An Evaluation of Financial Implications of Legume Technologies on Smallholder Cereal Farmers in Central Malawi

by

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Pectora roborant cultus recti

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DECLARATION

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the authorship owner thereof (unless to the extent explicitly otherwise stated) and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

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ABSTRACT

Most Malawians are directly dependent on cereal production. Smallholder farmers in central Malawi have been affected by decline in soil fertility, due to crop harvest removals, soil erosion and leaching. The consequence is a decline of agricultural productivity leaving Malawi food insecure over the longer term. Nitrogen is the most affected of the soil nutrients. This necessitates a legume inclusion approach in production systems. Legume intercropping is promoted in the tropics with the aim to replenish soil fertility. The importance of legumes include: their potential to improve soil fertility through Biological Nitrogen Fixation, provide nutritional values to humans with their high amounts of proteins and income source for the rural smallholders farmers.

This study was conducted to evaluate the financial implications on smallholder farmers regarding the implementation of BNF (Biological Nitrogen Fixation) and inoculant technologies in current production systems. It focused on certain districts in Malawi including: Ntcheu, Dedza, Mchinji, Salima and Kasungu. The main aim of the study was to; (i) determine current production systems used in the selected areas, (ii) assess the proposed alternatives based on research results, (iii) assess the practical implications of adoption of BNF and inoculation technologies on crop systems in the selected areas and (iv) determine the financial implications of the implementation of legume technologies on smallholders production systems.

Group discussion methods were used to stimulate interaction among participants to describe the current production systems, to validate the outcome of trial results on farm level and to determine practical implications of adopting alternative systems. The method needed to be suitable for capturing the complex smallholder farming systems and collect data to evaluate profitability implications on farm level. Both gross margin and partial budget models were developed to determine the financial implications of the adoption of legume technologies. For each area a typical farm was used as the basis for comparing the before and after adoption financial situation of smallholder production systems. The crops typically included, in a system with maize, are: soy beans, common beans, cowpeas and groundnuts.

Gross margins increased for all crops and for all the districts after the adoption of the legume technologies. Low crop yields before the adoption of the legume technologies are attributed to recycling of seed, low-yielding varieties or lack of legumes, insufficient fertilizer use and low levels of knowledge and skills. Intercropping system helps the farmers minimize risk against total crop failure and maximize cultivation per area. This lessens the challenges of small farms to some extent. Furthermore, the results reveal that farmers have benefitted financially from the implementation of

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legume technologies. The results have not been able to identify any negative implications on the adoption of legume technologies on the intercropping systems in the selected areas in Malawi. The gain from the inclusion of legume technology is, however, indicative of the low yield levels before the adoption. The legume technologies hold potential to contribute to productive and sustainable agricultural systems for the smallholder farmers in Malawi.

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OPSOMMING

Die meeste Malawiërs is direk afhanklik van graanproduksie. Kleinboere in sentraal Malawi word geaffekteer deur dalende grondvrugbaarheid weens verwydering van oeste en oesreste, gronderosie en dreinering. Die gevolg is ŉ afname in landbou produktiwiteit wat Malawi oor die langer termyn in ŉ voedsel onseker situasie laat. Die mees geaffekteerde grond voedingstof is stikstof. Dit noodsaak ŉ benadering van insluiting van stikstofbinders in produksie sisteme. Stikstofbinder tussenverbouing word in die trope aangemoedig met die doel om grondvrugbaarheid te herstel. Die belangrikheid van stikstofbinders sluit in: vermoë om grondvrugbaarheid te herstel deur biologiese stikstof binding, dra by tot menslike voeding weens hoë proteïen inhoud en dien as bron van inkomste van kleinskaalse, plattelandse, boerderye.

Hierdie studie is uitgevoer om die finansiële implikasies van die insluiting van stikstofbindende tegnologie en inokulante in bestaande produksiesisteme te evalueer. Die studie fokus op bepaalde areas in Malawi insluitende: Ntcheu, Dedza, Mchinji, Salima en Kasungu. Die hoofdoelwitte van die studie was om: (i) die huidige produksiestelsel vir elke area te bepaal, (ii) die voorgestelde alternatiewe te asseseer, gebaseer op navorsingsresultate, (iii) die praktiese implikasies van die inkorporering van biologiese stikstof binder tegnologie in die gewasstelsels vir elke area te bepaal en (iv) bepaal die finansiële implikasies van die implementering van alternatiewe tegnologie op bestaande kleinboereproduksiestelsels.

Groepbesprekings is as metode aangewend om interaksie tussen deelnemers aan te moedig om die huidige produksiestelsels te beskryf. Dit ondersteun ook die validasie van die uitkoms van die proefresultate en die bepaling van praktiese implikasies van die implementering van ŉ alternatiewe produksiestelsel. Die metodiek moes toepaslik wees om die kompleksiteit van die kleinboerstelsel te akkommodeer en om die nodige data te versamel. Die data is geï mplementeer om die impak op winsgewendheid van kleinboere produksiestelsel te evalueer. Beide vertakkingsbegrotings sowel as gedeeltelike begrotings is aangewend om die implikasies van alternatiewe produksiestelsels op winsgewendheid te evalueer. Vir elke area is ŉ tipiese kleinboereenheid gebruik as basis vir vergelyking tussen die voor en na tegnologie implementering in terme van winsgewendheid van ŉ produksiestelsel. Gewasse wat tipies aangewend is as stikstofbindend, in wisselwerking met mielies, sluit in: sojabone, gewone bone, swartbekbone en grondbone.

Die bruto-marge het toegeneem vir alle gewasse en oor alle areas na die implementering van stikstofbinder tegnologie. Lae opbrengste voor die aanvang van die tegnologie is toegeskryf aan hergebruik van saad, lae opbrengs variteite of geen gebruik van stikstofbinders, ondoeltreffende kunsmis aanwending en gebrekkige kennis en vaardighede. Tussenverbouing help minimaliseer die

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produksie-risiko van klienboere teen totale misoeste en maksimeer verbouing per area. Dit verminder die uitdagings vir kleinboere, tot ’n mate. Verder wys die resultate dat die klienboere finansiële voordeel trek uit die implementering van die stikstofbindende tegnologie. Die resultate wys geen negatiewe implikasies vir tussenverbouing vir enige van die areas in Malawi nie. Die toename in opbrengs dui egter op die lae opbrengs wat voor implementering gehandhaaf is. Die stikstofbindende tegnologie het potensiaal om positief by te dra tot volhoubare produksiestelsel vir kleinboere in Malawi.

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DEDICATION

I dedicate this thesis to you my father Michael (late) and mother Patricia for showing me that not even the sky is the limit.

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ACRONYMS AND ABBREVIATIONS

ADD	Agricultural Development Division
AEDC	Agricultural Extension Development Coordinator
AEZ	Agro-ecological zone
ATP	Adenosine Triphosphate
BNF	Biological Nitrogen Fixation
DARTS	Department of Agricultural Research & Technical Service
ECAH	East and Central Africa Highland
EPA	Extension Planning Area
FGD	Focus Group Discussion
FISP	Farm Input Subsidy Programme
GM	Gross Margin
ISFM	Integrated Soil Fertility Management
KG	Kilogram
MDG	Millennium Development Goal
MoA	Ministry of Agriculture
MoAFS	Ministry of Agriculture and Food Security
MK	Malawi Kwacha
MEGS	Malawi Economic Growth Strategy
MGDS	Malawi Growth and Development Strategy
NGO	Non-governmental Organizations
PRA	Participatory Rural Appraisal
RRA	Rapid Rural Appraisal
SSI	Semi Structured Interview
SAP	Southern Africa Plateau
SSA	Sub Sahara Africa
T/ha	Metric Tons per hectare
USD	Unites States Dollar
WAGS	West Africa Guinea Savannah

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CHAPTER I: INTRODUCTION

1.1 Background

Food insecurity in Malawi has been prevalent (Chinsinga, 2005) and has primarily been attributed to poor soil fertility and a decline in agricultural productivity (Devereux, 2002). Soil nutrient depletion has come about gradually as a result of crop harvest removals, soil erosion and leaching. Unfortunately, farmers have not been able to replenish soil fertility sufficiently through application of inorganic fertilizers, manure or through the retention of crop residues (Shepherd and Soule, 1998). High costs of inputs have caused the use of inorganic fertilizers to be limited, which has hampered solutions to the challenge of low soil fertility. Furthermore, smallholder farmers do not use the recommended rates of inorganic fertilizers (Mutuma, 2013). Malawi's national yields of maize have averaged 1.3 metric tons per hectare (t/ha) during the last 20 years. In contrast, the average yield of rain fed maize in Iowa in the United States (1997–2007) exceeded 10 t/ha (Sanchez, 2002). Over half of Malawi's farming households operate below subsistence. Because of low productivity and small farm size, only 20 percent of maize farmers produce surplus and sell their product (Sanchez, 2002).

Among the essential soil nutrients, nitrogen is the most affected due to its high vulnerability to leaching, high uptake by plants, losses in gaseous form and through crop harvests (Mutuma, 2013). Low cost and sustainable technical solutions, compatible with the socio economic conditions of smallholder farmers, are needed to solve soil fertility problems.

Legumes are significant crops for Malawi and serve as a supplement to the staple food crop, maize (Zea mays L.) (Goyder and Mang'anya, 2009). Legumes are especially important in Malawi for various reasons, namely: their potential to improve soil fertility by nitrogen fixation, their ability to reduce soil erosion, the presence of high amounts of protein, vitamin A and oils which help overcome nutritional deficiencies, and their potential to serve as income sources for rural and smallholder farmers (Chamango et al., 2013).

In view of this legume intercropping, an organic farming approach is being promoted in the tropical areas with an aim of replacing soil nutrients, improving soil structure and controlling weeds by suppressing them while generally improving overall yield (Mutuma, 2013). Integrated Soil Fertility Management (ISFM) has been developed as a new paradigm in order to try and address the issue of soil infertility. The main aim of ISFM is to develop and promote technologies that replenish soil fertility and are suitable for various kinds of resource-poor farm households (Crowley and Carter, 2000). One such technology is the use of Rhizobia inoculants that enhance Biological Nitrogen Fixation (BNF). BNF can be a cost effective substitute of lessening the problem of low soil fertility

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(Giller, 2001). Most soil types contain Rhizobia but are usually available in either small populations, or are poorly effective or non-effective to many host legumes at symbiotic BNF. In addition, native Rhizobia may act as a barrier to nodulation by inoculants (FAO, 1984; Thies et al., 1991). This necessitates the use of inoculation with a choice Rhizobia strain in high quality formulation. Legumes will, in this case, play a vital role of improving soil fertility through BNF (Jonas et al., 2011). BNF could be a key source of nitrogen for farmers using little or no fertilizer and constitutes one of the potential solutions and key roles in sustainable grain legume production (Jonas et al., 2011). Improved agricultural productivity could thus be achieved by production of grain legumes (Woomer et al., 2014).

Malawi is no exception to other countries which have been affected by low agricultural productivity due to poor soil fertility. Many years of intensive cultivation by smallholders, in the absence of significant fertilizer use, have depleted soils of nutrients; particularly nitrogen (Denning et al., 2009). In response to the challenges highlighted above, the N2Africa project carried out an extensive study between 2009 and 2013. The main aim of the project was to promote nitrogen fixation to work for smallholder legume farmers through effective production technologies, including inoculants and fertilizers. The study was done in eight African countries (Ghana, Nigeria, Ethiopia, Tanzania, Uganda, Democratic Republic of Congo, Rwanda, Malawi, Kenya, Mozambique and Zimbabwe) and reached more than 230,000 farmers (Woomer et al., 2014).

In Malawi the study was implemented in the central region in six districts: Dowa, Ntcheu, Salima, Kasungu, Mchinji and Dedza (Woomer et al., 2014). All of the project's four target legumes: groundnuts, cowpeas, common beans and soya beans were evaluated and 27,000 households participated. The project formed partnerships with non-governmental organizations, farmers' associations, agro-dealer networks and the Malawi government through the Ministry of Agriculture and Food Security (MoAFS) (Woomer et al., 2014). Much of the project's focus was on the promotion of legume and inoculant technologies through participatory research, and delivery and dissemination of the tested technologies through lead farmers and their grassroots groups (Woomer et al., 2014).

1.2 Problem statement and research question

Malawi is among the countries that have been the worst affected by low agricultural productivity due to poor soil fertility. Poor soil fertility has come about because smallholder farmers have, for a long time, been cultivating either without using fertilizer or using fertilizers in insufficient amounts. This has resulted in depletion of soil nutrients particularly nitrogen (Denning et al., 2009). Recent reports indicate that agronomic efficiency in smallholder crop production remains very low (Tchale, 2009; GoM, 2007 and Chirwa, 2003). Improved agricultural productivity could be achieved by production of grain legumes (Woomer et al., 2014). Legumes for small scale farmers play both the roles of cash crops for income and subsistence crops for family nutrition (FAO, 2015). A number of studies have been carried out to assess the agronomic and economic paybacks of legume-cereal intercrops in various parts of the world (Rao and Mathuva, 2000; Mburu, et al., 2003). Further assessment is required to understand financial and managerial implications that legume technologies may have on smallholder farmers. This could contribute towards an even higher adoption rate of the technologies if it can be shown that, despite the positive attributes of BNF and inoculants on soil health, it also has financial benefits. The general problem is thus a lack of insight in the possible financial and managerial implications for smallholder farmers in Malawi to adopt this technology.

In light of the research problem, the research question this work engages with is as follows: What are the financial and managerial implications on smallholder farmers regarding the implementation of BNF and inoculant technology in current production systems in selected areas in Malawi?

1.3 Research objective and goals

The main objective of this study is to determine and evaluate the financial and managerial implications of BNF and inoculant technologies on smallholder production systems in selected areas in Malawi.

The study particularly focuses on the following goals:

i To assess current production systems being used in selected areas in Malawi, as well as the proposed alternatives based on research results, and

ii To determine the financial implications of the implementing BNF technologies and use of inoculants on legumes.

1.4 Justification for the project

There is still limited knowledge and understanding regarding the farm-level financial and managerial implications of the inclusion of nitrogen fixers in crop production systems for smallholders. The inclusion of a new crop diversifies the farmers' production and market, but also adds some complexity. It is thus important to understand the profitability of producing legumes and also quantify the implications of the inclusion of legume technologies and their impact on legume production systems particularly soya beans, cow peas, common beans and groundnuts.

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This study therefore will investigate whether the technologies previously disseminated by the N2Africa project have had favourable results on the financial and managerial aspects of the production activities of Malawi's smallholder crop farmers. Such benefits will increase farm income and agricultural productivity, improve rural livelihoods for poor farmers in Malawi and enhance soil health. This study will mainly contribute to the body of knowledge on the significance of BNF and inoculation technologies on legumes for the agricultural productivity of the smallholder legume industry in Malawi. Furthermore, the study will also contribute to the body of knowledge for local and international non-governmental organizations and stakeholders on whether the use of these technologies holds any financial and managerial benefits for the Malawian smallholder farmers.

1.5 Limitations and proposed methods

The geographical area of data collection was restricted to five of the six administrative districts in which N2Africa implemented the project in phase I. Dowa district was excluded due to administrative challenges that were there between N2Africa and one of the NGOs who have since pulled out of the partnership.

The study also did not focus on the analysis of implications of the same technologies on all other stakeholders who participated in the project, such as non-governmental organizations (NGOs), agro-processors and input suppliers.

The sample population included adopters who have been with the project since the onset, non-adopters and those who adopted but discontinued in the course of the project. This aspect will be discussed more fully in the Chapter 3.

Another limitation to the study is that it has been assumed that all inputs have been taken into account. However, in this study as well as in other studies, it is possible to raise questions about whether all inputs have actually been accounted for, since farms that are apparently inefficient may just use less of certain measured inputs.

1.6 Layout of the rest of study

Chapter Two presents a literature overview. The reviewed studies are in areas of legume production in Malawi and it further reviews studies that applied improved technologies on legume production,

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which is the core focus in this study. The chapter further reviews literature on the policies and strategies the Malawi government has put in place to promote legume productivity, particularly for smallholder farmers in Malawi and the importance of the legume industry. It finishes with an overview of the literature focusing mainly on the research approach and budget model relevant to this study, and definitions of keys terms of the study.

Chapter Three sets out the research design and method. The chapter presents the research design and the rationale behind it. The chapter then justifies the reliability and validity of the study; describing the research methods and study location. It further presents the description of how research data was analysed and research ethics that were followed in carrying out the study.

Chapter Four presents the study results, which are then related to the formulated objectives of the study. The chapter focuses on the profitability of the legume technologies based on the use of the partial budget model and the managerial implications that are associated with the legume production. It further suggests crop rotation scenarios that would increase legume productivity for the smallholder farmers.

Chapter Five contains the conclusion, summary and recommendations that flow from the study.

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CHAPTER II: OVERVIEW OF LEGUME SYSTEMS IN MALAWI

2.1 Introduction

Chapter One highlighted the potential positive impact of various forms of BNF and inoculants on smallholder production systems. There is still a lack of knowledge regarding the potential financial benefits. This might improve the adoption rate of such technologies amongst smallholder farmers in Malawi. Chapter Two establishes the role of smallholder legume production in sub-Saharan Africa (SSA). This broadens the perspective of the potential role of nitrogen fixing technology for the individual smallholder farmer, also for Malawi and potentially the region. It is important to understand that Malawian smallholder farmers are mostly orientated towards maize production. It is often difficult for them to assess alternative options purely on scientific evidence, as maize production is almost "a way of life". This chapter focus mainly on the alternative to maize, although it must be kept in mind that maize will remain the core crop for food security purposes. The alternatives are merely proposed to enhance maize production and to widen the spectrum of nutrients in the household diets. The chapter further reviews the legume industry in Malawi, some of the government policies put in place to enhance production and factors that affect production. Special focus is given to the role and importance of legume technologies for improved legumes.

The second part of Chapter II focuses on the research methods applied during this study project. Firstly it is important that the complexity and limited options of smallholder farmers are understood. This is presented in a systems orientated method; in this instance an application of multidisciplinary research is proposed. This method is focus group discussions and is based on using knowledge obtained from communities in combinations with scientific expert knowledge to study specific problems. The results and comparisons are simulated with budget modelling, which is a method of simulation based on accounting principles.

2.2 Overview of Legume Industry

Low crop yields are a common challenge facing most farming systems in SSA (FAO, 2015). The low yields are more evident in grain legumes and are often linked to decreasing soil fertility and reduced nitrogen fixation due to biological and environmental factors (Jonas et al., 2011). Recently there has been a rise in international and domestic prices of inorganic fertilisers (Weddington, 2003). More than 75 percent of the inorganic fertilizers used in Africa are imported. This has created pressure on foreign exchange (Jonas et al., 2011). Most smallholder farmers in Africa are now incapable of purchasing these more expensive high mineral fertilizers (Jonas et al., 2011). This has stimulated

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more interest to increase the growing of legumes and to improve management in smallholder farming areas. Particularly in the semi-arid areas of Africa it can provide a source of nutrients at a low cost (Weddington, 2003).

In most of the southern region of Africa, smallholder arable farming is dominated by maize production. Agricultural productivity in the region is poor, with annual national average grain yields varying between 0.3 and 2.2 metric t/ha in 2008 to 2012 in Mozambique, Malawi and Zimbabwe (FAOSTAT, 2014). Grain legumes provide promising entry points to diversify cropping systems and improve soil fertility management due to their multiple benefits (Kamanga et al., 2010). Improved system productivity could be achieved by production of grain legumes, yet they are often intercropped as minor crops compared with cereals, roots or tubers (Woomer et al., 2014).

Legumes belong to the family "*Fabaceae*" and are the third largest family of flowering plants. The family of "legumes" includes many diverse and important agricultural crops. Legume species are found all over the world with a wide range of growth patterns. Legumes can grow as trees, shrubs or herbs (Doyle and Luckow, 2003). About 180 million hectares or 12 to 15 percent of the earth's arable land is used for grain and forage legume production (Vance et al., 2000). Legumes account for 27 percent of the world's primary crop production, with grain legumes alone contributing to 33 percent of the dietary protein nitrogen needs of humans. Under subsistence conditions the percentage of legume protein nitrogen in the diet can reach twice this figure (Vance et al., 2000). Smallholder farming systems have for long been growing grain legumes such as groundnut (*Arachis hypogaea L.*), soya bean (*Glycine max (L.) Merrill*), cowpea (*Vigna unguiculata (L.) Walp*.), common bean (*Phaseolusvulgaris L.*) and pigeon pea (*Cajanus Cajan (L.) Millsp*.). These are grown as intercrops or rotation crops with cereals throughout Southern and Eastern Africa.

