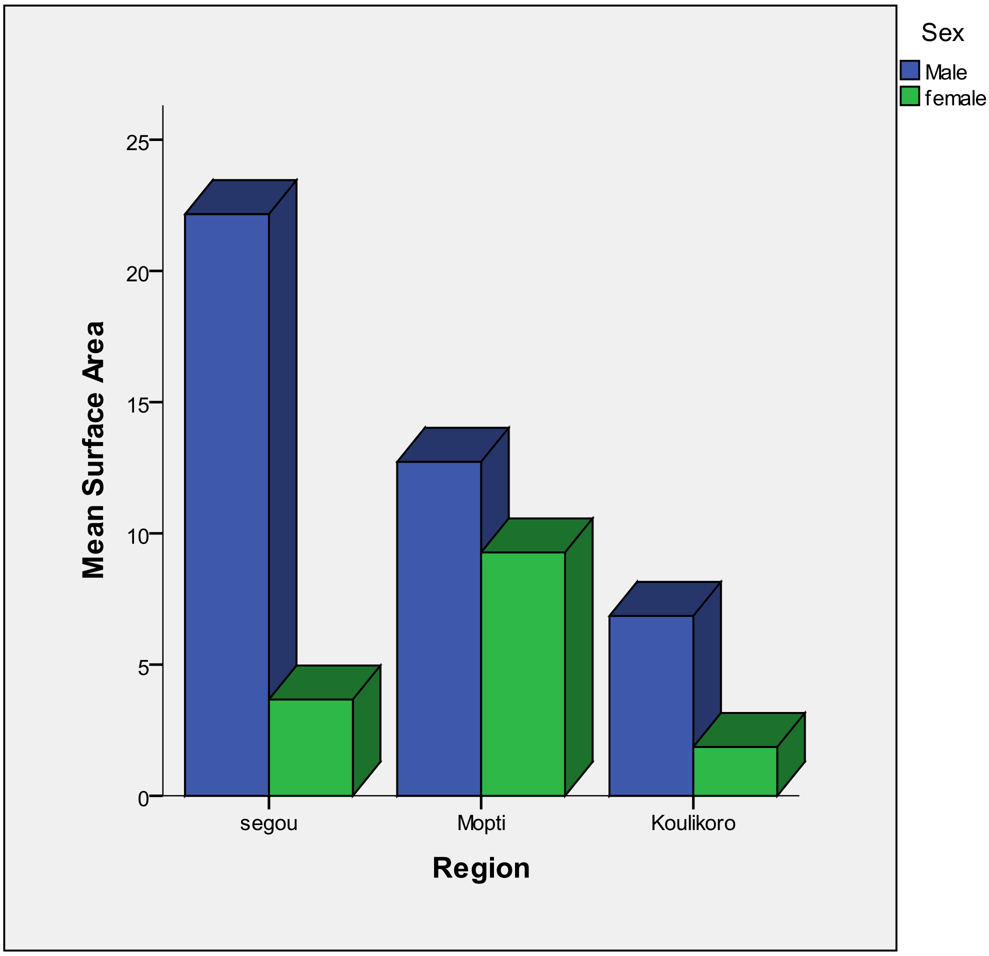
4.1.2 Resources owned and Agricultural practices

The resources available to rural farmers in Segou, Mopti and Koulikoro can be categorized into land, crops varieties and livestock while the later two indicates agricultural practices.

Land size owned by household heads: A large portion of land in the Ecofarm site is individual or family owned. While some portion of land is owned by extended families and the village. The extended family lands is own only by members of that particular family. However, the villages land could be accessed by all members of the village.

On the average, each household own approximately 11.54 hectares of land. However, there is a huge variation across regions and within regions. The households in Koulikoro own less land as compared to Segou. In Segou, each household owns about 18.0. Households in Mopti own more land than Koulikoro but less land than Segou. The variation is consistent with the amount of agricultural land available in the different regions. Mopti has limit agricultural land as compared to Segou; hence reason for the variation in land size owned.

Figure 4: Average land size per households by gender in Segou, Mopti and Koulikoro, survey, 2011



The impression is that men own large land than women with the difference more wide in Segou than Mopti and Koulikoro (See figure 4). The variations may be the cultural value attached to land and also the average agricultural land available in the three regions mentioned above.

Livestock owned: In the survey villages, non ruminant livestock such as sheep and goats are kept to display wealth while ruminants, mainly cattle and donkey are kept for farming purposes. In the questionnaires, it emerged that all households (100%) keep some kinds of livestock (see table 2). There is a variation in the number and kind of livestock kept. Common among all regions, wealthy households kept a huge number of sheep and cattle. While poor or middle class household kept basically goats and donkeys. The type of livestock kept is also influence by variation in market prices. The market price of sheep is about 56% higher than that of goat. While on the other hand, the market price of cattle is about 100% or more high than sheep.

Table 2: Average livestock per household per ecofarm region, survey 2011

Region/Villages	Cattle	Goats	Sheep	Donkeys
Segou	1.10	8.57	6.35	1.35
Mopti	1.82	4.80	4.85	.73
Koulikoro	3.25	3.70	4.0	.85
Total	2.06	5.69	5.07	.98

In comparison, households in Koulikoro own more cattle of about 3.3 but own less of goats and sheep while those in Segou own the highest number of goats and sheep but lowest number of cattle (See table 2). Households in Mopti own a few number of both Goats and Donkeys but own more cattle than those in Segou. In addition, household in Mopti own more Goats and sheep than the households in Koulikoro. On average, each household in the Ecofarm region has about 2.06 cattle. The average number of cattle own in all regions is lower than that of goats and sheep which each household access just about 5.69 and 5.7 respectively (See table 2). The number of Donkey own is the lowest for all regions. This is consistent with the explanation from the focus group discussion that farmers usually borrow Donkey from other farmers for plowing and sowing purposes.

Crop stock: Basically, after the harvesting season all households in the Ecofarm region store crops. This is important for the welfare of the households. The type of crops households' keep is similar across all the Ecofarm regions except crop mainly Okra which is cultivated mostly by women in Segou and Koulikoro but not common among women in Mopti. The variation is due to socio-economic and agro-ecological reasons. The common crops cultivated in most of the Ecofarm communities are millet, sorghum, cowpea and groundnuts (See table 3). These crops are drought resistant and give high productivity. In the focus groups discussion, it emerged that most farmers cultivate sorghum and millet because of the soil nature and the yield effect.

Table 3: Principal crops cultivated by farmers in the ecofarm region (N=120)

Crop types	Percent of respondents
Millet	61.7%
Sorghum	72.5%
Maize	20.8%
Cowpea	25.8%
Wouazou	12.5%
Sesam	12.5%
Foneo	19.2%
Peanuts	71.7%
Rice	40.8%

From table 3, about 72.5 percent of all households in the Ecofarm communities cultivate sorghum. Though millet was expected to have the same proportion grown as sorghum, it emerged that just about 61.7 percent of all farmers cultivate millet. Peanut is cultivated in about 71.7% in all households, a second largest crop cultivated after sorghum. The increase in groundnut cultivation is due to recent introduction of soil improving technologies and the crop importance as cash crop. Most household heads reviewed that part of peanuts harvested is consume and a major part of it is sold in the market to generate cash income. The same cash income reason was given for the cultivation of rice.

In the surveyed households, greater stock pile of peanuts and rice is a sign of good economic status. Cowpea is one of the major crops in the villages representing about 25.8

percent of all crops cultivated (See table 3). Not only is the grain used in household food

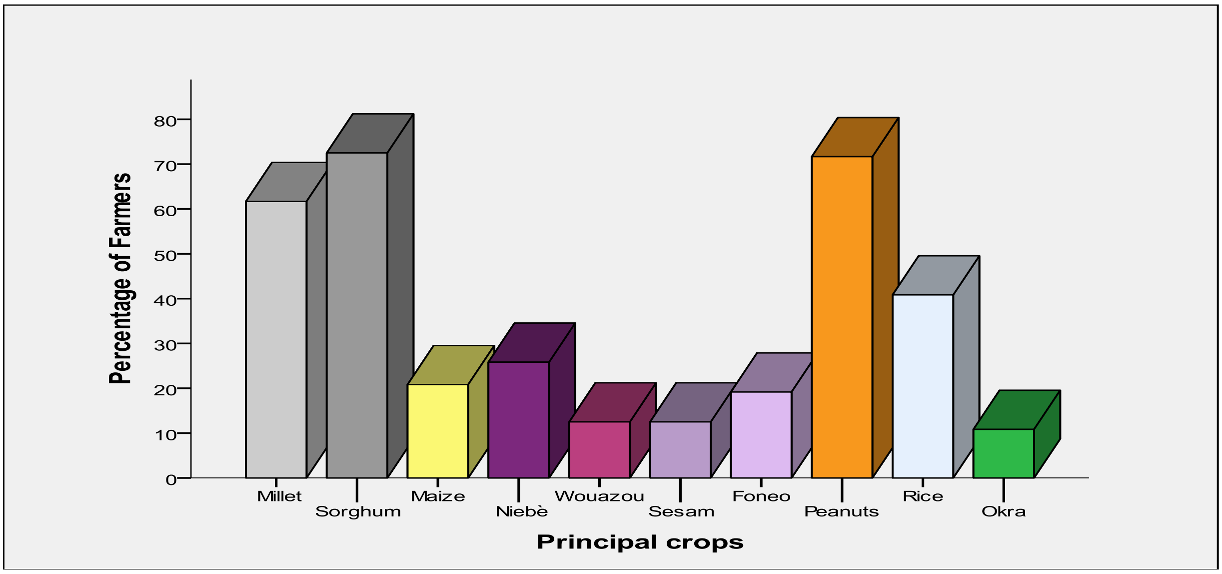


Figure 5: Principal crops cultivated by farmers in Segou, Mopti and Koulikoro, survey 2011

but the leave is used to feed livestock. Though Okra represents only 3.1 percent of all crops (See table 3), it is a major source of income for women. On the field, it was observed that mostly women gardens in all villages, particularly N'togosso, Fallani Congo, and Niengue Coura contain a large quantity of Okra cultivated for cash purposes. However, women in regions particularly, Segou and Koulikoro cultivate more okra than those in Mopti, an indication of variations in income and economic status.

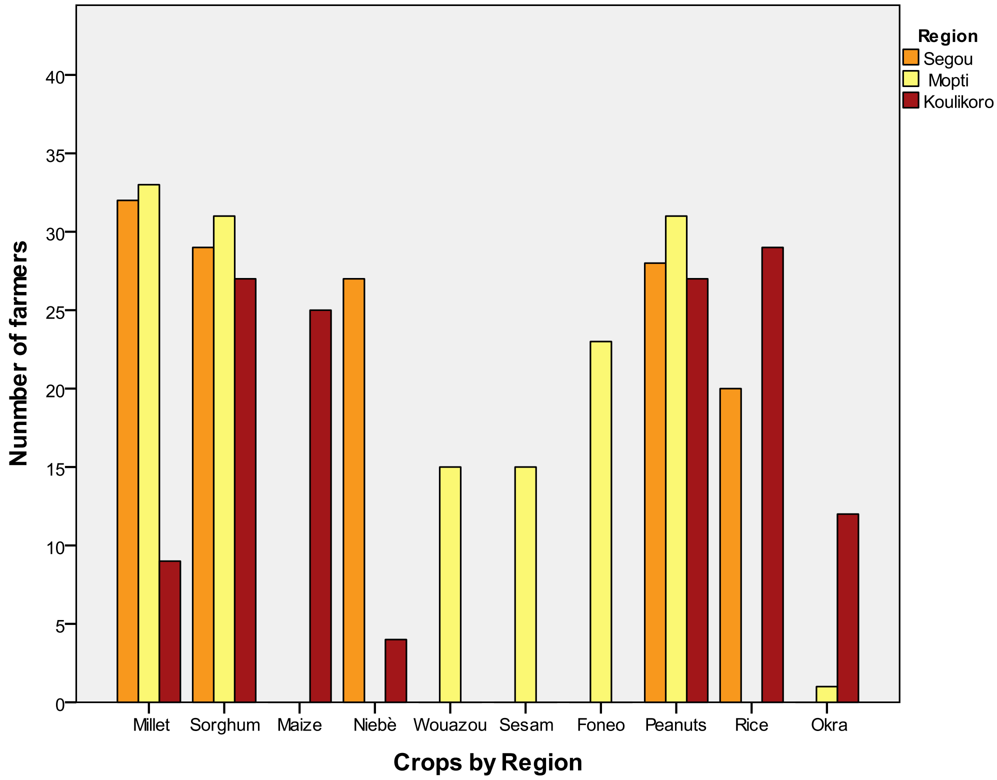


Figure 6: Regional distribution of crops, survey 2011

Millet and sorghum cultivation is highest in Mopti than Segou and Mopti (See figure 6). The low cultivation rate of millet and sorghum is influenced by the number of farmers who responded positively to these crops. Responses from the questionnaire review that no farmer in Koulikoro region, specifically in the villages of Songoria, Niengue Coula and Falani Congo cultivates millet. While just about 3 out of the 10 household heads surveyed in the same villages cultivate sorghum. Though millet and sorghum cultivation is high in Segou region as compared to Koulikoro, irregularities were observed, specifically in the villages of Nabaso and Nsirimanso, where not all the farmers cultivate millet and sorghum as compared to Ntogosso and Taro villages surveyed in the same region.

4.1.3 Other practices and income sources

Agriculture is the largest source of income among all the surveyed villages. About 80 percent of all households in the rural communities of Mali earn their livelihood from agriculture. In addition, households pursued other means of income that contribute to improving livelihood resources. From the focus group discussion, it came clear that a diversified income source is necessary as the cultivation season is short due to erratic rainfall and unstable climatic conditions. Almost all farmers in the surveyed regions have problem with low rainfall (See table 5). However, the intensity of the problem varies across regions. The regions of Koulikoro and Segou responded more positively to low rainfall than those in Mopti.

The variability in rainfall across regions influence the kind of other income sources households pursued. For instance, Mopti experience an extreme low and erratic rainfall, as a result the young male are usually sent to the capital Bamako and the neighboring countries of Ivory Coast and Guinea to work and sent money home. From Table 4, about 13 out of 19 households in Mopti mentioned that they generate a share of their income from both internal and external migration while only 2 out of 19 households in Segou as compared to 4 out of 19 generate income from migration sources in Koulikoro (See figure 7). In a focus group discussion, a household head in the village of Sogora, a province of Bankass, gave telephone numbers of some of his siblings in neighboring country of Ivory Coast working and sending money home.

Erratic rainfall is one of the main factors that induce rural-urban migration. From Amidou Sacko, a DCG Mali coordinator, erratic rainfall and drought in the northern part of Mali is one of the major causes of migration of the Soninke and the Fulani youths to France and other European countries. Evidences shows that the youths of the Soninke and the Fulani migrate mostly to European countries to work and send money home as a share of the household income.

Similar to migration, arts and craft is a popular source of household income (See figure 7, table 4). Though, just about 19 households heads mentioned arts and craft as a share of household income, it is still a major source of income among the youth in the Mopti region particularly in Sangha, Banani, Amani Nombori and surrounding villages. Mopti is considered as a tourist region; most young men own shops that sell arts and craft to tourist to generate cash income.

Table 4 : Alternative households Income sources per region, surveyed 2011

Alternative income sources	Number of respondents per Region			Total
	segou	Mopti	Koulikoro	
Arts&Craft	8	4	7	19
LabourerWork	10	4	9	23
Charcoal Burning	5	0	4	9
Trading in Agri.c Product	15	19	16	50
Migration Income	2	13	4	19
Total	40	40	40	120

Trading of agricultural products is a major contribution to households' cash and subsistence income (see table 4, figure 7). The main products are mostly inputs and food crops. The common food crops are groundnuts, sorghum, peanuts, cowpea, maize and millet. In a period of bumper harvest, a part of the seed crops are sold in the market to generate cash income. Fruits like Shea fruits, Mangoes and Ziziphus Mauritania are collected and sold by women and children on the main highways to generate cash income for the households. Buying and retailing inputs mainly fertilizer, seeds and tools contribute to a major share of the households' meager income. In the Mopti region, Tuesday is considered as market day. On this day, women and men from villages converge at the Bandiagara market place to sell their agricultural products.

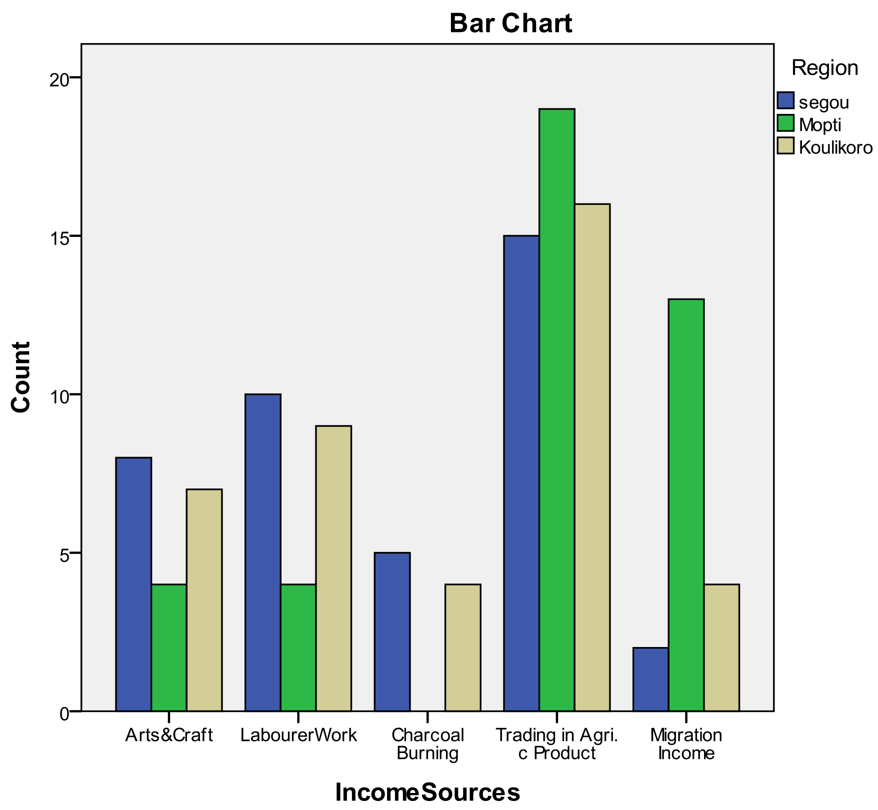


Figure 7: Alternative income sources pursue by farmers to sustain livelihood, survey 2011

4.1.4 Constraints to agricultural practices as sources of income

From table 5 and figure 8, infertile soil, low rainfall, access to inputs, access to information and problem with insects are the main problems farmers on the ecofarm sites.

Soil infertility and low rainfall (climate change): About 69 of all farmers mentioned soil infertility as a major problem encounter practicing agriculture. More than 60 percent of these farmers are mainly from the villages of Nabaso in Segou region and Parou and Wousare in Mopti.

The soil in Nabaso is clay. In the raining season, the land becomes waterlogged and holds water over a long period. However, in the dry season, the land turns hard and difficult to prepare. In the villages of Parou and Wousare in Bandiagra province, the observation is that stones and rocks are scattered over the entire land. To cultivate on the land, farmers have to go through the demanding work of collecting the stones before cultivation.

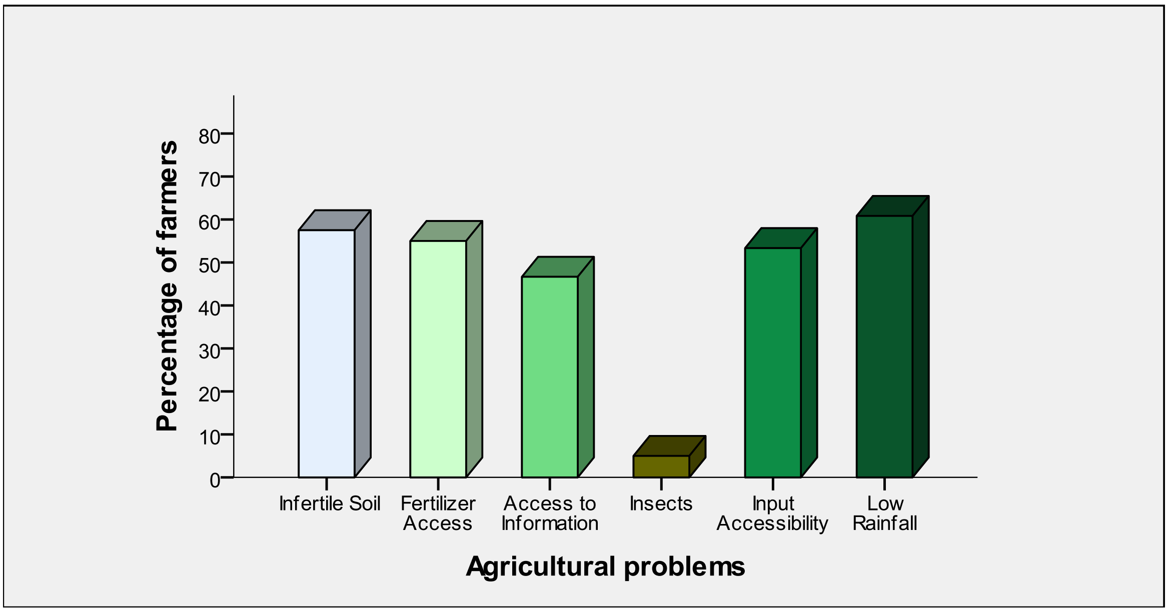
Table 5: Socio-economic and environmental constraints to agriculture, survey 2011

Constraints to agricultural practices	Percent of respondents
Infertile soil	57.5%
Fertilizer access	55.0%
Access to information	46.7%
Problems with insects	5.0%
Lack of inputs	53.3%
Low rainfall	60.8%

Changing climate, improper crop and land rotation are other major challenges to soil fertility in Mali. Climate changes bring more extreme weather events such as drought and unpredictable weather (IPCC, 2007). The changes deepen problems with soil fertility. Due to drought, soil usually contains little water and induces poor nutrient content. In Songora, a village in Bankass, and Nsirimanso, Segou, farms usually become flooded in the raining season. The flood then washed away nutrient depleting the soil.

