AN ANALYSIS OF THE RETURNS TO ADOPTION OF AGRICULTURAL TECHNOLOGIES IN SOUTH WESTERN KENYA

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ABSTRACT

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In Kenya, there is an understanding that good research has been done and that beneficial new agricultural technologies have been identified. What remains unclear is the extent of adoption and the returns that accrue to the adoption of new agricultural technologies particularly among the smallholder farming systems. The main objective of this thesis was to identify the determinants of adoption and the returns associated with new agricultural technologies and then assess their impact on the smallholder farm household food security in the study area. A socio-economic profile of the farmers was established as a basis to provide an insight into the similarities in organization, management, actual economic performance, and regional disparity. A non-parametric analysis was done to ascertain the perception and opinion of agricultural researchers and practitioners as well as their ranking of various agricultural information sources, patterns of response to questions raised, and the significance of the different patterns.

For identification of adoption determinants, contingency tables and odd ratios of technology adoption in the study area were calculated. The cross-tabulation presented two distinct technologies, which are treated dichotomously. The odd ratio is the product of the on-diagonal cells divided by the product of the off-diagonal cells. A higher ratio indicates that farmers are likely to simultaneously adopt or reject a given pair of technologies.

Food security was measured in terms of maize equivalent which estimates that 270 kg of maize, that is, 3 (90 kg bags) per capita as the threshold for hardcore poverty line. By the same token, 440 kg, which translates to 4.89 (90 kg bags) of maize was the minimum amount required per capita per year for a person to be food secure, or enjoy normal livelihood. The returns to adoption of new agricultural technology in the study area was therefore, assessed using the threshold production requirements for food security. The results of the analysis of the vulnerability status of population groups based on the Maize Equivalent ranking was based on major food crops produced in the study area.

Results

A socio-economic profile of the smallholder farm household in the study area would be described as typically middle aged resource poor male farmer, with primary level of education and a medium size family of between 5 and 10 persons in the household. Respondents' rating of perceived benefits from the different information sources showed a preference for interpersonal sources of communication than mass media type. This was an important finding despite the current trend with emphasis on interactive modes of communication in the wake of retrenchment in the public sector.

The returns to adoption of new agricultural technology in the study area were assessed using the threshold production requirements for food security. The results indicated farmers who adopted farm inputs, for example, improved seeds were more likely to receive higher yields and be more food secure than those who did not adopt. Evidence of simultaneity of technology choices imply that farmers in the study area respond to extension services available in the region and this also underscores the need to design integrated development programmes.

The Current Vulnerability Assessment (CVA) analysis based on the maize equivalent estimates at the Regional level indicated that no district in the sample was food secure. For individual smallholder farmers in the study sample, Rongo zone reported the highest MEQ ranking of 11.74 above the threshold minimum of 7.77 (90 kg bags) of maize required for normal livelihood, or enjoyment of food security. Both Kendu Bay (5.94) and Oyugis (4.93) regions recorded MEQ rankings within a range classified as moderately food insecure, that is between 4.89 and 7.77 (90 kg bags) of maize per capita.

Conclusion

Socio-economic profile of respondents is important for identifying recommendation domains and organization of farm household food security assessment. Interpersonal sources of agricultural information were more preferred than the mass media, implying caution on retrenchment in sectors providing public services such as agricultural extension. Evidence of simultaneity of adoption implied that farmers in the study area respond to extension services available in the region and underscores the need to design integrated development programmes. Regional data analysed for current vulnerability assessment indicated existence of moderate, to high and extreme food insecurity in the study area.

Recommendations

1. Given the current official policy of retrenchment in the public service and emphasis on interactive modes of communication, it would be important to investigate this apparent contradiction between public policy and needs of the people who require public services.

2. Simultaneity of adoption indicated that farmers in the study area responds to extension services available in the region. This underscore need to design integrated (package) approach to agricultural development

3. Need for a more in-depth analysis of the food insecurity status of the region as this may have far reaching policy implications.

DECLARATION

This Thesis is my original work and has not been presented for a degree in any other University.

8/12/08

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This thesis has been re-submitted for examination under the PhD thesis supervisor:

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Professor Chris Ackello-Ogutu Date

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ACRONYMS

AE	Adult Equivalent
AFC	Agricultural Finance Corporation
AFRACA	African Rural and Agricultural Credit Association
ANOVA	Analysis of Variance
ASAL	Arid and Semi Arid Land
BAT	British American Tobacco
CAFBRPH	Calories in Average Food Bundle for Relatively Poor Households
CAFB	Cost of the Average Food Bundle
CBO	Community Based Organization
CCEI-B	Caisse Commune d'Epargne et d'Investment Bank
CGIAR	Consultative Group for Agricultural Research
CVA	Current Vulnerability Assessment
DSS	Demographic Surveillance System
ERS	Economic Recovery Strategy
FARMINCO	Farm Income
FHF	Farm Household Family
FAO	Food and Agricultural Organization
FAOSTAT	Food and Agricultural Organization Statistics
FHS	Farm Household Systems
FSR	Farming Systems Research
FSP	Farming Systems Programme
FSRD	Farming Systems Research and Development
FSRE	Farming System Research and Experimentation
GDP	Gross Domestic Product
GOK	Government of Kenya
HCDA	Horticultural Crops Development Authority
HH	House Hold
HIV/AIDS	Human Immune Virus/Acquired Immune Deficiency Syndrome
IDA	International Development Association
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IFSA	International Farming Systems Association
IPAR	Institute of Policy Analysis and Research
KBL	Kenya Breweries Limited
KTDA	Kenya Tea Development Authority
KPCU	Kenya Planters Co-operative
MEQ	Maize Equivalent
MoA	Ministry of Agriculture

MOARD	Ministry of Agriculture and Rural Development
MSPNDV	Ministry of State for Planning, National Development, and Vision 2030
MSE	Micro-Small Enterprise
MTC	Mastermind Tobacco Company
NARS	National Agricultural Research Stations
NGO	Non Governmental Organization
OFR	On Farm Research
PURCHFER	Purchased Fertilizers
ROK	Republic of Kenya
SACCO	Savings and Credit Cooperative Organizations
TFP	Total Factor Productivity
UNDP	United Nations Development Programme
VAM	Vulnerability Assessment Mapping
WAMCR	World Health Organization Minimum Calorie Requirement
WHO	World Health Organization

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CHAPTER 1

1.0: INTRODUCTION

1.1: Background Information

When considering the problem of economic development and growth, one of the basic realities that must be faced is that a large proportion of the population in developing countries is engaged in a form of small-scale agricultural production and marketing that is characterized by a multitude of constraints and market imperfections. Limited land availability, poor physical and legal infrastructure, high transactions costs and few available and more remunerative livelihood alternatives often lead these rural agricultural households into lives beset by chronic poverty (Abdoulaye, 2002).

Compared to other major regions of the developing countries, Sub-Saharan Africa has had the most rapid growth of population and the slowest growth of food output during the past two decades. This has lead to a dramatic increase in demand for food against a backdrop of insufficient food production which has depended more on growth in crop area and labor force and much less on yield increase compared to other parts of the world. Previous studies on African agricultural development (Jeffrey, 2005; and World Bank, 2000) show that sub-Saharan Africa is characterized by poor and deteriorating performance and little modernization. Expectations were that lower population growth rates should be associated with higher incomes as evidenced in other regions of the world; however, the opposite has been the case in Sub-Saharan Africa. This study was focused on identification of important determinants of adoption of new agricultural technologies by smallholder farm households and then assessing the impact of the returns to adoption on the household food security.

Though technically there is substantial scope for bringing more cultivable land under cultivation, in the majority of cases, it is not economically viable due to lower fertility of the marginal land and higher investment costs. Increase in crop productivity has resulted from what may be grouped under technological changes, which include mechanization of different agricultural operations, use of chemical fertilizers and pesticides, and improved seeds among others. In the livestock sector, increased productivity has been brought about by adoption of improved grade livestock, vaccination, use of accaricides, and dipping.

Trends in the use of agricultural inputs in Sub-Saharan Africa provide clues about reasons for the slow increase of food output in the past two decades and suggest a need for accelerating production growth in the future. Compared to other regions of the developing countries, Sub-Saharan Africa, has little cropped area per worker, little irrigation, and little use of fertilizer and tractors (Ndjeunga et al, 2003).

Table 1.1 suggests an explanation, showing 1961-3 and 1996-8 levels of three key farm technologies: irrigation, fertilisers, and tractors. Their differing spread leads to differing growth in output per worker and/or per hectare. According to Lipton et al (2001), this explanation is proximate since countries, farming systems, innovations, and farm products vary hugely in the ultimate explanations of why technical improvements are adopted, and in the effect of such changes and resulting outputs.

The huge (but shifting) 'agro technology gaps' in Table 1 do not simply and solely reflect (changing) differences in farmers' capacity to generate income per hectare or per hour of work - let alone human development. Local soil, water, prices, and other techniques (new seeds, pesticides) matter too. Table clearly shows that Kenya compares quite poorly with other developing countries such as Brazil and India in the adoption of irrigation, fertilizer consumption, and tractor use over the 1963-96 period implying missed opportunities for increased food production in the face of a relatively robust rate of population growth over the same period.

Table 1.1: Irrigation, fertilisers, tractors: 1961-3 and 1996-8

	Land area arable (m/ ha)		Irrigated area				Fertiliser consumption				Tractors in use			
			m ha		% Area in arable + permanent crops		m tonnes		kg per ha in arable + perm. crops		Thousands		number/000 ha arable crop only	
	1961-3	1996-8	1961-3	1996-8	1961-3	1996-8	1961-3	1996-8	1961-3	1996-8	1961-3	1996-8	1961-3	1996-8
World	1269.7	1379.7	141.7	268.1	11.2	19.4	34.3	136.2	25	90	11866	26243	9.3	13.3
(Developed)	646.8	631.0	37.9	66.3	5.7	10.1	29.9	53.8	45	82	11125	19753	17.2	31.3
(Developing)	622.9	748.7	103.7	201.9	15.2	23.6	4.3	82.4	6	96	742	6496	1.2	8.7
(Least developed)	98.1	121.5	6.0	14.3	5.8	10.8	0.1	2.1	1	16	33	94	0.3	0.8
Asia, developed	6.0	4.9	3.1	2.9	45.2	53.8	1.7	1.6	267	300	20	223	3.4	45.4
Asia, developing	405.4	432.0	88.6	172.4	20.5	33.9	2.7	68.6	6	135	207	4447	0.5	9.8
(China)	103.1	124.1	30.1	51.8	29.5	38.3	1.0	35.5	9	262	56	699	0.5	5.6
(India)	156.7	161.6	25.1	57.0	15.5	33.6	0.4	15.8	3	93	35	1447	0.2	9.0
Africa, developing	129.1	162.6	6.6	11.1	3.5	6.0	0.5	2.9	4	16	116	452	0.9	2.8
Africa, S. of Sahara	108.9	138.4	2.7	5.2	2.3	3.3	0.2	1.3	1	7	54	158	0.5	1.1
(Kenya)	3.5	4.0	0.014	0.067	0.3	1.6	13.1	142.7	3	34	6.3	14.4	1.8	3.6
L. Amer., Caribbean	88.1	136.7	8.5	18.3	8.1	11.5	7.1	10.9	11	68	415	1580	4.7	9.9
(Brazil)	21.3	53.3	0.5	2.6	1.8	4.1	0.3	5.4	9	83	82	805	3.8	15.1
N. America (developed)	222.3	222.5	14.7	22.1	6.6	9.8	9.0	22.8	40	101	5284	5551	23.8	24.8
EU 15	87.5	75.6	6.7	12.1	6.8	14.0	12.0	17.5	123	202	3514	6894	40.1	92.0
USSR (former area)	235.0	214.4	9.5	20.2	2.7	6.4	3.1	4.3	13	20	1328	2036	5.7	9.5

Source: Food and Agricultural Organization-Statistics (FAOSTAT, January 2001).

According Todaro (2000), it is in the agricultural sector that the battle for long term economic development will be won or lost and the main burden of development and employment creation will have to be borne by the part of the economy in which agriculture is the predominant activity; that is, the rural sector. From independence to date, each of Kenya's subsequent development plans has mentioned raising the standard of living of the rural community (an integral part of which are the small-scale farmers) as one of the primary goals to be achieved. An overview of the overall growth of the economy by sector shows a mixed experience of peaks and troughs since independence, Republic Of Kenya (ROK, 2000). Table 1.2 shows Sectoral Shares in the Real Gross Domestic Products (GDP) since 1964. In relative terms, there were marked structural transformation indicated by the changes in sectoral share contributions to total GDP (Table 2). The picture depicted a steady increase in the share of manufacturing sector from an average of about 10 percent between 1964 and 1973 to 14 percent in the 1990-95 periods. This trend supports the empirical evidence that as a country develops, the contribution of manufacturing sector to the GDP would increase and subsequently surpass that of agriculture and other primary industries.

Table 1.2: Distribution of GDP in Kenya, by Productive Sector (%).

	1964-73	1974-79	1980-89	1990-95	1996-2000
Agriculture	36.6	33.2	29.8	26.2	24.5
Manufacturing	10.0	11.8	12.8	13.6	13.3
Public Services	14.7	15.3	15.0	15.7	14.8
Other Services	38.7	39.7	42.4	44.5	47.4
Total	100.0	100.0	100.0	100.0	100.0

Source: Republic of Kenya, National Development Plan 2000 - 2008.

Though manufacturing still stands out as the engine of growth even at the worst of times, and despite considerable expansion in industry and manufacturing sectors, agriculture remains the single most important sector in the Kenyan economy (ROK, 2000). Taking into account the size of the agricultural sector, its growth (though declining) will remain the key factor in stimulating rapid growth and attainment of higher income for the majority of the country's population in the rural areas as shown in Table 1.3. In the past, growth in the sector had come from expansion of area under cultivation as well as the transition from low value to high value agricultural activity. The potential for the above path has greatly diminished, first due to the low potential of the uncultivated areas, which are, either low in fertility or are too arid to produce without irrigation. Secondly, though it is possible to continue the transition to high value agricultural activity, there is a growing inclination for food crop production to keep pace with demand from the increasing population (ROK, 2003).

Table 1.3: Kenyan Projected Sectoral Growth Rates for GDP, by Sector Shares: 1997-2001 (Percentages)

Sector	Projected Growth Rate 2002-2008	Sector Shares 2000	Projected Sector Shares 2008
Agriculture	3.3	24.0	22.4
Manufacturing	3.3	13.1	12.2
Finance, Real Estate	5.7	10.6	12.1
Government Services	2.5	14.6	13.0
Private Household	8.1	2.9	4.0
Other Services	4.6	34.8	36.3
GDP	4.0	100.0	100.0

Source: Republic of Kenya, National Development Plan 2002 - 2008

Kenya has in the past had two long-term policies and several 5-Year Development Plans that have guided planning and investment: The first was *Sessional Paper No. 10 of 1965: African Socialism and its Application to Kenya*, and the second was Sessional Paper No.1 1986:

Economic Management for Renewed Growth. These plans attempted to confront the country's most entrenched problems- by charting a vision of how development would tackle them. Since 2003, the country has made tremendous effort to get the economy back on track through the Economic Recovery Strategy (ERS) with the GDP growth rate shooting back to 5.8 per cent by 2005. However, the major concern remains on how to consolidate and increase this in the long-term (ROK, 2007).