2.3 Legume industry in Malawi

Malawi is a landlocked country in Southern Africa and is situated between the latitudes 9°22′S and 17°03′S and longitudes 33°40′E and 35°55′E. The country remains one of the poorest countries in the world. Around eight percent of Malawians are at risk of food insecurity each year, often because of poor harvests due to erratic rains and dry spells, and limited alternative income sources (Sichali et al., 2013). Malawi's Human Development Index of 0.464 ranked the country 163rd out of 174 countries in the year 2000. About 74 percent of the population still lives below the income poverty line of US$1.25 a day and 90 percent below the US$2 a day threshold (Sichali et al., 2013).

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The human population of Malawi in 2014 was estimated at almost 17 million, with 80 percent living in the rural areas and about 45 percent of the population classified as poor (GoM, 2006). Malawi's soils lose on average 40.0, 6.6 and 32.2 kg per hectare per year in nitrogen (N), phosphorus (P) and potassium (K), respectively. Apart from declining soil fertility, Malawi's land holding sizes, especially in the smallholder sector, are also declining (Smaling, 1998). According to the Malawi Poverty and Vulnerability Assessment report (GoM, 2007), over 90 percent of the total agricultural value added comes from about 1.8 million smallholders who own on average less than 1.0 ha of land. Malawi's agricultural productivity is therefore under threat.

A rapid increase in population has given rise to great pressure on the land. Fallow phases for restoring soil fertility have been greatly reduced, especially in the smallholder farming systems, and agricultural production is expanding to marginal and less fertile areas. This is leading to severe deforestation, soil erosion and a general degradation of the natural resource base (FAO, 2008). The rapid population increase also puts enormous pressure on agriculture to grow at levels sufficient to feed the growing population. Given the declining land holding sizes, the only plausible way to improve agricultural productivity is to enhance efficiency (Tchale, 2009). To maintain high productivity in the face of declining land holding sizes, there is a particular need to improve the efficiency of the smallholder sub-sector, which is by far the largest, with nearly three million farm families cultivating on over 70 percent of Malawi's arable land held under customary tenure.

2.4 Malawi's Agriculture Sector Policy

Malawi's agricultural policy is to promote and facilitate productivity in order to safeguard food security, increase incomes and create employment. This is to be achieved through sustainable management and utilization of natural resources, adaptive research and effective extension service delivery system, promotion of value addition, agri-business and irrigation development (GoM, 2006). This agricultural policy is developed in line with the Malawi Growth and Development Strategy (MGDS), Malawi Economic Growth Strategy (MEGS), Malawi Vision 2020 and the Millennium Development Goals (MDGs).

Agriculture is by far the most important sector of Malawi's economy, accounting for 35 to 40 percent of Gross Domestic Product (GDP). The sector employs about 85 percent of the labour force, contributes to over 90 percent of export earnings and accounts for 83 percent of foreign exchange earnings (GoM, 2007). Malawi's agricultural sector is composed of two main sub-sectors: estates and smallholders.

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2.4.1 Estates Sub-Sector

The estate sub-sector contributes only about 20 percent of total national agriculture production and it provides over 80 percent of the agricultural exports (GoM, 2003). This sub-sector is comprised of estates mostly growing tea, coffee and tobacco for export (Chirwa, et al., 2006). Tobacco is the major export earner and contributes to about 65 percent of the country's export earnings, followed by tea at eight percent and sugar at six percent. Maize is a major food crop seconded by rice, which contributes to about 0.2 percent export earnings (GoM, 2003).

2.4.2. Smallholder Farm Sub-Sector

The smallholder farmer sub-sector comprises an estimated 2 million farm households. These farmers use about 6.5 million hectares for cultivation (GoM, 2003). The smallholder sector, with cropping systems dominated by rain-fed farming, is characterized by low levels of inputs and outputs yet it produces more than 80 percent of the total food and contributes to about 20 percent of Malawi's agricultural exports (Chirwa, et al., 2006).

2.5 Poverty Reduction and Rural Development

The Malawi government put in place strategies that aim at increasing agricultural productivity. The key objectives include: encouraging the expansion and intensification of staple food production by smallholder farmers, promoting soil and water conservation, and farming techniques (GoM, 2006). This is to be achieved through increased access to land, credit and farm inputs by smallholder farmers. Additionally, improvement in agricultural technology, prevention of land degradation and deforestation, improving agricultural diversification, improvement of extension and farming and development of irrigation systems is necessary as well (GoM, 2006).

Malawi is working towards diversifying its predominantly maize and tobacco-based production systems. It further aims to engage traditional (often subsistence) smallholder farmers in more market oriented agriculture through better market access and integration into agricultural value chains (Sichali et al., 2013). Crops like groundnuts, pigeon peas and beans offer high nutritional value and potential income sources for poor farmers, but good quality seed is rarely available, partly because of a self-reinforcing "vicious circle" in which seed producers believe there is no market for improved seed as farmers use recycled seeds (Sichali et al., 2013).

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2.5.1 The Presidential Initiative on Poverty and Hunger Reduction

A recent government strategy that focuses on legume production in Malawi is the Presidential Initiative on Poverty and Hunger Reduction. The project was launched in 2012 and its aim is to promote the production, processing, storage, utilization and marketing of legumes. Poverty levels in Malawi are especially high in rural areas which face severe climatic challenges. Over 80 percent of the rural population depends on agriculture for their livelihood. The legume initiative focuses on agricultural diversification and enhancement of economic growth (Mayer, 2014).

2.5.2 The Farm Input Subsidy

Previously the Malawi government also embarked on an ambitious agricultural input subsidy program - the Farm Input Subsidy Program (FISP). This is just one of the initiatives that have significantly revolutionized agricultural productivity and that has caused Malawi to progress from being food insecure in 2002 to recording surplus maize production in 2006 and consecutive subsequent years (Monyo and Gowda, 2014). The main objective of this program is to increase agricultural production and ensure food security through the provision of government-subsidized agricultural inputs to smallholding farmers (Chibwana et al., 2012).

The program has since been extended to legume seeds such as groundnuts, beans, soy beans and cowpeas, stimulating private sector participation in legume enterprise development (Monyo and Gowda, 2014). The inclusion of legumes in the FISP was strongly advocated by the donors of the programme in order to incentivize legume agriculture, boost farmers' incomes, improve nutrition and preserve soil health (Chinsinga, 2011). Poor crop productivity has partly been addressed by the FISP (Chibwana et al., 2012). FISP has contributed to an increase in agricultural production due to the input subsidy program and to some extent, an increase in cropping areas (GoM, 2003).

Smallholder agriculture in Malawi is dominated by maize cultivation at very low levels of productivity. Maize accounts for over 85 percent of the smallholder cultivated land (Jewell et al., 1995). The government aims at broadening the scope of crops involved in the subsidy programme, particularly the inclusion of legumes as a means of diversifying away from maize, improving soil fertility and boosting farmers' income and nutrition (GoM, 2003). The Malawi government, through FISP, has contributed to raising national maize productivity and reducing rural poverty but the programme is not without controversy.

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Households participating in the FISP have been found to simplify crop rotations by allocating more land to maize and tobacco at the expense of other crops such as groundnuts, soya beans and beans (Chibwana et al., 2012). The over-reliance on maize has led to repeated recommendations for crop diversification using legumes. Efforts to promote green manure legumes did not result in wide-scale adoption in Malawi, due to the land and labour investments required and the lack of edible or marketable yield (Snapp and Silim, 2002; Sirrine et al., 2010).

2.6 Importance of Legumes

As mentioned earlier legumes contribute to a wide range of functions in a cropping system. These include contributions to family nutrition, improved soil fertility and as a potential source of extra family income.

2.6.1 Nutritional value

Legume crops are important to smallholder farmers for a number of reasons. Most legumes play a crucial role in human food, nutrition security and agro-ecosystems (Monyo and Gowda, 2014). Grain legumes in particular are key components of healthy diets because these contain essential protein and minerals, help in reducing pest and disease build-up associated with mono-cropping of maize, and improve nitrogen availability for succeeding crops. Significant yield increases of cereal crops and subsequent legumes, in comparison with monocultures of cereal, have been observed broadly throughout the SSA (Ncube et al., 2007).

Legumes also help intensify staple cereal, roots and tuber cropping systems as catch, relay and intercrop options and provide nitrogen and other soil health benefits associated with crop rotation (Franke et al., 2008). The protein content in legume grains are two to three times higher than in the starchy staples that form the bulk of the diets of smallholder and poor urban families, thus providing critical nutritional and health benefits (Monyo and Gowda, 2014). Grain legumes signify a vital source of protein for human nourishment and often compete successfully with annual proteins as the major source of dietary protein in tropical third world countries (Miller and May, 1991). An assessment of traditional cropping systems in Africa reveals that crop rotation involving legume and cereal monocultures, is much more sustainable than intercropping; the most central practice culturally in the continent. Realizing sustainable yields in SSA would entail a better understanding of how BNF in legume residues are managed in the soil setting (Dakora and Keya, 1997).

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2.6.2 Soil fertility

One of the most common benefits of legumes is its contribution to soil fertility. It is mainly due to its role in Nitrogen fixation that results in increased nitrogen availability for other crops.

2.6.2.1 The significance and role of legume technologies in Agriculture

Some 40 to 60 million metric tons (Mt) of atmospheric Nitrogen are fixed by agriculturally important legumes annually, and another three to five million Mt are fixed by legumes in natural ecosystems (Smil, 1999). A large number of studies have been done on the role that legumes play in farming systems ('t Mannetje et al., 1980; Norman, 1982; Crowder and Chheda, 1982; Haque and Jutzi, 1984; Agishi, 1985). The primary role that legumes play is to fix atmospheric nitrogen (N_2) through their symbiotic relationship with Rhizobium spp., usually associated with the root system of the plant's host. This contributes nitrogenous compounds to the soil, either directly by nodule excretion, or indirectly, by decomposition of root nodules and tissues (Haque et al., 1986). Nitrogen is also distributed to the soil from the top growth through litter fall, through leaching, by rain from above-ground parts and by deposition of excretory materials from herbivores, both above and below the ground (Haque et al., 1986).

2.6.2.2 The process of Biological Nitrogen Fixation

Legumes are important in agriculture as they form associations with bacteria that "fix nitrogen" from the air. Effectively this amounts to internal fertilisation and is the main reason that legumes are richer in proteins than all other plants (Broughton et al., 2002). This crucial role of fixation of atmospheric N_2 leads to two dependent or consequential roles of legumes: (1) their capacity to increase soil fertility and, (2) the generally high levels of protein in the herbage and hence its high forage or mulching quality (Haque et al, 1986). Figure 2.1 illustrates the nitrogen fixation process in detail:

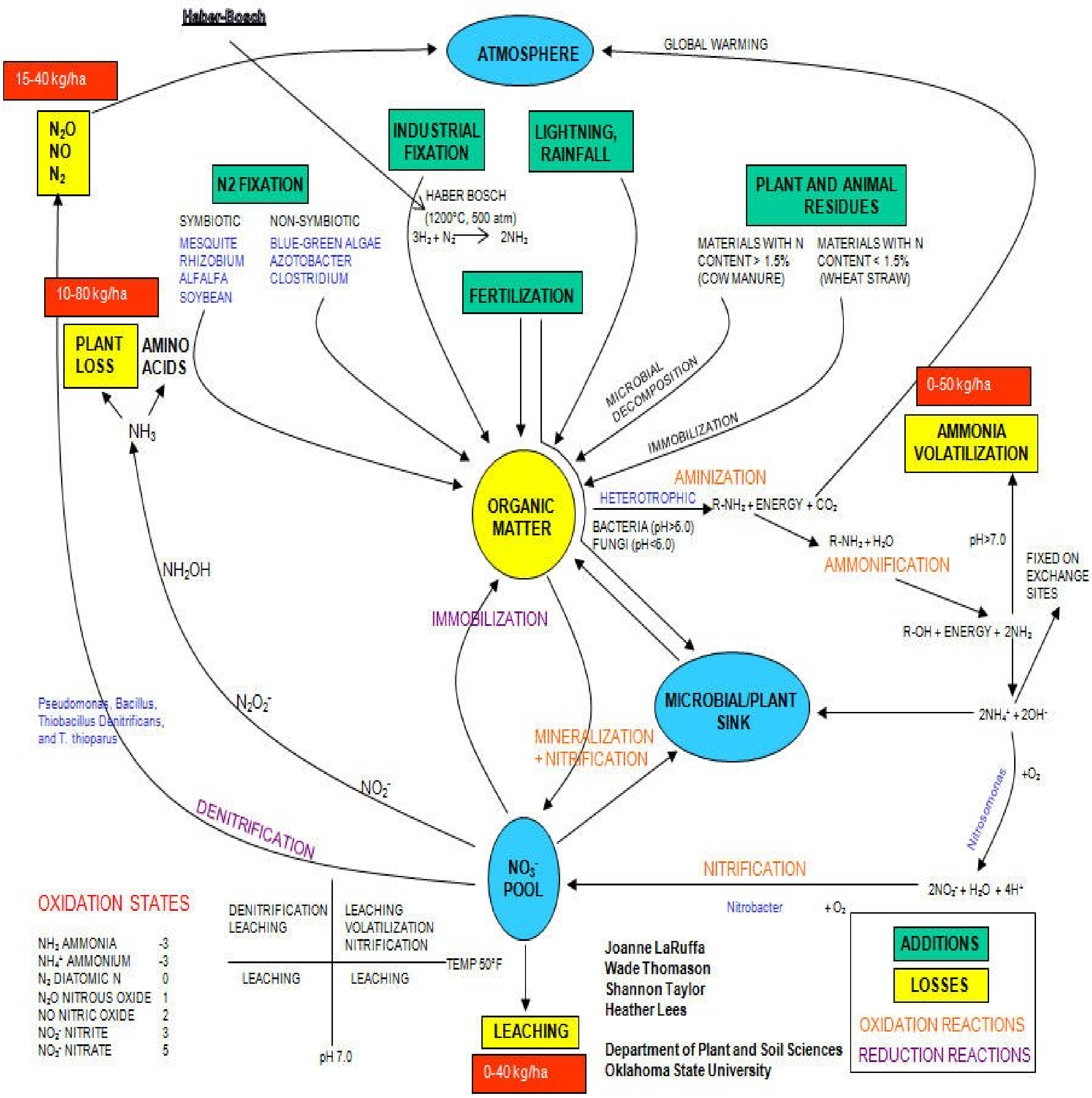

Figure 2:1 Biological Nitrogen Fixation

Source: www.nue.okstate.edu/ncycle.htm

Although the process involves a number of complex biochemical reactions, it may be summarized in a relatively simple way by the following equation:

$N_2 + 8H_2 + 16ATP \text{ ------> } 2\,NH_3 + 2H_2 + 16ADP + 16\,P_i$

The equation above indicates that one molecule of nitrogen gas (N_2) combines with eight hydrogen ions (also known as protons) (8H+) to form two molecules of ammonia ($2NH_3$) and two molecules of hydrogen gas ($2H_2$). This reaction is conducted by an enzyme known as Nitrogenase. The 16 molecules of Adenosine Tri-Phosphate (an energy storing compound) represent the energy required

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for the BNF reaction to take place. In biochemical terms 16 ATP represents a relatively large amount of plant energy (Oregon State University, 2008). Thus, the process of BNF is “expensive” to the plant in terms of energy usage. The sun is the ultimate source of this energy needed for BNF via the process of photosynthesis. As ammonia (NH_3) is formed it is converted to an amino acid such as glutamine. The nitrogen in amino acids can be used by the plant to synthesize proteins for its growth and development (Oregon State University, 2008).

Inoculation of legume crops with rhizobia has been widely used on farms in agricultural systems to enhance legume productivity (Hartmann et al., 1998). Inoculation of leguminous seeds with selected rhizobial strains is practised in agriculture to boost the plant yield by improved nodulation of roots and uptake of nitrogen by the plant. However, effective symbiosis between rhizobia and legumes does not only depend on the capacity of nitrogen fixation but also on the entire nitrogen turnover in the rhizosphere (HuicBabic´ et al., 2008). Also, commercially available rhizobial inoculants often fail to become established in soils with indigenous rhizobial populations (Hartmann et al., 1998). In sustainable agriculture, biological atmospheric nitrogen fixation is an important pathway of nitrogen input into agricultural soils besides the application of organic and mineral fertilizers (Sharma et al., 2005).

2.6.3 Source of income

Grain legumes are an important source of cash income, particularly in semi-arid areas (Abate and Orr, 2012). Legumes in general are considered to be relatively profitable crops compared to other options such as cereals (Broughton et al., 2002). For small scale farmers they double up as cash crops for income and subsistence crops for family nutrition (FAO, 2015). In eastern and southern Africa for example, Kenya and Malawi are the two biggest producers of pigeon peas. In Kenya, 45 percent of the crop is sold, while in Malawi the corresponding share is 35 percent (Shiferaw et al., 2008, Simtowe et al., 2009). In Ethiopia, which is Africa’s biggest producer of chickpeas, 80 percent of the crop is sold (Kassie et al., 2009). In Malawi, the region’s biggest producer of groundnuts, 29 percent of the crop is marketed (Simtowe et al. 2009). The share of farm households selling legumes is high. In Kenya, 60 percent of growers sell pigeon peas (Shiferaw et al., 2008), while in Malawi the share is 91 percent (Simtowe et al. 2009). In Malawi, 73 percent of growers sell groundnuts (Simtowe et al. 2009).

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2.6.4 Definitions of key terms

Grain legumes, also known as pulses, are plants belonging to the family Leguminosae (alternatively Fabaceae) and are grown primarily for their edible seeds. The seeds are harvested when mature and marketed dry to be used as food or feed or processed into various products. Being legumes, these plants have the advantage of fixing atmospheric nitrogen for their own needs and for soil enrichment, thereby reducing the cost of fertilizer inputs in crop farming. Crops that are harvested green for forage and for vegetables are excluded, as well as those grown for grazing or green manure. Also excluded are the leguminous crops with seeds which are used exclusively for sowing, such as alfalfa and clover (FAO, 2010).

Biological nitrogen fixation (BNF) is the term used for a process in which nitrogen gas (N_2) from the atmosphere is incorporated into the tissue of certain plants. Only a select group of plants is able to obtain Nitrogen (N) this way, with the help of soil microorganisms. Among forage plants, the group of plants known as legumes (plants in the botanical family Fabaceae) are well known for being able to obtain N from air N_2 (Oregon State University, 2008).

The Webster (2014) dictionary defines rhizobium as a genus (family Rhizobiaceae) of small heterotrophic soil bacteria capable of forming symbiotic nodules on the roots of leguminous plants and there become bacteroids that fix atmospheric nitrogen. Rhizobia require a plant host; they cannot fix nitrogen independently. In general, they are Gram-negative, motile, non-sporulating rods. This symbiosis can relieve the requirements for added nitrogenous fertilizer during the growth of leguminous crops.

Inoculation in plants is the introduction of an antigenic substance, usually a bacteria, into a host organism or growth medium to produce immunity to a specific disease. Inoculation of legume seed is an efficient and convenient way of introducing effective rhizobia to soil and subsequently the rhizosphere of legumes (Deaker et al., 2004).

Household denotes all persons living under one roof or occupying a separate housing unit, having either direct access to the outside (or to a public area) or a separate cooking facility. Where the members of a household are related by blood or law, they constitute a family (Business dictionary, 2015).

Agro-ecological zones (AEZ), as applied in FAO studies, are zones categorized on the basis of combinations of soil, landform and climatic characteristics. The particular parameters used in the definition focus attention on the climatic and edaphic requirements of crops and on the management systems under which the crops are grown. Each zone has a similar combination of constraints and potentials for land use, and serves as a focus for the targeting of recommendations designed to improve the existing land-use situation, either through increasing production or by limiting land degradation (FAO, 1996).