Access to information: from table 5, about 56 farmers mentioned access to information as a major problem they face while practicing agriculture. Information helps farmers to identify the type of crop and soil improvement technologies to adopt or not to adopt. In the rural areas of Mali, information is spread through NGOs, and social network. The main problem facing these information sources is accessibility. Most of the villages in rural Mali are inaccessible by road. A carrier of information has to travel several kilometers on a motor bike or on a donkey back to deliver information. There is also a problem of flood. Access to most villages in Segou is almost impossible after rainfall. The roads get flooded. As a result, NGO coordinators working in Nabaso, a viallges in Segou, have to wait three to four days in Ntogosso for the road to dry before joining the people of that village. A similar case is true in Songora, Bankass in the Mopti region. In focus group discussions, it emerged that social network help to spread information about technologies mainly Ecofarm among farmers in the rural Mali. The challenges relying on this source is that farmer's spread information about new technologies mainly to their relatives in the neighboring villages. For instances, during focus group discussion, it emerged that those who benefitted from the Ecofarm in Nsirimanso are mainly relatives of those who participated in the project in Ntogosso.

Figure 8: Agricultural problems farmers encounter, surveyed 2011



Access to fertilizer and insecticides: the problems relating to households access to fertilizer and insecticides are in twofold; first, lack of the means to purchase input due to low endowment and second, distance to input as well as availability of inputs on the market. Unlike Segou region, the market for inputs in Mopti and Koulikoro, particularly Parou, Niengue Coula and Sanongora are well developed. Yet, poor households are not able to afford it. In Segou, where farmers have relatively better economy, they are face with the problem of accessibility. In the village of Nabaso and Nserimanso, some farmers mentioned that they have to travel about 60km on inaccessible road on a motor bike to purchase fertilizer and insecticides during the raining season. Farmers' inability to access inorganic fertilizer has forced many of them to turn to organic sources such as manure and mulching to maintain soil fertility and increase productivity. The main problem using these sources is that most households do not own enough livestock to gather enough waste to fertilize their soil.

4.1.5 Previous technologies farmers used to mitigate agricultural constraints and improve soil fertility

The three main technologies previously used to maintain soil fertility are Zai, compost and organic manure (see table 6). About 22 farmers mentioned using Zai, 23 uses organic manure, while 58 farmers depend on compost. The adoption of these practices varies from region to region and depends mostly on the socio-ecological and environmental conditions of the area.

The technology of Zai is practiced mostly in Segou, a semi-arid region with relatively high drought and a flat photography of land. Framers dig a hole of about two to four feet into soil known as zai pit. Once the pit is dug, it is filled with a compost of leaves and stems then topped with manure. This hold water, and then crop is grown on it. The zai technology is simple, yet ingenious low-technology innovation for most farmers in Nabaso and Nsirimanso where rainfall is feeble and soil is depleted.

"Digging zai hole is backbreaking, yet the only means to feed my family. My family will starve if I do not make many Zai pits" Rokia Coulibaly, a 50 year old farmer in Nabaso said while slamming a hoe into a parched soil.

Zai technology is relatively cheap but involves lots of work. This technology was used by a majority of farmers in the Segou region prior to the arrival of the Ecofram.

Compost: about 56.3% of all households in rural Mali practice compost in their homes or on their farm lands (See table 6). Several farmers in Segou claim that their soil regains fertility after dumping heap of compost.

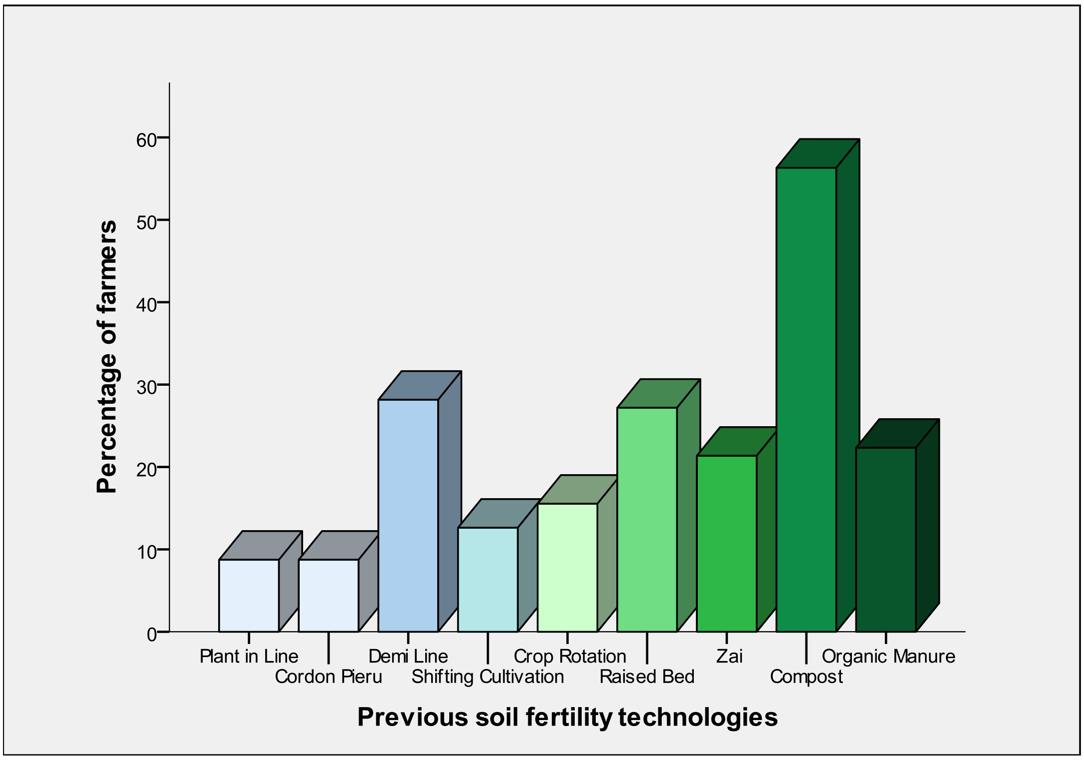
"Few years ago, my soil did not support any crop. Besides, I could not afford fertilizer. But since I started practicing compostage, my land has regain fertility and I am able to grow crop and feed my family"Dauda Djara, a 40 year old man said during focus group at Ntoggosso

Table 6: Previous technologies farmers used to maintain soil fertility, survey 2011

Previous soil technologies	Number of respondents	percentage of respondents
Plant in Line	9	8.7%
Cordon Pieru	9	8.7%
Half Moon	29	28.2
Shifting Cultivation	13	12.6%
Crop Rotation	16	15.5%
Raised Bed	28	27.2%
Zai	22	21.4%
Compost	58	56.3%
Organic Manure	23	22.3%

Making compost is easy with little or no cost involved. The main challenge is access to green leaves during the dry season just before cultivation start in June. Framers have to travel long distance in search of green leaves or rely sole on crop residues and household waste to produce compost.

Figure 9: Previous soil and crop improved technologies adopted by households in the surveyed regions



Manure: In many of the surveyed villages, cow dung is the main source of manure. Farmers allow cows to feed on their farm. The cow waste is left on the soil to decompose, adding nitrogen and other nutrients into the soil. However, the challenges associated with this method are that most farmers in the surveyed areas do not own enough cows.

"I am aware that animal manure can help my soil gain fertility. But I cannot depend on my one cow to fertilize my entire 20 hectares of land. I am saving money to purchase one or two more cows next year". Mousa Tanga, a 40 year old farmer in Ntogosso said.

A common practice in all villages is that farmers allow other pastoralists in their village and nearby village to feed on their farms. This practice is mostly observed among farmers in Bankass and Bandiagara municipalities.

4.1.6 Present technologies adopted to improve soil fertility and increase productivity

The main modern technologies introduced through recent projects and adopted by rural farmers in the survey regions are fertilizer microdosing, seed priming and plant in line (See table 7).

Table 7: Technologies presently introduce through project and adoption status, survey 2011

Present technologies	Number of respondents	Percent of respondents
Plant in line	42	35.3%
Fertilizer Microdosing	81	68.1%
Seed Priming	61	51.3%

Seed priming; soaking seed in water before cultivation and microdosing of fertilizer; mixing same seed and quantity of fertilizer or placing 0.3 gram of fertilizer at the base of the plant 15 to 20 days after germination were the two most adopted technologies. These technologies are also the main improved crop technologies introduced through the Ecofarm project.

4.2 Assess the degree of adoption of the Ecofarm technologies

This part of the thesis assesses the degree of adoption of the Ecofarm technologies. It starts by assessing a number of technologies adopted by the 120 households surveyed. It is then followed by identification of variables that may influence adoption. A simple linear regression is performed to identify significant and non significant variables that influence adoption (quantity of fertilizer used). A multiple regression is then performed with adoption as the dependent variable(Y) and several other independent variable such as age, sex, land, prices of fertilizer, distance to fertilizer (X variables) to see their relationship. The outcome of the regressions will help to determine relationship between household characteristics variable used as independent variables and adoption

4.2.1 Assess soil and crop improving technologies adopted

A number of technologies are used by farmers in rural Mali to improve soil fertility and increase production of crops. The technologies identified were those recommended by NGOs working in those areas and have been disseminated extensively by their agents and through networking. These technologies include both traditional and improved varieties such as Zai, half moon, line planting, compost, seed priming and fertilizer microdosing; not the 1:1 ratio but the application of 0.3 g mineral fertilizer per pocket. Microdosing was the most adopted technology by 67.5% of all surveyed households (Table:8). Seed priming was the second most adopted technology among farmers after fertilizer microdosing as about 50.8% of all farmers surveyed is using it (Table 8). While compost is the third largest technology adopted with about 46.7% of all farmers adopting it.

Table 8: Comparing percentage of technologies to improve soil fertility and crop yields diffused in villages and their adoption status (N=120)

Type of Crop and soil improving technologies	Percentage of farmers adopted
Plant in Line	(35.0%)
Fertilizer Microdosing	(67.5%)
Zai	(19.2%)
Seed priming	(50.8%)
Compost	(46.7%)
Half Moon	(18.3%)

Table 9: Percentages of a number of soil fertility and crop improving technologies adopted by farmers

Number of technologies adopted	Percent
< or equal to 1 technology	15.8
2 -3 technologies	48.3
4 and above technologies	35.8

In Songoria, household heads adopted more of microdosing but less of compost and seed priming. Plant in line was moderately adopted. On average about 42 household heads mentioned that they adopted plant in line technology (table 8). A majority of plant in line adoption was in the villages of Koumudu and Sogora in the Bankass region. However, none of the household heads in the villages of Ntogosso, Nabaso, Nsirimanso and Taro adopted plant in line technologies. The highest adoption of plant in line technologies was in the village of Falani Coula and surrounding villages in Koulikoro. Zai and half moon are least adopted. The technologies were diffused by NGO AMAPROS in villages in Segou mainly Ntogosso, Nabaso and Nsirimanso. The proportion of households head adopted Zai and Demi-lue were 19.2 percent and 18.3 percent respectively. Zai and Demi-lue are both rain and soil nutrient conservation technologies as such farmers adopt both simultaneously. The latter two technologies are still diffused during the period of survey in Ntogosso and Nabaso by the NGO AMAPROS. In addition, when analyzed overall adoption by number of technologies, the impression is that a significant proportion of respondents (48%) had adopted between 2 to 3 technologies out of 6 technologies (See table 9). The impression is that about 50% of all households in the surveyed region depend on some kind of technology for their livelihood. However, factors hindering or inducing adoption of technologies (Salasya et al., 2007) need further research and analysis.

4.2.3 Comparing households' characteristics with technologies adopted

Households characteristics (Table 10a and 10b) mainly age, sex, educational level, household size (number of children and other dependent) and land size differ in terms of the type and amount of technologies adopted. Of a total of 120 households heads surveyed, 84 of them were males and 36 of them were females. Within the male heads, about 70.2% of them adopted fertilizer microdosing while 61% of all females simultaneously responded that they have adopted fertilizer microdosing. Some differences were also observed between gender and adoption of seed priming.

Table 10a: Effects of households' characteristics on technologies adoption status N=120)

Household Characteristics	Technologies adopted								
	Microdosing			Half Moon			Plant in Line		
	Count	% within sex	n	Count	% within sex	n	Count	% within sex	n
Gender:									
Male	59	70.2	84	18	21.4	84	35	41.7	84
Female	22	61.1	36	4	11.1	36	7	19.4	36
Level of Education:									
Primary school	15	75.0	20	2	10.0	20	8	40.0	20
Coran studies	6	75.0	8	5	62.5	8	3	37.5	8
Alphabets	10	66.7	15	5	33.3	15	3	20.0	15
No education	50	65.8	76	10	13.2	76	28	36.8	76
Marital Status:									
Married	80	67.8	118	22	18.6	118	41	34.7	118
Widow	1	50.0	2	0	0	2	1	50.0	2
Dependants:									
1-5 dependants	27	56.3	48	15	31.3	48	11	22.9	48
6-10dependants	11	73.3	15	2	13.3	15	4	26.7	15
11-15dependants	13	76.5	17	1	5.9	17	7	41.2	17
16-20dependants	2	50.0	4	0	0	4	1	1.2	4
Land size									
Small	50	72.5	69	6	8.7	69	28	40.6	69
Medium	23	62.3	37	9	24.3	37	12	32.4	37
Large	8	57.1	14	7	50. 0	14	2	14.3	14

Unlike fertilizer microdosing which more male household heads adopted more of it than female household heads; more females adopted seed priming than males (See table 10a and 10b). About 52.8% of all female heads responded that they have adopted seed priming as compared to 50.0% of males who responded affirmative to seed priming (See table 10b). The gender differences in micro dosing and seed priming adoption can be attributed to cost and the amount of workload involve in using the two technologies. Most female households' heads surveyed particularly, in the villages of Niengue Coula and Songoria in Koulikoro region mentioned that putting 0.3gram of fertilizer in a pocket under each plant is a lot of work and they do not have the patient for it. On the other hand, soaking seeds for

8 hours before cultivation was seen by female heads as relatively easy. In addition to the amount of effort used, the cost and the means of transport of fertilizer to site were some of the hindrances inducing gender differences in microdosing and seed priming adoption. In Nabaso, none of the female heads mentioned using microdosing due to the cost of purchasing fertilizer and the transportation of fertilizer to site. However, cost and transportation of fertilizer were not a major problem to most men in the same village, rather erratic rainfall.

In relation to a number of dependence and microdosing, the observation is that microdosing adoption increases with a number of dependants until it reaches a certain level and it begins to fall. For instance, 56.3% of households surveyed with 1-5 dependants responded positive to fertilizer microdosing. This proportion increased to 73.3% as dependence increased from 1-5 to 6-10. A further increase was observed to about 76.5% as dependants increase from 11-15. However, an additional increased in dependence from 16 led to a decrease in proportion of respondents adopting microdosing from 76.5% to 50.0%, a drop difference of over 20% (Table 10a) The reason for the decrease as gathered during focus group discussion is the cost of fertilizer as people with high dependants are not able to afford a large quantity of fertilizer. However, relating to seed priming, where no cost is involved and not much work load, inconsistent, yet convincing movements were observed. About 50.0% of household heads with 16 and more dependants responded to adopting seed priming as compared to 43.8% for those with 1to5 dependants and 33.3% for those 6 to 10 dependants respectively (Table 10b)

Table 10b: Effects of households' characteristics on adoption of technologies status, survey 2011

Household Characteristics	Technologies adopted								
	Organic manure			Zai			Seed priming		
	Count	Percent	N	Count	Perecent	N	Count	Perecent	N
Gender:									
Male	21	25.0	84	17	20.2	84	42	50.0	84
Female	2	5.6	36	5	13.9	36	19	52.8	36
Level of Education:									
Primary school	3	15.0	20	3	15.0	20	12	60.0	20
Coran studies	2	25.0	8	3	37.5	8	4	50.0	8
Alphabets	7	46.7	15	7	46.7	15	10	66.7	15
No education	10	13.2	76	9	11.8	76	35	46.1	76
Marital Status:									
Married	23	19.5	118	22	18.6	118	60	50.8	118
Widow	0	0	2	0	0	2	1	50.0	2
Dependants:									
1-5 dependants	16	80.0	48	15	75.0	48	21	43.8	48
6-10dependants	2	10.0	15	4	20.0	15	5	33.3	15
11-15dependant	1	5.0	17	0	0	17	8	47.1	17
16-20dependant	1	5.0	4	1	5.0	4	2	50.0	4
Land size									
Small	5	21.7	69	6	8.7	69	44	63.8	69
Medium	10	43.5	37	10	27.0	37	12	32.4	37
Large	8	34.8	14	7	50.0	14	5	35.7	14

On land size and adoption, the impression is that proportion of household heads adopting a technology decreases with the amount of land available to the household. A similar trend of decrease in technology adopted and land size was observed for both microdosing and seed priming. For instance, about 72.5 % of households with small land size (1-10 hectares) were using some form of fertilizer microdosing as compared to 57.1% of those with large land size (20 and above hectares) using some form of microdosing. This trend is similar in the case of seed priming in which 63.8% of farmers with small land size adopted seed priming while just about 35.7% of those with large land size (20 hecatares) and above adopted some form of seed priming. A common explanation was that those with a large amount of land that cannot afford to use crop improving technology mainly fertilizer microdosing can cultivate a large portion of land in order to obtain the same output as those applying the technology on a small portion of land.

4.2.4 Assessing the relationship between gender and fertilizer microdosing adoption

As shown in Table 11, the gender breakdown of this sample is 120. Out of the 120 household heads, 84 are males and 36 are females. The first cell shows that 29.8 % of all males are non microdosing users. While the remaining 70.2% are using some form of fertilizer microdosing.

Table 11: Cross tabulation of fertilizer microdosing adoption by Gender, survey 2011 in Segou, Mopti and Koulikoro region of Mali (N=120)

			Sex		Total
			Male	Female	
Microdose	No	Count	25	14	39
		Expected Count	27,3	11,7	39,0
		% within Sex	29,8%	38,9%	32,5%
	Yes	Count	59	22	81
		Expected Count	56,7	24,3	81,0
		% within Sex	70,2%	61,1%	67,5%
Total		Count	84	36	120
		Expected Count	84,0	36,0	120,0
		% within Sex	100,0%	100,0%	100,0%

In relation to females, 38.9% declared themselves to be non fertilizer microdosing users while 61.1% claim to be fertilizer microdosing users. Based on this 120 samples surveyed, there is an association between gender and microdosing adoption as the percentage differs across males and females.

To estimate that the differences between males and females observed are the result of a real association between gender and microdosing in the population as a whole, a chi square test is used to test the following hypothesis:

Ho: There is no difference between adoptions of microdosing based on gender

H1: There is a difference between adoptions of microdosing based on gender

Using chi square formula:
(O-E)2/E

Where O is the observed frequencies and E is the expected frequencies (Table 11) We can see from the inferential statistics (table 12) that the chi square result of 0.957 has a significance level of 0.328. This could be read as p> 0.05 with 95% confidence interval. Since the P-value is greater than 0.05, we retain the null hypothesis and conclude that there is no significant differences between males and females adoption of microdosing technology based on gender. The outcome of the chi-square implies that

Table 12: The Chi-Square output for gender and adoption of microdosing

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	,957[a]	1	,328

$X^2(1)=.957$, $P>.05$ (keep the null hypothesis)

If in a population of all households, half uses microdosing and half does not, and if we randomly select 84 males and 36 females households heads, the probability of getting 59 males to say yes I use fertilizer microdosing and 25 males to say No I don't, and 22 females to say yes we do and 14 to say no, we don't due to chance is 0.328 which is about 32.8%. This is by far higher than our alpha level of 5%. Therefore, we keep the null hypothesis and argue that gender and microdosing adoption are independent; any observed differences has occurred by chance.

4.2.5 Assessing the relationship between gender and seed priming adoption

Table 13: Gender and Seed Priming adoption in Segou, Mopti and Koulikoro, survey 2011

			Sex		Total
			Male	Female	
Seed Priming	No	Count	42	17	59
		Expected Count	41,3	17,7	59,0
		% within Sex	50,0%	47,2%	49,2%
	Yes	Count	42	19	61
		Expected Count	42,7	18,3	61,0
		% within Sex	50,0%	52,8%	50,8%
Total		Count	84	36	120
		Expected Count	84,0	36,0	120,0

Table 13: Gender and Seed Priming adoption in Segou, Mopti and Koulikoro, survey 2011

			Sex		Total
			Male	Female	
Seed Priming	No	Count	42	17	59
		Expected Count	41,3	17,7	59,0
		% within Sex	50,0%	47,2%	49,2%
	Yes	Count	42	19	61
		Expected Count	42,7	18,3	61,0
		% within Sex	50,0%	52,8%	50,8%
Total		Count	84	36	120
		Expected Count	84,0	36,0	120,0
		% within Sex	100,0%	100,0%	100,0%

As shown in Table13, the gender breakdown of this sample is 120. Out of the 120 household heads, 84 are males and 36 are females. The first cell shows that 50.0% of all males are non seed priming users. The second cell reviews that 50.0% of all males, declared themselves to be seed priming users. In relation to females, 47,2% declared themselves to be non seed priming users while 52.8% claim to be seed priming users. Based on this 120 samples surveyed, there is a difference between gender and seed priming adoption as the percentages differs across males and females.

To estimate that the differences between males and females observed are the result of a real association between gender and seed priming adoption in the population as a whole, a chi square test is used to test the following hypothesis:

Ho: There is no difference between seed priming adoption based on gender

H1: There is a difference between seed priming adoption based on gender

Using chi square formula:

(O-E)2/E

Where O is the observed frequencies and E is the expected frequencies (Table13). We can see from the inferential statistics (table14) that the chi square result of 0.078 has a significance level of 0.780. This could be read as $p>0.05$ with 95% confidence interval.

