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In Search of alternatives to Tobacco

The Dynamics of Groundnut Production, Efficiency, Profitability and Adoption of Technology in Sub-Saharan Africa

The Malawi Case

By
Abdi-Khalil Edriss

THE DYNAMICS OF GROUNDNUT PRODUCTION, EFFICIENCY, PROFITABILITY AND ADOPTION OF TECHNOLOGY IN SUB-SAHARAN AFRICA

THE MALAWI CASE

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-Abdi-Khalil Edriss

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ACRONYMS

ADD	: Agricultural Development Division
ADMARC	:Agricultural Development and Marketing Corporation
APIP	: Agricultural Productivity Investment Programme
ARET	: Agricultural Research and Extension Trust
C-D	: Cobb-Douglas production function
Cm	: Centimetres
DEMATT	: Development and Marketing Trust
EDU	: Education
EPA	: Extension Planning Area
Est	: Estimates (coefficient)
EXVT	: Extension Visits (Extension Services)
FEXP	: Farmer's Experience
FLAB	: Family Labour
FMSZ	: Farm Size
GDP	: Gross Domestic Product
GI	: Gross Income
GM	: Gross Margins
GOM	: Government of Malawi
ICRISAT	: International Crops Research Institute for the Semi-Arid Tropics
Km	:Kilometres
Kg	: Kilograms
LIMDEP	: Linear Modelling and Programming Package
MK	: Malawi Kwacha (the local currency)
MIPA	: Malawi Investment Promotion Agency
MRFC	:Malawi Rural Finance Company
MUSCCO	: Malawi Union of Savings and Credit Cooperatives
NARS	: National Agricultural Research System
NASFAM	: National Smallholder Farmers Association of Malawi
NGOs	: Non-Governmental Organizations
NSCM	: National Seed Company of Malawi
NTEC	: New Technology (any new technology practice or farming System thought to enhance agricultural (groundnut) production
OFFINC	: Off-farm Income
PDF	: Probability Density Function
PDS	: Population Data Sheet
PMLE	: Pseudo Maximum Likelihood Estimators
PRA	: Participatory Rural Appraisal
PRB	: Population Reference Bureau
Prob	: Probability
R & D	: Research and Development
RDP	: Rural Development Project
RG1	: Resistant (Rosette) Groundnut One
SADC	: Southern Africa Development Community
SEDOM	: Small Enterprise Development Organization of Malav
SSSP	: Small Scale Seed Programs
TVC	: Total Variable Cost

CHAPTER I

INTRODUCTION

Background Information on Malawi

Malawi is a smallholder agriculture country. Like most sub-Saharan African countries, the Malawi economy is highly dependent on agriculture and is constrained by limited resources and a rapidly expanding population. A small land-locked nation in South East Africa, Malawi lacks the mineral resource endowments of its neighbouring countries.

Agricultural land constitutes the primary natural resources for the Malawian economy. The importance of agricultural sector is evidenced by its share in the gross product (GDP), which was approximated at 36.4 per cent of total GDP in 1997 (Government of Malawi (GoM), 1998). Furthermore, 85 per cent of all Malawians earn their livelihood from agriculture, and over 85 per cent of the nation's export revenue is generated from this source. Malawi's population was about 10.4 million with a growth rate of 1.9 per cent per annum (Population Reference Bureau, 2000). The slow growth of the industrial or manufacturing sector means that the agricultural sector will continue to shoulder the burden of providing a livelihood for a large proportion of Malawi's growing population. It is not surprising that policy action in Malawi, both agricultural and economy-wide, is largely based on influencing the dynamism of the agricultural sector.

The new government of Malawi is placing the highest priority on rural poverty alleviation among its policy objectives and, given the overwhelming importance of agriculture to the economy, is determined to accelerate broad-based agricultural and rural development as a major element of its fight against poverty (GoM, 1995). The process of economic growth is one of continuous structural transformation channeled through various linkages between the individual sectors of the domestic economy. Crucial for this process and poverty alleviation are markets that operate efficiently to accommodate decisions within and across sectors that lead to improved availability and access to new technologies, efficient use of inputs and outputs of agriculture.

Location

Malawi is a small land-locked country. It is bordered by Mozambique in the south and east, Zambia to the west, and Tanzania to the east and north. Malawi lies between latitudes 9°45' and 17° 16' South and longitudes of 32° and 36° East. The length of Malawi from north to south is about 900 km, but its width varies from 10 to 250 km. The total land area is 94, 274 square kilometers of which 55 percent is arable. It is estimated that 25 percent of the total area is water, comprising mostly Lakes Malawi, Chirwa, Chiuta and Malombe. Lake Malawi covers one-fifth of the country and lies above 460 meters above sea level. The country is divided into three administrative regions: Northern, Central and Southern regions with Mzuzu, Lilongwe and Blantyre as the respective main regional centers for commerce, trade and governmental affairs. The administrative system consists of the Central Government, Local Government and Traditional Authorities with the twenty-six districts in the country (GoM, 1995).

Topography

There are three topographic regions in Malawi: the hill zones, the middle plateau, and the rift valley floor. The hill zones have an altitude ranging from 1,370 to 1,540 meters above sea level. Agricultural production is still taking place on moderate and in places within the zone where weathered soils exist, perhaps with virtually no agricultural potential in the area.

The middles plateau lies between 750 and 1,400 meters above sea level. This topographic region has the highest agricultural potential in Malawi. Because of this agricultural potential, the middle plateau is the most densely populated topographic region in Malawi, and whereby several types of crops are sown the during rainy season. Finally, the rift valley floor covers areas ranging from 35 meters above sea level, the Lower Shire Valley in the southern region, to an altitude of 760 meters covering mostly the low land areas of the western side of the shores of Lake Malawi (GoM, 1995). The rift valley floor is suitable for rice, sugar cane and legumes including soybeans, pigeon peas and groundnut crops.

Climate

Malawi has a tropical climate with four seasons: hot dry spring (September to early November, hot wet summer (mid November to March), cool moist autumn (April to May), and cool dry winter (June to August). Mean maximum temperatures vary from 12.5 °C to 33 °C in winter and 15-35 °C in summer (Nzima, 1985).

The main rains come between December and April but sometimes the country gets early rains in October and November. The annual rainfall in the country varies greatly. The highest rainfall, estimated at about 2,350 mm, falls on Zomba Plateau and lowest rainfall, estimated at 800 mm, falls in Kasungu district. Rainfall distribution in the country largely depends on proximity of the area under consideration to sea, its altitude, as well as, its relationship to the rain bearing winds. The largest proportion of the rainfall is conventional which falls in form of showers and thunderstorms (Nzima, 1985; UNICEF and Ministry of Finance, 1993).

Population

The country has 10.4 million people and population growth rate at 1.9% per annum in June 2000. According to Population Reference Bureau (2000), this means that the population will double in the next thirty-six years. The same population estimate showed that children under 15 years account for 46 per cent of the population while those between 15 and 65 years of age account for 51 per cent and those over 65 years of age make up only 3 per cent of the total population of Malawi. Life expectancy at birth for the total population is 39 years and total fertility rate is 5.9 children born per women (Population Reference Bureau, 2000).

Malawi is one of the most densely populated countries in Africa with 85 persons per square kilometers in 1987. The population is unevenly distributed across the country. According to 1987 census (the only reliable spatial distribution data emerges from the 1987 census), the Southern Region contains one-third of the total land area and 39% of the arable land, supporting almost 50% of the total population with a density of 125 per square kilometers. The Northern Region, which contains 29% of all land of which 20% is arable, had only 11% of the total population and a density of 34. The Central Region, which contains 41% of arable land, had 39% of the population and a density of 87.

The census further reports that about 85% of Malawi's population is rural and it depends on farming for its livelihood. The national population density stands at 87 persons per square kilometers with approximately 171 persons per square kilometers of arable land, making Malawi one of the most densely populated countries in sub-Saharan Africa (National Statistics Office, 1987).

Agriculture in Malawi

Malawi's agriculture is characterized by a dual structure consisting of the smallholder and estate sub-sectors. The sub-sectors are distinguished according to legal and institutional rules regulating crop production, land tenure, and marketing and pricing arrangement for agricultural commodities. Agricultural production occurring on the traditional tenure or customary land is defined as that of smallholders, whereas estate production occurs on leasehold (or freehold) land.

The characterization may be somewhat oversimplified as the two sub-sectors are not mutually exclusive. There are important interdependent elements that exist between and within the estate and smallholder sub-sectors, where are more complex interrelationships. During the 1980s, an intermediary group of small estates has emerged. A dual approach was adopted after Independence in 1964. Dualism can be viewed as a determining factor of the economic and social disparities and differences between smallholder and estate owners, as well as, preferential treatment that affects the two economic groupings, and the development of agriculture in Malawi (GoM, 1998).

The smallholder sub-sector

Agricultural production in Malawi is derived from both the estate and smallholder sub-sectors. The smallholder sector based on customary land tenure is primarily subsistence-oriented, providing the bulk of food production, almost 80%. It involves some 1.6 million families operating under customary tenure on approximately 1.8 million hectares. About 56% of the households cultivate less than 1 hectare, 31% between 1-2 hectares, and 13% above 2 hectares. Maize of local low yielding varieties dominates the smallholder farming system accounting for about 75% of the cropped area (GoM, 1998). The other important crops are groundnuts, dark fired tobacco, cassava, cotton, rice, pulses and potatoes. Production primarily for subsistence, the combined effects of small farm holdings, unimproved varieties, negligible inputs, high losses in storage and processing, contribute to low productivity.

The estate sub-sector

It was estimated that at the end of 1989 there were about 15,000 estates (leasehold and freehold) occupying an area of about 900,000 hectares or 10% of the country's total land area. Estates operate primarily under leasehold tenure. They produce mostly export commodities notably flue cured and burley tobacco followed by tea, sugar, coffee and grain legumes.

In general, estates use higher level of technology and achieve higher yields than smallholders, because of their access to inputs, credit, supporting agricultural services and markets. Tobacco as the main crop occupies about 60% of estate land, tea 20% and sugarcane 18%, the balance being taken by coffee and macadamia nuts.

Groundnut Production Problems

Groundnut production has been declining steadily for the past ten years until 1996 when production started rising. The declining trend could be attributed to several factors. Malawi government pricing policy before the liberalization of the market in the late 1980s made the growing of groundnuts less profitable both in nominal and real terms relative to hybrid maize and tobacco.

In addition, the export prospects have been declining due to importers' preferences against the bigger sizes "Malawi nuts" (e.g., chalimbana). Domestically, the country experienced the drought that hit most sub-Saharan Africa coupled with the rosette disease attack in most areas of the country during the 1991 to 1994 seasons. Data from the past few years reveal that the highest groundnut production was obtained in 1985/86 season, and the lowest in 1991/92 season when the crop was devastated by drought (Ministry of Agriculture and Irrigation (MoAI), 1998).

The overall constraints to groundnut production in Malawi are – declining of producer prices, use of low yielding varieties, inferior cultural techniques, prevalence of early leaf spot and rosette diseases and extended dry spells within the growing season in the past few years (Nyirenda, 1992; Luhana *et al*., 1994; Subrahmanyam *et al*., 1997; Chiymebekiza *et al*., 1998).

PROBLEM STATEMENT

Poverty in Africa is compounded by the complexity of household structures and household relations. Household level issues, and particularly intra-household resource allocation are of great importance in understanding poverty and in identifying actions to reduce it. Evidence from Africa suggests great diversity in the structure and composition of households, where men and women have largely separate sources of income and resources. This often leads to inequality in resource allocation (World Bank, 1998). It is difficult to

assess or design policies to change household productivity or distribution of income without looking at intra-household distributions.

There is a need to know who controls what resources in the household, and all the evidence suggests that it matters who in the household makes the decisions. Gender differentiated effects arise because control of productive resources differs between men and women, as well as, the institutional environment perpetuates economic exclusion by gender. It is, therefore, important to determine not only who is making decisions in a household but also what criteria they are using to make those decisions (World Bank, 1998). Because economic development policies are not neutral in their effects, ignoring gender can impede development, especially where over 30% households are female-headed in Malawi (GoM, 1998). Besides agricultural production improvements, in terms of adoption of new technologies, it is therefore important to understand how resources are allocated within households and what types of policies are likely to be effective.

This Groundnut research is in the global constraint area of socio-economic forces and will specifically address the two priority opportunities defined as the role of groundnut in household structure and dynamics, and the socio-cultural context of product use. These areas of study are developed in reference to a set of differentiating social factors identified as gender, household type, and farm type, as well as economic factors such as physical capital, land size, technology and management practices.

Extensive reviews of the groundnut publications (Carr, 1991; Cloud, 1986; Daddieh, 1989; GoM, 1995) indicate that the social research integrating relevant gender issues and adopting of new technologies may be absent. In addition, the consumption related studies (Ngwira, 1984; Truscott, 1986; Spring, 1989; Udry, 1994; Phiri, 1997) only address groundnut product development with the intent of increasing the commercial value of groundnuts in the formal sector. However, the invisible dynamics of groundnut production, profitability and consumption within the subsistence and smallholder farmers have not been addressed. Groundnuts are cash crops, in both formal export market and local market. Yet, in many African's small and subsistence production systems much emphasis has been placed on value of groundnuts as women's crops with social and economic values essential for livelihood security (Bryson, 1979; Chiyembekeza *et al*., 1994; Daddieh, 1989; Ministry of Agriculture and Irrigation (MoAI), 1998; Phiri, 1999).

In Sub-Saharan Africa the institutional complexity of a typical farm household stems from distinct production units within the household, some managed by men and some by women and some jointly (Saito *et al*., 1994). Spring (1989) and GoM (1993) reported that approximately one-third of Malawi rural households are female-headed and male labour migration is an important social force that contributed to the emergence of this type of household.

In Malawi, groundnuts are crucial inputs to enhance household economic resources and sustain food security. The ever growing number of studies (Bryson, 1979; Singal and Balakrishnan, 1988; Carr, 1991; Saito *et al*., 1994; Niles, 1996) on women's key roles in small and subsistence farming do not isolate the important gendered interactions in groundnut production-consumption systems. With particular emphasis placed on the importance of groundnuts as a women's crop and the contribution of groundnuts to pay for items of expenditure for their children. Their importance is illustrated in the growing efforts to provide various technologies for groundnut shelling and groundnut oil pressing to women as income generating activities (Carr, 1991).

Hence, a need exists to capture the intra-household and inter-sector dynamics of gender roles in the production, processing and marketing of groundnuts. It also becomes paramount to examine the economic and social values of groundnut crops, to understand the indigenous knowledge system in the selected areas relevant to groundnut systems and to understand the role of groundnut crops in household economics, and hence to the nation.

The role of socio-economic and demographic factors such as family size, age of the household, education of household head, off-farm income, the value of farm assets per acre, value of non-farm assets, rural credit per acre, degree of land fragmentation, and meeting with extension workers would be analyzed along with the framework of technical efficiency and adoption of technology determinants.

OBJECTIVES OF THE STUDY

Grain legumes are important components of Malawi's maize based farming systems and have been proved to make a major contribution in sustainable agricultural development. In the case of Malawi, groundnut is a potential crop to replace tobacco as a backbone of the economy. Thus, the research primarily focuses on identifying determinants of groundnut productivity, profitability, opportunities, potentials and constraints of marketing and its policy implications in the country, as well as identifying key factors influencing adoption of technology and technical efficiency in the production of groundnut in Malawi.

Specific Objectives

The specific objectives are to:

1. Identify differences in access to labour, land and other resources to groundnut production by gender, household type, community and farm organizations and market exchanges with implications for technology adoption and productivity in groundnut output.
2. Find out major determinants of technical efficiency in groundnut production, and construct groundnut enterprise budgets and compare profitability of groundnuts with maize and tobacco, as well as, rank them in terms of profitability.
3. Measure gender differential in groundnut productivity and profitability in the context of changing agricultural policies, and
4. Analyze factors influencing adoption of technologies, improved varieties, intercropping, ridging and rotation and management practices such as extension services, weeding, early planting etc.

HYPOTHESES OF THE STUDY

The following five hypotheses were postulated in order to reach to the specific objectives outlined previously.

Hypothesis 1: Socio-economic variables (non-physical factors) do not determine the dynamics of groundnut production, inter-household and intra-household transactions.

Hypothesis 2: Groundnuts are not profitable compared to competing cash crops (soyabean, pigeon pea, and tobacco) grown after maize in the country.

Hypothesis 3: There is no gender differential in groundnut productivity in Malawi.

Hypothesis 4: New groundnut variety (CG7) is not significant in groundnut production at the household level.

Hypothesis 5: New (improved) farming systems do not affect groundnut production at smallholder farms

SCOPE AND LIMITATIONS OF THE STUDY

In this report, the theoretical analyses are largely based on static models, in which production is treated as a static phenomenon and issues of expectations and dynamic adjustment are ignored. Though, incorporation of dynamics and expectations into tractable models is likely to remain a key issue in agriculture research for the foreseeable future, the dynamic model avenue is excluded due to the unavailability of time series data sets in the empirical investigations of the groundnut production in Malawi.

Second, even though the models discussed in this study are used to represent the agriculture sector, they are based largely on the micro economic production and pricing theories, and thus prices are treated as exogenous. The equilibrium of the sector is ignored in most cases. Particularly, regarding the explanation of technological adoption, the question of inter-temporal relations (or causality) among the various physical factors, labour and capital, related to productivity are excluded, as they are fixed and apparently hard to measure in Malawi's agricultural setting. However, the non-physical factors, socio-economic factors such as household size, age, education level, extension services and access to farm credit play major role in agricultural productivity and they are likely to remain as key issues to be discussed relating to subsistence farmers.

Though it is beyond the scope of this report to deal with theoretical research, the study focuses to critically assess specific crop (groundnut) and specific country's (Malawi) agricultural productivity; seeking empirical results for agricultural development policy in the country.

BOOK ORGANIZATION

This book is organized in seven chapters. *Chapter I* has presented profile of Malawi on location, topography, climate and population. It further discusses agriculture in Malawi including smallholder and estate sub-sectors, land tenure, agricultural administrations, and the role of agriculture in the economy of the country. Finally, the chapter has provided problem statements, objectives and hypotheses of the study, as well as, the scope and limitations of the report.

Chapter II reviews related literature on importance of groundnuts including groundnut research in Malawi, smallholder farming system, the small-scale seed programs, gender differentials in groundnut productivity, groundnut marketing prospects and approaches to seed activities and loan

operations. It will also discuss groundnut technology adoption including improved groundnut variety and farming practices. Chapter III presents variables and measurements, study design, population and sample, the study area, data collection method and participatory rural appraisal under the survey methodology sub-section. It also focuses on recent theoretical models and measurements, as well as survey methodology in details. Theoretical model underpinnings include discussion on Cobb-Douglas production function, technical efficiency model, gross margin analysis, and groundnut technology models (Poisson model and its derivatives, as well as, logistic regression model).

The socio-economic characteristics of the sampled households are presented in *Chapter IV*. The key socio-economic characteristics investigated were age of household head, household size, marital status, gender (sex), marriage systems, literacy status, farm size, farm capital, extension practices, and farmers' perception of technology. *Chapter V* gives the model results of production function analysis, technical efficiency, gross margin analyses and budget enterprises. It further provides results and discussions on gender differential in groundnut productivity, as well as, focused group-focused discussions (PRA).

Chapter VI discusses results from adoption of groundnut technology models, namely, Poisson and its derivatives (negative binomial function) and Logistic regression models.

Finally, *Chapter VII* provides a summary of the major findings and conclusions drawn based on the findings, as well as, their policy implications in agricultural development. The chapter ends by presenting recommendations on groundnut activities, management practices, as well as, on participatory research discussions.

CHAPTER II

LITERATURE REVIEW

IMPORTANCE OF GRAIN LEGUMES IN MALAWI

Grain legumes[1] are important components of Malawi's maize[2] based farming systems and have been proved to make a major contribution in sustainable agricultural development. In particular, grain legumes make three important contributions to Malawi's economy. Firstly, grain legumes enhance soil fertility because of their ability to fix atmospheric nitrogen into the soil. Mkandawire (1998) indicated that nitrogen-fixing leguminous tree species offer an economically attractive and ecologically sound means of reducing external inputs of mineral fertilizers. Most African countries, including Malawi, can reduce expenditure on inorganic fertilizers through exploitation of atmospheric biological nitrogen fixation.

Secondly, legumes are cheap sources of vegetable protein and vitamins. Given that over 50% of the children under the age of five in the rural Malawi are malnourished, as reported by UNICEF (1993), provision of highly nutritious baby foods from legumes such as groundnuts, soybeans, beans and pigeon peas could alleviate this problem. Thirdly, most grain legumes are relatively high value crops compared to cereals, such as maize. The inclusion of these in the cropping systems can generate more cash income for the smallholder farmer (MoAI, 1998). Given the fact that real commodity prices for most grain legumes are relatively higher than maize price coupled with low fertilizer inputs in legumes, high gross margins would be expected from the legumes.

Groundnuts

Until the early 1980s, groundnuts ranked the second, behind maize, in terms of land use and nutritional values (MoAI, 1997). The national objective is to substantially increase production of both confectionery and oil groundnuts in

[1] Grain legumes mainly grown in Malawi are groundnuts, soybean, pigeonpea and beans.
[2] Malawi's staple food

order to meet the local and export demand and to provide raw materials for the domestic oil industry (GoM, 1995).

Smallholder farmers have traditionally produced groundnuts and used extensively for household consumption. Groundnuts have been relatively minor estate crops but with recent price increases, more estates adopted the production of groundnuts as enterprises (GoM, 1995).

Nationwide, groundnut yields are low and have remained static over time. A general decline in seed quality and supply was attributed to poor husbandry standards (GoM, 1995; Simtowe, 2001). Inadequate producer prices and hence low returns to labour have also contributed to production decline. Under good management, yields up to 1,000 to 1,500 kg is possible but results at the research stations indicate that yields up to 2,000 kg per hectare are possible if good seed is used and a balanced fertilizer (including a nitrogen starter) and fungicide are applied (GoM, 1995).

Smallholder farming system

Although grain legumes are essential components in the diet and often serving as a major source of protein, they account for only a minor percentage of total cultivated land in Malawi. About 76 percent of arable land is devoted to maize (Mataya *et al*., 1996). Apparently, a large proportion of small farms are continuously monocropped with maize because of the need to allocate nearly all the land to maize to satisfy domestic food needs. This is to the extent that smallholders with less than 0.5 hectare considering groundnut as a relatively less important crop (Cromwell and Zambezi, 1993). Most smallholders prioritise planting of maize leading to late planting of groundnuts and late weeding. In fact, most farmers weed groundnuts only once (Luhana *et al*., 1994). Research has shown that late sowing of groundnuts (3 weeks after the onset of rains) can reduce yield by 20-50% (Nyirenda *et al*., 1992).

Furthermore, weeding competition is very intense 30 days after emergence and can affect both yield and quality of groundnuts (*ibid*). Studies (MoAI, 1998) on groundnut cultural practices indicate that most farmers interplant groundnuts in Malawi and a significant percentage plant a mixture of varieties in the same plot. Farmers often plant groundnuts in pure stand when they are grown for sale as a cash crop (Cromwell and Zambezi, 1993). However, agronomic research indicates that there is a loss of between 56-70% in groundnut yield intercropped with maize (Nyirenda *et al*., 1992).

Groundnut Market Prospects

There is a market potential for both oil seed and confectionery groundnut varieties. Domestically, Agricultural Development and Marketing Corporation (ADMARC) and Lever Brothers are among the buyers of groundnuts. Universal Industries in Malawi is also a buyer of groundnut and processes it into peanut butter and roasted nuts for sale countrywide. In prevalence of adequate production, most groundnuts sales are for export with bulk destined for Europe and to a lesser extent for India and Zimbabwe (GoM, 1997).

Ministry of Agriculture and Irrigation study (1998) had shown also that much of the groundnut export market has gradually been lost due to irregularly shaped kernels, considerable variation in nut size, unpredictable delivery times resulting from transport delays. Another important constraint to increased groundnut exports is the increasingly stringent *aflatoxin*[3] regulations operative in a number of important countries (Babu *et al*., 1994; MoAI, 1997; Subrahmanyam, 1997). The potential for expansion of Malawi's confectionery groundnut exports is good but high priority must be given to improving the crop's production yield and marketing aspects.

Until 1987, smallholders had one market outlet for their produce, i.e. ADMARC, the only parastatal that had the legal mandate to buy smallholder agricultural produce (Phiri, 1997). Much of Malawi's agricultural policy towards the smallholder, therefore, had been channelled through ADMARC. The main impact of this policy had been deliberately high implicit tax imposed on smallholder produce including grain legumes, which had for a long time determined the amount of incentives to smallholder farmers for growing the various crops in Malawi. Before market liberalization of agricultural produces, ADMARC used to administer a guaranteed minimum price, which was set below the export parity price (MoAI, 1998).

The liberalization of agricultural produce markets in 1987, which had allowed private traders to participate in the agricultural produce market alongside ADMARC was meant to increase competition in the market in order to ensure remunerative prices to farmers as an incentive to boost their production (MoAI, 1998).

Gender Differential in Groundnut Productivity

Many literature attempts to document gender differentials in farm productivity of rural women. Substantive work has been done concerning, for example, the distribution of resources and work within household (Kanbur and

[3] Secondary toxic metabolites produced by fungi of *A. flavus* group

Haddad 1994); the various roles played by women and men in a variety of farming system (Carney and Watts, 1991; Aredo, 1992); the access of women to credit markets (Morris and Meyer, 1993); discrimination against women in formal sector interventions in smallholder agriculture (Bindlish and Evenson, 1993); and the relative effects of increases in men's and women's incomes on the health, nutrition and, education of children (Strauss and Thomas, 1995).

A growing body of empirical evidence (Bryson, 1979; Daddieh, 1989; Newbury, 1989; Oduor-Noah, 1995; Udry, 1994; World Bank, 1998) links also gender inequalities in resources control to lost productivity and incomes in agriculture. For example, in Cameroon, farm studies have shown that women allocate more labor to sorghum than to rice because they control revenue from sorghum but not for rice. A study of women's productivity in Kenya shows that women farmers in general are disadvantaged in their access to resources and factors of production compared to men. If women had the same human capital endowments and used the same amounts of factors and inputs as men, the value of their output would increase by 22 percent (Saito *et al.*, 1994).

Aggregate data from Malawi in the late eighties shows that the increased profitability of hybrid maize, the men's cash crop, elicited a more than doubling the supply. Extra land was being appropriated from land that women had been using to grow groundnuts (Due and Gladwin, 1991). Men were thus responding to the increased profitability of their cash crop by drawing land away from the women. In Burkina Faso, it was found that plots controlled by women are farmed much less intensively than similar plots simultaneously planted to the same crop but controlled by men in the same household (Udry, 1994).

Alderman (1995) stated that an important characteristic of the farming system of rural villages (more generally in Sub-Saharan Africa) is that different individuals hold decision-making authority and nominal control over output on different plots within the household. Individuals do not have absolute autonomy with respect to decision making on their own plots, but a large literature makes it clear that people have substantive control over cultivation decisions on their own plots (Ramaswamy, 1991; Saito, Mekonnen, and Spruling, 1994).

Only few studies in Malawi have analyzed productivity differences between men and women farmers. Niles (1996) had explicitly examined the impact of gender specific constraints to smallholder production, and found that there was little difference in the production environment for male and female household heads. While Malawian female-headed households were less technically efficient and had lower predicted yields than other households, they are nonetheless allocatively efficient. In fact lack of access to factor inputs like fertilizers and hybrid maize seeds were shown to exist, causes surplus labor across all technology regimes and gender groups (Niles, 1996). These findings confirm Udry's findings that asymmetric roles and obligations within the household may have implications that are more serious on allocative rather than technical efficiency (Udry, 1994).

Daddieh (1989) reports that women in Africa have always been crucial to the success of the farming system of their societies either as direct producers of agricultural commodities or as contributors of (un) paid labor to the production process. Women produce a great deal of food in a small space, a characteristics that tends to work against them. Although production may be far more significant, women's crops can be invisible due to the limited use of land, finally resulting in a lack of development resources available to some kinds of food production (Cloud, 1986). Spring (1989) reports that approximately one-third of Malawi rural households are female-headed and male labor migration is an important social force that contributed to the emergence of this type of household.

Evidence from Africa suggests great diversity in the structure and composition of households, where men and women have largely separate sources of income and resources. This often leads to inequality in resources allocation (World Bank, 1998). It is difficult to assess or design policies to change household productivity or distribution of income without looking at intra-household distributions, and all the evidences suggest that it matters who in the household makes decisions.

It is therefore important to understand how resources are allocated and recognizing the sources of the yield difference is a necessary step in the determination of an appropriate policy intervention. Many previous studies (reviewed in Quisumbing, 1993) have indicated differences in output per acre or per person but have failed to isolate the source of these differences.

Documenting Groundnuts as a Women's crop

Following Carney (1988), the gender literature on agriculture production categorizes crops as being a woman's or a man's crop depending on who is primary producer and decision maker on the field. In the case of groundnut production in most parts of Africa, the distinction seems to be more on who controls the cash proceeds from groundnut sales rather than who did what activity and for how long on the groundnut field. In general, it is documented that men in charge of all cash crops while women take care of food crops. The following examples, however, show that these distinctions where made (and supported) are not always clear-cut.

In Cameroon, Atayi (1980) finds that the production of cash crops (coffee and cocoa) is clearly dominated by men while women dominated in

food production. Groundnut is taken as a woman's crop. All the farm operations except weeding are dominated by women. Bryson (1979) had reported that the pattern of sex roles in provision of labor, crop ownership, and how much the crop is sold and the beneficiary of the income from groundnuts in Cameroon varied from region to region.

In Kenya, Oduor-Noah *et al.* (1995) finds that women who grow groundnuts give the profits to their husbands. Women indicated that groundnut cultivation is highly labor intensive and that its profits are minimal. Men prepare the land with oxen and plow or with hand tools. Although husbands make decisions on what crops to plant groundnuts is a woman's crop. Truscott (1986) showed a declining trend in groundnut production and consumption in Zimbabwe yet groundnut is the only crop from which women were able to retain control of the income. Without giving reasons for this finding, Truscott nonetheless observes that groundnut is regarded primarily as a "women's crop" and are not accorded a high priority when the household plans its agricultural production for the season. There is little market for groundnut either informally or formally; groundnut is viewed as "traditional" and therefore unfashionable as food; and households prefer to meet their protein needs with meat rather than nuts or beans. Clearly, the notion of groundnuts being a woman's crop does not appear to be supported by any evidence whatsoever.