2.7 The smallholder production system

Smallholder farmers are the drivers of many economies in Africa even though their potential is often underestimated. Smallholder farmers are defined in various ways depending on the context, country and even ecological zone. Often the term "smallholder" is interchangeably used with "small-scale", "resource poor" and sometimes "peasant farmer". In general terms smallholder only refers to their limited resource endowment relative to other farmers in the sector (DAFF, 2012). Smallholder farmers are also defined as those farmers owning small-based plots of land on which they grow subsistence crops and one or two cash crops relying almost exclusively on family labour. One of the main characteristics of production systems of smallholder farmers are of simple, outdated technologies, low returns, high seasonal labour fluctuations and women playing a vital role in production. Within the broader concept of smallholder farmers there is a wide variety of individual characteristics. These include:

- Farm size,
- Resource distribution between food and cash crops,
- Livestock and off-farm activities,
- Their use of external inputs and hired labour,
- The proportion of food crops sold, and
- Household expenditure patterns (DAFF, 2012).

The smallholder production systems' lack of alternatives, and the constraint of the budget, makes it relatively complex in terms of decision making. The way to manage the growing complexities of today's smallholder production systems is through developing systems thinking capability. It is necessary therefore that any study aiming at understanding farming systems be executed within the systems thinking domain (Gharajedaghi and Ackoff, 1985). System thinking is the cognitive ability to: first, perceive and understand the containing whole which is producing a particular state of affairs (environment) within which an organisation, a society, an organism or a mechanism must function; second, it means thinking about the purpose (or function) that a particular system or subsystem (social or organic) fulfils; third, it entails thinking in terms of interrelations, i.e. how the subsystem and elements of a particular system, (e.g. an organization) are interested in terms of dependency, and how

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they impact on each other; fourth, it is about thinking in terms of processes, i.e. how results are produced within a particular system and last, it is thinking in terms of governance, which means understanding how the integrity of a particular system is maintained. The core idea of systems thinking is that of synergy. That is the notion that the whole is different, or has alternative abilities, from the sum of the parts (Gharajedaghi and Ackoff, 1985). System thinking sensitizes decision makers and planners towards the need for nonlinear thinking when faced with a problem situation. System thinking also means creative thinking (Gharajedaghi and Ackoff, 1985).

2.7.1 Systems Thinking Domain for smallholder production

Systems thinking became prominent in agriculture in the 1960s in agronomy, animal husbandry and the physiology of crops and farm animals. This was followed by a second colonization of agriculture in "systems thinking", as an attempt by agricultural economists in Farm Management Research to enhance their tools for economic "problem solving" in farm management, by replacing static "production functions" with dynamic production models (Dent and Anderson, 1971). Such a normative approach features substitution for farmers' own assessment of the situation by theoretical analysis of the environment and the provision of recommendations for action, i.e. decisions that a farmer ought to follow, if he/she were rational (Dent and Anderson, 1971).

Exploratory research is one of the primary reasons for the use of multi-disciplinary group discussions (Hoffmann, 2010). This knowledge is created within group discussions, where different perspectives stimulate creative thinking and help verbalise new ideas. Experts are challenged with issues where they need to rely on their knowledge and experience to generate new information (Hoffmann, 2010). With the aim of promoting individual and group creativity, two factors require attention: the first factor is an environment that consistently challenges the individual's current perception, which could enhance inventive and innovative thinking, which in turn, depends on interaction with other experts; the other factor is combining the appropriate intellectual resources as the basis for creativity (Hoffmann, 2010).

2.7.2 Participatory Research Approach

To achieve the research objectives of this study, qualitative data and the participatory rural appraisal (PRA) approach was selected. PRA is a research technique and specific form of rapid rural appraisal (RRA). The approach dates back to the late 1970s and early 1980s and was developed by the researchers in the international development as an alternative and compliment to the conventional sample survey (Anwar and Ihsan, 2012). PRA is a way of learning from and with community

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members to investigate, analyse and evaluate constraints and opportunities, and make informed and timely decisions regarding development projects (Anwar and Ihsan, 2012). It is the method by which a research team can quickly and systematically collect information for the general analysis of a specific topic, question or a problem. It is commonly applied in: need assessment, feasibility studies, identifying and prioritizing projects and project or program evaluations. In other words, its purpose is to gain an understanding of the complexities rather than to gather highly accurate statistics on a list of variables (Anwar and Ihsan, 2012).

The central part of any PRA is semi-structured interviewing and semi-structured interviewing is the principal method used in RRA. It is conducted using the sub-topics to guide the specific questions thought up by the researchers during the interview. A semi-structured interview (SSI) is a method that engages villagers in a conversation through a series of guided questions (not a structured questionnaire) relevant to the villagers. Important information is generated by talking with villagers about topics that interest them. SSI can be used with individuals, key informants, interest groups or other small groups of villagers (i.e. women's groups) (Pokharel and Balla, 2003). SSI is conducted with key informants who have good knowledge about the history of the village and its resources, and others using pre-selected sub-topics as guidelines (Pokharel and Balla, 2003). Semi-structured interviews are guided conversations where broad questions are asked, which do not constrain the conversation, and new questions are allowed to arise as a result of the discussion. This is different from questionnaires and surveys where there are very structured questions that are not deviated from. A semi-structured interview is therefore a relatively informal, relaxed discussion based around a predetermined topic (Thorn, et al., 1999).

While sensitive topics are often better addressed in interviews with individuals, other topics of more general concern are amenable to focus group discussions (FDGs) and community meetings. During these interviews and discussions, several diagrammatic techniques are frequently used to stimulate debate and record the results. In this method, actual questions are created during the interview. Questions should be precise and easy to understand. Leading questions should not be used while conducting interviews (Thorn, et al., 1999). It is usually best to conduct such interviews in pairs with the person doing the interview and one taking detailed notes. The process of an SSI involves the interviewer presenting the context of the study and its objectives to the interviewee or interview group (such as a family or household). The set of questions are prepared but open, allowing the interviewees to express opinions through discussion (Thorn, et al., 1999). Questions are generally simple, with a logical sequence to help the discussion flow. Interview questions are tested prior to interviews. Training people to conduct a semi-structured interview is important and practice is required to become an effective interviewer. Training needs to address team preparation, interview context,

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sensitive listening, sensitive questioning, judging responses, recording the interview and self-critical review (Pokharel and Balla, 2003).

The advantages of FGDs in research are: firstly, in the comprehension of complex objects of study such as the farm system; secondly, in bridging gaps caused by discipline-based research and specialisation; thirdly, in its ability to bring about a fertile environment for creative thinking; fourthly, the approach makes interviewing of a number of different persons more systematic and comprehensive by delimiting the issues to be taken up in the interview (Pokharel and Balla, 2003). Logical gaps in the data collected can be anticipated and closed, while the interviews remain fairly conversational and situational and lastly, other members in the group can initiate a state of creativity by challenging the individual's perspective. The interaction between participants in discussion groups stimulates creative thinking by constantly challenging the perspectives of the participants.

FGDs, as a technique for generating information, do have potential limitations. Its weaknesses include that the approach does not permit the interviewer to pursue topics or issues of interest that were not anticipated when the interview guide was elaborated. Interviewer flexibility in wording and sequencing questions may result in substantially different responses from different persons, thus reducing comparability (Thorn, et al., 1999). Furthermore, most of the participants may know each other and the familiarity may influence the willingness to disagree in such a group. Familiarity amongst members could present a more open discussion, but the presence of an influential figure may influence the opinion of other members. The awareness of the chairperson of this can be overcome by encouraging participation by other experts.

2.7.3 Applications of group discussions in research

Group discussions and methods of generating ideas started in the 1950s with simple brainstorming in advertising (Thompson and Choi, 2006:162). Two of the most prominent group discussion methods that directly contribute to establishing an environment conducive to creativity in research include the Delphi method and Idealised Design method. The Delphi Method is a structured communication process comprising a group of individuals who aim to solve complex problems (Kenis, 1995:1; Linstone and Turoff, 1975:3). The most important features of Delphi as a research technique are the following:

- That anonymity is guaranteed,
- Iterations are made and fed back in a controlled manner, which achieves the objective of attaining reliable consensus, and

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- Statistics are used to represent the status of the opinion of the group for a given response (Kenis, 1995:2).

The major advantage of Delphi is that it provides participants with a great degree of individuality and freedom because of its anonymity. The Delphi Method thus allows subjective information to be incorporated into models dealing with complex problems (Linstone and Turoff, 1975:11). A potential problem with Delphi is often the poor level of professionalism with which it is conducted. Poor design of questionnaires or poorly structured questions can lead to skewed results. Delphi relies on a questionnaire and individuals are asked only to expand on points of view if they significantly differ from the group's results. The aim of this project is to identify ways to improve farm-level profitability. Interaction between participants is precisely what is required to stimulate creative thinking, which is important to identify ways of improving profitability. The exclusive use of the Delphi method may not generate the same amount of creativity, as participants are actively kept apart. It is also, compared to group discussions, a time-consuming method.

2.8 Simulation modelling by using budgets

In order to assess financial implications associated with the adoption of legume technologies in this study, a model was carefully chosen that is suited to the purpose of one of the specific research goals. To explore the options in financial terms, budgeting is a simple enough tool that farmers can understand its working, but can incorporate enough complexity to provide a valid assessment of the financial implications of the alternative options (Hoffmann, 2010). The aims of the model are: firstly, to describe the current financial situation of the typical smallholder farm and; secondly, to serve as a method for evaluating various strategies to increase the profitability of the typical farm (Hoffmann, 2010). Models are classified according to the objective, the system being modelled, the underlying research approach, the time dimension, the economics of agricultural production practices and sustainability. The validity of the type and complexity of the model applied to research should be based on the level of efficiency with which the model reaches its specific aim or objective (Marks, 2007:272-273).

There are four categories of empirical modelling methods based on agricultural production economics and sustainability; these include:

- Econometric models,
- Optimisation models,
- Simulation models, and

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- Accounting models (Weersink et al., 2002:131-133).

Econometric models are statistical representations of farm-level systems, focusing on input demand and output supply, are derived from duality theory. Optimisation models and simulation models are systems of equations designed to replicate farm-level activities related to production, marketing, financing, etc. The difference between optimisation models and simulation models is that the former involves the specification of a behavioural function such as profit maximisation. Accounting models use farm–level budgets (partial budgets, enterprise budgets, whole-farm budgets and cash-flow budgets) to assess farm-level activities, usually based on some profitability indicator (Hoffmann, 2010).

It is important to note that models themselves do not generate new information; they only facilitate the processing of information. In multidisciplinary discussion groups, models serve as tools to facilitate discussions and generate new discussion points (Hoffmann, 2010). The role of the model would thus be to provide an accurate description of the structure and interrelationships of the system being studied. This facilitation allows researchers to determine the financial outcome of various strategies and changes in exogenous factors (Hoffmann, 2010). This study employed the partial budgeting model and this model is briefly discussed, with a special focus on its functioning, its uses in agricultural economics and the main advantages and disadvantages of each model. The most important consideration in selecting a modelling model is that the model should match the requirements of the specific research problem.

2.8.1 The Partial Budget Model

Many changes proposed by a manager on a farm affect only part of the business. Therefore, a complete farm budget is not needed to determine the profitability of these specific changes in the operation of the farm. The farmer analyses only those costs and incomes that change with a proposed business adjustment (Wander, 2001). He can accomplish this in an organized fashion by using the partial budget, which means that only the relevant costs and incomes are included in the analysis. He can use the partial budget to analyse many practical farm management problems, such as substituting crop and livestock enterprises, changing input levels or types of inputs, changing the size of enterprises in the business and buying new or used machinery, equipment, buildings and facilities (Wander, 2001).

Partial budgeting is the evaluation of the impact on farm profit resulting from a proposed management change (Harper et al., 2013). The model acts as an economic analysis tool that offers conventional ways for estimating the financial impact of implementing a new technology. Partial budgets also assist

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farmers in comparisons of pre- and post-change scenarios by calculating the expected impact on both income and expenses associated with a particular management change (Drum and Marsh, 1997). Partial budgeting helps a farmer to make better decisions on the profitability of his farm (Harper et al., 2013).

This budgeting approach is called partial because it does not include all production costs, but only those which change or vary between the farmer's current production practices and the proposed one(s). PBA allows assessing the impact of a change in the production system on a farmer's net income without knowing all costs of production (Roth, 2002).

The model has four categorical parts: additional income, reduced costs, reduced income and additional costs (Lessley et al., 1991). In a partial budget model, economic effects are calculated as the sum of positive economic effects minus the negative economic effects. Positive economic effects are calculated as extra revenues plus reduced costs. The negative economic effects are calculated as the reduced revenues plus the extra costs. Table 2.1 presents a simple format of partial budgeting model:

Table 2:1 Sample Partial Budget model

Positive Economic Effects	**Value**	**Negative Economic Effects**	**Value**
1. Reduced Costs	R	2. Additional Income	R
1. Additional Costs	R	2. Reduced Income	R
Total Positive Effects	R	Total Negative Effects	R
Net Effects	R		

During the preparation of a partial budget four basic questions must be answered: (1) What new or additional costs will be incurred? (2) How much will current income be reduced? (3) What new or additional income will be received? (4) What current costs will be reduced or eliminated? (Harper et al. 2013).

The advantages of this model include:

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- The technique is simple (it can be performed with a hand calculator) and is easy to learn for non-economists,
- It examines only net changes in costs and benefits; therefore it is effective for assessing economic viability of single interventions technologies,
- It requires less data than whole farm budgeting since fixed costs are not examined,
- The data required for partial budget analysis are collected for almost all other economic analyses, and
- It allows early conclusions about the adaptability of the new technology (Ehui and Rey, 1992).

There are disadvantages to this model and these include:

- There is a danger of forgetting that farmer's resources are limited and sometimes knowledge about the resource base may be lacking; this happens as most new technologies require an increase in purchased inputs and additional labour,
- Often scientists do not understand the farmer's objectives; the partial view of a farming system might obscure the secondary character of a given farm component,
- Lack of a time analysis; researchers do not understand the time needed for various farming activities which may overlap with, or contradict a new schedule, and
- Linearity of factors is assumed by using small-scale input/output data for a large-scale operation. The assumption that an increase in a unit of resource will increase the profit proportionally is questionable. The increase in management skills by many technologies often is not considered (Ehui and Rey, 1992).

2.8.2 Criteria for partial budget analysis

In the partial budget analysis three criteria can be applied:

- If the net income remains the same or decreases the new technology should be rejected because it is not more profitable than the farmer's present technology,
- If the net income increases and variable costs remains the same or decrease the new technology should be accepted because it is more profitable than the farmer's present technology.
- If both gross income and variable costs increase, the rate of return should be looked at; the greater increase in the gross income and the higher rate of return, the more economical an alternative technology is. The new technology should be accepted only if its rate of return is higher than 1.0.

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2.9 Summary

Smallholder farming dominates agricultural production in most parts of SSA. Poor agricultural systems are usually characterised by poor productivity, usually as a result of inadequate supply of nitrogen. The productivity of tropical legumes remains low due to limited use of improved legume technologies among other reasons. There is a wide diversity of farms and farming systems determining the opportunities of acceptance of different agricultural technologies including legume technologies. There is a pressing need to expand food production in the tropical areas to meet the demand for food for the growing masses of the developing world. And there is a need that crop yields per hectare must be increased without compromising the resource base for generations to come. Creativity can be enhanced by better designing and implementing a method suitable for capturing complexity through system thinking, and data collected can safely enhance profitability analysis through financial models. The process BNF, particularly when associated with legumes, holds a great potential to contribute to productive and sustainable agricultural systems for the tropics.

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CHAPTER III: RESEARCH PROCEDURES

3.1 Introduction

Chapter Two presented the overview of the legume industry, both at Africa and Malawi level. The chapter further reviewed literature on the importance of the legume industry in Malawi and the policies and strategies the Malawi government has put in place to promote production of legume, specifically at the smallholder farmers' levels. The chapter also highlighted the importance of system thinking as a way of achieving creativity in capturing complexity for decision making in smallholder farming systems. Group discussions and financial modelling were selected and discussed as the approach suitable in achieving the solutions to the research objectives of the study. The chapter ends with definitions of key terms used in the study. Chapter Three presents the implementation of the research methods of the study. It includes a description of the research design, study locations, data collection methods and process, sampling procedure and sample size. This chapter further describes how this research project was designed and implemented, with a focus on how group participation was implemented and on the design of the budgeting model. It ends with a description of research ethics that were followed in carrying out the study.

3.2. Research design

3.2.1 Data collection

To achieve the objectives of this study both primary and secondary data were used. Information on understanding the role of BNF technology, the financial and managerial implications of the inclusion of such technologies on the production was generated by using a semi-structured checklist in each of the selected districts. Data on arable land, livestock ownership, assets and quality of housing was collected for each area and all these variables functioned as wealth indicators.

3.2.1.1 Selecting the participants

This study adopted the purposive sampling method. Purposive sampling has been defined as a type of sampling in which, "particular settings, persons, or events are deliberately selected for the important information they can provide that cannot be gotten as well from other choices" (Maxwell, 1997). This type of sampling is also known as judgmental**,** selective or subjective sampling, and is a type of non-probability sampling technique (Patton, 2002). Non-probability sampling focuses on sampling

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techniques where the units that are investigated are based on the judgement of the researcher (Patton, 2002).

The main goal of purposive sampling is to focus on particular characteristics of a population that are of interest, which will best enable you to answer your research questions (Strauss and Corbin, 1998). The sample being studied is not representative of the population, but for researchers pursuing qualitative or mixed method research designs, this is not considered to be a weakness. Rather, it is a choice, the purpose of which varies depending on the type of purposive sampling technique that is used (Strauss and Corbin, 1998). The goal of purposeful sampling is to understand a specific phenomenon, not to represent a population, by selecting information-rich cases for research (Creswell and Clark, 2011). Studying information-rich cases yields in-depth understanding of the phenomenon that gives insights into questions under study (Patton, 2002). Thus the sample is always intentionally selected according to the needs of the study.

3.2.1.2 Rationale for the selection method

Purposive sampling techniques provide researchers with the justification to make generalizations from the sample that is being studied, whether such generalisations are theoretical, analytical and/or logical in nature (Dlamini, 2007). Qualitative research designs can involve multiple phases, with each phase building on the previous one. In such instances, different types of sampling technique may be required at each phase (Bernard, 2002). Purposive sampling is also useful in these instances because it provides a wide range of non-probability sampling techniques for the researcher to draw on.

The sampling technique however has its own limitation in that it can be highly prone to researcher bias due to technique being based on the judgement of the researcher (Creswell and Plano Clark, 2011). However, this judgemental, subjective component of purposive sampling is only a major disadvantage when such judgements are ill-conceived or poorly considered; that is, where judgements have not been based on clear criteria, whether a theoretical framework, expert elicitation or some other accepted criteria (Dlamini, 2007).

3.2.1.3 Number of participants

A total number of 60 participants were calculated as the sample size. There were five Focus Group Discussions (FGDs) that were done, and in each FGD there were 10 participants plus one AEDC from the Ministry of Agriculture and Food Security, and an officer for N2Africa. The selection of the groups was purposive; each group was composed of household heads, both male and female farmers with a long-term perspective on agriculture within the districts. FGDs comprised of men and women

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jointly because the subject was not sensitive and thus women could participate freely. The sample population included adopters who have been with the project since the onset, non-adopters and those that adopted but discontinued in the course of the project.

3.2.1.4 Primary information

Primary data was sourced through interviews with the legume-producer lead farmers using a semi structured questionnaire through FGDs in the local vernacular, Chichewa. Primary data collection took place from the 3rd of May 2015 through to the 24th of May 2015 with the use of a semi-structured checklist. All interviews were conducted by the principal researcher and a research assistant. Each FGD opened with the AEDC of the Extension Planning Area (EPA) welcoming the participants, facilitator and the assistant facilitator followed by an opening prayer. Then the participants introduced themselves and their area of representation. The facilitator then introduced herself and the assistant facilitator. The facilitator also explained the objective and the expectations of the gathering. The facilitator mainly asked questions and the assistant facilitator recorded proceedings. The facilitator obtained permission from the FGD participants to take an audio recording of the discussions before the discussion started. There was no objection from participants to record the discussions since the topic was not sensitive.

An FGD in its simplest definition is an informal discussion among a group of selected individuals about a particular topic (Wilkinson, 2004). Furthermore a focus group is defined as a technique involving the use of in-depth group interviews in which participants are selected because they are a purposive, although not necessarily representative, sampling of a specific population; the group being "focused' on a given topic" (Thomas et al, 1995). The group is said to be focused because "it involves some kind of collective activity", for example, debating a specific set of social or health issues, reflecting on common perspectives or experiences, or discussing a health or welfare campaign (Kitzinger, 1994).