According to the Ministry of State for Planning, National Development, and Vision 2030 (MSPNDV, 2008), as a minimum, there is need to transform the Socio-economic Structure from a situation where Agriculture still accounts for 23 per cent of GDP and 56 per cent of employment while manufacturing accounts for barely 9.9 per cent of GDP and less than 2 per cent of employment. Services account for the bulk of economic activity at 51.6 per cent of GDP constituted mainly by informal sector activities. Kenya Vision 2030 is the new country's development blueprint which cover the period 2008 – 2030 and aims at making the country newly industrialized, that is, becoming a middle income country providing high quality life for all citizens by the 2030. The six key sectors prioritised as key growth drivers in the journey to 2030 include: tourism, increasing value in agriculture, better and more inclusive wholesale and retail trade, manufacturing for the regional market, business process off-shoring, and financial services. The Vision 2030 flagship projects for the Agricultural and Livestock sector will comprise preparation and passage of consolidated agricultural policy reforms and legislation; development and commencement of the implementation of 3-tier fertilizer cost reduction programme; improvement of the value gained in the production and supply chain through branding Kenyan farm products; the planning and implementation of 4-5 disease free zones and livestock processing facilities in order to meet international standards in the meat, hides and skins market; creation of publicly accessible land registries under improved governance framework; development of agricultural land use master plan; and the Tana river basin agricultural development scheme (MSPNDV, 2008).

There is evidence that over the past three decades, the Kenyan farming community has, in general, understood the benefits of adopting new and/or innovative technologies and farming practices provided that the cost/return relationships are perceived as favorable (ROK, 2007). However, a closer look at the transfer and/or adoption of technological advancement and improved farming practices shows that it is the Kenyan large-scale farming systems that have benefited from the use of heavy tractors, other large implements and/or improved farming practices. The small-scale farming system, which incidentally accounts for the bulk of agricultural production, has lagged behind in farm mechanization and adoption of improved practices.

Kenya is among a group of countries in the Sub-Saharan Africa region, which have a rich natural endowment in terms of agricultural potential and a population density heavily, skewed towards the rural areas. Recent estimations (ROK, 2003) still put the bulk of the population in rural areas and in spite of high percentages of population influx in the urban centers, projections indicate that rural areas will remain relatively highly populated for years to come. It is with this scenario in mind that an analysis of developments in the agricultural sector, associated linkages and impacts in relation to smallholder productivity particularly for increased food security in the rural areas needs to be undertaken.

The basic unit of the farming systems analysis is the Farm-Household-Family (FHF) web and its internal and external factors. The internal relationships in the FHF system would include factors such as cash flow, investment, liquidity, family labor and supplies (for example, food, energy, household materials housing, water, clothing and medicine). External relationships of the system would include; capital market, labor market, socio-cultural environs and services (for example, education, and extension).

This study focuses on the analysis of smallholder farming systems in the study area with the primary aim of identifying the determinants to adoption of new technologies and also to use the empirical results of this analysis as a basis for recommending solutions to the problems identified. The role of technological progress and/or improved farming practices in raising the standard of living of the rural community warranted a special interest for the study.

In this study, new technology and improved farming practices refer to agricultural equipment (for example, ox-plough, tractor), improved seed varieties, livestock breeds, use of fertilizers, artificial insemination, alley cropping, pesticides and herbicides, and also vaccines and accuracies. Farming systems is used as a phenomenon in which the "whole farm" setting is studied or taken into consideration: the basic units of farming systems are the farm, household, and the farm-family. The FHF web has both internal and external relationships that affect its planning, development, and productivity. Subject to the limitations of this study in terms of resources and scope, external factors (for example, environment, and off-farm activities) will not be considered in the calculation of the economic returns to the adoption of new technology and improved farming practices on the small farming systems.

1.2: Statement of the Problem

Adoption of new and innovative agricultural technologies has emerged as an important pre-occupation of many development economists first because the majority of the population of the developing countries derive their livelihood from agricultural production; and secondly because new agricultural technologies apparently offer opportunity to increase production substantially (Baidu-Forson, 1999). Suffice it to say that while tremendous breakthroughs have been made in designing new agricultural technologies and recommending improved farming practices in regional and definite agro-climatic zones to precision within countries, success in use and adoption of the available technological progress and practices has only been partial. In Kenya, there is an understanding that good research has been done and that beneficial new agricultural technologies have been identified (RoK, 2000). What remains unclear is the extent of adoption and the returns that accrue to the adoption of new agricultural technologies particularly among the smallholder farming systems. In addition adoption of new and innovative agricultural technologies is thought to enhance smallholder household food security and therefore plays a crucial role in poverty reduction.

Although previous studies, for example, Nekesa et al (1999), and Makhokah et al (1999) tended to assess farmer perceptions on adoption, however at the micro level, not much is known about the linkage between the returns to adoption of new agricultural technologies and smallholder household food security and poverty reduction. Adoption of new and innovative agricultural technologies is also believed to increase productivity in the smallholder farming systems through increased yields, incomes and commercialization of farming operations. Therefore, this lack of knowledge and understanding of the impact of returns to adoption of new agricultural technologies among smallholders shows the need to investigate and identify determinants which influence adoption and diffusion rates of beneficial new and/or innovative agricultural technologies by smallholder farming systems for effective household food security and poverty reduction strategy. Furthermore, National agricultural research institutions and local International research centers have also done much on generation of new agricultural technologies and information packages. However, the impact of this effort particularly on smallholder farming systems has not been clearly quantified in terms of returns and effects on the household food security and poverty reduction among smallholders.

Typical agricultural research and development constraints to adoption process include such factors as the lack of credit, limited access to information, inadequate incentives associated with land tenure arrangement, absence of equipment to relieve labor shortages (thus preventing timeliness of operations); chaotic supply of complementary inputs (such as seed, chemical, fertilizer, and water), inefficient transportation infrastructure, inappropriateness of technology in terms of form, time and cost, and risk aversion. Past technological design, transfer, and adoption have tended to favor large-scale farming systems and by-pass the small-scale farmers (Mavrotas et al 2007; ROK, 2007). Even where proven farm implements and improved seed varieties, animal breeds, and innovative farming practices have been targeted to the small-scale farming systems, adoption and economic impact of these technological developments have only been minimal in relation to productivity as measured in terms of net farm income. It is on the basis of these facts that this study analyzed the returns to adoption of new agricultural technologies and then examined their impact on smallholder farming systems in South Western Kenya as a strategy in improving the household food security and poverty reduction.

1.3: Objectives of the Study

The overall purpose of this study was to analyze returns that accrue to adoption of new and/or innovative agricultural technologies and determine their impact on smallholder farming systems' household food security and poverty reduction in the study area.

The specific objectives of this study were to:

1. Establish the socio-economic profile (i.e. characteristics) of the smallholder farm household as a basis for economic recommendation domains for specific interventions in the study area.
2. Analyze the returns to adoption of selected new agricultural technologies in the study area.
3. Identify the socio-economic determinants of adoption of the selected new agricultural technologies in the study area.
4. Assess the impact of the returns to adoption on the smallholder farm household food security in the study area.

1.4: Hypothesis

The study was set out to identify the returns and determinants of new agricultural technology adoption and assess their impact on smallholder farm household food security in the study area. The Hypothesis of the study states that: Farm households that adopt new agricultural technologies are likely to have higher yields, and income, and therefore would be more food secure.

1.5: Justification of the Study

Despite the undeniable evidence of continual change in farming practices, considerable disaffection concerning the ability of researchers and extension officers to effectively provide advice and technology to resource-poor farmers still persists. Many varieties released for farmers still find limited acceptance. Production campaigns and agricultural development projects often fail (Nina, 2008). Efforts to develop technology for small farmers frequently meet with low adoption and sometimes new inputs remain unused or are misused (Rukuni, et al 1998; and Sibale et al, 2001; Adams, 2002).

In terms of perspectives, farming systems research is, more than anything, a perspective on research. It requires that researchers take account of the whole farm and see the farm-family's welfare as dependent on a wide range of variables. Small farmers typically produce a number of crops and animals for subsistence and/or sale. An understanding of the complexity of farming systems and the trade-offs that farmers must make in taking production decisions has inspired a shift away from searching for optimal technologies and towards identifying acceptable compromises (Byerlee, 1998; and Walker 2006). While it is true that a lot of research has already been done and quite a good number of useful technological and/or innovative farming practices have been identified for agricultural development purposes in the developing countries, an impression still exists to the effect that development of a number of innovations may still be inverse to their appropriateness and effectiveness as per the goals and needs of intended users. According to International Farming Systems Association (IFSA, 2008), only a part of the farming systems, which exist in reality, is investigated. Crop oriented concept with economic elements often restricted to simple gross margin calculations for single crops and based on one hectare, are still dominant as can be verified by the annual reports of most agricultural production oriented international research centers.

To its credit, the farming systems perspectives have also encouraged a growing acceptance of a problem-oriented approach to planning agricultural research (Kelly et al, 2003). Agricultural programs are now less frequently planned from the "top-down", while more effort is being made to understand local farming conditions and problems as a basis for planning research. Related to this change in strategy is a move towards more participation by farmers themselves in identifying research priorities. This study first profiles the new agricultural technologies adopted in the study area and then assess the returns and impacts of adoption on small-scale farming systems in the study area in relation to household food security and poverty reduction.

Development approaches should concentrate more on the constraints and development potentials of small-scale farmers because: small farmers form the backbone of the economy in many developing countries, they often produce about 80 percent of the food crops (cereal and pulses) in developing countries, the greatest scope for improving food production and rural incomes lies in the small farming sector. The contribution of large-scale or state cooperative farms on the total agricultural production is usually small. Small farmers are often neglected in policy making and in the planning of extension and development programmes of their farming systems, constraints and potential are rarely understood, even by the professionals (Onyuma, 2008).

South Western Kenya was selected for the study due to the dual agro-climatic zones that prevails in the area with the low-lying, relatively dryer regions closer to Lake Victoria as opposed to the high potential relatively wet regions that dominates the foot-hills of Kisii highlands in the background and the relatively more mechanized farming in the Rongo-Migori sub regions. This type of set-up provides an ideal situation for a comparative analysis with the embedded advantage of replicating the benefits elsewhere in the regions of the country with similar agro-climatic characteristics.

CHAPTER 2

2.0: LITERATURE REVIEW

2.1: Farming Systems Research and Development

The focus of literature reviewed on farming systems is the quest to establish Farming Systems Research and Development (FSRD) as a viable alternative to previous agricultural development approaches, which have been variously tried with mixed success in improving the welfare of the rural community in general and farmers in particular. The conceptual framework of the farming systems approach is addressed by IFSA (2008), when the twin questions of what are FSRD? and why farming systems development? Are answered.

Taking the first question first, IFSA (2008) explained that as an approach in agricultural development, FSRD is concerned with the development of the Farm-Household Systems (FHS) and rural communities on a sustainable basis. A distinction is made of the FHS as rural households consisting of three basic subsystems with the household as the decision-making unit, the farm and its crop and livestock activities, and the off-farm activities as the third component. Secondly, the systems analysis and development approach becomes more meaningful since it separates targeted groups into varied classes based on their socio-economic characteristics. It is these socio-economic clusters that form the systems or development domains used to tailor the priority needs and technology requirements appropriated to each group. For example, the priority needs of farmers in the lower income groups is expected to be quite different from those of their upper income group. Similarly, farmers with more years of education are expected to be more responsive towards change as compared to their compatriots with less years of education.

Farming systems are highly complex and stochastic, with many interacting sub-components (Benin, 2006). They are characterized by the active role played by farmers in an attempt to control the physio-biological systems so as to satisfy their objectives. The system is dynamic and intrinsically stochastic with the climate and socio-economic systems acting as the environment. Climatic factors broadly limit the physical performance of the farmers (or what they would like to do) and largely determine the economic performance of their action (World Resources Institute, 2002). According to Eicher (2003) choosing policies for agricultural development requires the use of information about the existing farming situation. The collection of information presupposes the ordering of the great number of phenomena, which can be observed in a given rural area into entities, which are meaningful in terms of development, and these entities are systems (sets of related elements). Systems theory is therefore employed as the guideline for Farming Systems Research (FSR) description and analysis. For example, goal oriented systems such as, improving the income of farmers. For geographers, a region is often seen as a system, while sociologist may use village or a group of farmers as a system, and agricultural economists may use farms as a system.

The farming systems is part of larger systems, for example, the local community can be divided into target areas or target groups of farmers which can also be subdivided according to common physical, biological, and/or socio-economic characteristics, this is referred to as stratification. Such stratification separates environmental conditions and farming systems into reasonably homogeneous segments (Benin, 2006). However, Byerlee (1998) explained that; by working with these homogenous segments, improved technology for farmers operating under similar conditions throughout the target area can be developed. Thus, appropriate stratification systems enable the identification of farmers who are expected to benefit from the same recommendations.

IFSA (2008) indicated that, a special form of FSR has been dabbed on-farm research/farming systems perspective (OFR/FSP). This type of FSR has the following characteristic, which is:

1. Is conceptually based on a farming system perspective, that is, deals with the whole production systems.
2. Aims to generate technology to increase resource productivity for an identified group of farmers, especially in the short-run.
3. Explicitly integrates socio-economic and biological circumstances of the farmers in developing the technology. Diverse objective of the farmers are incorporated.
4. Is farmer based and a close research, extension, and farmer interaction is considered to be indispensable.
5. Quickly begins to focus on a few major problems (leverage points in the systems) even while a broader systems perspective is maintained.
6. Is complementary to on-station research and depends, heavily on station based research results.
7. Is multidisciplinary.
8. Is site specific?
9. Is cost effective and focus on well-defined target groups, thus heterogeneity among farmers is given explicit recognition.
10. Strengthens research, extension, farmer linkages

At the initial stage of its establishment, Farming Systems Research and Experimentation (FSRE) was seen as an alternative approach to address the apprehension about the limited effectiveness of conventional research. Concerns about low levels of farmer adoption of new technology have continued to be a major engine behind continued refinement of FSRE techniques. Farming Systems Research and Experimentation aimed to overcome the problem of limited farmer adoption by developing new technology as compatible as possible with farmer's circumstances, Food and Agricultural Organization (FAO, 2007). This study adopted the systems approach of analysis based on the social-economic characteristics smallholders in the study area with the aim of making a comparative analysis between adopter and non-adopter of new agricultural technologies.