In eastern Zaire, groundnut is generally recognized as a man's crop. This view apparently persists even though women have a major role in groundnut production. Men cut bushes and trees to clear the fields and helped women hoe the fields. Then women sow groundnut, did most of the weeding, harvest the groundnut, and transported them to their home. Men and women do shelling groundnuts but women carry most of the groundnuts to the market (Newbury and Schoepf, 1989). In Gambia, men predominate groundnut production (Carney, 1992). In Senegal, Linares (1992) finds that though women invest 17 percent of their time in helping their husbands with groundnuts, they have no control over any part of the product, they do not partake of the profits, and they have no usufructory right to groundnut land.

Adoption of Groundnut Technology

The Groundnut Improvement Program started early in the 1960s under the grain legume unit of the Agriculture Research Council of Central Africa, which is now known as Groundnut Improvement Program (Ngwira, 1984). Over the years, a number of groundnut varieties both for confectionary and oil extraction purposes have been bred or improved in Malawi. Collaboration among the Southern African Development Community (SADC), International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) Groundnut project and the Malawi National Agricultural Research Systems (NARS) has resulted in the release of a number of cultivars that could potentially boost production (Chiyembekeza *et al.*, 1994; Subrahmanyam *et al.*, 1998, 2000). Some of these varieties are large seeded nuts like chalimbana and chitembana, rosette-resistant variety of RG1, oil nuts like manipintar and malimba. The latest variety is CG7, a medium red seeded variety that was approved for release in Malawi in 1990 (Chiyembekeza *et al.*, 1994; Subrahmanyam *et al.*, 2000). On farm trials by the SADC/ICRISAT Project between 1993 and 1995 showed an average yield of 734 kilogram per hectare (kg/ha) for CG7 compared with 358 kg/ha for chalimbana, which is the most popularly grown variety among smallholders (Maliro, 1994).

Cromwell and Zambezi (1993) observed that groundnut breeding in Malawi has been more market oriented. Breeding has been for high yields, producing groundnuts primarily for export and as domestic cash crop, which is reflected, in the high oil content of the available varieties. Most smallholders find difficulties when they used high oil content nuts to season relish because such relish easily turns rancid. Studies show that smallholders grow different varieties of groundnut although the most widely grown is chalimbana, which is favoured for its taste and big kernels (Luhana *et al.*, 1994).

In the early 1970's, there was a strong international market demand for large seeded confectionary nuts, and the varieties like chalimbana and chitembana faired well then. However, Phiri (1999) observed that this is no longer the case, since international demand now favours relatively smaller seeded nuts. This gives CG7, which is a medium seeded nut, a comparative advantage over the other varieties, and hence this research focuses on the determinants of adopting CG7 variety in Malawi.

Adoption of Improved Groundnut Varieties in Malawi

A number of adoption studies of improved varieties carried out in Malawi have been on other crops other than groundnuts. Most adoption studies in Malawi have concentrated on improved varieties of staple food, maize and maize related inputs like fertilizer. In her study of the adoption of maize technology by smallholder farmers in Malawi, Mpiri (1994) and Smale (1995) found that farmers adoption decisions consist of several interrelated, but distinguishable choices on whether to adopt or not, the extent of adoption. This is how much land to allocate to the new and old techniques and the intensity of adoption, which is to do with the rate of input application. In her study, it was found that the percentage of farmers adopting hybrid maize seed (adoption) appears to vary sharply by agro-economic zone. It was also found

that provision of the appropriate seed for a particular locality at the proper planting time and provision of seed to markets to enable farmers to obtain inputs with cash rather than on credit can result in a number of farmers growing at least some hybrid maize. Kisyombe (1998) using a probit analysis to analyze the effects of seasonal agricultural credit on adoption of production technology and income in smallholder agriculture in Malawi found that agricultural credit has a significant effect on the hybrid maize adoption.

Ng'ongo'la and Green (1988) using multivariate logit analysis found that among other factors farming system, off-farm employment and access to credit affect adoption at farm household level. Also using logit estimation, Jere (1996) showed that land holding, farm size and access to credit are very significant in influencing the likelihood of adopting new bean varieties.

Some studies (Marais *et al*., 1994) have shown the probability of adopting a new technology will depend on the difference in profitability between the new and old technologies. Ramaswamy *et al*. (1992) found that the farmers' preference for high yielding modern varieties of rice suggested that the level of adoption could be related to income advantage achieved from improved yields of the modern varieties over the traditional varieties. However, it was seen that in the early phases of spread of technologies, no significant variations existed in the adoption rate across production environments. Cromwell and Zambezi (1993) concurred with these findings when they observed that there was low use of improved varieties in Malawi because there was no great yield advantage to using improved variety under smallholder farmer conditions, although yield is an important criterion by which small farmers judge performance.

According to Malawi government (1997), smallholder farmers in Malawi may cultivate improved groundnut varieties but they may not necessarily follow the recommended farming practice technologies for high yields. In addition, there has been some suggestions to the effect that the high groundnut seed prices is the main reason for groundnut recycling in Malawi, and hence the major constraint to encouraging greater use of improved variety. However, Cromwell and Zambezi (1993) argued that since groundnut retail prices have been competitive with consumer grain prices in recent years, there is no clear financial benefit to using grain rather than seed, and therefore if seed is available smallholder farmers should not reject it on price ground alone. Thus, they concluded that seed prices were not the only factor, nor even the major one and in any case it was not the absolute level of seed prices but their relationship to other agricultural producer and input prices that has the most significant impact on the use of improved seed.

CONCLUDING SUMMARY

This chapter was devoted to literature review. The literature reviewed in this chapter is intended to provide a working definition of measuring the dynamics of groundnut production and intra-household transactions within the agricultural production, profitability and technology adoption in subsistence economy like Malawi. The chapter has introduced smallholder farming systems, groundnut marketing prospects and gender differential in groundnut productivity, and adoption of farm technologies.

The most important messages in the chapter are that there are a number of constraints associates with smallholder farm productivity including not adopting farm technology, unequal control of agricultural resources and productivity and production inefficiency. Of paramount importance, it was noticed that farmers' adoption decisions consist of several interrelated, but distinguishable choices on whether to adopt or not to adopt a technology, which is the extent of adoption. This also refers to how much land to allocate to the new and old techniques, as well as, the intensity of adoption that mainly includes the rate of input application.

Furthermore, the gender differential in farm productivity is another important topic extensively covered to understand who controls farming produces, makes decision on farming activities; whereby women are equally, if not more, involved intensively by providing family labour to groundnut production in developing countries.

Increasing groundnut production will –

- Increase exports of confectionery nuts
- Reduce import requirements for edible oils
- Improve the quality of smallholder diets, and
- Significantly improve smallholder cash income.

- Nyirenda, Cusack and Sak

CHAPTER III

SURVEY METHODOLOGY AND THEORETICAL MODELS

INTRODUCTION

Modern production theory is the basis for modern approaches to productivity measurements. This part of the study seeks to introduce the conceptual framework, developments in production theory, and its applications to productivity measurements and gender differential in agricultural activities, as well as adoption of technology in subsistence economy. Some fundamental topics in modern production theory that relate to the productivity literature, including functional structure, functional form and derivatives are discussed hereafter.

CONCEPTUAL FRAMEWORK

The socio-economic forces that influence the household production and use system are complex. A diagram illustrating the essential dynamics of production, efficiency, inter-sectoral and intra-household transactions is presented in figure 1. These socio-economic forces are studied with much emphasis on delineating gender interactions, household type, farm type, marketing and technology variations that impact on groundnut production and use. The proposed models focus on the socio-economic forces in the family/household and communal and market systems that influence groundnut production, output potential and technical efficiency.

The model specifications also consider the distribution of groundnut crop and its by-products in various exchange channels, with implications for household economics and livelihood security. The household level variables of interest are social organization, local knowledge system, education level, gender, labour, farm credits and resource organizations. In the market system, both input and output market forces are of interest.

It is particularly important to isolate gender-differentiated opportunities and constraints relevant to increase groundnut productivity and to enhance income from groundnut crop production. Furthermore, the research also heavily focuses on identifying determinants and technical efficiency of groundnut technology, as well as, groundnut productivity, aiming mainly at

the physical capital, human capital, management and technological factors in rural settings.

SURVEY METHODOLOGY

This part of chapter III provides discussions on survey methodology employed to collect data from the villages in Malawi. The main emphasis is on variables, measurements, validity and reliability of measurements, study design, population, the study area, data collection method, analysis and analytical tools.

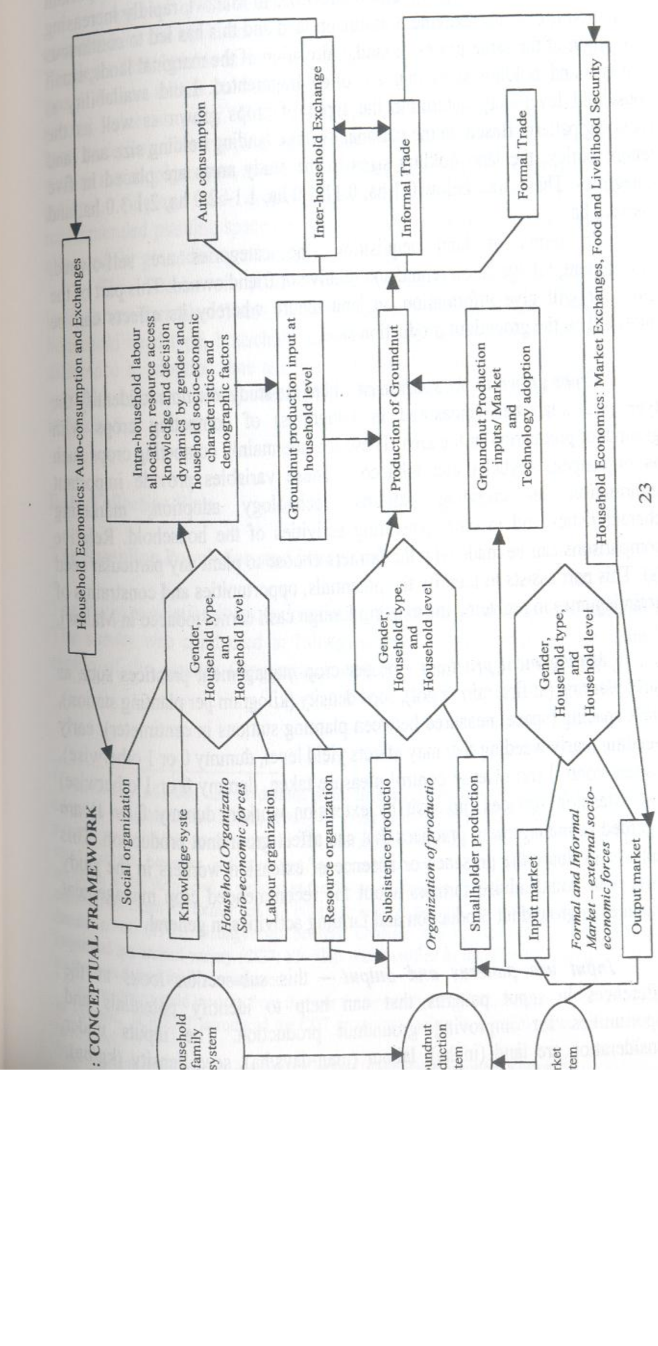
Operational definitions and measurements of Socio-economic characteristics

Age of the household head – age is one of the factors that affect production decisions and the efficiency of carrying out farm activities. It is categorized in age groups (<20, 20-49, 50-59 and above 60) so that it should be possible to determine which age group is actively involved in farm activities (labour supply potential to the family farm activities).

Educational status of the household head – education is described as an essential element in any development process. It is argued that educated people can understand agricultural instructions very easily and be able to apply technical skills imparted to them than the uneducated ones. Education also plays roles in farming activities such as in adopting agricultural technologies. Thus, the levels of education of the household heads measurements could be taken from the four categories of education attained, namely, primary education, secondary education, tertiary and none.

Sex of the household head – in Malawi, female-headed households constitute about 30% of the total households heads and female also play a major role in subsistence farming activities (Malawi Government, 1997). Thus, this variable measures women's contribution to household groundnut production in terms of their time and family labour supply and therefore it may be possible to determine the gender differential in groundnut productivity. Household head is categorized into male and female (dummy variable, male = 0, female = 1).

: CONCEPTUAL FRAMEWORK



Land holding size and acquisition – land is one of the most important and scarce resources in agricultural production. In Malawi, rapidly increasing population is exerting extreme pressure on land and this has led to continuous cultivation of the same pieces of land, cultivation of the marginal lands, small farmers land holding sizes that are often fragmented. Land availability at household level may determine the types of crops grown as well as the cropping pattern. Based on the national average landing holding size and land tenure policy, the land holding sizes in the study areas are placed in five categories. These are: below 0.1 ha, 0.11-1.0 ha, 1.1– 2.0 ha, 2.1-3.0 ha, and above 3 ha.

In terms of land acquisition, the categories are self-owned, government, village chief, rented and relative or friend owned. This part of the indicator will give information on land tenure whereby its effects can be analyzed on the groundnut production side.

Crops grown in the study area – here the study attempts to identify the type and quantities (measured in kilograms) of competing crops with groundnut production in the area. These include mainly competing crops such as pigeonpea, soybean and tobacco. These variables provide important information on cropping patterns, technology adoption, marketing characteristics and income generating activities of the household. Relative comparisons can be made why the farmers choose to plant any particular seed (s). This part assists to identify the potentials, opportunities and constraints of grain legumes in replacing the existing foreign cash earner tobacco in Malawi.

Management practices - proper crop management practices such as early planting (at first rain or not), seed density (kilogram per planting station), plant spacing (space measured between planting stations in centimeter), early weeding (early weeding that may affects yield level, dummy 0 or 1 otherwise), disease control (no disease control measure taken, dummy 0 or 1 otherwise) and extension services (no visit by extension worker, dummy 0 or 1) are regarded as management practices that can affect groundnut production. This helps to evaluate the presence or absence of extension workers in the study areas who could advise farmers about the recommended crop management practices in groundnut production and farming activities in general.

Input use patterns and output – this sub-section looks at the differences in input patterns that can help to identify potentials and opportunities for improving groundnut production. The inputs under consideration are land (in ha), labour (man-days/ha), seed density (kg/ha), fertilizer (in kilogram) and farm credit (whether the farmers have access to credit) been obtained.

Adoption[4] of Groundnut Technologies – here the study attempts to examine how the socio-economics variables affect the technology adoption. The dependent variable is the number of years[5] after a technology is available that a farmer adopts it. The dependent variable takes on discrete integer (count) values in years. The technologies are improved varieties (CG7 and local varieties), intercropping (groundnut mix planting with other major crops such as maize, pigeonpea, soybean, sorghum, etc.), rotation (seasonal cropping pattern), ridging, and erosion control (where the farmers practice recommended planting space and conservation practices on the piece of land allocated for groundnut production).

The vector of socio-economics characteristics represents the independent variables. These are farmer education, farm size, extension visit, household head type, household size, etc. These are expected to explain the difference in adoption time among farmers and which of the socio-economic variables are responsible in determining the adoption of groundnut technology in Malawi.

Data Collection Plan

The Sampling Population and Study Area

The study population is groundnut farmers in the Central Region of Malawi[6]. The survey was conducted in Lilongwe and Salima districts in the central region of the country (Appendix 1 and 2). These two districts lie within

[4] Technology adoption can be defined from different perspectives. The basic definition of adoption as quoted from Rogers (1962) by Feder *et al.* (1995) is that adoption is a mental process an individual passes from the first hearing about an innovation to final adoption. The same authors, however, indicated that for rigorous theoretical and empirical analysis final adoption at the farm level is defined as the degree of use of a new technology in the long-run equilibrium when the farmer has full information about the new technology and its potentials. Smale *et al.* (1995) distinguished between divisible and non-divisible technologies and improved groundnut variety (CG7) adoption was classified as divisible since divisible inputs such as seeds and fertilizers are used.

[5] The counting would be done from the year the new technology (CG7 variety) was introduced in Malawi. ICRISAT introduced the CG7 groundnut variety in 1989/90 agricultural seasons in Malawi.

[6] Malawi is divided into three regions: Northern, Central and Southern Regions.

Lilongwe and Salima ADDs[7], respectively, which constitutes over 70% of groundnut production in Malawi (MoAI, 1998).

Lilongwe ADD is situated on an altitude of about 600m above sea level while Salima ADD lies on the lakeshore flood plain at about 450m above sea level. The Central region has a warm to hot weather and cloudy with light to heavy rains, rainfall rages from 600-1000mm per annum, falling in one continuous rainy season from November to March. This type of rainfall supports crops, such as groundnut, tobacco and maize that are planted early in the growing season.

The choice of the two districts is necessitated by the need to cover as many diverse factors as possible that might affect the household's decision to grow groundnuts. These factors are income levels, input and output prices, access to land and socio-cultural factors related to labour transactions within family groups.

Sampling Design and Instruments

The cross-sectional data were collected in the form of:

- Questionnaires - structured questionnaires was used to collect primary data through interviews with selected households (see questionnaire, appendix 5).
- A checklist was used to collect more information from some key informants on policy and other issues as regards to the grain legume sub-sector in Malawi, particularly marketing before and after market liberalization. Secondary data were also collected from Non-Governmental Organizations (NGO_s) that participate in the grain legume sub-sector research. Some of the major organizations are -- Concern Universal, Action-Aid, World Vision and Self-Help Development International, ICRISAT and University of Malawi[8].
- Participatory Appraisal Methods – this was to collect additional data from key informants and focus-group discussions. A qualitative analysis complementary to the quantitative analysis. It was used to learn the decision-making processes and outcomes within the households and findings from the field surveys that are conducted regularly by Agricultural Development Divisions (ADDs) supplemented this study.

[7] Malawi is divided into eight ADDs that form different agro-ecological zones. These ADDs lie within the three regions of the country. The ADDs constitute the primary management unit of extension services. The ADDs are subdivided into Rural Development Projects (RDPs), which are further subdivided into Extension Planning Areas (EPAs). Extension agents called Field Assistants supervise at the EPA level.

[8] The study is part of the Norwegian Initiative Projects at Bunda College of Agriculture (University of Malawi) in close collaboration with the Rural Development Department and Ministry of Agriculture and Irrigation. Supplementary (secondary) data were obtained from such non-governmental organizations and government agencies in Malawi.

Sample Frame

The sampling frame (comprehensive sampling units) for this research is:

1. The study population was groundnut farmers in Central Region of Malawi
2. Lilongwe and Salima Agricultural Development Divisions (ADDs) within the Central Region
3. Lilongwe West, Salima East Rural Development Projects (RDPs) within Lilongwe and Salima ADDs
4. Mkokera, Machenchi, Cheseka, Kaphateya, Chafumbewa and Chinguluwe EPAs within the two RDPs
5. A total of 200 smallholder farmers were randomly selected within the villages in the six EPAs for both quantitative and qualitative (PRA) interviews.

Sample Size

Sample Size Calculations

To calculate a good representative sample size for the groundnut productivity survey, the study focused on groundnut farmers in the Central Region of Malawi, which comprises about 70% (p =0.7) of the total groundnut production in the country. Hence, for 95% (Z=1.96, 2-tailed test) level of confidence, within ±5% (e = 0.05) margin of error and taking into account the proportion of groundnut farmers in the central region, the sample size n, was calculated as

$$n = \frac{Z^2(1-p)p}{e^2} = \frac{1.96^2(1-0.7)0.7}{0.5^2} = 323$$

and adding 5% non-respondents, the sample size was n = 339 farmers. Nevertheless, only 200 farmers were interviewed. The choice of a sample of

200 farmers of the 339 calculated for interview was based on budgetary and time constraints. The primary data set had provided the bulk of the information that was required for the study, however, secondary data from the national offices and related research centers were used to complement the shortfalls on top of the information gathered through Participatory Rural Appraisal (PRA) method.

Of the 200 farmers targeted for interviews, there were no callbacks and interestingly recorded 0% non-respondents.

Sampling Method

Village and Farmer Selection

A multi-stage cluster sampling procedure involving a combination of purposeful and random sampling procedures were used to draw the sample. The first step in village selection was a purposeful selection of EPAs (cluster of groundnut producing EPAs) with relatively high level of groundnut production[9]. This criterion was chosen with the need for active farmer participation in mind, farmers having a commercial orientation and farmers having a subsistent orientation toward the groundnut crop. Because groundnut was a minor crop in area terms, it was important to choose EPAs where the areas allocated to groundnuts were relatively large in order to improve the likelihood that farmers would be motivated to participate actively in the research.

Only two EPAs, Chafumbwa from Lilongwe ADD and Chinguluwe from Salima ADD, were provisionally selected in such a way to capture variation in population associated greatly in adopting improved technologies, as the alternative of increasing production from expansion in cultivated area was not available. The rest of the EPAs were selected randomly from the list of EPAs obtained from the Field Assistants. These were Mkokera, Machenchi and Cheseka EPAs from Lilongwe ADD and Kaphateya EPA from Salima ADD.

The second stage was the probability of selecting sample villages (clusters) from the list of villages in six EPAs selected above. A total of ten villages were selected from the EPAs ensuring that villages with larger

[9] EPAs with relatively high groundnut production are identified from maps prepared by Famine Early Warning System (FEWS) office in Agro-Economic Survey (AES) Department of Ministry of Agriculture and Irrigation, Malawi.

proportion had proportionally[10] greater chance of containing a selected cluster than small villages.

The final stage was the section of households to be interviewed. Households were selected randomly from each village selected in the second stage. The lists of names of the villages were also obtained from the Field Assistants (Extension workers) who were responsible for the respective EPAs. These names were assigned numbers and using table of random numbers a total number of 20 farmers were therefore randomly selected from each village. From the 10 villages, a total sample size of 200 farmers was obtained for the study.

Training Enumerators

Prior to data collection, the enumerators were first trained by the principal researcher on techniques of administering the questionnaire for collecting agronomic and socio-economic data. This involved explaining in detail all the questions to the enumerators. This was done to ensure that the enumerators understood what each question was asking for, and that the enumerators should be asking the same questions to the respondents thereby minimizing enumerator bias and other errors.

Pre-testing

Pre-testing of the questionnaires followed the training of the enumerators, and this was aimed at detecting problems in the wording of questions bearing in mind that the questionnaire was written in English but it was administered in Chichewa[11].

Questionnaire pre-testing had also allowed enumerators to be exposed to the real field situations and get used to the questionnaire. After these exercises, all the necessary changes were made on the questionnaires that were administered to the selected or sampled households in the villages.

[10] This type of sampling method is self-weighting, which simplifies the analysis and improves the representativeness of the sample.

[11] National language widely spoken by the majority of the people (or farmers in the villages).

Ethical Considerations

The project managers in the ADDs and Field Assistants in EPAs in the selected areas were responsible for sensitizing the Chiefs, Village Committees, the farmers and related government agencies in the study areas.

Time of Actual Survey

The actual survey was conducted from October to November 2000 by the principal researcher with the help of ten enumerators. Data collection exercises involved administering a structured questionnaire to the sampled household heads or their spouses where the household heads were not available, as well as, participatory focus group discussions with the stakeholders – chiefs, field assistances, extension workers, project managers and researchers.

Participatory Rural Appraisal

The social-economic forces were studied applying intensive participatory approaches. "By using participatory methodologies, engaging community members in the research process. Local men and women act as informants, as advisors, and as guides. They therefore both contribute to and learn from the research process. Finally, the products of research will be returned to the communities for their review and use" (Desfil, 1994).

In many instances, the social researcher's heavy reliance on quantifiable variables has not served well in understanding the true dynamics of socio-economic variables that influence household's production and consumption. In addition, the single respondent has often been a male member of the household who may or may not have direct role in production, and may provide biased information on the production system.

It was essential to complement and supplement quantitative data in selected aspects of the market and output, for which separate sample survey method was used. Therefore, the research process applied complementary methods of qualitative participatory approaches discussing with at least 20 farmers and other stakeholder in the study area.

DATA ANALYSIS AND MODEL SPECIFICATIONS

The second part of chapter 3 now focuses on data analysis and model specifications that were applied on 1999/2000 growing season data in Central Malawi region.

In addition to descriptive statistical analysis, the research was subdivided into two major analytical categories. The first category looked at how well the groundnut farmers performed in their farming activities. Namely, groundnut production analysis that broadly includes yield analysis, technical efficiency, gross margin, profitability, marketing and gender differentiated productivity. The second level looked at groundnut technology and management practices, which includes adopting of improved seed varieties, crop rotation, ridging and intercropping as technologies or farming practices, and extension services, weeding, plant timing, harvesting and others as management practices.

PART I – PRODUCTION FUNCTION ANALYSES

Cobb-Douglas Models

In microeconomic theory, a production function is defined in terms of maximum output that can be produced from a specified set of inputs, given the existing technology available to the firms involved. This part looked at input-output relationships that exist in groundnut production. It emphasized on physical inputs such as seed, labour, land and their effects on the physical output. It was obvious that a production function portrays an input-output relationship describing the rate at which inputs were being transformed into products.

Among several production models, there are the linear function, semilog models, quadratic models and stochastic frontier production model. Each of this model has its pros and cons, however, for this study the modified Cobb-Douglas production model was used because there has been a number of desirable properties that encompass the factors involved in.

From the 1920s, the Cobb-Douglas (C-D) production function is the function of choice for production analysis, both theoretical and empirical, due to elegance, simplicity and ease of interpretation and estimation (Douglas, 1976). It is noted that the Cobb and Douglas (1928) observed that the logarithms of output (Q) and inputs (X_i) in aggregate data appeared to be linearly related. This observation led researchers to hypothesize that the aggregate production function took the log form as:

$$\ln Q = \ln \beta_o + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \ldots + \beta_n \ln X_n + \varepsilon \qquad (3\text{-}1)$$

Nevertheless, economists began to recognize some of the function's limitations and to explore alternatives. Heady and Dillon (1962) used the quadratic function, which is less restrictive in some respects than the Cobb-Douglas function, and the flexible functional forms, such as the translog functional forms are discussed in Christensen, Lau and Jorgenson (1973). For an in-depth discussion of functional forms in production analysis, see Fuss, Mundlak and McFadden (1978).

These developments in functional form reflect the growing understanding that the functional forms used in production analysis may impose restrictions on the economic relationships embedded in the corresponding behavioural relationships – that is, the firm's output supply and input demand functions. It was recognized that for empirical research it is desirable to impose as few restriction on the functional form as possible while maintaining a function that is empirically tractable. The Cobb-Douglas has the virtue of simplicity, but this simplicity comes at the cost of imposing several restrictions, including unitary elasticities of substitution, constant production elasticities, and constant factor demand elasticities (Fuss *et al.*, 1978). One important generalization of the Cobb-Douglas is the translog function that can be obtained by specifying the Cobb-Douglas production elasticities to be log-linear functions of the inputs. That is, in equation (3-1) add the following conditions:

$$\beta_i = \beta_{io} + (0.5) \Sigma_j \beta_{ij} \ln X_j \qquad i = 1, 2, \ldots, n \qquad (3\text{-}2)$$

substitution of equation (3-2) into equation (3-1) gives the translog function:

$$\ln Q = \ln \beta_o + \Sigma_{i=1} \beta_{io} \ln X_i + 0.5 \Sigma_i \Sigma_j \beta_{ij} (\ln X_i)(\ln X_j) \qquad (3\text{-}3)$$

As discussed by Denny and Fuss (1977), the translog can also be viewed as a second-degree (logarithmic) approximation to a general function about the point $\ln X_i = 0$, where $i = 1, \ldots, n$. The translog is attractive because it is, in the terminology of Fuss, McFadden and Mundlak (1978), a "parsimonious flexible functional form," that is, it has the minimum number of parameters needed to represent economic behaviour without imposing arbitrary restrictions on that behaviour. This idea was originally that of Diewert (1971). Theorists have developed various mathematical concepts to characterize the important dimensions of functional structure for economic analysis. An exhaustive survey of functional structure is beyond the scope of

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As discussed in detail in Blackorby *et al.* (1978) and Binger *et al.* (1988), the Cobb-Douglas function has the fundamental structural properties - homogeneity, homothetic, separability and substitutability for single output technologies – of a production function. In addition, this production function has been used in a number of empirical studies, and therefore chosen in this groundnut research because it has a number of desirable properties. These are mentioned briefly below. As given in equation (3-1),

1. The βi represents the percentage change in output for a one percent change in the unit of input i. These technical coefficients can be derived from the cost of production data or can be estimated econometrically.
2. The sum of βi gives the degree of homogeneity or return to scale. The $\sum \beta_i < 1$ indicates the decreasing return to scale, $\sum \beta_i = 1$ indicates constant returns to scale, and $\sum \beta_i > 1$ indicates increasing returns to scale.
3. The elasticity of substitution between inputs is equal to one.
4. The production function implies declining marginal products of the inputs.
5. The βi 's also represent the ratio between the total cost of a factor i and total revenue (i.e. factor shares) and assumes that $\sum \beta_i < 1$. Also $\sum \beta_i < 1$ indicates that one or more factors of production earn economic rent. Normally when statistical analysis is used to explain the determinants of productivity, the most common approach is to look at some major factors involved in production such as physical and non-physical inputs, farming practices, water availability and their impact on yield.

In Malawi, the common factors of production employed by smallholder farmers have been established to be labour, land, fertilizer and seed (Malawi Government, 1998; Kamanga, 1999; Ngulube, 2000). In this report, these factors[12] were used to estimate the following production function.

$$Q = \beta_0 S^{\beta 1} L^{\beta 2} N^{\beta 3} e^{v} \qquad (3\text{-}4)$$

[12] Excluding fertilizer because farmers are aware of soil fertility that comes with groundnut production, and hence do not apply any inorganic fertilizer.

$$\ln Q = \ln \beta_o + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \ldots + \beta_n \ln X_n + \varepsilon \quad (3\text{-}1)$$

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[12] Excluding fertilizer because farmers are aware of soil fertility that comes with groundnut production, and hence do not apply any inorganic fertilizer.