Since the P-value is greater than 0.05, we retain the null hypothesis and conclude that there is no difference between seed priming adoption based on gender. The outcome implies that

Table 14: Chi-Square output showing the chi square value, the degree of freedom and the asymp. Sig

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	,078[a]	1	,780

$X^2(1)=.078$, $P>.05$ (keep the null hypothesis)

if in a population of all households, half uses seed priming and half does not, and if we randomly select 84 males and 36 females households heads, the probability of getting 50.0% males to say yes I use seed priming and 50.0% males to say No I don't, and 52.8% females to say yes we do and 47.2% to say no, we don't due to chance is 0.780 which is about 78%. This is by far higher than our alpha level of 5%. Therefore, we keep the null hypothesis and argue that gender and seed priming usage are independent; any observed association has occurred by chance. We can conclude from the chi square result that although the percentages are different, they occurred due to chance, and there is no significant difference between males and females adopting seed priming.

4.2.6 Factors influencing the adoption of fertilizer microdosing

In this section, adoption (quantity of fertilizer use) is used as dependent variable and households characteristics including prices of input (fertilizer), distance to input and other variables in table 15 as independent variables to see if the relationship is statistically significant. We assume that households characteristics such as sex, age, number of dependants (Number of children), and prices and distance to fertilizer has a significant effects on the type quantity of fertilizer used by households.

Table 15: Descriptions of variables used in the regression and expected effects (signs)

Variables	Description	Expected effects (sign)
Dependent variable:		
Adoption(Y)	Quantity of fertilizer use	
Independent Variables:		
Sex (X1)	(dummy) Sex of household heads	+
Age (X2)	Household heads age (years)	+/-
Number of dependants(X3)	Other people households heads cater for	+/-
Fertilizer sources (Km) (X4)	Distance to fertilizer source (km)	-
Number of children(X5)	Number of children within a household	+/-
Land Size (X6)	Amount of land available to household	+/-
Prix of fertilizer (X7)	Prices of fertilizer in FCFA	-

Table 16: Simple linear regression analysis of factors influencing adoption of microdosing technology with dependent variable being quantity of fertilizer used

Independent Variables	Unstandardized Coefficients	Standardized Coefficient				
	B	**std. Error**	**Beta**	**Rsquare**	**t**	**Sig**
Sex(X1)	3,111	20,38	-,014	,000	-,153	,879
Age(X2)	-,901	1,05	-,079	,006	-856	,393
Dependants(X3)	1,924	,751	,229	,053	2,560	,012*
Distance to fertilizer(X4)	-3,12	,280	-,716	,513	-11,15	,000*
Number of kids (X5)	5.956	2.96	,160	,078	1.787	,076
Land size (X6)	-,2,57	,943	-,244	,059	-2,73	,007*
Price of fertilizer(X7)	-,016	,006	-,243	,059	-2,77	,007*

Dependent Variable: Quantity of fertilizer use

A simple linear regression was carried out (see table 16 above) using each of the households' characteristics to find the influence on quantity of fertilizer use (adoption). Results from table 16 indicate that other dependants, distance to fertilizer, land size and prices of fertilizer were all significant with adoption. However, in the multiple regression, number of other dependants was the only significantly variable with adoption (quantity of fertilizer use).

Distance to fertilizer, land size and price of fertilizer were significantly negatively related with quantity of fertilizer use (adoption) in the simple regression (Table 16). This could be interpreted that a long distance to fertilizer is most likely to discourage a farmer from using fertilizer . Distance is likely to affect a price of fertilizer. The increase in fertilizer prices may affect poor households' ability to purchase fertilizer for a large hectare of land. This implies that distance may confound with prices and land size; an explanation for a 51% coefficient of determination as compared to 5% in the case of land size and prices of fertilizer (table 16).

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Sex, age and number of children were not significant with quantity of fertilizer use (table 16) implying that they are other variables predict adoption better than these variables (Table 16). The size of the sample may be a factor that has induce the non significance particularly number of children and fertilizer. Probably, number of children could have been significant if we had a large sample size.

To better explain the influence of all the variables on adoption, we regressed all the household characteristics variable used in the simple regression (table 16) with quantity of fertilizer use (adoption) in a multiple regression (Table 17). From the multiple regression equation, quantity of fertilizer use (adoption) was set as dependent variable(Y) and household characteristics mainly price of fertilizer(X1), fertilizer sources (km)(X2), sex(X3), age(X4), number of children(X5), other dependants(X6) and surface area(X7) were introduced as the independent variables (See table 17).

$$Y = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \beta 5X5 + \beta 6X6 + \beta 7X7$$

Quantity of fertilizer use (Y) = 236,921 - 0.001*price of fertilizer (FCFA) - 3,255*fertilizer source (km) - 11,270*sex - 0.522*age + 4,031*number of children +0.393*other dependants + 0.891*surface area.

Table 17: Multiple linear regression analysis for factors that influence adoption of fertilizer microdosing with dependent variable being quantity of fertilizer use

Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	236,921	80,195		2,954	,004
Price of fertilizer (FCFA)(X1)	-,001	,005	-,011	-,158	,874
Fertilizer Source(Km)(X2)	-3,255	,342	-,747	-9,511	,000*
Sex(X3)	-11,270	16,637	-,051	-,677	,500
Age(X4)	-,522	,801	-,046	-,652	,516
Number ofChildren(X5)	4,031	2,451	,122	1,645	,103
Dependants(X6)	,393	,578	,047	,679	,498
Surface Area(X7)	,891	,898	,084	,992	,323

R^2 = 0.53 and Significant at P<0.05, P<0.01 and P< 0.001 respectively. Recorded P Value = 0.000

The simple regression output (table 16) indicates that price of fertilizer, sources of fertilizer, sex, age number of children, other dependants and surface area were positively and significantly related with overall quantity of fertilizer use (adoption). However, when household characteristic variables were used in combination with each other in the multiple regression, only fertilizer sources (km) or distance to fertilizer was significantly related with quantity of fertilizer use (adoption). Variables such as other dependants, land size and prices of fertilizer that were significant in the simple regression became insignificant when used in combination with the other variables.

4.2.7 Comparing the degree of adoption and non adoption of microdosing with seed priming technologies

The SPSS output review that adoption of microdosing and seed priming technologies differs across region (Figure 11). Out of the 120 sampled households, about 77,5% (figure 11) of them adopted fertilizer microdosing while just about 22,5% did not adopt any form of microdosing. In the case of seed priming, about 60% of all households head surveyed responded that they have adopted while the remaining 40% did not (figure 10).

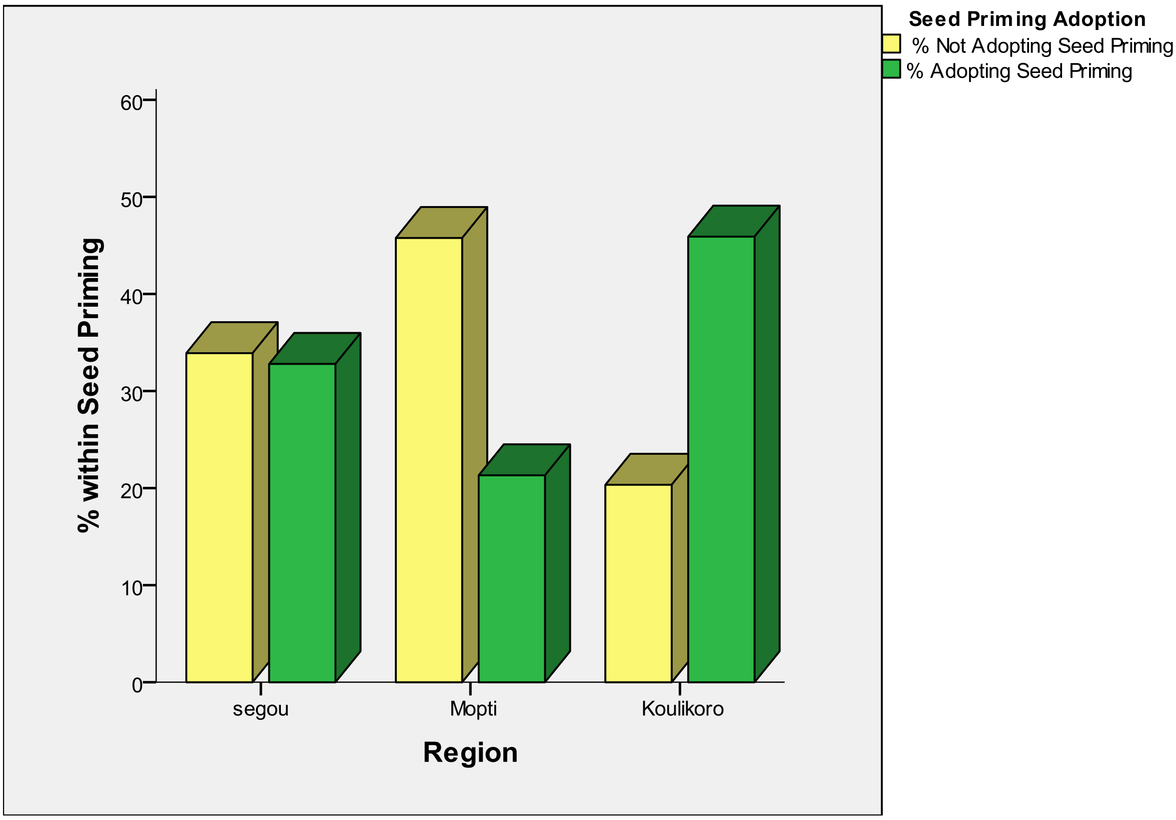


Figure 10: Comparing percentage of seed priming adoption rate across region, survey 2011

The highest degree of adoption of fertilizer microdosing technology was recorded in Segou region where about 70% of all farmers surveyed responded positive to the use of microdosing while Koulikoro recorded the lowest as compared to Segou and Mopti with just about 50% of the households heads responding positively to the use of microdosing. The variation in adoption of microdosing may be attributed to factors such as gender, the work attached to the technology, and access to input. In the focus group discussion, it emerged that women were unwilling to adopt microdosing as it requires lots of efforts to put 0.3gram of fertilizer at the base of each plant.

"I know microdosing could help me increase productivity but I do not have the patience. I am not able to put fertilizer at the base of all my crops, its impossible"Hawa Coulibaly a 45 year old woman from Falani Coungo said while laughing

Not only in Koulikoro region women confirmed workload attached to microdosing as a reason for non-adoption but also in Segou and Mopti. Proximity and the cost of fertilizer also reduce the degree of adoption of microdosing. From focus group discussion, it emerged that that though a majority of farmers in Segou, specifically in Nabaso and Nsirimanso could afford to buy fertilizer, distance from fertilizer source to site was a problem. On the other hand, the market for fertilizer is well developed in Koulikoro, yet most farmers could not afford large quantities unless taking on credit from the farmers union.

"Access to fertilizer is not a problem, money is the problem. If I have money, I could purchase fertilizer from our village boutique, the traders around or I could even buy from Dialakoroba market" Mamdou Keita, a 51 year old farmer from Nienguen Coula said in a focus group discussion

In addition to cost and access, the risk of losing seeds due to lack of rain also affects the degree of microdosing adoption, specifically, ratio 1:1. For instance, in Niengue Coula, a farmer confirmed that he loss all his crops in the previous cultivation period by mixing seed with fertilizer at a ratio of 1:1. The rain did not fall hence all seed were destroyed. A similar incident was reported in Ntogosso in the Mopti region where farmers are still skeptical about the use of microdosing particularly ratio 1:1 on a large scale.

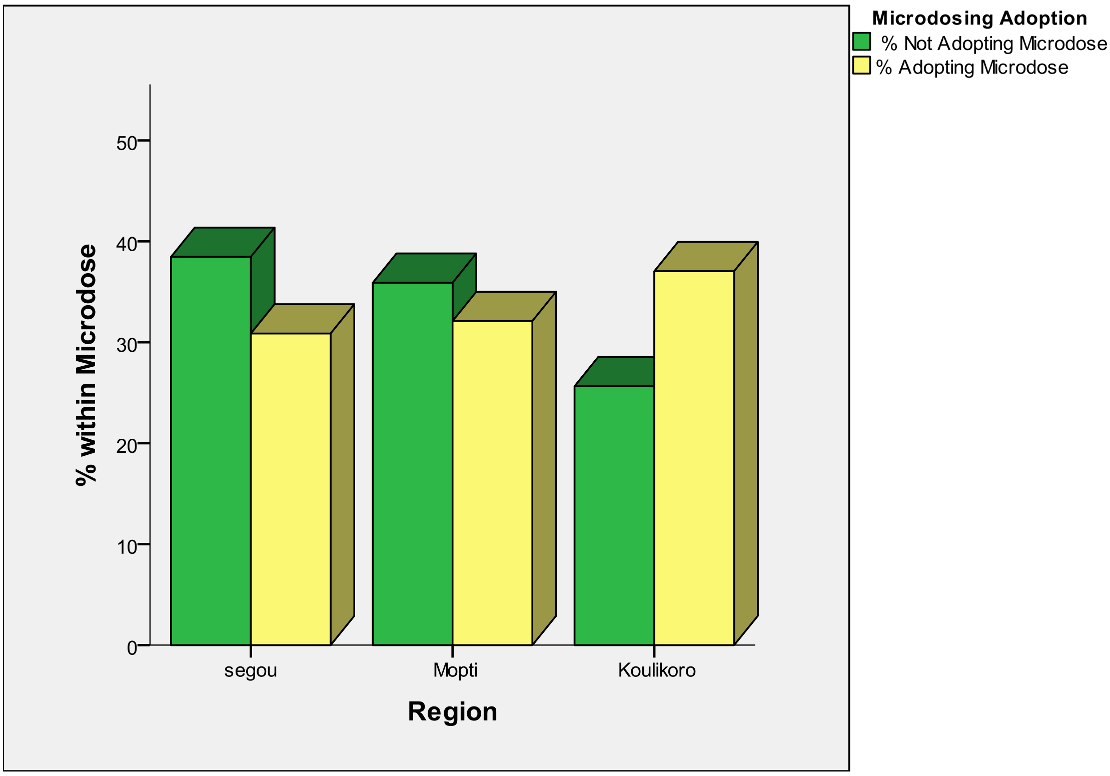


Figure 11: Comparing percentage of adoption of fertilizer microdosing across regions, **survey 2011**

Seed priming on the other hand that requires less work and cost effective is well adopt among women particularly, Koulikoro region where there is a high level of poverty. From figure10, about 60% of all farmers from Koulikoro adopted seed priming as compared to 40% in Segou and 30% in Mopti respectively. The reason for adopting seed priming differs across region. In the focus group, it emerged that, in Segou and Mopti where rainfall is erratic and relatively low, farmers adopt seed priming as they are sure that all their seeds will germinate at the same time. While in Koulikoro, where there is relatively good amount of rainfall, seed priming is adopted as crop increasing technology. However, loosing seed after soaking and not planting all of it the same day was a common reason giving for non adoption of seed priming across all regions during focus group discussions.

4.2.8 Comparing average land size available to households with the amount of land used per technology per region

To determine the degree of adoption of the Ecofarm crop technologies, the average land size available to households is compared to the size use for the technologies of seed priming and fertilizer microdosing. The result shows a huge variation in land size available to households, yet a close relationship between the average land size use for both seed priming and microdosing. On the average, 18.0 hectares of land is available to each household in Segou as compared to 4.9 hectares for each household in Koulikoro. While each households in Mopti, on the other hand, owned an average of about 11.8 hectares (See table 18).

Table 18: Comparing average land size own per household with average land size used for microdosing, and seed priming in the study regions, survey, 2011

Region	**Average total land size(hectare)**	**Average landsize(hectare) microdosing**	**Average land(hectare) Seed priming**
Segou	18.0	1.1	1.2
Mopti	11.8	4.8	4.7
Koulikoro	4.9	2.2	2.8

The impression is that though Segou recorded the highest average land size of about 18.0 hectares, just about 1.1 hectares and 1.2 hectres on the average are used for microdosing and seed priming respectively. On the other hand, an average of about 2.2 and 2.8 hectares of land respectively are used for fertilizer microdosing and seed priming technologies out of an average of 4.9 hectares per households in Koulikoro (table 18).

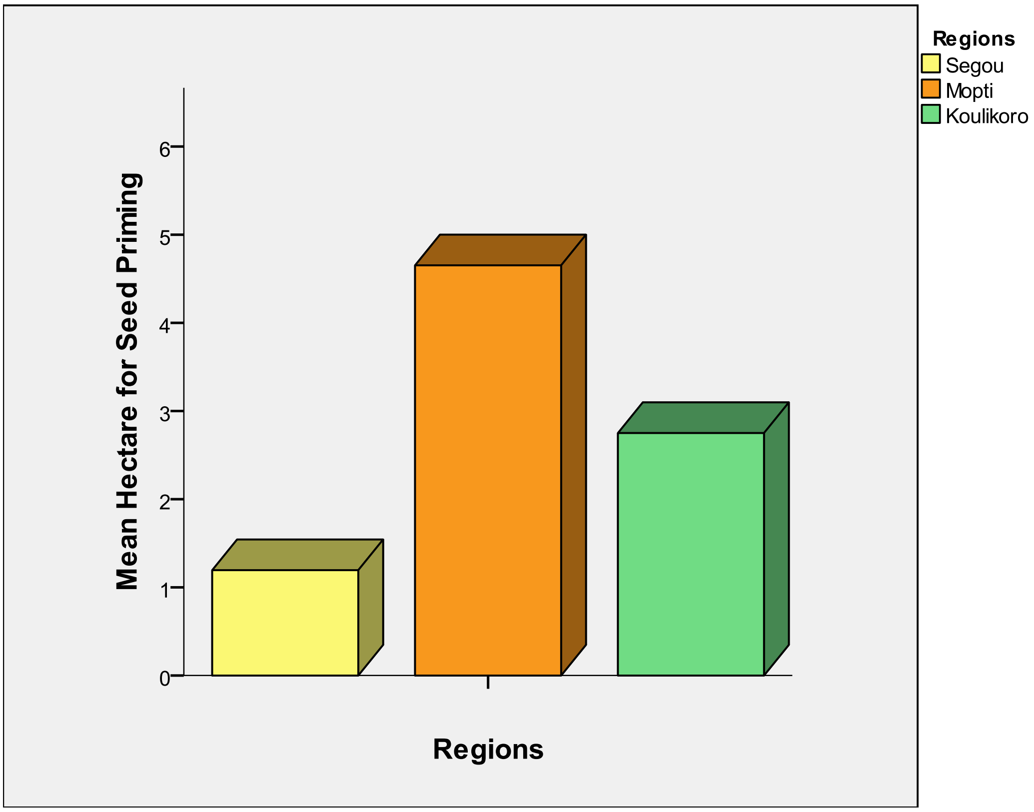


Figure 12: Average hectare of land used for seed priming per farmer in Segou, Mopti and Koulikoro

Of an average of 11.8 hectares available to each household in Mopti, about 4.8 hectares is used for microdosing technologies while 4.7 is used for seed priming (see table 18). These figures is in line with the responses received during the focus group discussion where respondents in Segou said that they used just about 1 hectare of land for the technologies while those who adopted the technologies in Mopti and Koulikoro said they use almost all their land for the technologies.

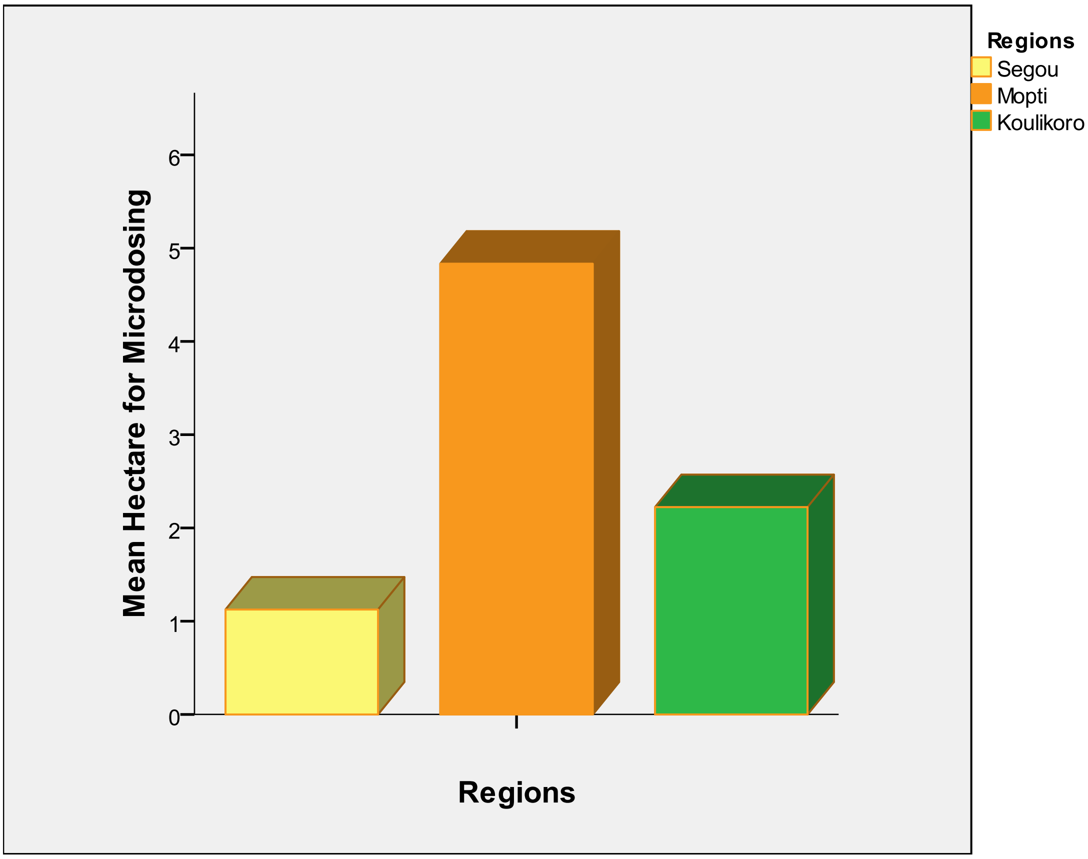


Figure 13: Average hectare of land used for seed priming per a farmer in Segou, Mopti and Koulikoro

However, it is wealth mentioning that although land size available to households' surveyed in Segou is generally high, some extreme case may have influenced the figures as the minimum and maximum land size ranges between 1 and 45. The highest land sizes in Segou region was recorded in the villages of Nabaso and Nsirimanso while sizes in N'togosso were generally low particularly among women. The highest land size recorded in in Koulikoro is 13 hectares in the village of Falani Coungo as compared to 25 hectares size in Mopti recorded in the villages of Koumudu and Sogora. On the average, men owned more land in the entire ecofarm region than women. While most men owned an average of about 10 hectares of land, each women owned just about 2 hectares in all the three regions surveyed.