2.2: Adoption/Diffusion of Agricultural Technology and Impact Measurement

Agriculture is the original technology. Adoption of agricultural techniques moved humans from societies of nomadic hunter/gatherers to geographically-stable sustainable communities. Civilizations and governments rest on their ability to feed their people. All other technology, culture, and human advance stand on the foundation of agricultural technology. Von Braun et al (2004) indicated that each new agricultural technology has advanced the ability of fewer farmers to feed more people. In a world where rapidly growing populations are putting greater demands on our available arable lands and our environment, improved agricultural technologies are critical for our future. Changing technologies are nothing new to agriculture. Ploughs, selective breeding, artificial insemination, vaccines, antibiotics, computers; all of these technologies once were new and now seem "normal." Each new technology was introduced with its champions and its detractors. Sometimes new ideas never take hold and sometimes old technology is replaced. The market generally sorts out which technologies offer a competitive advantage and which do not. No technology is appropriate for every farm.

The issue for any single farmer is whether to adopt a new technology on his own farm (Eicher, 2003).

Expectations were that adoption of the improved practices and changes in crop composition would lead to increased average farm incomes. However, experience shows that immediate and uniform adoption of innovation in agriculture is quite rare. In most cases, adoption behavior differs across socio-economic groups and over time. Some innovations have been well received while other improvements have been adopted by only a very small group of farmers (Kelly, et al 2003).

In the Kenyan context, most of the available new agricultural technologies and/or improved farming practices have largely only been adopted and benefited the large-scale farmer, the other half of the farming community (the small-scale farmers who actually produce the lion's share of the national agricultural output) cannot be referred to as users of the new and/or improved farming practices (RoK, 2007). If anything the adoption of new technologies by small-scale farmers has been negligible. According to Gabre-Madhin et al (2003) a new technology is generally useful only if farmers adopt it. Hence, an assessment of effects at the farm level is at the heart of any evaluation process. The impact at the farm level and the probability of adoption depend on how well the requirements of the technology fit into the particular niche in which a farmer operates.

The requirements of a technology may be divided into the socio-economic and biophysical components. Similarly, the farmer's niche is described by a particular endowment of resources. Most of the time technologies have been designed in isolated research stations or abroad to be disseminated to farmers without due consultation with the target group. Probably small-scale farmers in Kenya have lagged behind due to this lack of consultation in the new technologies and/or improved farming practices which do not quite fit into their niche in terms of form, cost and time. Ndjeunga et al (2003) further explained that the introduction of high-yield cultivation techniques in agriculture during the 1960s and the socio-economic impact of these innovations on agricultural sectors in the developing countries have been subjects of considerable interest in empirical economic research.

Among the factors listed as constraints on adoption of new technologies and the importance of individual farmer characteristics are; farm size, land tenure, labor availability, credit constraints, sociological and other factors. In addition, poor information transfer between research and extension has been identified as a major factor limiting the supply of appropriate new technology to resource poor farmers in the developing countries.

Nerlove et al (1996) indicated that focusing research and agricultural extension services on farms of a particular size or type is unlikely to yield greater returns than treating all farms alike. The report found that a 1 percent increase in total output would generate a 1 percent increase in use of modern inputs no matter what combination of products is produced or how stable the mix. Supply constraints, particularly lack of credit, may largely determine whether a technology is adopted, and supply constraints affect almost all farms equally.

The report looked at how farmers' decided about what crops or livestock to produce and what proportions were linked to technology adoption. Since technologies are usually developed with certain crops in mind, a farmer's decision to grow that crop may mean that he will adopt new technologies as well.

Conducted in the poor but agriculturally diverse Zona da Mata region of Minas Gerais, Brazil, and the study used statistical cluster analysis to identify farms by their product mix. Farms, were assigned to groups according to the share of farm output devoted to a particular product, and were divided into five categories: farms that produce coffee, corn products, dairy products, and rice; off-farm labour is the fifth category. These categories served as a basis for examining the factors that influence adoption of new technologies such as the size and scale of operation of a farm, its expenditure on modern inputs, its degree of specialization (the diversity of its agricultural products), and the quality of its land. Despite varying agro ecological conditions, farmers were readily able to change their product mix among coffee, corn, and dairy products, and off-farm labour, but rice requires flat, irrigated land.

The study found that farmers' decisions about changing product mix were influenced by price policies and the agricultural extension services available, which vary from product to product. Many farmers in the Zona da Mata grew coffee because input and output prices were subsidized and preferential credit terms were available. The size and timing of investments and returns for different products also influenced farmers' choices. According to Nina et al (2008) assessing farmer adoption of new technology and the impact of FSRE programs have in the past tended to emphasis on three different levels of inquiry: monitoring farmer adoption behaviour; estimating economic returns to investment in agricultural research; and using general equilibrium analysis to examine the effects of farmer adoption on non-adopting population. An analysis of the returns to adoption of agricultural technologies in South Western Kenya investigated the influence of socio-economic characteristics as likely determinants of the returns to adoption of new agricultural technologies in the study area.

Diffusion studies do not consider the innovation process, but begin at the point in time when the innovation is already in use. The earliest adopters may be called innovators, and the diffusion process is the spread of the new technique across the rest of the population. Adoption studies consider the reasons for adoption at one point in time, or reasons for time of adoption for individual users. In contrast, most diffusion models are dynamic and study the behavior of the diffusion process over time. Thus, relative to adoption, diffusion may be viewed as a dynamic and aggregate process over continuous time (Thirtle et al, 2003).

According to Abdoulaye (2002) there are several important characteristics that determine adoption decisions including observed adoption choice on a given technology, for example improved crop variety, hypothesized to be the end result of a complex set of inter-technology preference comparisons made by farmers.

The relation of perceived benefits derived from adopting improved seed as opposed to the traditional variety, socio-economic, and demographic characteristics of the farm households may affect the adoption decision. An index function approach can be used to determine the effect of perceptions of technology attributes on adoption of decisions by comparing the inter-varietal attribute preferences such that the farmer is adopts the improved variety when it has a relative advantage to a traditional variety.

This study instead focused on analyzing returns that accrue as a result of adoption of new and innovative agricultural technologies, that is, the effects of adoption on smallholder farming systems which adopt as compared to the none adopters.

According to International Fund for Agricultural Development (IFAD, 2007), among the many factors that contribute to growth in agricultural productivity, technology is the most important. The rate of adoption of a new technology is subject to its profitability and the degree of risk and uncertainty associated with it, and is highly influenced by the capital requirement, agricultural policies, and the socio-economic characteristics of farmers. The question of adoption or non-adoption is important; however, intensity of adoption is actually the most critical criterion in the adoption process.

Measuring the effectiveness of a project in developing and transferring improved technologies to end-users is an important step in assessing its impact. This measurement can be achieved by: identifying and analysing the socio-economic characteristics that influence adoption, including the acceptance of technology, adoption rates, performance, and constraints in adoption; analysing the degree of adoption of a new technology; analysing the intensity of adoption; measuring farm-level impact of introduced technologies; assessing market-level impact of technologies adopted (FAO, 2006).

These components can be analysed using cross-sectional data from farmers in targeted areas. An understanding of how individual characteristics tend to influence adoption decisions could improve the effectiveness of technology in enhancing growth in productivity. Three methods are commonly used for assessing the economic impacts at farm level of a technology. The first method is to calculate the relative cost and revenue differences between the proposed technology and the existing production systems, within a set of gross-margin budgets; the second method is to build a set of representative-farm linear programming models, which incorporate the output from the gross-margin analyses, but in addition consider the overhead and other costs associated with the adoption of new technology; and the third method is multiple regression analysis of farm production data using information obtained from technology adoption surveys. A production function is also used to isolate the impact of varietal technology on total factor productivity (Diagne et al 2000).

Widespread adoption of new production technology might also be expected to have important market effects. Mavrotas et al (2007) indicated that, a widely used method in estimating the ex ante market impacts of a technology is to calculate the economic surplus changes and distributions from the technology adoption. Economic surplus comprises both consumer's and producer's surplus. This method is based on the assumption that technology adoption leads to an outward shift in the product's supply curve. Certain assumptions are required about the slopes of the supply and demand curves, the nature of the supply shift, and the relationship between producer and consumer prices. In addition, some base or initial equilibrium sets of prices and quantities are used for making these calculations (IFAD 2007). This study identified farm production levels and income as the primary return associated with the returns to adoption of new agricultural technology in the study area.

2.3: Access to Credit, Markets and Issues of Farmer Organizations

The issue of rural finance and credit as a critical element for rural development as a whole and agricultural sector in particular cannot be gainsaid. Important components of the sector requiring credit facilities include agricultural production, marketing, processing, storage, and long-term farm investments. Inadequate access to credit would therefore be a big constraint leading to low productivity and food insecurity.

Kimuyu and Omiti (2000) found that given the very low incomes and savings rate, micro and small scale enterprises usually fall back on a variety of sources which include own or family funds, loan from family friends, and non-bank financial institutions. Table 2.1 shows a summary of the various sources of initial and additional capital used by micro and small-scale enterprises. The table indicates that own family funds were by far the most relied on source of initial and additional funds used by micro and small-scale enterprises. Thus the findings also suggest that Micro-Small Enterprises (MSEs) fall back on these sources for lack of alternatives and out of desperation. Implying that alternative sources are either costly or out of reach for the majority of these enterprises.

Table 2.1: Sources of Initial and Additional Capital

Sources	Relative contribution of sources (%)	
	Initial capital	Additional capital
Own or family	88.6	80.4
Loan from family or friends	7.0	6.2
Commercial bank	0.7	1.8
Formal and informal co-operatives	1.2	1.3
Non-bank finance institutions	0.7	1.1
Rotating saving and credit schemes	0.7	1.1
Others (NGOs, Government programmes, trade credit, money lenders and others)	1.1	8.1
Relevant sample size (n)	1795	454

Source: Kimuyu and Omiti (2000)

In Kenya rural finance has been made available through various financial intermediaries such as Commercial Banks, the Cooperatives, Agricultural Finance Corporation (AFC) Rural and Urban Savings and Credit Cooperative Organizations (SACCOs), Non Governmental Organizations (NGOs), and Agricultural Boards. According to Omiti et al (2002) Agriculture gets between 10-12 % of total credit disbursed and the stipulated target for agricultural advances as a percentage of deposits is 17 %. However, the most important concern is that this stipulation has not been enforced by the Central Bank. As a result the volume of credit availability in the agricultural sector had drastically declined over time (Kimuyu and Omiti 2000). According to Omiti (2002), and Sharma et al (2000), apart from the overall decline, available rural credit is biased towards large-scale farms and short term lending. A major player in the agricultural credit provision is AFC, which started operations in 1969 with a mandate of enhancing agricultural lending through the provision of short and long term loans. Records of its lending patterns showed the following breakdown; the corporation mostly targets wheat and maize production for seasonal credit, one-year loans for other crops, 3-to-5 years loans for mechanization, 10 year loans for dairy development, and plantation crop loans with repayment periods of up to 2 years. The corporation has a network of 49 branches in the major farming areas, which act as crucial avenues for disbursement of loans. Table 2.2 shows the pattern of disbursement in the country by farmer category.

Table 2.2: AFC Annual Disbursements by category of farms, 2002.

Category	**Average percentage**	As % total approved
• Large scale	27.0	4.1
• Small scale	15.0	38.0
• Seasonal	3.2	1.0
• Seasonal	56.0	57.0

Source: Omiti et al, 2002.

Although the figures from the table showed that smallholders were second only to the seasonal farms in disbursement, further analysis of the seasonal farm categories would be warranted to ascertain the proportion of large verses small holders in that category. Similarly it should be imperative to note that the Corporation only operates in the Medium to High potential agro-ecological zones of the country. The bulk of small holders reside in the Low to Arid/Semi-arid agro-ecological zones in the country. Hence, nation wide the disbursement by the Corporation to smallholders as a whole would be ranked quite lowly. The implication is that the envisaged enhanced lending in the agricultural sector by the corporation, particularly to smallholders still remains elusive.

According to Omiti (2002), in terms of loan recovery trends, the Corporation has had a poor record in loan collections, which as a percentage of collectables, declined from 41% in 1983 to 24% in 1994. However, opportunities exist for increasing access to credit and banking services to farmers if AFC is restructured into a specialized commercialized banking institution for agriculture and rural development. Other notable sources of rural finance include Cooperatives and SACCOs. Trends in Cooperative lending is exemplified by the Cooperative Banking system which has registered a decline in agricultural advances, as a percentage of the total, from 82% in 1990 to 60% by 1994 on the one hand while on the other hand, total advances increased by 99.5%, agricultural advances had increased by only 46% between 1990 and 1994 (Omiti et al, 2002).

Distribution of SACCOs as important supplementary source of credit in the agricultural sector indicated that there were 57 rural SACCOs in the country with tea having the largest number of 21 followed by coffee 15, dairy 8, sugar 4, cotton 3, handicraft 2, pyrethrum 2, fisheries and rice 1 each. Of the total number of rural SACCOs, 22 were based in Western and Nyanza provinces, 17 in Central, Eastern 13, and Coast 5, Institute for Policy Analysis and Research (IPAR, 2004). A sample of the primary services offered by the SACCOs included purchase of shares, withdrawable savings, fixed savings as security for loans, welfare loans, and working capital and capital investment loans. This indicates that SACCOs and Cooperative lending form an integral and complementary channel of credit in the agricultural sector and by nature of being grassroots oriented would be a vital avenue for smallholder credit disbursement

The last group of organizations with important contributions in credit access for the agricultural sector are NGOs, parastatals, and private companies. Ministry of Agriculture (MoA, 2008) shows that there were over 500 registered NGOs engaged in various micro enterprises, mostly business and commercial oriented activities These organizations invariably utilize four models of lending arrangements including individual credit for those with tangible collateral; credit using group guarantee where a group guarantees loans to individual members; integrated credit and technical assistance that utilizes project staff for assisting and formulating business plans and credit needs; and group oriented schemes with technical assistance. Notable parastatals and private companies involved in the provision of agricultural credit sub-sector include Kenya Tea Development Agency (KTDA), Horticultural Crops Development Aithority (HCDA), and Kenya Planters Co-operative Union (KPCU) together this group provide about Ksh. 1.5 billion a year to farmers. Among private companies, Mastermind Tobacco Company (MTC), British American Tobacco (BAT) and Kenya Breweries Limited (KBL) have experiences in agricultural credit provision. BAT disburses credit to about 1200 tobacco farmers annually. A recent but increasingly major private company, which has joined the agricultural credit sub-sector, is the Standard Chartered Estate Management Company with interests in sisal, ranching, coffee, tea, and sugar industry. However, this last group of organizations, particularly the private companies have little or no interest in smallholder credit provision except where proven cash crops are involved MoA (2008). The implication is that smallholders with food crop oriented production are not important clients. Towards the national goal of adequate and accessible food for all, private companies and commodity parastatals have a role to play in agricultural credit provision to reverse the spiral increase in food insecurity and worsening incidence of absolute poverty among smallholders. A study on redressing institutional impediments to micro and small-scale enterprises access to credit by Kimuyu and Omiti (2000) found that enterprises with poor access to credit tend to be less productive and are unable to operate efficiently. Hence inadequate access to credit means that the potential role of MSE sector in reducing poverty and in Kenya's socio-economic transformation will be difficult to realize. Evidently, rural Kenya is less attractive to credit suppliers because these areas are more affected by deteriorating infrastructure. Improving rural infrastructure to open up rural commerce and increase the profitability of rural-based enterprises can therefore increase credit availability.