Where:

Q = yield of groundnuts (shelled) per unit area
S, L and N = units of seed (in kg/ha), labour input (in person days) land (in hectare), respectively.
β_1, β_2 and β_3 = elasticity of yield with respect to seed, labour purchase variables, respectively.
β_0 = a constant which shows the state of technology and v is vecto the error terms.

The estimation of coefficients for the establishment of the elastici involves transformation of equation (3-4) to logarithmic linear function fact, the Cobb-Douglas function is an example of a deterministic fron model that has been used by several researchers to measure techn efficiency levels in both industries and farms. Fan (1997), for exam estimated technological change in Egyptian rice using a Cobb-Doug frontier production function using data from1964-1994. Hence, the modif version of Cobb-Douglas (or translog function) is discussed related groundnut production in Malawi.

Modified Cobb-Douglas and Translog function

In this study, the estimated production function included land, labor and se as the expected factors that would affect groundnut productivity, cr management practices and gender of the cultivator. The crop managem practices considered are time of planting (month), weeding levels and numb of seed per planting station. The following form of production function mo was estimated:

$$\ln Q = \beta_o + \beta_1 \ln LAND + \beta_2 \ln LAB + \beta_3 \ln SEED + \beta_4 NUMSEED + \beta_5 WEE + \beta_6 MONTH + v_j \qquad (3\text{-}5)$$

Where:

ln Q = Natural log of Yield in Kg/ha
lnLAND = Natural log of amount of land in hectares
lnLAB = Natural log of labour in man-days/ha.
lnSEED = Natural log of amount of seed used in kg/ha
NUMSEED = Dummy variable for number of seed per pla station, where 1 equals for planting 1 or 2 seeds per pla station and 0 otherwise.

WEED = Dummy variable for weeding, where 1= early weeding, 0 otherwise
MONTH = Dummy variable for month of planting, where 1 = planting after November, 0 = otherwise.
β_1, β_2 and β_3, are elasticities of yield with respect to land, labour, seed and β_4, β_5 and β_6 are coefficients for crop management practices (NUMSEED, WEED and MONTH, respectively) and β_7 coefficient to be estimated for gender of cultivator.
β_o = Constant (or y-intercept)
v_j = Error terms (j = 1, 2, ...,6).

Only endogenous factors were included in the model and these include the farm household factors that influence an individual's capacity to produce. These were those variables that were under farmer's control. Land was treated as endogenous because almost 90% of the cultivated land was owned and not rented and there was no formal land market for purchase and sale of land (refer to Table 4.5). Labor was expressed in man-days per hectare, and was the sum of family and hired labor. It was treated as endogenous because it was mainly family labor that was commonly used in the production process among smallholder farmers in Malawi.

Seed is a universal input for all crop-based farming systems. The genetic information contained within the seed determines the upper limit on yield and ultimately the productivity of all other inputs (Jones, 1996). The quantity of seed affects productivity in two ways. First, a very high seeding density results in high competition for nutrients leading to low yields and secondly, low seeding density leads to low yields resulting from the under utilization of land.

Dummy variables included in the model were used to capture the effect of crop management practices on the yield of groundnut. Management practices might have determined the level of production and hence productivity. For example, early planting might have a positive effect on groundnut productivity because it might ensure the groundnut plants to develop sufficient vegetative growth before they flower, which ensured higher yield. Late planting would affect productivity negatively so was weeding. Groundnut has an initial slow growth rate and this makes it less competitive with weed (ICRISAT, 1992). Poor weeding might make it hard to control insect pests using insecticides as weeds reduce penetration of the chemical into the crop canopy.

This analysis however, was aimed at looking at the effect of second and third weeding on groundnut productivity bearing in mind that almost every farmer conducted first weeding exercise. This regression also explored

the variation in yields between plots controlled by men and women farming the same crop, groundnut, in a given year.

Analysis of Technical Efficiency

The C-D function can also be used to estimate technical efficiency of production. In fact, several researchers, such as Aly (1987) and Fan (1997) have used the Cobb-Douglas model to measure technical efficiency levels in both industries and farms. However, the major weakness is that the technical efficiency indices vary depending on the number of farmers involved in a study (sample size), and combination of farmers. Thus, the results on technical efficiency cannot be inferred to a larger area, as they are area-specific (Simtowe, 2000).

On the other hand, the deterministic frontier production function may complement the short fall in the technical efficiency measures using C-D function. After measuring the level of technical efficiency, it was necessary to identify what determines the level of technical efficiency. Whereby, the research mainly explored the non-physical factors of production such as education, age of the farmer, gender, access to credit, number contacts with extension workers, and access to groundnut technology, which might be responsible for the existence of technical inefficiencies in small farms engaged in production.

Battese (1992) gives updated accounts of frontier production functions associated with the estimation of technical efficiency of individual firms. He discusses production frontier models involving deterministic frontiers, stochastic frontiers and panel data models.

In this book, deterministic frontier model was used due to the nature of the data collected. Stochastic frontier was not applied because the data did not contain weather, errors in production, government action, etc. information that were not under the control of the farmers. Likewise, the panel data model was not used because the data did not contain time-series observations. However, the deterministic frontier model was used for the analysis of technical efficiency of farms in the study.

The deterministic frontier model is defined by

$$Y_j = f(x_j;\beta)\exp(-U_j) \qquad j = 1, 2, \ldots, N \qquad (3\text{-}6)$$

Where:

Y_j represents the possible production level for the jth sample farm; $f(x_j;\beta)$ is a suitable function, which was modified Cobb-Douglas function, equation (3-5), as discussed previously,

Vector, x_j, inputs for the jth farm and a vector, β, parameter estimates for land, labour, seed and crop management practices (number of seed, weed and month).

U_j is a non-negative random variable associated with farm-specific factors, which contribute to the jth farm not attaining maximum efficiency of production. This factors include non-use of fertilizer, absence of pesticides, non-use manure and absence of technology adoption, and

N represents the 200 farmers involved in the cross-sectional survey in this study.

The presence of the non-negative random variable, U_j, in equation (3-6), is associated with technical inefficiency of the household farm and implies that the random variable $\exp(-U_j)$, has values between zero and one. Thus, it follows that the possible production function Y_j, is bounded above by the non-stochastic (i.e. deterministic) quantity, $f(x_j;\beta)$. Hence, model (3-6) is referred to as a deterministic frontier production function.

Thus, the technical efficiency of a given farm is defined to be the vector by which level of production for the firm is less than its frontier output. Given the deterministic frontier model (3-6), the frontier output for the *j*th farm is $Y_j^* = f(x_j;\beta)$ and so the technical efficiency for the jth farm, denoted by TE_j, is:

$$TE_j = \frac{Y_j}{Y_j^*} \qquad (3\text{-}7)$$

$$= f(x_j;\beta)\exp(-U_j) / f(x_j;\beta)$$

$$= \exp(-U_j)$$

Technical efficiencies for individual farms in the context of the deterministic frontier production function (3-6) are predicted by obtaining the ratio of the observed production values to the corresponding estimated frontier

values $\hat{TE} = \frac{Y_j}{f(x_j;\hat{\beta})}$ where $\hat{\beta}$ is either the maximum-likelihood estimator or the corrected ordinary least-square estimator for β.

Generally, given the frontier output for the *j*th household farm, the exp($-U_j$) expression can be defined as the ratio of the actual yield (Y_j) to the yield of the best practice (Y_j^*) household farm at the same level of resources, and this value is obtained from equation (3-5). Thus, the value 1 for the household farm on the production frontier means achieving maximum output, and therefore efficient. It is less than 1 for the inefficient farmers, producing below the frontier at a given level of inputs.

Finally, regression model was applied to identify determinants of technical efficiency in groundnut productivity in Malawi.

Gross Margins Analyses

In order to find out profitability of groundnut production, and other competing cash crops that are alternative to tobacco as foreign exchange earner, gross margin analyses were performed for all the cash crops including tobacco in chapter 5. The gross margins are defined as the difference between the Gross income (GI) and total variable cost (TVC) involved for each competing cash crops production process as described in equation (3-8) next.

Mathematically, it is expressed as

$$GM = GI - TVC \quad (3\text{-}8)$$

Where:

GM is gross margin (MK/ha)
GI is total income (MK/ha)
TVC is total variable cost (MK/ha)

Gross income is the product of the output from the production process and the price of that output.

Gross margins are useful first step in deciding on the best combination of activities on a farm. The activity with the highest gross margin per unit of the most common limiting resource is chosen. Labour as a production unit common to all the farm activities is the most appropriate basis for comparison in the gross margins (Abbot and Makerham, 1990; Becker, 1990). In this study, output of competing cash crops (groundnut, soyabean, pigeonpea and tobacco) were used to calculate the gross margins so that relative profitability

comparisons were made regardless of the smallholder farming systems in the central Malawi.

Gender Differentials in Groundnut productivity

As shown in the literature review, groundnut is considered women's crop in most countries in Africa (Newbury, 1988). Relatively, it is also important to measure the household efficiency and relative incomes of men and women related to groundnut production in Malawi. Recognizing the source of the yield difference is a necessary step in the determination of an appropriate policy intervention.

The analysis was done using a restricted form of Cobb-Douglas production function. Among other independent variables, the gender of the cultivator as dummy independent variable (men = 0 and female = 1) was included to separate gender differential in groundnut production at the household level.

PART II – ADOPTION OF TECHNOLOG ANALYSES

Adoption of Groundnut Technology

Here the study examined how the socio-economics variables affected the adoption of groundnut technology. The dependent variable is the number of years after a technology is available that a farmer adopts it. The dependent variable took on discrete integer (count) values. The technology considered was latest groundnut technology, CG7 variety. The independent variables represented by the vector of socio-economics variables were – education of a farmer, farm size, extension visit, household head type, household size, etc. These variables were expected to explain the difference in adoption time among farmers.

Generally, the study attempted to find which variables were the determinants of groundnut technology adoption. Furthermore, logistic regression model was fitted to each technology or farming systems, which were intercropping (groundnut mix planting with other major crops such as maize, pigeonpea, soybean, sorghum, potato, etc.), rotation (seasonal cropping pattern), ridging (spacing on the row) and improved groundnut variety (CG7) in their fields. The logistic regression model was used to examine farmers' perceptions of adopting one of these technologies or farming systems in the study areas.

Count Data Econometric Models

Several factors are responsible for a farmer's decision to adopt groundnut technologies. Extension creates awareness of the existence of seed technologies. Then farmers assess whether the technologies are acceptable to them given the crops they grow, farm size, experience, labor availability or demand, expected improvement in fertility (groundnut nitrogen fixation), availability of credit facilities, fertilizer input cost, and other factors (Hildebrand *et al*., 1994; GoM, 1998).

This process of determining whether it is feasible and profitable for farmers to adopt and implement the technology on their farms may be instantaneous, i.e., they can adopt immediately, in the same year that the technology is introduced or it can take several years depending on the factors such as education and frequency of extension contact. Various assumptions can be made regarding technology choice. One assumption is that technology and crop choice is sequential, that is, farmers choose the technology first and then decide what crops to grow to suit the chosen technology (Mangisoni, 1999).

An alternative is to model the choices simultaneously, that is, crop and technology choices take place at the same time (Green *et al*., 1996). Since the crops grown in Malawi are both unimproved and improved seed varieties, simultaneous choice of crop and technology is a more appropriate representation because production of crops in Malawi does not need highly specialized capital (*ibid*).

Nature and Application of Count Data

Adoption of agricultural technologies is increasingly becoming a major consideration in agriculture. Once invented, a technological innovation must be adopted by producers, and it is here that the demand side of the technology market plays an important role in agricultural productivity. Beginning with Griliches' (1957) seminal research on the adoption of hybrid corn varieties and explanation of adoption as a function of profitability, many studies have been devoted to explaining technology adoption and technological change in agriculture. They introduced numerous other variables: human capital and farmer education (Lockheed *et al*., 1980); agricultural extension (Evenson and Kislev, 1975); and risk (Feder, 1982).

Count data econometric models were used to study problems where the dependent variable took on only non-negative values. Hausman, Hall and

Griliches (1984) used a count data regression model to evaluate the relationship between Research and Development (R&D) and number of patents, while Tsur and Hochman (undated) demonstrated the application of count data regression models to explain time to adopt irrigation technologies. Mangisoni (1999) also used these models to study key factors governing the speed of adoption of soil conservation and erosion-control technologies.

The dependent variable in the current study is a non-negative integer variable. It is taken to be the number of years it took a farmer j, to adopt the groundnut technologies after their introduction in the Central Region of Malawi. Farmer j, j = 1, 2, … n, where n a sample of 200 farmers, is believed to be influenced by a vector of socio-economic explanatory variables (x_j) in decision of the farmer to adopt the technologies.

Following Tsur and Hochman (undated) and as reviewed in Mangisoni (1999), let y_j be the realization of the random variable Y_j, where Y_j is the number of years it took farmer j to adopt groundnut technologies in central region of Malawi. The distribution of Y_j is dependent on a set of observed exogenous variables x_j and unobserved variables u_j. Let E be the expectations operator and β be a vector of k parameters to be estimated so that the mean of the count data model is

$$E(Y_j/x_j,u_j)=\lambda_j(x_j,\beta,u_j)=\lambda_j \qquad (3\text{-}9)$$

In most applications, the log-linear specification of the mean λ on the explanatory variables is used and assuming this relationship, equation (3-9) becomes

$$\log\lambda_j = x_j\beta + u_j = \sum_{k=1}^{K} x_{jk}\beta_k + u_j \qquad (3\text{-}10)$$

where e^{u_j}, j = 1, 2, 3, …, n are assumed to be independently and identically distributed (i.i.d) with $E(e^{u_j})=1$, and $Var(e^{u_j})=\eta^2$. In this specification, when the x_j has a constant term, the assumption of unit mean value for $E(e^{u_j})$ does not lead to loss of generality (Tsur and Hochman, undated). Following Gourieroux *et al*. (1980) and assuming independence of u_j from x_j, obtain

$$E(Y_j/x_j)=E_uE(Y_j/x_j,u_j)=e^{x_j\beta}=\mu_j \qquad (3\text{-}11)$$

and

$$Var(Y_j/x_j)=\mu_j+\eta^2\mu^2 \qquad (3\text{-}12)$$

Thus, the choice of the count data model to use is governed by the assumption made about the distribution of u_j (Tsur and Hochman, undated).

The Poisson Regression Model

The starting point in count data models is the basic Poisson regression model. The fundamental specification of the Poisson model is that the discrete random variate Y_j conditional on x_j and u_j, is distributed as a Poisson (λ_j) variate

$$Prob(Y_j = y_j / x_j, u_j) = \frac{e^{-\lambda_j}\lambda_j^{y_j}}{y_j!}, \quad y_j = 0, 1, 2, \ldots \text{(3-13)}$$

Where y_j is the realized value of the random variate, Y_j. When $u_j = 0$ for all j equation (3-12) reduces to the Poisson specification since $\eta^2 = 0$ in the case (Tsur *et al*., undated).

The most common formulation for λ_j is the log-linear model,

$$\ln \lambda_j = \beta' \mathbf{x_j} \quad \text{(3-14)}$$

In principle, the Poisson model is simply a non-linear regression model. However, it is far easier to estimate the parameters with maximum likelihood technique. For an independent sample of n observations, the log-likelihood function for the Poisson is

$$\ln L = \sum_{j=1}^{n}\{-\lambda_j + y_j\beta' x_j - \ln(y_j!)\} \quad \text{(3-15)}$$

and the vector score or the likelihood equations given by the First Order Necessary Condition are

$$\frac{\partial \ln L}{\partial \beta} = \sum_{j=1}^{n} x_j'(y_j - \lambda_j) = 0. \quad \text{(3-16)}$$

The maximum likelihood estimate (MLE) of β is a solution to the following moment equations

$$\sum_{j=1}^{N} x_j' y_j = \sum_{j=1}^{N} x_j' e^{x_j \beta}. \quad \text{(3-17)}$$

from equation (3-16) Hessian is or the second order derivative matrix becomes

$$\frac{\partial^2 \ln L}{\partial \beta \partial \beta'} = \sum \lambda_j x_j x_j'. \quad \text{(3-18)}$$

Under regularity conditions, the Hessian is negative definite for all **x** and β. The log-likelihood function equation (3-15) is strictly concave and the MLE is unique (Lee, 1986; Green, 1997).

Negative Binomial Regression Model

Testing of over-dispersion – the problem with the Poisson model is that it makes the strong assumption that $E(Y_j/x_j) = Var(Y_j/x_j)$. In other words, the Poisson model assumes that the conditional expectation of the endogenous variable, given the exogenous variables, and the corresponding conditional variance cannot vary independently. This, therefore, means that the Poisson model does not take into account farmer effects as well as measurement error (Tsur *et al*., undated). The problem with this restrictive assumption is that when there is over-dispersion, that is, $E(Y_j/x_j) < Var(Y_j/x_j)$ or when $\eta^2 > 0$, the Poisson model breaks down and therefore cannot be used to explain farmer adoption behaviour.

Various techniques have been proposed for detection (or testing for) of over-dispersion in the Poisson model (Lee, 1986; Cameron and Trivedi, 1986, 1990), which they referred to as "Regression-based tests for over-dispersion". This technique is used to test the following hypotheses.

$$H_0: Var[y_j] = E[y_j] \quad \text{(3-19)}$$
$$H_1: Var[y_j] = E[y_j] + \alpha g(E[y_j]). \quad \text{(3-20)}$$

H_o fits the basic Poisson assumption since it says that variance is equal to the mean while H_1 postulates that in the case of over-dispersion, the variance is not equal to the mean or is greater than the mean by some function of the mean, $g(E[y_j])$. The hypothesis test for over-dispersion is performed by regression

$$z_j = \frac{(y_j - \lambda_j)^2 - y_j}{\lambda_j\sqrt{2}} \quad \text{on} \quad w_j = \frac{g(\lambda_j)}{\sqrt{2\lambda_j}} \quad \text{(3-21)}$$

where λ_j is the predicted value of y_j from the Poisson regression and $g(\lambda_j)$ is the assumed probability density function (pdf) of u_j (Green, 1991, 1997; Cameron and Trivedi, 1990).

This test makes several assumptions but the most important one is that under either H_o or H_1 consistent estimates of $E[y_j] = \lambda_j$ are obtained from the Poisson regression model (Cameron and Trivedi, 1990; Green, 1992, 1997). Cameron and Trivedi further showed that the test for over-dispersion, which they called T_{op}, can easily be performed by testing the significance of the single coefficient in the Linear Ordinary Least Squares (OLS) regression of z_j on w_j. They proposed the following assumptions on $g(\lambda_j)$ when performing the test for over-dispersion

$$g(\lambda_j) = \lambda_j \quad \text{and} \quad g(\lambda_j) = \lambda_j^2 \qquad (3\text{-}22)$$

When the regressions are conducted, the t-statistic is used to test whether the coefficients on the regression are significantly different from zero. If the coefficient is significantly different from zero, it implies that there is evidence of over-dispersion in the data and the basic Poisson specification rejected. This test is preferred because it is much more specific to over-dispersion as opposed to the more general tests such as the conditional moment test (Green, 1997). Thus depending on the response of the data to the model, if the basic Poisson model is rejected then a compound Poisson (or negative binomial) model will be the alternative model because it allows for over-dispersion (Green, 1997). For complete derivative of negative binomial model, follow Gourieroux (1984) and Tsur (undated)[13].

As such, a basic Poisson regression model and a negative binomial (compound Poisson) models was fitted to cross-sectional data of 200 farmers to determine what factors affect the number of years, after introduction, it took farmers to adopt a groundnut technology. The technology considered was seed technology, CG7 improved variety), which was introduced in the central region of Malawi in 1990 by ICRISAT and Government of Malawi through Ministry of Agriculture and Irrigation (Subrahmanyam *et al*., 2000b).

The dependent variable in the current study was a non-negative integer variable. It was taken to be the number of years it took a farmer j, to adopt the groundnut technology after its introduction in Central Regions of Malawi, where over 70% groundnut is produced. Several factor were responsible for a farmer's desire to adopt a farm technology. Extension had created awareness of the existence of groundnut production increasing technology. Then farmers assessed whether the technologies were acceptable to them given the crops they grew, farm size, experience, labour availability or demand, expected in fertility, availability of credit facilities, fertilizer input cost, type of household head (female or male headed household) and other factors.

This process of determining whether it is feasible and profitable for farmers to adopt and implement the technology on their farms might be instantaneous, that is, they could not adopt immediately, in the same year that the technology is introduced or it can take several years depending on other factors such as education and frequency of extension contact. Again, various assumptions could be made regarding technology choice. One assumption was that technology and crop choice was sequential, i.e., farmers chose the technology first and then decided what crops to grow to suit the chosen technology (Mangisoni, 1999). An alternative was to model the choices simultaneously (i.e., crop variety and soil technology choices take place at the same time (Green *et al*., 1996)). Since the crops grown in Malawi are grains, simultaneous choice of seed variety and farming system is a more appropriate representation because production of crops in Malawi does not need highly specialized capital (Green *et al*., 1997).

[13] For derivation of negative binomial model refer to chapter six, equations (6-1) to (6-20).

Adoption of Improved Groundnut Varieties in Malawi

A number of adoption studies of improved varieties carried out in Malawi have been on other crops other than groundnuts (Hildebrand *et al*., 1994; Maliro and Nyirenda, 1994; Subrahmanyam, 2000). Most adoption studies in Malawi have concentrated on improved varieties of staple food, maize and maize related inputs like fertilizer. In her study of the adoption of maize technology by smallholder farmers in Malawi, Smale *et al*. (1991) found that farmers adoption decisions consisted of several interrelated but distinguishable choices on whether to adopt or not, the extent of adoption, this is how much land to allocate to the new and old techniques and the intensity of adoption, which is to do with the rate of input application.

In her study, it was found that the percentage of farmers adopting hybrid maize seed (adoption) appeared to vary sharply by agro-economic zone. It was also found that provision of the appropriate seed for a particular locality at the proper planting time and provision of seed to markets to enable farmers to obtain inputs with cash rather than on credit can result in a number of farmers growing at least some hybrid maize. Kisyombe (1998) using a probit analysis to analyze the effects of seasonal agricultural credit on adoption of production technology and income in smallholder agriculture in Malawi found that agricultural credit has a significant effect on the hybrid maize adoption.

Ng'ong'ola and Green (1988) using multivariate logit analysis found that among other factors farming system, off-farm employment and access to credit affected adoption at farm household level. Also using logit estimation, Jere (1996) showed that land holding (farm size) and access to credit were very significant in influencing the likelihood of adopting new bean varieties.

Some studies have shown the probability of adopting a new technology will depend on the difference in profitability between the new and old technologies. Ramaswamy *et al*. (1992) found that the farmers' preference for high yielding modern varieties of rice suggested that the level of adoption could be related to income advantage achieved from improved yields of the modern varieties over the traditional varieties. However, it was seen that in the early phases of spread of technologies, no significant variations existed in the adoption rate across production environments. Cromwell and Zambezi (1993) concurred with these findings when they observed that there was low use of improved varieties in Malawi because there was no great yield advantage to using improved groundnut seed under smallholder farmer conditions, although yield is an important criterion by which small farmers judge performance.

Reports from Ministry of Agriculture and Irrigation (1997) showed that smallholder farmers in Malawi might cultivate improved groundnut varieties but they might not necessarily follow the recommended farming practice technologies for high yields. In addition, there has been some suggestions to the effect that the high groundnut seed prices is the main reason for groundnut recycling in Malawi hence the major constraint to encouraging greater use of improved groundnut seed.

However, Cromwell and Zambezi (1993) argued that since groundnut retail prices had been competitive with consumer grain prices in recent years, there was no clear financial benefit to using grain rather than groundnut, and therefore if groundnut seed is available smallholder farmers should not reject it on price ground alone. Thus, they concluded that seed prices were not the only factor, nor even the major one and in any case it was not the absolute level of seed prices but their relationship to other agricultural producer and input prices that had the most significant impact on the use of improved seed.

Logistic Regression Model

Farmers' Perceptions of Adopting Technology

Adoption of each technology or farming system is a dichotomous dependent variable (adopt or not adopt), which is influenced by some explanatory variables (Amemiya, 1981; Maddala, 1988, 1992). It is possible to compute Ordinary Least Squares (OLS) for binary choice models, however, this results

into heteroskedasticity error terms, that is, the variance term is not constant for all observations, so that parameter estimates obtained are inefficient, thus classical hypothesis tests, such as t-ratios, are inappropriate (Pindyk and Rubinfeld, 1981). The alternative is to use probability models, but Linear Probability Models results into predicted values falling outside the (0,1) interval thereby violating the basic tenets of probability.

The possible solution recommended to overcome most of these problems is the use of Probit and Logit models. All parameter estimates in these models are asymptotically consistent, efficient and normal since the models use maximum likelihood estimation (MLE) procedures. In this case, the analogy of the regression t-test can be applied. The t-ratio follows the normal distribution and the chi-square test replaces the F-test when testing the significant of all or a subset of the parameters in the mode (*ibid*).

Empirical evidence suggests that neither Logit nor Probit have superiority over the other. The choice becomes a matter of preference (Gujarati, 1988). In this study, adoption of groundnut technology analysis uses the Logit model because of its computational and mathematical conveniences. Thus, the following model type was used in most adoption technology researches, where the dependent variable takes the value 1 (adopting a technology) and 0 (not adopting a technology) is regressed on a number of socio-economic characteristics of households.

In Malawi, ICRISAT and other NGOs have introduced Small Scale Seed Programs (SSSP) aiming to fill the gap that has been left open by commercial seed companies in terms of making improved groundnut seeds available and accessible to the smallholders. Since 1989/90 seasons, ICRISAT has widely distributed CG7 improved variety to the smallholder farmers in Malawi. Although CG7 is superior to popularly grown chalimbana (local variety) in many ways including yield, there has been little information on its adoption (Nyirenda *et al*., 1994).

However, Phiri (1999) observed that some farmers were given information about the new variety, they even took part in the evaluation of the performance of the variety, but there has been no follow up to assess its adoption. Chiyembekeza (1994) suggested that insufficient participation by farmers in the process of cultivars development is a contributory cause of non-adoption of the improved varieties. Thus, there is a need to assess the impact of the small scale seed multiplication program in Malawi, and the probability of adoption of groundnut technology (CG7) that can be influenced by several factors including land holding size, education of household, sex of the head, access to credit, off farm income and CG7 seed program membership.

The scenario for CG7 is also true for the other technologies or farming systems, especially intercropping, ridging and rotation. Thus, similar analysis was done using logistic regression model in determining which socio-

economic factors influence the adoption of these aforementioned technologies or farming system in Central Malawi.

CONCLUDING SUMMARY

The chapter is solely dedicated to sampling methods and analytical techniques. It has presented detailed discussions on how the multistage stratified random sampling was done in Lilongwe and Salima Agricultural Development Divisions in order to obtain the cross-sectional data of 200 farmers from the villages.

It has also focused on theoretical models used in the study for empirical estimation of the models. The chapter has demonstrated how to apply C-D model to find out the input-out relationship of groundnut production, technical efficiency model to identify the factors that lead to inefficiency in groundnut production and count data econometric models and its derivatives to find out which factors are responsible in adopting CG7 technology.

The chapter has ended by thoroughly discussing the application of logistic regression model in order to identify which socio-economic factors influence farmers' perception in adopting each of the main technology (or farming system), namely, intercropping, ridging, improved seed variety and rotation, in groundnut production in central Malawi.

CHAPTER IV

SOCIO-ECONOMIC CHARACTERISTICS OF SAMPLE HOUSEHOLDS

INTRODUCTION

In relation to major cash crops (groundnut, soyabean, pigeonpea, tobacco and others) grown after maize for the 1999/2000 seasons, this chapter highlights the major socio-economic characteristics of the 200 farmers interviewed in both Lilongwe and Salima ADDs in central Malawi region. Emphasis is placed on age of household head, age distribution in households, household size, marital status of respondents, marriage system, literacy status, farm size, farm capital, farm credit and management practices.

In chapters 5 and 6, most of these socio-economic characteristics are used in the models to determine which factors play major role in groundnut production, profitability and adoption of technology.

Age of Household Head

As shown in Table 4.1, age of household head is categorized in age groups (less than 20, 20-49, 50-59 and above 60) so that it should be possible to determine which age group is actively involved in farm activities (labour supply potential to the family farm activities).

Table 4.1: Distribution of age of household head

Age (years)	Number of farmers	Percent
Less 20	0	0
20 – 49	141	70.5
50 – 59	39	19.5
Above 60	20	10.0
Total	200	100
Mean age was 46.3 years for the study areas		

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)

average age of the household head was 46.3 years of age, which indicates that there is a good potential of labour in the areas. Age is one of the factors that affect production decisions and the efficiency of carrying out farm activities. Younger people are said to be more innovative and efficient than older people are in labour demanding activities.

Ninety percent of the household heads were in the age groups of 20 to 59, which were considered to be productive age of most society, and actively involved in the farm activities in central region of Malawi. This implies that farmers in age category of 20 – 59 years provide farm labour compared to the age categories below 20 or above 60 years. The results indicate that there is higher labour supply potential in the study areas that enhance farming activities with minimal child and older farmers labour involvements.

Other important observation is that the overall average age (46.3 years) among the farmers is higher than the life expectancy age in Malawi of about 39 years (Population Reference Bureau, 2000). Perhaps most of the farmers in this age group contribute effectively to the agricultural and development activities including in the labour intensive groundnut and tobacco cash crops in the area.

Table 4.2: Age of farmers by main crops grown after maize (percent)

Age (Years)	Main crops grown after Maize				
	Soya bean	**Groundnut**	**Pigeonpea**	**Tobacco**	**Others**
Less 20	0.0	0.0	0.0	0.0	0.0
20 – 49	72.0	75.9	35.4	76.2	69.3
50 – 59	13.2	12.1	20.8	18.2	15.4
60 – 80	9.6	9.0	11.7	5.7	15.4
Above 80	0.0	0.0	0.0	0.0	0.0

Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)

As seen in Table 4.2, since $\chi^2_{12,0.05} = 190.04 > \chi^2_{12,0.05} = 5.226$, there is association between the main crops grown after maize and the age of the farmers. Over 75% who produced groundnut were in presumed productive age range, that is, 20-49 age groups, which imply that the younger farmers grow such labour demanding cash crops as groundnut, soyabean, pigeonpea and tobacco more often that the older farmers in the region. This finding support the claim made previously that there is higher labour supply potential in the study areas that may enhance farming activities in general.