Participants in this type of research are therefore selected on the criteria that they would have something to say on the topic, are within the age-range, have similar socio-characteristics and would be comfortable talking to the interviewer and each other (Richardson and Rabiee, 2001). This approach to selection relates to the concept of "Applicability", in which subjects are selected because of their knowledge of the study area (Burrows and Kendall, 1997). This study specifically sought to understand meanings and interpretations of specific issues of a typical farmer at household level in each of the selected EPAs. Each FGD meeting usually lasts approximately 1 to 2 hours, based on the complexity of the topic under investigation, the number of questions and the number of participants

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(Wilkinson, 2004). In this study each FGD lasted about 1 hour 30 minutes. The participants were warned of their time commitment as ethics and good practice demands.

The semi-structured checklist captured data on farmer's legume production levels and costs incurred in legumes before and after the adoption of the Nitrogen technologies. The FGDs specifically captured data on the types and amount of inputs used in the production of each of the four legumes involved: soya beans, common beans, cowpeas and groundnuts. The FGDs also captured data on the crops' respective yields and expected income per crop per hectare from the selected EPAs. Furthermore, information on housing structure, livestock, farm implements and assets before and after the adoption of the legume technologies was collected. Some information was obtained through personal communication with the National Coordinator - Malawi for N2Africa, and Agricultural Extension Development Coordinators (AEDCs) were also interviewed on some core issues for N2Africa.

3.2.1.5 Secondary information

Secondary data was mainly sourced from publications from various stakeholders like N2Africa's final report on the first phase 2009-2013 by Woomer, Huising and Giller (2014), which was published and can be accessed on www.n2africa.org. Secondary data was also sourced from documents by the Ministry of Agriculture, Malawi government policy documents and past research findings on impacts of legume technologies on smallholder production.

3.2.1.6 Rationale for research design

FGDs in particular were used as a tool to collect data in this study because the method allows the participants to agree or disagree with each other and provides an insight into how a group thinks about an issue (Lindlof and Taylor, 2002). FGDs also make known a range of opinions and ideas, and the inconsistencies and variation that exist in a particular community in terms of beliefs as well as their experiences and practices. In FGDs, dynamics of the group are well utilized to discuss topics in depth and the views of all the participants can be considered (Flick, 2006). The interaction among the people in the group is one of the most important parts of the process. FGDs are appropriate for probing people's views and behaviour (Barbour and Schostak, 2005; Punch, 2005), and insight into these issues cannot be easily obtained through individual interviews (Barbour and Schostak, 2005). Unlike interviews, where the researcher's main role is to ask questions, in group discussions the researcher acts more as moderator (Punch, 2005). FGDs are relatively inexpensive (Punch, 2005; Flick, 2006) and they also provide a lot of data and are "flexible, elaborative and stimulating" (Punch

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2005). One other distinct feature of FGDs is its group dynamics; hence the type and range of data generated through the social interaction of the group are often deeper and richer than those obtained from one-to-one interviews (Thomas et al., 1995). An FGD produces data and insights that would be less accessible without interaction found in a group setting; listening to others' verbalized experiences stimulates memories, ideas, and experiences in participants. This is also known as the group effect where group members engage in "a kind of 'chaining' or 'cascading' effect; talk links to, or tumbles out of, the topics and expressions preceding it" (Lindlof and Taylor, 2002).

There are some limitations of the method and these include the fact that findings of the research work cannot be applied beyond that group (Harrell and Bradley, 2009). During FGDs it may also be difficult to have balanced group interactions (Punch, 2005) as some participants can dominate the discussions, while other participants may fail to express their views (Flick, 2006). FGDs may also be inappropriate for investigating sensitive topics (Gill et al*.,* 2008). FGDs also tend to concentrate on macro rather than micro issues, and one does not need statistical accuracy to gather extremely useful information in this context (Lindlof and Taylor, 2002).

It is important to note that the question about the number of FGDs to be carried out per study should be properly addressed. It is suggested that the researcher should continue with running focus groups until a clear pattern emerges and subsequent groups produce only repetitious information (theoretical saturation), (Krueger, 1994). A number of authors suggest that for a simple research question the number of FGDs necessary may only be three or four (Burrows and Kendall, 1997). FGDs do not aim to reach consensus on the discussed issues. Rather, FGDs promote a range of responses which offer a greater understanding of the attitudes, behaviour, opinions or perceptions of participants on the research issues (Krueger, 1994).

3.3 Validity of the information

To ensure data relevance and consistency, a one-day checklist pre-testing was carried out with randomly selected households to ensure relevance of the checklists and clarify misunderstandings. The tested checklist was used for corrections and production of final checklists which were used to collect data from the FGD interviews. Prior to this the assistant researcher was trained for a day. All FGDs interviews were audio-taped. The audiotape records were translated from the local language into English and transcribed. The principal researcher reviewed all the transcripts and identified major themes arising from the interviews. The data collected was then thoroughly checked and systematically organized for study suitability before entry. Data collected was entered into an excel

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database, checked for outliers and categorical appropriateness. Thereafter the data was processed and rearranged, ready for entry.

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3.4 Implementation of research methods

The nature of this study was mixed research methods, because it produced both quantitative data which enabled the study with partial budget analysis, and qualitative research methods, which enabled descriptive data; using words and sentences to qualify and record information. This study also adopted qualitative research methods and results were presented in their qualitative form. This methodological approach is appropriate for investigating complex social phenomena in their real life contexts.

3.4.1 Rationale for choice of research design

Semi-structured interviews are suitable for relatively small groups or populations, e.g. case studies (Balnaves and Caputi, 2001). Compared to structured interviews, semi-structured interviews are more flexible (Gill et al., 2008). They also allow researchers to discover important aspects of the subject (being investigated), which they may originally not have thought as being relevant (Gill et al., 2008). However, it may be difficult to control discussions during semi-structured interviews (Gill et al., 2008), thereby leading to more time being spent in conducting the interviews than originally intended. It may also be difficult to come to conclusions, since the questions asked are unlikely to be exactly the same with each individual as it would be in a structured interview.

Unlike structured interviews, not all questions in semi-structured interviews are pre-determined (Newton, 2010) and most questions and responses are open-ended (FAO, 1990). Interviews start off with more general questions, based on an interview guide or check list. The interviews use questions, conversation and discussion to get in-depth understanding of the subject being investigated (Newton, 2010) and success of the method is highly dependent on the relationship and rapport established between interviewer and interviewee (FAO, 1990; Newton, 2010).

3.5 Study location

Malawi is a landlocked country located in the southeast of Africa; it is surrounded by Mozambique, Zambia, and Tanzania. Lake Malawi, formerly Lake Nyasa, occupies most of the country's eastern border. The north-south Rift Valley is flanked by mountain ranges and high plateau areas. Malawi is divided into three administrative regions, namely: north, centre and south. These are in turn divided into 28 districts. There are 6 districts in the north; 9 in the centre and 13 districts in the south. The districts in this study were chosen purposely as they have the smallholder farmers working with N2Africa and are within the agro-ecological zones.

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This study took place in central region of Malawi, specifically in Ntcheu, Mchinji, Dedza, Salima and Kasungu districts. It is in these areas where the N2Africa program promotes BNF technologies on its target legumes; cowpeas, soya beans, common beans and groundnuts among smallholder farmers. From Ntcheu the study particularly took place in Bilira EPA which is 90 km away from Ntcheu town. This FGD included farmers from Manjawira EPA within the Ntcheu district and 50km away from Ntcheu town. In Mchinji the study took place at Mikundi EPA, 50 km from Mchinji town. From Dedza the study took place at Linthipe EPA, 50km away from Dedza town. In Salima the FGD was held at Makande EPA and this meeting also included farmers from Chinguluwe EPA. Both these EPAs are 20km and 40km respectively away from Salima town. And from Kasungu district the study took place at Chamama EPA and farmers from Nkhamenya EPA were part of the FGD. Chamama EPA and Nkhamenya EPAs are 40km and 70km away from Kasungu town respectively.

This study excluded Dowa district (which is one of the districts that was part of the N2Africa project in the first phase) due to administrative challenges highlighted in Section 1.7. Figure 3.1 shows the various districts where the study took place:

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Figure 3.1 Map of Malawi showing the districts where the study took place: Kasungu, Mchinji, Salima, Dedza and Ntcheu

Source: http://d-maps.com/carte.php?num_car=4781&lang=en

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3.5.1 Structure of the Ministry of Agriculture and Food Security (MoAFS)

In order to understand how the MoAFS operates it is important to understand its structure. The Ministry is structured like any typical Malawian government ministry. The top management structure is headed by the Secretary for Agriculture, below which are the six departments. Below the departments there are eight Agricultural Development Divisions (ADDs) which replicate the activities of the six departments at the national level. The ADDs are Karonga, Mzuzu, Kasungu, Lilongwe, Salima, Machinga, Blantyre and Ngabu. Each ADD covers several districts but this does not, however, coincide neatly with regional boundaries. The ADDs used to be split into 30 Rural Development Projects and these have now been restructured into the 28 District Agriculture Development Offices. They are further divided into 154 Extension Planning Areas (EPAs). The EPAs are subdivided into Sections which is the point of service delivery to farmers. In addition, the Department of Agricultural Research & Technical Services (DARTS) operates a network of 16 experimental sites strategically located throughout the country. The MoAFS structure is illustrated in Figure 3.2:

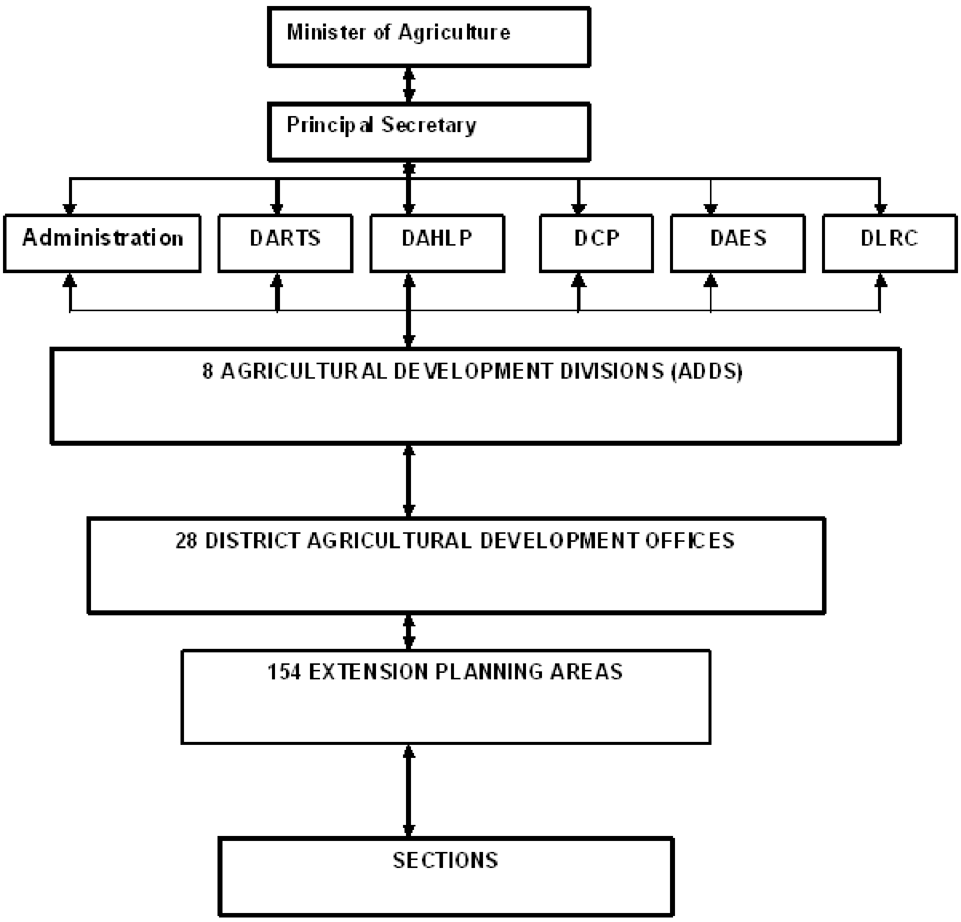

Figure 3:2 The Structure of Ministry of Agriculture and Food Security in Malawi
Source: GoM (2003)

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3.6 Data analysis

This study employed both the Gross Margin tool and Partial Budget model for analysis of its quantitative data. A gross margin refers to the total income derived from an enterprise less the variable costs incurred in the enterprise (Agriculture, 2015). The results are presented as gross margins, as no account has been taken of fixed costs (e.g. land) of the enterprises; those costs which are not attributed to a specific enterprise. Gross margin is the appropriate measure for assessing and comparing crop enterprises in farm business management (Defra, 2010).

The analysis examines three measures of financial performance; the main measure is the enterprise gross margin per hectare, which shows the gross income of each crop per growing season. Furthermore an overall enterprise gross margin follows a partial budget analysis for each crop.

For the qualitative data the study employed classification, description and induction of data. The process of qualitative analysis aims to bring meaning to a situation rather than the search for truth focused on by quantitative research. Strauss and Corbin (1998) describe analysis as ". . . the interplay between researchers and data"; acknowledging that there is an extent of subjective selection and interpretation of the generated data.

Table 3.1 is an outline of the analysis plan indicating the analysis tools used to obtain meaning from data in order to reach each of the four objectives of this study:

Table 3:1 Analysis plan

Number	Goal	Analysis tool
1	To assess current production systems being used in selected areas in Malawi, as well as the proposed alternatives based on research results	Classification, description and induction
2	To determine the financial implications of the implementing BNF technologies and use of inoculants on legumes	Gross margin and partial budgeting model

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3.6.1 Partial Budget Model

A partial budgeting model was constructed to analyse the data that was collected from the field work and trials. The model was used particularly in the analysis of financial implications to determine the profitability of proposed changes in the operation of a typical farm enterprise in selected districts of Malawi. The model was used to assess the average costs and benefits associated with the adoption of legume technologies in soya beans, common beans, cowpeas and groundnuts for both three years before and three years after adoption of legume technologies. A partial budget is based on a unit, so data was collected from one farm from each of the districts in the study.

The calculation of a gross margin is the essential first step in farm budgeting and planning. It enables you to directly compare the relative profitability of similar enterprises and, consequently, provides a starting point to deciding or altering the farms overall enterprise mix. Gross margins were calculated for each particular crop per hectare, using specific production technology and inputs, and over a production cycle. The gross margin was obtained by calculating the gross output (by multiplying the production by the "farm-gate" price received for the product), and deducting the variable costs of the production for each of the crops grown in the selected districts.

A type of gross margin analysis is also referred to as partial budgeting when only variable costs are included and fixed costs are excluded to compare two alternatives. For the same reason it is called gross margin instead of net margin. The cost of land was not included in the calculation of the gross margin of each crop. Land was considered a household resource, for which use different productive activities compete.

Partial-budget analysis was used as part of a cost-benefit model. In a cost-benefit model, economic effects for any given scenario are calculated as total revenues weighed against total costs. In this model, the expected cost or income of a specific crop from each district was calculated. Partial-budget analysis was used to calculate the relative costs and income. In partial-budget analysis, alternatives were compared without calculating a complete budget for each scenario. Only revenues and costs that are affected by the adoption of the legume technologies were considered. Total returns were calculated as extra returns plus reduced costs. Total costs were calculated as reduced returns plus extra costs. This framework does not account for changes in the value of money over time.

A partial budget uses the same basic equation (Option A vs. B):

- Change in revenue = Increased revenues (A) + saved costs (B) – increased costs (A) – forfeited revenues (B)

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3.6.3 Key data implementation

3.6.3.1 Land holding size

On average the land holding size for the farmers from each district was estimated and determined by the farmers themselves and was confirmed by the MoAFS officials present at the time of FGDs. Malawi's land holding sizes, especially in the smallholder sector, according to the Malawi Poverty and Vulnerability Assessment report (GoM, 2007) are on average less than 1.0 ha of land. An overview of the arable land used by the participating farmers in each district was made by adding up the total cultivated area of a typical farm. This was done by adding up the total area per crop and calculating the share of the total area allocated to the respective crops in the total cultivated area.

3.6.3.2 Yield

Yield was determined by the number of 50 kg bags that were realised, expressed per hectare. For the purposes of this study both gross margin and partial budget analysis require that all data be analysed on per hectare terms. Yield of soya bean, common bean, groundnut, cowpea and maize were usually reported threshed and shelled. Otherwise all unshelled crop yields were estimated and converted to actual grain weights of 50 kg bags.

3.6.3.3 Selling price

Selling price was determined by the farmers participating in the FGDs by calculating the average price of the official market prices in the areas before the legume technologies and the same was done for the selling price for the period after the introduction of the legume technologies. This was confirmed with the agri-business officer at each EPA in the respective districts.

3.6.3.4 Inputs

Labour was determined by multiplying cost of labour by the amount of time (in hours) taken to finish a task on a farm, i.e. the amount of labour allocated to each crop was calculated by adding up the hours spent on each activity for each crop separately on a typical farm of each district. These numbers were multiplied with the corresponding area in person hours/hectare for each typical farm from each district. These farm activities that required labour were both pre- and post-harvest activities and these included: land preparation, weeding, harvesting, shelling and drying.

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Other inputs such as cost of seed, fertilizers, pesticides and inoculants were provided by the N2Africa official and this can be found under the appendices. In a case where the farmers have purchased and used any of the input(s), this then was added to what was provided by the N2Africa project. Transport was determined by multiplying the cost of hiring an ox-cart per day by the number of days hired.

3.7 Research ethics

Permission to carry out a research study was sought from the District Agricultural Development Offices (DADO) at each of the District Agricultural Offices in these five districts. Many collaborative projects insist on a written and signed consent form, but this is not always appropriate for developing country populations (Shapiro and Meslin, 2001). The majority of the population sample could not read or write. The DADO therefore, with the help of the AEDCs, consulted local chiefs who called for meetings in their respective communities and explained the study, and the procedures in their own words and oral consent was granted from all participants. Before every FGD meeting the researcher assured the participants that the results of the results would be kept confidential unless authorised by the participants. Participants were also informed that they were entitled to ask any questions and if at any time they wanted to terminate the interview they could do so, or if they wished, decline to participate.

3.8 Conclusion

This project focused on 5 different crop production areas in Malawi. The areas were identified based on its inclusion in the N2Africa project and also based on existing smallholder crop production practices. In each of the areas a participatory group discussion was organised and carried out. The purpose of these discussions was to assess the implementation of BNF technologies amongst the smallholder producers; that it is to evaluate the impact that adoption has or could have on producers. A partial budget was used to demonstrate the financial implications of implementation of BNF technology.

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CHAPTER IV: RESULTS AND DISCUSSION

4.1 Introduction

Chapter Three presented the general research design and methods applied to determine the implications of adopting BNF technologies for smallholder grain producers in Malawi. The study locations and description of the analytical model and the techniques employed to analyse data for this study was also introduced. Chapter Four begins by discussing, briefly, the general cropping system of typical smallholder farmers in Malawi. Focus falls on intercropping systems which are common in Malawi and also the differences in such systems between the various areas. Other differences between the areas such as typical farm size, crops that form part of the typical production system and types of equipment, are also highlighted. This chapter also presents findings emanating from the study in terms of the financial implications of the various forms of BNF technology. This is presented for each of the specific areas in the form of a partial budget that shows the implications of the inclusion of the BNF technology.

4.2 Cropping systems

Intercropping systems has been defined as the combination of crops grown on a given area and time (Reddy, Floyd and Willey, 1980). Intercropping system is a type of mixed cropping and defined as the agricultural practice of cultivating two or more crops in the same space at the same time (Andrews and Kassam, 1976). This cropping system is commonly practised in SSA, and is mostly practiced by smallholder famers. The common crop combinations in intercropping systems of this region are cereal-legume, particularly maize-cowpea, maize-soya bean, maize-pigeon pea, maize-groundnut, maize-bean, sorghum-cowpea, millet-groundnut, and rice-pulses (Beets, 1982). The features of an intercropping system differ with soil, local climate, economic situation and preferences of the local community (Rees, 1986).

Several scientists have been working with cereal-legume intercropping systems in SSA and proved its success compared to the mono-cropping systems (Waddington and Karigwindi, 2001; Kambabe and Mkandawire, 2003; Waddington et al., 2007; Obadoni et al., 2010; Addo-Quaye et al., 2011; Osman et al., 2011). In this region, one of the most important reasons for smallholder farmers to intercrop is to minimize measures against total crop failures and to get different produces to take for his family's food and income (Ofori and Stern, 1987). Furthermore, intercropping systems use the growth factors more efficiently, because they capture more radiation and make better use of the available water and nutrients, reduce pests, diseases and suppress weeds and favour soil-physical conditions, particularly

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intercropping cereal and legume crops which help maintain and improve soil fertility (Ofori and Stern, 1987; Sanginga and Woomer, 2009).