4.2.9 The influence of distance on fertilizer prices

From (table 19), it can be seen that distance has an effect on fertilizer. The average distance to fertilizer among the three regions is 26.9 kilometers and the average price is 15,000FCFA. While distance increases to 53,3kilometers, fertilizer prices also increases to 16,138FCFA in Segou (table 19). As distance decrease to 22 kilometers in Mopti, the price of fertilizer also decreases to 14,638 FCFA.

Table 19: Comparing average distance to fertilizer influence on average fertilizer prices, survey in Segou, Mopti and Koulikoro 2011

Region	Prices of fertilicer(FCFA)	Distance to fertilizer market (Km)
Segou	16.137,50	53.25
Mopti	14.637,50	22.40
Koulikoro	14.200,00	4.9
Total	14.991,67	26.85

A further decrease in distance from 22.4 kilometers in Mopti as compared to 4.9 kilometers in Koulikoro induces a decrease in fertilizer prices from 14638FCFA to 14200FCFA. However, the differences in prices cannot explain the degree of adoption of microdosing (figure 11 and table 19) as though the price of fertilizer is high in Segou and Mopti; farmers there still adopt more of microdosing than in Koulikoro in terms of numbers not land size. Other factors may be influencing the adoption of fertilizer microdosing. The distance effect on fertilizer prices is further analyzed using a simple linear regression model below.

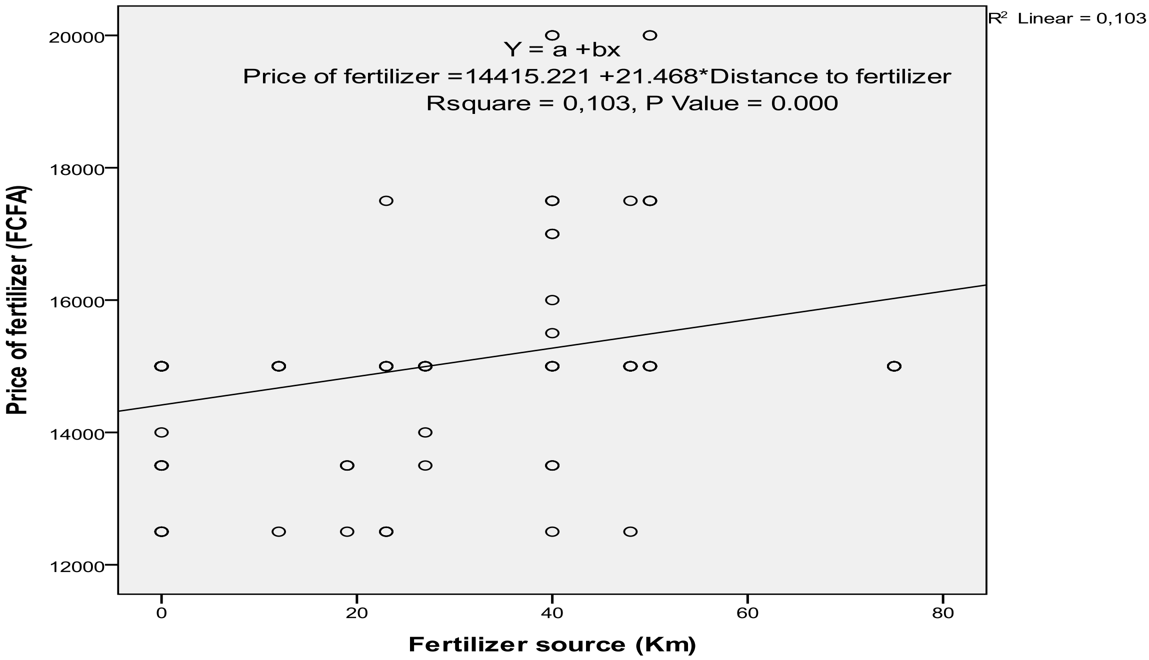


Figure 14: A linear regression showing the distance to fertilizer effects on the amount of fertilizer use

From figure 14, the regression line shows a positive relationship between price of fertilizer and sources of fertilizer. The impression is that as distance increase the price of fertilizer is expected to increase. However, the correlation value indicates that the relationship is not very strong because it is close to 0. From the regression, one unit change in distance will increase price by 21.5 fcfa all things being equal. Our P-value of 0.000 shows a significant relationship between prices of fertilizer and fertilizer source. The coefficient of determination, which explains the variability in price from the fertilizer sources (km), is 10%. This implies that only 10% of changes in price is explain or affected by distance to fertilizer. The confidence interval for fertilizer sources ranges from 9.9kms to 33.0kms. At 95% confidence interval the lower and the upper boundaries are 9.9 and 33.0 respectively. As this does not include 0, it confirms that there is a significant difference between prices and distance. It also implies that there is less than 5% chance that our outcome is due to error.

4.2.10 Influence of distance to fertilizer on the quantity of fertilizer use

Table 20: Average distance effects on quantity of fertilizer use per region, survey 2011

Region	Fertilizer Sources (Km)	Quantity of fertilizer used/kg
Segou	53, 25	73, 17
Mopti	22, 40	139, 62
Koulikoro	4, 90	209, 00
Total	26, 85	140.60

There regression line shows a downward sloping (See figure 15). This implies that as distance increase the quantity of fertilizer drops indicating an inverse relationship. The R-value of 0.7 shows a strong correlation between quantity of fertilizer used and distance. From the regression, one unit change in distance will decrease quantity of fertilizer used by 3.1 kg. Our P-value of 0.000 shows a significant relationship between quantity of fertilizer use and distance.

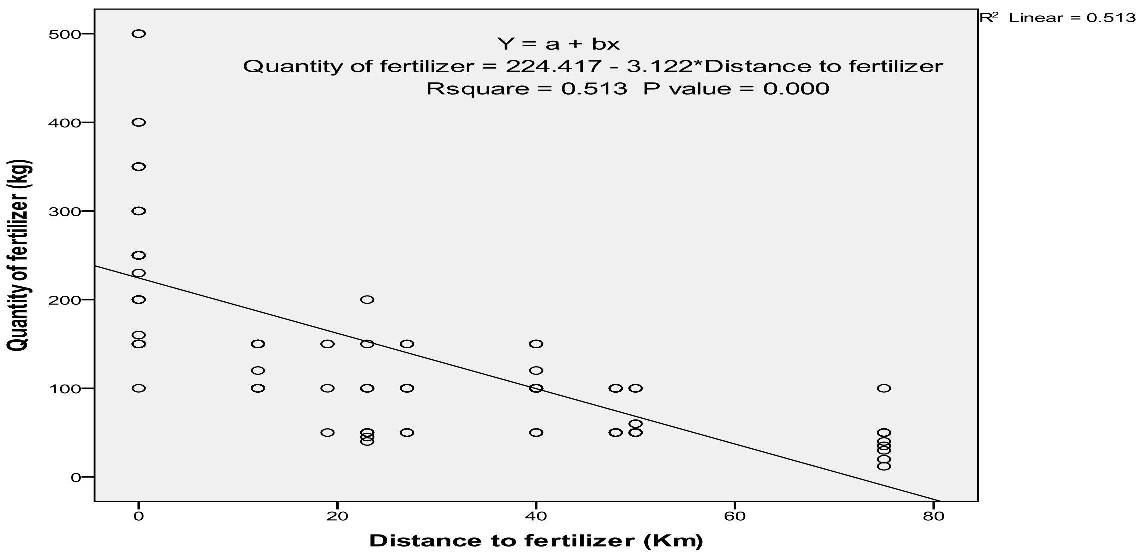


Fig 15: A linear regression showing distance effects on quantity of fertilizer used

The coefficient of determination, which explains the variability in quantity of fertilizer use to distance, is 51%. This is a very high explanatory power of distance on the amount of fertilizer use. This implies that about 51% of changes in quantity of fertilizer is explain or affected by distance to fertilizer. At 95% confidence interval the lower and the upper boundaries are -3.7 and -2.6 respectively. As this does not include 0, it confirms that there is a significant relation between amount of fertilizer us and distance. It also implies that there is only 5% chance that our outcome is due to error.

4.2.11 The influence of land size own on quantity of fertilizer use

The Linear regression indicates that those with large land size tend to use less quantity of fertilizer (Fig:) This implies that the quantity of fertilizer decreases as the size of land own increases. Regression analysis indicates that the quantity of fertilizer (kg) a farmer use is a linear function (among other things) the size of land (hectares) own by that farmer. The p-value of 0.007 shows that significant relation exists between land size own and quantity of fertilizer use.

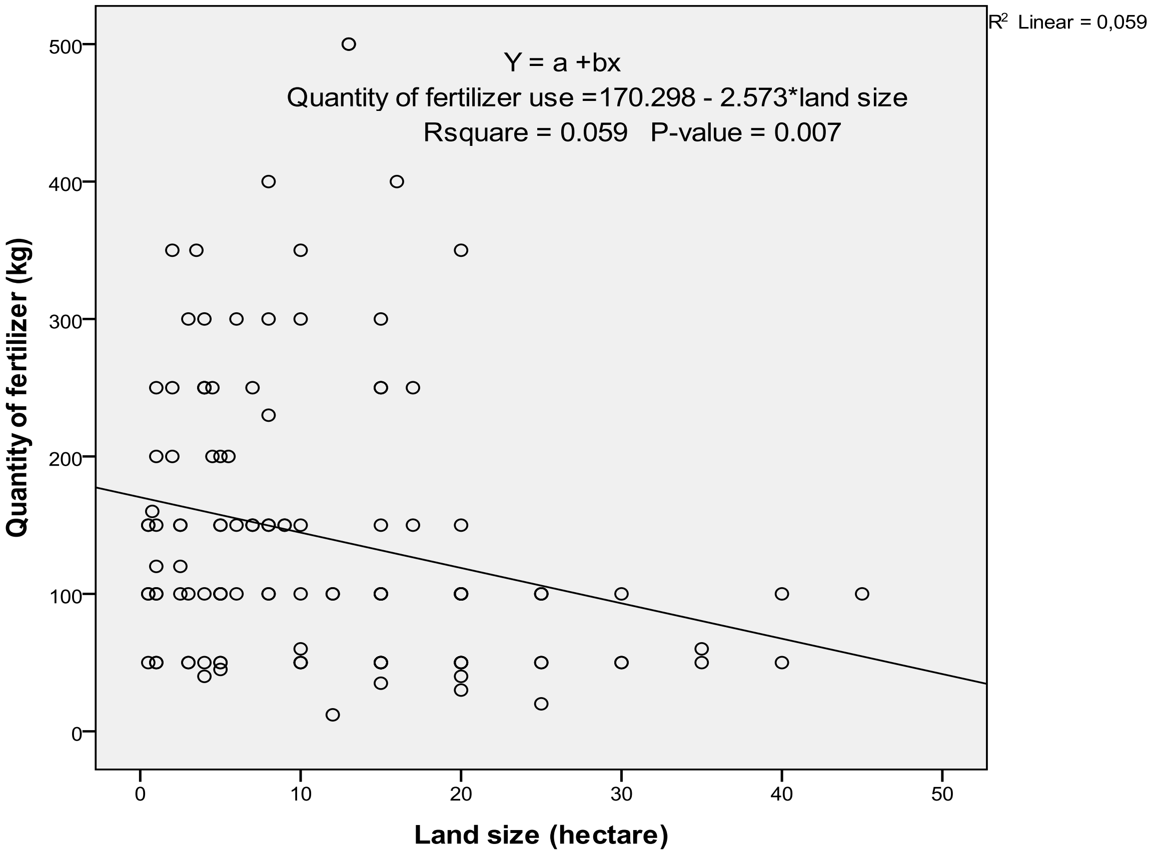


Figure16: The relationship between land size own and the quantity of fertilizer use.

However, given that the coefficient of determination (Rsquare); the one which explains the variability in quantity of fertilizer use to land size own is just 5.9%. We assume that the relation is weak though significant. As the graph indicates, many outliers fall far from the regression line which affects the outcome. Besides, other factors may influence the quantity of fertilizer use in addition to land size own.

Land size own, one indicator of wealth is a variable that overlap with number of children and other dependants as farmers with a large number of children and other dependants may be poor and cannot afford a large quantity of fertilizer. As we saw in the linear regression above, number of children and other dependent explains the variability in quantity of fertilizer use almost at the same percentage as land size own.

4.3 Assess the reason for adoption of the Ecofarm technologies

The objective of this section of the thesis is to assess the reasons for adoption of the Ecofarm technologies. The section seeks to investigate factors that motivate adoption. It goes further to investigate farmers' reasons for adopting more of some technologies than others. A greater part of it will also indicate the reasons for non adoption of technologies.

4.3.1Factors motivating adoption of crop improving technologies

Yield increase: Of the total 120 household heads surveyed, 81.7% mentioned yield increase as the main reason for adoption of fertilizer microdosing (table 21). In the focus group, it emerged that before the adoption of microdosing technologies a majority of households could not produce enough to feed themselves and their families. Though a large amount of land was use for cultivation, the yield effect was low.

Table 21: Percentages and frequencies of response on the reasons for adoption of microdosing

Reason using Microdosing		Frequency	Percent
Yield Increased	No	22	18,3
	Yes	98	81,7
	Total	120	100,0

*"I used to cultivate a large size of land, yet I could not feed my family for the whole year. Sometimes I use to credit from my neighbors and people use to laugh at me. But thanks to Allah, since I benefitted from microdosing project, me and my entire households are self sufficient"*Issa Gindo, a 39 year old farmer man from Parou-Bandiagara said in an looking emotional voice

From Traore et al. (2010), the application of 0.3gram of fertilizer could double millet and sorghum yield. This increase was confirmed by the average yield effects gathered on the field (see table 22).On the average, millet productivity has increased from 240kg per hectare without fertilizer application to 855kg per hectare with fertilizer application in Segou.

Table 22: Comparing average yield effects per kg of sorghum, millet, Niebe and groundnut before and after adoption of microdosing by region

Region	Crop yield/kg/hectare before adoption				Crop yield/kg/hectare after adoption			
	Millet	Sorghum	Niebe	groundnut	Millet	Sorghum	Niebe	groundnut
Segou	240	260	115	100	855	805	460	600
Mopti	125	155	0	80	500	430	0	255
Koulikoro	70	200	30	120	930	275	125	545

In Mopti, farmers recorded millet increase from 125kg per hectare without fertilizer microdosing to about 500kg per hectare using microdosing. Koulikoro recorded a highest increase in millet of about 70kg per hectare without fertilizer application to 930kg per hectare with fertilizer application. Sorghum also increased from 260kg per hectare to 805kg per hectare in Segou. While, the average sorghum per hectare increased from 155kg to 430kg in Mopti (See table 22). In Koulikoro, an increase from 70kg to 275kg was observed for sorhum. Groundnut output was best in Segou than all the other regions. The yield increase of Groundnut was from 100kg to 600kg in Segou as compared to 80kg to 255kg in Mopti. However, Koulikoro recorded a better output of about 545kg after adopting microdosing than those in Mopti. The increase in crop yield may be attributed to changes that farmers have made on the technologies. From focus group discussion, farmers in Falani Coungo mentioned that not only do they put fertilizer of the size of coca cola bottle top at the pocket of each crop 15 to 20 days after cultivation but also they spread some of the fertilizer on the field. These practices indicate a double use of fertilizer that may increase productivity than the method recommended at the initial stage of the technology. Besides, changes in the amount of rainfall and improvement in soil quality over the years due to manure and fertilizer application may have induced the current increases in productivity.

4.3.2 Farmers expectations for priming and microdosing output giving that all conditions are perfect

Given that all conditions are in place; constant rainfall and access to fertilizer, farmers in Segou expect productivity of millet and sorghum to reach an average of about 1.2 tons per hectare using seed priming alone. This yield is expected to increase to about 1.9 tons per hectare using fertilizer microdosing alone and 2.7 tons per hectare when combine microdosing with seed priming. Those in Mopti expect seed priming, microdosing and combination of the latter two technologies to increase productivity to about 0.7, 1.7 and 2.4 respectively. While those in Koulikoro expect to reach productivity level using seed priming, microdosing and combination of both to increase productivity to 0.8, 2.5 and 4.2 respectively (See table 23).

Table 23: Comparing average yield effects of millet and sorghum per ton per hectare using only seed priming, microdosing, and priming and microdosing based on farmers expectation, survey (2011) (N=120)

Region	Yield/ton/hectare for millet and sorghum		
	Priming alone	Microdosing alone	Priming and Microdosing
Segou	1.2	1.9	2.7
Mopti	0.7	1.7	2.4
Koulikoro	0.8	2.5	4.2

The variation in regional expectation of productivity level is highly influence by factors such as rainfall and quality of soil. In Segou and Koulikoro where rainfall is relatively good, farmers expect higher productivity than those in Mopti. My observation on the field is that farmers in Segou and Koulikoro have access to better agricultural land as compared to their counterparts in Mopti (See table 18).

4.3.4 Scaling up of the Ecofarm technologies into neighboring villages

The total scaling up of the Ecofarm technologies from the response from the 12 villages surveyed is about 51 (table 21). The number of scaled up villages in from the list of villages mentioned by farmers is 38, the highest of all scaled ups. While in Segou and Koulikoro, the total scaling up recorded was about 13.7% and 11.8% respectively (see table). Among the list of scaled up villages mentioned in Segou includes; Adamabougou, Papala, kleke and Nokore. In Mopti, some of the viallages mentioned includes: Dogobala, Eguela, Monogondo, Tjara, Nomono, Djalo, Gani just to mention a few. While in Koulikoro, Farmers mentioned Moulebougou, Katebougou, Koule, Moulobala and Sosoukoro as some of the scaled up villages.

The huge variation in scaling up between Mopti and the two other regions is influence by recent development in input (fertilizer) sources, accessibility to neighboring villages, the women unions that aid in spreading information and previous socio-economic conditions of the regions prior to the Ecofarm.

Table 24: Comparing farmers response to scaling up of technologies in Segou, Mopti and Koulikoro regions, survey 2011

Region			Scale up	
			No new village mentioned	New village mentioned
	segou	Number of villages	33	7
		% within Scale up	47,8%	13,7%
		% of Total	27,5%	5,8%
	Mopti	Number of villages	2	38
		% within Scale up	2,9%	74,5%
		% of Total	1,7%	31,7%
	Koulikoro	Number of villages	34	6
		% within Scale up	49,3%	11,8%
		% of Total	28,3%	5,0%
Total		Number of villages	69	51
		% within Scale up	100,0%	100,0%
		% of Total	57,5%	42,5%

In addition, field observation reviews that most of the scaled up villages in Mopti falls near the big towns of Bandiagara and Bankass. In these towns, farmers can easily access several permanent fertilizer selling outlets. In addition, there are several merchandised that travel and sell fertilizer to farmer on their farms. However, this practice is also common in Mopti in Segou and Koulikoro as well. The government fertilizer subsidy has also plays a role. Before the cultivation period, farmers can go to the local agricultural center and collect a fertilizer subsidy form (appendix 2.). With the form, farmers can benefit from a subsidy of 2500fcfa per sack (50kg) of fertilizer.

The socio-economic condition of the households in the three regions also determines the huge variations in scaling up. Kone Kalilou, NGO Yagtu field coordinator review that most of the farmers in Mopti are extremely poor and before the introduction of the technologies, they could not even feed themselves.

"It gratifies my heart to see households in Wousare looking healthy and happy. Few years ago before the introduction of the Ecofarm project, families were very poor; the kids were sick and malnourished. When there was no food stock, the young boys and girls were sent to the capital Bamako and the neighboring countries to work and send money home to supplement the family income. But now, I can see that the children are healthy, the women look happy and the young boys and girls are going to school, thanks to the Ecofarm project" Kone Kalilou, NGO Yagtu field coordinator in Bandiagara province-Mopti region said while we ride on his motorbike out of Wousare village

After years of suffering from poverty and food insecurity (See table 25), most of the households in Mopti are content with the positive changes that the Ecofarm project brings to their food security and income levels. Spread of information about the Ecofarm technologies is also a factor that contributes to the huge variations in scaling up of the Ecofarm technologies. Farmers are architect of spreading the Ecofarm into neighboring villages. In this regard, accessibility to neighboring villages is a major concern. In Mopti, there are quiet a good road access to villages as compared to Segou and Koulikoro where the roads are not well developed. Some villages in Segou are located in indescribable places. Not only are there no access but also the villages are quiet far apart from each other. Therefore knowledge about Ecofarm technologies adoption in those remote villages may be difficult to access.

The NGOs follow up is another factor that may have influence the variations in adoption of the Ecofarm technologies. In Segou, AMAPROS field coordinators pulled out shortly after the testing face of the technologies. The farmers were left alone with no technical assistance. Face with lack of knowledge and motivation some of the farmers may have abandoned the technology or use just a little portion of their land to practice the technology. With such an experience, the true impact of the project may be reduced and this may negatively influence the farmers desire to spread the good news. The few remote places such as Nabaso and Nsirimanso where the technologies scaled up happened through relatives living in Ntogosso. While in Koulikoro and Mopti, the NGOs kept close tights with the farmers even after the testing face was over. For instance the field coordinator of Kilabo bought a farm and built a house in the village of Falani Congo. As a result, he made regular visits not only to the later village but also all the villages that participated in the project and beyond checking for progress. Having said that, there is no doubt that NGO participation and follow up is one of the factors that have induce the high scale up in Mopti.