On the issue of market access, it is one thing to encourage farmers to increase production and quite another to have a bumper harvest which they are unable to handle in terms of domestic consumption and marketing. The logical thing to do would be to approach farmers with a holistic view in terms of advice. That is to say, farmers should be given an information package that include improve production skills, as well as marketing skills. More often than not, even farmers who produce for subsistence purposes end up having a portion of their production offered for sale due to pressing socio-economic concerns. According to Siebel et al (2001) market development is one of the greatest challenges facing smallholder farmers, particularly in Africa. Thus, in order for smallholder farm business to grow, there is a need for access to reliable markets, at sustainable prices, and for appropriate crop choices. There are several markets available to the smallholder farmer, however the most appropriate of these need to be identified and exploited. At the heart of the debate for rural markets is the need to satisfy consumer demands while at the same time balance this against the want for a decent profit to the producer. Many farmers small and large often complain either fairly or unfairly that they are often fleeced by middlemen and that the bulk of the shilling paid by consumers often end up in the pockets of these middlemen. On the other hand, the consumers also often cry foul concerning the assumed high prices they pay for agricultural commodities. It seems like the only way to satisfy all stakeholders in the agricultural marketing system, just as in any other market, is to have an efficient market. This can be achieved in the rural setting by empowering smallholders to acquire skills that can allow them to analyze markets for their own produce, starting with the market structure which deals with assessing the number of buyers and sellers, the marketing hierarchy, that is existence of middlemen and their function or contribution to the marketing system, the number f markets available in the environs, the number of days the markets meet (i.e. once a week or twice a week), and unlimited access to market and marketing information. This would be followed by analysis of the market conduct, which concerns the behavior of participants in the market, that is, are there some rule and/or regulation about entry and exit to/from the produce market? What of the general arrangements and behavior of the participants in the market? Are there any patterns or is it a free for all kind of situation in the market? How about information flow? Do all participants and stakeholders have equal access to information relating to the market and marketing? Finally, the issue of price setting would be analyzed. This deals with understanding how prices are set. That is, are commodity prices set by the free market forces of supply and demand? Or are they set by some vested Authority, which regulates and sets prices for the various agricultural commodities? These are some of the important issues and concerns, which the smallholder needs to be aware of and have the capacity and ability to analyze for own survival. As important is the nagging concern that by and large, the African smallholder has not grasped the need to start taking farming as a business. In many cases, the smallholder farmer often take farming as a way of life, that is, farming for the sake of it, no plans no record keeping. This becomes an unattainable situation as progress and goals becomes difficult to measure. Additionally, in the true attitude of the smallholder, production is often seen as a way of satisfying the domestic needs rather than the profit motive. Experiences the world over, show that farming is indeed a business just like any other. And for sure, in any business, if one cannot make profit, then as the adage goes, one won't have any business being in that business. Commercialization of the agricultural sector would be one sure way of helping the smallholder to appreciate farming as a business. In this case, both production and marketing will be seen in commercial terms and the record keeping and accounting skills built to horn the entrepreneur prowess of the smallholder farmer.

Where individual farmer's bargaining power is limited, farmer organizational developments would be encouraged to facilitate the formation of groups or organizational arrangements which brings accrued benefits both at the production and marketing levels (Simtowe et al, 2006; Zeller, 2000). Examples include commodity associations, cooperatives, and group contract farming arrangements. These types of arrangements would assist in the identification of new, reliable buyers and establishment of linkages between producers and buyers, which would result into economic gains for the former. In this context, the major challenge would be developing producer organizations as the essential link between individual farmers and buyers. Another area to consider in increasing access to markets by smallholder farmers would be to improve the smallholder household livelihoods through enhanced agricultural productivity and establishment of viable forward and backward linkages between the smallholders and agribusiness including other related private sector enterprises. Farmer organizations, be it commodity based or multi-facet, would be a major source of growth at the smallholder farmer level. This is explained by the improved bargaining power that such groups or organizations bring with them, not to mention the economies of scale implied in the arrangement for production purposes. What have been lacking in many cases are not so much the formation of such farmer groups and organizations, but rather the organizational developments of the groups, that is, the capacity to properly manage and develop the established entities. Many a cooperative movement has often collapsed and farmer organizations disbanded due to un-ending wrangles and wanting management skills by those charged with such responsibilities. Organizational development would therefore be the number one strategy in the targeted initiatives, which aspire to make a contribution towards this challenge.

2.4: Returns to adoption of new agricultural technologies

While traditional technology still remains relevant in agricultural production by virtue of relative superiority in particular situations, for example, where affordability becomes an issue, there is a general understanding that adoption of new agricultural technologies have an important role to play in increased agricultural productivity, farm income, and therefore improved food security and poverty reduction. In this context, productivity as measured by improved yields, income, and farm size would represent pertinent returns to adoption. A study by Isinika et.al (1998) on returns to research and extension investment in crop production in Tanzania found that there was a strong principle linking productivity, technical change, and development. Thus, while agricultural research and extension components compliment each other in improving agricultural productivity, most studies on quantitative returns put emphasis on agricultural research. Assessing the performance of agriculture by measuring its productivity is an important part of monitoring returns to previous investments in agricultural technologies in order to guide future investments. This study identifies the returns to adoption of new agricultural technologies as improved yields, farm income, and farm size. Hence, the study uses the concept of food insecurity as a control problem to analyze the effects of returns to adoption of new agricultural technologies on smallholder household food security in the study area.

The Isinika et.al (1998) model measures the effect of investment in agricultural research on productivity and output by using the production function method in a two step-process. First a research production function is established where the output is knowledge, defined as agricultural technical information evolving from research stations. Then the model incorporates an agricultural production function as an explanatory variable. The conceptual model is presented thus:

$I_t = (R_t, R_{t-1}, R_{t-2}, \ldots R_{t-k}, N_t, Z_t)$ (2.1)

Where

I = increment in useful knowledge

R = investment in research

N = stock of knowledge

Z = a vector of other variables

T = a subscript denoting time

(t-k) for k = 1,2 ....k indicates lagged variables.

The model further assumes that the implicit knowledge production function then enters the agricultural production function (Y_t), as a flow of services (F_t), emanating from the stock of knowledge (N_t). This flow of services is augmented by conventional inputs (X_t) and random factors such as weather (W_t), such that

$Y_t = f(X_t, W_t, F_t)$ (2.2)

Since the flow of services (F_t) is influenced by the stock of knowledge (N_t), relative prices (Pr_t), the educational level of farmers (H_t) and expenditures on extension ((Ex_t) among others, this can be expressed as

$T_t = f(N_t, Pr_t, H_t, Ex_t, T_t)$ (2.3)

Where

Pr = factor relative prices

H = the educational level of farmers

Ex = quantity and quality of extension services,

then by substitution, it follows that agricultural production (equation 2), which is a function of conventional inputs (X), random factors such as weather (W) and the flow of services from the stock of knowledge ((F), can be written as

$$Y_t = f(X_t, W_t, Pr_t, H_t, N_t, R_t, R_{t-1}, \ldots R_{t-K}, Ex_t, Ex_{t-1}, \ldots Ex_{t-K}, T_t) \quad (2.4)$$

Where

Y = agricultural output

W = weather variable

T = interaction between research and extension

All other variables are as previously defined. It is observed that in practice, researchers have incorporated research and extension in the agricultural production function both directly and indirectly. Thus using the direct method, expenditures on agricultural research and extension become a proxy for knowledge produced in the research process. However, using the indirect method, indices of output and inputs are calculated first, based on an underlying production function. The total factor productivity (TFP) for each time period is then defined as a ratio of the output index to the index of conventional inputs. In the second stage, the rate of change of total factor productivity with respect to time is regressed against expenditures in research and extension, among others, to measure the time path of technological change. This study will instead go further and examine the impact of identified returns to adoption of new agricultural technologies on the smallholder household food security in the study area. Therefore, food security is identified as the dependent variable which is affected by the adoption of new agricultural technology, as estimated by increased productivity, that is improved yields, income and farm size.

2.5: Poverty reduction and Food Security debate

Achieving food security in its totality continues to be a challenge not only for the developing nations, but also for the developed world. The difference lies in the magnitude of the problem in terms of its severity and proportion affected. In the developed nations the problem is alleviated by providing targeted food security interventions, including food aid in the form of direct food relief, food stamps, or indirectly through subsidized food production. These efforts have significantly reduced food insecurity in these regions. However, similar approaches have been employed in the developing countries but with less success. The discrepancies in results may have been due to insufficient resource base, short duration of intervention, or different systems most of which are inherently heterogeneous among other factors (Jeffrey, 2000).

Food security is defined as a situation in which all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active healthy life. According to International Monetary Fund et al (2005), this phenomena is often affected by a complexity of factors which include; unstable social and political environments that preclude sustainable economic growth, war and civil strive, macroeconomic imbalances in trade, natural resource constraints, poor human resource base, gender inequality, inadequate education, poor health, natural disaster, such as floods and locust infestation, and the absence of good governance. It is imperative to notice that all these factors contribute to either insufficient national food availability or insufficient food access to food by households and individuals

The root cause of food insecurity in developing countries is the inability of people to gain access to food due to poverty. While the rest of the world has made significant progress towards poverty alleviation, Africa, particularly Sub-Saharan Africa

There are several variations (World Bank, 2000; Andrew et al 2008; Benin et al 2006) of plausible strategies for poverty reduction with a discernable evolution of the deepening understanding of the approaches spread over four decades including the 1950's/60's whence large investments in physical capital and infrastructure were viewed as the primary means of development. This was followed by a growing awareness in the 1970's that physical capital alone was inadequate, and that at least as important was other variables such as health and education. The debt crisis and global recession coupled with the contrasting experiences in Latin America, South East Asia, and Sub-Saharan Africa in the 1980's saw improving economic management and allowing grater play for market forces as the crucial area of emphasis. However, governance and institutions had moved to center stage by 1990's as well as issues of vulnerability at both the local and national levels.

According to International Food and Agricultural Development (IFAD, 2007), Kenya's population has tripled over the past 30 years, leading to increasing pressure on natural resources, a widening income gap and rising poverty levels that erode gains in education, health, food security, employment and incomes. The causes of rural poverty include: low agricultural productivity, exacerbated by land degradation and insecure land tenure; unemployment and low wages; difficulty in accessing financing for self-employment; poor governance; bad roads; high costs of health and education; and Human Immune Virus/ Acquired Immune Deficiency Syndrome (HIV/AIDS).

Agricultural growth has been well below potential in recent years due to a number of constraints. Those which result partly from an accumulation of poor past policies and which will take time to remedy include; (i) non availability of quality seeds and inappropriate production technologies especially for small holder farming, (ii) lack of access to credit, by the majority of small holder farmers, particularly women, (iii) high cost of farm inputs, (iv) poor and inadequate rural infrastructure, especially feeder roads, power supply and market facilities. Other constraints, which Government intends to make relatively rapid efforts to ameliorate include (v) inconsistencies in policy/poor institutional and legal framework, (vi) inadequate research, inefficient extension delivery systems as well as inadequate extension services and support, (vii) poor sequencing of the liberalisation process, (viii) lack of effective co-ordination of investment activities among the key stakeholders in agriculture. Lastly, there are constraints which are almost entirely exogenous, including (ix) insecurity in high potential areas and cattle rustling in some Arid and Semi-Arid Land (ASAL) areas, (x) unfavourable weather conditions and high dependence on rain fed production, and (xi) population pressure on the natural resource base. As a result, many indicators of rural livelihood have been worsening, indicating an increase in rural poverty (ROK, 2003).

According to MSPNDV (2008) the Agriculture sub-sector needs to grow at about 4-6% per annum if it is to contribute to national growth and increasing rural wealth. For this to happen in a way that effectively supports poverty reduction over most of the sector, a number of important elements need to be in place and actions to facilitate them need to be taken. These include: (i) building an effective and efficient participatory extension and technology delivery service; (ii) undertaking affirmative action in agriculture by facilitating participation of women; (iii) establishing efficient rural finance and credit supply system for smallholders and rural primary agro processors; (iv) ensuring policies, institutional and legal frameworks are investor friendly; (v) implementing sound land use, water and environmental policies; (vi) facilitating long term investments in farm improvement; (vii) protecting water catchments areas by developing forest plantations; and (viii) improving the governance of the co-operative sector by empowering farmers. To address specific problems of ASAL areas livestock marketing needs to be improved and small-scale irrigation investments undertaken in poverty-stricken areas.

For effective poverty reduction strategy to be devised, an important starting point would be to have a working definition of what is understood by the term poverty. According to International Food Policy Research Institute (IFPRI, 2001) poverty is " welfare level below a reasonable minimum" with variations in dimensions, which include income security, education, health-nutrition, and multiple deprivations. The primary focus is on individuals or groups suffering from multiple deprivations. . However, the World Bank (2000) defines poverty by comparing the daily cost of living, infant mortality rates, and malnutrition worldwide. Thus the poor are those who live on less than $1 a day who are mostly found in South East Asia, Sub-Saharan Africa, and Latin America where as many as a fifth of the children do not live beyond their fifth birthday and as many as 50 percent are malnourished. This compares quite poorly by the situation in rich countries, where almost half the people live on at least $2 a day, fewer than 1 child in 100 does not reach its fifth birthday, and less than 5 percent of all children under five are malnourished (IFAD, 2007; Andrew et al 2008).

There are often two issues in generating poverty estimates that is, fixing a poverty line, which is concerned with identification as opposed to measuring poverty, which focuses on aggregation. Considering the cost of-basic food needs, that is, food-share method which involves determination of the cost of basic food needs as well as the cost of basic non-food needs, can do methods of fixing poverty lines. Alternatively, employing the food-energy method, which considers the expenditure level that meets the food energy requirement, based on calorie-income relationships, and fitting and tracing calorie-expenditure graph can fix poverty lines. An illustration of the Cost-of-Basic-Needs Method is thus presented:

Total Poverty Line = Z

and $Z = ZF + ZN$ (2.5)

Where:

ZF = Food Poverty Line

ZN = Non-Food Poverty Line

Hence, Food Poverty Line can be calculated by calculating the average household (HH) size, finding the minimum requirement of daily per-capita calories for World Health Organization (WHO), finding the typical food bundle of the relative poor HH, calculating the calories of this food bundle, and determining the cost of this food bundle. This can be expressed thus

$$ZF = [WAMCR / CAFBRPH] * [CAFB] \quad (2.6)$$

Where :

ZF = Food Poverty Line

WAMCR = World Health Organization Minimum Calorie Requirement

CAFBRPH = Calories in Average Food Bundle for Relatively Poor Households

CAFB = Cost of the Average Food Bundle.