4.2.1 Compactable crops.

Choosing the right crop combination is very important in intercropping systems due to the fact that plant competition could be minimized, not only by spatial arrangement, but also by combining those crops best able to exploit soil nutrients (Fisher, 1977). Intercropping of cereals and legumes would be valuable because the component crops can utilize different sources of Nitrogen (Benites et al., 1993; Jensen, 1996; Chu et al., 2004), which is scarce in most soils of small scale farms in SSA (Palm et al., 1997). This is mainly due to soil nutrient depletion. The cereal may be more competitive than the legume for soil mineral Nitrogen, but the legume can fix Nitrogen symbiotically if effective strains of Rhizobium are present in the soil.

4.2.2 Benefits of intercropping system

It is widely believed that an intercropping system is especially beneficial to the smallholder farmers in the low-input or high-risk environment of the tropics (Willey et al., 1983). The intercropping of cereals and legumes is widespread among smallholder farmers due to the ability of the legume to counter soil erosion and declining levels of soil fertility. The principal reasons for smallholder farmers to intercrop are:

- Flexibility,
- Profit maximization,
- Risk minimization against total crop failure,
- Soil conservation and improvement of soil fertility, and
- Weed control and balanced nutrition (Jensen, 1996).

Other advantages of intercropping include potential for increased profitability and low fixed costs for land as a result of a second crop in the same field (Chu et al., 2004). Furthermore, intercropping can result in higher yields than sole crop yields, greater yield stability, more efficient use of nutrients, better weed control, provision of insurance against total crop failure and improved quality by variety. Also, cereal as a sole crop requires a larger area to produce the same yield as cereal in an intercropping system (Willey et al., 1983).

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This study focused on maize-based mixed cropping system. The maize-based mixed farming system is the most important food production system in east and southern Africa (Akinnifesi et al., 2010). The maize-based mixed farming system covers the highland and plateau regions at 800–1,500 metres altitudes, from Tanzania and Kenya to Zambia, South Africa, Zimbabwe, Malawi, Lesotho and Swaziland (Dixon et al., 2001). Sixty percent of the cropped area covers maize in countries such as Malawi, Zimbabwe and Zambia and is almost a dominant crop in other countries including Kenya and Tanzania (Smale and Jayne, 2003). Maize is estimated to be grown on over 70 percent of Malawi's arable land and almost 90 percent of the area under cereal. Malawi is the world's highest per capita consumer of maize at 148 kilograms per capita per year (Smale and Jayne, 2003). Consequently, maize will continue to be a dominant crop in the food security equation even if the agricultural economy diversifies (Sauer et al., 2007). A feature common to agriculture in most regions of the tropics is the widespread use of multiple cropping in which several crops are grown in the same field, either in rotation within a year, or in combination in various forms of intercropping.

Malawi's rapidly increasing population and reliance on maize as a staple food has led to continuous maize cultivation. This however, as indicated in Section 1.1, has led to depletion of soil organic matter levels. The removal of subsidies on fertilizer and maize prices plus the devaluation of the MK have further contributed to increased interest in legumes as sources of human nutrition and soil fertility in the Nitrogen depleted soils of Malawi (Gilbert, 2004). Pressure on land use means that any leguminous system must be competitive with continuous maize in terms of calorie production per hectare as well as economic benefits. Legumes that can meet the economic and food security criteria while still improving soil fertility are termed "best-bet" systems because smallholder maize producers are more likely to adopt them (Gilbert, 2004). Much recent research and extension effort has gone into comparisons of best-bet legumes that present farmers with as many options as possible so that they can choose cropping systems best suited to their needs. If challenges such as improved human utilization and increased market demand are met, these legumes will play an important role in diversifying Malawian farming systems and ensuring improved household food security (Gilbert, 2004).

A majority of farmers in the maize-based farming systems are not able to acquire agricultural inputs such as optimal quantities of inorganic fertiliser (Sauer et al., 2007). The rapid deterioration of soils in this farming system directly affects productivity and it perpetuates rural poverty. Malawi alone loses US$350 million worth of nitrogen and phosphorus through erosion each year, which translates to a gross annual loss of income equivalent to three percent of the agricultural GDP of Malawi (Bojo, 1996). If the situation is to be improved, agricultural production needs to be intensified through the application of agro-ecological technologies that do not require large amounts of capital and labour; a development paradigm termed the "Doubly Green Revolution" (Conway and Toenniessen, 2003). The

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systems being applied vary across areas, in terms of crops being employed, and also in sequence and the farm area per farmer. Each of the areas included in this study will consequently be discussed.

There is a wide gap between yields observed in farm and experimental trials and the actual yields obtained by farmers (Tchale, 2009). For example, while potential yields for maize range from five to eight tons per hectare, the average actual yields range from 1.5 to 2.5 tons and rarely exceed this. Evidence from past studies suggests that levels of efficiency among the majority of Malawian smallholders are low to moderate (Chirwa, 2003). This gap between potential and actual average farm crop yields, suggests abundant scope for improvements in productivity. The Malawian farming system is also characterized by poor backward linkages, like uncoordinated input supply as well as limited access to technologies, extension services and credit.

4.3 Effects of legume technologies

It is generally acknowledged that legumes do have the potential to contribute positively to the financial position of the farms and not only to soil health. The aim of this section is to identify the cropping systems being used in each area and discuss the potential effect of the employment of the nitrogen technologies in each area. The implications of the nitrogen technologies are in each instance accessed using a "typical farm" for each area. The size, structure and cropping systems that were deemed "typical" was determined during field visits to each area as described in Sections 2.8.1 and 2.8.3. The concept of a typical farm is well known in agriculture (Hoffmann, 2010). The discussion on the various areas will each start with description of area and typical farm system, followed by focus on the various crops grown in the area.

4.3.1 Procedure for gross margin calculation

Gross margin was obtained by calculating the gross output (by multiplying total yield by the farm-gate price received for each crop), and deducting the variable costs of the production (total input cost). Gross margin was calculated for each particular crop in a typical farm on per ha basis for the before and after period of using improved legume seed and legume production technology and inputs. In gross margin analysis only variable costs are included and fixed costs are excluded; it is called gross margin instead of net margin.

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4.3.2 Procedure for partial budget analysis

In order to assess financial implications of the adoption of legume technologies in this study, the partial budget model was used. A partial budget model is based on the principle that small business changes have effects in one or more of the following areas: (1) increase in income, (2) reduction or elimination of costs, (3) increase in costs and, (4) reduction or elimination of income. The net impact of the above effects will be the positive financial changes minus the negative financial changes. A positive net indicates that farm income will increase due to the change, while a negative net indicates the change will reduce farm income. Positive economic effects are calculated as extra revenues plus reduced costs. The negative economic effects are calculated as the reduced revenues plus the extra costs. A partial budget consists of two columns, a subtotal for each column and a grand total. The left-hand column contains the items that increase income while the right-hand column notes those that reduce income for a farm business. The budget is divided into four parts:

1. Gained income

In this section any income increase is included that may have come from the adoption of the legume technology.

2. Added costs

All increased expenses due to the adoption of the legume technology were considered. Most of these were costs of production for the period after the adoption of the legume technologies.

3. Saved costs

In this section expenses on crop that were no longer incurred as a result of adoption of the legume technologies were included.

4. Forfeited income

All items considered to be causing a reduction in crop sales due to the adoption of the legume technology were considered in this section.

A total of additional costs minus reduced costs (under positive effects column) are reflected in subtotal line total positive effects in column 1. The process is repeated for the negative effects column where additional returns subtract reduced returns for column 2. This is reflected in total negative effects. Total negative effects are then subtracted from total positive to arrive at a projected net return from the adoption of the legume technology. A positive number indicates that the legume technologies were profitable and a negative number indicates the legume technologies were not profitable.

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4.4 Results

This chapter presents results as follows: (1) wealth indicators in this study such as land holding size, farm implements owned and household assets owned, (2) gross margins for each crop cultivated in the period of the study, and (3) partial budget analysis for each crop cultivated for the period of the study in the selected districts. Prices for all crops; soya bean, common bean, cowpea, groundnut and maize were expressed in Malawi Kwacha (MK) during the time of data collection and the official exchange rate for US Dollar (USD) to MK was 1USD to 475.631 MK during the month of May (Exchange rate, 2015). It must be kept in mind throughout that although the relative (percentage) impact of adoption seems accentuated the initial base of measurement is low compared to commercial standards.

4.4.1 Mchinji District

In Mchinji the smallholder farmers have, on average, access to 0.5 hectare of land for crop cultivation. The farmers cultivated cowpeas, groundnuts, and maize during the period of the N2africa study and the three crops were grown on the same piece of land and are intercropped. During this study, field visits were carried out to determine, *inter alia*, the typical cropping systems and practices. Data was collected on:

- Land holding size,
- Livestock ownership,
- Assets,
- Housing structure, and
- Production orientation.

Eight out of the ten participants of the focus group discussion (FGD) for Mchinji were participating members of the project at the time of interview, while two members of the FGD were not. These two non-members could not participate in the project because they were not among those farmers that were selected when the project rolled out. These farmers, however, expressed interest in the project's initiatives and would like to join if the project decides to add more participating members in the future. This serves again as an indication of the relative poverty that most households face. They are simply not able to implement these technologies with their own financial means.

Before the introduction of the legume technologies in the area, a typical farm structure consisted of a housing structure with earth walls and floors, and grass thatched roofs. There have not been any

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significant improvements in the structures after the adoption of the legume technologies. There was an increase of 39 percent in the number of poultry owned by the households after the adoption of the legume technologies in the district; already a significant increase in both wealth and access to food. Livestock ownership in this area, as in most of Malawi, also functions as a wealth indicator. Table 4:1 provides more detail on livestock for a typical farm structure for Mchinji before and after the adoption of the legume technologies:

Table 4:1 Livestock for a typical farm before and after adoption of legume technologies

	Without legume technologies		With legume technologies		
Type	Number	Value (MK)	Number	Value (MK)	% increase
Poultry	20	1,800.00	50	2,500.00	39%
Goats	5	15,000.00	10	20,000.00	33%
Cows					
Pigs	6	20,000.00	10	30,000.00	50%
Rabbits					
Others					

In terms of farm implements there were no significant changes from what the households had before adoption of the legume technologies and after the legume technologies. There were changes in market values on the farm implements but the farmers were not affected by the changes since they had not purchased new farm implements yet. Again, ownership of implements functions as wealth indicator. Table 4.2 gives more details on the farm implements:

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Table 4:2 Farm implements for a typical farm in Mchinji district

	Without legume technologies		With legume technologies		
Implement	Number	Value (MK)	Number	Value (MK)	% increase
Hoe	4	2,500.00	4	3,000.00	20%
Machete					
Spade			1	150.00	-
Watering can	2	2,000.00	2	2,200.00	10%
Slasher			1	850	-
Axe	1	1,000.00	1	1,000.00	0%
Sickle	1	500.00	1	500.00	0%
Wheelbarrow					
Sprayer					
Ox-cart					
Irrigation pump					
Other					

Table 4:3 Assets for a typical farm in Mchinji district

	Without legume technologies		With legume technologies		
Asset	Number	Value (MK)	Number	Value (MK)	% increase
Radio	1	4,000.00	1	6,000.00	50%
Mobile phone	1	6,500.00	1	10,000.00	54%
Television					
Bicycle	1	30,000.00	1	35,000.00	17%
Motor vehicle					
Other					

Farmers in the area had a few household assets before the introduction of the technologies as shown in table 4.3. The assets table aims at indicating wealth held by a typical farmer in general in the area. There were no changes in numbers of assets in possession by these farmers after the adoption of the legume technologies. The changes in values are as a result of time; the value of money increased between the time of the onset of the project in 2010, to the last growing season in 2014. It is however also claimed by the producers that the value, in terms of usage, have increased. The increase is mostly

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due to simple inflation, and this factor should not weigh too heavily in terms of assessing the contribution of new technology. Table 4.3 presents the details of the assets for the Mchinji district.

4.4.1.1 Soya beans

The average land holding size for smallholder farmers in Mchinji is 0.5 hectares, and soya beans, cowpeas and maize were cultivated. Out of the 0.5 hectares cultivated, soya beans and cowpeas were intercropped with maize. Total sales revenue from soya beans in Mchinji district was MK48, 000.00 and cost of production registered MK13, 081.55 before the adoption of the legume technologies. After the adoption of the technologies cost of production and sales revenue rose to MK35, 318.00 and MK135, 000.00 respectively. Gross margin for the crop without the legume technologies was MK34, 918.45 but grew to MK99, 682.00 after the adoption of the legume technologies indicating an increase of 185 percent in gross margin. Table 4.4 illustrates more on sales revenue, cost of production and gross margin of soya beans per hectare before and after adoption of legume technologies in Mchinji. The increase is dramatic, but one needs to keep in mind that the basis from which it grew was extremely low.

Table 4:4 Agronomical financial results for soya bean production in Mchinji district

Agronomic Indicators	Without legume technologies	With legume technologies
Average yield (kg/ha)	400	750
Average price (MK)	120.00	180.00
Sales revenue (MK)	48,000.00	135,000.00
Input costs		
Seed (MK/Kg)	1,800.00	3,500.00
Labour	7,000.00	10,000.00
Fertiliser	2,281.55	3,800.00
Pesticides	0,00	2,000.00
Inoculant	0,00	4,018.00
Transport	2,000.00	12,000.00
Total input costs	13,081.55	35,318.00
Gross margin	34,918.45	99,682.00
Percentage increase of gross margin		185%

Table 4.5 shows more detail on partial analysis of soya beans for Mchinji district. According to the procedure for partial budget analysis in Section 4.3 there is a positive difference of MK64, 700.55 per hectare for a typical smallholder in the area. The farmers therefore have benefitted from the use of the legume technologies. In spite of inputs increasing by 170 percent, plus two items, pesticides and inoculants being added, the net positive results is almost threefold. For comparison purposes all costs are expressed in a value per ha. One must however remember that the typical area is only 0.5 ha and the effect on the household is MK32, 350.00 in other words $68. It is perceived that the price also increases with the introduction of technologies. This is because farmers actually trade more, because there is some surplus, also, the quality is improved. The increase in price over the period of the project was however in line with inflation on other general household items.

Table 4:5 Partial Budget for soya bean production in Mchinji district

Positive effects	**Value (MK)**	**Negative effects Value**	**Value ()**
Additional income:		**Reduced income:**	
(750 kg x MK180.00) - (400 kg x MK120.00) = (MK135,000.00 - MK48,000.00)	87,000.00	None	0
Total additional income	87,000.00	Total reduced income	0
Reduced costs:		**Additional costs:**	
None	0	Change in total input cost (With - Without technology) (MK35,318.00 – MK13,018.55)	22,299.45
Total reduced costs	0	Total additional costs	22,299.45
Total additional income and reduced costs (TAIRC)	87,000.00	Total reduced income and additional costs (TRIAC)	22,299.45
Net effect (MK/ ha)			**64,700.55**

Source: Own calculation based (Audsley, 1989).

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4.4.1.2 Cowpeas

Cowpea crop was grown together with soya beans and maize on the same 0.5 hectares piece of land. For cowpeas, total sales revenue amounted to MK32, 500.00 and there were no costs on the production of the crop before the adoption of the legume technologies. Sales revenue grew to MK100, 000.00 and MK23, 099.55 was used for input for the growth of cowpeas after the adoption of the technologies. Gross margin for the crop without the legume technologies was MK32, 500.00 and MK76, 900.45 after the adoption of the legume technologies. There was therefore a gross margin increase of 136 percent. Table 4.6 gives more details:

Table 4:6 Agronomical financial results for cowpeas production in Mchinji district

Agronomic Indicators	Without legume technologies	With legume technologies
Average yield (kg/ha)	500	1,250
Price (MK)	65.00	80.00
Sales Revenue (MK)	32,500.00	100,000.00
Input costs		
Seed (MK/Kg)	0,00	4,800.00
Labour	0,00	0,00
Fertiliser	0,00	6,281.55
Pesticides	0,00	0,00
Inoculant	0,00	4,018.00
Transport	0,00	8,000.00
Total input costs	0,00	23,099.55
Gross margin	32,500.00	76,900.45
Percentage increase in gross margin		136%

Table 4.7 shows more detail on partial analysis of cowpeas for Mchinji district. According to Section 4.3 there is a positive difference of MK44, 401per hectare for a typical smallholder in the area. The farmers therefore have benefitted from the use of the legume technologies. Care was taken to separate the costs of the cowpea production from the other main crops. Because it is an intercropping system, only the costs for adding the cowpeas needed to be taken into account at this stage.

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Table 4:5 Partial Budget for cowpeas production

Positive effects	Value (MK)	Negative effects Value	Value (MK)
Additional income: (1,250 kg x MK80.00) - (500 kg x MK65.00) =(MK100,000.00 – MK32,500.00)	67,500.00	**Reduced income:** None	0
Total additional income	67,500.00	Total reduced income	0
Reduced costs:		**Additional costs:**	
None	0	Change in total input cost (With - Without technology) (MK23,099.00 - MK0.00)	23,099.00
Total reduced costs	0	Total additional costs	23,099.00
Total additional income and reduced costs (TAIRC)	67,500.00	Total reduced income and additional costs (TRIAC)	23,099.00
Net effect /ha:			**44,401.00**

Source: Own calculation based (Audsley, 1989).

4.4.1.3 Maize

Before the adoption of the legume technologies the farmers in Mchinji were cultivating maize crop at no cost. The farmers used recycled seed and never used any other inputs such as fertiliser and pesticides and mostly used family labour for cultivation of maize. Sales revenue however was at MK26, 000.00. However, after the adoption of the legume technologies, cost of production was MK59, 000.00 and sales revenue has even gone up to MK116, 000.00. This indicated a growth of 119 percent in gross margin. Table 4.8 gives more detail:

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Table 4:6 Agronomical financial results for maize production in Mchinji district

Agronomic Indicators	Without legume technologies	With legume technologies
Average yield (kg/ha)	650	1,450
Price (MK)	40.00	80.00
Sales Revenue (MK)	26,000.00	116,000.00
Input costs		
Seed (MK/Kg)	0,00	8,000.00
Labour	0,00	6,000.00
Fertiliser	0,00	45,000.00
Pesticides	0,00	0,00
Inoculant	0,00	0,00
Transport	0,00	0,00
Total input costs	0,00	59,000.00
Gross Margin	26,000.00	57,000.00
Percentage increase in Gross Margin		119%

Table 4.9 shows more detail on partial analysis of maize for Mchinji district. According to the procedure for partial budget analysis in Section 4.3 there is a positive difference of MK31, 000.00 per hectare for a typical smallholder in the area. The farmers therefore have benefitted from the use of the legume technologies.

The net effect of the adoption of BNF technology for a typical 0.5 ha farm for the Mchinji district is thus MK70, 050.76 or $147.3. Again it was indicated by the farmers that did not participate that it was merely a case of not being selected, but that they would be depending on inputs from other sources if they do opt to take the BNF technology.

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Table 4:7 Partial Budget for maize production.

Positive effects	Value (MK)	Negative effects Value	Value (MK)
Additional income:		**Reduced income:**	
(1,450 kg x MK80.00) - (650 kg x MK40.00) = (MK116,000.00 - MK26,000.00)	90,000.00	None	0
Total additional income	90,000.00	Total reduced income	0
Reduced costs:		**Additional costs:**	
None	0	Change in total input cost (With - Without technology) (MK59,000.00 - MK0.00)	59,000.00
Total reduced costs	0	Total additional costs	59,000.00
Total additional income and reduced costs (TAIRC)	90,000.00	Total reduced income and additional costs (TRIAC)	59,000.00
Net effect / ha			**31,000.00**

Source: Own calculation based (Audsley, 1989).

4.4.2 Salima District

In Salima the smallholder farmers, on average, hold 1.0 hectare of land for crop cultivation. The farmers were cultivating cowpeas, groundnuts and maize during this period of study, and all three crops were grown on the same piece of land.