4.4 Assess the impacts of the Ecofarm technologies

This part of the thesis assesses the impact of the Ecofarm technologies on livelihood of farmers in the survey regions. The chapter investigates total productivity before and after adoption of the Ecofarm technologies searching for changes in output. The amount spent purchasing input is investigated. A major aspect of this chapter is dedicated to finding out if productivity increase induces changes in the number of food insecure month and the size of land use for agriculture. The chapter further dips into gross output to find changes in income. Changes in the number of trees covered after adoption of the agro-forestry technologies is also presented.

4.4.1 Changes in month(s) of food insecurity before and after adoption of Ecofarm technologies

Improvement in the month of food insecurity is one of the major factors associated with the adoption of Ecofarm technologies. On the average, households in Segou has experience a decrease in food insecure months from 4.2 to 1.0. In Mopti, food insecure months decreased from 4.2 to 1.1 while Koulikoro experienced a similar trend from 4.1 to 1.3 months (See table 25)

Table 25: Changes in average food insecure months per household before and after adoption of Ecofarm technologies across regions, survey 2011 (N=120)

Region	Average Food insecure months before	Average Food insecure months now
Segou	4,15	1,0
Mopti	4,23	1,1
Koulikoro	4,05	1,8
Total (for 3 regions)	4,14	1,3

The changes in food insecure month are consistent with the adoption of fertilizer microdosing and seed priming (Figure 11) From table 22, we observed that millet yield increase from 240kg to 855kg per hectare in Segou through the use of fertilizer microdosing technologies. While the same technology recorded a yield increase from 125kg to 500kg in Mopti (see table 22). This increase is one of the likely factors influencing months of food insecurity.

Number of food insecure months	Frequency	Percent
0	54	45,0
1	21	17,5
2	1	,8
2	11	9,2
3	2	1,7
3	23	19,2
4	3	2,5
5	2	1,7
6	2	1,7
7	1	,8
Total	120	100,0

Table 26: Frequencies of current food insecure month in Segou, Mopti and Koulikoro (N=120)

From the frequency (table 26), we observed that the food insecure months of a majority of those who adopted the technologies are close to the mean between 0 and 4. However, those who did not adopt the technologies fall far away from the mean with months of food insecurity ranging from 5 to 7. The later data implies that yield increase through adoption of technologies have an influence on the number of food insecure months.

However, other factors may have also influenced the months since just about 1.1 hectare and 1.2 hectare of agricultural land respectively out of an average of 18.0 is used for microdosing and seed priming in Segou. Common sense shows that yield increases by using just 1.0 and 1.2 hectares of land for microdosing and priming cannot convincingly explain the overwhelming drop in the number of food insecure months. Other factors mainly family size, number of dependants, improve soil fertility, rainfall and land size own in addition to Ecofarm may have cause the drop in months of food months in Segou

4.4.2 Comparing gross output of millet and sorghum after adoption of fertilizer microdosing technologies

From the zone of Segou, the analysis of result indicates that gain per hectare using fertilizer microdosing on millet gave a net benefit of 144837 Fcfa per hectare. In

Table 27: Gross output of fertilizer microdosing application on millet survey 2011

Output and cost of Production of millet	**Region**		
	Segou	**Mopti**	**Koulikoro**
Average yield (kg/ha)	855	500	930
Gross benefit (Fcfa/ha)	171.000	100.000	186.000
Cost of fertilizer (Fcfa/ha)	16.137	14.637	14.200
Cost of labour (Fcfa)	10.026	4.000	12.292
Total cost variables (Fcfa)	26163	18637	26492
Net benefit (Fcfa/ha)	**144837**	**81363**	**159508**

In Koulikoro, microdosing of millet gave farmers a net benefit of 159508fcfa per hectare as compared to 1708fcfa using traditional practices (See table 27 and 22). In Segou, microdosing of millet gave a net benefit of 144837fcfa as compared to 37974fcfa using traditional practices. While in Mopti, microdosing of millet gave farmers a net benefit of 81363 fcfa per hectare as compared to 21000fcfa using traditional practices.

Table 28: Gross output of fertilizer microdosing on sorghum productivity per region, survey 2011

Output and cost of Production of sorghum	Region		
	Segou	Mopti	Koulikoro
Average yield (sacks/ha)	805	430	275
Gross benefit (Fcfa/ha)	201.250	107.500	68.750
Cost of fertilizer (Fcfa/ha)	16.137	14.637	14.200
Cost of labour (Fcfa)	10.026	4.000	12.291
Total cost variables (Fcfa)	26163	18637	26492
Net benefit (Fcfa)	**175087**	**88863**	**42259**

With sorghum, farmers who applied microdosing technology recorded an impressive net benefit of about 175087fcfa per hectare in Segou as compared to 54974fcfa using traditional practices. While those in Mopti and Koulikoro recorded a net benefit of 88863fcfa and 42259fcfa per hectare with microdosing technology, respectively as compared to 34750fcfa and 37708fcfa using traditional practices respectively (Table 28 and 22).

4.4.3 Changes in prices of fertilizer after introducing microdosing technologies

From table 29 and regression output above, we saw that changes in prices of fertilizer are highly linked with changes in distance. As distance increases, the prices of fertilizer also increase (table 19.). However, in the focus group discussion, it emerged that introduction of microdosing technologies through the Ecofarm project has contributed immensely to increasing fertilizer outlets In most of the villages, farmers can easily assess fertilizer as close as 0km. However, since sellers have to travel some distance before getting the fertilizer to some villages, there are still distance effect on prices though better prices than before due to several outlets.

Table 29: Changes in prices of fertilizer per region 5 years ago and now, survey 2011

Region		Present prices of fertilizer(FCFA)	Prices of fertilizer 5 years ago (FCFA)
Segou	Mean	16137,50	18475,00
Mopti	Mean	14637,50	16237,50
Koulikoro	Mean	14200,00	17212,50
Total	Mean	14991,67	17308,33

The results of the data show that Segou, a zone with highest distances to fertilizer saw a reduction in prices from 18475fcfa to 16137fcfa. Mopti, with a moderate distance to fertilizer, the average purchasing price of fertilizer has reduced from 16237 fcfa to 14637 fcfa. Koulikoro, with an average of 4kms to fertilizer (table 19.) recorded a reduction in fertilizer from 17212fcfa for the last 5 years to 14200 fcfa during the surveyed period.

4.4. 4 Comparing increase or decrease in land size use after adoption of fertilizer Microdosing

A total of 53.8% of all households mentioned that the size of their land use for agriculture has reduced after adopting fertilizer microdosing technologies. While about 38.7% claim an increase in land size use. The results for analysis indicate that out of the 53.8% people who mentioned reduction in land size, 40.6% were in Segou. While 31.3% and 28.1% were in Mopti and Koulikoro respectively (table 30.)

Table 30: Cross tabulations comparing changes in the size of land size used for agriculture after adoption of fertilizer microdosing per region, survey 2011

			Surface area increased or decreased responses			
			No idea	Surface area reduced	Surface area increased	Total
Region	segou	Count	2	26	12	40
		% within surface area	22,2%	40,6%	26,1%	33,6%
		% of Total	1,7%	21,8%	10,1%	33,6%
	Mopti	Count	2	20	17	39
		% within surface area	22,2%	31,3%	37,0%	32,8%
		% of Total	1,7%	16,8%	14,3%	32,8%
	Koulikoro	Count	5	18	17	40
		% within surface area	55,6%	28,1%	37,0%	33,6%
		% of Total	4,2%	15,1%	14,3%	33,6%
Total		Count	9	64	46	119
		% within surface area	100,0%	100,0%	100,0%	100,0%
		% of Total	7,6%	53,8%	38,7%	100,0%

The point worth mentioning is that the term land size increase and decrease were used inter-changeably. This is because though some of the farmers mentioned that the land size use for farming has increase, it actually meant a purposeful increase of land to gain more productivity but not because the technology requires more space. Base on this explanation, one can say that the technology has reduced land size but farmers increase land size to increase total productivity probably for commercial purposes.

4.4.5 Impact of the Ecofarm agricultural technologies on the number of trees planted on farmers' field and gardens after adoption

The project has motivated planting of trees in all villages. Prior to the Ecofarm, most farmers did not plant trees. However, after the project, a wide range of trees have ben planted in farmers garden and on the fields. On the average, about 109.2 trees have been planted by each farmer. Segou recorded the highest number of trees of about 122, 2 while Koulikoro recorded the lowest number of trees. In between Segou and Koulikoro is Mopti with about 105, 8 trees available to each farmer.

Table 31:Comparing average number of trees available on farmers field during the survey period, 2011

Region	Moringa	Baobab	Ziziphus	Acacia Niolitica	Acacia Tumida	Gliricidia	Average Total Quantity of Tres
Segou	4,33	4,60	,10	71,79	40,60	2,23	122,15
Mopti	10,00	7,48	,20	76,78	7,35	3,10	105,75
Koulikor o	15,48	15,30	,80	59,05	4,80	4,85	99,78
Total	9,93	9,12	,37	69,18	17,58	3,39	109,22

On the average, Segou recorded the highest number of trees. Yet, it has the lowest number of Moringa and Baobab trees, a very important trees with an average of 4,3 and 4.6 as compared to Koulikoro with about 15,5 and 15.3 trees respectively. Though in Koulikoro, more Acacia Niolitica trees are planted with an average of about 59.0 trees, it recorded a very low average number of Acacia Tumida with just 4.8 as compared to an avaearage of 40.6 trees in Segou. Ziziphus Mauritania and Glicicidia are the lowest planted trees in the three regions. Framers in Segou had the lowest average of Gliricidia with just 2.2 trees as compared to 4.9 in Koulikoro. The reason for the lowest number of Ziziphus and Gliricidia as gathered during the focus group is that the trees are attracted to livestock. To maintain a high number of trees, a farmer must build a high fence to avoid ruminants and non ruminants from eating and destroying the trees. The estimated time to make a decent fence is one month or 30 working days.

“My garden was invaded by goats and sheep; they eat all my 120 trees of Gliricidia and 70 trees of Ziziphus. Now I am left with no Babobab tree and just 10 trees of Moringa in my garden. I will plant more trees only if I make a decent fence”

In the village of Nienguen Coula, it was estimated by all the 10 farmers’ surveyed that the cost of making a decent fence is about 100,000fcfa. This cost includes materials cost and the hours spent on making the fence if it had been used on other job. Instead of making fence with expensive woods, farmers adopt the technique of using Acacia Tumida and Acacia Niolitica to make their fence:a reason for high average number of these trees in all regions.

Figure 17: A 40 year old farmer at Nienguen Coula showing Ziziphus Mauritania in his garden, field image, 2011

Figure 18: Acacia Niolitica and Acacia Tumida planted as fence in Sonkoria village, field image 2011

Meanwhile, the problem with using Tumida and Niolitica to make fence is that livestocks are still able to penetrate and eat plants or destroy the fence. However, unlike Gliricidia and Ziziphus, Moringa and Baobab are cultivated in the home garden. Growing in the home garden allows farmers to pay closer attention to the trees and also able to prevent livestocks from invading the garden.

Figure 19: Mohammed Gindo, Koumudu-Bankass and Issah Gindo, Parou-Bandiagara respectively showing Ecofarm trees planted in their home garden

4.4.6 Comparing feeding technologies impact on changes in prices of livestock

The result of the data for analysis (Table 32) shows an overwhelming change in prices of sheep after 6 months of applying fattening technology.

Table 32: Purchasing and selling prices of farm animals in regions

Region	**Average purchasing Price (Fcfa) of sheep**	**Average selling price (Fcfa) after 6 months**
Segou	23.000	55.000
Mopti	23.000	60.000
Koulikoro	23.000	65.000

In Segou, a sheep bought at the price of 23.000fcfa is sold for an average price of 55.000fcfa just after 6 months of applying animal husbandry technology of sheep fattening. These selling prices indicate a gross benefit of about 32.000fcfa in 6 months. In Mopti, a sheep bought at the same price is sold for an average price of 60.000fcfa in 6 month, given the farmers a gross profit of about 37.000fcfa. The result of the output from Koulikoro shows a similar trend with an average selling price of 65.000fcfa, a highest price for a sheep bought at a price of 23.000fcfa (table 32).

4.4.7 Assessing the quantity of milk before and after adoption of animal husbandry technology

The result of analysis (table 33.) shows changes in quantity of milk before and after adoption of animal husbandry technologies. From focus group discussion, farmers in all regions expressed their satisfaction to the use of feeding technologies through the Ecofarm project.

Table 33: Changes in quantity of milk before and after adoption of feeding technology, survey 2011

Region	Average quantity of milk before	Average quantity of milk now
Segou	1 liter	2 liters
Mopti	1 liters	1.9 liters
Koulikoro	1.1 liter	2.3 liters

In Segou, farmers could boast of an increase in average quantity of milk from 1liter to 2 liters. In Mopti, the average quantity of milk increase from 1 liter to 1.9 liters (table 33) . While the highest liters of 2.3 liters of milk was recorded in Koulikoro where farmers previously could collect just 1 liter of milk using the tradition feeding and raising methods.

4.4.8 Assessing the age livestock could be sluttered by using Ecofarm feeding technology as compared to traditional practices

Testimonies review that fattening technology enable livestock to eat less yet gain enormous weight. The well fed cows are able to grow well and as such produce quantity of milk double the ones left on their own. The gaining in weight is a sign of maturity; hence the cows in the Ecofarm projects could be slaughtered earlier than those not applying the Ecofarm technology.

Table 34: Effects of feeding technologies on age (Month) livestock can be slaughtered, survey 2011

Region	Age (months) livestock slaughtered before Ecofarm technology			Age (Month) livestock Slaughtered now		
	Sheep	**Cattle**	**Goat**	**Sheep**	**Cattle**	**Goat**
Segou	14	25	19	6	1.8	12
Mopti	17	24	24	8	24	12
Koulikoro	15	26	24	6	24	12

From the results in (table 34), before the introduction of the Ecofarm animal feeding technologies, a sheep could be ready for slaughtering only after 1.2 years while cattle and goats could be slaughtered in 2.1 and 1.7 years respectively in Segou. However, In Segou after the technology, a sheep could be ready for slaughtering in just about 6 months and cattle and goats could be slaughtered in 1.8 and 1 year(s) respectively. In Koulikoro, sheep could be ready for slaughtering in 1.3 years while cattle and goat could be ready for slaughtering after 2.2 and 2.0 years respectively. Meanwhile, with the Ecofarm technology, a sheep could be ready for slaughtering after 6 months while cows and goats are ready for slaughtering after 2 and 1 year respectively.

CHAPTER V: LIVELIHOOD RESULT AND DISCUSION

5.1 Introduction

This part of the thesis draws on Scoones and DFID (1998) livelihood framework of analysis to discuss the overall impact of the Ecofarm technologies on the livelihood of households in the study regions.

Figure 20: Description of farmers' livelihood in the surveyed villages (A modified version of Scoones, 1998 livelihood framework of analsysis)

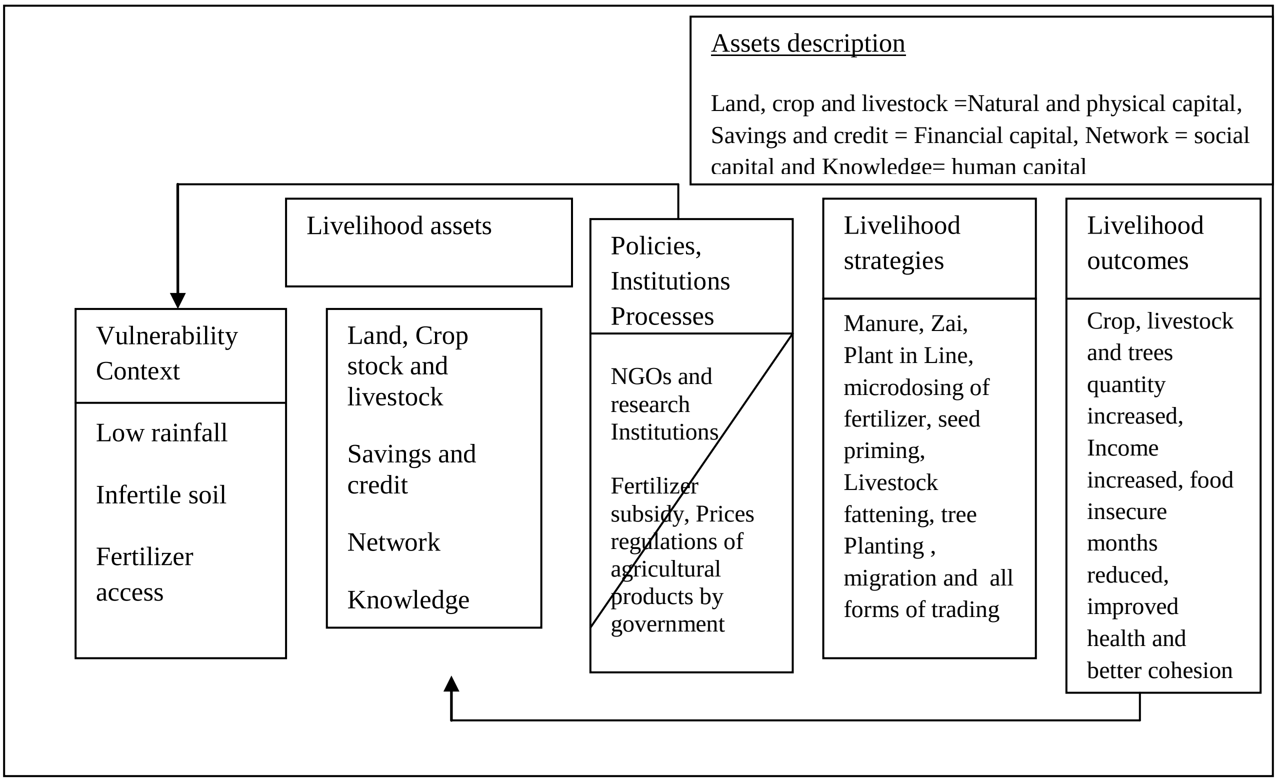


Figure 20 shows that farmers face shocks such as low rainfall, infertile soil and access to input resultants in vulnerable aspects such as food insecurity, sicknesses and poverty. To produce improve livelihood outcome, livelihood assets are combine with livelihood strategies. However, the process of combining assets and livelihoods strategies to achieve an outcome is influence by policies, institutions which Scoones refer to as processes in his framework of analysis. In this study, the Ecofarm is the main factor that the NGOs use to influence farmers combination of assets and strategies to achieve a livelihood outcome of food insecurity, improved health, income, reduced land size use for cultivation and better livelihoodprocesses of improving livelihood resources. The section that follows access the livelihood strategies adopted by rural farmers in the surveyed region. Then final part of this section discusses the overall outcome of the livelihood strategies adapted by households. The different stages of rural farmers livelihood is shown in figure 20 above.

5.2 The context of Vulnerability

The main shocks facing farmers in the surveyed areas are low rainfall 60.8%, infertile soil 57.5%, fertilizer access 55.0%, access to information 46.7% and the problems with pest and insects 5.0% (See table 5).

These shocks are the key factors resultant in aspects of vulnerability such as; poverty, food insecurity, malnutrition and poor health. Dependence on traditional practices such as manure application, crop rotation and shifting cultivation to mitigate shocks and reduce vulnerability prior to the arrival of the Ecofarm did not bring much success to farmers. From farmers own testimonies, prior to the arrival of the Ecofarm a majority of them could not produce enough food to feed themselves and their families. This led to high incidence of malnutrition related sicknesses and poverty; to the extent that people spent a lot on pharmaceutical medicine and even had to borrow from friends and relatives to make ends meet.

Testimonies and the results indicate that since the Ecofarm project was introduced, a majority of farmers are experiencing changes in their livelihood. In the village of Wousare, Badiagara municipality, the head of women group testified that the Ecofarm has contributed immensely to increases in productivity and income of women. The increases in productivity enable children to eat enough which further reduces food related sicknesses such as Kwakshiorkor. The increases in women income also enable them to purchase cloths as well as basic needs of their children. Further testimony from the village of Songoria, Bankass indicates yield increase through the Ecofarm has enable farmers to send their children to distance schools and yet able to supply them with food and basic needs.

With the testimonies and results, there is no doubt that Ecofarm technologies introduced on farmers field supersedes traditional practices by contributing immensely to improving stress and shocks facing farmers, which is further simplified below;

Shocks /Vulnerability	Ecofarm project impact on shocks and vulnerability
Infertile soil	the microdosing of fertilizer technology add phosphorous and nitrogen to the soil; enhancing crop growth.
Erratic rainfall	Primed seeds required little rain to germinate. Besides, farmers are secured that seeds will germinate together by adopting seed priming technologies. Microdosing also stimulates early crop establishment
Fertilizer access	tremendous increase in a number of fertilizer outlets. Testimonies review that most villages have their own fertilizer outlet where farmers can purchase from. This was not common prior to the Ecofarm. The prices of fertilizer have also reduced tremdously.
Access to information	The Ecofarm project emphasis on spread of information and Scaling up. For instance, the nutritional content of Moringa and Baobab were known by almost all the farmers in the villages

By right, the government of Mali could have provided incentives to help farmers reduce the extent of some of the shock, for instance inputs access. Yet prior to the Ecofarm, such measures were rarely available. Rather people tend to depend on their own basic resources or social networks to mitigate stress and risk. As already mentioned, prior to the Ecofarm, access to credit did not exist in most villages. This made it difficult for the already poor farmers to embark on strategies that will increase productivity. Currently, farmers from the same village and beyond have started forming social groups. The members of these groups believe in the potentials of the Ecofarm fertilizer microdosing technology as capable of increasing yield of adopters. Therefore, a farmer in a social group could borrow fertilizer and repay back with crop after harvesting. This was a risky practice before the Ecofarm project as a majority of farmers could not produce enough to feed themselves and pay back credit at the same time.