Other important observation is that tobacco is the main foreign exchange earner crop in Malawi, but the smallholder farmers in the study area significantly produce groundnut as much as tobacco. This may also suggest that the farmers who usually have small farms equally prefer to allocate their

farm to soyabean and groundnut production than the other crops in the area, *ceteris paribus*. These findings also imply that there are potentials and opportunities for grain legumes (mainly groundnut, pigeonpea and soyabean) to replace tobacco with further intensifications of the productions in the region.

Education Status

Education is generally described as an essential element in any development process in a country. It is claimed that educated farmers understand agricultural instructions including extension services, management and technology adoption procedures more than the uneducated farmers do.

Table 4.3 presents the levels of education of farmers in groundnut areas in Central Malawi. Most of the household heads (63.5%) have primary education (standard one to eight), which is regarded as adequate level of education for an individual to read and write without problems in Malawi. Farmers in this educational category were the one who mostly grew groundnut and tobacco (25.5% and 23%, respectively) as main cash crops after maize. The farmers who did not have education at all also grew groundnut (7.5%) and (12.5%) tobacco as main crops after maize.

Table 4.3: Percent distribution of education level of farmers by main crops grown after maize

Education Level	Main crops grown after maize					
	Soya bean	**Groundnut**	**Pigeonpea**	**Tobacco**	**Others**	**Total**
None	1.5	7.5	2.0	12.5	2.0	25.5
Primary (Standard 1-8)	7.0	25.5	5.5	23.0	2.5	63.5
Secondary	0.5	4.5	1.0	3.0	2.0	10.5
Others	1.0	0.5	0.0	0.0	0.0	1.5
Total	10.0	38.0	8.5	38.5	6.5	100.0

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)

The secondary level of education farmers were only 11% and other (for example, tertiary) level were 1%, which might imply that the higher the level of education is the less individuals involve in such farming activities. Interestingly, still farmers who were with limited educational levels (primary) grew more groundnuts compared to the uneducated farmers in the area. Perhaps, the farmers at the primary level might have more exposure to new groundnut developments in modern agriculture with improved seed variety for

higher production level, as well as, understood the profitability of the groundnut as cash crop in the country.

Generally, the most preferred crop grown after maize was tobacco, 38.5%, across all educational levels in the area. The second most favoured cash crop was groundnuts (37.5%), and the least was other types of cash crops (6.5%) such as beans and potatoes, which might be again due to perhaps land and cash constrains in the country.

Sex of the household and Average household size

In Malawi, female-headed households constitute about 30% of the total household heads and female also play a major role in subsistence farming activities (GoM, 1997).

Table 4.4 summaries distribution of the type of household heads by main crops grown after maize. This categorization of sexes might lead to measure women's contributions to household groundnut production in terms of their family labour supply, and perhaps gives an indication of gender differential in groundnut activities, which is investigated in details through Cobb-Douglas production function analysis in chapter 5.

Table 4.4: Percent distribution of household head by main crops grown after maize

Sex Household head	Main crops grown after maize					
	Soya bean	Groundnut	Pigeonpea	Tobacco	Other	Total
Female	3.5	20.0	3.0	13.0	4.0	43.5
Male	5.5	17.5	5.5	25.5	2.5	56.5
Total	9.0	37.5	8.5	38.5	6.5	100

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)

Of the entire household headed interviewed 42% were female-head while the male-headed households constitute 58% in Salima and Lilongwe Agricultural Development Divisions. Interestingly, the figure for female-headed household in the central region is slightly higher than the national proportion of 30%. The female-headed households were those who divorced, widowed or separated during the survey.

There is association between the type of household head and the main crop grown after maize since $\chi^2_{4,0.05} = 6.55 > \chi^2_{4,0.05} = 0.711$. In contrast to Carney (1988) and Oduor-Noah *et al.* (1995) who reported that groundnut is women's crop in Kenya, the results here indicate that male-headed (17.5%) and female-headed household (20%) almost equally grew groundnut as the

main cash crop after maize. However, it is important to note that most households were male-headed households, and therefore, it would not be surprising if the production of groundnut were about the same with the female counter part.

According to Sahn (1990), female-headed households were one of the vulnerable groups and most of the time poorer, as well as, fewer labour equivalents than their male counterparts. Therefore, similarly conditions might constrain the female-headed households to get involved in groundnut farming activities, other things being constant.

The average family size was four persons in the area, which is less than the national average of six persons (GOM, 1998). It was also found that 2 to 5 persons from most families participated in farming activities, and 37.5% of the family members were involved in producing groundnut and 38.5% grew tobacco as cash crops after maize. There is a significant association between the household head type and main crops grown after maize at $p < 0.01$.

Land holding size and Acquisition

Land is one of the most important and scarce resources in agricultural production. In Malawi, rapidly increasing population (5.9% fertility rate as report in, World 2000 Population Data Sheet) is exerting extreme pressure on land, and this has led to continuous cultivation of the same pieces of land, cultivation of the marginal lands and small farmers landholding sizes that are often fragmented. Therefore, land availability at household level may determine the types of crops grown, as well as, the cropping pattern.

Table 4.5 shows the distribution of farm size allocated to different crops and acquisition by main crops grown after maize. There is statistically significant association between land sizes and main crops grown after maize at 5% level of significance. It is clear that the larger the farm size the more farmers allocate their land to variety of crops including groundnut after production of maize which is also examined using production function analysis in chapter 5.

The average farm size allocated to groundnut is about 0.47 hectare. The overall average farm size in the area was 2.35 hectare, which larger than the national average of 1.3 hectare (GoM, 1998), perhaps due to availability of more arable farm land in the central and southern regions unlike in the northern region which is mountainous and hilly lands. In the study area, farmers allocated, on the average, 20% their farmland to preferably produce groundnut compared to other grain legumes such as soybeans, pigeon peas, beans and potatoes.

Table 4.5: Percent distribution of farm size and mode of acquisitions by main crops grown after maize

Farm	Main crops grown after maize					
	Soya bean	Groundnut	Pigeonpea	Tobacco	Other	Total
Farm size (hectares)						
< 0.10	0.0	0.5	4.0	2.0	0.0	6.5
0.11 – 1.0	0.0	10.0	1.4	16.0	2.1	29.5
1.1 – 2.0	4.0	10.5	2.0	22.0	1.0	39.5
2.1 – 3.0	2.0	4.0	3.0	6.0	2.5	17.5
3^+	0.0	1.5	1.0	3.0	1.5	10.0
Total	6.0	26.5	11.4	49.0	7.1	100.0

Allocation (hectares)	Minimum	Maximum	Mean
Land allocated to groundnut only	0.1	1.75	0.47
Total land size for a farmers	0.7	5.0	2.35

Mode of Acquisition (Land)	Soya bean	Ground-nut	Pigeon-pea	Tobacco	Others	Total
Self owned (inheritance)	8.0	34.5	7.0	34.0	5.0	88.5
Government	0.0	0.0	0.0	0.0	0.1	0.1
Village Chief	0.0	0.5	0.0	1.5	0.5	2.5
Rented	0.0	0.5	0.0	1.4	0.5	2.4
Relative	0.0	1.5	1.0	2.0	1.0	5.5

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)

Farmers allocated 26.5% of their land to groundnut production and 49% to tobacco. There is a statistically significant difference between groundnut and groundnut production at $p < 0.05$. However, this result implies also that farmers still prefer to allocate the remaining (after allocation to maize and tobacco) piece of their farm to groundnut comparing to other grain legumes.

In Malawi, the mode of land acquisition has tremendous effect on land use and production strategies. Land is one of the important and scarce resources in agricultural production. With rapid population growth resulting in increasing land fragmentation, and holdings becoming smaller so that they are unable to adequately sustain a household. This has led to continuous cultivation of the same pieces of land, cultivation of the marginal lands and small household land. Nevertheless, at the same time farmers cultivate such

pieces of land with different types of cash crops to augment the shortfalls in income to sustain their household livelihood.

Central region of Malawi is predominantly composed of matrilineal societies where land is inherited through the lineage of the women. As indicated in Table 4.5, 88.5% of the respondents acquired land through inheritance, 0.1% from government, 2% from the village chief. Of the 88.5% self-owned (or inherited land) about 34.5% of the respondents grew groundnut, 8% soyabean and 34% tobacco as cash crops after maize for the 1999/2000 growing seasons. Across all type of mode of acquisition, about 37% of the farmers preferred to grow groundnut, 8% soyabean, 8% pigeonpea and 39% tobacco.

The overall results illustrate that the potentials and opportunities for growing grain legumes; especially groundnut is higher, given larger land size for the smallholder farmers. In effect, this shows the potential of groundnut replacing the existing foreign cash earner tobacco, which is locally and internationally under pressure due to anti-tobacco campaign.

Reasons farmers grow groundnut

Table 4.6 displays some of the main reasons farmers grew groundnut and their employment status in the Lilongwe and Salima ADDs in Central Malawi.

Table 4.6: Distribution of reasons farmers grow groundnut

Reasons	Percent
Food only	7.3
Income only	0.5
Food and Cash	63.7
Soil fertility improvement	1.0
Food, cash and soil fertility improvement	27.5

Employment status	Percent
Off-farm work	51.0
No off-farm work	49.0

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)

Most farmers, 63.7%, grew groundnut because of food and cash problems, but only 7.3% said that they grew groundnut because of only food, which leaves 56.4% saying they grew groundnut mainly because of cash problems. It was obvious that of those farmers who opted for extra cash

through farming activities, they preferred to grow groundnut than the other competing cash crops. Furthermore, 27.5% of the farmers responded that they grew groundnut because of food, cash and soil fertility improvements. This might imply that farmers in the region had identified that groundnut might be useful as a nutritious food, cash crop and as the same time for soil fertility improvement.

When income and/or food were inadequate to meet household basic needs, members of some households sought off-farm employment. In the study areas, the results revealed that 51% of the respondents had been engaged in off-farm work. The choice of groundnut as a cash crop might support the claim that the households resorted to all sort of income generating activities including growing preferably groundnut as a cash crop.

Table 4.7: Percent distribution how long the farmers grew the crops

Years	Main crops grown after maize				
	Soya bean	Groundnut	Pigeonpea	Tobacco	Other
Less than 5 years	0	5.2	1.0	2.6	0.5
5.1 – 10 years	2.1	13.1	2.1	14.7	3.1
Over 10 years	7.3	20.9	5.3	20.4	1.5
Most farmers grew groundnut for over 10 years					

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)

About 40% of the farmers were growing groundnut and tobacco for at least 10 years. This implies that farmers were engaged in growing groundnut for food, cash and soil fertility improvement for quite sometimes, which in turn suggests there are potentials and opportunities on improving the groundnut production if resources such as land, cash and other production enhancement mechanisms are made available to the resource poor farmers in the areas. Generally, despite a number of constraints (financial, land, technological, etc.) farmers were facing, it appeared that farmers with smallholdings continue to cultivate and had greater desire to improve their groundnut production in the areas as much as they did with tobacco production.

Farm Credits

As in most African countries, Malawi also heavily relies on agriculture, and with no surprise, farming is by far the first occupation of most household heads across the country. Recognizing the critical role that farm credit (cash or

in-kind) can play in alleviating rural poverty and in fostering the development of rural economy, the government has introduced formal farm credit institutions since 1987. Based on the data collected, this study also has quantified some of the roles of farm credits available to farmers and their impact on agricultural production in central Malawi.

Table 4.7 presents distribution of farm credits received by farmers who grew mainly grow soyabean, groundnut, pigeonpea, tobacco and other crops for 1999/2000 agricultural seasons.

Table 4.8: Percent distribution of farm credit received by seed type

	Main crops grown after maize					
	Soya bean	Groundnut	Pigeonpea	Tobacco	Others	Total
Yes	7.5	11.0	4.5	33.0	5.0	61.0
No	1.5	6.5	4.0	25.5	1.5	39.0
Total	9.0	27.5	8.5	58.5	6.5	100.0

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)

As seen in Table 4.8, 61% of the farmers had received in-kind or cash farm loans from credit institutions and of these farmers, most of them had received loans for tobacco followed by groundnut farm credits in the region.

Table 4.9 summaries also the type of farm credit received by the smallholder farmers, and the majority, 83.9% have received seed loans and 85% fertilizers. Tobacco growers received three times more farm credits than the groundnut farmers did.

Table 4.9: Percent distribution of type of farm credit

	Main crops grown after maize					
	Soya bean	Groundnut	Pigeonpea	Tobacco	Others	Total
Cash	1.1	3.4	0.0	1.1	0.0	5.7
Seed	2.3	26.8	10.3	43.3	1.1	83.9
Fertilizers	0.0	0.0	3.4	74.1	7.5	85.0

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)
Note that column total is over 100% because of multiple responses due to availability of loans from other sources such as friends and relative.

As indicated in Table 4.10, non-commercial institutes, NGOs such as Concern Universal, World Vision International and others provided almost a third of the total small loans through their micro-enterprise programs (usually revolving funds with virtually no interest rate). While commercial institutions

such as Malawi Rural Finance Company (MRFC), which is strictly business oriented government financial institute, provided about 50% of the farm loans with high interest rate (40%) per annum.

Table 4.10: Percent distribution of credit institutions farmers dealt with

Institution	Main crops grown after maize					Total
	Soya bean	Groundnut	Pigeonpea	Tobacco	Others	
MRFC	1.1	9.0	2.2	31.4	1.1	44.9
SEDOM	1.1	1.1	0.0	0.0	0.0	2.2
Farmers World	0.0	4.5	1.1	3.3	0.0	8.9
APIP	0.0	4.5	4.5	4.5	0.0	13.5
DEMATT	0.0	1.1	0.0	1.1	0.0	2.2
ADMARC	0.0	0.0	0.0	1.1	0.0	1.1
NGOs	2.3	10.2	5.6	6.9	2.2	27.2
Total	4.5	30.4	13.4	48.3	3.3	100.0

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)

As displayed in Table 4.11, most of the farmers (58.4%) were borrowing agricultural loans for over three years regardless of the type of crops they were growing.

Table 4.11: Percent distribution of how long credit scheme was used

Years	Main crops grown after maize					Total
	Soya bean	Groundnut	Pigeonpea	Tobacco	Others	
Less than 1 year	1.2	5.7	1.2	6.9	0.0	15.0
1-3 years	0.0	4.0	2.9	16.3	3.4	26.6
3+ years	2.3	6.8	4.1	45.2	0.0	58.4
Total	3.5	16.5	8.2	68.4	3.4	100.0

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)

Note that this table reports only formal loans from financial institutions, not informal loans from friends, relatives and others

Again, almost 70% of farm loans were used from tobacco production as shown above that the formal credit institutions stipulated (or dictated) the farm loans must be used strictly for tobacco production. It is also observed that over 58% of the farmers had taken loans for over three years for their farm production.

The impact of farm credit on crop production is explored through econometric model in chapter 5. However, the preceding preliminary analysis had shown that most farmers had concentrated in tobacco production that the grain legumes as loans were not specifically available for these cash crops.

Groundnut Production in Lilongwe and Salima ADDs

Groundnut is one of the major crops that are widely grown in Lilongwe and Salima Agricultural Development Divisions in Central Malawi. Groundnut is usually monocropped, intercropped or grown in mixtures with maize, cassava, pigeonpea and other crops in the areas.

Table 4.12 displays distribution of main crops grown after maize by ADDs and EPAs.

Table 4.12: Percent distribution of main crops grown after maize by ADDs and EPAs

Area	Main crops grown after maize				
	Soya bean	**Groundnut**	**Pigeonpea**	**Tobacco**	**Other**
ADD					
Lilongwe	1.5	19.5	3.0	18.0	3.5
Salima	7.5	18.0	5.5	20.5	3.0
Over all, 75% of the farmers grew groundnut after maize in both ADDs					
EPA					
Mkokera	0.0	2.5	2.5	3.0	1.5
Machenchi	1.0	10.0	2.0	8.0	1.0
Cheska	0.5	4.0	0.5	6.0	1.5
Kaphateya	1.5	4.5	0.0	4.0	1.0
Chafumbewa	2.5	12.0	2.0	13.0	1.5
Chinguluwe	3.5	4.5	1.5	4.5	0.5
Machenchi EPA in Lilongwe ADD and Chafumbewa EPA in Salima ADD grew more groundnut than the rest of the EPAs in the 1999/2000 seasons					

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)

In both ADDs, over 75% of the total farmers interviewed indicated that they grew mainly tobacco and groundnut after maize as cash crops for the 1999/2000 seasons. Similarly, Machenchi EPA in Lilongwe ADD and Chafumbewa EPA in Salima ADD grew more groundnut (10% and 12%, respectively) than the rest of the EPAs in the 1999/2000 seasons. However, the overall result showed that in Lilongwe ADD there was a slightly higher groundnut production, 19.5%, than Salima ADD with 18%, but with no statistically significant difference between the two ADD at $p < 0.05$.

CONCLUDING SUMMARY

The socio-economic demographic characteristics in Lilongwe and Salima Agricultural Divisions had indicated that most farmers were growing tobacco and groundnut as main cash crops after maize in the 1999/2000 growing seasons. However, of the main grain legumes grown in the two ADDs, groundnut was preferred as a cash crop to soy, pigeonpea and others.

Of paramount importance, the socio-economic factors played major roles in the groundnut production in the two development areas. Farmers in the age group 20-49 years provided most of the farm labour, indicating higher supply potential in farming activities. Most farmers (63.5%) have primary education level, which is regarded as adequate level of education for an individual to read and write without difficulties in Malawi. With slightly higher rate, but with no statistically significant difference, female grew more groundnut than men in the region.

On an average land holding size of 2.35 hectares, the average farm size allocated to groundnut is about 0.47 hectares (i.e. about 20% of the average size) of which tobacco and maize took the rest. As expected, more land (88.5%) was acquired through inheritance, as matrilineal marriage system is predominantly practice in central Malawi region.

It was discovered that most farmers grew groundnut because of food and cash requirements, but also more farmers realized the importance of grain legumes as soil fertility improvements. It was also noted that most farmers grew groundnut and tobacco for over 10 years, and the majority had used the farm credits (cash or in-kind) for tobacco production.

Finally, it was observed that farmers in Lilongwe ADD grew more groundnuts than their counterpart (Salima ADD), but with no statistically significant difference between the two ADDs at $\rho < 0.05$.

CHAPTER V

GROUNDNUT PRODUCTION, EFFICIENCY AND PROFITABILITY

INTRODUCTION

This chapter is dedicated to discuss the results from loglinear production functions, deterministic technical efficiency model and gross margin analysis that were applied to groundnut survey data for the 1999/2000 seasons in Central Malawi. Input and output patterns along with model results thoroughly discussed hereafter.

PRODUCTION FUNCTION ANALYSIS

Production function analysis was performed to identify the determinants of groundnut production. The initial production function included land, labor and seed, as well as, other socio-economic factors including crops management practices as the expected factors that would affect groundnut productivity. The socio-economic factors considered were time of planting (month), cropping pattern, weeding levels, household age, education and extension services. Following discussion of C-D production equations (3-4) and (3-5), the following model was adequately fitted to the data:

$$Q_G = 1.89(land)^{0.41}(labour)^{0.23}(seed)^{0.68} \quad (5\text{-}1)$$

Table 5.1 presents coefficient estimates, standard errors, t-values, and significant test for the modified Cobb-Douglas production fitted to the data. Generally, the model was fitted adequately to the data since $R^2 = 0.691$ (or adjusted $R^2 = 0.673$), and the overall $F_{4,180,0.05} = 39.15 > F_{4,180,0.05} = 2.43$. All the coefficient estimates, land, labour and seed are statistically significant at 5% level thereby determining groundnut production in central Malawi. The non-physical factors including education of household, extension services and age of the farmer were found to be statistically insignificant, and thus did not necessarily determine the smallholder groundnut production in the areas.

Table 5.1: Coefficient estimates for groundnut production function

Variable	Coefficient Estimates	Standard Error	t-value	Significance
Constant	1.89	0.474	3.987	0.000
Land (ha)	0.41	0.092	4.46	0.000
Labour (person-days/ha)	0.23	0.074	3.108	0.006
Seed (kg/ha)	0.68	0.096	7.083	0.000
The dependent variable (Q_G) is defined as production of groundnut in kg per hectare				

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)

Furthermore, in the Cobb-Douglas model the sum of the coefficients gives information on returns to scale, which is the response of groundnut output to a proportionate change in inputs. Groundnut production has been found to be characterized by increasing returns to scale since 0.41 + 0.23 + 0.68 = 1.33 is greater than 1, indicating that there was a need to increase use of land, labour and seed in groundnut production.

Though the question of efficient use or optimal choice of inputs will be discussed later, the above results imply that increasing the use of these inputs (labour, land and seed density) in groundnut production by a certain percentage, then yield will increase by higher proportion than the percentage increase in the input factors. This means that increasing amounts of seed, labour and land has an advantage of increasing groundnut productivity in the surveyed area.

Referring to the first objective and hypotheses of the study as given in chapter 1, the results supported the postulated hypothesis as follows. Recall one of the objectives and hypotheses of the study:

> **Specific objective 1:** To identify differences in access to labour, land and other resources to groundnut production by gender, household type, community and farm organizations and market exchanges with implications for technology adoption and productivity in groundnut output.

And,

> **Hypothesis 1:** Socio-economic variables (non-physical factors) do not determine the dynamics of groundnut production, inter-household and intra-household transactions.

Land Allocation

Land is one of the important fixed inputs in agricultural production, and scarce commodity in Malawi. The average farm size allocated to all crops

was 1.63 hectare, but the mean farm size allocated to groundnut production was 0.41 hectare with no statistically significant difference in the two Agricultural Development Divisions in study.

Among smallholder farmers, though, on the average farmers have allocated over 20% of their total farm size to groundnut production, it is true that more land is usually allocated to maize as it is the main crop (staple food) in Malawi. Grain legumes such as groundnut, pigeonpea and soyabean generally are considered as subsidiary crops so that there are given marginal role in farmers' livelihood that limit their productivity (Ngulube, 2000).

In addition, land allocation to crops such as groundnut depends on the land holding sizes whereby farmers with large land holding sizes are expected to allocate relatively more land sizes to various subsidiary crops than those with small holding sizes. Despite such constraints to groundnut production, still 75% of the smallholder farmers allocated 20% of their small farms to groundnut production in the study areas.

The model shows that land is one of the determinant factors of groundnut production since it is statistically significant at 5% level. The elasticity for land was found to be less than one ($\beta_1 = 0.41$) but greater than zero. This implies an elastic response to groundnut production, thus a unit increase in land would result into proportionate increase in groundnut production. This means that output would be higher compared to the input use in groundnut production. Perhaps since the smallholder farmers generally have small pieces of land, which was on average only 0.41 hectare allocated to groundnut production, the elastic response might suggest if farmers had allocated more land (beyond the 20% groundnut share now) a large groundnut production could be obtained.

However, the allocation of more land to the groundnut production depends on a number of factors including profitability and subsistence production of staple food on the fixed amount of land (as land is a scarce commodity in Malawi) the smallholder farmers have in the area.

Labour Allocation

The average household size has a bearing on availability of labour especially considering that most smallholder farmers depend on family labour. The more the number of people in the household the more the family labour supply is, all other things being held constant. Family labour supply could have a bearing on the types of crops grown; the amount of land cultivated and hence yields of preferred crop.

The average family size was five persons in the area, which is about the same as the national average of 6 persons (GoM, 1998). However, on

average 3 persons from a household participated in farming activities, and 64.1% of the family members were involved in producing groundnut as a cash crop after maize. There is a significant association between the members of a family as labour sources, and the main crops grown after maize at $\rho < 0.05$.

Labour is also found to be one of the determinants of groundnut production in the study area with statistically significant coefficient estimate, $\beta_2 = 0.23$ at 5% level. It is elastic to groundnut production since 0.23 is greater than zero, but less than one. This means that for a unit increase in labour (persons-days per hectare), there will be more than a proportionate increase in groundnut production.

Table 5.2 reports that the 203.5 person-days per hectare, on average, slightly exceed the 200 person-days per hectare at national level (GoM, 1998). This is because of the readily available family labour due to the large number of household members in the region. With this estimation, however, it is could be possible the yield response to labour to be greater than the incremental labour input.

Table 5.2: Labour requirements in the production of main crops after maize (person-days/ha)

Crop Type	Preparation	Planting	Weeding	Harvesting	Average (person-days per ha)
Soyabean	184	101	116	150	137.75
Groundnut	251	94	256	213	203.50
Pigeonpea	150	85	234	120	147.25
Tobacco	340	210	360	1190	525.00
All crops Average	231.25	122.50	241.50	418.25	253.38

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)

Furthermore, comparing the Cobb-Douglas model parameter estimation and other results given in Table 5.2, the labour data estimation could be higher than what actually supplied in the villages since this study had concentrated only on adult labour equivalents.

Since labour requirements differ according to the types of crops grown on the farm, it is sometimes difficult to separate the exact amount labour used for each crops, especially if the farmers use intercropping or mixture cropping patterns. However, it was possible to estimate the labour requirements according to field operations that were categorized into four critical operations, namely, land preparation, planting, weeding and harvesting as shown in Table 5.2.

In Malawi, smallholder farmers use hoe, sticks, ploughs, shovels, ox-cart and other unmechanized hand tools for digging their farm, and it was not surprising to find out that very high labour (persons-day/hectare) input across all types of crops in the farming seasons. About 97% of the farmers in all the EPAs surveyed mainly used hoes, which indirectly indicated that farmers spent a lot of time in their fields to prepare and plant the crops.

As seen in Table 5.2, tobacco is the most labour intensive crop in terms of land preparation for cultivation, planting, weeding and harvesting. Overall, groundnut production is also more labour intensive than soyabean and pigeonpea.

It is also important to note that almost all household members and hired labour simultaneously carried out field operations, and therefore question of substitution between types of labour is irrelevant. Furthermore, The equivalent person-days per hectare are derived from the assumption that the average month has 25 working days and 4 farming month, allowing for rest days, sicknesses and traditional duties. For comparisons to be made between different types of labour, it is necessary to express days and hours in terms of common denominator like person-days, person-hours or person-hectare.

To assign adult equivalents to different sex and age groups, two assumptions were made. First, the physical labour productivity shows initially a positive correlation and then a negative one with age, and secondly, the physical productivity of women is less than that of men. The conversion scale was adopted from Johnson (1990)[14] as given in appendix 3, Table A3. However, the conversion coefficient has severe limitations. The performance differential between the men and women narrows as the job becomes lighter, suggesting that physical strength strongly influences performance, that is, working rates of men, women and children vary from one task to another. When a woman works at half the speed of a man on one job and twice as fast on another, fixing her equivalent value based on the first observation will grossly underestimate family labour capacity.

Assumption of constant performance differential among men, women and children that was implied by using a single coefficient over the whole season, is unrealistic as relative performance varies according to energy requirements (Johnson, 1990). As seen previously, however, this methodology was used in this study to facilitate the comparison with cautiously interpreting the results.

[14] Adopted from D. T. Johnson (1990), The Business of Farming: A Guide to Farm Business Management in the Tropics.

Seed Density

Another determinant of groundnut productivity is the density of seed used on the pieces of land. As seen in Table 5.1, the coefficient estimated for seed is 0.68 and statistically significant at ρ-value < 0.05.

Elasticity for seed density is greater than both land and labour, which implies that the yield response is greater for seed rate than land and labour. A high groundnut yield could be obtained through an increased seed density of groundnut for the given farm, provided other things being constant (recommended spacing and seed density were followed).

Seed density determines the yield provided other factors *ceteris paribus*. On average, the smallholder farmers used 21.33 kg of groundnut and 58.94 kg of seed per hectare, which was lower than the recommended seed rate of 90 - 110 kg per hectare (Chiyambekeza *et al.*, 1998) in both Lilongwe and Salima ADDs.

Farmers hardly bought groundnut seed as a purchase input whereby most of the farmers either obtained seed from their relatives, fellow producers or recycled from previous growing seasons. Most of the farmers had no access to improved varieties; information might not have reached the farmers in the area, or less purchasing power that had resulted in lower seed rate usage. However, the model estimation suggested that increasing seed density is one of the feasible solutions of low productivity in the study area.

Table 5.3 summarizes seed availability, affordability and sources of groundnut seeds in the 1999/2000 growing seasons in all the EPAs surveyed.

Table 5.3: Percent distribution of groundnut seed availability, affordability and sources in all EPAs

Seed Availability	Percent	Seed Affordability	Percent	Where seed was bought	Percent
Available	73.5	Affordable	27.9	ADMARC	52.6
Scarce	26.5	Expensive	67.8	Fellow Producers	26.3
		Cheap	4.4	NGOs	21.1
Seed for groundnut, pigeon pea and soyabean were valued at MK10/kg					

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)

About 74% of the respondents said that groundnut seeds were available, but at the same time about 68% of them responded that the groundnut seeds were expensive. These results might indicate that even though farmers knew where to buy the seeds (52.6% ADMARC and 26.3% from fellow producers) they found them expensive. In addition, this perhaps

implies the low density of sowing groundnut per station or ridges on the farm, which led to lower productivity.

The results indicated also that ADMARC, a government subsidiary company that buys farm surpluses and sells crops, still plays major role in farming activities in the country. Only 21.1% of the respondents bought seeds or obtained from non-governmental organizations because of either unavailability or unaffordability of seeds from such organizations in the country.

Besides such discouraging scenarios, farmers also faced other groundnut production problems. These included lack of seed, lack of markets, low producer prices, severe pest and disease incidences, as well as, poor roads that lead to infrequency marketing accessibility.

Table 5.4 lists the difficulties farmers faced when producing groundnut in 1999/2000 seasons.