Ten farmers participated in the FGD in Salima and seven out of the ten farmers were still members of the project, representing 70 percent. Three of the ten farmers, which were once members when the project started, dropped out along the way. Thirty percent of the members dropped out because they were staying far away from where the trainings and demonstration plots were. This meant that they had to walk long distances in order to attend these meetings and demonstrations if they wanted to continue to be part of the group of farmers involved with the legume technologies.

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Before the introduction of the legume technologies in the Salima district, a typical farm structure in the area consisted of a housing structure with earth walls and floors and grass thatched roofs. In terms of livestock, goats increased in number by 66 percent followed by rabbits which increased in number by a 100 percent. Table 4:10 gives more details on livestock for a typical farm structure for Salima.

Table 4:8 Livestock for a typical farm in Salima district

	Without legume technologies		With legume technologies		
Type	Number	Value (MK)	Number	Value (MK)	% increase
Poultry	20	1,500.00	20	2,000.00	33%
Goat	6	10,000.00	10	20,000.00	66%
Cow					
Pig					
Rabbits	10	3,000.00	20	5,000.00	100%
Others					

In terms of farm implements there was no significant change from what the household had before the legume technologies and after the legume technologies. There were changes in market values on the farm implements but the farmers were not affected by the changes since they had not purchased new farm implements yet. Table 4.11 gives more details on the farm implements.

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Table 4:9 Farm implements for a typical farm in Salima district

	Without legume technologies		With legume technologies		
Implement	Number	Value (MK)	Number	Value (MK)	% increase
Hoe	2	1,500.00	2	2,000.00	33%
Machete	1	500.00	1	900.00	80%
Spade					
Watering can					
Slasher					
Axe	1	1,200.00	1	2,500.00	108.3%
Sickle	1	450	1	700.00	56%
Wheelbarrow					
Sprayer					
Ox-cart					
Irrigation pump					
Other					

Farmers in the Salima had a few household assets before the introduction of the technologies as shown in the table 4.12. Before the legume technologies most farmers had no mobile phones. There was a significant increase in the number of mobile phones obtained per household on average after the adoption of the legume technologies. All other assets remained the same. Table 4.12 shows more details:

Table 4:10 Farm implements for a typical farm in Salima district

	Without legume technologies		With legume technologies		
Asset	Number	Value (MK)	Number	Value (MK)	% increase
Radio	1	5,000.00	1	10,000.00	100%
Mobile phone			2	5,000.00	-
Television					
Bicycle	1	20,000.00	1	35,000.00	75%
Motor vehicle					
Other					

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4.4.2.1 Groundnuts

The cost of production for groundnuts in the area was MK7, 800.00 and sales revenue was MK70, 000.00 before the adoption of the legume technologies. After the adoption of the technologies, both the cost of production and sales revenue rose to MK30, 000.00 and MK236, 250.00 respectively. Gross margin for the crop without the legume technologies was MK62, 200.00 and MK183, 750.00 after the adoption of the legume technologies. This resulted in a 195 percent increase in gross margin. Table 4.13 gives more details:

Table 4:11 Agronomical financial results for groundnut production in Salima district

Agronomic Indicators	Without legume technologies	With legume technologies
Average yield (kg/ha)	1,000	1,750
Price (MK)	70.00	135.00
Sales Revenue (MK)	70,000.00	236,250.00
Input costs		
Seed (MK/Kg)	7,800.00	10,500.00
Labour	0,00	30,000.00
Fertiliser	0,00	0,00
Pesticides	0,00	0,00
Inoculant	0,00	0,00
Transport	0,00	12,000.00
Total input costs	7,800.00	52,500.00
Gross Margin	62,200.00	183,750.00
Percentage increase in Gross Margin		195%

Table 4.14 shows more detail on partial analysis of groundnuts for Salima district. Despite the increase in production costs from MK7, 800 to MK52, 500 (573%) the net effect is beneficial. According to the procedure for partial budget analysis in Section 4.3, there is a positive difference of MK113, 750.00 per hectare for a typical smallholder in the area. The farmers therefore have benefitted from the use of the legume technologies.

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Table 4:12 Partial Budget for groundnut production

Positive effects	Value (MK)	Negative effects Value	Value (MK)
Additional income:		**Reduced income:**	
(1,750 kg x MK135.00) - (1000 kg x MK70.00) = (MK236,250.00 - MK70,000.00)	166,250.00	None	0
Total additional income	166,250.00	Total reduced income	0
Reduced costs:		**Additional costs:**	
None	0	Change in total input cost (With – Without technology) (MK52,500.00 - MK 0.00)	52,500.00
Total reduced costs	0	Total additional costs	52,500.00
Total additional income and reduced costs (TAIRC)	166,250.00	Total reduced income and additional costs (TRIAC)	52,500.00
Net effect/ ha			**113,750.00**

Source: Own calculation based (Audsley, 1989).

4.4.2.2 Cowpeas

Cowpea crop was grown together with soya beans and maize on the same 0.5 hectares piece of land. For cowpeas the total sales revenue amounted to MK32, 500.00, and there were no costs on the production of the crop before the adoption of the legume technologies. Sales revenue grew to MK100, 000.00 and MK23, 099.55 was used for input for the growth of cowpeas after the adoption of the technologies. Gross margin for the crop without the legume technologies was MK32, 500.00 and MK76, 900.45 after the adoption of the legume technologies. There was therefore a gross margin increase of 136 percent. Table 4.15 gives more detail:

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Table 4:13 Agronomical financial results for cowpea production in Salima district

Agronomic Indicators	Without legume technologies	With legume technologies
Average yield (kg/ha)	500	1,250
Price (MK)	65.00	80.00
Sales Revenue (MK)	32,500.00	100,000.00
Input costs		
Seed (MK/Kg)	0,00	4,800.00
Labour	0,00	0,00
Fertiliser	0,00	6,281.55
Pesticides	0,00	0,00
Inoculant	0,00	4,018.00
Transport	0,00	8,000.00
Total input costs	0,00	23,099.55
Gross margin	32,500.00	76,900.45
Percentage increase in Gross Margin		136%

Table 4.16 shows more detail on partial analysis of cowpeas for Salima district. According to the procedure for partial budget analysis in Section 4.3 there is a positive difference of MK44, 400.45 per hectare for a typical smallholder in the area. The farmers therefore have benefitted from the use of the legume technologies.

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Table 4:14 Partial Budget for cowpea production

Positive effects	Value (MK)	Negative effects Value	Value (MK)
Additional income:		**Reduced income:**	
(1,250 kg x MK80.00) - (500 kg x MK65.00) = (MK100,000.00 - MK35,000.00)	67,500.00	None	0
Total additional income	67,500.00	Total reduced income	0
Reduced costs:		**Additional costs:**	
None	0	Change in total input cost (With - Without technology) (MK52,500.00 - MK 0.00)	23,099.55
Total reduced costs	0	Total additional costs	23,099.55
Total additional income and reduced costs (TAIRC)	67,500.00	Total reduced income and additional costs (TRIAC)	23,099.55
Net effect/ha			**44,400.45**

Source: Own calculation based (Audsley, 1989)

4.4.2.3 Maize

Before the adoption of the legume technologies the cost of inputs for the smallholder farmers in Salima was MK20, 400.00 and their yields from maize gave sales revenue of MK52, 000.00. However, after the adoption of the legume technologies, cost of production was MK106, 800.00 and sales revenue also rose to MK204, 000.00 indicating a growth of 207 percent in gross margin. Table 4.17 gives more detail:

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Table 4:15 Agronomical financial results for maize production in Salima district

Agronomic Indicators	Without legume technologies	With legume technologies
Average yield (kg/ha)	1,300	2,400
Price (MK)	40.00	85.00
Sales Revenue (MK)	52,000.00	204,000.00
Input costs		
Seed (MK/Kg)	5,000.00	23,900.00
Labour	3,800.00	31,000.00
Fertiliser	9,000.00	36,000.00
Pesticides	2,600.00	3,900.00
Inoculant	0,00	0,00
Transport	0,00	12,000.00
Total input costs	20,400.00	106,800.00
Gross Margin	31,600.00	97,200.00
Percentage increase in Gross Margin		207%

Table 4.18 shows more detail on partial analysis of maize for Salima district. According to the procedure for partial budget analysis in Section 4.3, there is a positive difference of MK65, 600.00 per hectare for a typical smallholder in the area. The farmers therefore have benefitted from the use of the legume technologies.

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Table 4:16 Partial Budget for maize production for Salima district

Positive effects	**Value (MK)**	**Negative effects Value**	**Value (MK)**
Additional income:		**Reduced income:**	
(2,400 kg x MK85.00) - (1,300 kg x MK40.00) = (MK204,000.00 - MK52,000.00)	152,000.00	None	0
Total additional income	152,000.00	Total reduced income	0
Reduced costs:		**Additional costs:**	
None	0	Change in total input cost (With - Without technology) (MK106,800.00 - MK20,400.00)	86,400.00
Total reduced costs	0	Total additional costs	86,400.00
Total additional income and reduced costs (TAIRC)	152,000.00	Total reduced income and additional costs (TRIAC)	86,400.00
Net effect/ ha			**65,600.00**

Source: Own calculation based (Audsley, 1989).

In the case of Salima, the net effect is MK223, 750.45 or $470.5. In this instance it is on a typical farm of 1 ha. This is an area with relatively wealthier farmers and the effect of the BNF technologies is more pronounced in absolute terms.

4.4.3 Dedza District

In Dedza the smallholder farmers on average hold 0.5 hectares of land for crop cultivation. The farmers were cultivating soya beans, groundnuts, common bean and maize during the period of study and all three crops were grown on the same piece of land. Ten farmers participated in the FGD in Dedza and eight out of the ten farmers were still members of the project, representing 80 percent. One farmer was not selected when the project started and the remaining farmer was once a member but dropped out of the project because she felt that the cowpeas seed she received as starter pack,

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produced cowpeas that were difficult to cook and were not fetching a good price on the market compared to the seed that she had been growing before the adoption of the legume technologies.
Before the introduction of the legume technologies in the Dedza district, a typical farm structure in the area consisted of a housing structure with earth walls and floors and grass thatched roofs. The housing structure of the farmers has remained the same after the adoption of the legume technologies. In terms of livestock there were no significant changes after the adoption of the legume technologies except for goats that these farmers did not previously have and also rabbits which increased in number by 150 percent. Table 4:19 gives more detail on livestock for a typical farm structure for Dedza:

Table 4:17 Livestock for a typical farm in Dedza district

	Without legume technologies		With legume technologies		
Type	Number	Value (MK)	Number	Value (MK)	% increase
Poultry	10	1,500.00	10	1,800.00	20
Goat			3	30,000.00	-
Cow					
Pig					
Rabbits	10	3,000.00	25	3,500.00	150%
Others(Sheep)	5	5,000.00	5	15,000.00	200%

With farm implements there were no significant changes from what the household had before the legume technologies and after the legume technologies. There were changes in market values on the farm implements but the farmers were not affected by the changes since they had not purchased new farm implements yet. Table 4.20 gives more details on the farm implements.

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Table 4:18 Farm implements for a typical farm in Dedza district

	Without legume technologies		With legume technologies		
Implement	Number	Value (MK)	Number	Value (MK)	% increase
Hoe	2	1,500.00	2	1,500.00	0
Machete	1	500.00	1	500.00	0
Spade					
Watering can	2	300.00	2	300.00	0
Slasher					
Axe	1	800.00	1	2,000.00	0
Sickle	1	450	1	700.00	0
Wheelbarrow					
Sprayer					
Ox-cart					
Irrigation pump					
Other (shovel)	1	1,500.00	1	1,500.00	0

Before the legume technologies most farmers in Dedza district had, on average, only a bicycle and no other farm level assets. However, after the adoption of the legume technologies, there were significant changes, like the farmers being able to purchase a radio for household-level use and two mobile phones for the eldest members of the household. All other assets remained the same. Table 4.21 shows more details:

Table 4:19 Assets for a typical farm in Dedza district

	Without legume technologies		With legume technologies		
Asset	Number	Value (MK)	Number	Value (MK)	% increase
Radio			1	5000.00	-
Mobile phone			2	5,000.00	-
Television					
Bicycle	1	20,000.00	1	25,000.00	0%
Motor vehicle					
Other					

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Smallholder farmers of Dedza hold, on average, 0.5 hectares of land for cultivation. The farmers cultivated soya beans, groundnuts, common beans and maize during the period of study and all four crops were grown on the same piece of land.

4.4.3.1 Soya beans

The cost of production for soya beans in the area was MK6, 500.00 and sales revenue was MK55, 000.00 before the adoption of the legume technologies. After the adoption of the technologies both the cost of production and sales revenue rose to MK33, 650.00 and MK127, 500.00 respectively. Gross margin for the crop without the legume technologies was MK48, 500.00 and MK93, 650.00 after the adoption of the legume technologies. This resulted in an increase of 93 percent increase in gross margin. Table 4.22 gives more detail:

Table 4:20 Agronomical financial results for soya beans production in Dedza district

Agronomic Indicators	Without legume technologies	With legume technologies
Average yield (kg/ha)	500	750
Price (MK)	110.00	170.00
Sales Revenue (MK)	55,000.00	127,500.00
Input costs		
Seed (MK/Kg)	1,500.00	4,000.00
Labour	5,000.00	11,500.00
Fertiliser	0,00	4,000.00
Pesticides	0,00	1,850.00
Inoculant	0,00	4,500.00
Transport	0,00	8,000.00
Total input costs	6,500.00	33,850.00
Gross Margin	48,500.00	93,650.00
Percentage increase in Gross Margin		93%

Table 4.23 shows more detail on the analysis of soya beans for Dedza district. According to the procedure for partial budget analysis in Section 4.3, there is a positive difference of MK45, 150.00 per

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hectare for a typical smallholder in the area. The farmers therefore have benefitted from the use of the legume technologies.

Table 4:21 Partial Budget for soya beans production

Positive effects	Value (MK)	Negative effects Value	Value (MK)
Additional income: (750 kg x MK170.00) - (500 kg x MK110.00) = (MK127,500.00 - MK55,000.00)	72,500.00	**Reduced income:** None	0
Total additional income	72,500.00	Total reduced income	0
Reduced costs:		**Additional costs:**	
None	0	Change in total input cost (With - Without technology) (MK33,850.00 - MK6,500 0.00)	27,350.00
Total reduced costs	0	Total additional costs	27,350.00
Total additional income and reduced costs (TAIRC)	72,500.00	Total reduced income and additional costs (TRIAC)	27,350.00
Net effect/ha			**45,150.00**

Source: Own calculation based (Audsley, 1989).

4.4.3.2 Groundnuts

The cost of production for groundnuts in the area was MK45, 300.00 and sales revenue was MK104, 000.00 before the adoption of the legume technologies. After the adoption of the technologies, both the cost of production and sales revenue rose to MK119, 400.00 and MK456, 000.00 respectively. Gross margins for groundnuts before the legume technologies were MK58, 700.00 and MK336, 600.00 after the adoption of the legume technologies. This resulted in a 473 percent increase in gross margin. Table 4.24 gives more detail:

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Table 4:22 Agronomical financial results for groundnuts production in Dedza district

Agronomic Indicators	Without legume technologies	With legume technologies
Average yield (kg/ha)	1,300	760
Price (MK)	80.00	600.00
Sales Revenue (MK)	104,000.00	456,000.00
Input costs		
Seed (MK/Kg)	18,800.00	30,200.00
Labour	26,500.00	49,000.00
Fertiliser	0,00	16,200.00
Pesticides	0,00	0,00
Inoculant	0,00	24,000.00
Transport	0,00	0,00
Total input costs	45,300.00	119,400.00
Gross Margin	58,700.00	336,600.00
Percentage increase in Gross Margin		473%

Table 4.25 shows more detail on partial analysis of groundnuts for Dedza district. According to the procedure for partial budget analysis in Section 4.3, there is a positive difference of MK277, 900.00 per hectare for a typical smallholder in the area. The farmers therefore have benefitted from the use of the legume technologies. The price increase is significant for groundnuts if farmed properly. This causes relatively high expectations from the farmers who also requested more support regarding groundnut production.

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Table 4:23 Partial Budget for groundnuts production

Positive effects	**Value (MK)**	**Negative effects Value**	**Value (MK)**
Additional income:		**Reduced income:**	
(760 kg x MK600.00) - (1,300 kg x MK80.00) = (MK456,00.00 - MK104,000.00)	352,000.00	None	0
Total additional income	352,000.00	Total reduced income	0
Reduced costs:		**Additional costs:**	
None	0	Change in total input cost (With - Without technology) (MK119,400.00 - MK 45,300.00)	74,100.00
Total reduced costs	0	Total additional costs	74,100.00
Total additional income and reduced costs (TAIRC)	352,000.00	Total reduced income and additional costs (TRIAC)	74,100.00
Net effect/ha			**277,900.00**

Source: Own calculation based (Audsley, 1989).

4.4.3.3 Common beans

The cost of production for common beans in the area was MK43, 500.00 and sales revenue was MK180, 000.00 before the adoption of the legume technologies. After the adoption of the technologies, both the cost of production and sales revenue rose to MK113, 600.00 and MK336, 000.00 respectively. Gross margins for common beans before the legume technologies were MK136, 500.00 and MK222, 700.00 after the adoption of the legume technologies. This resulted into an increase of 63 percent increase in gross margin. Table 4.26 gives more detail:

Table 4:24 Agronomical financial results for common beans production in Dedza district

Agronomic Indicators	Without legume technologies	With legume technologies
Average yield (kg/0.5ha)	1,500	1,200
Price (MK)	120.00	280.00
Sales Revenue (MK)	180,000.00	336,000.00
Input costs		
Seed (MK/Kg)	18,500.00	36,200.00
Labour	25,000.00	45,000.00
Fertiliser	0,00	12,000.00
Pesticides	0,00	0,00
Inoculant	0,00	7,600.00
Transport	0,00	12,500.00
Total input costs	43,500.00	113,300.00
Gross Margin	136,500.00	222,700.00
Percentage increase in Gross Margin		63%

Table 4.27 shows the partial budget analysis of common beans for Dedza district. According to the procedure for partial budget analysis in Section 4.3, there is a positive difference of MK86, 200.00 per hectare for a typical smallholder in the area. The farmers therefore have benefitted from the use of the legume technologies.

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Table 4:25 Partial Budget for common beans production

Positive effects	Value (MK)	Negative effects Value	Value (MK)
Additional income:		**Reduced income:**	
(1,200 kg x MK280.00) - (1,500 kg x MK120.00) = (MK336,00.00 - MK180,000.00)	156,000.00	None	0
Total additional income	156,000.00	Total reduced income	0
Reduced costs:		**Additional costs:**	
None	0	Change in total input cost (With - Without technology) (MK113,300.00 - MK43,500.00)	69,800.00
Total reduced costs	0	Total additional costs	69,800.00
Total additional income and reduced costs (TAIRC)	156,000.00	Total reduced income and additional costs (TRIAC)	69,800.00
Net effect/ha			**86,200.00**

Source: Own calculation based (Audsley, 1989).

4.4.3.4 Maize

Before the adoption of the legume technologies the cost of inputs for the smallholder farmers in Dedza was MK9, 700.00 and their yields from maize gave a sales revenue of MK66, 000.00. However after the adoption of the legume technologies cost of production was MK41, 500.00 and sales revenue has also rose to MK106, 250.00, indicating a growth of 15 percent in gross margin. Table 4.28 gives the detail:

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Table 4:26 Agronomical financial results for maize production in Dedza district

Agronomic Indicators	Without legume technologies	With legume technologies
Average yield (kg/ha)	1,650	1,250
Price (MK)	40.00	85.00
Sales Revenue (MK)	66,000.00	106,250.00
Input costs		
Seed (MK/Kg)	0,00	12,000.00
Labour	0,00	14,000.00
Fertiliser	8,300.00	13,000.00
Pesticides	1,400.00	2,500.00
Inoculant	0,00	0,00
Transport	0,00	0,00
Total input costs	9,700.00	41,500.00
Gross Margin	56,300.00	64,750.00
Percentage increase in Gross Margin		15%

Table 4.29 shows more detail on partial analysis of maize for Dedza district. According to the procedure for partial budget analysis in Section 4.3, there is a positive difference of MK8, 450.00 per hectare for a typical smallholder in the area. The farmers therefore have benefitted from the use of the legume technologies.