Other measures of poverty often focuses on the incidence of poverty, that is, poverty rate, which is derived from the use of head-count rate to calculate the poverty rate of the % of population below the poverty line. Another measure of poverty is by considering the depth of poverty, that is, how far a person is below the poverty line. Alternatively poverty can also be measured through the assessment of the Poverty gap, that is, aggregation of depth of poverty. Lastly, measures of poverty can involve considering poverty severity, that is, aggregation with weights. This study will differ from these previous models by recasting the debate on food security as a means of poverty reduction strategy. Thus eradication of food insecurity has a direct link to poverty reduction, particularly at the household level. Like poverty, food security definition has also changed over the years such that earlier discussions of food security in the 1970's tended to have been influenced by the shortfall in world food productions and rising prices of that decade. Hence food security at the time meant avoiding transitory shortfalls in the aggregate supply of food. However, in the following decade of the 1980's, despite the global availability of surplus food supplies, there was widespread famine in Africa. This shows clearly that inadequate levels of global food supply were not the cause of hunger (Jayne, 2007). Thus the focus had shifted attention to the lack of access by households and individuals to food due to low incomes (entitlements) as the primary cause of food insecurity in addition to the fact that for most of the hungry in the world, this lack of access is chronic, and not transitory. Since then, the conceptual understanding of food insecurity has gradually evolved to include not only transitory problems of inadequate supply at the national level but also chronic problems of inadequate access and unequal distribution at the household level. According to the Center on Hunger (2008), the World Bank defines food security as " access by all people at all times to enough food for an active, healthy life". Therefore, lack of access to enough food is denoted as food insecurity. This implies that there is a special distinction between chronic and transitory food insecurity, that is, persistent as opposed to temporary failures of access to sufficient food. It follows that transitory food insecurity can become severe, large-scale famine. It is therefore postulated that farmers who adopt new agricultural technologies are expected to receive some returns, which ameliorate access to food. When adoption is properly and successfully done food security is improved and poverty is reduced.

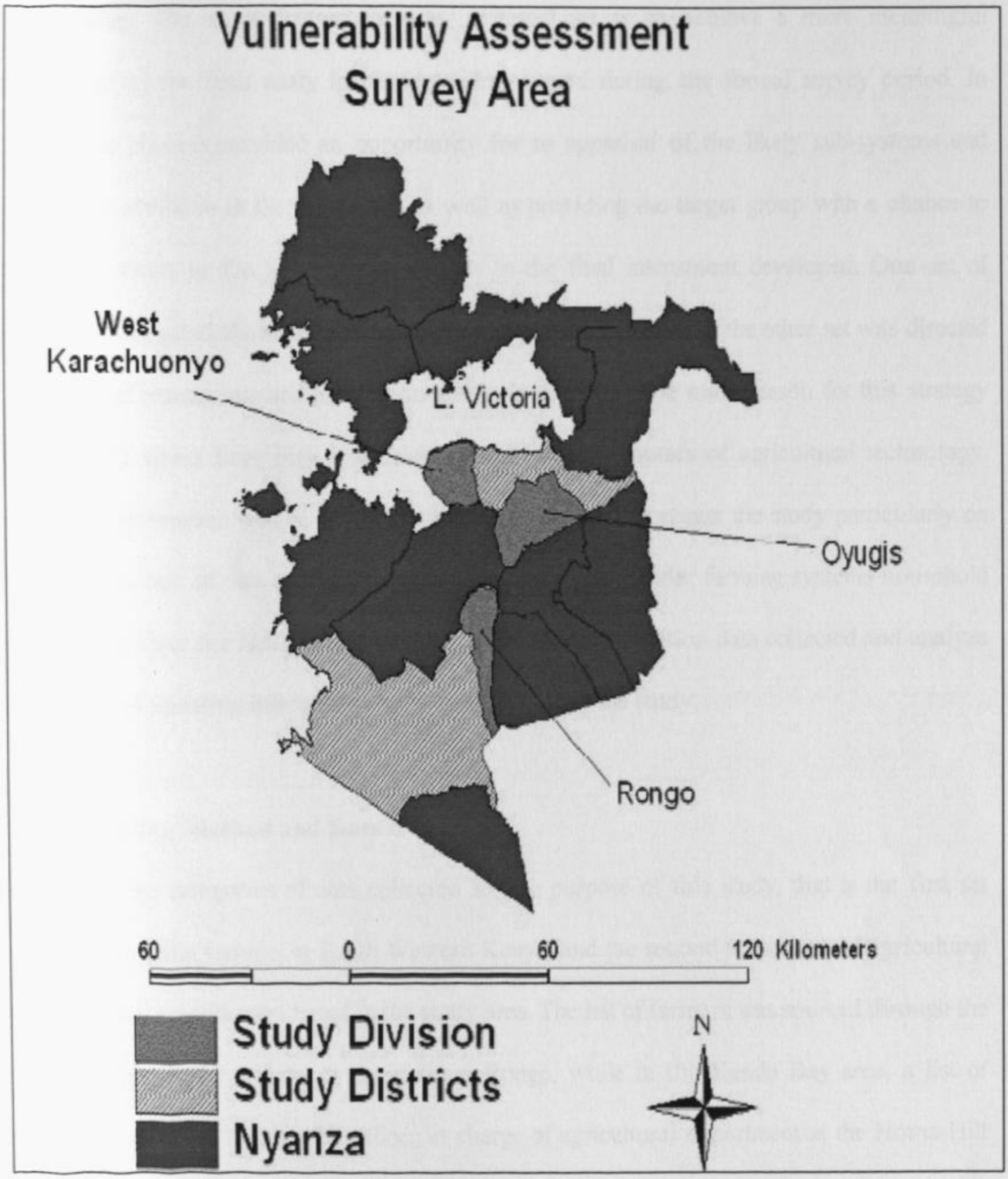
CHAPTER 3

3.0: RESEARCH METHODOLOGY

3.1: About the Study Area

Two distinct agro-climatic zones traverse the South Nyanza districts of Migori, Suba, Homa Bay, and Rachuonyo with the dryer lowlands in the Kendu/Homa Bay-Mbita point sub-region along the shores of Lake Victoria, and the wet high agricultural potential area over the Oyugis-Migori sub region dominating the foothills of Kisii highlands. For comparative analysis purposes, the study area was partitioned into three sub regions; Kendu Bay, Oyugis and Rongo-Migori sub regions as indicated in Map-1 below and Map-2, and 3 in the appendix. Each of these sub regions is characterized by outstanding farming systems with small-scale mixed farming dominating the Kendu Bay area. The cropping system here comprises mostly cereal grain (for example, maize, millet and sorghum) production, as well as groundnuts, cotton and indigenous animal keeping. Farming systems in the Oyugis sub regions consist of intensive small-scale farming of fruits (for example, pineapples, mangoes, bananas and oranges), vegetables, onions, sweet potatoes and maize. Animal production systems concerns grade dairy farming plus indigenous animal keeping. The Rongo-Migori sub region is relatively mechanized in farming with tractors and commercialised cane production in addition to tobacco production as well as grains, such as maize and millet.

Map-1: The Current Vulnerability Assessment of Food Security Survey Area November 2007.



3.2: Research Design and Survey methods

Diagnostic activities included a pretest of the study instrument, a formal survey, and two sets of questionnaires. The study instrument was pretested so as to achieve a more meaningful development of the final study instrument administered during the formal survey period. In addition, the pre-test provided an opportunity for an appraisal of the likely sub-systems and technologies available in the study area as well as providing the target group with a chance to infuse their views in the form of suggestions in the final instrument developed. One set of questionnaire targeted the small-scale farmers in the study area, while the other set was directed to agricultural researchers and practitioners base in the field. The main reason for this strategy was to solicit views from both ends, that is, users and promoters of agricultural technology. Additional information will be sourced from secondary data to recast the study particularly on impact of adoption of new agricultural technologies on smallholder farming systems household food security. Over the November/December 2007 period, validation data collected and analyze for purposes of updating information and factors related to the study.

3.3: Sampling Method and Data Collection

There were two categories of data collected for the purpose of this study, that is the first set targeted small-scale farmers in South Western Kenya, and the second set addressed agricultural researchers and practitioners based in the study area. The list of farmers was sourced through the divisional agricultural officers at Oyugis and Rongo, while in the Kendu Bay area, a list of farmers was accessed through the officer in charge of agricultural department at the Homa-Hill Centre (Kowuor Agricultural Institute). In all cases, a sequential random sampling was used to select potential respondents of 90 farmers in each of the three sub-regions for a combined total of 270-sample group. Trained enumerators between June and August 1993 administered the study instrument. In the case of the second target group of agricultural researchers and practitioners, a cluster group of researchers and officers at the divisional head offices were approached for the questionnaire interviews between August and September 1994. Secondary data on new agricultural technologies, performance indicators, and household budgets will be compiled from the Central Bureau of Statistics, Annual district and provincial reports, and other technical reports covering the study area.

For the small-scale farmers group, the study instrument consisted of a questionnaire with 23 questions. The questions were divided into three major categories with the first section dealing with administrative and personal information, the second part concerned constraints and identification of new agricultural technology and farming practices available in the study area, and the last section considered the socio-economic attributes of the farmers. Most of the questions were closed, while others were open-ended, and structured. Control questions were constructed to cross check the validity of responses.

3.4: Conceptual Issues and Survey Methods

According to Byerlee (1998, Persaran et al. 2000), a few innovative researchers felt that suitable new technology could be developed for farmers by-passed by the previous approaches in technological designs and transfer (for example, green revolution). Proponents of this argument were aware of the complexity of many small farming systems and recognize that research using a systems perspective, and featuring contribution from researchers, extension workers and farmers, might greatly increase the probability of successfully generating suitable new technology. Farming systems research and experiment aimed to overcome the problem of limited farmer adoption by developing new technology as compatible as possible with farmer's circumstances.

When widespread farmer adoption of productive new technology can be demonstrated, several levels of impact assessment may become important. Linking adoption of new technology with improvements in the welfare of farm households and rural villages can be an issue (IFAD, 2007). Questions of research efficiency, and the economic returns to adoption of new technology cannot end with the adoption by farm households. Impact on non-adopting population (for example, consumers) mediated through product prices and wage rates may be equally important. Three methods of assessing farmer adoption of new technology and its economic impact on the small-scale farmers were featured, which were:

1. Monitoring farmers adoption behaviour
2. Estimating economic returns to adoption of new technology and/or farming practices, and
3. Using general equilibrium analysis to examine the effects of farmer adoption on non-adopting population.

Previous studies on adoption and diffusion found that monitoring changes in farmers' circumstances and practices, including use of technology is crucial if meaningful and sustainable improvement in farmers' standard of living is to be achieved (Kelly et al, 2003; Lipton et al, 2001). Related to this fact is the postulation that new technology is rarely introduced into a static setting; rather, farmers' circumstances evolve and change over time. Roads may be completed; off-farm employment opportunities may open up; product and input prices may change; new pests and diseases may become important. Thus, FSR teams are typically aiming at a moving target (FAO, 2007). While it is true that theory often differ from practice, monitoring adoption behaviour need to be periodically effected in order to refocus research towards higher propriety problems. Problems ranking may change over time as farmers adopt solutions to some problems and/or as new and important problems appear. In addition, monitoring is, at least in theory, a standard part of FSR procedure and is contained in the concept of diagnosis as a "continuous process" (Byerlee, 1998).

When farmers at a given point define “adoption” in time, several interpretations come to mind. For example, adoption may then be interpreted as a binary variable (for example, fertilizer dose) on the one hand. And yet on the other, it may be interpreted in terms of a particular point in time for example today; a time range; or over the last five years. In addition, adoption can be reversible, that is, farmers' use of new technology may only be temporary. It is therefore possible to stratify farmers' population into two categories, "adopters" and "non-adopters". However, this type of classification may be inadequate and a more exhaustive set of farmer categories would therefore be "users" (farmers fully using a recommended technology at the current time), "partial users" (farmers using only a part of a recommended technology, for example, recommended cropping pattern, and non-recommended planting dates), ex-users (farmers having tried a recommended technology and consequently having decided that it is not suitable), and non-users. Non-users come in two sub-categories; farmers who have consciously decided not to use recommended technology and farmers who do not yet have enough information to make up their minds one way or the other (Eicher, 2003). This study considers only the "users" and "non-users".

3.5 The Empirical Model

The uncertainty in the *a priori* choice of an appropriate function form necessitates the specification of the multiple function forms. In estimating agricultural productivity parameters, such functional forms other than the three-stage least squares, like single-equation, two-stage squares, semi-logarithmic and double-logarithmic forms may be tried. Evaluating our estimated parameters was based on the functional forms that give superior results. The model as implicitly expressed in the function has the endogenous variable and exogenous variables defined as follows:

Y = Income 2007 (net cash farm earnings, in Kenya shillings),

X_1 = Crop yield 2007 ('000 kilogram's)

X_2 = Number of cattle owned by the farmer during the year,

X_3 = Number of labourers (both family and hired labour used for agricultural work),

X_4 = Quantity of fertilizers used for major crop 2007,

X_5 = Total expenses on pesticides/insecticides for 2007,

X_6 = Quantity of improved seed for major crop used in 2007

X_7 = Educational level of respondent (number of years of education),

X_8 = Family size (number of persons in the household),

X_9 = Crop yield 2006,

X_{10} = Total number of new agricultural technologies adopted for crop production,

X_{11} = Age of respondent and

X_{12} = Gender status (male/female)

The *a priori* expectation of signs of the parameters is as follows:

1. The parameter β_1 for the variable X_1 is expected to have a positive sign. This is based on the expectation that farmers with high annual yields (surplus) in 2007 will have more produce for sale and therefore higher net-cash earnings of 2007.
2. The parameter β_2 for the variable X_2 is expected to have a positive sign on the expectation that the larger the herd of cattle, the higher the likelihood of the farmer's ability to meet required cash for purchase of agricultural inputs believed to influence yields and annual net-cash earnings.

3. The parameter β_3 for the variable X_3 is expected to have a positive sign on the intuition that farmers with adequate labour capacity will be able to make effective use of the farm inputs that may be made available.

4. The parameter β_4 for the variable X_4 is expected to have a positive sign based on the belief that should the farmer be able to use an appropriate quantity of fertilizer, the productivity of the farm in terms of yields is expected to increase and thus the possibility of increased sales of the surplus and hence the expected increase in net cash farm earnings.

5. The parameter β_5 for the variable X_5 is expected to have a positive sign based on the postulation that those who spend more on pesticides and insecticides are most likely to have better yields which in turn can increase the net-cash farm earnings for the farmer.

6. The parameter β_6 for the variable X_6 is expected to have a positive sign on the basis that farmers who use improved seed varieties are expected to have higher yields (surplus) which can be sold to increase the net cash farm earnings.

7. The parameter β_7 for the variable X_7 is expected to have a positive sign based on the expectation that those with higher education (more years of school) would be more responsive to change and use of new technology and farming practices hence increased productivity and increased net cash farm earnings.