Table 5.4: Percent distribution of difficulties farmers face in all EPAs

Problems	Percent
Lack of seed	9.8
Lack of markets	5.4
Low producer prices	25.0
Severe pest and disease incidences	57.6
Others	2.2

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)

About 83% of the farmers said that other major problems associated with groundnut production were severe pest and disease incidences, as well as, low producer prices. Again, these discouraging facts support the low groundnut productivity, even though over 75% of farmers preferred to grow groundnut after maize in all the EPAs.

Therefore, it is possible to conclude that the compounded problems, unaffordability of seeds, severe pest and disease incidences, low producers prices (MK11-15 per kg), as well as lack of other farm resources had resulted in low groundnut productivity per hectare that did not reach the expected national yield (1500kg/ha (GoM, 1998)) per hectare in the study area. As such, Malawi government and non-governmental organizations should be at the forefront of improving groundnut productivity at smallholder farmers level in the country through improved services.

Farm Credit

No special farm credit packages designed to promote groundnut production in the areas. As evidenced in Table 4.7 and 4.8, there were credit packages by Malawi Rural Finance Company (MRFC), but were for tobacco farmers only. Besides the main physical factors considered in estimating groundnut production, the negligible farm credits available for groundnut farmers were also significantly affecting groundnut production. Though statistically insignificant, the parameter estimate for credit in the C-D model indicated that credit was inelastic to groundnut production since -0.021 is less than zero. This means that for a unit increase in farm credit, there would be less than a proportionate increase in groundnut production. The more the farmer took farm credits the lower the reported production of groundnut since most farmers allocated the credits to tobacco production. Credit could be in cash or in-kind from the lending institutions, and therefore some of the production might go back to the institutions or to the informal lenders such as fellow producers, relatives or friends.

On the other hand, since most of credit institutions required collateral in order to lend, such conditions might have led to lower groundnut production in the areas. Generally, it could be said that government and the private sectors had provided no incentive for groundnut farmers to increase groundnut production in the areas. The market liberalization has been an incentive to all crops in general, and farmers have preferred to grow tobacco. Most farmers opt for tobacco, as it is the best crop in terms of brining money to the households. This is the main reason that over 90% of farmers had given only a smaller proportion (20%) of the total household land size to groundnut production.

CROP MANAGEMENT PRACTICES

In Malawi, proper crop management practices such as early planting, seed density, good plant spacing, early weeding, disease control (Maliro *et al.*, 1994) and extension services (information and advice from MoAI) are regarded as management practices that can affect groundnut production in the country.

Among all management practices listed (weeding time, seed per planting station and extension services), only cropping pattern (mono-cropping or intercropping) was found to be one of the determinants of groundnut production in the two ADDs surveyed.

Density and Spacing[15]

Poor farming crop management practices are also some of the problems associated with low groundnut productivity in the country. Ministry of Agriculture and Irrigation and Groundnut Research Institutes recommend early planting or planting at first rains, 90 kg per hectare for a ridge-spacing of 90 cm, and 110 kg per hectare for a ridging-space of 75 cm., as well as, 15 cm between planting station (MoAI, 1997, Simtowe, 2000).

As have been mentioned earlier, this study found that the average seed density was only 58.94 kg per hectare far below the 90 kg/ha recommended density. With respect to ridge-spacing, over 95% of the farmers used less than the recommended ridge-spacing of 75 cm. About 44% used less than 30 cm between planting station, 55.8% between 15-20 cm and 1% over 30 cm in the area. This implies farmers who used less ridge spacing might have over-crowded groundnut planting or planting too many crops (sweet potato, maize, etc.) on the same piece of land creating congested seed capacity that compete for nutrients beyond its capacity and leading to low groundnut productivity. On the other hand, about one-third of the farmers used the recommended planting space of 15 cm between planting stations.

Planting Time

Groundnut planting is usually done within the first few rains. Planting around this time allows the crop to develop sufficient vegetative growth before flowering, and depending of the varieties, it is expected to mature with 3 to 4 months indicating when the rain is about to stop. Over 90% of the farmers planted groundnut along with maize in November which implies that most farmers were aware of the planting time provided that they got their seed on time or recycled the seed from previous years.

However, 77.4% of the farmers preferred monocropping while this figure is 22.6% for intercropping groundnut. The intercropping was done with maize, sweet potato, pigeonpea and other cereal crops.

Except for the density of planting, most farmers had planted their groundnut at the correct time that might ensured them higher yields provided that other constraints had been minimized. In fact, most households have small land holdings and grain legumes including groundnut were usually

[15] Number of seed per planting station, where 1 equals for planting 1-2 seeds per planting station, which is often the case per planting station, 0 otherwise in the model.

intercropped earlier as land preparation was faster and able to plant with the first few rains.

Weeding[16] and Disease Control

No one disputes that crop plants in poorly weeded fields had to compete with weeds for sunlight, moisture, and nutrients. Another problem was the time of weeding and it is essential to weed at the initial stage of crop establishment. When groundnut is hand-weeded, the plants are ridged, which means that the first internodes (where the first flowers and branches are formed) are buried. Thus, weeding at the wrong time, especially at the flowering stage, can cause yield loss of up to 20% (Ndunguru *et al.*, 1994). The same authors reported that under weeding could conceivably be the poor nutritional levels prevailing in many small farming communities.

In addition, Chiyembekeza and Sibale (1986) reported that yield losses of up to 40% could be incurred with chalimbana if weeding is done later than 35 days after crop emergence. Weed competition is very intense 30-50 days after emergences and can affect both yield and quality.

Overall, 8% of the farmers weeded their small groundnut farms once, 91% of the farmers weeded their fields twice and 1% thrice. It is clear that most of the farmers in the study villages had kept their weed free farms that might ensure good yields for the season.

On the issue of pests and diseases control, high incidence of disease and pests can cause substantial yield losses (Subrahmanyam *et al.*, 1997) Though the study did not examined the type of pests and diseases[17] in groundnut fields, over 85% of the farmers did not report any disease associated with their groundnut farms, and almost all the farmers had used no pesticides because of unaffordability.

Finally, the coefficient estimates for weeding time and frequency were found to be negatively associated with groundnut yield, but with no statistically significance in determining groundnut yield in the smallholder farms.

Extension Services

Malawi's economy is dependent on agriculture. For extension purposes, the country is divided into eight ADDs, which form the focus of

[16] dummy variable for weeding, where 1= early weeding, 0 otherwise

[17] The pests and diseases in the groundnut fields are usually early leaf spot, late leaf spot, rosette, aphids, leaf eaters, termites and Hilda (Subrahmanyam, 2001, pp 103-116).

major agricultural activities. Within these activities, the crop management practices include the role of field workers who provide extension services to the smallholder farmers. The presence or absence of extension workers in the study area who could instruct farmers about the recommended crop management practices in groundnut production and farming activities would partially determine the crop productivity, in general.

Of paramount importance, extension services usually play a major role in transmitting new and improved farming techniques from the research institutes. Extension contacts are also needed for communication of farmer experience and problems to researchers for refinement of existing technologies or for research to solve existing problems.

It is impressive to note that 88.5% of the farmers had some kind of contact with the field workers. About 60% of the farmers had said that they made contacts 1 to 2 times per year, while 31% said 3 to 4 times and 11.5% of the farmers made more than 5 contacts with the extension workers in the area.

On average, the farmers had made enough contacts for the 1999/2000 seasons, but the extension services did not make tremendous effects on groundnut production, perhaps due to compounded constraints including lack of information on groundnut production specifically.

Output Patterns

In the surveyed area, the overall mean groundnut yield was 500.2 kg per hectare, which is lower than the expected national yield of 1500 kg per hectare (GoM, 1998). The use of inorganic fertilizers or organic fertilizers were not reported as inorganic fertilizers were found to be very expensive (and not used in the groundnut plots) to the smallholder farmers, and the use of organic fertilizer or manure is traditionally avoided as farmers believed that it causes further pest problems. Hence, compounded with other problems (socio-economic factors) discussed above, this had resulted in lower groundnut production rate per hectare, about a third of the production in an ideal environment (1500 kg/ha).

In conclusion, as stated in the specific objective it was found that only the physical factors land, labour and seed density (with the exception of non-physical factor of cropping patterns) determined the production of groundnut. While the non-physical factors such as education of the household head, age of the farmer, gender, extension services and others had been associated to some extent, but with no statistical significant effect on groundnut production.

However, land, labour and cropping pattern inputs implied diminishing returns, as the elasticities are between zero and one exclusive. On the other hand, groundnut production exhibited increasing returns to seed density input

level. From this study, it is concluded that only physical factors such as land, labour and seed density (proxy to capital) determine groundnut production and thus accept the hypothesis that socio-economic variables (non-physical factors) do not necessarily determine the dynamics of groundnut production in smallholder farms in central Malawi.

TECHNICAL EFFICIENCY ANALYSIS

As defined in Battese (1992), technical efficiency of farm is defined to be the factor by which the level of production for the farm is less than its frontier output. Given the estimated deterministic Cobb-Douglas function (chapter 5, equation 5-1) and technical efficiency model (chapter 3, equations 3-6 and 3-7), the study had identified technical efficiency indices of 200 household farms in Lilongwe and Salima ADDs in central Malawi.

Russel and Young (1983) estimated a deterministic Cobb-Douglas frontier using corrected ordinary least-squares regression with a cross-sectional of 56 farms in the North-West region of England during 1977-78. Kontos and Young (1983) conducted similar frontier analysis to those of Russel and Young (1983) for a data set for 83 Greek farms for the 1980-81 harvest year.

Kontos and Young (1983) applied a Box-Cox transformation to the variables of the model and obtained similar elasticities to those obtained by estimating the Cobb-Douglas production function by ordinary least-squares regression. Since the likelihood ratio test indicated that the Box-Cox model was not significantly different from the traditional Cobb-Douglas model, the deterministic frontier model was estimated by corrected ordinary least-squares regression. The estimated frontier model was used to obtain the values of technical efficiency for individual farms involved.

Similarly, considering a deterministic Cobb-Douglas frontier production function (equations 3-5 and 3-7), this study had investigated the effectiveness of Malawian groundnut farmers in central Malawi.

Table 5.5 presents technical efficiency index for smallholder farmers in Lilongwe and Salima Agricultural Development Divisions for 1999/2000 growing seasons. As shown in Table 5.5, the technical efficiency indices ranged from a minimum of 0.31 to a maximum of 0.68, with an average of 0.496. As indicated in chapter 3, the value 1 for the household farm on the production frontier means achieving maximum output, and therefore efficient. It is less than one for inefficient farmers, producing below the frontier at given level of inputs.

Table 5.5: Technical efficiency index for smallholder farms Lilongwe and Salima ADDs for 1999/2000 seasons

Efficiency Index	Number of farmers	Percent
< 0.30	0	0.00
0.31 – 0.40	2	1.00
0.41 – 0.50	148	74.00
0.51 – 0.60	35	17.50
0.61 – 1.00	15	7.50
Total	200	100.0

Minimum	Maximum	Range	Mean (standard deviation)
0.31	0.68	0.36	0.496 (0.0054)

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)

Even about 75% of the farmers were falling below the average technical efficient index of 0.496, indicating that considerable technical inefficiencies existed in the Malawi farms surveyed.

Determinant of Technical Efficiency

After measuring the level of technical efficiency index, it was necessary to identify which non-physical factors determine the level of technical efficiencies or inefficiencies in groundnut production in Malawi.

The research explored both physical (land, labour, seed) input factors and non-physical factors of production such as education, age of farmers, availability of farm credit, household head, off-farm employment and extension services, which might be responsible for the existence of technical inefficiencies in small farms engaged in groundnut production. In order to reach to objective 2 (Chapter 1) stated as:

> *To find out major determinants of technical efficiency in groundnut production, and construct groundnut enterprise budgets and compare profitability of groundnuts with maize and tobacco, as well as, rank them in terms of profitability.*

Firstly, the following linear regression model was proposed to identify determinants of technical efficiency in groundnut production.

$$TE = f(Ld, Lb, Sd, Ed, Ag, Cr, Hh, Fz, Ofe, Ex, Ta) + \varepsilon \quad (5\text{-}2)$$

Where:

TE is technical efficiency index
Ld is land allocated to groundnut production in hectares
Lb is adult equivalent labour used in persons-day/ha
Sd is amount of seed rate per hectare in kg/ha
Ed is education level of a farmer (number of years attended)
Ag is age of the household head in years
Cr is agricultural credit received in Malawi Kwacha
Hh is sex of the household (male = 1, female = 0)
Fz is family size in hectares
Ofe is off-farm employment in Malawi Kwacha
Ex is contact with extension workers (number of visits)
Ta is technology adoption (adopted = 1, not adopted = 0)
ε is the error term

Table 5.6 displays parameter estimates obtained through ordinary least-squares (OLS) methods.

Table 5.6: OLS parameter estimates for technical efficiency model

Variable	Coefficient* Estimate	Standard Error	t-value	Significance
Constant	0.3460	0.027	12.683	0.000
Seed density	0.0341	0.007	5.023	0.000
Land	0.0268	0.004	6.262	0.000
Credit	0.0256	0.005	5.062	0.000
Technology	0.0090	0.002	4.775	0.000
The dependent variable was technical efficiency (TE)				
$R^2 = 0.636$ and $F_{4, 200, 0.05} = 24.75 > F_{4, 200, 0.05} = 2.42$				

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)
* Non-significant coefficient estimates were deleted as the model was fitted through stepwise model selection procedures.

Of the physical factors used in the model, it was only land and seed density (proxy to capital) were found statistically significant in determining technical efficiency in smallholder farms. Similarly, it was also found that access to farm credit (whether a farmer received agricultural credit) and adoption of technology (improved variety) was the only two non-physical factors that determined efficiency of groundnut production in the region.

Non-physical factors including education level of a farmer, age of the household head, sex of the household, family size, off-farm employment and number of contacts with extension workers were found to be non-determining factors of technical efficiency in smallholder farms in the area. Most of the non-physical factors had shown positive association with technical efficiency of groundnut production, but with no statistical significance.

All the physical and non-physical factors of production listed in Table 5.6 indicate positive relationship with technical efficiency. Unit increases of these factors increase technical efficiency, but with different magnitudes. For example, the maximum increase of technical efficiency varies with seed density, while the minimum increase varies with adoption of technology. An increase of 1 kg per hectare seed will increase the technical efficiency by 3.4 percent on average, while a change in adopting technology (seed variety or adopting recommended technology such as intercropping, ridging, rotation or mixture) will result in about 1% increase in technical efficiency.

These findings support the determinants of groundnut production obtained when estimating Cobb-Douglas production function previously. The low seed rate 59.8 kg per hectare (as compared to the recommended 90 – 110 kg per hectare) and the small farm size (average of 0.41) indicated the low groundnut yield. Likewise, the considerable technical inefficiencies in over 75% of the farms were partially associated with shortage of seed, planting patterns and scarcity of land in the areas, as land is generally scarce in Malawi.

In addition, the non-physical indicators suggest that low rate of adoption of technology because of low contacts with field workers on such developments, and with virtually non-accessibility to farm credits for resource poor farmers (with no collateral) led to very low technical efficiency value of 0.496 in Malawi smallholder farms.

Profitability of Groundnut Production

In order to reach objective number 2 as stated in chapter 1 and hypothesis number 2 postulated as:

> '**Hypothesis 2:** Groundnuts are not profitable compared to competing cash crops (soyabean, pigeonpea, tobacco) grown after maize in the country'

The study had examined profitability of groundnut with other competing cash crops such as soyabean, pigeonpea and beans as an alternative

in replacing tobacco as foreign currency earner. The relative profitability or net benefit from these crops, other things held constant, would determine the amount of resources allocated to each. The relative profitability of the different crops and their yields were important determinants of the crop grown and cropping patterns. As such, gross margin analysis was performed to find out groundnut profitability in the in central Malawi.

Gross margins are a useful step in deciding on the best combination of activities on a farm. Abbot and Makeham (1990) and Ngulube (2000) had used farm activity with the highest gross margin per unit of the most common limiting resource, which was labour. In this study, the main determinants of factors of main crops production were found to be labour, seed density and land. Thus, The analysis involved gross margins to land (MK/ha), labour (MK/person-days) and seed (MK/kg of seed) for these crops.

Table 5.7: Variable cost calculation per hectare of groundnut production

Variable Input	Quantity (Kg)	Unit Cost (MK)	Total Cost (MK)
Own seed	13.1	25	325.00
Purchased seed	10.0	25	250.00
Hired labour* (person-day/ha)	4.11	7.50	30.83
Family labour (person-day/ha)	193.38	7.50	1450.35
Fertilizer	0	0	0
Pesticide	0	0	0
Total Variable Costs (TVC)			**2056.18**
Output	**Quantity**	**Unit selling price (MK)****	**Gross Income**
Yield (Kg/ha)	500.19	15.00	**7502.85**
Gross Margin			**5446.67**
Input-output ratio (gross income divided by input costs)			**3.65**

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)

* Labour was valued at MK7.50/working day (Ministry of Labour and Vocational Training, 1999)

**Output prices for groundnut, pigeon pea and tobacco were obtained from ADMARC for 1999/2000 growing seasons.

This is a measure of the average economic return to factors of production. The gross margins are defined as the difference between the Gross income (GI) and total variable cost (TVC) involved in the groundnut production process as described in chapter 3, equation (3-8). Gross income is the product of the output from the production process and the price of that output.

Tables 5.7, 5.8 and 5.9 present the complete relative profitability analyses for all competing crops under investigation. Table 5.7 presents enterprise budgets for groundnut, which indicating variable costs incurred due to input quantities for one hectare of land. Only two factors of production, labour and seed, vary considerably as land is inherited, not rented, whereby there is no formal land market for purchase and sale of land in Malawi.

As reported in Table 5.7, with on surprise, no fertilizer was used in the groundnut plots, as farmers were aware that groundnut contributes to soil fertility through nitrogen fixation. However, the fertilizer issue is a critical one in Malawi since farmers apply to their farms, and fertilizer prices are beyond the purchasing power of smallholder farmers (Carr, 2001). Hence, focus has to be made on alternative means of enhancing soil fertility through organic matters such as agroforestry legume plants.

Similarly, Table 5.8 summarizes the budge enterprises for groundnut, soyabean, pigeonpea and tobacco in Central Malawi region for 1999/2000 growing seasons.

Table 5.8: Input quantities and variable costs per hectare for each main crop grown after maize for 1999/2000 seasons

Indicator	Main crops grown after maize			
	Groundnut	**Pigeonpea**	**Soyabean**	**Tobacco**
Inputs				
Own seed (kg)	13.0	8.0	5.0	1.03
Purchased Seed (kg)	10.0	3.0	4.0	0.04
Hired labour (persons-days/ha)				
Family labour (person-days/ha)	4.11	4.01	6.00	70.00
Fertilizer (kg)				
	197.38	140	131.75	455.00
	0.0	0.0	0.0	400.00
Unit cost*				
Own seed (MK)	25.00	15.00	15.00	9.00
Purchased Seed (MK)	25.00	15.00	15.00	9.00
Hired labour (MK)	7.50	7.50	7.50	7.50
Family labour (MK)	7.50	7.50	7.50	7.50
Fertilizer (MK)	0.00	0.0	0.0	20.00
Total Variable Cost (TVC)	**2056.18**	**1245.00**	**1168.13**	**8347.13**

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)

* Seed for groundnut, pigeon pea and soyabean were valued at MK25, MK15 and MK15, respectively. These were the selling prices for Agricultural Development and Marketing (ADMARC) in Malawi.

Table 5.9 displays the gross margins, average physical productivity, net returns to inputs of groundnut production.

Table 5.9: Gross margin, average and net financial return values

Indicator	Groundnut	Pigeon pea	Soyabean	Tobacco
Average yield (kg/ha)	500.19	265	115	716
Selling price (MK)	15.00	9.00	15.00	42.80
Gross income (MK/ha)	7502.85	2385.00	1725.00	30644.80
Total Variable Cost (TVC)	2056.18	1245.00	1168.13	8347.13
Gross Margin (MK/ha)	5446.67	1140.00	556.87	22297.67
Input-output (Cost-Benefit) ratio	3.65	1.92	1.48	3.67
Average Product and Net Return Indicators	**Main crops grown after maize**			
	Groundnut	**Pigeon pea**	**Soyabean**	**Tobacco**
Average Physical Product (APP)				
APP of person-day of labour	197.38	144.01	137.75	525.00
APP of a kilogram of seed	23.00	11.00	9.00	1.07
Net Financial Returns				
Net return per person labour day	27.60	7.92	4.04	42.47
Net return per kilogram seed	236.85	103.63	61.87	21648.22

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)

Table 5.9 displays the gross margins and the economic returns to factors of production for main crops grown after maize, namely, groundnuts, pigeon pea, soyabean and tobacco. Tobacco showed the highest gross margin (MK22297.67) for 1999/2000 seasons seconded by groundnut (MK5446.67), followed by pigeonpea (MK1140.00) and soyabean with the lowest gross margin (MK556.87), though unexpected low. These results agree with other studies conducted in Africa, for example, Cromwell and Zambezi (1993) concluded that seed prices were not the only factor, but their relationship to other agricultural producer and input prices that had the most significant impact on the use of improved seed or alternative crop.

In terms of costs of production, soyabean had the lowest production cost (MK1168.63), while tobacco has the highest (MK8347.13). Based on gross margin results tobacco is still more profitable than the crops, however, of the grain legumes and other crops groundnut is more profitable at the 1999/2000 input and output prices in Malawi. Bear in mind that in tobacco production the leaves were sold, rather than the seeds of tobacco, which results in very high yield for marketing. Comparing to tobacco, the low yield of all the other crops could still be attributed to the seed yield, rather than leaves yield, coupled with the fact that farmers used local varieties that had naturally low yielding potentials.

Even though, variable cost for groundnut was almost double that of pigeon pea and soyabean, the yield per hectare is almost twice that of pigeon peas, and over four times that of soyabean. Of all the grain legumes, the prices for groundnuts were higher compared to pigeon pea and soyabean. In terms of economic returns to labour, groundnut gave the highest return to person-days (MK27.60), seconded by pigeon pea (MK7.92) and soyabean the lowest (M4.04) whereby the minimum labour price for 1999/2000 seasons was MK7.50 per person-days of labour.

Net financial return analysis indicated that all the crops showed higher net economic returns per kilogram seed. Groundnut gave the highest net return per kilogram seed (MK236.85) than both pigeon peas (MK103.63) and soyabean (MK61.87). Furthermore, tobacco had the highest benefit-cost ratio (3.67), which is almost the same as groundnut (3.65), comparing to pigeonpea (1.92) and soyabean (1.48) on full cost basis (including priced family labour).

From the above analysis, the results indicated that groundnut is more profitable compared to pigeon pea and soyabean at the current input and output prices, as well as, productivity levels of grain legumes. Groundnut gave the highest gross margin per hectare, the highest returns to factors of production than the two crops mainly grown after maize. Given these results, the hypothesis that groundnuts are not profitable, compared to competing cash crops (soyabean, pigeonpea, beans) grown after maize in the country, is rejected. Therefore, it is possible to say that comparing to other cash crops, groundnut might be an alternative to replacing tobacco given the full potential and opportunities for smallholder farmers in the area.

Market prices and Adoption of Alternative cash Crops

The common market for groundnut, pigeon pea and soyabean and other crops is the Agricultural Development and Marketing Company (ADMARC), which is a government subsidiary company that buys and sells agricultural produces in Malawi. This organization acts as both monopoly and monopsony in agricultural activities by dictating both buying and selling prices of agricultural produces in Malawi for over 30 years now.

Over 80% of the smallholder farmers acknowledged the absence of a competitive market for alternative cash crops to tobacco. Some private traders provide an alternative market to ADMARC for groundnuts, pigeon pea and soyabean, but the prices (very similar to ADMARC) offered are not encouraging for farmers to produce more of crops and diversify away from tobacco. The prices for groundnuts and soyabean were in the range of MK11-15 per kilogram, while the price for pigeonpea ranged between MK7.00 – 10.00 per kilogram for the 1999/2000 seasons in Malawi (ADMARC, 1999).

Comparably, tobacco was mainly sold to intermediate traders and at the Auction floors in the major trading market centers to international traders in the range of MK15 – 30 per kilogram in 1999/2000 seasons.

Thus, the monopolized low prices for groundnuts, pigeon pea and soyabean attributed to lack of competition among the buyers in rural markets that was not the case with tobacco. As such, output prices had adverse effects in the production of these alternative cash crops in Malawi.

Adoption Rates of Alternative Crops

In addition to the determinants of groundnut production obtained through Cobb-Douglas production function analysis, farmers were asked which crop they grow instead of tobacco given an increased trend in prices.

Table 5.10 presents adoption rate of alternative cash crops to tobacco when rural market prices increase in their areas.

As reported in Table 5.10, most farmers were willing to increase adoption of alternative cash crops to tobacco provided other things remain the same. However, increasing in rural market prices alone is a necessary condition but not sufficient condition to increase adoption rate.

Table 5.10: Percentage distribution of smallholder farmers adopting rural market prices of alternative cash crops to tobacco

Price (MK/kg)	Groundnut	Pigeon pea	Soyabean	Others*
<9	4.0	6.0	5.0	6.0
10 –15	30.2	39.0	56.4	40.0
16 – 20	32.0	40.0	68.0	89.0
21 – 25	44.3	60.0	80.0	94.0
26 – 30	73.4	80.0	90.0	98
31 – 35	87.4	99.3	98.3	-
36 – 40	94.3		-	-
41 +	98		-	-
Auction selling	90.2	80.1	84.2	-

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)
* mainly includes beans and sweet potatoes

The proceeding Cobb-Douglas production function analysis had shown that the main determinants to groundnut production were land, labour and seed density coupled with market prices as discussed above.

CONSTRAINTS TO ADOPTION OF ALTERNATIVE CASH CROPS

As discussed earlier, the potentials and opportunities of groundnuts and other cash crops in replacing tobacco exist, but with some constraints to adoption as alternative crops to tobacco in Malawi. This section focuses on major constraints that farmers faced to adopt alternative cash crops to tobacco in the 1999/2000 growing seasons. Some of the major obstacles include government policy, marketing and institutional constraints in Malawi.

Government Policy

The government of Malawi through the Ministry of Agriculture and Irrigation had opened up the market for private sector entry to buy farm produce from farmers and export without government control. The Ministry of Agriculture and Irrigation was also empowering farmers to produce high quality products and had negotiation skills through joint operations with organizations such as National Smallholder Farmers Association of Malawi (NASFAM).

Despite promoting the private sector to take a leading role in the market, they are still less competitive than imagined. This has made prices of alternative cash crops to tobacco less attractive than those of tobacco have. On the other hand, export markets are still not adequately explored for alternative crops thereby impinging on the competitiveness of buyers. Above all, government policies are still weak especially in implementing and addressing traditional production methodologies with those of scientific research institutions. The results had been production of poor quality products that are less attractive and competitive at international markets.

Furthermore, there had been general lack of policy incentives for financial support to private investors, and this had affected technical development and information generation, as well as adequately disseminating the information about alternative crops to both farmers and private sectors.

Access to Markets

Several surveys conducted over the years (Chiyembekeza *et al*., 1994; Luhana *et al*., 1994; Due and Gladwin, 1991; Nyirenda *et al*., 1994) had identified low official producer prices, lack of seed, pests and diseases, lack of machinery and drought or unreliable rainfall as the main reasons for the decline in groundnut production. Some have concluded that groundnut has

become a smallholder food crop and male farmers have therefore abandoned it for more profitable cash crops; leaving only women to grow and manage the crop (Luhana *et al*., 1994).

In this study, over 75% of the farmers had indicated that there were generally lack of supporting infrastructures to markets from the farming communities. Lack of roads, transport and financial support were the major constraints to access the markets. In addition, most farmers reported lack of access to farm credits, and the few who had access to credit cited very high interest rate (as high as 54% per annum) and collateral (resources poor farmers whereby the majority have no collateral) as major drawbacks to adopt alternative crops. Others had indicated non-membership to credit clubs as a cause to fail to secure agricultural loans.

Benson (1996) argues that a "green revolution" package is not profitable for the majority of Malawian farmers at the current prices of fertilizers and seed maize in Malawi. The same applies to groundnuts as a major grain legume since its production has declined considerably in recent years due to biological and economic factors.

Market Promotion Institutions

In Malawi, various institutions were put in place to promote investments and marketing of various enterprises. Malawi Investment Promotion Agency (MIPA) is on of the major institutions. According to MIPA, their main role is to identify markets and link farmers to industry. Domestically, there is high demand for grain legumes, for example, soybean and groundnut. Lever Brothers Company and National Seed Company of Malawi are the major industries in need of soyabean and groundnut for oil and other by-products (MIPA, 1999).

Nonetheless, adoption of alternative cash crops to tobacco had been affected due to financial problems to empower the existing and new entrepreneurs. The financial markets charge high interest rates (up to 55%) on loan and demand complicated collateral. The institutions also fail to fully promote the crops due to poor infrastructure such as road networks, electricity and others, which make Malawi less attractive to international investors. These findings were similar to that of Johansen *et al*. (2000) who had reported that legumes are considered as subsidiary crops to major crops such as tobacco and cereals, and are often relegated to marginal environments, as well as, given fewer amounts of inputs that limits their productivity.

Research Institutions and Access to information

Main research institutions such as Agricultural Research and Extension Trust (ARET) solely are involved in tobacco. ARET undertakes research on production, marketing, extension and engineering on tobacco. However, there have been issues of specialization and diversification on its agenda, emphasis has been on estate tobacco farmers in the country. Other institutions such as ICRISAT specialize on genetic and agronomical researches in groundnut, pigeon pea, soyabean and others with virtually little marketing and entrepreneurial adventures.

Reports (ICRISAT, 1997) from other developing countries such as India indicated that farmers knew little about the improved varieties of short-and-extra-short-duration pigeonpea varieties that were development and released for production some years before. Pande *et al*. (1995) reported that lack of knowledge about improved technologies is one of the socio-economic constraints limiting legume productivity among smallholder farmers in India. He reported that farmers generally lack knowledge about recently developed improved seed varieties, as well as, legume production technologies.

Hence, the major problems the research institutions in Malawi face include lack of promoting their research findings, lack of information dissemination, and poor coordination between extension services and the end users (the farmers). Although some tangible and practical recommendations have been made through various studies, there is no attempt to implement such recommendations on sector wide approach (MoAI, 1999) such that adoption of the cash crops has hardly been promoted to the smallholder farmers.