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Table 4:27 Partial Budget for maize production

Positive effects	Value (MK)	Negative effects Value	Value (MK)
Additional income:		**Reduced income:**	
(1,250 kg x MK85.00) - (1,650 kg x MK85.00) = (MK106,250.00 - MK66,000.00)	40,250.00	None	0
Total additional income	40,250.00	Total reduced income	0
Reduced costs:		**Additional costs:**	
None	0	Change in total input cost (With - Without technology) (MK41,500.00 - MK 9,700.00)	31,800.00
Total reduced costs	0	Total additional costs	31,800.00
Total additional income and reduced costs (TAIRC)	40,250.00	Total reduced income and additional costs (TRIAC)	31,800.00
Net effect/ ha			**8,450.00**

Source: Own calculation based (Audsley, 1989).

The net increase in potential income for the typical smallholder farmers is Dedza is MK208, 850.00 or $439.1

4.4.4 Ntcheu District

In Ntcheu the smallholder farmers typically holds 0.5 hectares of land for crop cultivation. The farmers cultivated cowpeas, groundnuts, and maize during the period of study and all three crops were grown on the same piece of land.

Ten farmers participated in the FGD in Ntcheu and seven out of the ten farmers were still members of the project. One farmer was not selected when the project started and the remaining two farmers were once members but dropped out of the project last growing season since there was insufficient distribution of seed for cultivation in the area.

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Before the introduction of the legume technologies in the Ntcheu district, a typical farm structure in the area consisted of a housing structure with earth walls and floors and grass thatched roofs. The housing structures of the farmers have improved and the farmers now have houses plastered with cement, and iron sheet roofs. However, the farmers indicated that the majority of their floors are still made of earth after the adoption of the legume technologies.

In terms of livestock there were significant changes after the adoption of the legume technologies, particularly in rabbits and pigs. The farmers had no pigs before the adoption of the legume technologies but have now started raising them. There was a 200 percent increase in rabbits after the adoption of legume technologies. Table 4:30 gives more details on livestock for a typical farm structure for Ntcheu:

Table 4:28 Livestock for a typical farm in Ntcheu district

	Without legume technologies		With legume technologies		
Type	Number	Value (MK)	Number	Value (MK)	% increase
Poultry	20	1,000.00	20	2,500.00	150%
Goats	5	25,000.00	7	30,000.00	20%
Cattle					
Pigs			12	30,000.00	-
Rabbits	10	600.00	30	1,500.00	200%
Others					

With farm implements there were no significant changes from what the farm households had before the legume technologies and after the legume technologies. However, there were changes in market values on the farm implements but the farmers were not affected by the changes since they had not purchased new farm implements yet. Table 4.31 gives more detail on the farm implements.

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Table 4:29 Farm implements for a typical farm in Ntcheu district

	Without legume technologies		With legume technologies		
Implement	Number	Value (MK)	Number	Value (MK)	% increase
Hoe	2	1,500.00	2	2,000.00	33%
Machete					
Spade					
Watering can					
Slasher					
Axe	1	1,000.00	1	1,500.00	50%
Sickle	1	500.00	1	700.00	40%
Wheelbarrow					
Sprayer	1	8,500.00	1	10,000.00	18%
Ox-cart	1	250,000.00	1	250,000.00	0%
Irrigation pump					
Other					

Before the legume technologies most households did not possess any real assets in Ntcheu district. However the farmers have been able to obtain assets like a radio, a mobile phone and a bicycle after the adoption of the legume technologies. Table 4.32 shows more detail:

Table 4:30 Assets for a typical farm in Ntcheu district

	Without legume technologies		With legume technologies		
Asset	Number	Value (MK)	Number	Value (MK)	% increase
Radio			1	10,000.00	-
Mobile phone			1	7,500.00	-
Television					
Bicycle			1	40,000.00	-
Motor vehicle					
Other					

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4.4.4.1 Cowpeas

There was no cost of production of cowpeas in Ntcheu district, however the farmers managed to gain a total of MK2, 750.00 as sales revenue before the adoption of the legume technologies. After the adoption of the technologies, cost of production was MK7, 500.00 and sales revenue rose to MK40, 000.00. Gross margin for the crop without the legume technologies remained at MK2, 750.00 and MK32, 500.00 after the adoption of the legume technologies. This resulted in a 1,081.8 percent increase in gross margin. Please note that in this instance the relative effect (% change) should be seen in relation to the low base of only 50kg/ha. The response was however positive and that is the effect of depleted soils to start with. Table 4.33 gives more detail:

Table 4:31 Agronomical financial results for cowpeas production in Ntcheu district

Agronomic Indicators	Without legume technologies	With legume technologies
Average yield (kg/0.5ha)	50	500
Price (MK)	55.00	80.00
Sales Revenue (MK)	2,750.00	40,000.00
Input costs		
Seed (MK/Kg)	0,00	3,000.00
Labour	0,00	0,00
Fertiliser	0,00	0,00
Pesticides	0,00	0,00
Inoculant	0,00	4,500.00
Transport	0,00	0,00
Total input costs	0,00	7,500.00
Gross Margin	2,750.00	32,500.00
Percentage increase in Gross Margin		1,092%

Table 4.34 shows the detail on partial analysis of cowpeas for Ntcheu district. According to the procedure for partial budget analysis in Section 4.3, there is a positive difference of MK29, 750.00 per hectare for a typical smallholder in the area. The farmers therefore have benefitted from the use of the legume technologies.

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Table 4:32 Partial Budget for cowpeas production

Positive effects	Value (MK)	Negative effects Value	Value (MK)
Additional income:		**Reduced income:**	
(500 kg x MK80.00) - (50 kg x MK55.00) = (MK40,000.00 - MK2,750.00)	37,250.00	None	0
Total additional income	37,250.00	Total reduced income	0
Reduced costs:		**Additional costs:**	
None	0	Change in total input cost (With - without technology) (MK7,500.00 - MK0.00)	7,500.00
Total reduced costs	0	Total additional costs	7,500.00
Total additional income and reduced costs (TAIRC)	37,250.00	Total reduced income and additional costs (TRIAC)	7,500.00
Net effect/ha			**29,750.00**

Source: Own calculation based (Audsley, 1989).

4.4.4.2 Groundnuts

The cost of production for groundnuts in Ntcheu district before the adoption of the legume technologies was MK3, 500.00 and sales revenue was MK70, 000.00. After the adoption of the technologies both the cost of production and sales revenue rose to MK109, 100.00 and MK536, 250.00 respectively. Gross margins for groundnuts before the legume technologies were MK66, 500.00 and MK427, 150.00 after the adoption of the legume technologies. This resulted in a 542 percent increase in gross margin. Table 4.35 gives more detail:

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Table 4:33 Agronomical financial results for groundnuts production in Ntcheu district

Agronomic Indicators	Without legume technologies	With legume technologies
Average yield (kg/ha)	700	975
Price (MK)	100.00	550.00
Sales Revenue (MK)	70,000.00	536,250.00
Input costs		
Seed (MK/Kg)	3,500.00	33,400.00
Labour	0,00	45,000.00
Fertiliser	0,00	18,700.00
Pesticides	0,00	0,00
Inoculant	0,00	12,000.00
Transport	0,00	0,00
Total input costs	3,500.00	109,100.00
Gross Margin	66,500.00	427,150.00
Percentage increase in Gross Margin		542%

Table 4.36 shows more detail on partial analysis of ground nuts for Ntcheu district. According to the procedure for partial budget analysis in Section 4.3, there is a positive difference of MK360, 650.00 per hectare for a typical smallholder in the area. The farmers therefore have benefitted from the use of the legume technologies.

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Table 4:34 Partial Budget for groundnuts production

Positive effects	Value (MK)	Negative effects Value	Value (MK)
Additional income:		**Reduced income:**	
(975 kg x MK550.00) - (700 kg x MK100.00) = (MK536,250.00 - MK70,000.00)	466,250.00	None	0
Total additional income	466,250.00	Total reduced income	0
Reduced costs:		**Additional costs:**	
None	0	Change in total input cost (With - without technology) (MK109,100.00 - MK3,500.00)	105,600.00
Total reduced costs	0	Total additional costs	105,600.00
Total additional income and reduced costs (TAIRC)	466,250.00	Total reduced income and additional costs (TRIAC)	105,600.00
Net effect/ha			**360,650.00**

Source: Own calculation based (Audsley, 1989).

4.4.4.3 Maize

The cost of production for maize in Ntcheu district before the adoption of the legume technologies was MK13, 500.00 and sales revenue was MK50, 000.00. After the adoption of the technologies both the cost of production and sales revenue rose to MK39, 500.00 and MK80, 750.00 respectively. Gross margins for maize before the legume technologies were MK36, 500.00 and MK41, 250.00 after the adoption of the legume technologies. This resulted in a 13 percent increase in gross margin. Table 4.37 gives more detail. The decline in yield of 300 kg was due to two main reasons: one being a drought and the other was late implementation of the legumes due to late delivery. There were also some complaints about the use of inoculants as there are very limited cooling facilities in the form of refrigerators. Cool storage is necessary for inoculant efficiency. As was the case with Dedza, the drought seems to have impacted the prices of various cereals upwards.

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Table 4:35 Agronomical financial results for maize production in Ntcheu district

Agronomic Indicators	Without legume technologies	With legume technologies
Average yield (kg/ha)	1,250	950
Price (MK)	40.00	85.00
Sales Revenue (MK)	50,000.00	80,750.00
Input costs		
Seed (MK/Kg)	0,00	8,000.00
Labour	0,00	16,000.00
Fertiliser	13,500.00	13,000.00
Pesticides	0,00	2,500.00
Inoculant	0,00	0,00
Transport	0,00	0,00
Total input costs	13,500.00	39,500.00
Gross Margin	36,500.00	41,250.00
Percentage increase in Gross Margin		13%

Table 4.38 shows more detail on partial analysis of maize for Ntcheu district. According to the procedure for partial budget analysis in Section 4.3, there is a positive difference of MK4, 750.00 per hectare for a typical smallholder in the area. In this instance the positive effect on the maize gross margin was due to a price increase. The actual yield was lower, which is somewhat contradictory to expectations.

Table 4:36 Partial Budget for maize production

Positive effects	**Value (MK)**	**Negative effects Value**	**Value (MK)**
Additional income:		**Reduced income:**	
(950 kg x MK85.00) - (1,250 kg x MK40.00) = (MK80,750.00 - MK50,000.00)	30,750.00	None	0
Total additional income	30,750.00	Total reduced income	0
Reduced costs:		**Additional costs:**	
None	0	Change in total (MK39,500.00 - MK13,500.00) input cost (With - Without technology)	26,000.00
Total reduced costs	0	Total additional costs	26,000.00
Total additional income and reduced costs	30,750.00	Total reduced income and additional costs	26,000.00
Net effect/ha			**4,750.00**

Source: Own calculation based (Audsley, 1989).

The net impact of the introduction of BNF technology for the Ntcheu is MK197, 575.00 or $415.4.

4.4.5 Kasungu District

In Kasungu, a typical smallholder farmer holds on average 0.5 hectares of land for cultivation of crops. The farmers cultivated soya beans, groundnuts, and maize during this period of study and all three crops were grown on the same piece of land; in other words, intercropped.

All of the ten farmers who participated in the FGD in Kasungu have been members ever since the project started, representing 100 percent membership. There were no drop outs in the district and the farmers reported that all those selected for the project are still with the project. Before the introduction of the legume technologies in the Ntcheu district, a typical farm structure in the area consisted of a housing structure with earth walls, cemented floors and iron sheet roofs. The housing structure of the farmers has since remained the same except for one member who has built a house with burnt bricks,

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iron sheet roof and cement plastered walls, which is an improvement of a typical house in the district. This shows a 10 percent representation of improved housing structure in Kasungu district after the adoption of the legume technologies.

In terms of livestock there were no significant changes after the adoption of the legume technologies, except for pigs which have now increased from 10 per household to 25 per household representing a 150 percent increase in pig production. Table 4:39 gives more details on livestock for a typical farm structure for Kasungu:

Table 4:37 Livestock for a typical farm in Kasungu district

	Without legume technologies		With legume technologies		
Type	Number	Value (MK)	Number	Value (MK)	% increase
Poultry	30	1,800.00	30	2,500.00	39%
Goats	10	15,000.00	10	25,000.00	67%
Cattle					
Pigs	10	25,000.00	25	30,000.00	1500%
Rabbits					
Others					

There were no significant changes from what the farm households had as farm implements before the legume technologies and after the legume technologies. However, there were changes in market values on the farm implements but the farmers were not affected by the changes since they had not purchased new farm implements yet. Table 4.40 gives more detail on the farm implements.

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Table 4:38 Farm implements for a typical farm in Kasungu district

	Without legume technologies		With legume technologies		
Implement	Number	Value (MK)	Number	Value (MK)	% increase
Hoe	4	2000.00	4	2,000.00	0
Machete					
Spade					
Watering can	2	1,700.00	2	2,000.00	18%
Slasher					
Axe	1	1,000.00	1	1,350.00	35%
Sickle	1	500.00	1	800.00	60%
Wheelbarrow					
Sprayer					
Ox-cart					
Irrigation pump					
Other					

In Kasungu district, before the legume technologies were introduced, most households could afford assets like a radio, mobile phone and a bicycle. The farmers have however not been able to obtain any other assets apart from the ones they already had after the adoption of the legume technologies. Table 4.41 shows more detail:

Table 4:39 Assets for a typical farm in Kasungu district

	Without legume technologies		With legume technologies		
Asset	Number	Value (MK)	Number	Value (MK)	% increase
Radio	1	4,000.00	1	5,000.00	25%
Mobile phone	1	6,500.00	1	8,500.00	31%
Television					
Bicycle	1	30,000.00	1	45,000.00	50%
Motor vehicle					
Other					

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4.4.5.1 Soya beans

The cost of production for soya beans in this area was MK15, 982.00 and sales revenue was MK56, 000.00 before the adoption of the legume technologies. After the adoption of the technologies, cost of production was MK41, 718.00 and sales revenue rose to MK210, 600.00. Gross margins for the crop before the legume technologies were MK40, 018.00 and MK168, 882.00 after the adoption of the legume technologies. This resulted in a 322 percent increase in gross margin. Table 4.42 gives the detail:

Table 4:40 Agronomical financial results for soya beans production in Kasungu district

Agronomic Indicators	Without legume technologies	With legume technologies
Average yield (kg/0.5ha)	400	1,170
Price (MK)	140.00	180.00
Sales Revenue (MK)	56,000.00	210,600.00
Input costs		
Seed (MK/Kg)	2,200.00	3,500.00
Labour	9,000.00	12,000.00
Fertiliser	2,282.00	4,200.00
Pesticides	0,00	3,000.00
Inoculant	0,00	4,018.00
Transport	2,500.00	15,000.00
Total input costs	15,982.00	41,718.00
Gross Margin	40,018.00	168,882.00
Percentage increase in Gross Margin		322%

Table 4.43 shows more detail on partial analysis of soya beans for Kasungu district. According to the procedure for partial budget analysis in Section 4.3, there is a positive difference of MK128, 864.00 per hectare for a typical smallholder in the area. The farmers therefore have benefitted from the use of the legume technologies.

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Table 4:41 Partial Budget for soya beans production

Positive effects	Value (MK)	Negative effects Value	Value (MK)
Additional income:		**Reduced income:**	
(1,1700 kg x MK180.00) - (400 kg x MK140.00) = (MK210,600.00 - MK56,000.00)	154,600.00	None	0
Total additional income	154,600.00	Total reduced income	0
Reduced costs:		**Additional costs:**	
None	0	Change in total input cost (With - Without technology) (MK41,718.00 - MK15,982.00)	25,736.00
Total reduced costs	0	Total additional costs	25,736.00
Total additional income and reduced costs (TAIRC)	154,600.00	Total reduced income and additional costs (TRIAC)	25,736.00
Net effect/ha			**128,864.00**

Source: Own calculation based (Audsley, 1989).

4.4.5.2 Groundnuts

Farmers in Kasungu did not incur any costs for the production of groundnuts before the adoption of the legume technologies, however, they were able to get MK27, 000.00 as sales revenue. After the adoption of the technologies, cost of production was MK116, 750.00 and sales revenue was MK319, 000.00. Gross margins for the crop before the legume technologies remained at MK27, 000.00 and MK202, 250.00 after the adoption of the legume technologies. There was an increase of 649 percent in gross margin. Table 4.44 gives more detail:

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Table 4:42 Agronomical financial results for groundnuts production in Kasungu district

Agronomic Indicators	Without legume technologies	With legume technologies
Average yield (kg/ha)	300	550
Price (MK)	90.00	580.00
Sales Revenue (MK)	27,000.00	319,000.00
Input costs		
Seed (MK/Kg)	0,00	33,750.00
Labour	0,00	38,000.00
Fertiliser	0,00	22,000.00
Pesticides	0,00	0,00
Inoculant	0,00	15,000.00
Transport	0,00	8,000.00
Total input costs	0,00	116,750.00
Gross Margin	27,000.00	202,250.00
Percentage increase in Gross Margin		649%

Table 4.45 shows more detail on partial analysis of groundnuts for Kasungu district. According to the procedure for partial budget analysis in Section 4.3, there is a difference of MK175 250 per hectare for a typical smallholder in the area. The farmers therefore have benefitted from the use of the legume technologies.

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Table 4:43 Partial Budget for groundnuts production

Positive effects	Value (MK)	Negative effects Value	Value (MK)
Additional income: (550 kg x MK580.00) - (300 kg x MK90.00) = (MK319,000.00 - MK27,000.00)	292,000.00	**Reduced income:** None	0
Total additional income	292,000	Total reduced income	0
Reduced costs:		**Additional costs:**	
None	0	Change in total input cost (With - Without technology) (MK116.750.00 - MK0.00)	116,750.00
Total reduced costs	0	Total additional costs	116,750.00
Total additional income and reduced costs (TAIRC)	292,000	Total reduced income and additional costs (TRIAC)	116,750.00
Net effect/ha			**175,250.00**

Source: Own calculation based (Audsley, 1989).

4.4.5.3 Maize

The cost of production for maize in Kasungu district, before the adoption of the legume technologies, was MK27, 300.00 and sales revenue was MK100, 000.00. After the adoption of the technologies, both the cost of production and sales revenue rose to MK79, 000.00 and MK248, 000.00 respectively. Gross margins for maize before the legume technologies were MK72, 700.00 and MK169, 000.00 after the adoption of the legume technologies. This resulted in an increase of 132 percent in gross margin. Table 4.46 gives more detail:

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Table 4:44 Agronomical financial results for maize production in Kasungu district

Agronomic Indicators	Without legume technologies	With legume technologies
Average yield (kg/ha)	2,500	3,100
Price (MK)	40.00	80.00
Sales Revenue (MK)	100,000.00	248,000.00
Input costs		
Seed (MK/Kg)	4,800.00	14,000.00
Labour	8,000.00	26,000.00
Fertiliser	12,000.00	16,000.00
Pesticides	2,500.00	8,000.00
Inoculant	0,00	0.00
Transport	0,00	15,000.00
Total input costs	27,300.00	79,000.00
Gross Margin	72,700.00	169,000.00
Percentage increase in Gross Margin		132%

Table 4.47 shows more detail on partial analysis of maize for the Kasungu district. According to the procedure for partial budget analysis in Section 4.3, there is a positive difference of MK96, 300.00 per hectare for a typical smallholder in the area. The farmers therefore have benefitted from the use of the legume technologies.

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Table 4:45 Partial Budget for maize production

Positive effects	**Value (MK)**	**Negative effects Value**	**Value (MK)**
Additional income:		**Reduced income:**	
(3,100 kg x MK80.00) - (2,500 kg x MK40.00) = (MK248,000.00 - MK100,000.00)	148,000.00	None	0
Total additional income	148,000.00	Total reduced income	0
Reduced costs:		**Additional costs:**	
None	0	Change in total input cost (With - Without technology) (MK79, 000.00 - MK27,300.00)	51,700.00
Total reduced costs	0	Total additional costs	51,700.00
Total additional income and reduced costs (TAIRC)	148,000.00	Total reduced income and additional costs (TRIAC)	51,700.00
Net effect/ha			**96,300.00**

Source: Own calculation based (Audsley, 1989).

The net implications of the introduction of BNF technology for the Kasungu area on smallholder farm level is MK200, 207 or $421.0

4.5 General results

In general the results of the adoption were overwhelmingly positive. In some instances the yields of crops increased remarkably after the adoption of BNF technology, mostly alternative crops or the use of inoculants. Table 4.48 gives an overview of the impact of BNF technology as experienced by the producers in the selected areas of Malawi.