8. The parameter β_8 for the variable X_8 is expected to have a negative sign with the postulation that larger families are more likely to spend less on farm inputs as there are more mouths to feed thus competing with expenses on inputs.

9. The parameter β_9 for the variable X_9 is expected to have a positive sign on the basis that higher yields in 2006 may result into a surplus for sales thus enhancing

the farmer's ability to purchase inputs for use in 2007, hence the expected high yield in 2007 translates into increased productivity, hence higher incomes.

10. The parameter β_{10} for the variable X_{10} is predicted to have a positive sign with the expectation that the higher the number of new technologies adopted by the farmer, the higher the probability of increased productivity, hence higher incomes.

11. The parameter β_{11} for the variable X_{11} is expected to have a negative sign with the postulation that younger farmers are more responsive to change (adoption) hence the likelihood of increased productivity and income.

12. The parameter β_{12} and for the variable X_{12} is predicted to have either positive or negative signs, because male farmers are more likely to reach decision to adopt faster thus increased productivity and income. On the other hand female farmers may not have the leverage of making decision to adopt without consulting the head of the household who is more often than not a male. Hence the lower productivity associated with the longer time taken before adoption by female farmers.

3.6: Model specification

Baidu-Forson (1999) recognised that the problem of choice of technique arises from the fact that any relationship of economic theory is almost certain to belong to a system of simultaneous equations, whose parameters may be estimated by various econometric techniques. A structural system of simultaneous equations may be obtained either by single equation techniques, that is, methods which are applied to one equation of the system at a time, or by complete systems technique, that is, methods which involve the solution of all the equations simultaneously and the estimation of the parameters of all the coefficients of the system at the same time.

According Patrick (2005) the efficacy of the simultaneous equation system is important, but being constrained by lack of adequate computational facilities, used the single equation procedure. It therefore suffices to say either of these techniques may be used in estimating the coefficients of economic relationship.

The choice of technique depends to a considerable extent on the purpose for which the model is being estimated. For example, in testing economic theory the researcher is interested in obtaining as accurate as possible estimates of the individual structural coefficients of the model, because those coefficients are the elasticities and other parameters of economic theory. Secondly, the purpose may be for policy making or evaluation of alternative policy measures. In that case, the researcher is interested in obtaining as accurate as possible, estimates of the reduced-form coefficients of a model, given that these coefficients are the basis for estimation of policy multipliers, or impact multipliers. And lastly, the purpose may be for forecasting. Thus, the model in this case is for predicting the magnitude of the endogenous variable, given the value of predetermined variable, that is, prediction of the values of the endogenous variables on the condition that the predetermined variables will take the assumed values (Mackinon, 2004).

Shenggen and Rosegrant (2008) observed that the single-equation procedure does not necessarily produce bad estimates even though the true model involves simultaneous equations. Vogel and Adams (1999) has argued that the two-stage least squares has provided satisfactory results estimates of structural parameters and has been accepted as the most important of the single-equation techniques for estimation of over-identified models. However, the two-stage least squares technique does not have any advantage over the ordinary least squares in the estimation of the recursive models. It also has the disadvantage of requiring a large number of observations, especially if the model includes many predetermined variables. According to

Shenggen and Rosegrant (2008), the three-stage least squares is a systems method, that is, it is applied to all equations of the model at the same time and gives estimates of all the parameters simultaneously. It takes into account the entire structure of the model with all the restrictions that the structure imposes on the values of the parameters. The single-equation technique make use only of the variables appearing in the entire model, but they ignore the restrictions set by the structure on the coefficients of other equations as well as the contemporaneous dependence of the random terms of the various equations.

Kunter et al (2004) indicated that, taking into account the nature of economic phenomena and the simplification which we adopt in specifying the econometric models, we may well expect the random variables to be contemporaneously correlated, that is $\varepsilon(\mu_{i,}\ \mu_j)$ # o, where i refers to the i^{th} equation and j to the j^{th} equation. Thus, for various reasons, we include explicitly in a relationship only the most important variables, leaving the influence of other less important variables to be absorbed by the random variable of the relation. If some variables are omitted from more relations of the system, it is inevitable that the random variables of these relations are correlated and hence the application of the three-stage least squares is appropriate. Application of two-stage least squares under these circumstances would ignore part of the information included in the entire system and hence the estimates of the parameters would be less efficient. For this study, there were several variables, which were dropped from further analysis due to correlation (Annex 1 and 2), and we expect that in the relations established in our model, there are obviously other random variables that might influence the relations but have not been considered in our model.

This study will adopt the Logit/Probit Maximum Likelihood model as used by Baidu-Forson (1999) to identify the determinants to adoption of selected new agricultural technologies.

According to Demographic Surveillance System (DSS, 2008), food security can often be determined in terms of levels of grain calorie consumption. This can be measured by the daily dietary energy and protein intake levels, adjusted for household size, age and composition as recommended by FAO/WHO, (DSS, 2008). However, since in many developing countries foods other than cereals contribute about 20% of energy in the diet, it is assumed that cereals supply 80% of energy in diets of the people. Given that maize is the main cereal, food security is determined based on maize and maize equivalent energy content of other non-maize carbohydrate foodstuffs. The average daily calorie requirement for a moderately active adult equivalent (AE) is 2850 kcal/day. According to WHO (DSS, 2008), a safe minimum daily intake should not fall below 80% of the above calorie requirement, which means that the minimum intake should be 2,280 kcal/AE/day. Based on the above data, the minimum daily maize requirement per adult equivalent per day is 568 grams, which is equivalent to 207.3 kg of maize (or any grain expressed in maize equivalents) per year. To measure food security at household level, all household members were converted into adults using the formula:

$$AE = (A + 0.5\,C)^{0.9}, \qquad (3.1)$$

Where:

AE= Adult equivalent units;

A= Number of adults, grains bought, and grains received from relatives or other sources.

C= Number of children.

The interpretation is that, based on the given standard estimates, households with AE of less than 2,280 kcal per day or those consuming less than 568 grams of maize per day per adult equivalent will be considered as food insecure. Eventually, all household members are converted into adult equivalents, then maize and other grains consumed by household members per adult equivalent are compared with the above minimum of 207.3 kg of maize and maize equivalent per year to isolate respondents into food secure and food insecure households. Maize and other grains consumed include a sum of grains produced by respondent household (DSS, 2008).

This study used a comparable model called the aggregation method of the income accounting approach in which the current vulnerability, that is food insecurity, was assessed by calculating the total income for each administrative unit, that is, the district, as derived from the summation of income from crop and livestock production, fisheries and non-agricultural income during a specified period, for example, annually. Per capita income for each district was then expressed in terms of maize equivalent, as a measure of the ability to purchase maize and other expenditure items. The aggregation method is derived from the Vulnerability Assessment Mapping report for Zambia (FAO, 1998). Two hundred and seventy (270) kilograms of maize per person per annum, that is, 3 Maize Equivalents were considered the minimum amount of food required for survival, thus the hardcore poverty line. Likewise, 440 kilograms of maize per capita per annum were required to ensure sufficient quantities of cereals, other foods, goods and services just to attain the national poverty line.

Although the conceptual framework was based on the household, the Current Vulnerability Assessment (CVA) takes the third administrative level, that is, the district, as the unit of analysis for two reasons; most complete data are often available at this level, and emergency, mitigation, and development actions are also undertaken at this level. Where relevant, attempts were made to describe food access conditions for homogeneous groups of households within the district level who have similar strategies for meeting their food needs, that is, livelihood. The approach is oriented towards estimation of a household's income and assets position. The household is used as a theoretical construct and is generalized at the district or socio-economic group level. Therefore, as employed in this analysis, the term household serves as an illustrative construct to represent an average household across the unit of analysis. This study adopted the Vulnerability Assessment Mapping to assess the impact of the returns to agricultural technology adoption on small farm household food security as used in the report for Zambia (FAO, 1998) based on the type of data available for this study.

3.7: Framework of Analysis

3.7.1: Socio-Economics

In order to better understand the mode of operations of the small-scale farmers in the study area, a systems approach was used in which farmers were classified according to their socio-economic attributes such as annual income level, agricultural technology adoption, years of education attained, constraints to adoption, region, family size, and age category. It is these-socio-economic characterizations that are referred to as the systems within which farmers operate. There are three main reasons for this type of systems analysis: firstly; grouping farmers (or farm populations) in terms of similarities in organization, management, actual economic performance, constraints, and problems gives an impetus for the desired analysis. Secondly; the characterization of different small-scale farmers into various sub-systems in the study area provides a basis for economic recommendation domains for specific innovations. And thirdly; the systems approach will assist in the quantitative technical and economic description of the organization and structure of the small-scale farming systems in the study area.

Using the systems approach, respondents were classified into different sub-systems such as adopters verses non-adopters, high income verses small income, years of education, age categories, and constraints to adoption and adoption impact was measured in terms of annual net cash farm income and annual yields of major crops and livestock produce obtained by different groups.

3.7.1.1: Non-parametric

A non-parametric analysis was done to ascertain the perception and opinion of agricultural researchers and practitioners as well as their ranking of various agricultural information sources, patterns of response to questions raised, and the significance of the different patterns, if any. Friedman's two-way analysis of variance (ANOVA) was used to generate the mean rankings of benefits associated with sources of agricultural information, probable statements on extension services, and respondent's opinion on new technology adoption rates. Mean ranks were computed by dividing the sum of ranks of each category by number of cases. Kruskal-Wallis one-way ANOVA was used to determine whether there were any significant differences in the pattern of responses based on explanatory variables (for example, region, years of experience, and personnel position). The result was determined by finding out if the sums of the ranks of each group differ significantly from each other at an alpha value set at 0.05 or less. The Mann-Whitney U-test was then applied to all possible pairs of contrasts. Alpha was set at 0.01 or less in accordance with the post-factum analysis procedure. The analysis was used to determine whether there was a significant difference in the way two groups rate the independent variables, for example, beneficial sources of agricultural information, statements on extension services, and adoption rates of new technology available in the study area. Mean ranks, Z-scores, Chi-squares were used to organize the data into groups in order to show the significant differences in the relative order of ratings, patterns of responses, and rating patterns within different categories of the variables studied.

Three variables were selected for non-parametric analysis involving a qualitative estimation of practitioners' opinions and perceptions. The variables included perceived benefits associated with deferent sources of agricultural information, opinions about the adoption of agricultural technologies, and opinions about four statements on extension services

3.7.2: Returns to adoption of agricultural technology

The returns to adoption of selected new agricultural technologies were determined by comparing the levels of production and income of those farmer households who purchased farm inputs, hence adopters, against those farmers who did not spend on farm inputs, that is, non-adopters. While previous studies on analysis of returns to adoption hinged on the reduction of a given enterprise production to specific management practices which determine the final production outcome, This study was focused on reducing the net cash farm income to specific use of a range of new agricultural inputs and farm implements which determine the annual net farm income for a maize farmer. For example, these practices would include quantity of fertilizer used, means of land preparation, quantity of improved seeds used, expenditure on pesticides/insecticides, and availability of labour for the farm family.

For a livestock farmer, the practices would include the breed of livestock raised, vaccination, dipping and use of accaricides. The assumption here is that, farmers who adopt new agricultural technology and farm practices are likely to have higher productivity, produce surplus, and eventually higher net farm income.

3.7.3: Determinants of Agricultural technology adoption

Logit/Tobit maximum likelihood analysis was done to identify the determinants to adoption of selected new agricultural technologies. Farm households in South-western Kenya are not homogeneous systems on which new agricultural technology "t" is adopted. There were expectations of individual farm households with zero adoption of new agricultural technologies. According to Baidu-Forson (2000) the application of LogitTobit analysis is preferred in such cases because it uses both, data at the limit as well as those above the limit to estimate regression. Maize equivalent (MEQ) for all farm enterprises was used as the dependent variable and was derived by calculating the total annual value of each farm enterprise, for example sorghum, and then dividing the value by the retail market price for maize of a given base year, in this case 1997 was used as a base year when the price of maize in the country was relatively stable. The maize equivalent for all farm enterprises was then arrived at by the summation of MEQ for all enterprises produced by individual farmers. A direct application of Logit/Tobit estimation sufficiently provides the needed probability and intensity of use of technologies. This study will adopt the model as used by Baidi-Forson (2000).

Thus let **U (t)** represent the perceived utility from adoption of improved technology **`t´** While the utility from existing traditional farming practices is **U (0)**. Also let X_i represent the set of socio-economic, institutional factors and beliefs, which influence adoption decisions of the farmer. Thus $U(X_{it})$ and $U(X_{i0})$ designate utilities from improved and traditional practices. The stochastic model, which underlies Tobit, is then specified as:

$t_1 = X_i\beta + \mu_i$, if $X_i + \mu_i > 0$, positive unobserved latent variable. (3.2)

where $U(X_{it}) > U(X_{i0})$ and adoption of improved agricultural technology t occurs;

$t_i = 0$ if $X_i + \mu_i \leq 0$ in cases of non-adoption of t, (3.3)

where $U(X_{io}) > U(X_{it})$;

Here, $i = 1,2\ldots N$ denotes the sample size surveyed, t_i, the dependent variable, and X_i represents a vector of independent socio-economic, institutional variables, β a vector of unknown coefficients or parameters to be estimated, and μ_i the independent normally distributed error term assumed to be normal with zero mean and constant variance σ. The relationship between the expected value of all observations, E_t and the expected conditional value above the limit E^*_t is given by:

$$E_t = F(z)E^*_t \qquad (3.4)$$

Where F (z) is the cumulative density normal distribution function and

$$z = X\beta/\sigma. \qquad (3.5)$$

Consideration of the effect of the kth variable of X on t led to decomposition as

$$\delta E_t/\delta X_k = F(z)(\delta E^*_t/\delta X_k) + E^*_t(\delta F(z)/\delta X_k) \qquad (3.6)$$

This equation suggests that the total change in elasticity of t can be disaggregated into:

1) a change in probability of the expected level of adoption of t for smallholders who are already adopter.

Change in the elasticity of the probability of being an adopter and that consistent estimates of β and σ are obtained by using maximum likelihood techniques. where plim **(b)** = β and plim **(s)** = σ.

3.7.4: Impact of the Returns to adoption on Farm Household food Security

The impact of returns to adoption of new and innovative agricultural technologies on smallholder farm household food security was done by a comparative analysis of the maize equivalent for adopters and non-adopters in the study area using the aggregation method of the income accounting approach to assess the current vulnerability, that is food insecurity, of individual farmers in the study area. The CVA for individual farmers was then compared for adopters, non-adopters, and regionally.

The CVA analysis is founded on a model of household income, or more specifically household's use of acquired food, that is, whether the food is acquired directly or through cash purchase or batter trade. The assumption is that household income is composed of production for home consumption and sales of crop, livestock and fisheries production, income generating activities, ability to access transfers and assets, both current and acquired.