In a nutshell, the Ecofarm project is a resilient strategy; that contributes to the process of eradicating and mitigates shocks among farmers in rural Mali. Though there is always a cost, the results indicate a benefit that outruns the cost; hence important starting points in the quest of helping poor people achieve a sustainable livelihood (Scoones 1998).

5.3 Assets portfolio

Linking Scoones (1998) definition of assets with the results from the field, it came up that assets available to households were land, crops stock, livestock and trees (Natural and physical capital), skills, knowledge and ability to work, nutrition and good health that allow livelihood to be achieved (human capital), stocks of gold and jewelries, cash savings and credits (financial capital) and network connection and membership of formalized organizations such as women or men group and farmers union (social capital). The impression is that a majority of farmers owned and combined some form of the different assets capital for a livelihood to be achieved. The different components of assets in the form of capital are further elaborated.

Human capital

Human capital is an important asset which poor people have at their disposal, their ability to sell their labour is a key determinant of their income generating capacity (Lucky Lowe and Theo Schilderman, 2001). Lack of formal education and poor health were identified as some of the factors that limit households' adaptation to improved livelihood. From the result, about 63% of the household heads surveyed are not formally educated. Those educated did not spend more than six years at school. The low level of education implies that project aimed at improving livelihood should not be knowledge demanding.

The Ecofarm appears to be not knowledge demanding as such all household without formal education are able to adopt it. The point worth mentioning is that though farmers are not formally educated, they have local knowledge which enables them to fully utilize technologies that improve their livelihood. Farmers also discuss among themselves about the effects of new technologies before adoption. This basic knowledge and approach towards new technologies shows that farmers are very rational irrespective of their educational background.

The health of a household is also a major determinant of how much livelihood activity to pursue. Most of farmers were healthy people except few in Koulikoro and Segou who were put under Moringa treatment. From Scoones (1998) poor health exposes people to shocks and stress and they are not able to better livelihood. The adoption of the Ecofarm introduced farmers to pharmacopeia techniques that contribute to their health status.

Social capital

Prior to the Ecofarm project, farmers in the survey villages had limited access to network. At least a total of 24 men and women groups, representing 2 in each village have been formed in the surveyed villages after the Ecofarm project. From the testimony of the head of women group in Wousare, Bandiagara, the women group helps to transmit information about the Ecofarm technology to women across the Bandiagara Municipality. The group is not only concern about information but also assist women with credit and marital conflict resolutions.

A similar trend of organization was observed among men in the Bankass region of Songora. After success with the Ecofarm, the men in the village of Songora formed association to save their surplus cash income and crops. Currently, the association has grown to the extent that not only the women of the village have joined but also about farmers from 3 other neighboring villages. The union support members with financial difficulties with fertilizer, seeds and cash to be refunded after harvest. Helping each other with credit due to the Ecofarm is a new thing since such union did not exist in villages prior to the Ecofarm.

In Dafara, 5 women each living in the 4 sections of the Dafara village have come together to form the moringa group. The group of 20 women cultivates, harvest and sell Moringa powder to generate income. From the women testimonies above, the income generated is used for community development such as building women relaxation center for them to converge after day work.

In Segou, the Ecofram project has promoted networking among men and women in the neighboring villages. From testimonies, it came up that farmers in Nabaso, Nsirimanso, and Taro traveled to Ntogosso not only for socialization but also to observed the technology usage on the farmers field. Since Ntogosso is the head quarters of the NGO

AMAPROS, farmers in this village get the first hand information and this is spread to the neighboring village by the farmers particularly to the relatives and friends in the villages.

In a nutshell, the Ecofarm project has promoted strong social cohesion not only at village level but beyond. Prior to the project, there was limited access to credit in the villages. The main sources of credit for the poor farmers were through families and friends. However, after the Ecofarm project, there is a strong social cohesion in a majority of the villages. The farmers own testimonies indicate that there is now a multiplicities of unions for farmers to join and can obtain some form of credit to enhance livelihood.

Natural capital and physical capital

Households in the Ecofram region soecifically those in Koulikoro own an average of 4.9 hectares used to cultivate crop. Yet the average size of each household is 19 members. Relying on traditional practices, a farmer in Koulikoro can produce an average of 70kg of millet per hectare and 200kg of sorghum per hectare. If we assume that an average person requires about 200kg of food to survive in a year, then households in Koulikoro are most likely to experience food insecurity. Evidence from the result indicate that due to degraded soil fertility, farmers used traditional practices such as shifting cultivation, crop rotations and mulching to replenish soil and increase productivity. However, due to low availability of crop residuals and increasing population, those practices were not effective to meet the level of productivity significant enough to ensure livelihood security. From focus group, it emerged that more farm land were used to increase yield. This lead to more degraded land and reduction in the amount of land available to a farmer.

The Ecofarm project has not only contributed to reduction in land size used (See table 30) for cultivation but also increase in productivity. From 22, we see tremendous increases in yield per hectare using microdsing as compared to traditional practices. In Mopti, farmers recorded millet increase from 125kg per hectare without fertilizer microdosing to about 500kg per hectare using microdosing. Koulikoro recorded a highest increase in millet of about 70kg per hectare without fertilizer application to 930kg per hectare with fertilizer application. Sorghum also increased from 260kg per hectare to805kg per hectare in Segou. While, the average sorghum per hectare increased from 125kg to 430kg. In Koulikoro, an increase from 70kg to 275kg was observed. Groundnut output was best in Segou than all the other regions. The yield increase of Groundnut was from 100kg to 600kg in Segou as compared to 80kg to 255kg in Mopti. However, Koulikoro recorded a better output of about 545kg after adopting microdosing than those in Mopti (See table 22).

The size of cultivated land has also reduced or increased in a positive way under the jurisdiction of farmers for commercial purpose. The cross tabulation results below indicate that the 53.8% of the farmers have reduced their cultivation area. In Koulikoro where average land size is just 4.9 hectares, about 15.1% of the farmers have still reduced their cultivated area (See table 30).

Grazing land is tremendously reduced in the rural villages after the Ecofarm technologies since livestock are not often allowed roaming on fields in search for food. These days, farmers tie their livestock and feed them with the leftover of cowpea, and the leaves of Gliricidia sepium and Pterocarpus. The advantage of using this method is that not only is less food is given to livestock but also the livestock gain weight within the shortest possible time. The rate of maturity reduces the cost on feed and yet increases in income. From testimonies and the result, a sheep bought at 23.000fcfa could be sold for an average of about 60000fcfa (See table 32). The period of gestation of livestock has been reduced and the quantity of milk produced per cow increased with the Ecofarm technology.

In addition to land management, the Ecofarm has contributed to increase in the number of trees planted (See table 31). Prior to the Ecofarm, there were little or no trees found on a majority of farmers field in a majority of villages. The common tree mostly maintained were the Vitellaria paradoxa, probably because this tree is an importance as cash tree. Just before the cultivation period, women and children harvest the trees and sell it on the road sides to generate income. Important trees such as Pterocarpus species were at the verge of extinction due to the high harvesting to feed livestock but low replanting.

The only village that I saw with tall trees was in the village of Niengue Coula at Koulikoro region where some forests were preserved for religious and taboo purposes. No woman was allowed to visit the men forest and vice versa. Cutting of wood in the forest was also a taboo. This restriction on the forest has turned the place green with tall trees.

Through the Ecofarm, a greater number of trees have been planted not only on farms but also in the farmers' garden. In Segou, farmers have planted an average of about 122.2 tress while an average of 105,8 and 99.8 tress are planted by each farmer in Mopti and Koulikoro respectively (See table 31). The benefit of the trees particularly the Moringa and Baobab have been testified by many farmers across all regions. From farmers own testimonies, not only do some of them generate income through the trees Moringa and Boabab but also they are a major source of nutrition. The Moringa adds vitamins to the diet of farmers while the Baobab add zinc; intake of both Moringa and baobab reduce disease associated with these sicknesses. Trees such as Acacia Tumida and Acacia Senegal are planted in high numbers as fence around gardens (See table 31). While Gliricidia sepium is a very palatable to livestock. From focus group interview, it emerged that the Gliricidia sepium is likely to replace the Pterocarpus as this plant is close to extinct. The fruit of Ziziphus mauritiana is also sold by many women and constitute a major source of income.

Financial capital

The results and testimonies indicate that the Ecofarm has contributed immensely to improving the financial capital of farmers which adopted the technology. The gross output result indicates that gain per hectare using fertilizer microdosing on millet gave a net benefit of 144837 Fcfa per hectare (See table 27). In Koulikoro, a net benefit of 159508 fcfa was the highest among all the three regions in terms of using fertilizer microdosing on millet. While in Mopti, a net benefit of 81363 fcfa was lowest in all the three regions (See table 27).

The results of analysis using microdosing on sorghum show quit an opposite outcome as compared to using the same technology on millet. The net benefit of the application of

The results of analysis using microdosing on sorghum show quit an opposite outcome as compared to using the same technology on millet. The net benefit of the application of sorghum was 88863fcfa as compared to 42259fcfa in Koulikoro (See table 28). The highest net benefit per hectare using microdosing on sorghum was 175087 fcfa recorded in Segou (See table 28). The results and testimonies indicate that the increases in income from the Ecofarm crop technologies, allow farmers to purchase input used for the next growing season. Some of the crops are save as capital and risk avoidance from food shortages. Some income generated from the sale of extra crops is used to purchase households needs and the surplus cash is also save with credit union to increase financial capital.

Testimonies also indicate that farmers, particularly women generate income through the sale of Moringa leaves. This income permits farmers to invest in communal development such as building of a relaxation area for the group. The money spent on pharmaceutical medicine is also reducing as the nutrient content in Moringa and Baobab reduces nutritional related sicknesses. The quantity of milk is increased through the application of improved animal feeding technology. The result indicates that average quantity of milk has increased from 1 liter to approximately 2 liters (see table 33). This contributes to increasing the income previously gains from milk. Milk selling is a major source of income for the young boys and girls in the community. These groups of people normally traveled with the milk from house to house. An interview with one of the boys in the village of Kandjan review that some of the earnings through the sale of milk is used on food where the rest is kept by the saved towards school and purchasing of other livestock. Tress is also sold to researchers and people from other villages to generate income. In Parou, selling of trees is a major source of income for the village chief. He has specialized in nursing a large quantity of trees. When the researchers need trees, he is called and he sells them to generate income. Other farmer in the villages of Taro also sells trees acquired through the Ecofarm to enhance financial capital.

5.4 Policies and institutions

The livelihoods strategies pursue by households are influence by the initiatives of the Government of Mali and its development partners including NGOs. One of the major concerns of the government is the pricing of agricultural products to the advantage of farmers. This concern led to the establishment of L’observatoire des Marche Agricole (OMA) and L’Assemble Permanente des Chamber Agriculture du Mali (APCAM). OMA was established during an extraordinary session of APCAM in 1998. The objective of the OMA is to collect and analyze indicators that may affect prices in the short and long term. In addition, the OMA is a medium of exchange between agricultural producers and those who trade in agricultural product. It also collaborates with concerned groups on topics related to the functioning of the agricultural market such as the best period to buy or to sell (IFAD, 2011).

The APCAM serves the interest of farmers both locally and at the international level. Established in 1993, the APCAM is a platform that network government organization promoting rural agriculture and agricultural product at the international level in the interest of farmers through the spread and exchange of information (IFAD 2011).

In addition, several policies and rural poverty approaches have been prioritized by the government of Mali. The government strategy framework for growth and poverty reduction (CSCRP) was put in place from 2007-2011. The aim is to boost economic growth, improve food security and raise incomes of rural producers by increasing and diversifying food production. To attain this objective, emphasis was placed on ensuring sustainable management of natural resources, modernizing farms, expanding productive infrastructure and developing agro-processing (IFAD, 2011).

In 2006, the government adopted the Loi d'orientation agricole. This strategy maps the way forward toward a modern and competitive agricultural sector, moving smallholder farms beyond subsistence, at the same time promoting agro-industries and private investment. This strategy works to improve the country's food security and transform the agricultural sector into an engine of growth. Besides, Mali is one of the few countries that has met the comprehensive Africa Agriculture Development Programme (CAADP) of allocating 10 percent of the national budget to agriculture (IFAD 2011).

Despites all these policies and approaches adopted, agriculture is extremely vulnerable to risk and shocks. Rainfall has declined by 30 percent over the last 10 years (IFAD, 2011). The changing climate combines with poverty and depleted soil highlight the urgency of introducing new approaches and technologies that enhance agricultural growth and ensures sustainability important to rural household livelihood present and the future (IFAD, 2011).

Both local and international NGOs influence the livelihood of farmers in rural Mali. For instance, soil and crop improving technologies and such as the use of organic manure, line planting, soaking of seed, microdosing of fertilizer and Zai were introduced to households through both local and NGOs working in Mali. From the result, it was reviewed that households' that adopt the technologies experience better livelihood while those who for some reason not able to adopt face economic hardship. In one way or the other, we can say that through projects, the NGOs contribute positively to improving livelihood but also create social difference between adopters and non-adopters

5.5 Livelihood strategies

Adoption of Ecofarm technology to increase productivity and income is the main livelihood strategy in the rural areas of Mali. As already mentioned, people in the surveyed villages are agro-pastoral farmers. They grow crops mainly millet sorghum, cowpea, groundnut and okra just to mention a few to feed themselves and generate income. They also raise livestock mainly sheep, goats, cattle and donkeys. The livestock are slaughtered as meet for household consumption and sometimes sold in the market for income when the need arise. Testimonies show that, prior to the Ecofarm, farmers waited longer period before their livestock were ready for sale. However, through the Ecofarm technology of sheep fattening, a sheep could be ready for sale in about 6 months. The testimonies further indicates that not only the time frame makes the sheep fattening technology attractive to farmers but also the less work and cost attached to it. These factors had motivated greater adoption of the Ecofarm livestock fattening technology than traditional practices as a livelihood strategy.

Fertilizer microdosing and seed priming are the main strategies farmers adopt to increase crop productivity and income. The result from table 7 below indicated that approximately 68.1% of all modern technologies adopted by farmers were microdosing, the highest, while seed priming is the second largest with about 51.3% of total adoption. Evidence from table 21 shows that about 81, 7% of all farmers representing 98 respondents out of 120 mentioned yield increase as the main reason for adopting microdosing technology. Testimonies indicate that more women adopt seed priming to increase productivity towards improving livelihood (See table10a and 10b). The reason for variations in adoption was attributed to the work load. However, the positive side of the differences is that no one is left out concerning strategies to better livelihood.

As already mentioned in the result, other livelihood activities pursued by farmers include trading in agricultural products, charcoal burning, laborer work and migration just to mention a few (See figure 7). Women and children collect fruits such as mangoes, melon, and shea fruits which they sell on main streets to generate cash income. In the village of Ntogosso and surrounding villages, I saw women carrying eggs on their heads from nearby villages and selling to farmers. I also observed some women selling medicinal plants which they claim can help children to walk and also can make men potent.

There was also a large sale of cola nuts by women which they carried on their head in a pot and moving from one village to the other. While seated at the back of a motor bike, I saw several women from villages travelling for a distance of about 20 kilometers; carrying loads on their head with babies on their back, walking to the major towns of Bandiagara and Bankass on market days to sell their farm products. In Koulikoro, I saw several women with fake brand clothes such as Giogio Armani, Gucci, Dolce and Gabanna just to mentioned a few, which they were retailing in village markets to generate cash income that contributes to livelihood.

In the focus group, farmers review that young boys and girls are sent to Bamako and neighboring countries after the cultivation period to work and send money home. From the testimonies, some farmers mentioned that the money from migration was previously used to purchase food. However, since the Ecofarm came into existence, cash income from migration is invested in other livelihood activities such as the purchasing of livestock and paying of taxes.

Saving in gold and other precious jewelries is other ways farmers keep and amass capital to enhance and maintain their livelihood. In towns and villages, specifically in the town of Sangha; a Mopti area, there are several artifacts shops where most farmers could sell their jewelries to shop keepers to generate cash income when needed. Precious stones like gold are kept as a symbol of wealth and passed on from one generation to the other. Families with huge quantity of gold are considered wealthy. Farmers generally purchase gold only when there is enough harvest and the surplus money or product is invested in it as savings. In periods of economic stress and shocks, the gold is sold to generate cash income either to maintain or enhanced livelihood or better still to pursue other livelihoods.

5.6 Livelihood outcome

The overall living standards of households in the surveyed region are improving relatively fast. The livelihood strategies of adopting Ecofam technologies of fertilizer microdosing, seed priming, animal husbandry and agro-forestry technologies in it single form or in combination with each other has brought tremendous positive impacts to a majority of agro-pastoralists farmers in rural villages of Mali. The most visible impacts after adoption of the Ecofarm technologies include; changes in income, improved health and nutrition, improved soil quality and reduced land size use for agriculture, improved soil quality and reduced land size used for agriculture, better adaptive and mitigation measures to erratic rainfall (risk reduction), improved fertilizer outlets and prices and social cohesion.

Changes in income: The results indicate that the net benefit of the application of fertilizer microdosing technology recorded a net benefit of sorghum for 175087fcfa per hectare in Segou. This represents an increase in sorghum net benefit of about 95993fcfa in Segou as compared to the outcomes in Traore et al. (2010). In their report, Traore et al. established that the application of fertilizer microdosing technology recorded a net benefit of sorghum for about 79094fcfa per hectare in Segou. The variation may be attributed to the average quantity of fertilizer use and the socio-ecomic and environmental conditions present in the two regions at the time of the evaluation. However, the average net benefit of using fertilizer microdosing is still higher in both regions than using traditional practices (Traore et al, 2010).

The animal husbandry technology is mostly adopted by women in all the villages surveyed probably due to the less work attached.

Figure 21: A woman showing her sheep in the village of Sonongoria, Koulikoro, survey 2011 in Mali

Farmers, particularly women tie and feed their livestock with a small portion of the leftover of cowpea for an average of about 4 times a day. This technique has proved not only to be very effective in helping livestock gain weight but also avoid food waste. In the focus group discussion, a majority of farmers testified that the technique is very cost effective since livestock eat less, yet grows faster and gain more weight.

"Thanks to the project Ecofarm, I am now able to contribute to the family income. Last year, I sold two sheep and one goat and I was able to earn about 185000fcfa. The money helped my husband to purchase clothes and make preparations towards the festival of Tabaski" A woman said in the village of Sonongoria, Koulikoro

The results indicates that in Segou, a sheep bought at the price of 23.000fcfa is sold for an average price of 55.000fcfa just after 6 months of applying animal husbandry technology of sheep fattening. This selling price indicates a gross benefit of about 32.000fcfa in 6 months. In Mopti, a sheep bought at the same price is sold for an average price of 60.000fcfa in 6 month, given the farmers a gross profit of about 37.000fcfa. The result of the output from Koulikoro shows a similar trend with an average selling price of 65.000fcfa, a highest price for a sheep bought at a price of 23.000fcfa. The livelihood strategy of adopting feeding technology is what Scoones (1998) described as "sustainable" when a chosen strategy enables poor people to cope with shocks and enhance other livelihood at the same time. From the results and testimonies, we saw that a combination of technologies not only help farmers to get enough to feed on but also sell the surplus to generate cash income that is used to generate other livelihoods.

In general we can say that the Ecofarm project is flexible as it accommodates both men and women in their effort to making a living. For instance, the result indicates that due to the work load attached to fertilizer microdosing technologies, about 70.2% men adopted it as compared to 61.1% women (See table). However, on seed priming technology that requires less workload, about 52.2% women adopted it as compared to 50.0% for men (see table). This outcome shows that though women are not fully able to utilize fertilizer microdosing technology, they could still make a living out of seed priming technology. This possibilities for farmers to shift from one technology to the other present the Ecofarm project as dynamic; a knowledge oriented project that took into account the different skills and abilities possessed by farmers and as such no one is left out.

Improved health and nutrition:

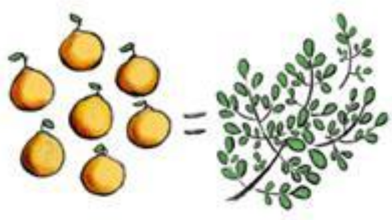
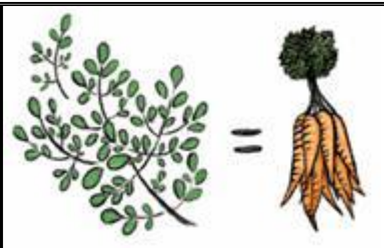
Health centers are mostly located in the big towns. In the focus groups, it emerged that before the Ecofarm project farmers and their households not only used to fall sick but also have to travel for an average of 20km to get treatment. Sicknesses in most rural villages relate to nutrition and include: malnutrition (Kwashiorkor), growth retardation, scurvy (lack of vitamin C), anemia (iron deficiency) and others such as impotency in men just to mention a few.

After the Ecofarm, households have enough food to eat and could also afford to buy extra ingredient from the sale of surplus food. This better life style has reduced the amount of nutritional sickness. In an interview with Madam Kuma Tembele, a child nutrition specialist in Bandiagara health center, it emerged that the total number of children admitted on malnutrition cases has dramatically reduced since the 2006.

Figure 22: Madam, Kuma Tembele, food nutritionist at the child nutrition center showing nutritional sickness level scale and a rich nutrient food given to children admitted at the center in Bandiagara

From Dr. the children currently admitted are in the range of the mild group and quickly recover after putting them on “plumpy nut” treatment for 2 to 3 days. Before 2006, most cases were acute and children were put on the same treatment for 2 to 3 weeks before recovering. Though the doctor did not specifically refer to the Ecofarm project as the cause of the changes in the health of most of the children in the communities, we can still relate it to the Ecofarm. From testimonies and the report of Traore (2010), the Ecofarm was put into test in 2005 and by 2006, it had spread to several villages and farmers were already experiences increase in productivity and income. The feeding on Baobab and Moringa have added vitamins, iron and zinc to the diet of farmers

Most women also testified in the women focus group that when they add Moringa powder to the diet of their husbands in the Morning, the men get potent at night. They also gain appetite which enables them to finish all their meal served. To find out the nutrient content of the Baobab and Moringa, I visited the food research institute of Bamako. At the research insitutte, I had the opportunity to meet Madam Bolle Fanta Gindo, Phd candidate specializing on the nutritional contents in Baobab and Moringa plants at the Food and Nutrition Department of the Ministry of Food and Agriculture, Mali. Evidence from Madam Gindo’s research indicates that the Moringa contains a high content of vitamin C, 7 times than the one in orange, 4 times vitamin A than the one in carrots, more protein than in egg, 4 times more calcium than in milk and 7 times potassium than the one in Banana. This is further simplified below;

 7 times vitamin C than in oranges !	 4 times vitamin A than in carrots !