GENDER DIFFERENTIAL IN GROUNDNUT PRODUCTIVITY

As indicating in the literature review, substantial attempts were made to document gender differential in farm productivity of rural women in various developing countries. For example, the distribution of resources and work within household (Kanbur and Haddad, 1994), the various roles played by women and men in a variety of farming system (Carney and Watts, 1991; Aredo, 1992) and access to credit markets for women (Morris and Meyer, 1993). Other empirical evidences (Bryson, 1979; Daddieh, 1989; Newbury, 1989; Oduor-Noah, 1995; Udry, 1994; World Bank, 1998) link also gender inequalities in resources control to lost productivity and incomes from agriculture in developing countries.

Table 5.11 presents the three main grain legumes and others grown after maize by gender of smallholder farmers in central Malawi for 1999/2000 seasons.

Regardless of the sex of the household, the majority of the farmers grew tobacco and groundnut in the area, but with no statistically significant difference between the producers of these crops. As displayed in Table 5.11, the majority of the female farmers (20%) produced groundnut as the main grain legume after maize, while the male farmers (25.5%) produced tobacco.

Table 5.11: Percent distribution of primary crops after maize by gender

Household Head	Main crops grown after maize				
	Soya bean	Groundnut	Pigeonpea	Tobacco	Others
Female	3.5	20.0	3.0	13.0	2.5
Male	5.5	17.5	5.5	25.5	4.0
Total	9.0	37.5	8.5	38.5	6.5

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)

Table 5.12 presents summary statistics concerning the mean yield achieved, area, and labour per plot and other inputs used on men and women's plots.

On average, women (540.53 kg) achieved higher values of groundnut production per hectare than men (487.78 kg) on about the same size plots. Family labour (including hired labour) input is higher on men's plots than the female plots, which was 408.69 persons-days/hectare and 341.25 persons-days per hectare, respectively, for all crops sown across the plots.

Table 5.12: Mean yield, area, seed density and labour per plot by gender of cultivator

Gender	Land to all crops (ha)	Land only to G/nut (ha)	Seed all crops (kg)	G/nut seed (kg)	All crops Labour (person-days)	G/nut labour (person -days)	Yield all crops (kg)	Yield G/nut (kg)
Female (Std)	2.00 (0.8)	0.49 (0.3)	29.02 (22.0)	27.40 (19.4)	341.25 (126.9)	200 (75)	582.81 (647.1)	540.53 (670.0)
Male (Std)	2.31 (2.0)	0.44 (0.3)	28.96 (17.4)	30.15 (17.9)	408.69 (211.7)	199.5 (140.5)	597.01 (601.3)	487.78 (428.8)
Total (Std)	2.17 (1.6)	0.47 (0.3)	28.97 (18.7)	27.92 (17.5)	381.03 (184.4)	199.75 (107.7)	592.79 (613.6)	501.98 (502.1)
H_o: $\mu_f = \mu_m$ t-statistics; 5% sig. level; n =200	-0.75	0.75	-1.01	0.085	-25.47	-27.73	-0.146	-0.044

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)

Note: Standard deviation in parentheses

However, both men (199.5 person-days) and women (200 person-days) had used about the same amount of labour on groundnut plots. Women used labour intensively on their plots. The higher groundnut yields achieved on plots controlled by women reflects in part, at least, the tendency of women growing groundnut as cash crops as much as tobacco is men dominated crop in Malawi as reported in Tables 5.10 and 5.11.

On the other hand, the mean differences of yield, seed used, labour applied and land allocation showed no statistically differences between plots controlled by women and men. As is always the case in resource poor households, this fact reflects that family labour (men, women and children) is used in the small farms in the region, as children help both parents. However, the intensity of labour is higher on women's plot as women were continuously cultivating their garden located within the vicinity of the dwellings.

Determinants of Gender Productivity

Taking into account the possible determinants of all crops and only groundnut production, the study also focused on comparing yield achieved by men and women in the region. Restricted Cobb-Douglas production model was applied to the village level cross-section data as follows by estimating the following equation (Haddad, 1994).

$$Y_{phc} = X_{phc}\beta + \phi G_{phc} + \varepsilon_{phc} \qquad (5\text{-}3)$$

where Y_{phc} is the log yield achieved on plot p of household h to crop c in 1999/2000 growing season. X_{phc} is a vector of socio-economic variable including plot area, seed density and labour, as well as, dummy variables corresponding to the plots distance from the dwellings (perhaps plots closer to the residences might optimally be cultivated more intensively). G_{phc} is dummy variable corresponding to the gender of the cultivator (household head), and ε_{phc} is the error term.

A restricted C-D production function[18] was used as in equation (5-3) for all crops and groundnut only. The dependent variable was log of yield per hectare for 1999/2000 growing seasons in Malawi. Table 5.13 reports estimates from this functional form.

Column 2 of Table 5.13 presents C-D estimates for the entire sample (soyabean, groundnut, pigeonpea, tobacco, and other crops), and column 3

[18] Unlike translog form used in equation (5-1), which required large number of parameters, here the restricted C-D model used selected parameter estimates from the more flexible translog specification as explained with equation 5-3.

presents estimates for groundnut separately. Since $R^2 = 0.71$ and the joint F-statistic is very large, the model was adequately fitted to the data, and hence determinants of all crops, as well as, only groundnut yield can be identified accordingly.

Table 5.13: C-D function parameter estimates for all crops and groundnut only

Independent Variable	All crops	Groundnut
Constant	0.355	3.319
	(0.473)	(5.737)
Gender (1 = female)*	0.051	0.075
	(0.765)	(1.455)**
Plot area (ha)	0.390	0.360
	(3.328)	(4.010)
Seed Density (kg/ha)	1.173	0.779
	(19.186)**	(7.932)**
Female labour (person-days/ha)	0.187	0.108
	(1.841)**	(1.442)**
Male labour (person-days/ha)	0.119	-0.026
	(1.475)**	(-0.473)
Distance (km)	0.011	-0.001
	(0.342)	(-0.0563)
Joint F-Statistic	95.235	65.429
Degree of Freedom	5; 194	5; 194
(Significance = p)	0.000	0.000
R^2	0.711	0.628
$R^2_{adjusted}$	0.703	0.618
Dependent variable: log of production in kilograms per hectare		

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)
Note: t-statistics are in parentheses
*Except for gender, all other independent variables are given in natural log form.
**Statistically significant at 10% level

Plots controlled by women have significantly lower yields than other plots within the household planted by men to all types of crops (soyabean, pigeon pea, tobacco) and groundnut only. The effect is large. On average, yield are about 5.1 percent for all crops and 7.5 percent for groundnut higher in women's plots than on similar men's plots in the both Lilongwe and Salima ADDs.

This result complies with the report in Table 5.12 showing the contributions of slight difference of labour intensity on women's plots.

However, the coefficient on gender shows no statistically significant difference between female and male smallholder farmers in the region.

Output per hectare is strongly increasing in the size of the plot, and for 1 unit increase in the size of the farm there may be 39 percent increase in yield for all crops, and 36 percent for groundnut production, other things being held constant, such as soil type, amount of fertilizer used, labour intensity, and seed density. The simple imperfect labour market explanation commonly used to rationalize the farm size-yield relationship is relevant to this case, as well; whereby the intensity of labour applied and the yield were not proportionally related to each other. The inverse plot size-yield relationship that was observed in other African data (Bindlish and Evenson, 1993; Carter, 1994) without satisfactory explanations[19] is not applicable in this case, rather positive association exists as shown with coefficient estimates 0.39 and 0.36 for all crops and only groundnut, respectively.

Though, the finding that there is a slight gender differences in yield, but not statistically significant ($t_{0.05,\,194} = 1.455 < t_{0.05,\,194} = 1.653$), therefore, does not necessarily imply that men are less efficient cultivators than women are, but rather the extra labour applied on the groundnut farms. Apparently, the yield differences might reflect also the differences in the soil type, weather and other conditions that are beyond the control of the farmers.

Second, female labour is much more productive than male labour in each specification (all crops and only groundnut production). A unit increase of female labour (person-days/hectare) might increase yield by 18.7% in all crops and 10.8% in groundnut yield, while these figures are 11.9% and –2.6% for male labour. A striking difference is observed on groundnut yield when applying female and male labour whereby a reduction of yield in groundnut production for a unit increment of male labour. This result might suggest that women tend to specialize in groundnut production in the area. This result is similar to production function estimates from western Africa regions (Saito *et al.*, 1994), but in contrast to estimates from Asia and Latin America (Jacoby, 1992).

Furthermore, the coefficient for plots distance from the dwellings shows that positive relationship with yield in case of all crops, but negative relationship for groundnut production. Since groundnut is labour intensive crop the negative relationship might imply that the farther the groundnut plot the less the farmer spends in the plots (preparing, weeding and harvesting), and thus the decline of groundnut production. On average, 20% of the total land size was allocated to groundnut and perhaps the smaller plot, which might be closer to the dwellings assigned to groundnut or similar crops such as

[19] Some of the potential explanation could would be – labour market, planting dates, weeding time, weather, labour allocation and soil quality.

vegetable production. The coefficient estimate for distance is not statistically significant, but it showed some negative effect on groundnut yield.

Finally, the C-D model had shown that difference in female and male labour and seed rate applications on the field determine the yield in groundnut production. On average, a unit increase in female labour (higher intensity of female labour perhaps specializing in groundnut production) would change groundnut yield by about 10%. The econometric evidence that factors of production are not allocated efficiently across plots controlled by female and male farmers presented production losses or gains with respect to intensities with which inputs were applied. Controlling for fine variations in plot characteristics such as unobserved land quality and other non-socio economic characteristics, it can be concluded that there is a slight gender differential in groundnut productivity in Malawi.

SUMMARY FOCUSED GROUP DISCUSSIONS

As stated in the methodology section of this study, the social-economic forces were also studied applying intensive participatory approaches. Desfil (1994) stated that by using participatory methodologies, engaging community members in the research process, it is possible therefore to both contribute to and learn from the villagers, as well as, return research results to the communities for their review and use.

Similarly, in many instances, the social researcher's heavy reliance on quantifiable variables has not served well in understanding the true dynamics of socio-economic variables that influence household's production and consumption. Moreover, the single respondent has often been a male member of the household who may or may not have direct role in production, and may provide biased information on the production system. As such, qualitative data were gathered through focused group discussions during the survey. The summaries of the major issues raised during the discussions were reported as separate transcripts for Lilongwe and Salima ADDs as follows.

Lilongwe ADD

Seed

Most farmers reported that inadequate groundnut seed was the major constraints in groundnut production. They said that higher input seed prices demanded by ADMARC (parastatal agencies) and private traders discouraged them from intensively involved groundnut production in the area.

Major crops grown in the area were maize, tobacco and groundnut, while minor crops include pigeonpea, beans and sweet potatoes. There was little crop rotation being practiced in the area, however, there was some inter-cropping of maize and pigeonpea. Groundnuts were also intercropped with maize very small plots were cultivated, where groundnuts were grown as a sole crop. These qualitative results were also evidenced in the quantitative analysis.

Labour

Women informants had reported that domestic work had taken most of their time, and at the same time lack of money were their major constraints to hire occasional labourers in the field. These had resulted untimely weeding and harvesting of crops that might have contributed to low productivity of groundnut as a whole.

Farmers reported that it is rare to find a tradition among farmers of visiting each other's fields. This was mainly due to the fear of being accused of *kukawa*, the theft of part of the crop yields by witchcraft. The visiting of fields of others was usually limited to that of close relatives. Sometimes if people wish to learn a new technique they would either hire labourers or hire themselves out to farmers who needed farm piecework in the fields. Labourers often have access to different farming practices on various farms, and sometimes, in various villages. This provides opportunities for farmers to gain knowledge from well beyond their local farming areas.

Farm Credits

Besides low producer prices, lack of access to farm credits were given as one of the major reasons for low groundnut production. Women informants also reported that lack of money to buy input seed was their major constraints in groundnut productivity.

Most farmers reported that the credit institutions in the area were not developing the farmers socially and did not care about the farm productivity. Rather, the institutions were lending the farmers loans with high interest rates if the farmers have collateral and loans for specific crop (only for tobacco farmers). Besides the unavailability of farm credits specifically designed for groundnut production, the issue of collateral and high interest rates discouraged the resource poor farmers to borrow money for groundnut production.

Output

Coupled with higher seed prices, the lower output prices offered by ADMARC and private agencies, who sell the input seed with higher prices to international markets, demoralized the farmers from producing all sorts of cash crops such as groundnut, pigeonpea, and soyabean in the area.

It was also indicated that women equally grew groundnuts. However, more and more women nowadays have a tendency of producing less of groundnuts and more of tobacco because of the high prices obtained from tobacco.

Other issues

Women farmers reported that men usually dominated decision-making in the household. The men usually paid for seed, hired labour and transport costs. In general, in the male-headed households the man is the one who suggested and arranged for the sale of the groundnuts while the wife was the one who often times followed the instructions and delivered the farm products to the buyers (local traders, market or sell at home).

For the household plot, the husband is the one who decides how the income from groundnuts should be used while the wife decides how the income from her groundnut plot should be used. However, the man takes control of the proceeds from groundnuts but distributes it according to the needs of the household members.

Advise to Government and others

Credit institutions must lower their exorbitant interest rates (as high as 60% per annum) and loans should be issued in time before the onset of rains. Also, both in-kind and cash loans should be readily available to resource poor farmers, perhaps with limited collaterals.

The government should get involved in raising farm produce prices, and lowering input seed price rather than leaving these to private traders who usually do not care about farmers except profit maximizations for their businesses.

Salima ADD

Seed

The major problem faced in Salima ADD was also lack of seeds. Most farmers complained that seed was not readily available at ADMARC and the seeds were expensive, and yet producer prices were very low comparatively.

In Salima, the major crops grown were cotton, groundnuts and maize but farmers relied more on cotton for their source of income. Apart from climatic reasons, cotton is the only crop that still gets good money from ADMARC, the sole buyer. As for groundnuts, the types of groundnuts that were mainly grow, but with small scale is malimbra (ground seed known for its drought resistance), could be used only for food or sold either raw or roasted.

Labour

Women did most of the activities in groundnut fields, which were often located closer to the dwellings. Unless the women were able to hire labour they ended up spending more time on the cotton fields with their husbands. Only female headed households who had much time and were free to choose which plot to work on, and consequently were able to produce more groundnuts. Moreover, women farmers reported shortage of labour mainly when harvesting the crop.

Farm Credits

The farmers did not apply for farm credits because they were afraid of the high interest which they might not able to pay because of the low the gross margin of the farm produce. The loan screening process of the lending institutions also discouraged most of the smallholder farmers from borrowing in-kind or cash loans.

Many said that they could not buy inputs on cash basis, as cash was not readily available in their hands. They expressed that without credit schemes their standard of living would further drop, as they were no other means of improving farm productivity.

Most farmers were dissatisfied with the major lending institutions that were delegated by the government because the credit institutions were not close to the farmers unlike in the past the system went directly via the field assistants. As of the government, not every household or smallholder farmers received free seed and fertilizer packages in what the government calls 'starter

pack programs" that were implemented for the last two years with some success.

Output

Similar to Lilongwe ADD, Salima ADD farmers had faced low producer prices. Farmers had cited pests and diseases, low producer prices at markets (ADMARC and private traders), lack of extension messages regarding groundnut production and shortage of land as major constraints to increase groundnut production in the areas.

Advise to Government and others

Farmers felt that the government should have control over private traders and subsidiary organizations so that producer prices should be raised for farmers to cultivate more groundnut crops.

Government should also hear the cry of farmers on loan schemes and warn the credit institutions on the issue of high interest rates. The interest rates should be reduced to reflect commercial base lending as charged by major banks in the country or government should redesign the farm credit scheme in consultations with the farmers.

More extension services should be given specifically regarding alternative cash crops such as groundnuts, pigeon pea, cassava and others.

CONCLUDING SUMMARY

This chapter focused on determinants of groundnuts production, technical efficiency, profitability and gender differential in groundnuts productivity. Of the socio-economic factors investigated land, labour, cropping pattern and seed density inputs implied diminishing returns, as the elasticities are between zero and one exclusive. On the other hand, groundnut production exhibited increasing returns to seed density input level. The results had demonstrated that only physical factors such as land, labour and seed density (proxy to capital) determine groundnut production, which led to accepting the postulated hypothesis that socio-economic variables (non-physical factors) do not determine the dynamics of groundnut production in smallholder farms in Malawi.

Of the physical factors used in the model, it was only land and seed density (proxy to capital) were found statistically significant in determining technical efficiency in smallholder farms. Similarly, it was also found that access to farm credit (whether a farmer received agricultural credit) and adoptions of technology (using farm technologies including seed variety) were the only two non-physical factors that determined groundnut production in the study area.

The analysis revealed that groundnut is more profitable compared to pigeon pea and soyabean at the current input and output prices, as well as, productivity levels of grain legumes. Groundnut gave the highest gross margin per hectare, the highest returns to factors of production than the two major grain legumes mainly grown after maize. Given these results, the hypothesis that groundnuts are not profitable, compared to competing cash crops (soyabean and pigeonpea) grown after maize in the country, is rejected. Therefore, it is possible to say that given the full potential and opportunities for smallholder farmers, groundnut is relatively the best alternative in replacing tobacco in the region.

The restricted C-D function had shown that gender differentials in groundnuts productivity exists among the smallholder farmers with women producing slightly higher than men because of the intensity of labour they applied in their farm fields close to their dwellings. The econometric evidence that factors of production were not efficiently allocated across plots controlled by female and male farmers presented production losses with respect to intensities with which inputs were applied. Controlling for fine variations in plot characteristics such as unobserved land quality and other non-socio economic characteristics, it can be concluded that there is a slight gender differential in groundnut productivity in Malawi, but with no statistically significant difference.

Most of the focused group discussion results had also been reflected in the quantitative analyses, except that small farmers would like to have access to farm credits to finance their farming activities. Therefore, it is possible to conclude that the compounded problems, unaffordability of seeds, high pest and disease incidences, low producers prices, as well as lack of other farm resources had resulted in low groundnut productivity per hectare that did not reach the expected yield per hectare in the study area.

Finally, both the qualitative and the quantitative analyses revealed that the major constraints in efficient groundnut production were low producer prices, high input prices, poor coordination between research institutes and farmers (lack of dissemination of new research information), weak government policy in implementing and addressing traditional production

[20] The new Malawi government, British Development Agency and other NGOs have started giving a package of free seeds and fertilizer to smallholder farmers within the poverty alleviation program since 1997/98.

technologies. As such, Malawi government and NGOs should be at the forefront of improving groundnut productivity at smallholder farmers level through improved services across the country.

CHAPTER VI

ADOPTION OF GROUNDNUT TECHNOLOGY

INTRODUCTION

Increase in productivity can be realized through adoption of improved production technologies such as high yielding varieties. Apart from the increase in productivity, Smale and Heisey (1995) observed that improving maize yields was necessary if land were to be released for cultivation of other food crops that are essential to improving the nutritional standards and for promotion of exports to earn valuable foreign exchange. Thus, in Malawi the issue of land saving technologies with high productivity per hectare of land arises.

The Ministry of Agriculture and Irrigation has argued that Malawi's prosperity continue to depend on agriculture given its low industrial bases. Increasing farm production will achieve and maintain food self-sufficiency, import substitution and foreign exchange earnings. Thus, the government's objectives include achievement and maintenance of food self-sufficiency; expansion and diversification of cash crop production for export and import substitution (MoAI, 1993, 1998).

A number of adoption studies of improved varieties carried out in Malawi have been on other crops other than groundnuts (Kisyombe, 1998; Subrahmanyam *et al.*, 2000). Most adoption studies in Malawi have concentrated on improved varieties of staple food, maize and maize related inputs like fertilizer. This study has investigated groundnut technologies such as improved varieties and cultivation methods in central Malawi.

The study examined how socio-economic variables affect the adoption of groundnut technology. The dependent variable is the number of years after a technology is available that a farmer adopts it. The dependent variable takes on discrete integer (count) values.

The technologies[21] considered were - varieties such as CG7, chalimbana and other types of groundnut variety, intercropping (groundnut

[21] Mainly includes improved groundnut variety and farm cultivation systems that are considered as part of adoption of new farm technology in smallholder farms in Malawi (MoAI, 1998). Since the new farming systems or practices are part of the new farming technologies, farming systems and farming technologies are interchangeably used throughout this study.

mix planting with other major crops such as maize, pigeonpea, soybean, sorghum, potato, etc), rotation (seasonal cropping pattern), ridging (spacing on the row) and erosion control (where the farmer practices any kind of conservation practices on the piece of land allocated for groundnut production).

The study has mainly used Poisson model and its derivative (negative binomial model) to identify variables, which were influencing the adoption of CG7 groundnut technology, as well as, used logistic regression models to examine farmers' perception of adopting groundnut technologies (or farming systems) in the country.

SOCIO-ECONOMIC CHARACTERISTICS AND TECHNOLOGY

This section highlights the major socio-economic characteristics of farmers associated with farming technologies (intercropping, ridging, improved variety and rotation) used in Lilongwe and Salima ADDs in central Malawi.

For better understanding of the difference between the technology categories, efforts were made to compare characteristics of farmers across the technologies emphasising on age of household head, education, training organization, extension services, land size, seed varieties and farmers' experiences. Most of these characteristics were also used in the Poisson and Logistic regression models later in the analysis in order to test hypothesis 4, which deals with determinants and the significance of adoption of farm technology in this study.

Tables 6.1 to 6.8 report descriptive statistics on adoption of farm technology in central Malawi. Table 6.1 summarizes the age distribution associated with the type technology adopted by the farmers in central Malawi region.

The overall average age of the household heads in Lilongwe and Salima ADDs is 46.3 years. Over 85% of the households within 31-60 age groups had adopted intercropping, ridging, improved seed variety and rotation technologies in the study area. However, most of the farmers (46.5%) had adopted intercropping technology followed by rotation (29.5%) and used improved seed varieties (17%), which were mainly CG7 seeds.

When the ages of the farm categories were compared, the farmers who seasonally rotate their crops within the plots of their farm fields were older, that is, have highest average age (47.3 years). However, t-test showed that the mean age differences among the four categories were not statistically different at $\rho < 0.05$.

Table 6.1: Percent distribution of age of household head by technology

Age (Years)	Adoption of Farm Technology				
	Intercropping	Ridging	Improved variety	Rotation	Total
20-30	1.5	0.0	1.0	4.0	6.5
31-40	8.0	2.5	3.0	5.5	19.0
41-50	21.5	3.0	8.0	13.0	47.0
51-60	12.0	8.0	3.0	4.0	19.5
60^{+}	3.5	0.5	1.5	3.0	9.0
Total	46.5	7.0	17.0	29.5	100.0
Number of households	93	14	34	59	200
Average age	46.5 (2.61)	45.3 (2.64)	46.1 (2.43)	47.3 (1.92)	46.3 (2.39)
The overall mean age is 46.3 years					

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)
Note: Figures in parentheses are standard deviations

Furthermore, it is observed that the average age (46.3 years) is higher than the life expectancy age in Malawi of about 39 years (Population Reference Bureau, 2000). As mentioned above, the majority of the smallholder farmers are in the economically active age group (20 – 60 years), which presumably contributed effectively to agricultural development in the country.

Table 6.2 also summaries the education levels of the household heads and adoption of technology for 1999/2000 seasons in Lilongwe and Salima ADDs.

Regardless of the education level of household heads, the majority of the farmers had adopted intercropping farm technology (45.5%) followed by rotation (30.5%) and adopting improved seed variety (18%). The results in table 6.2 also reflect that the majority of the household heads (or farmers) were literate (74.5%), and of this figure 63.5% and 11% have reached primary and secondary school levels, respectively.

These results imply that some farmers most likely followed new farm technology instructions introduced, but inadequately disseminated, by the government agents and the research institutes in the region, which had slight impact on their farming activities and production.

Table 6.2 Percent distribution of education levels and technology

Education Level	Adoption of Farm Technology				Total
	Intercropping	Ridging	Improved variety	Rotation	
None	17.0	2.0	3.0	3.5	25.5
Primary	24.0	4.0	14.0	21.5	63.5
Secondary	4.5	0.0	1.0	5.5	11.0
Total	45.5	6.0	18.0	30.5	100.0
About 75% of the farmers who adopted some kind of technology are literate					

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations); $\chi^2 = 16.94$, significant at $\rho = 0.01$ level

Such lower adopting rate of technology, especially improved seed variety, was also reflected in the PRA analysis (chapter 5), where most farmers reported that lack of information, poor coordination between farmers, research institutes and government agencies might be responsible for lower production. The gap between the farmers' readiness (with basic education) to learn and adopt new farm technology and dissemination of information by the responsible agencies to resource poor farmers was wider and insufficient in the study areas.

Table 6.2 also reveals that 25.5% of the farmers were illiterate and adopted some type of technology and preferably intercropping (17%). Given the small farm sizes that most farmers own, it appears that intercropping is most preferred technology to adopt than the other farm technologies. Similar arguments could be made concerning rotation and adopting improved variety (CG7). It seems that most literate farmers tend to seasonally rotate their crops and use improved seed variety despite shortage of seeds due to unavailability or unaffordability in the area as discussed in chapter 5.

Table 6.3 also displays the distribution of land size by adoption of farm technology in central Malawi region. The overall average farm size was 2.35 hectares in Lilongwe and Salima ADDs. It is interesting to note that most of the farmers (77.1%) who have land size in the range of 1 to 3 hectares have adopted some type of farm technology. This implies that most farmers within the average farm size have also adopted the farm technologies in the areas. Regardless of the farm size, 45.3% adopted intercropping technology, followed by rotation (30.7%) and improved seed variety (16.7%) since 1990.

The intercropping farms are greater than the other category of technologies, and there is statistically significant difference between them at ρ < 0.05 level. In addition, the Chi-square statistic ($\chi^2 = 16.94$) has shown that there is association between land size and the type of technology adopted.

Table 6.3 Percent distribution of land size and technology

Land size (Hectares)	Adoption of Farm Technology				Total
	Intercropping	Ridging	Improved variety	Rotation	
Less than 1.0	0.0	0.5	0.5	0.0	1.0
1.0 – 2.0	17.7	3.7	5.2	13.0	39.6
2.1 – 3.0	15.6	1.6	7.3	13.0	37.5
3.1 – 4.0	7.3	1.5	3.1	3.1	15.0
Above 4.0	4.7	0.0	0.6	1.6	6.9
Total	45.3	7.3	16.7	30.7	100.0
The overall average farm size in the area was 2.35 hectare					

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations); $\chi^2 = 16.94$, significant at $\rho = 0.05$ level

The intercropping farms are greater than the other category of technologies, and there is statistically significant difference between them at ρ < 0.05 level. In addition, the Chi-square statistic ($\chi^2 = 16.94$) has shown that there is association between land size and the type of technology adopted.

It would not be surprising to find that farmers with less than 1 hectare of land have hardly used the farming methods discussed here. Apparently, these farmers continuously monocropped with maize because of the need to allocate nearly all the land to maize to satisfy domestic food needs. According to Mataya *et al.* (1996), despite the fact that grain legumes such as groundnuts were essential components in the diet (major source of protein), about 76% of arable land was solely devoted to maize and only minor percentage of land is cultivated to such crops. Cromwell and Zambezi (1993) had also found that to the extent that smallholders with less than 0.5 hectare consider groundnut as a relatively less important crop. As seen chapter 5, this study had also revealed that farmers with less that 0.5 hectares, of course, gave priority to grow mainly maize (stable food), however, farmers with average land size of about 2 hectares allocate about 0.41 hectares (on average) to groundnut production in central Malawi.

Table 6.4 reports that male-headed households dominated the sample and chi-square statistics showed significant differences in adoption between the sex categories. The results reflect that male-headed households had a higher probability of adopting intercropping technology than their female counterparts. Fifty eight percent of the male farmers had adopted some kind of technology, while this figure was 42% for the female.

However, the differences of adopting rotation techniques and improved seed variety are statistically negligible.

Table 6.4 Percent distribution of sex of household head and technology

Sex	Adoption of Farm Technology				Total
	Intercropping	Ridging	Improved variety	Rotation	
Female	16.2	2.5	8.0	15.0	42.0
Male	30.0	4.5	9.0	14.5	58.0

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations); $\chi^2 = 4.101$, significant at ρ= 0.05 level

This is probably because of the small-scale seed programs targeted female-headed households who were considered among the most vulnerable groups in the farming community as also found in other developing countries (Cromwell and Zambezi, 1994).

The study also examined who provided the training in adopting a technology, and the number of contacts made with the extension workers based in the region. This was done in order to find out how much agricultural related information was passed to the farmers from government agencies and research institutes in the country.

Table 6.5 Percent distribution of who provided farm technology information

Trainer	Adoption of Farm Technology				Total
	Intercropping	Ridging	Improved variety	Rotation	
Extension workers	32.5	5.0	9.5	10.5	57.5
ICRISAT	4.5	1.5	4.0	8.5	18.5
Friends	5.0	1.5	3.5	9.5	19.5
Others	4.5	0.0	0.0	0.0	4.5
Total	46.5	8.0	17.0	28.5	100.0

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations); $\chi^2 = 44.599$, significant at ρ= 0.05 level

The results in Table 6.5 have revealed that most of the farm technology information was from extension workers (57.5%) followed by friends/relative (19.5%) and ICRISAT (19.5%), as well as, the contribution from others NGOs is only 4.5%.

Again, most of the farm technology information was on intercropping (46.5%), followed by rotation (28.5%) and improved varieties (17%). These results support that land is scarce in Malawi, and most farmers have small farms (on average less than 2 hectares nationally). As a result, the obvious choice of farming technology or system is intercropping on limited land available as a strategy of maximizing the land use.

On the other hand, rotation within the small farm was also favoured since most farmers were aware of soil fertility improvements that came with rotation of crops seasonally. It was found that 74% of the farmers in surveyed area were intercropping and rotating groundnut within their fields because they believed that planting groundnut improves soil fertility. In addition, increasing yield of crops was the main objective of most farmers, they were engaged also in using improved seed varieties in their fields; but farmers had limited information as was revealed in the PRA discussions.