The income accounting model was applied to the Kenyan CVA analysis. Total income for each administrative unit, that is, the district, is derived from the summation of income from crop and livestock production, fisheries and non-agricultural income during a specified period, for example, 1997. Per capita income for each district is then expressed in terms of maize equivalent, as a measure of the ability to purchase maize and other expenditure items. The method used to classify districts by their degree of food security is derived from the Vulnerability Assessment Mapping report for Zambia (FAO, 1998). Two hundred and seventy (270) kilograms of maize per person per annum, that is, 3 Maize Equivalents were considered the minimum amount of food required for survival, thus the hardcore poverty line. Likewise, 440 kilograms of maize per capita per annum were required to ensure sufficient quantities of cereals, other foods, goods and services just to attain the national poverty line.

Although the conceptual framework was based on the household, the CVA takes the third administrative level, that is, the district, as the unit of analysis for two reasons; most complete data are often available at this level, and emergency, mitigation, and development actions are also undertaken at this level. Where relevant, attempts were made to describe food access conditions for homogeneous groups of households within the district level who have similar strategies for meeting their food needs, that is, livelihood. The approach is oriented towards estimation of a household's income and assets position. The household is used as a theoretical construct and is generalized at the district or socio-economic group level. Therefore, as employed in this analysis, the term household serves as an illustrative construct to represent an average household across the unit of analysis.

3.7.4.1: Setting Up the Analysis

Table 3.1 shows the Nyanza socio-economic groups' population, by district. Three major Socio-economic categories were considered namely:

1. The mixed farmers situated in the high potential agricultural areas of Kisii Central, Nyamira, and Gucha districts
2. The cereal and dairy farmers situated in the high potential grain-basket areas of Migori, Upper Rachuonyo, Kisumu, and Nyando districts
3. The marginal agricultural farmers situated in the semi-arid areas of Bondo, Homa Bay, Lower Rachuonyo, Suba, and Siaya districts.

Table 3.1: Nyanza socio-economic groups' population, by district, 2001.

Category	District	Population	Total
Mixed high potential	Kisii Central	498102	1,450,830
	Nyamira	491786	
	Gucha	460939	
High potential Cereal/Dairy	Migori	504359	2,431,350
	Kisii Central	498102	
	Kisumu	514897	
	Gucha	460939	
	Upper Rachuonyo	153126	
	Nyando	299930	
Marginal, Semi-arid	Bondo	238780	1,317,170
	Homa Bay	288540	
	Siaya	480184	
	Suba	155666	
	Lower Rachuonyo	154000	

Source: ROK, 1999 Census Results.

3.7.4.2: Livelihood Strategies Among the Socio-economic Categories

3.7.4.2.1: The Mixed Farmers in the High Potential Areas of Nyanza Province

The mixed farmers in the high potential areas of the province derive between 40 to 60 percent of their income from crop production. The rainfall pattern is largely bi-modal. The short rainy season runs from October to January, while the long rainy season is from February to August. Nearly 60 to 70 percent of total output is derived from the long rains period. Food crops, for example maize, beans, potatoes, and bananas, contribute 5 to 15 percent of total crop income, while horticultural crops account for close to 20 percent of total income. Tea, coffee and pyrethrum production are the main source of cash crop income in this socio-economic category. Improved livestock breeds also supplement household income in addition to rearing predominantly for subsistence. In this category, more than 50 percent of the households possess between 1 to 3 acres of land. Hence, off farm income is an important contributor to household income. Over 30 percent of household income is derived from off-farm activities such as petty trade, selling labor to local urban centers and artisan production.

3.7.4.2.2: The High Potential Predominantly Cereal and Dairy Farmers

The rainfall in these areas is largely unmoral and subsequently, virtually all crop output is derived normally from the reliable long rainy seasons. The farm households in this socio-economic category often grow cereals, predominantly maize, and rear grade dairy animals for both commercial and domestic consumption. Maize is grown both as the main food and cash crop. Cash crops in the area include tobacco, coffee, and sugar cane. Both dairy and crop production contribute between 30 to 40 percent each to total household income. Horticultural production supplements the household income and between 20 to 30 percent of household income is derived from non-agricultural activities

3.7.4.2.3: The Marginal Agricultural Farmers in the Semi-arid areas of Nyanza Province

The rainfall patterns in this sub-region are bi-modal with the long rains expected from February/March to August, while the short rains are expected from September/October to January. The marginal agricultural zones are often characterized by frequent crop failures. The long rainy season is particularly susceptible to the failures. Despite the reliability and low rains, the relatively less resilient maize is the major crop grown. Other important crops in the area include the more drought resistant sorghum, millet, pigeon/cow peas, green grams, beans, cassava, and sweet potato. Livestock production is dominated by the relatively drought tolerant, albeit low yielding indigenous zebu cattle and goats. Importantly, livestock are reared more as a "fall-back" during poor seasons than as a source of income. Although crop production is undertaken largely for subsistence purposes, crop out put is often sold soon after harvesting so as to finance other household needs. Area cash crops include groundnuts, cotton, and sugar cane. In this socio-economic category, crop production contributes an estimated 30 t0 40 percent of the total household income, while livestock supplement 10 percent and non-agricultural activities contribute about 50 percent of the total household income. Major constraints to off-farm income include rural-to-rural labor migration to the high potential districts, proliferation by artisan production, charcoal production, petty trade and remittance.

Specifically the Income Accounting Approach considers four primary sources of income:

1. Crop production (food, horticultural, and industrial)
2. Livestock production
3. Fisheries
4. Off-farm income

For lack of reliable data, this study employed only crop and livestock production sources of income for the assessment of district vulnerability. The major food crops grown included maize, beans, sorghum, millet, cassava, cowpea, green grams, and sweet potatoes. The major horticultural crops included vegetables and fruits for local and export consumption namely; tomatoes, onions, cabbages, mangoes, pineapples, and paw paw. All food and horticultural crops were used both as a source of food and income. Major industrial cum cash crops produced included Tea, Coffee, Pyrethrum, Cotton, Tobacco, and Sugar cane. These crops were produced almost exclusively as cash crops.

3.7.4.3: Calculation of Income and Maize Equivalents from Crop Production.

Income from crop production, namely, per capita crop income and the respective per capita Maize Equivalent from crop production in each district during the year 2001 was calculated as follows:

1. In each district, total value of crop production is obtained by summing up the value of output for each crop, that is, food, horticultural and cash crops, for each district.
2. Dividing the total value of crop output by the district population derives the per capita value of crop output from each district. Human population data was obtained from the Government of Kenya (GOK) district annual reports
3. The per capita value of each crop enterprise, food crop, horticultural, and cash crop, for each district was obtained by dividing the total income from each sector by the total population of the relevant district
4. The earnings derived from crop production are converted to maize equivalents by dividing the total income by the districts average retail price of maize during the year 2001. The average retail price of maize was obtained from the Marketing Information Branch of the MOARD. The value of the maize equivalent depicts the purchasing power of crop output.
5. Likewise, the maize equivalent value for each of the crop sub-sector, horticultural and cash crop production for each district is obtained by dividing separately income from each of the enterprises by the year 2001 average retail maize price

6. The districts are then classified on the basis of their maize equivalent. It follows that the higher the per capita maize equivalent, the less food insecure the household is. The converse is also the case.

3.7.4.4: The Maize Equivalent Ranking in the Kenyan CVA, the case of Nyanza province

Maize is the single most important staple food crop to the majority of the population. The maize equivalent provides an easily understandable and comparable yardstick of the purchasing capacity from crop production and other farm and non-farm income. The classification of the various categories of food security is obtained from the Vulnerability Assessment Mapping for Zambia, derived from the 1994 World Bank Poverty assessment study in which 270 kilograms of maize (3 bags) was equated to the threshold food poverty line United Nations Development Programme (UNDP, 2007). Conversely, 440 kilograms of maize per capita (approximately 4.89 bags) constitute the amount of maize per capita, necessary for normal livelihood. On the basis of the Maize Equivalent threshold values, derived from the 1996 Zambia Vulnerability Assessment Mapping (VAM), (FAO, 1998), the following classification was used to categorize districts in terms of their food security status during the year 2001. The classification encompasses only flows of income from crops and livestock and the results are shown in Table 4.16 in chapter 4. The Maize Equivalent categorization is defined as follows:

1. **Extremely Food Insecure:** Those districts with a MEQ value less than 3.00
2. **Highly Food Insecure:** Those districts whose MEQ ranges between 3.00 to 4.88
3. **Moderately Food Insecure:** Those districts whose MEQ ranges between 4.89 to 7.77
4. **Food Secure:** Those districts whose maize equivalent is greater than 7.78.

These standards are comparable to the DSS (2008) estimations in which food security can often be determined in terms of levels of grain calorie consumption. In the DSS standards, food security is determined based on maize and maize equivalent energy content of other non-maize carbohydrate foodstuffs. The minimum daily maize requirement per adult equivalent per day is 568 grams, which is equivalent to 207.3 kg of maize (or any grain expressed in maize equivalents) per year (DSS, 2008).

A maize equivalent ranking on the basis of auto-production, that is, exclusive of non-farm income is also possible to undertake. The results of such analysis illustrate the extent to which population groups are able to meet their livelihood needs through on-farm production.

CHAPTER 4

4.0: EMPIRICAL DATA

4.1: Socio-economic Profile

Annex 3 shows the socio-economic profile of the respondents in the study area. The issue of gender has emerged as one of the most critical socio-cultural variables in community development. Theoretically female farmers take longer adoption-decision periods than male farmers, this is often explained by the fact that, female farmers may have to consult with their spouses, who sometimes may be away from home, before making a decision to reject or adopt. Data analyzed indicated that except in the Kendu Bay area where the gender distribution was equal, female respondents were fewer than male respondents in Oyugis and Rongo regions. Overall within the area of study, female farmers constituted 43 percent while their male counterparts formed 57 percent of the respondents.

Equally important was the age structure distribution in the community. The postulation was that the older the person, the more conservative, and therefore a tendency to resist change on the one hand. On the other hand, the younger the person, the more open-minded, and hence the propensity to accept and adopt change. Socio-economic data analyzed show that within the age categories, Oyugis region had the highest, 44 percent, of younger farmers (less than 31 years old) than Kendu Bay and Rongo regions, which reported 31 percent and 15 percent in that age category respectively. Regionally, the majority (46.1 percent) were in the middle age category of between 32 and 49 years of age. This means that given the dominant middle age category in the area of study, farmers would be fairly predisposed towards change without the extremes associated with either old or young age.

Adoption/diffusion theory states that the lager the family size, the less likely were farmers to purchase farm inputs for agricultural production purposes. This notion was informed by the fact that, faced with a meager income, or profit level, the farmer was more likely to spend on family subsistence than purchase of farm inputs. Thus family size may have an influence on adoption of farm inputs for increased production levels. Data analyzed show that all respondents from the Kendu Bay region indicated having large size families, that is, more than 10 persons in the household and most of the respondents from Rongo, 72 percent, had medium size families, that is, between 5 and 10 persons in the house-hold. Over 55 percent of the respondents in the study area had medium size families. These results indicated a middle ground in terms of family size distribution in the study area with the understanding that family size as a variable in the adoption matrix may not pose a major hindrance in the adoption cum diffusion process. Other important socio-economic variables analyzed included farm size, education, farm income, years of experience in farming, and farm production levels. The empirical results were as shown in Annex 3.

4.1.1: Non-parametric Analysis

A non-parametric analysis was done to ascertain the perception and opinion of agricultural researchers and practitioners as well as their ranking of various agricultural information sources, patterns of response to questions raised, and the significance of the different patterns, if any. Friedman's two-way analysis of variance (ANOVA) was used to generate the mean rankings of benefits associated with sources of agricultural information, probable statements on extension services, and respondent's opinion on new technology adoption rates. Mean ranks were computed by dividing the sum of ranks of each category by number of cases. Kruskal-Wallis one-way ANOVA was used to determine whether there were any significant differences in the pattern of responses based on explanatory variables (for example, region, years of experience, and personnel position). The result is determined by finding out if the sums of the ranks of each group differ significantly from each other at an alpha value set at 0.05 or less. The variables selected for non-parametric analysis involving a qualitative estimation of practitioners' opinions and perceptions included perceived benefits associated with deferent sources of agricultural information, opinions about the adoption of agricultural technologies, and opinions about four statements on extension services

Respondents' rating of perceived benefits from the different information sources as indicated in Table 4.1 show that extension officers had the highest rating with 78 percent of the respondents ranking it as extremely beneficial with a mean rank of 6.13. The second most highly rated sources of agricultural information were neighbors/friends/family members and Non-Governmental Organizations (NGOs) with mean ranks of 9.13 each and 83 percent and 89 percent of respondents ranking them as somewhat to extremely beneficial source, respectively. Government sponsored agencies, as a source of agricultural information was also favorably rated with 70 percent of respondents ranking them as somewhat to extremely beneficial with a mean rank of 13.5. The mean ranks of each information source was generated from the Friedman's two-way ANOVA, and are indication of the relative order of the respondents' ratings in descending order. The specific ratings of each of the information sources should be viewed in terms of the relationship to each other. Daily newspapers and farm magazines were rated as the least beneficial sources of agricultural information with 37 and 22 percent of the respondents ranking them as somewhat to not beneficial sources with mean ranks of 22.9 and 19.4, respectively.

Table 4.1: Respondents' Rating of Perceived Benefits from Different Information sources in South Western Kenya.

Information Source	Mean Rank*	Rating Categories (Frequencies)			
		Extremely Beneficial	Somewhat Beneficial	Somewhat Not -Beneficial	Not Beneficial
Farm Magazine	19.38	09(19.6)	22(47.8)	06(13.0)	04(8.7)
Local Farm Newspapers	17.25	08(17.4)	16(34.8)	10(21.7)	04(6.7)
Daily Newspapers	22.88	09(19.6)	15(32.6)	12(26.1)	05(10.9)
Farm radio/Tel. programs	16.63	16(34.8)	19(41.3)	05(10.9)	01(2.2)
Extension officers	6.13	36(78.3)	04(8.7)	--	01(2.2)
Government sponsored agencies	13.5	21(45.7)	11(23.9)	07(15.2)	01(2.2)
Non-Governmental organizations	9.13	24(52.2)	14(30.4)	02(4.3)	05(10.9)
Commodity associations	16.63	16(34.8)	13(28.3)	07(4.3)	--
Neighbors/friends/family members	9.13	19(41.3)	22(47.8)	02(4.3)	--
Others	14.38	03(6.5)	04(8.7)	01(2.2)	

Note: *Based on Friedman's Two-way ANOVA; 1=Extremely Beneficial, 2=Somewhat Beneficial, 3=Somewhat non-beneficial, 4=Not beneficial.
Figures in brackets are percent of 46 respondents.

In terms of experience, most of the respondents had more than 5 years of work experience with the over 12 years category being the most experienced (43 percent) followed by the 6-11 years group and 1- 5 years group which had 26 percent of the respondents as shown in Annex 5. The least reported years' of work experience was less than 1-year category, which had only 2 percent of the respondents.