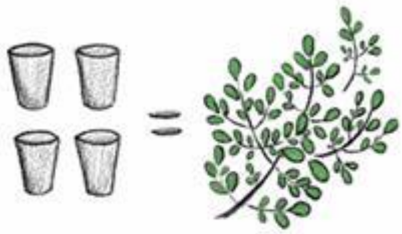
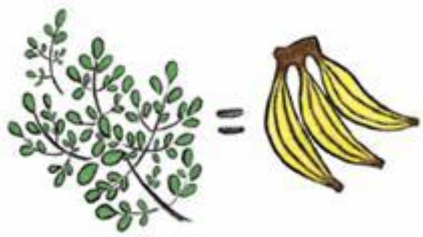
 More protein than in eggs	 4 times more calcium than in milk
 3 times more potassium, fiber, vitamin C and manganese than in bananas!	3 times iron and calcium than in spinach!

Image sources: AGADA (1997)

With this high nutrient content, there is a high likelihood that a person feeding on Moringa and Baobab powder for a long period of time could be cured from nutritional deficiency sicknesses. However, she emphasized that further research is ongoing to verify the types and amount of nutrient lost through evaporation during the boiling of the Morinaga and Baobab leaves on fire.

Improved soil quality and reduced land size used for agriculture: poor soil quality is a major challenge to dryland farming. From the results, approximately 57.3% of all agricultural problems farmers face was related to infertile soil (See table). Prior to the Ecofarm project, farmers were very poor to the extent that taking everything from the already impoverished soil was one of the means of survival from agriculture. Failure to replenish soil due to poverty leads to a serious nutrient declining cycle.

Evidences from the result indicate that farmers basically rely on the traditional system of organic manure 22.3%, compost 56.3%, shifting cultivation 12.6% and Zai 21.4% to replenish soil fertility and increase crop production (See table 5). Yet from the testimonies and output result (table 22) soil quality did not improved to a level good enough to sustain farmers livelihood. The reasons given for low productivity outcome for depending on compost, zai and organic manure is the supply of organic materials. There are not sufficient crops residuals kept on the farm from previous seasons to increase nutrient content as residuals serve as ration for livestock. In addition, farmers do not own enough cattle to facilitate manure collection to support crop production on all fields (De Ridder and Van Keulen, 1990).

On the issue of shifting cultivation, evidence from Swinkels et al. (1997), indicates that increasing population pressure has resulted in decrease in the length of shifting cultivation period and this has continued to the point that the system is not effective enough to support crop growth and to increase productivity in Kenya (Swinkels et al., 1997). Nutrient recovery through shifting cultivation is not sufficient enough in restoring soil fertility and caters for the demand of crops in rural Mali (Van der Pol, 1992).

In focus groups, it emerged that though some farmers had an idea about the effect of chemical fertilizer on crops, they did not have the technical knowledge about it applications. Through the Ecofarm, farmers discovered that the application of just 0.3 gram of fertilizer to the pocket of crop or equal mixing of fertilizer and seed (ratio 1:1) add nitrogen and phosphorus to the soil. These nutrients help soil to regain fertility and tremendously increase crop productivity (See table). From the results and Traore (2010), productivity of farmers who adopted the crop improving technologies of fertilizer microdosing have had their crops more than doubled. The results further shows that not only have the technology double productivity but also the average land size use for cultivation has reduced. From the results about 38.75 of all respondents mentioned that they have reduced their surface area due to increases in productivity. While about 53.8% mentioned that they have increase surface area to increase productivity for commercial purposes (See table 30.).

Better adaptive and mitigation measures to erratic rainfall: (Risk reduction)

Poor and erratic rainfall is one of the major constraints to traditional agricultural practices. From the results, about 60.8% of the agricultural problems farmers face is low and erratic rainfall, the highest as compared to infertile soil. In the focus group discussion, it emerged that poor and erratic rainfall makes practicing agriculture, specifically seed sowing aspect very risky as there is no guarantee that the seeds will germinate. A majority of the farmers claimed that due to failed rainfall, they lost most of their sown seeds. A frustrating aspect of it all is that in most cases after sowing, not all the seeds germinate together.

With the Ecofarm technology of soaking seeds, farmers are secure that with a little amount of rainfall, all their seeds will germinate together. In all the Ecofarm regions, farmers explained that after observing the sky, they soaked their millet or sorghum grains for 8 hours. The grain is spread out in a dry humid place for approximately 2 hours before sowing. This seed priming technology allows all the sown grains to germinate together and as such productivity is relatively high as compared to traditional practices (See table). However, the main challenges that farmers in all villages mentioned is that all the seeds have to be sown after soaking as it is not possible to replant the left over seeds. Meanwhile, an interview with Dr Adama Coulibaly, a researcher at IER, Bamako reviewed that farmers lacked information about preservation of the left over seeds. Dr Adama, IER explained that the seeds could be dried and kept in a cool dry place for 3 days. This scientific explanation about the preservation of the leftover soaking seed removes the only doubt about seed priming technology farmers encountered. In this case, the risk associated with loosing seeds due to poor rainfall is very low and as such, more farmers are likely to adopt seed priming technology as a mitigating strategy against low and erratic rainfall. From the results, an average of 51.3% of the surveyed households has already adopted seed priming technology (See table 10b). The result further shows that of the 51.3% of farmers that have adopted the seed priming technology, approximately 52.8% of them are women (see table 10b). The huge adoption among women is encouraging since the IPCC (2007) report shows that global warming, which is driving global climate and environmental change threatens humanity (IPCC, 2007). If the IPCC (2007) prediction is true, then poor people in rural villages, particular vulnerable groups such as women and children in the already hot rural Sahelian zones will suffer the most (IPCC, 2007). Having said this, technologies such as seed priming that help women to mitigate climate change effects is good and as such, further investigation on its improvement is relevant.

Social cohesion:

In an area with limited access to information and credit, social networking is an important factor to nurture. In the focus group discussion in Segou, it emerged that the Ecofarm project reached Nabaso, Taro and Nsirimanso because of a recommendation made by the farmers in N'togosso. The farmers from the above mentioned villages meet often to share ideas about the technologies and way forward. A similar trend was observed in Koulikoro, where the technology spread of the technologies into neighboring Niengeu Coula and Sonongora happened due to recommendation by farmers from Falani Coungo.

There are several historical social groups that has been form since the introduction of the Ecofarm group that was seem almost impossible few year ago. In a focus group discussion, it emerged that in Dafara, a single Koulikoro town divided into areas, women from one area did not relate to the ones from other areas. To establish the Moringa group, the Kilabo coordinator selected 5 women from the 4 areas of the village. The 20 women were put together for training. Through the training, the women got to know each other and related well as a group with common goal. They planted and harvested the Moringa together. The earning from the sale of the Moringa was used to build a meeting place where all the women could meet for relaxation.

Access to credit is another area that the Ecofarm has promoting social cohesion. Several men and women groups are formed as a result of the Ecofarm. In Songora, Bankass, it emerged due to increases in productivity, 3 villages joined to form a union. The union has opened a village bank where they collect and save cash money and crops. The poor people in the union could borrow money from the union to purchase fertilizer and pay back after harvesting their crops. This is possible according to testimonies since farmers had trust in those who adopt the technologies as capable of increasing productivity to a level high enough to meet their obligations.

A similar association was observed in Wousare, a village of Bandiagara. Women living in villages surrounding Wousare have formed a women union with the president living in the mentioned village. The president of the union benefitted from the animal husbandry technology. When she realized the effectiveness of the technology as increasing income and economic independent, she decided to teach the other women in her village and beyond so that greater number of women could benefit from it. After several visits new villages, she formed the union group. The women in the group go to other villages in the Bandiagara municipalities to teach other new ones. This has brought about changes in the livelihood of many women in the municipalities and it is perhaps one of the reasons for the high scaling up of the Ecofarm technologies in the Mopti region.

Environmental Sustainability

The planting of trees through the agro-ecological technique has contributed to improve soil and environmental sustainability. The leaves dropping from the trees are decaying by termites and later retained in the soil as nutrient. Tall trees not only serve as a protective cover for crops, but also (supply oxygen) or help trapped some of the green house gases harmful to the ozone layer and the environment.

CHAPTER VI: FARMERS OWN STORIES, TESTIMONIES COLLECTED IN THE FIELD

To illustrate the impact of the Ecofarm project on the livelihood of farmers in the surveyed region, I will in this part share the most significant changes testimonies gathered on the field**.** These testimonies were told by the farmers themselves and had not been modified or rewritten. The observation from the testimonies is that it relates to the statistical results of this thesis.

6.1.1 Animal feeding technology testimonies

Sita Doumbia, a 40 year old woman in Sonkorila, Koulikoro

"It all started when I purchased a sheep for 30.000 fcfa after hearing of the Ecofarm project from the neighboring village. Later I benefited 2 sheep from the project when introduced in our village. Now I have a total of about 8 sheep and 12 goats but killed 2 during the Tabaski. Before the project, I was feeding the sheep very often thinking that they will be fat. Yet they did not grow to my satisfaction. But now I feed them only 4 times a day and the result is impressive. I have invested a total of 30.000 fcfa in livestock and after 5 years now I have about 300.000 fcfa in savings. I am very happy with the Ecofarm project and I am always encouraging fellow women in this village to do the same."

6.1.2 Crop improving technologies testimonies

Yacouba, Sonkorila village

"Prior to the project I had several months of food insecurity. With soaking of seed and fertilizer microdosing technologies, I use less land, yet my productivity has increased. If someone had ever told me that I Yacouba, could be food sufficient, I would not have believe the person. But thanks to the project, I am now 100% self sufficient. I also sell the surplus of my millet and sorghum on the market to generate income. Through the project, I have also changed my way of practicing agriculture. Now I use less land yet I am able to increase productivity. The planting in line technology has also make working on my farm easier."

Mahma Diane, a 53 year old farmer at Ntogosso with 2 wives and 8 children

"I started with seed priming and microdosing of millet together. But due to poor rainfall, my entire seed did not germinate. I was disappointed and almost gave up. But I decided to continue but this time I applied a coca cola bottle top quantity of fertilizer 15 to 20 days after the millet seed germinated. It worked and now I am able to increase productivity and feed my family throughout the year. There has also been a positive change in the quantity of fertilizer use. Before the technology, I was using 100kg of fertilizer on 1 hectare of my land. But now, through knowledge gathered from the Ecofarm project, I am suing 50 kg of fertilizer on one hectare of y land. I am planning to se fertilizer on all my 12 hectares of land this year in other to increase productivity."

Sidike-Kandjan

"The technologies of soaking seed and microdosing of fertilizer have helped me to be food secure. I am able to meet demands that I could not meet before. The use of Moringa powder in soup has improved health in my family. The leave of Baobab is also a major source of vitamins for me and the family. To give you an example, before the project, I had fever and tension but through the use of Moringa, I feel very strong and healthy."

Households in the village of Songora testifying about the Ecofarm project

"It took a long time to appraise the Ecofarm project in our village. It was difficult to embrace the NGOs stories that soaking seeds and putting 0.3gram of fertilizer in a pocket under crops could increase yield. The entire village did not believe in it and we were very skeptical. No one wanted to purchase fertilizer because we did not believe it could be of any help. But when few of us tried and saw the effect, the others joined. Now we take credit to buy fertilizer and after harvesting, we sell part of it to pay the credit. We are sure that the technology could help meet such demands. We take credit because we did not benefit from free fertilizer through the project as compared to other villages."

6.1.3 Testimonies about changes in livelihood through adoption of crop and animal feeding technology

Binta S. Dibo, head of women association-Wousare Bankass

"Since the Ecofarm came, it trained people. The technology of microdose and seed priming have really helped people in this entire municipality. It is good to talk on behalf of everyone because it is not a work of one person. The project has really helped to increase productivity. The training we received was very good and I hope that every in this municipality get opportunity to be trained in the same way. This will help to increase productivity and ensure food security among women. I am aware that the women in this municipality have enough food to eat thanks to the project Ecofarm. There is always common harvest, but in their private farms the women farms get enough harvest and they are able to sell and buy their children needs. Because when women productivity increases the children also benefit. It is the same for all the villages in the entire community. Prior to the arrival of the project, the women use to buy millet from the market but now they don't do that again. Before, the women could not afford to buy medicine and clothes for the children but now they can afford it. The Moringa plant is a major source of vitamins and a cure for many sicknesses among children. Now the women don't need to buy medicine or go to the health center often. The Baobad can also cure yellow fever. The Gigibie greffes was also introduced through the Eecofarm. It is not only a source of food but also income. The fruits of Gigibie Greffes is eaten and the rest is sold for income. My request is that the NGOs should not stop bringing new technologies in this municipality. I pray that God bless all those who brought the the Ecofarm to existence."

Fatimata, Bankas

"There are several advantages attached to the Ecofarm project. Not only has the technologies of soaking seed and microdosing of fertilizer increases productivity but also changed my social life. Through the project, productivity has increased. Thanks to the project, my social relation toward people has changed. People now come to me not only for advice but also to see how I am practicing the technologies on my crops and livestock. Now, I am able to buy a sheep for 20.000fcfa and sell it for 60,000 after 6 months. While before the same sheep could be sold for just 35,000fcfa for the same period. I use to make

about 0.5 sack of Niebe before the arrival of the technology but now I make about 1.5 sacks; making a surplus of 1 sack. Our health is good thanks to the fresh leaves of Moringa and Baobab that gives us enough vitamins in or diet."

Mohammed Gindo, Koumudu Bankass

"Erratic rainfall is a major problem in this zone. I am aware that small irrigation can help. Yet I do not have enough money to buy irrigation equipments. The technology of soaking of seed introduced through the Ecofarm is a cheap but effective alternative to irrigation. When I soak my seed, I am very convinced that with little amount of rain, my entire seeds will germinate together. Seed priming together with application of fertilizer has double my productivity. Prior to the arrival of the project, I did not know much about the benefit of garden Moringa, and the Baobab. Thanks to the project Ecofarm, now I am aware that the Moringa heals several sicknesses and a source of vitamins. My food security level has also improved. Before the project my food uses to finish 3 months before the next harvest. But now, thanks to the project Ecofarm, I have sufficient food throughout the year. I do not buy millet from the market anymore."

Garibo Gindo, Sogora Bankass

"Before the arrival of the project, I could not afford to send my children to school. But now thanks to the project Ecofarm, I have the capacity to send my children to school in Bankass and also send them food regularly. The soaking seed technology and microdosing of fertilizer has increased my millet and sorghum productivity. Before the technology, my millet use to finish 6 months before the new one is harvested. Presently, I have enough to eat and sell to generate cash income. Knowledge from the technology has also changed my perception towards the raising of livestock. Now I use 3 sheep and feed them but before, what one animal eats in 1 day could feed the same animal for 10 days. The project has been useful and I pray that God bless those who introduced it to this village. I am willing to learn more project so the NGOs should remember us whenever there is an opportunity. I was due to travel before your arrival but had to cancel my trip because I heard that you were coming to our village. This shows how much I appreciate the Ecofarm project."

Issah Gindo-Bankass, a farmer using mechanical placement technology

"The Semua is good. It does not destroy the fertilizer. The holes are not too large. It also reduces the amount of labor use. Before it arrival, we had to mobilize several people during cultivation. The hole is also not too big. It is just about 30cm. The livestock pulling it does not also change the holes whether moving too fast or too slow. It is the person controlling the animal that has to see to it that the animal go straight. I got the machine free through the project. If bought, it was going to cost about 65.000fcfa. The labor cost has also reduced tremendously. Before, I used about 10 laborers to cultivate 1 hectare of land; costing approximately 10.000fcfa per hectare. But now I used just 2 laborers to cultivate 1 hectare of land. "

Amidou-Sogora Bankass

"The training we got through the project was very useful. Before the arrival of the project, people use to laugh at me and my family. We were like beggers in our own village. But thanks to the project, we are self sufficient and no one laughs at us.. The project was very beneficial to us. If there are other possibilities, we will want to be part of it"

6.1.4 Agro-forestry and crop improving testimonies

Gindo, Village Chief of Parou-Bandiagara

"Since the project was introduced, it has change livelihood. In this village, there is the problem of rain. The rainfall is erratic. With the soaking of seed technology, the seed germinates together even with little rain. We are happy to discover that even with little rain we could still sow our seed and can be sure that our seed will germinate. With the Ecofarm technology of microdosing of fertilizer, we are able to produce more than we can eat. The income of most people in this village has also increased thanks to the project Ecofarm . Prior to the project arrival, money received from the children abroad was used to purchase food. But presently the money from abroad is used to buy cows and donkey for farm work.

Productivity level is very high than before. In the past, millet used to finishes long before the month of August. But presently, the new harvest meets the old one in stock. In the past all the money that they children were making from migration was invested in purchasing of food. Presently, when they are back, we can use the money to purchase meat, pay tax and make other expenses. While in the past the money was used solely on food purchasing. We depend on the project for support. Now, we have moved from food insecurity. The plants also help a lot. With the Moringa, we can cure several sicknesses. Thanks to the project."

Mobibo-Kandjan

"Before the arrival of the project, I could hardly feed myself and my family. Now I produce enough food thanks to the project Ecofarm. I can testify that I have lots of trees in my garden. The training we receive through the project was very useful and I wish that such trainings could continue. Getting extra training on crop productivity and increase trees production is helpful. There is always the need to have new strategies because if I had remained in the traditional practices, I wouldn't have reached this level of security. I believe that there is always something new to learn and I am always willing to learn."

Alfa Dibo, wousare-Bandiagara province

"Ecofarm is beneficial for me and my households. We have enough food in stock thank to Ecofarm. I and my households are not afraid of hunger because we have enough to eat. Ecofarm has made our life very easy. The children are in good health and everyone is happy. I thank all those who did the research and brought the project to his village. I did not have an idea that seed must be soaked in water sowing and neither did I know that application of small quantity of fertilizer on crops could double productivity. The trees introduced through Ecofarm are also beneficial to us and our livestock. The acacia is a major cure for many diseases. The baobab also cures diseases. The Gliricidia is source of food for livestock. We give Gliricidea to the animals and they like it. The Moringa cure lots of sickness. It is a very important plant and people come from far to ask after the Moringa."

"Moringa, the miraculous healer" The moringa women group in Dafara-Koulikoro
Minata Samanke, "the mother with no breast milk"

After giving birth to my baby, I soon realized that there was no milk in my breast. My son also had problem with his testicle. One testicle was bigger than the other and he constantly had pain. The NGO coordinator advice me to use the Moringa powder in our meal. For three months, I added the Moringa powder to all our meal. Surprisingly, my child could feed on my breast milk after 3 months. His swollen testicle also became normal. I am convinced that the Moringa treatment cured us. Within the 3 months, the sole treatment was the Moringa powder. We did not go to the hospital or use any pharmaceutical medicine. To us the Moringa is a "miraculous healer". The Moringa women group was form shortly after my cure with the help of people from NGO Kilabo. We saw the importance of the Moringa and wanted to supply Moringa to all the households in Dafara and sell the surplus to villages beyond to generate income. We started a garden with 50 to 80 trees. Each tree gave a total of about 10kg of leaves or 2kg, when turned to powder. The 2kg of powder is sold for about 6000fcfa. The Moringa created a source of income for the women. People travel from Bamako to purchase the leaves. The only problem is that there is not enough to satisfy the demand. As I am talking, we have someone who wants to purchase about 20.000fcfa of the powder. But we do not have it in stock. We want to increase productivity but the only problem is lack of seed. When the leaves are harvested, it cannot re-germinate. Kilabo supply us with the seed but for some time now, we have not gotten any from them. They told us that the seed is expensive and besides, ICRISAT is no longer producing them. We are interested in planting more trees. We are also encouraging each household in Dafara to plant Moringa at least for the household consumption. Planting Moringa on the farmer own farm besides the common cultivation will not only make the household self sufficient but also they will be able to sell surplus to generate income. I am convinced that the Moringa brought us good health and income. The money we made though the sale of Moringa was used to built women relaxation place. We spent a total of about 50000fcfa on the house. Our social relation has also changed. Prior to the project, the 4 sections of the village were not relating to each other. The project selected 5 persons from each side of the village. Now we meet very often to discuss and also share ideas. I think there is a positive cohesion in our village, thanks to Ecofarm.

CHAPTER VII: CONCLUSIONS AND POLICY RELATED RECOMMENDATIONS

7.1 Conclusions

The main objectives of this thesis have been; to assess the degree of adoption of the Ecofarm technologies, the reasons for adoption and the impact of adoption on the livelihood of rural agro-pastoral households in Segou, Mopti and Koulikoro.

Household characteristics and socio-economic status of the households influenced the degree of adoption of technologies. Distance to fertilizer outlets increased the price of fertilizer which is reducing the quantity of fertilizer use (adoption). Households in shorter distance to fertilizer outlet used more fertilizer at a reduced cost than those farther from the outlets. From the analysis, the results indicate that distance to fertilizer outlets increases the price of fertilizer which is reducing the quantity of fertilizer use (adoption). In the results, we saw that farmers in Segou access fertilizer at an average distance of 53.2kms at price of 16138fcfa. Due to distance effect, the average quantity of fertilizer used by framers in Segou is 73.2 kg as compared to Koulikoro where distance to fertilizer was 4.9kms with an average price of 14200fcfa and a quantity of 140.6kg used per cultivation season.

Land size owned was one of the major determinants of the quantity of fertilizer use (adoption). The result indicates that the adoption of microdosing continues to increase with land size until it reaches a point where it starts decreasing. Similar trend was observed across regions. In Segou, average land owned by a framer was 18.1 hectares. Yet, just 1.1 hectares were used for microdosing as compared to Mopti and Koulikoro where average land size owned was 11.8 hectares and 4.9 hectares respectively, yet 4.8 hectares and 2.2 respectively were used for fertilizer microdosing technology.