Table 6.6 summaries groundnut variety mostly farmers grow using the four farm technologies discussed so far.

Regardless of the type of adoption of farm technology, 68.5% of the farmers still prefer to grow the local groundnut variety (chalimbana), while 12.5% of the farmers grow the new groundnut variety (CG7), which was introduced by ICRISAT in Malawi in 1990.

Table 6.6 Percent distribution of ground varieties grown by technology

Variety	Adoption of Farm Technology				Total
	Intercropping	Ridging	Improved variety	Rotation	
Chalimbana	30.0	6.0	11.0	23.5	68.5
Tchailosi	5.5	0.0	0.0	0.0	5.5
Kalisere	2.5	0.0	0.0	0.0	2.5
CG7	6.5	0.0	6.0	4.0	12.5
Others	2.0	1.5	1.5	2.0	7.0
Total	46.5	7.5	18.5	29.5	100.0

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations); $\chi^2 = 31.788$, significant at ρ= 0.05 level

Regardless of the seed variety preferred, Table 6.6 also shows that most farmers preferred intercropping the groundnut varieties with other crops especially maize, which is the staple food in Malawi. As a second preference, most farmers also rotated chalimbana with other crops, which agrees with the findings of Kanyama-Phiri *et al.* (1996) who reported that when crop rotation was commonly practiced, for example, in central region groundnut is one of the main legumes used in rotation to enrich the infertile soils. This is particularly important for the poorest farmers who may not be able to buy inorganic fertilizers having low income and limited access to farm credits.

Table 6.7 also summarizes the reasons farmers intercrop groundnut varieties and other major crops in the villages.

About 64% of the farmers intercropped groundnut varieties with other crops because of land shortages. As mentioned earlier, most farmers have small size farms, on average 2.35 hectare, and coupled with the growing population pressure land is scare, and therefore, intercropping is the most preferred farming system in Malawi.

Table 6.7: Distribution of reasons farmers prefer intercropping

Reasons	Percent
Lack of land	63.7
Labour saving	25.0
Easy management	6.8
Reduce competition and have better yield	4.5
Total	100.0

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)

It appears that 25% of the farmers also prefer intercropping method because of labour saving for off-farm employment, though family labour is readily available for farming activities in the region.

About 5% of the farmers used intercropping method to reduce competition among plants and to have better yield. This finding is insignificant relative to other reasons, but it agrees with groundnut/maize intercropping research (Edje, 1981) that the groundnut yields were reduced by 56-70% compared to sole crop yields. The taller maize crop develops more rapidly and maintains a competitive advantage over the slower-growing and shorter groundnut crop.

Table 6.8 summarizes farmers' reasons of preference one-groundnut variety to other in relation to the seeds characteristics.

Table 6.8 Distribution of preferred groundnut characteristics

Characteristics	Percent
High Yield	10.5
Market appeal (morphological characteristics, the kernel size)	25.0
Early maturity	16.0
Taste (relish seasoning and source of nutrition)	34.5
Drought resistance	7.0
Disease resistance	7.0
Total	100.0

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)

Note: Proportion differences of the four highly rated characteristics (taste, market appeal, early maturity and high yield) were found to be statistically significant at $p<0.05$.

In contrast to Cromwell and Zambezi (1993) who reported that yield per hectare was a very important criterion by which farmers judge performance of seed variety, the preference of high yield characteristics was ranked number four in this study. Most farmers (34.5%) preferred taste characteristics of groundnut followed by market appeal (25%), early maturity (16%) and high yield (10.5%).

These results support the previous results (Table 6.6) indicating that most farmers preferred chalimbana to CG7 variety (high yield groundnut), but with less tasty characteristics. In addition, these findings are in line with earlier results in chapter 4 (Table 4.6) that most farmers produced groundnut because of food as source of nutrition and marketing to get more cash to sustain their family's livelihood.

On the other hand, it is surprising to find out that farmers did not virtually choose groundnut varieties because of drought and disease resistance though most farmers hardly use pesticides in their small farms as reported in table 5.7.

Apart from farmers' preferences for adopting one type of farm technology to another, several socio-economic factors also determine adoption groundnut technology in developing countries. This study has also explored the determinants of adoption of groundnut technology through count data econometric model as discussed next.

DETERMINANTS OF IMPROVED SEED TECHNOLOGY

Land scarcity has forced poor farmers to cultivate marginal areas and continuous cropping of unfertilised maize (staple food) has been the norm in Malawi. Fallow rotations practiced since 1960 can no longer implemented due to the growing land shortage because of population growing pressure. Furthermore, unaffordability of inorganic fertilizer, poor rotation and insufficient or lack of integration of trees and other appropriate plants in the rotation are becoming common (Kanyam-Phiri *et al.*, 1996; Adesina, 1996, 1997, 1998; Kamanga, 1999).

Use of inorganic fertilizers is of limited impact because the cost of fertilizer is beyond the economic reach of the majority of the farmers in Malawi (MoAI, 1998). Similarly, organic fertilizers in the form of farmyard manure and compost are rarely used because few farmers own cattle and there is lack of knowledge regarding production of compost manure.

For these main reasons, it is imperative to use soil fertility and yield enhancing technologies legume plant combination and improved varieties of crops such as CG7 groundnut variety in the farm. As indicated in many

studies (Kanyama-Phiri *et al.*, 1996; Kamanga, 1999;), the advantage of using such leguminous seeds is that it helps soil fertility (nitrogen fixation) and expands agricultural output per unit area compared to other groundnut varieties whereby increases income for smallholder farmers. At the same time, it provides nutrition (protein seasoning of food) for the health of the households for the growing population in the country.

As discussed in Table 6.8, when farmers are making a choice of which variety to grow they give different reasons ranging from high yield to the taste characteristics of a groundnut variety. Thus, given the above reasons and since CG7 groundnut technology is the latest technology introduced in Malawi as of 1990, a count data econometric model is used to analyze the determinants of adoption CG7 variety focusing on the relationship between the probability of adopting the latest technology and the various socio-economic characteristics of the smallholder farmers in Malawi.

Count Data Econometric Model

As detailed in methodology section of chapter 3 (equations 3-12 to 3-22), the count data models are used to study problems where the dependent variable takes on only non-negative integer values. Hellerstein (1991) used count data regression models to study recreation demand based on travel cost data. Hausman, Hall and Griliches (1984) evaluated the relationship between Research and Development (R&D) and number of patents, while Tsur and Hochman (undated) demonstrated the application of count data regression models to explain time to adopt irrigation technologies.

Several factors are responsible for a farmer's decision to adopt groundnut technologies. Extension creates awareness of the existence of seed technologies. Then farmers assess whether the technologies are acceptable to them given the crops they grow, farm size, experience, labor availability or demand, expected improvement in fertility, availability of credit facilities, fertilizer input cost, and other factors (GoM, 1998).

This process of determining whether it is feasible and profitable for farmers to adopt and implement the technology on their farms may be instantaneous, i.e., they can adopt immediately, in the same year that the technology is introduced or it can take several years depending on socio-economic factors such as education and frequency of extension contact. Various assumptions can be made regarding technology choice. One assumption is that technology and crop choice is sequential, that is, farmers choose the technology first and then decide what crops to grow to suit the chosen technology. An alternative is to model the choices simultaneously, that

is, improved crop and other technology choices taking place at the same time (Green *et al.*, 1996).

EMPIRICAL ESTIMATION

Data and Variables

Primary data for the count data and logistic models of adoption were obtained from household farm survey of the adopters of groundnut technologies in Lilongwe and Salima ADDs for the 1999/2000 growing seasons.

Dependent Variable

The dependent variable in the current study is a non-negative integer value. It is taken to be the number of years it took a farmer to adopt groundnut technology (YADOPTGT[22]) after the introduction of new groundnut seed variety in Malawi. The new adopted technology, CG7 seed variety, considered was introduced in Malawi in 1990. This is used as a base year for each of the farmers in the sample. For example, a farmer adopted the groundnut technology in 1995, then the number of years that took to adopt the technology was taken as 5 years (year 2000 – 1995).

It is obvious that field officers (extension services) want to reduce the number of year that farmers take to adopt a technology. This is desirable because the earlier the farmers start using a technology, the earlier the intended benefits of the technology are expected to show up.

Information regarding new variety was obtained from ICRISAT, whereby over years a number of groundnut varieties both for confectionery and oil extraction purposes have been bred or improved in Malawi. Collaboration between the SADC/ICRISAT Groundnut project and the Malawi National Agricultural Research System (NARS) has resulted in the release of a number of cultivars that could potentially boost production (Chiyembekeza *et al.*, 1994). Some of these varieties are large seeded nuts like chalimbana and chitembana, rosette resistant variety of RG1, oil nuts like manipinar and malimba. The latest variety is CG7, a medium red seeded variety that was approved for release in Malawi in 1990 was considered to give high yield per hectare than the lower yield chalimbana variety, but most popularly grown variety among smallholders (SADC/ICRISAT, 1994), which was verified with results in Table 6.8.

[22] YADOPYGT stands for number of Years to Adopt Groundnut Technology

Explanatory Variables

As hypothesized in chapter 3 (hypothesis 4), improved seed variety (CG7 groundnut type) is not significant in groundnut production at the household level. In which this hypothesis was tested through a farmer's decision-making; whereby a farmer j, j = 1, 2, 3, 4, …, n (where n=200 farmers) was believed to be influenced by a vector of socio-economic explanatory variables (x_j) in the farmer's decision to adopt the CG7 technology.

The independent variables represented by the vector of socio-economics variables are mainly farmer education, family labour, farm size, extension visits, farm capital and farmer experience. These were expected to mainly explain the differences in adoption time among farmers in central Malawi, where most of the groundnut production taking place in the country.

In adoption equation (Poisson model), a positive coefficient on the explanatory variable implies that the variable under consideration discourages adoption while a negative coefficient means that the variable encourages adoption. Following are operational definitions of the explanatory variable used in the Poisson and negative binomial models.

Farm size (FMSZ)

Again, land is scarce and it is a major resource of livelihoods of small farmers in Malawi. Adopting different technologies on the limited farm size is critical for smallholder farmers and therefore it has implications on decision on adopting agricultural innovations. The land scarce farmers equally (if not faster) tend to adopt the CG7 technology (as it is a high yield seed variety) on their pieces of land as the land abundant farmers. Thus, it is postulated that FMSZ (in hectares) has positive relationship with YADOPTGT.

Education (EDU)

EDU in the model was taken to be the number of years of complete schooling for each respondent. It is expected that the more years a farmer is exposed to education; the more open a farmer would be to new ideas or innovations. The literate farmers are able to realize the

gains or loses associated with improved variety, and assess the new technology in terms of reasonable rate of return. Furthermore, education also helps farmers to analyze alternatives critically and forecast the expected benefits to their farming activities. Therefore, number of years of schooling expected to reduce the number of years it takes a farmer to adopt a new technology once the technology has been introduced in the farming community. A negative relationship was postulated between education and YADOPTGT.

Farmer Experience (FEXP)

One factor that may work for or against adoption is farmer experience with groundnut production. If the experience of farmers with regard to new technology (improved variety) has been bad, they may take their time to adopt the new technology that has been introduced in the area. On the other hand, experience may enhance the speed of adoption if the farmer's experience has been that new technologies enhance profitability. Under these circumstances, experience will reduce the number of years it takes farmers to adopt the technology. As a result, there will be a negative relationship between FEXP and YADOPTGT. In this study, farmer experience is taken to be the number of years the farmer was engaged in farming activities. Since the sample farmers in Lilongwe and Salima ADDs were relatively middle aged (average 46.3 years), a positive relationship was postulated between farmer experience and YADOPTGT.

Family Labour (FLAB)

Family labour in the model is taken as family labour that is available to farming activities measured as person-days per hectare. FLAB labour is a paramount input as almost all farming activities are unmechanized in Malawi. Labour becomes even more important when dealing with labour intensive crops such as groundnuts and tobacco as more weeding, ridging and harvesting on time are required. Accordingly, it was expected that households with more family members would have more labour supply and would adopt crop technology faster than those with inadequate labour supply families. It was therefore postulated that FLAB would have a negative relationship with YADOPTGT.

Off-farm income or farm credit is expected to influence the adoption behaviour of smallholder farmers as it provides in-kind input or cash for the acquirement of the innovation and its related inputs. It was postulated that families off-farm income eases the capital constraints of the farmers so that the relationship between income or farm credit and YADOPTGT is negative as farmers with more income or credit would adopt the new technology earlier by reducing the number of years the farmers wait to acquire the technology. Off-farm income is measured in Malawi Kwacha (MK), local currency (US$1 = K80.00, February 2001).

Extension visits (EXVT)

In Malawi, Ministry of Agriculture including NGOs provide extension services. The field assistants in the country are engaged in dissemination of new technologies, and advise to the farmers in order to improve crop productivity and livestock enterprises. It was conceptualised that increasing contacts between the farmers and the extension agents would increase the probability of adopting the new farm technology faster.

The survey for this study measured the contact period between the farmer and extension agent by the number of visits of the extension agents per month per year. It was, therefore, hypothesized that EXVT and YADOPGT would have positive relationship implying that farmers who had frequent visits adopted the new technologies much earlier thereby extension visits would increase the speed of adoption by reducing the number of years it takes a farmer to adopt the groundnut technology.

ESTIMATIONS AND DISCUSSIONS

Both the Poisson regression model and its compound derivative[23], the negative binomial regression model, were estimated using LIMDEP (Greene, 1991). The estimated Poisson model was tested for overdispersion since Poisson

[23] Refer to chapter three, equations (3-9) to (3-22) for theoretical details on testing for overdispersion, as well as, equations (6-1) to (6-20) for negative binomial derivatives.

model has been criticized because of its implicit assumption that the variance of the dependent variable equals its mean.

A number of authors (Cameron and Trivedi, 1990; Lee, 1986) have devised tests for overdispersion within the context of the Poisson model. In this study, however, the estimated Poisson model was tested for overdispersion[24] using a regression-based test proposed by Cameron and Trivedi (1990) and the results are presented in Table 6.9. The coefficients in the two regressions (using equations 3-21, chapter 3) of the test are positive and significant at 5% significant level.

Table 6.9: Regression-based test for overdispersion of the Poisson model

Regressor	Coefficient	Std. Error	t-ratio	Mean regressor
W_1	1.794**	4.241	4.241	0.1894
W_2	2.361**	1.929	1.929	1.2202

** significant at the 5 percent level

Therefore, this implies that there is overdispersion in the data. Thus, the assumed equality of the conditional mean and variance of Poisson regression model or the shortcoming of the Poisson regression model is rejected. Alternatively, among the several suggested models (Hausman *et al.*, 1984; Cameron and Trivedi, 1986; Gurmu and Trivedi, 1994; Johnson and Kotz, 1993) that allow overdispersion, the negative binomial model, which arises from a natural formulation of cross-section heterogeneity, was fitted to the data as follows.

Heterogeneity and the Negative Binomial Regression Model

As seen above, the Poisson model was estimated first and the regression-based tests revealed that there was evidence of overdispersion. Thus, the basic Poisson model was rejected, and therefore a compound Poisson (negative binomial) model was chosen since it allows for overdispersion (Green, 1997).

Following Gourieroux *et al.* (1980), Tsur *et al.* (undated) and Mangisoni (1999) had derived the negative binomial model as follows. First, the Poisson mode was generalized by introducing an individual, unobserved effect into the conditional mean, let

$$\log \mu_j = \beta' \mathbf{x}_j + \varepsilon_j$$

[24] Out of the three common overdispersion tests (Regression based-test, Conditional Moment test and Lagrangian Multiplier Test), regression based test is used for its mathematical convenience as detailed in chapter 3, equations (3-12) to (3-22).

$$= \log \lambda_j + \log u_j, \qquad (6\text{-}1)$$

where the disturbance ε_j reflects either specification error as in the classical regression model or the kind of cross-sectional heterogeneity that normally characterizes microeconomic data. That is, the introduction of u_j means that μ_j in now random variable and u_j is independent from x_j. Then, the distribution of y_j conditioned on x_j and u_j (i.e. ε_j) remains Poisson with conditional mean and variance μ_j :

$$f(y_j / u_j) = \frac{e^{-\lambda_j u_j}(\lambda_j u_j)^{y_j}}{y_j!}. \qquad (6\text{-}2)$$

Given the density function (6-2) of the Poisson distribution, $\Pr ob(\exp(x_i\beta + u_j))$, then given, x_j and u_j, the conditional distribution of $y_j, j = 1,.....,n$ can be represented by

$$\prod_{j=1}^{n} f(y_j / x_j, u_j). \qquad (6\text{-}3)$$

Since the conditional distribution of y_j given x_j is needed, but since u_j is an unobserved random variable, u_j is integrated out to obtain the desired conditional distribution as follows:

$$f(y_j / x_j) = \int_0^\infty \frac{e^{-\lambda_j u_j}(\lambda_j u_j)^{y_j}}{y_j!} g(u_j) du_j \qquad (6\text{-}4)$$

where the *pdf* of u_j is represented by $g(u_j)$. What is needed from (6-4) is a density function for u_j. For mathematical convenience, a gamma distribution is usually assumed for the density of u_j. Hausman, Hall and Griliches (1984) suggested that to simplify matters assume that $s = \exp(u_j)$ has a Gamma $(\alpha, 1/\alpha)$ distribution with *pdf*:

$$\Pr(\exp(u_i) = s) = \frac{s^{(\alpha-1)} e^{-s/(1/\alpha)}}{\Gamma(\alpha).(1/\alpha)^\alpha} \qquad (6\text{-}5)$$

where $\alpha = 1/\eta^2 = \text{var}(\exp(u_j))$ and $E[\exp(u_j)] = 1$. The last term here is achieved when the product of the first and second parameters of the Gamma distribution gives unity[25].

With this normalization, derivation of the pdf for the negative binomial is done by integrating out e^{u_j} as follows. Since $s_j = e^{u_j}$, then using (6-4) and (6-5), obtain:

$$\Pr(Y = y/x) = \int_0^\infty \left\{\frac{s_j^{y_j}\lambda_j^{y_j}e^{-s_j\lambda_j}}{y!}\right\} \frac{e^{-s_j/(1/\alpha)} s_j^{(\alpha-1)}}{\Gamma(\alpha).(1/\alpha)^\alpha} \partial s_j \qquad (6\text{-}6)$$

Rearranging variables in (6-6) gives

$$\Pr(Y = y/x) = \int_0^\infty \frac{s^{(\alpha+y-1)}\lambda^y e^{-s(\mu+1/(1/\alpha))}}{\Gamma(\alpha).(1/\alpha)^\alpha y!} \partial s = \int_0^\infty \frac{s^{(y+\alpha-1)}\lambda^y e^{-s/(1/(\alpha+\lambda))}}{\Gamma(\alpha).(1/\alpha)^\alpha y!} \partial s_j \qquad (6\text{-}7)$$

Multiply and divide (6-7) by $(\Gamma(y+\alpha)(1/(\alpha+\lambda))^{y+\alpha})$ to get

$$\Pr(Y = y/x) = \int_0^\infty \frac{\mu^y\Gamma(y+\alpha)(1/(\alpha+\lambda))^{y+\alpha}}{y!\Gamma(\alpha).(1/\alpha)^\alpha} \frac{s^{(y+\alpha-1)}e^{-s/(1/(\alpha+\lambda))}}{\Gamma(y+\alpha)(1/(\alpha+\lambda))^{y+\alpha}} \partial s_j \qquad (6\text{-}8)$$

Notice that $\int_0^\infty \frac{s^{(y+\alpha-1)}e^{-s/(1/(\alpha+\lambda))}}{\Gamma(y+\alpha)(1/(\alpha+\lambda))^{y+\alpha}} \partial s_j$ integrates to 1 so that (6-8) becomes

$$\Pr(Y = y/x) = \frac{\lambda^y\Gamma(y+\alpha)(1/(\alpha+\lambda))^{y+\alpha}}{y!\Gamma(\alpha).(1/\alpha)^\alpha} \qquad (6\text{-}9)$$

$$= \frac{\Gamma(\alpha+y)}{\Gamma(\alpha)\Gamma(y+1)}\left(\frac{\lambda}{\alpha+\lambda}\right)^y\left(\frac{\alpha}{\alpha+\lambda}\right)^\alpha. \qquad (6\text{-}10)$$

$$= \frac{\Gamma(\alpha+y)}{\Gamma(\alpha)\Gamma(y+1)} r^y(1-r)^\alpha \qquad (6\text{-}11)$$

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25 As in other models of heterogeneity, the mean of the distribution is unidentified if the model contains a constant term (because the disturbance enters multiplicatively) so E[exp(u)] is assumed to be 1.

where $r_j = \dfrac{\lambda_j}{\alpha + \lambda_j}$, which is one form of the negative binomial distribution.
Based on (6-11) the log-likelihood function is given by

$$\ln \Pr(Y_j = y) = \ln \Gamma(\alpha + y_j) - \ln \Gamma(\alpha) - \ln y_j! + y_j \ln r_j + \alpha \ln(1 - r_j) \qquad (6\text{-}12)$$

Notice that since the gamma function of α is given by

$$\Gamma(\alpha) = \int_0^\infty y^{\alpha-1} e^{-y} \partial y \qquad (6\text{-}13)$$

it can be written as

$$\Gamma(\alpha + 1) = \int_0^\infty y^{\alpha} e^{-y} \partial y \qquad (6\text{-}14)$$

Integrating (6-14) by parts gives

$$\Gamma(\alpha + 1) = \int_0^\infty \alpha y^{\alpha-1} e^{-y} \partial y = \alpha \int_0^\infty y^{\alpha-1} e^{-y} \partial y \qquad (6\text{-}15)$$

Using (6-13), (6-15) can be written as

$$\Gamma(\alpha + 1) = \alpha \Gamma(\alpha) \qquad (6\text{-}16)$$

From (6-16), get

$$\Gamma(\alpha + y_i) = \alpha \Gamma(\alpha + y_i - 1) \qquad (6\text{-}17)$$

By recursion (6-17) can be expressed as follows

$$\Gamma(\alpha + y_i) = \prod_{n=0}^{y_i-1} (\alpha + n) \Gamma(\alpha) \qquad (6\text{-}18)$$

Taking logs, get

$$\ln \Gamma(\alpha + y_i) = \ln \prod_{n=0}^{y_i-1} (\alpha + n) \Gamma(\alpha)$$

$$= \ln \Gamma(\alpha) + \sum_{n=0}^{y_i-1} \ln(\alpha + n) \qquad (6\text{-}19)$$

Substituting (6-19) into (6-12), and the following simplified log-likelihood function is obtained:

$$\ln L_j = \ln \Pr(Y = y_j) = \sum_{n=0}^{y_j-1} \ln(\alpha + n) - \ln y_j! + y_j \ln r_j + \alpha \ln(1 - r_j) \qquad (6\text{-}20)$$

Since $\lambda_j > 0$ and $\alpha > 0$, it means that variance is greater than mean so that the negative binomial model in (6-11) allows for overdispersion (Cameron and Trivedi, 1986, 1990). The negative binomial model in (6-11) has conditional mean λ_j and conditional variance $\lambda_j(1 + (1/\alpha)\lambda_j)$. This form of negative binomial is called Negbin II (Cameron and Trivedi, 1986) and maximum likelihood methods are used to estimate the parameters of the model. Gourieroux *et al.* (1980) noted that if the gamma distribution of e^{u_j} is not the correct assumption, Pseudo Maximum Likelihood Estimators (PMLEs) of β should be used because they are consistent as long as the likelihood function is a member of the linear exponential families where the mean $E(Y_j / x_j) = \lambda = e^{x_j \beta}$ is specified correctly. The PMLEs are obtained from maximization of Negbin II, with α set at an arbitrary value.

A variety of negative binomial distributions can be formulated by simply combining the parameters λ and α of the underlying distribution for u_j to the explanatory variables x_j in different ways. The most important consideration is to ensure that the mean is nonnegative, for example by choosing an exponential function.

It is also possible to obtain a variety of variance-mean relationships, letting $\alpha = (\frac{1}{\theta}(\exp(x_j \beta))^c$, where c>0 and θ is an arbitrary constant. As in Cameron and Trivedi (1986), the variance is given as $Var(Y_j) = \exp(x_j \beta) + \theta \exp(2 - c) x_j \beta) = E(Y_j) + \theta(E(Y_j))^{2-c}$. When c=1 the $Var(Y_i) = (1 + \theta) E(Y_i)$, which is what Cameron and Trivedi called Negbin I. Negbin II is obtained by assuming that c = 0. As a result, in the Negbin II model, $Var(Y_i) = E(Y_j)(1 + \theta E(Y_j))$. Negbin II (log-likelihood function given in (6-20)), which is applied in this study, assumes that the variance-mean ratio is linear in the mean (Cameron and Trivedi, 1986). This model was also used by Hausman *et al.* (1984) to analyze the relationship between patents and R & D expenditures, and by Mangisoni (1999) to identify the key factors that influence the speed of erosion-control technologies in Malawi.

Using the maximum likelihood function given in (6-20), the negative binomial model is fitted into the groundnut technology data for 1999/2000 growing seasons in Malawi. Table 6.10 summarizes the parameter estimates.

Table 6.10: Maximum likelihood parameter estimates of the negative binomial regression model

Explanatory Variable	Coefficient (Std. Error)	t-ratio	ρ-value	Mean of Explanatory Variable
Constant	-8.5172** (1.8132)	-4.70	0.0001	-
Farm size (FMSZ)	1.9459** (1.0656)	1.83	0.0168	0.4696 hectares
Education (EDU)	-1.6094** (1.0934)	-1.47	0.0035	4.105 years
Farmer experience (FEXP)	0.4055 (0.9122)	0.44	0.1650	26.59 years
Family Labour (FLAB)	-1.3863** (0.7893)	-1.76	0.0196	203.50 person-day/ha
Off-farm income (OFFINC)	1.0986 (1.536)	0.95	0.085	MK537.97
Extension Visits (EXVT)	1.2528** (0.8012)	1.56	0.0297	1.882 number of contacts
α	0.0725 (0.0219)	3.311	0.00025	-
Log-likelihood	-	-102.13	0.0000	-
The dependent variable was log of the number of years taken to adopt groundnut technology (YADOPTGT)				

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)
** statistically significant at the 5 percent level.
Note: Figures in parentheses are standard deviation error.

Farm size, education, family labour and number of extension workers contact (visits) are significant at the 5 percent level, while farmer's experience and off-farm income are not statistically significant.

Unlike other technologies (ridging, soil conservation, rotation, etc.), the high yield technology (CG7 variety) does not take up a considerable amount of farm area. As postulated, the relationship between farm size (FMSZ) and YADOPTGT has the right sign (positive) and significant at 5% level. This implies that the land scare farmers adopted the seed technology at least equally (if not faster) than the land abundant farmers in central Malawi.

Notice that the average land size of those adopted this technology is 0.47 hectares far less that the overall average land size of 2.35 hectares.

In addition, the analysis showed that a unit increase in the total farm size of the farmer would decrease twice more likely the adoption of CG7 groundnut technology in the area. Since most average farmers with larger farms prefer to grow most profitable cash crops such as tobacco in the region in contrast to land abundant farmers who would diversify with other crops. These results differ from Hossain and Crouch (1992) who emphasized that land empowers farmers to have the ability and resources to adopt a new variety since land is surrogate for a larger number of factors that have important bearing on the adoption decision.

As hypothesized, the parameter estimate for education (EDU) has the right sign (negative) and significant at 5% level. This result implies that education of the household head was influential in the farmer's adoption behaviour and contributing to increasing speed of adoption. With no surprise, this result is similar to Feder *et al.* (1985) and Kisyombe (1998) who reported that education was positively, and significantly related to adoption of hybrid maize in Malawi.

However, the result in this study indicates that the entire sample of farmers in central Malawi was composed of individuals with an average of 4.1 years of education and average age of 46.3 years. Since most farmers were with incomplete primary education level and past the formal education age, the utilization of other forms of training through Ministry of Agriculture and Irrigation, NGOs, ICRISAT and private companies (National Seed Company of Malawi) would alleviate the problem of lack of information. The government agencies and NGOs who are formally involved in farm and seed variety technologies may help to create more awareness among the farmers regarding the advantages (or sometimes the disadvantages) of the new farm technology in the country.

In addition, encouraging and helping farmers to participate in farm programs such Small Scale Seed Programs (SSSP) may increase the likelihood of a farmer to adopt the new seed technology. Possibly because farmers who are involved in the program may have first hand information about the seed varieties, as well as, encouragements from extension workers to adopt the recommended variety. In Malawi, most new seed varieties of different crops were usually disbursed through SSSP to its members. This might have increased the probability of having access to CG7 groundnut variety, and farmers having almost free chance of experimenting and adopting the new groundnut technology as oppose to farm credit institution who expect exorbitant interest rates, which create fear among the smallholder farmers.

The parameter on farmer experience (FEXP) is not statistically significant, but has positive sign implying that the farmers did not have good

experience with the new CG7 seed technology. Perhaps, the influence of experience on technology adoption depends on whether the new experience fits the existing situation, whereby CG7 replaces the local variety (mostly favoured Chalimbana variety) with more advantages including good taste and local market appeal. As seen in Table 6.8, most farmers preferred groundnut with good taste, market appeal, early maturity and high yield characteristics (in order of preferences). Even though CG7 is known for its high yield characteristics but not for its taste and local market appeal, farmers had still appeared to have less appeal for the new seed technology in the region. Note that this was expected since the sample comprised generally old members of the population, who might not easily accept or adopt the new technology. In fact, this finding agrees with the result that the average number of years it has taken to adopt the CG7 groundnut technology is about 6.4 years since its introduction in 1990 in central Malawi.

As postulated, the result on family labour (FLAB) provides that labour is statistically significant at 5% level, and has the right sign (negative) implying that labour is a major factor in adopting the new groundnut technology. Since groundnut is labour intensive cash crop, it requires more labour for planting, frequent weeding, ridging and harvesting. The variation in labour supply in the survey area was, however, very little as almost all households used family labour, not hired labour in their farms. On the other hand, of the total average labour, 253.38 persons-days per hectare (Table 5.2), required for all sorts of farming activities, it is found that over half of this labour requirement (203.50 person-days per hectare) would be used for groundnut cultivation. Thus, the negative relationship between labour (FLAB) and number of years to adopt the groundnut technology (YADOPTGT) implies that it takes more years to adopt groundnut technology as family labour is allocated to other essential crops such as maize and off-farm employment to sustain their livelihoods.