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Table 4.48: The yield response experienced by farmers (t/ha) of various crops in the selected districts due to the adoptions of BNF technology

Area	Maize		G/nuts		Cowpeas		Common bean		Soya beans	
	*B	**A	*B	**A	*B	**A	*B	**A	*B	**A
Mchinji	0.65	1.45			0.5	1.25			0.45	0.75
Salima	1.3	2.4	1	1.75	0.5	1.25				
Dedza	1.65	1.25	1.3	0.76			1.5	1.2	0.5	0.75
Ntcheu	1.25	0.95	0.7	0.98	0.05	0.5				
Kasungu	2.5	3.1	0.3	0.55					0.4	1.17

*B = before the BNF technology was introduced

**A = after the adoption of the BNF technology

In the few cases where the effect of the introduction of BNF technology did not result in an increase in yields is was due to a drought coupled with late planting, or the inability to refrigerate the inoculants for the proper period that cool storage should be maintained. Overall the results are however, relatively positive as it presents households with a much improved basket of food for consumption as well as some potential income. Table 4.49 presents a summary of the net financial gains as experienced by the producers in these areas.

Table 4.49: Summary of the financial implications of adoption of BNF technology as experienced by smallholders producers in selected areas of Malawi

	Net financial implication for the household	
	MK (Malawian Kwacha)	$ (Dollar U.S.)
Mchinji	70,050.76	147.3.1
Salima	223,750.45	470.5
Dedza	208,850.00	439.1
Ntcheu	197,575.00	415.4
Kasungu	200,207.00	421.0

The exchange rate was $1 = MK475.6 (Exchange rates, 2015).

One interesting result is that of Salima, where the typical farm size is double that of the other areas while the net positive effect in terms of household income, is only slightly better. This is mostly ascribed to the fact that the basis from which the increase was measured was relatively high. These smallholder farmers are relatively better off and used more replenishing of the soil by manure etc.

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4.6 Conclusion

Chapter Four presented results with regards to wealth indicators such as land holding size, farm implements owned and household assets owned. The chapter further presented the results for each crop cultivated by use of gross margins and partial budget analysis from each of the selected districts in this study.

The study revealed that the farmers in all the districts cultivate maize as the staple crop. Maize is intercropped with the N2Africa target legume of cowpeas, groundnuts, soya beans and common beans. The intercropping system is commonly practised in the SSA and this study revealed that farmers in the selected districts of this study also follow the cropping system. Both the gross margin and partial budgets analyses revealed that the farmers in all the districts have benefitted financially from the adoption of the N2Africa legume technologies.

Among the legumes, groundnut crop proved to be the highest income earner and cowpeas were the lowest income earner. Apart from maize which was grown in all districts, groundnut crop was the second most commonly grown crop in the selected districts with common beans only grown in Dedza district.

The question about who the decision makers were regarding farm activities on various crops also revealed that the majority of the men were decision makers on the production of the legume crops even though the majority of men were in matrilineal marriages. The women own the land and the men have control on what legumes are to be cultivated on how much land. After harvest the men usually decide how much crop yield is to be sold on either the legumes or maize crop.

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CHAPTER V: CONCLUSION, SUMMARY AND RECOMMENDATIONS

5.1 Conclusion

The importance of the research lies within the need for increasing not only food supply to households in smallholder farming areas in Malawi, but also income. Smallholder farmers are relatively resource poor. In many instances this has led to some extent of soil nutrient depletion which negatively affects crop yields. The research was carried out to analyse the financial and managerial implications on smallholder farmers regarding the implementation of BNF and inoculant technology in current production systems in selected areas in Malawi. The main aim was to determine the financial implications of implementing BNF technologies and use of inoculants on legumes.

This study took place in the month of May 2015, in the central region of Malawi, specifically in Ntcheu, Mchinji, Dedza, Salima and Kasungu districts, where the N2Africa program promotes BNF technologies on its target legumes: cowpeas, soya beans, common beans and groundnuts among smallholder farmers. These districts are also located within the agro-ecological zones. The study particularly took place in Bilira EPA, which is 90 km away from the Ntcheu town. This included farmers from Manjawira EPA within the Ntcheu district and 50km away from Ntcheu town. In Mchinji the study took place at Mikundi EPA, 50 km from Mchinji town. From Dedza the study took place at Linthipe EPA, 50km away from Dedza town. In Salima the study was done at Makande EPA and this meeting also included farmers from Chinguluwe EPA. Both these EPAs are 20km and 40km away from Salima town respectively. From Kasungu district the study took place at Chamama EPA and farmers from Nkhamenya EPA were part of the study. Chamama EPA and Nkhamenya EPAs are 40km and 70km away from Kasungu town respectively. This study excluded Dowa district - one of the districts that was part of the N2Africa project in the first phase - due to administrative challenges.

The nature of this study was mixed research methods because it produced both quantitative data, which enabled the study to be carried out with a partial budget analysis, and also qualitative research methods which enabled the use of descriptive data; using words and sentences to qualify and record information. This study adopted qualitative research methods and results were presented in their qualitative form. The justification for using such a methodological approach is that it is appropriate for investigating complex social phenomena in their real-life contexts. It was not only sufficient to know what the potential benefits of BNF technology could be in terms of agronomical implications, but also how the producers experienced implementing the technology.

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To achieve the objectives of this study, both primary and secondary data were used. Information on understanding the role of BNF technology, the financial and managerial implications of the inclusion of such technologies on the production was generated by using a semi-structured checklist in each of the selected districts. Data on arable land, livestock ownership, assets and quality of housing was collected for each area and all these variables functioned as wealth indicators. Primary data was sourced through interviews with the legume producing lead farmers using a semi structured questionnaire through FGDs in the local vernacular, Chichewa, with the use of a semi-structured checklist. All interviews were conducted by the principal researcher and a research assistant. Secondary data was mainly sourced from publications of various stakeholders like N2Africa's final report on the first phase which has since been published. Other sources of secondary data were documents by MoAFS, Malawi government policy documents and past research findings on impacts of legume technologies on small holder production.

Purposive sampling was used in selecting the participants. The main goal of purposive sampling is to focus on particular characteristics of a population that are of interest, which will best enable you to answer your research questions and to understand a specific phenomenon; it is not aimed at representing a population. In this instance it was the need to understand the effect that producers experienced when adopting the BNF technology. The constraints they have also play a part in understanding why they often do not reach the expectations achieved in scientific trail results.

This study employed both a gross margin tool and a partial budget model for analysis of its quantitative data. The models were used particularly in the analysis of financial implications to determine the profitability of proposed changes in the operation of a typical farm enterprise in selected districts of Malawi. The models were used to assess the average costs and benefits associated with the adoption of legume technologies in soya beans, common beans, cowpeas and groundnuts for both five years before and five years after adoption of legume technologies. Partial budget is based on a unit, so data was collected from one farm from each of the districts in the study. In a partial budget model, economic effects are calculated as the sum of positive economic effects minus the negative economic effects. Positive economic effects are calculated as extra revenues plus reduced costs. The negative economic effects are calculated as the reduced revenues plus the extra costs. The main reasons for using this method is that it is relatively simple to use and also to explain to producers how to interpret results.

All districts, except Salima, reported that on average farmers own 0.5 hectares of land and Salima reported relatively larger pieces of land for cultivation, namely, 1 hectare. All districts had on average over 80 percent participation in the group discussions. The remaining 20 percent comprised of drop outs and prospective members. The members that dropped out reported to have dropped out because

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some were staying very far from the centres where trial plots were and some were just left out due to insufficient inputs in the past growing season.

All the selected districts reported to have received and used the improved seed variety of N2Africa and used these for cultivation apart from other inputs such as fertilizers and inoculation; all depending on the type of seed. All the selected districts reported to have employed the intercropping system during the period of the study and are currently doing the same.

Over 70 percent of the member farmers reported that their housing structures have not changed but were hopeful and had ambitions to improve their houses. However in terms of livestock, all districts reported to have been able to acquire some livestock or improved on the number of livestock they previously had. There were no changes in the type or numbers of farm implements owned and used by the farmers in all the districts. Three of the five districts reported to have improvements in the asset ownership representing a 60 percent increase, for instance farmers from Salima, Dedza and Ntcheu reported that they had no mobile phones before the introduction of the N2Africa project but now have. Not only were the Ntcheu farmers able to obtain mobile phones but they also obtained radios and bicycles.

There were increases in crop yields in all the crops for Mchinji, Salima and Kasungu after the adoption of the legume technologies and this could be attributed to the N2Africa legume technologies. However there was a decline in crop yields in Ntcheu and Dedza which the farmers blamed on the dry spell that affected the southern region in the past 2 growing seasons (2011 and 2012). Otherwise crop yields before the adoption of the legume technologies remained low and this could be attributed to farmers recycling seed, use of low-yielding varieties of legumes, lack of or insufficient fertiliser use (infertile soils) and low levels of knowledge and skills.

The increase in selling price in all districts after the adoption of the legume technologies could be attributed to better quality crops that fetched better selling prices on the market, as opposed to the low selling prices of crops before the adoption of the legume technologies.

The research study revealed that most of the farmers only produce enough maize for their household use and therefore it is not common to find maize production for commercial purposes. The farmers may sometimes sell maize only to meet needs dependent on cash, like school fees or medical costs or they would sell maize if they have no more space for maize harvest storage. The study also revealed that groundnut crop was relatively the highest income earner among all the crops and also relatively labour intensive.

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The study therefore was relevant as it was able to reveal the cropping system being followed by these selected districts. The intercropping system helps the farmers minimize risk against total crop failure and maximize on land for cultivation thereby lessening the challenges with land scarcity issues among other things. The results of the study revealed that the farmers have benefitted from the implementation of N2africa legume technologies financially; however, the results have not been able to identify any negative implications on the adoption of these legume technologies on the intercropping systems in the selected areas in Malawi.

5.3 Summary

In Chapter One, we were introduced to legumes as important crops for smallholder farmers, not only in Malawi, but also for the majority of smallholder farmers in the sub-Sahara Africa region. The importance of legumes included their potential to improve soil fertility by the BNF process, provide nutritional values to human with their high amounts of proteins, vitamin A and oils, and as income sources for the rural masses.

Loss of soil fertility which comes about usually due to crop harvest removals, soil erosion and leaching have led to the decline of agricultural productivity leaving Malawi food insecure through the years. Among the soil nutrients, lost nitrogen is the most affected and this calls for an organic legume approach: "legume intercropping" which is being promoted in the tropics with the aim to replenish soil nutrients.

In response to this an extensive study was carried out in Africa by N2Africa between 2009 and 2013 with the aim of promoting nitrogen fixation among smallholder farming through effective legume production technologies. The study was done in eight African countries namely: Ghana, Nigeria, Ethiopia, Tanzania, Uganda, Democratic Republic of Congo, Rwanda, Malawi, Kenya, Mozambique and Zimbabwe. N2Africa, in partnership with non-governmental organizations, the Malawi government, farmers associations and agro-dealers' networks, implemented the study in six districts: Ntcheu, Dedza, Mchinji, Salima, Kasungu and Dowa, and the entire project's target crops: groundnuts, cowpeas, soya beans and common beans were evaluated. The project mainly focused on promotion of legume and inoculant technologies through participatory research approach, and delivery and dissemination of the tested technologies through lead farmers and their grassroots groups.

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The research question this study engaged in was: What are the financial and managerial implications on smallholder farmers regarding the implementation of BNF and inoculant technology in current production systems in selected areas in Malawi? The study particularly focused on two specific goals:

i To assess current production systems being used in selected areas in Malawi, as well as the proposed alternatives based on research results, and
ii To determine the financial implications of implementing BNF technologies and use of inoculants on legumes.

This was explored further in Chapter Two, in which a review of the overview literature for smallholder legume production in both the SSA and the legume industry in Malawi was presented. It was reported that legumes are important crops in agriculture, particularly in smallholder farming systems in SSA and Malawi. Agriculture is the most important sector in Malawi. The country is promoting and facilitating agricultural productivity in order to safeguard food security, increase incomes and create employment. Some of the Malawi government policies and strategies that have been put in place to enhance production and factors that affect production. One of the key policies by the Malawi government is the Poverty Reduction and Rural Development. This is to be implemented through the strategies of the Presidential Initiative on Poverty and Hunger Reduction and the Farm Input Subsidy. It further reviewed the literature of the importance of legumes and the role of legume technologies for improved productivity of legumes. The main importance includes: (1) legumes have high nutritional value to both human and animals due to their high protein content, vitamin A and essential oils, (2) legumes play a role in nitrogen fixation thereby improving soil fertility, and (3) legumes are a source of income to smallholder legume farmers.

The chapter further presented an overview of the literature of analytical tools that were selected, with a focus specifically on the partial budget model as the ideal tool for this research project to analyse the financial implications of the legume technologies. The chapter also presented a literature overview of group discussion methods with a special focus on how interaction among participants adds value to the outcome. The ways in which the dynamics of group discussions enhance creative thinking were highlighted. The chapter ended with definitions of the key terms of the study.

Chapter Three focused on the research methods of the study; it includes a description of the research design, study locations, data collection methods and process, sampling procedure and sample size. This study took place in the central region of Malawi in five districts: Kasungu, Salima, Mchinji, Dedza, and Ntcheu. Dowa was excluded due to administrative challenges. These are five of the districts in which N2Africa implemented its project in the first phase.

Data was collected using a semi-structured questionnaire through FGDs. Five FGDs were done; one from each of the five selected districts, and each FGD comprised of 10 participating farmers. This chapter further described how group participation was implemented and based on the design of the budgeting model. The partial budget model was used to analyse data and to assess the financial implications of the legume technologies adopted by these farmers. The chapters ended with a brief description of research ethics followed in carrying out the study.

The results in Chapter Four reveal that the adoption rate was high and that on average over 80 percent of the participating farmers in the study areas adopted the N2Africa legume technologies. There were smallholder farmers and 80 percent had a land holding of 0.5 hectares. The study identified four main indicators of wealth for the smallholder farmers namely: housing structure, livestock, farm implements and household assets. Looking at periods before and after the adoption the chapter revealed that the housing structures for three districts, out of the five, had improved after the adoption of the technologies but only for some of the farmers representing a figure of not more than 60 percent. Just like the housing structure, livestock for the farmers also increased in numbers after the adoption of the technologies for all the selected districts. However the results do not record any changes in the farmers' farm implements between the two periods of time.

The study further showed that the majority of smallholder farmers in Malawi grow maize as their main crop, as this is the staple food in the country. Maize is usually intercropped with legumes, among other reasons, to supplement dietary needs, to control soil erosion and to maximise land use for cultivation. The results of the partial budget model employed in this study subsequently revealed that there were increases in gross margins for all targets crops: cowpeas, soya beans, common beans and groundnuts in all five selected areas. Consequently, the whole area reported the same positive effect on the staple crop maize. However, the results for Ntcheu and Dedza showed declined yields for the 2012 - 2013 and 2013 - 2014 growing seasons due to dry spells that affected the area and late distribution of inputs. The farmers however did not get affected on the market much as the selling prices made up for the reduced yields which resulted in positive gross margins for their crops. Overall the partial budget analyses revealed that the smallholder farmers have benefitted from the N2Africa legume technologies.

5.4 Recommendations

This study highlights the financial and managerial implications for legume technologies for smallholder farmers in Malawi. However, it is important that N2Africa invests in further research into the marketing chain and processing of the legume industry. It might be important for the future

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research to particularly focus on the target N2Africa. This will solve the challenge of the lack of processing and marketing facilities that these smallholder farmers are currently facing.

One other avenue for further study would be research into development towards a semi or full commercial legume industry in Malawi and for the Malawi government to divert its focus on tobacco as the sole export earner and try to come up with policies that work towards enhancing legume productivity. This will enable a better understanding of how smallholder producers can overcome the gap between semi and fully commercial producers.

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APPENDICES

Appendix A: Questionnaire

Date: / /2015 Phone number:

EPA

District:…………………………………………………………

Any kind of comments from farmer's side relevant to the questions are welcome.

1. How many of you here have been participating in any of the N2Africa technologies trainings/meetings ever since they started?
   Number: Percentage:
2. How many have never participated any of the N2Africa technologies trainings/meetings?
   Number: Percentage:
3. Why not?
   ……………………………………………………………………………………………
   ……………………………………………………………………………………………
   ……………………………………………………………………………………………

4. How many have participated but stopped at some point?
   Number: Percentage:

5. What was (were) the reason(s) that made you stop?
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6. Typical farm structure in the area before N2Arica Project?

a. Housing:

i Wall: Earth □ Bricks □ Cement □

ii Roof: Thatched □ Iron Sheets □

iii Floor: Earth □ Cement □

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b. Crops:

Crop	Type: Cash/ Food	Ha	Value/kg (R)
Maize			
Tobacco			
Soya beans			
Common beans			
Cowpeas			
Groundnuts			
Tubers			
Other			

c. Livestock:

Type	Number	Value
Poultry		
Goat		
Cow		
Pig		
Rabbits		
Others		

d. Farm implements:

Implement	Number	Value
Hoe		
Machete		
Spade		
Watering can		
Slasher		
Axe		
Sickle		
Wheelbarrow		
Sprayer		
Ox-cart		
Irrigation pump		
Other		

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e. Assets

Asset	Number	Value
Radio		
Mobile phone		
Television		
Bicycle		
Motor vehicle		
Other		

f. Seasonal cost of production of five main crops

Input	Soya bean	Common bean	Cowpeas	G/nuts	Maize
Seed					
Fertilizer					
Labour					
Pesticides					
Other costs					

g. Total cash income from the main crops (from the last harvest until now before harvest)

Crop	Total yield/ha	Price per kg	Avg mkt price (R)	Income (R)
Soya bean				
Common beans				
Cowpeas				
G/nuts				
Maize				

7. Farm structure in the area after adoption of N2Africa Project?

h. Housing:

iv Wall: Earth □ Bricks □ Cement □

v Roof: Thatched □ Iron Sheets □

vi Floor: Earth □ Cement □

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i. Crops:

Crop	Type: Cash/ Food	Ha	Value/kg (R)
Maize			
Tobacco			
Soya beans			
Common beans			
Cowpeas			
Groundnuts			
Tubers			
Other			

j. Livestock:

Type	Number	Value
Poultry		
Goat		
Cow		
Pig		
Rabbits		
Others		

k. Farm implements:

Implement	Number	Value
Hoe		
Machete		
Spade		
Watering can		
Slasher		
Axe		
Sickle		
Wheelbarrow		
Sprayer		
Ox-cart		
Irrigation pump		
Other		

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l. Assets

Asset	Number	Value
Radio		
Mobile phone		
Television		
Bicycle		
Motor vehicle		
Other		

m. Seasonal cost of production of five main crops

Input	Soya bean	Common bean	Cowpeas	G/nuts	Maize
Seed					
Fertilizer					
Labour					
Pesticides					
Other costs					

n. Total cash income from the main crops (from the last harvest until now before harvest)

Crop	Total yield/ha	Price per kg	Avg mkt price (R)	Income (R)
Soya bean				
Common beans				
Cowpeas				
G/nuts				
Maize				

8. Legume and women empowerment

a. Which crops in your household are women mainly in charge of?

……

b. Between the wife and the husband-

c. Who has moved to the other's village? Man□ Woman□

d. Who owns the cultivated land? Man□ Woman□

e. Who decides what kind of legume to plant? Man□ Woman□

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f. Who decides on the size of land for legume cultivation? Man□ Woman□
g. Who decides which inputs to buy and which amounts of legume? Man□ Woman□
h. Who decides how much legume to sell? Man□ Woman□
i. Who decides on expenditure of money from the sale of legume? Man□ Woman□
j. Who sells the legumes of household production? Man□ Woman□

9. Are there any recommendations on the N2Africa legume technology intervention that you would like to make?

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10. Are there other things you would like to say before we wind up?

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Thank you for your time

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Appendix B: Cost inputs provided by N2Africa

District	**G/nuts**	**Soya beans**	**Beans**	**Cowpeas**	**Fertilizer**	**Inoculation**
	Price (MK)/kg	Price (MK)/kg	Price (MK)/kg	Price (MK)/kg	Price ($)/kg	Price ($)/kg
Salima	375	350	350	340	0,88	7,75
Ntcheu	375	350	350	340	0,88	7,75
Dowa	375	350	350	340	0,88	7,75
Dedza	375	350	350	340	0,88	7,75
Mchinji	375	350	350	340	0,88	7,75
Kasungu	375	350	350	340	0,88	7,75
TOTALS						