The result show the adoption rate of microdosing is 68.1%, the highest agricultural technology adopted. While there are about 51.3% farmers practicing seed priming adoption. The cross tabulation result indicates a variation in gender adoption of microdosing and seed priming. About 70.2% of men adopted microdosing while 61.1% women of women adopted microdsoing. Yet the chi square result shows no significant association between gender and adoption of microdosing technology. From the focus group discussion, it emerged that women adopt less of fertilizer microdosing technology as compared to seed priming because of the workload attached.

The result from the simple linear regression indicates that household characteristics and socio-economic status variables mainly distance to fertilizer, land size and prices of fertilizer were negatively significant with quantity of fertilizer used (adoption) while number of other dependence was positively significant with adoption. However, only distance to fertilizer sources variable was significant with adoption in a multiple regression.

The main reason for the adoption of crop improved technologies by 87.1% of the respondents was yield increase. Results show increased crop yield with the application of fertilizer microdosing across regions. In Segou, average quantity of millet increased from 240 kg per hectare using traditional practices to 855 kg per hectare with microdosing technology. Sorghum yield increased from 260 kg using traditional practices to 805 kg per hectare using microdosing technology in Segou. At Mopti millet and sorghum, yield increased from 125 kg and 155 kg per hectare using traditional practices, to 500 kg and 430 kg per hectare respectively with microdosing technology. While the same crops increased from 70 kg and 200 kg per hectare using traditional practices to 930 kg and 275 kg per hectare respectively with microdosing in Koulikoro.

The assessment of farmers' net benefit indicates that the project has contributed to increasing profitability of farming. In Koulikoro, microdosing of millet gave farmers a net benefit of 159508fcfa per hectare as compared to 1708fcfa using traditional practices. In Segou, microdosing of millet gave a net benefit of 144837fcfa as compared to 37974fcfa using traditional practices. While in Mopti, microdosing of millet gave farmers a net benefit of 81363 fcfa per hectare as compared to 21000fcfa using traditional practices. With sorghum, farmers who applied microdosing technology recorded an impressive net benefit of about 175087fcfa per hectare in Segou as compared to 54974fcfa using traditional practices. While those in Mopti and Koulikoro recorded a net benefit of 88863fcfa and 42259fcfa per hectare with microdosing technology, respectively as compared to 34750fcfa and 37708fcfa using traditional practices respectively.

From the results, the technology has contributed to increasing the number of trees planted in the rural areas surveyed. The average trees planted by farmers in Segou is approximately 122.2, while those in Mopti and Koulikoro have planted an average of about 105,8 and 99.9 trees respectively. This is very impressive as most of the farmers testified in a focus group discussion that they did not plant trees prior to the arrival of the Ecofarm project. The results and testimonies further indicate that tying livestock to a tree and feeding it with the leftover of cowpeas not only help farmers to spend less on livestock ration but also generate profit within a short period. From the result and testimonies, it emerged that a sheep bought at a price of 23.000fcfa could be sold for 55.000fcfa within 6 months in Segou. The same amount spent on the same livestock could generate an average of about 60.000fcfa and 65.000fcfa in Mopti and Koulikoro respectively. This is good taking into account that farmers spent less time and food raising the livestock as compared to traditional practices.

Evidence from farmers own testimonies indicate that prior to the Ecofram project, a majority of farmers were poor and could not produce enough to feed themselves throughout the year. Many of them have to buy food from the market or beg friends and families to make ends meet. Children were constantly sick from lack of food and nutrition; this affected the amount spent on purchasing pharmaceutical medicine and treatment at hospitals. However, after the Ecofarm project, farmers who adopted the technologies have experience reduction in months of food insecurity, increase in income, better health and nutrition and a general improvement in livelihood. The seed priming and livestock raising technologies introduced through the Ecofarm project have not only help a majority of women, the vulnerable ones, to be self sufficient but also enhance their social cohesion and overall livelihoods.

7.2 Policy and research related recommendations

- Distance to fertilizer was the main variable that influences adoption and that the quantity of fertilizer used decreases with distance and price, suggesting that fertilizer sources in the study area should be strengthened. Though the project has indirectly increased fertilizer outlets, there is still a long way to go.

- Further research should be done into factors that determine food insecurity in rural Mali. This will help to assess the variability in quantity of fertilizer use that explains months of food insecurity. The expectation is that such a research, if carried out, will review all factors relevant to food security.
- New techniques to reduce the work load attached to microdosing technology so that a greater number of women can adopt it will go a long way to enhance the livelihood of not only women but their entire household.
- Information about grains preservation after priming should be spread across the entire Ecofarm region. In focus group discussion, it emerged that most farmers did not adopt seed priming technology because of risk of losing the remaining seed uncultivated. However, key informant discussion with experts on the topic reviews that the remaining soaked seeds could be dried and preserved. Farmers do not have the information. Helping to get the information across to farmers will go a long way to increase priming adoption.
- Seed sources should be developed. The project should developed sources so that greater number of farmers could access seed mainly the Moringa. In the focus group, it emerged that farmers are not able to cultivate Moringa because the seed is expensive and not readily available. From the experts, I was told that farmers could replant the tree or seed from it. But no farmer knows about this. In this regard, it is necessary to train farmers or better still supply them with the necessary seeds particular the women group who derive their livelihood from it.
- Credit should be made available to the very poor farmers to help them purchase fertilizer, livestock and tools to be able to start the project.
- Extension services should be improved in some of the regions, particularly Segou so as to assist farmers. Improved extension service will go a long way to speed up scaling up in the Ecofarm region, particularly in Segou where farmers are lagging behind in scale up.

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Appendix I: Questionnaire (Translated from French into English language)

Background

I am Ernest Kwaku Amponsah, a master student with the Department of Environment and Development studies (Noragric) at the Norwegian University of Life Sciences (UMB), Norway. As part of my master degree programme, I am expected to research on a topic of interest. With a keen interest in food security and poverty related issues, I have decided to research on “Farm households’ adoption of Ecofarm integrated agriculture technologies and the effects on livelihood security” in Segou, Mopti and Koulikoro regions of Mali.

This is a pure academic research and I can guarantee that the information gathered here will be kept solely for purpose a research purpose. I will appreciate your kind participation and thank you for your kind cooperation.

Ernest Kwaku Amponsah

Section 1 Degree of Adoption

1.1 Could you kindly provide details about the following?

Sex	Age	Marital status	Number of Children	Number of other dependents	Farm Size	Region	Level of Education
Male☐		Married☐	1-2	1-2☐		Mopti☐	Primary School☐
Female☐		Single☐	3-4	3-4☐		Segou☐	Senior high School☐
			5 and above	5 and above☐		Koulikoro☐	University education☐

1.2 What are your most serious agricultural problems?

Low soil fertility☐ Diseases☐ Weeds☐ Pests☐, Drought☐ Difficult to access input☐

1.3 Which technology do you use to maintain soil fertility?

1.4 What is the most important change in your way of farming in recent 5 years?...
....
....
....
....

1.5 In order of importance, what are the main crops your households produce?..
....
....
....
....

1.6 How many hectares of the above crops do you sow? (Please specify)

1.7 What are your reasons for producing crops?

....
....
....
....
....

1.8 In order of importance, what is the number of livestock species does your household produce most?

Cattle	Goats	Sheep	Donkeys

1.9 Have you been introduced to any new crop technologies through projects?

1.10 Which of these technologies or farming methods that you have started to use?

1.11 Which of the new technologies you have adopted or non-adopted?

1.12 When did you start to use the new technology?

1.13 On which crop do you use the new technology?

1.14 How do you practice the technology?

1.15 On how much land do you practice the new technology? (list for millet , sorghum , cowpea and groundnut). On how much do you not practice the technology?

Crop types	**Amount of land**
Millet	
Sorgum	
Cowpea	
Groundnut	

1.16 How much have yield increased or decreased since you started using the new technology? Specify for each crop

Crop types	**Yield increase**	**Yield decrease**

1.17 How much extra labor use it is in using the technology?

1.18 What are the major advantages of the technology?

1.19 What are the major disadvantages of the technology?

1.20 Do you plan to increase the use of the technology?

1.21 Have you started to cultivate more or less land as a result of this technology?

1.22 If more, how much more land?

1.23 Are you aware if neighbors are using the technologies or farmers in neighboring villages are using the technologies?

Section 2: Reasons of Adoption

2.1 What are your major reasons for adopting new technology? (Specify the technology and reasons for adoption)

Trees technology adoption

2.2 What are the most important trees to you? List in order of importance.

2.3 Which benefit do you get from these trees?

2.4 What are the health effects of the trees?

2.5 Have you been introduced to any new trees through a project? (Please list the trees)

2.6 Which of these trees have you planted?

2.7 How many of the trees below have you planted?

Trees	**Number produced**
Moringa	
Baobab	
Oleifera	
Ziziphus Mauritaniana	
Acacia niolitica	
Acacia tumida	

2.8 How often do you harvest from the trees?

Trees	**Number of harvest**
Moringa	
Baobab	
Oleifera	
Ziziphus Mauritaniana	
Acacia niolitica	
Acacia tumida	

2.9 How do you utilize the products from the trees?

2.10 Do you have any problem with pest and diseases on trees?

2.11 What are the major benefits of using these trees?

2.12 What are the major disadvantages of using these trees?

2.13 How much income do you earn from the trees per year?

Trees	**Amount earn per year**
Moringa	
Baobab	
Oleifera	
Ziziphus Mauritaniana	
Acacia niolitica	
Acacia tumida	

2.14 Do you plan to plant more trees?

2.15 How much extra labor is required to harvest and tend trees?

2.16 Which are the new livestock activities you have been introduced to?

2.17 What is the effect of the new livestock activities on production?

2.18 Explain how you use the new livestock activities?

2.19 What are the benefits of using this livestock technology?

2.20 What are the disadvantages of using this livestock technology?

2.21 How much more income do you earn from new livestock activities?

2.22 Do you plan to expand on this new livestock technologies? (Explain how)……………………………………………………………………………………… ……………………………………………………………………………………………… …………………..………………………………………………………………………… ………………………………………………………………………………………… ………………………………………………………………………………………… ……………………………

Inputs effects on adoption

2.23 Where do farmers get their seeds or trees to plant?

Only the market☐ other cities☐ Self-grown seeds after harvest☐

Others(Specify):…………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………….

2.24 From where do you get the seeds?

2.25 From where do you get the fertilizer?

2.26 How close is the market for inputs or seeds to your farm in kilometers? (Please specify town and estimate distance?

2.27 How much is spent on inputs purchasing before and after the new technology?

	Before new technology		**After new technology**	
Input	**Price**	**Quantity**	**Price**	**Quantity**
Fertilizer				
Seeds				
Labor				

2.28 How easy or difficult is it to access fertilizer from the farm sites?

Very easy□ Easy□ Difficult□ Very difficult□

2.29 Have you received new technology information from:

NGOs?	Yes	No
Government?	Yes	No
Network?	Yes	No

2.29.1 If yes, what sort of information?

NGOs:……………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………..

Government:…………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
………………….

Networks:……………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
…………

<u>Section 3: Impact of adoption</u>

3.1 What are the effects of the new technologies on your food security situation?

3.2 What is the number of insecure most now as compared to five years ago?

3.3 How many bags per hectare were you harvesting using the traditional farming practices?

Crop types	**Bags/hectare using traditional farming practices**
Millet	
Sorgum	
Cowpea	
Groundnut	

3.4 What are what the output parameters for livestock? (Please specify liter of milk per day, time to slaughtering, length between claves, gestation period)

3.5 What are the changes in crop production after adopting the new technologies? (List exact figures per crop?

3.6 What are the changes in livestock production after adopting new technology? (please list and specify)

3.6 What are the numbers of food insecure months before adopting the new technologies? (Provide exact figures)

3.7 What are the numbers of food insecure months after adopting the new technologies?

3.**8 What is the effect of the new technologies on food security?**

3.9 How many trees do you have on your field?

3.10 How much of the products do you sell and how much do you consume in your household?

Farm products	Amount sell	Amount consume

3.11 How much do you sell before and after adopting the new technologies?

3.12 How would you assess the impact of the new technologies on production cost?

Input	Cost of pproduction
Fertilizer	
Seeds	
Labour	

Other:………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………

End of questionnaire

Thank you for your participation

Key informants interview guides

Dear Sir/Madam,

I am Ernest Kwaku Amponsah, a master student with the Department of Environment and Development studies (Noragric) at the Norwegian University of Life Sciences (UMB), Norway. As part of my master degree programme, I am expected to research on a topic of interest. With a keen interest in food security and poverty related issues, I have decided to research on "Farm households' adoption of Ecofarm integrated agriculture technologies and the effects on livelihood security" in Segou, Mopti and Koulikoro regions of Mali.

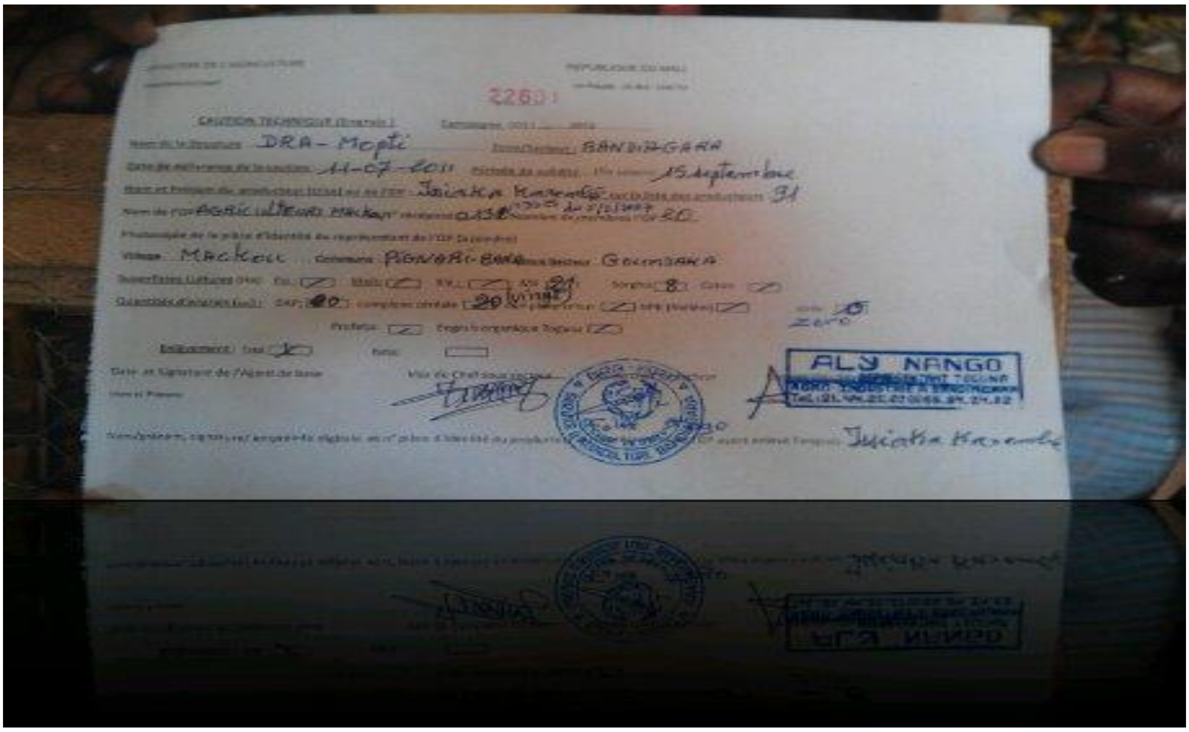
This is a pure academic research and I can guarantee that the information gathered here will be kept solely for research purpose. I will appreciate your kind participation and thank you for your cooperation.

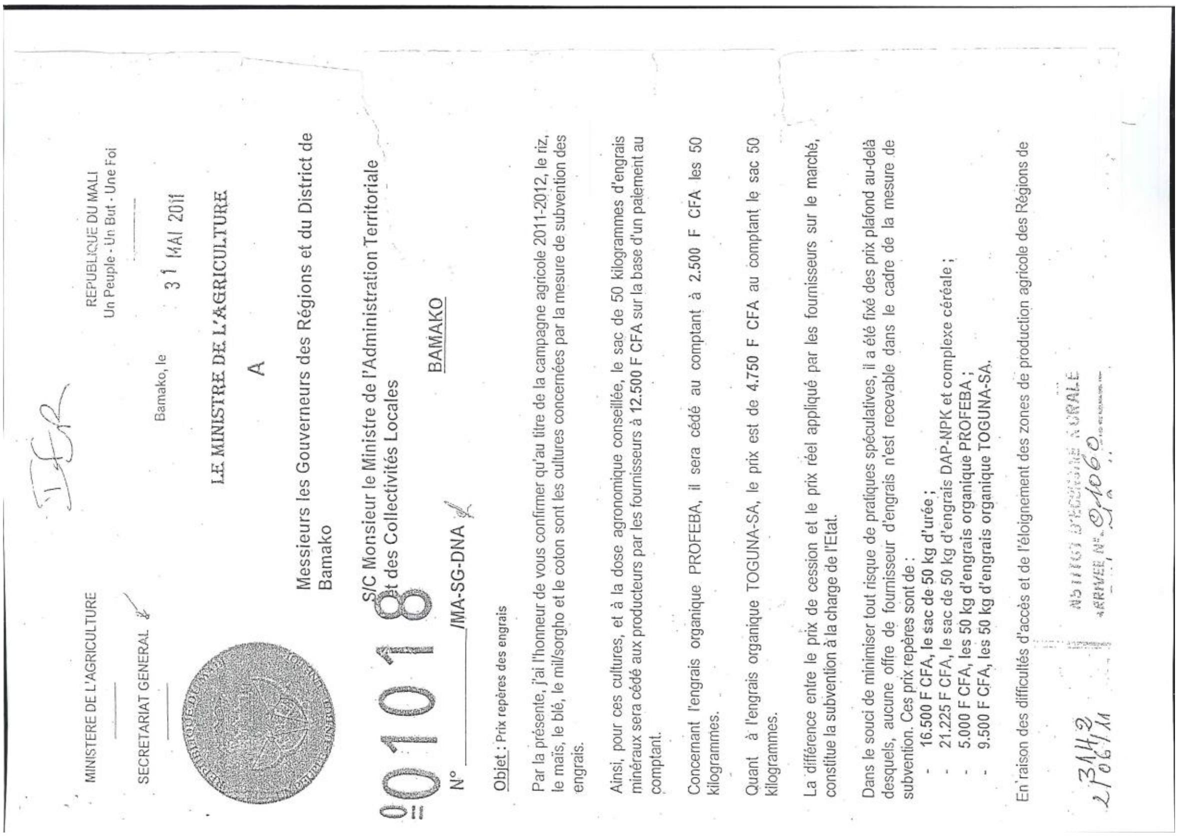
Interview questions

1. Can you give me a brief introduction of yourself?
2. How often have the regions of Segou, Mopti and Koulikoro experience food insecurity?
3. What are the causes of food insecurity in these regions and who are the vulnerable groups?
4. How do the vulnerable farm households mitigate periods of food shortages?
5. What are the traditional or indigenous farming strategies that local farmers used to maintain their livelihood during food insecure months?
6. What are the recent integrated farming strategies or technologies that help improve livelihood against food insecurity?
7. Where and when in the regions have these integrated farming technologies introduced and why?
8. What are the most significant changes in the farm households' livelihood after introducing the new agricultural technologies?
9. What are the side effects in relation to health of the new technologies?
10. What are the challenges associated with introducing those technologies?
11. What is your organization doing to help improve livelihood in terms of food insecurity?
12. What are policies put in place to promote and enhance agricultural and health related issues among the food insecure vulnerable households.

Thank you very much

Appendix II Fig: Government of Mali fertilizer subsidizing sheets. Image taking from an agricultural input retailing shop in Bandiagara town




MINISTERE DE L'AGRICULTURE

SECRETARIAT GENERAL

N° 00101 8 /MA-SG-DNA

REPUBLIQUE DU MALI
Un Peuple - Un But - Une Foi

Bamako, le 31 MAI 2011

LE MINISTRE DE L'AGRICULTURE

A

Messieurs les Gouverneurs des Régions et du District de Bamako

S/C Monsieur le Ministre de l'Administration Territoriale et des Collectivités Locales

BAMAKO

Objet : Prix repères des engrais

Par la présente, j'ai l'honneur de vous confirmer qu'au titre de la campagne agricole 2011-2012, le riz, le maïs, le blé, le mil/sorgho et le coton sont les cultures concernées par la mesure de subvention des engrais.

Ainsi, pour ces cultures, et à la dose agronomique conseillée, le sac de 50 kilogrammes d'engrais minéraux sera cédé aux producteurs par les fournisseurs à 12.500 F CFA sur la base d'un paiement au comptant.

Concernant l'engrais organique PROFEBA, il sera cédé au comptant à 2.500 F CFA les 50 kilogrammes.

Quant à l'engrais organique TOGUNA-SA, le prix est de 4.750 F CFA au comptant le sac 50 kilogrammes.

La différence entre le prix de cession et le prix réel appliqué par les fournisseurs sur le marché, constitue la subvention à la charge de l'Etat.

Dans le souci de minimiser tout risque de pratiques spéculatives, il a été fixé des prix plafond au-delà desquels, aucune offre de fournisseur d'engrais n'est recevable dans le cadre de la mesure de subvention. Ces prix repères sont de :

- 16.500 F CFA, le sac de 50 kg d'urée ;
- 21.225 F CFA, le sac de 50 kg d'engrais DAP-NPK et complexe céréale ;
- 5.000 F CFA, les 50 kg d'engrais organique PROFEBA ;
- 9.500 F CFA, les 50 kg d'engrais organique TOGUNA-SA.

En raison des difficultés d'accès et de l'éloignement des zones de production agricole des Régions de

ARRIVEE N° 01060

31442
27/06/11