The off-farm income (OFFINC) parameter is not statistically significant, but it has positive sign (not as postulated) indicating that off-farm income is not a major factor in adopting the CG7 technology. Perhaps, most farmers allocated their extra small income to other essentials, and less likely to the new seed variety since most farmers found seeds were unaffordable (Table 5.3, chapter 5) as ADMARC and private traders were monopolizing the market. As noted earlier in Table 5.3 (chapter 5), 67.8% of the farmers found that the groundnut seeds were unaffordable, and perhaps that the new seed variety was more capital intensive for the farmer to grow as so many other crops were cheaper comparatively. It was discovered that the need for working capital to cultivate a given amount of land was higher for the new groundnut variety as the demand for other competing cash crops such as hybrid maize (less expensive and less labour intensive), which had a significant influence on

the adoption behaviour of smallholder farmers. As some of non-leguminous crops (like hybrid maize) were cheaper, the tendency of spending extra cash on such less expensive alternative crops might indirectly increased the number of years of adopting the new groundnut technology in the region.

Finally, the parameter estimate of extension visits (EXVT) is statistically significant and has the expected sign (positive). This suggests that extension programs were important in adopting groundnut technology. Contacts with the smallholder farmers create awareness while frequency of contacts (number of visits) between the field assistants (or extension workers) allows for the timely provision of solutions to farmers problems to reduce the impact of negative experiences.

As indicated in chapter 5, it is impressive to note that 88.5% of the farmers had some kind of contact with the field workers. About 60% of the farmers had said that they made contacts 1 to 2 times per year, while 31% said 3 to 4 times and 11.5% of the farmers made more than 5 times contacts with the extension workers in the area.

Given the inadequate number of extension workers for the region, some farmers had made enough contacts for the 1999/2000 seasons, but the extension services did not make tremendous effects on groundnut production, perhaps due to lack of enough information on groundnut production coupled with some environmental and economical constraints discussed before. In addition to the parameter estimate (EXVT) given in Table 6.10, this result was in line with the earlier finding that extension workers contacted the farmers on average only once regarding groundnut technology of the average 4 times contacts made per year for the 1999/2000 seasons.

Of paramount importance, the negative binomial regression results revealed that to accelerate adoption of groundnut technologies, education, family labour, farm size and extension services (number of contacts) should be the prime considerations. Through, improved extension services it is possible and essential to formulate special session about the new technologies, and transmit the new and improved groundnut production techniques from the research and government institutes to the smallholder farmers. As a two-way communication, extension contacts are of paramount importance to communicate experiences and problems of farmers to researchers to seek solution to the existing problems or for refinement of existing technologies in compatible to the local needs.

QUALITATIVE MODEL

This section examines farmers' perceptions of adopting the four main farming systems or technologies, namely, intercropping, ridging, improved seed

central Malawi region.

For better understanding of the difference between the technology categories, efforts were made to compare characteristics of farmers across the technologies through logistic regression model for each technology. Emphasises were placed on education, off-farm income, extension services, household head type (sex), access to farm credit, land size, family labour and farmers farming experience. Most of these characteristics were used in the previous Poisson model, but now qualitative model is used in order to investigate factors that influence the willingness of farmers to adopt a technology or technologies thereby to reach to objective 4 (chapter 1) of this study.

Logistic Regression Model

The adoption of a farm technology - intercropping, ridging, improved seed variety or rotation – is considered as a dichotomous dependent variable that is influenced by some explanatory variables (socio-economic characteristics of a farmer). As discussed in Maddala (1988, 1992) and Amemiya (1981), the probit or logit model is to assume that there is an underlying response variable y_j^* defined by the regression relationship

$$y_j^* = \beta' x_j + u_j \qquad (6\text{-}21)$$

in practice, y_j^* is unobservable. What is observed is a dummy variable y defined by

$$y = 1 \text{ if } y_j^* > 0 \text{ (adopting a farm technology)}$$
$$y = 0 \text{ otherwise (not adopting a farm technology)} \qquad (6\text{-}22)$$

The explanatory variables (x_j) considered were education, off-farm income, extension services, household head type (sex), access to farm credit, land size, family labour and farming experiences.

Empirical evidence suggests that neither logit nor probit model have superiority over the other. The choice becomes a matter of preference (Gujarati, 1988; Maddala, 1988). Because of its computational and mathematical conveniences, the logistic regression model was used to obtain estimates of the factors that influence adoption of a farm technology

(intercropping, ridging, improved variety or rotation) in groundnut farming areas in central Malawi.

Table 6.11 summarizes univariate logistic model parameter estimates for each farm technology stated previously.

The log likelihood value for each model fitted to a farm technology is greater than the chi-square critical value of 3.84, and hence each model has been adequately fitted the farm survey data for 1999/2000 growing seasons in both Lilongwe and Salima ADDs.

Table 6.11: Parameter estimates for each groundnut technology

Variable	Adoption of Groundnut Technology							
	Intercropping		Ridging		Improved variety		Rotation	
	Est.	t-ratio	Est.	t-ratio	Est.	t-ratio	Est.	t-ratio
Constant	-3.5048 (1.381)	-2.528	-1.1649 (1.854)	0.63	2.8276 (1.848)	1.5301	-0.9036 (1.318)	-0.685
EDU	0.2162 (0.098)	2.206*	-0.007 (0.124)	-0.06	0.113 (0.159)	0.7107	0.1171 (0.095)	1.233
FEXP	-0.0003 (0.032)	-0.009	-0.076 (0.056)	-1.36	0.1127 (0.053)	2.126*	-0.038 (0.034)	-1.117
FLAB	-0.0026 (0.002)	-1.3	-0.001 (0.023)	-0.04	-0.003 (0.027)	-0.111	0.0049 (0.002)	2.000*
EXVT	1.6268 (0.401)	4.056*	0.1183 (0.483)	0.255	2.1588 (0.583)	3.703*	0.411 (0.351)	1.171
OFFINC	-0.0005 (0.001)	-0.5	0.0009 (0.009)	0.1	0.002 (0.001)	1.000	0.0018 (0.001)	1.800
FMSZ	0.6028 (0.360)	1.674**	0.1034 (1.853)	0.056	-0.477 (0.601)	0.793	0.904 (1.318)	0.685 8
-2 log likelihood	101.494		61.099		43.445		98.855	

Source: Bunda/Norwegian Initiative Farm Survey 1999/2000 (own calculations)
* significant at 5% level; ** significant at 10% level; Est. = Coefficient estimates
Figures in parentheses are standard errors

Intercropping – willingness to adopt intercropping groundnut technology is influenced by education, number of extension visits and farm size. All these three socio-economic characteristics of a farmer are positive and statistically significant at 5% and 10% level of significances as shown in Table 6.11. Therefore, it is concluded that these were the main factors that more likely

influenced the willingness of farmers to adopt intercropping groundnut farming system in the areas.

Though farmers' perceptions were influenced by these three socio-economic characteristics discussed earlier, farmers ought to adopt the technology taking into consideration the yield advantage of intercropping groundnut with main crops such as maize. For example, in 1980s studies (Edje, 1981) involving a single row arrangement experiment with groundnut/sorghum intercropping showed significant advantage (an average of 43% over the sole crop), but significant yield disadvantage involving groundnut/maize (-9%). Thus, the more the farmers were aware of different scenarios of intercropping through extension services from research institutes, the more they were willing to adopt the new technology.

Ridging – none of the socio-economic characteristics considered were significant in influencing farmers' perceptions in adopting ridging technology in the study areas. However, the coefficient estimates for extension visits, off-farm income and farm size are positive, while education, farmers' experience and family labour are all negative. With increasing farmers' education, farm experiences and labour, the more farmers likely to adopt the ridging system as required.

It was no surprise to find out that adopting of ridging farming system was not significantly influenced by the these socio-economic characteristics in the areas. There was no tendency of not practicing ridging system as if it were a new technology since ridging is already a common practice for all types of crops including groundnuts in the region. However, what matter is the recommended distance between the ridges, which most farmers were not aware of it and its impact on farm production. Under good management condition, optimal plant population was 60,000-90,000 plants per hectare for all recommended groundnut varieties at 90 cm between ridges, and a population of 111,00 plants per hectare at 60 cm between ridges (Nyirenda *et al*., 1992). Furthermore, sowing a single seed per hill results in slightly lower yield than sowing two seeds per hill (Brown, 1965); however, no significant difference in yield was obtained for the Chalimbana variety using one or two seeds per hill (on one or two rows per ridge at either 70 cm or 90 com between ridges).

Improved Variety - the logit analysis has shown that positive and significant relationship between improved seed variety and explanatory variables (extension visits and farmers' experiences). The more the farmers had farming experience the more likely the farmers adopted the improved seed technology. This also mainly depended on the number of contacts the field workers had made with the farmers. Through extension services new technology

information would be disseminated to the farmers, and the involvements of government agencies and research institutes to experiment the new seed variety might enhance the confidence the farmers to experiment and adopt the new seed variety.

Education of the head of household and the level of off-farm income for the farm household were found positive but not statistically significant in this study. This implies that education of the head of household and the level of off-farm income for the household was influential in the farmers' adoption behaviour of the new groundnut variety but their impact was not significant. In this study, the non-significant results differ from Feder *et al*. (1985) and Kisyombe (1998) who found that education was related positively and significantly to the farmers' adoption behaviour of hybrid maize variety in Malawi.

Rotation – the relationship between rotation and family labour was found to be statistically significant at 5% level. This result may suggest that the larger the family size, the more the family labour is available, and hence more likely in favour of adopting crops rotation within the farming fields. Other socio-economic factors were found to be insignificant, however, education, off-farm income, extension visits and farm size were positively associated with adoption of rotation farm technology, while farmer's experiences was negatively associated; perhaps the older the farmer, the less likely to use crop rotation method. It is important to note that with average land size of two hectares, most farmers tend to focus on the staple food rather than rotating crops with groundnut, which is less profitable than maize and tobacco since market prices are low as usual. On the other hand, farmers were aware that rotation with groundnut would benefit in soil fertility (nitrogen fixation), and the maximum safe frequency of a cropping system that includes groundnut in a rotation was found to be 1 year in 3 at Chitedze Research Institute (ICRISAT, 1992) in Malawi.

In a nutshell, analysis of fitting logistic regression model to each the four technology has revealed that the most influential socio-economic characteristics in adopting intercropping, improved seed variety and rotation farming technologies were education, extension visits, farm size, family labour and farmer's experience in central Malawi.

CONCLUDING SUMMARY

Improvements in productivity could be realized through adoption of new farm technologies such as seed variety. This chapter has examined how socio-economic variables affect the adoption of groundnut technology or sometimes

referred as improved farming systems. The technologies considered were intercropping, improved seed variety, ridging and rotation in both Lilongwe and Salima Agricultural Development Divisions in central Malawi region.

Descriptive analysis revealed that over 85% of smallholder farmers who adopted a farm technology or combination of technologies were in the age group 31-60 years, however, over half of these farmers had mostly adopted intercropping as land is scare in the region. Regardless of education level of the household heads, though a quarter of the farmers were illiterates, most farmers adopted intercropping, following by rotation, improved seed variety and ridging system. On the other hand, regardless of the type of farm technology adopted, about 70% of the farmers had preferred to grow the local groundnut variety (chalimbana), compared to the new high yield CG7 groundnut variety introduced in 1990. The main reasons given were that chalimbana was tastier (used as relish and source of nutrition) and had more market appeal locally, even though CG7 was known for its high yield characteristics. These results support hypotheses 4 that was posited as improved variety (CG7) is not significant in groundnut production at the household level.

The roles of socio-economic factors were examined in order to identify which of these factors influence the farmers' willingness in adopting a farm technology. Of paramount importance, the negative binomial regression (derivative of Poisson model) and the logistic regression estimates indicated that education, family labour, farm size, farmer's experience and extension services (number of contacts) had accelerated the adoption of groundnut technologies in central Malawi. Of prime considerations, however, extension services were essential in promoting more about the new farm technologies.

Generally, the results imply that increasing the number of contact hours to transmit the new and improved groundnut production techniques from the research and government institutes to the smallholder farmers is a key factor. To effectively cultivate the scarce land available, a two-way communication should be created, that is, extension contacts to communicate experiences and problems of farmers to researchers to seek solution to the existing problems, as well as, for refinement of existing technologies in compatible to the local needs and requirements.

CHAPTER VII

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY, OBSERVATIONS AND CONCLUSIONS

This groundnut research is in global constraint area of socio-economic forces, which specifically has addressed the priority opportunities defined as the role of groundnut in rural household structure and the socio-cultural context of produce use within Malawi's subsistence economy. To understand the dynamics of groundnut production in Malawi, the areas of study were developed in reference to a set of differentiating social factors identified as non-physical factors (household type, gender, education, etc.), as well as, physical or economic factors such as land size, labour, seed density and farm technologies.

Grain legumes are important components of Malawi's maize based farming systems, and the study has shown that such crops contribute to sustainable agricultural development, as grain legumes are the future crops and replacing tobacco as a backbone of the economic. To examine the roles of grain legumes and specifically groundnut production its intra and inter household transactions in Malawi, the following specific objectives were undertaken.

The specific objectives of the study were (1) to identify differences in access to labour, land and other resources to groundnut production by gender, household type, education, farmers' experiences, farm credit packages and farm organizations, as well as market exchanges with implications of groundnut output, (2) to find out major determinants of technical efficiency in groundnut production, and construct groundnut enterprise budgets to compare relative profitability of groundnuts with tobacco and other grain legumes, (3) to measure gender differential in groundnut productivity and profitability in the context of changing agricultural policies, and (4) to analyze factors influencing adoption of technologies such as CG7 improved variety, rotation, ridging and intercropping.

The hypotheses posited for the study were (1) socio-economic variables (non-physical factors) do not determine the dynamics of groundnut production, inter-household and intra-household transactions, (2) groundnuts are not profitable compared to competing cash crops (soyabean, pigeon pea, and tobacco) grown after maize in the country, (3) there is no gender

variety (CG7) is not significant in groundnut production at the household level, and (5) the improved farming systems (intercropping, ridging and rotation) do not affect groundnut production at smallholding farms.

To achieve these objectives and test the hypotheses, a cross-section data of 200 farmers were collected through multistage stratified sampling for interview from Lilongwe and Salima ADDs in central Malawi, where over 70% of groundnut production is taking place in the country.

The socio-economic demographic characteristics in Lilongwe and Salima ADDs had indicated that most farmers were growing tobacco and grain legumes grown as main cash crops after maize in the 1999/2000 growing seasons. Of the main grain legumes grown in the two ADDs, groundnut was the most preferred cash crop to soy, pigeonpea and others such as beans and potatoes.

Of paramount importance, the socio-economic factors played major roles in the groundnut production in the two agricultural development areas. Farmers in the age group 20-49 years provided most of the farm labour, indicating higher labour supply potential in the farm activities in both ADDs. Most farmers (63.5%) had primary level education, which is regarded as adequate level of education for an individual to read and write without difficulties in Malawi. With slightly higher rate, but not statistically significant difference, female grew more groundnut than men in the areas.

Of the average land holding size of 2.35 hectares, the average farm size allocated to groundnut is about 0.41 hectares (i.e. about 20% of the average size), which tobacco and maize took the remaining farm fields. As expected most of the land (88.5%) was acquired through inheritance, as matrilineal marriage system is predominantly practiced in central Malawi region.

It was also found that most farmers grew groundnut because of food and cash requirements, but also more farmers realized the importance of grain legumes such as groundnut as soil fertility improvements. It was noted that most farmers grew groundnut and tobacco for over 10 years, and the majority had used farm credit (cash or in-kind) mainly for tobacco production but not for groundnut. There were virtually no provisions of farm credits specifically designed for groundnut farmers.

In Chapter 4, it was also observed that farmers in Lilongwe Agricultural Development Divisions grew more groundnuts than their counterpart (Salima ADD), but with no statistically significant difference between the two ADDs at $\rho < 0.05$.

Chapter 5 examined the determinants of groundnuts production, technical efficiency, profitability and gender differential in groundnuts productivity. Of the socio-economic factors investigated land, labour and seed density inputs implied diminishing returns, as the elasticities are between zero

... that only physical factors such as land, labour and seed density (proxy to capital) significantly determined groundnut production. On the other hand, the non-physical factors age, household type, education level had shown some relationship with groundnut yield, but do not determine the dynamics of groundnut production in smallholder farms in Malawi.

Of the physical factors used in the model, it was only land and seed density (proxy to capital) were found statistically significant in determining *technical efficiency* in smallholder farms. Similarly, it was also found that access to farm credit (whether a farmer received agricultural credit) and adoptions of technology (using farm technologies including seed variety) were the only two non-physical factors that determinant groundnut production in the study area.

The analysis revealed that groundnut is relatively more profitable compared to pigeon pea and soyabean at the current input and output prices, as well as, productivity levels of grain legumes. Groundnut gave the highest gross margin per hectare, the highest returns to factors of production than other grain legumes mainly grown after maize. Given these results, the hypothesis that groundnuts are not profitable, compared to the competing cash crops (soyabean, pigeonpea), is rejected. Therefore, it is possible to say that comparing to other cash crops, and given the full potential and opportunities for smallholder farmers in the central region, grain legumes are the best alternative cash crop in replacing tobacco as foreign exchange earner.

The restricted C-D function had shown that gender differentials in groundnuts productivity exists among the smallholder farmers with women producing slightly higher than men because of the intensity of labour they applied in their farm fields closer to their dwellings. The econometric evidence that factors of production were not efficiently allocated across plots controlled by female and male farmers presented production losses with respect to intensities with which inputs were applied. Controlling for fine variations in plot characteristics such as unobserved land quality and other non-socio economic characteristics (morphological characteristics such as seed size), it can be concluded that there is gender differential in groundnut productivity in Malawi, but with no statistically significant difference between male and female farmers.

Most of the focused group discussion results had also been reflected in the quantitative analysis, except that small farmers proposed to have lenient farm credits to finance their farming activities. Both the qualitative and quantitative analyses revealed that the major constraints in efficient groundnut production were low producer prices, high input prices, poor coordination between research institutes and farmers (lack of dissemination of new research information), weak government policy in implementing and addressing

levels.

Improvements in productivity could be realized through adoption of new farm technologies such as seed variety. Chapter 6 had examined how socio-economic variables affect the adoption of groundnut technology or sometimes referred as improved farming systems. The technologies considered were intercropping, improved seed variety, ridging and rotation in both Lilongwe and Salima Agricultural Development Divisions in Central Malawi region.

Descriptive analysis revealed that over 85% of smallholder farmers who adopted a farm technology or combination of technologies were in the age group 31-60 years, however, over half of these farmers had adopted specifically intercropping as land is scare in the region. Regardless of education level of the household heads, though a quarter of the farmers were illiterates, most farmers adopted intercropping, following by rotation, improved seed variety and ridging system. On the other hand, regardless of the type of farm technology adopted, about 70% of the farmers still prefer to grow the local groundnut variety (chalimbana), compared to the new CG7 variety (which is high yield variety) introduced in 1990. The main reasons given were that chalimbana was tastier (as a source of nutrition) and had more market appeal locally; though CG7 is known for its high yield characteristics.

The roles of socio-economic factors were examined in order to identify which of these factors influence the farmers' willingness in adopting a farm technology. Of paramount importance, the negative binomial regression (derivative of Poisson model) and the logistic regression estimates indicated that education, family labour, farmer's experience and extension services (number of contacts) had accelerated the adoption of groundnut technologies in central Malawi.

RECOMMENDATIONS AND POLICY IMPLICATIONS

The study has shown the importance of grain legumes, especially groundnut, in Malawi. However, the following constraints were observed so that improvements could be made through coordination and policy interventions. As such, the following recommendations were drawn from the lessons learned in the analyses.

Groundnut Research and Marketing Activities

Most people feel that groundnuts are low income crops compare to tobacco, which has higher producers prices in the market. Such marketing constrains

... to allocate less land to groundnuts. Thus, the government should intervene through pricing policy in order to increase producers' prices for groundnut, as well as, teach entrepreneurial skills with agribusiness strategies and provide start-up financial help to create micro-enterprises, which aims at profit maximization at households level.

The study has discovered that there is lack of incentives for promotion of groundnut production. There are virtually no credit packages specially designed for promotion of groundnut production. Government agencies and farm credit institutions should nullify the collateral system of lending loans as most smallholder farmers do not have assets that could be used as collaterals. Thus, government agencies along with the credit institutions should create farmers cooperatives and farm clubs within the farming communities that will be accountable for the loans the farmers receive. Or, create some kind of income generating activities, which could fund the groundnut farming with revolving fund obtained from the profits.

It was also observed that seed source was a major constraint. Seed was expensive for almost all the smallholder farmers. Most farmers recycled the seed that might have resulted in low production because of recurrence of seed borne diseases and pests, which resulted in early seedling deaths and hence low plant population that resulted in low yields and poor quality. Again, research institutes and government agencies should teach farmers how to prevent the recurrence of disease and produce high quality crops by disseminating enough information and improved seed varieties to the communities.

On the gender issue, since more women were already involved in groundnut production, it is important to encourage women groups in the production that would even help improve household income and nutritional status of the household. This could be done through seed multiplication scheme involving women groups, as more women view groundnut is simple to grow within the proximity of their dwellings. Encourage NGOs to get involved in seed sector and training of women and the community at large to be self-reliant. In addition, government agencies, research institutes and NGOs should liaison with private companies to supply seed to the farmers such that the farmers would be required to grow the company's requested variety, which could be on high demand at the local and international markets.

Management Practices and Extension Services

According to the farmers, there were no special extension packages for the groundnut, but were mainly tobacco and maize. Of prime considerations, extension services were essential in promoting the new farm technologies. The

results imply that increasing the number of contact hours to transmit the new and improved groundnut production techniques from the research and government institutes to the smallholder farmers is a key factor. Create a two-way communication between farmers and researchers, whereby extension workers communicate experiences and problems of farmers to researchers to seek solution to the existing production problems. Or, for refinement of existing technologies to be compatible to the local needs thereby effectively cultivating the scarce land available in the region for maximum yield.

Taking farmers' concerns into consideration, researchers, government agencies and private organizations should relate their dissemination of technology information, as well as, adopt them in relation to farmers' specified set of characteristics that farmers choose to apply according to their needs.

Participatory Research Discussions

The farmers had a variety of recommendations and suggestions for all stakeholders in groundnut production. Among several suggestions, the following were given as major suggestions if government agencies, research institutes and private companies want to improve smallholders' livelihoods.

1. Government should foster partnership between farmers and businesspersons based on mutual interest and dependency. Linking smallholder farmers with markets will require partnership with the private sector because businesspersons know what the market wants. Thus, producers' prices could be improved on mutual basis.
2. For researchers, the major lesson is that researches must not only be oriented as production-led but also be consumer-led. New production technology cannot be developed in isolation from the market. This means that researchers must pay more attention to the place of technology in the enterprise web and innovation of farmers.
3. Grain legumes as soil fertility strategies, the same principle applies. The history of soil fertility and conservation in Malawi during the colonial era illustrates the futility of imposing technology on farmers in the absence of economic incentives. The experiences of Machakos in Kenya shows that environmental recovery is possible provided that market developments make farming profitable (Tiffen et al., 1994). New technology, in this case, may look profitable when compared to other food crops that are grown for sale. However, all the characteristics (advantages and disadvantages) of a new technology must be explained to the farmers so that they would not have fear

about the technology. This might be a possible reason for low adoption rate of CG7.

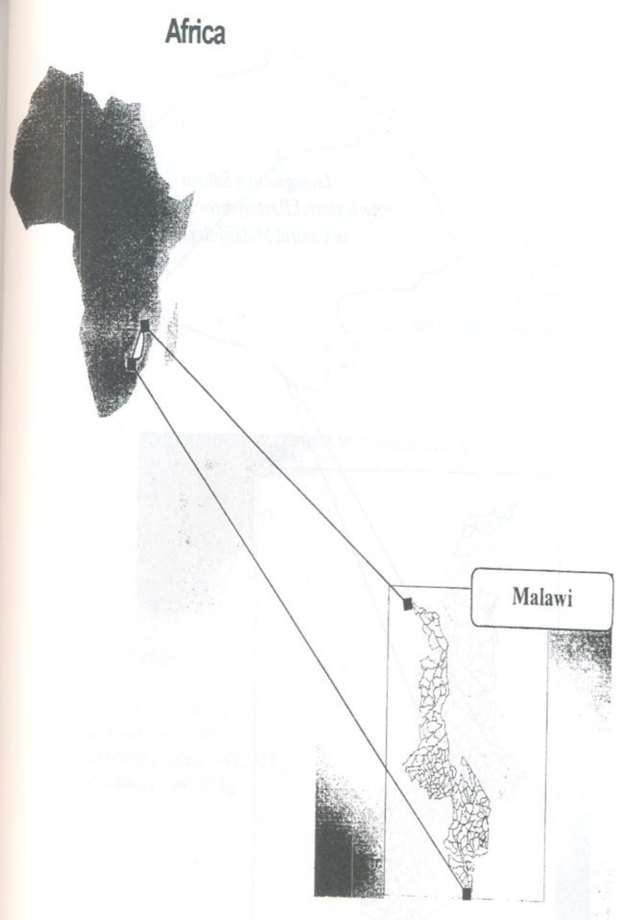
4. The underlining problem to all low farm productivity and poor economic activity is poverty. In a broader prospective, government should put in place implementable mechanisms that can create self-reliant environment so that the farmers themselves can eradicate dependency syndrome and poverty, in general.

There is
a widespread willingness
among farmers throughout the
SADC region
to test new and improved
cultivars, but adoption is
constrained by cash and/or seed
availability.

- D. J. Marais and K. Morrow

APPENDICES

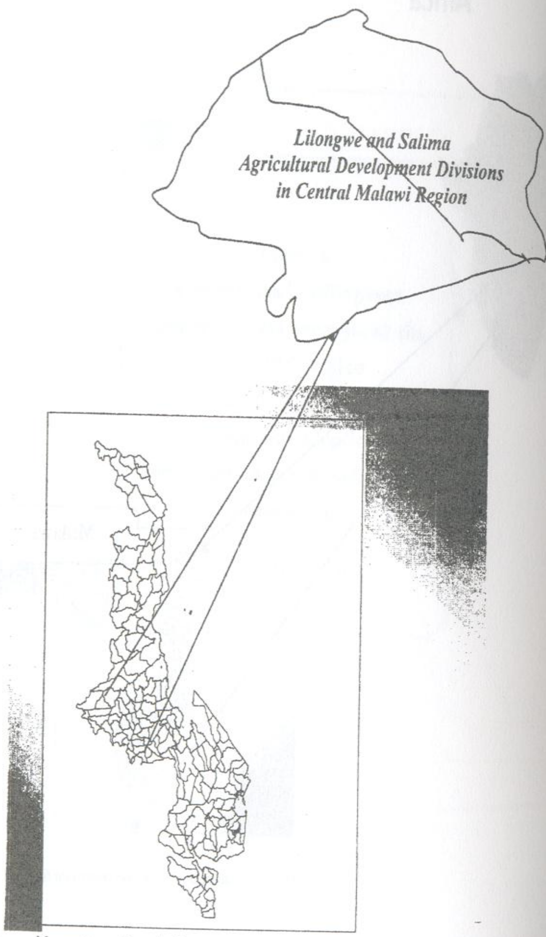
APPENDIX 1: MAP OF AFRICA AND MALAWI



Map not to scale and refer to chapter one for text detail.

APPENDIX 2: MAP OF CASE STUDY AREAS

LILONGWE AND SALIMA
AGRICULTURAL DEVELOPMENT DIVISIONS (ADDs)



Map not to scale and refer to chapter one for text details

APPENDIX 3: MEASUREMENT CONVERSIONS

Labour Measurement – Person-days per month

Table 3A: Labour conversion Scale to person-days per month

Labour Class	Age (years)	Person-units	Equivalent Person-days/month
Small child	Less than 7	0.0	0
Big child	7 – 14	0.4	10
Active male adult	15 – 64	1.0	25
Active female adult	15 – 64	0.8	25
Male adult	65 or more	0.5	12.5
Female adult	65 or more	0.5	12.5

Adopted from D. T. Johnson (1990), The Business of Farming. A Guide to Farm Business Management in the Tropics. Pp. 22 – 221.

Unit of Measurement from local units to international units

Area

1 hectare (ha) = 2.47 acres

Other Equivalents

1 ox-cart maize = 318.50 kg
1 ox-cart groundnut = 350 kg
1 ox-cart (sweet potatoes) =452.52 kg
1 ox-cart cassava = 696.00 kg

APPENDIX 4: SEED AVAILABILITY DETAILS

Table 4.0A: Percent distribution of seed availability

Availability	Main crops grown after maize					Total
	Soya bean	Groundnut	Pigeonpea	Tobacco	Others	
Available	6.4 (12)	29.1 (55)	7.4 (14)	26.5 (50)	4.2 (8)	73.5 (139)
Scarce	3.1 (6)	9.0 (17)	0 (0)	12.2 (23)	2.1 (4)	26.5 (50)
Total	9.5 (18)	38.1 (72)	7.4 (14)	37.7 (73)	6.3 (12)	100 (189)

Numbers in parenthesis are sample size for the given category

Table 4.1A: Percent distribution of seed source

Source	Main crops grown after maize					Total
	Soya bean	Groundnut	Pigeonpea	Tobacco	Others	
Own	4.8 (8)	24.0 (40)	6.6 (11)	27.5 (46)	3.6 (6)	66.5 (111)
Buy	3.6 (6)	9.6 (16)	1.2 (2)	8.4 (14)	1.2 (2)	23.9 (40)
Relative	0.6 (1)	2.4 (4)	1.2 (2)	1.2 (2)	0.6 (1)	6.0 (10)
Free	0.6 (1)	0 (0)	0 (0)	2.4 (4)	0.6 (1)	3.6 (6)
Total	9.6 (16)	35.9 (60)	9.0 (15)	39.5 (66)	6.0 (10)	100 (167)

Number in parenthesis are sample size for the given category

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