The opinion of agricultural practitioners and researchers in the study area was sought on four statements concerning extension services in the country. The specific ratings of each statement about the extension services should be viewed in terms of the relationship to each other. Over 80 percent of the respondents disagreed or strongly disagreed with the statement that "extension services are ineffective due to negative attitude of extension officers" with the lowest mean rank of 24.5 and only 13 percent of the respondents agreed or strongly agreed with that statement as shown in Table 4.2. Similarly, there was a strong agreement with the statement that 'extension services are ineffective due to lack of personnel' with over 60 percent of respondents approval in the affirmative and only 24 percent disagreed or strongly disagreed with that statement.

On the other hand, 78 percent of the respondents agreed or strongly agreed with the statement that "extension services are not effective due to poor funding" with the highest mean rank of 12 and only 15 percent of the respondents either disagreed or strongly disagreed with that statement. Based on the data analysed, this would mean a consensus among field based staff that poor funding and lack of personnel were the main constraints to effective extension services in the country. In the opinion of field based staff, 'negative attitude of extension officers" and "inadequate research information flow" were not major constraints to effective extension services.

Table 4.2: Respondents' Agreement with Four Statements about the Extension Services in the Country.

Statement	Rating Categories				
	*Mean Rank	Strongly agree	Agree	Disagree	Strongly Disagree
Extension Services ineffective because of poor funding	12.00	14**(30.4)	22(47.8)	03(6.5)	04(6.7)
Extension services ineffective due to lack of personnel	16.38	13(28.4)	20(43.5)	08(17.4)	03(6.5)
Extension services ineffective due to inadequate research information flow	19.38	16(34.8)	12(26.1)	14(30.4)	02(6.5)
Extension services ineffective due to negative attitude of extension officers	24.50	03(6.5)	03(6.5)	15(32.6)	22(47.8)

Note: *Based on Friedman's Two-Way ANOVA; 1=Strongly Agree, 2=Agree, 3=Disagree, 4=Strongly Disagree. **Frequency () The Figures in Parenthesis Represent Percent of 46 Respondents

Table 4.3 show that on the issue of adoption of various agricultural inputs and new farming practices; means of land preparation, that is, use of animal draft power or tractor, was the most highly rated technology adopted in the study area with 83 percent of the respondents ranking it as having a medium to high adoption with a mean rank of 11.4. In the opinion of the respondents, the second most highly adopted agricultural input was livestock vaccination, followed by environmental friendly farming practices, for example, crop rotation, mulching, terracing, and tree planting with 48 percent rating (mean rank, 15) and 70 percent rating (mean rank, 17.4) of the respondents respectively ranking the two practices as having medium to high adoption. According to the respondents, fertilizers was among the next highly adopted agricultural input with 36 percent rating and a mean rank of 19.5 after the means of land preparation, livestock vaccination, and environmental friendly farming practices among respondents in terms of medium to high adoption in the study area. The mean ranks for the least adopted technologies were 28, and 24 for grade livestock, and dipping of livestock, in that order.

Table 4.3: Respondents' Opinion about the Adoption of Various Agricultural Inputs In South Western Kenya.

Farm Inputs	*Mean Rank	**Rating Categories			
		High Adoption	Medium Adoption	Low Adoption	No Adoption
Fertilizers	19.50	03(6.5)	14(30.4)	23(50.0)	02(4.3)
Means of Land preparation	11.38	27(58.7)	11(23.9)	05(10.9)	--
Pesticides/Insecticides	24.75	--	10(21.7)	28(60.9)	--
Vaccination of Livestock	15.00	05(10.9)	17(37.0)	17(37.0)	02(4.3)
Dipping of Livestock	23.75	02(4.3)	09(19.6)	27(58.7)	04(8.7)
Grade animals	28.38	04(8.7)	16(34.8)	15(32.6)	05(10.9)
Environmental friendly practices	17.38	04(8.7)	28(60.9)	10(21.7)	--

Note: *Based on Friedman's Two-Way ANOVA; 1=High Adoption, 2=Medium Adoption, 3=Low Adoption, 4=No Adoption. **Frequency The Figures in bracket = Percent of 46 Respondents

4.2: Returns to Adoption of New and Agricultural Technologies

4.2.1: Agricultural Technology Adoption

The gist of this study was to identify new agricultural technologies in the study area by smallholder farming systems and then assess the returns that can accrue to their acceptance and adoption. Furthermore, the study intended to identify the important determinants to adoption of the identified new agricultural technologies in the study area. Expectations were that adoption of new agricultural technologies would lead to higher productivity with the accompanying increased farm income leading to a food secure farm household. Annex 7 shows the new agricultural technology adoption in southwestern Kenya, by region. Respondents were asked to estimate and state how much they spend per season on specific farm inputs listed in the questionnaire. Ten agricultural technologies were identified for adoption assessment based on their assumed importance and relation to key farm enterprises prevalent in the study area. These included crop based farm inputs such as improved seeds, fertilizers, pesticides/insecticides, and livestock based technologies including cattle veterinary services, commercial cattle feeds, cattle dipping, poultry veterinary services, and commercial poultry feeds. By far the most widely adopted (90 percent) relatively new agricultural technology was use of mould board plough in land preparation followed by use of improved seeds, 85 percent and cattle veterinary services 80 percent by respondents in the study area. Within each region, Kendu Bay had 100 percent adoption of mould board plough, improved seeds and fertilizers. Rongo region had 87 percent adoption of improved seeds, and 70 percent adoption of fertilizers and poultry veterinary services. In Oyugis region, the most prevalent new agricultural technologies adopted were fertilizers, 80 percent, mould board plough, 77 percent, and cattle dipping 73 percent. The least adopted agricultural technologies in the study area were use of pesticides/insecticides, 93 percent, use of tractor for land preparation, 92 percent, and commercial poultry feeds, 53 percent. These results indicated that smallholder farmers in the study area are aware of and probably use specific farm inputs identified as use of mould board plough, improved seeds, cattle veterinary services, fertilizers, and poultry veterinary services.

4.2.2: Returns to Adoption, Maize Production and Food Security

When farmers use new farm inputs, they are expected to achieve higher production levels and therefore higher income from the farm. It therefore follows that with increased income from the farm, the farmer's purchasing power will be increased and ultimately attain a level of food security. A farmer is then said to be food secure either if they are able to produce enough for subsistence or when they have the purchasing power to acquire the needed supply. Food security can be measured in terms of maize equivalent which estimates that 270 kg of maize, that is, 3 (90 kg bags) per capita is the border line for hardcore poverty. Thus persons who cannot produce or afford that amount of maize in a year would fall under the hardcore poverty line. By the same token, 440 kg, which translates to 4.89 (90 kg bags) of maize is the minimum amount required per capita per year for a person to be food secure, or enjoy normal livelihood. The returns to adoption of new agricultural technology in the study area was therefore assessed using the threshold production requirements for food security.

Since use of improved seeds was considered as one of the most widely adopted technologies by smallholder farmers in the study area, and given the integral part the variable plays in crop production, its adoption was thought to impact positively on increased chances of attaining the food security threshold. Table 4.4 shows the returns to adoption of new agricultural technology in southwestern Kenya, by region/food security. In terms of food security category, all respondents from Kendu Bay region who produced maize and were food secure, that is, produce amounts above the 440 kg threshold, had all adopted improved seeds. In Rongo region of those who produced maize and were food secure, 85 percent had adopted improved seeds and only 15 percent did not use improved seeds. A similar picture is repeated in Oyugis region where 70 percent of those who produced maize and were food secure had adopted improved seeds and only 30 per cent did not use improved seeds. The results indicate that farmers who adopted farm inputs, for example, improved seeds were more likely to reap higher yields and therefore be highly food secure than those who did not adopt.

Table 4.4: Returns to adoption of new agricultural technology in South-western Kenya, by region/maize output, November 2007.

Agricultural technology category		Oyugis (Maize production)			
		1*	2	3	Total
Improved Seeds Adoption (0)	Frequency	0	2	6	8
	Percent within technology category	.0	25.0	75.0	100.0
	Percent within maize output category	.0	50.0	30.0	29.6
Adopted (1)	Frequency	3	2	14	19
	Percent within technology category	15.8	10.5	73.7	100.0
	Percent within maize output category	100.0	50.0	70.0	70.4
	Total	3	4	20	27
		Kendu Bay (Maize production)			
Improved Seeds Adoption (0)	Frequency	-	-	-	-
	Percent within technology category	-	-	-	-
	Percent within maize output category	-	-	-	-
Adopted (1)	Frequency	1	4	11	16
	Percent within technology category	6.3	25.0	68.8	100.0
	Percent within maize output category	100.0	100.0	100.0	100.0
	Total	1	4	11	16
		Rongo (Maize production)			
Improved Seeds Adoption (0)	Frequency	0	1	3	4
	Percent within technology category	.0	25.0	75.0	100.0
	Percent within maize output category	.0	33.3	15.0	13.3
Adopted (1)	Frequency	7	2	17	26
	Percent within technology category	26.9	7.7	65.4	100.0
	Percent within maize output category	100.0	66.7	85.0	86.7
	Total	7	3	20	30

Source: Primary data from the study area

Key: (0) = none adopter; (1) = Adopter; * Maize output category 1= less than 271 kg of maize 3 (90 kg bags) equated to the threshold food poverty line; 2= 271-to- 440 kg of maize per capita, maximum 4.89 (90 kg bags) constituting the amount of maize per capita necessary for normal livelihood; 3= greater than 440 kg of maize per capita.

4.2.3: Returns to Adoption, Farm Income and Food Security

The returns to adoption of new agricultural technologies can also be estimated in the form of income from the farm enterprise with the understanding that even if a farmer may not be able to meet their food security threshold from farming activities, they can combine income from all sources including from the farm enterprise to boost their purchasing power to acquire the needed supplies to meet the goal of food security. Hence farm enterprise income becomes crucial in a farmer's efforts to achieve the food security status. Table 4.5 show returns to adoption of new agricultural technology in South Western Kenya by region and farm income category. All respondent farmers from the Kendu Bay region who were in the upper and medium income categories had adopted use of improved seeds. The same trend is repeated in Oyugis region. Additionally, 75 percent of respondents in the upper income category from Rongo region had adopted use of improved seeds and only 25 percent had not used improved seeds. The implication from these results is that farmers who use improved seeds tended to obtain higher yields and revenue from the farm activities enabling them to achieve food security status.

Table 4.5: Returns to adoption of new agricultural technology in South-western Kenya, by region/Farm income, November 2007.

Agricultural technology category		Oyugis (Farm income category)			
		1*	2	3	Total
Improved Seeds Adoption (0)	Frequency	7	0	0	7
	Percent within technology category	100.0	.0	.0	100.0
	Percent within farm income category	46.7	.0	.0	33.3
Adopted (1)	Frequency	8	3	3	14
	Percent within technology category	57.1	21.4	21.4	100.0
	Percent within farm income category	53.3	100.0	100.0	66.7
	Total	15	3	3	21
		Kendu Bay (Farm income category)			
Improved Seeds Adoption (0)	Frequency	-	-	-	-
	Percent within technology category	-	-	-	-
	Percent within farm income category	-	-	-	-
Adopted (1)	Frequency	9	3	3	15
	Percent within technology category	60.0	20.0	20.0	100.0
	Percent within farm income category	100.0	100.0	100.0	100.0
	Total	9	3	3	15
		Rongo (Farm income category)			
Improved Seeds Adoption (0)	Frequency	1	2	1	4
	Percent within technology category	25.0	50.0	25.0	100.0
	Percent within farm income category	4.8	66.7	25.0	14.3
Adopted (1)	Frequency	20	1	3	24
	Percent within technology category	83.3	4.2	12.5	100.0
	Percent within farm income category	95.2	33.3	75.0	85.7
	Total	21	3	4	28

Source: Primary data from the area of study.

Key: *1= lower income category (less than Kshs. 30,000 per annum); 2= middle income category (from Ksh 30,001 –to- 60,000 per annum); and 3 = upper income category (greater than Ksh 60,000 per annum).

4.3: Determinants of Adoption of New Agricultural Technologies

Commonly there are a series of hypotheses about the effects that different characteristics associated with the farmers, households and regions would have on adoption behaviour. Examples of such theories which were tested in this study include: young farmers tend to be more responsive to adoption of new ideas, practices, and technologies as opposed to older farmers; households that are characterised as large in size (number of persons) tend to spend less on new farm inputs as compared to households which are smaller in size; and that farmers from relatively high agricultural potential regions are more prone to adoption of new crops varieties than those from the low agricultural potential regions.

In addition, farmers decide whether or not to adopt new technologies or farming practices as a package. Secondly, farmers decide how much to adopt, for example, how much area to fertilize. Lastly, they decide the intensity of use, for example, the amount of pesticides to use per hectare. The introduction of improved seed varieties, for example, sorghum, beans, cotton, and tobacco is an important element of increasing agricultural productivity in the country. Also, the factors influencing adoption of improve seed varieties of other crops, hybrid maize, fertilizers, cultivation using animal draft power, and use of pesticides was analyzed.

4.3.1: Simultaneity of Technological Choices

Contingency tables and odd ratios of technology adoption in South Western Kenya were calculated. These are useful for evaluating the propensity of farmers to adopt the full package of technologies (consisting of hybrid maize, fertilizers, animal draft power/tractor, pesticides/insecticides, and new crops) or to adopt certain components selectively. Each segment of Table 4.6 represents a cross-tabulation of two distinct technologies, which are treated dichotomously. For example, comparing the decision to adopt hybrid maize with the chosen method of cultivation shows that 8 farmers use neither hybrid maize nor animal draft power/tractors, while 159 farmers use both. The odd ratio is the product of the on-diagonal cells divided by the product of the off-diagonal cells. A higher ratio indicates that farmers are likely to simultaneously adopt or reject a given pair of technologies.

Table 4.6: Cross Tabulation of Simultaneity of Adoption in South Western Kenya.

	Means of Cultivation		**Fertilizer Use**		**Pesticide Use**		**New Crop**	
Technology Option	Hand Tool	Oxen/ Tractor	Not Adopted	Adopted	Not Adopted	Adopted	Not Adopted	Adopted
Hybrid maize:								
Not adopted	8	56	32	32	31	33	47	17
Adopted	16	159	86	89	70	105	1	174
New Crop:								
Not adopted	7	41	20	29	24	25	-	-
Adopted	17	175	99	93	77	115	-	-
Pesticide Use:								
Not adopted	15	86	59	42	-	-	-	-
Adopted	9	130	60	80	-	-	-	-
Fertilizer Use:								
Not adopted	9	110	-	-	-	-	-	-
Adopted	15	106	-	-	-	-	-	-

Note: For the adoption of hybrid maize, the odd ratio to the use of Oxen/tractor is 1.42, to the adoption of fertilizers, 1.03, to the adoption of pesticides/insecticides 1.41 and to the adoption of new crops 481.1.
For the adoption of new crops, the odd ratio to the use of tractor is 1.75, to the use of fertilizers is 0.65 and to the adoption of pesticides/insecticides 1.43.
For pesticide/insecticide use, the odd ratio to the use of oxen/tractors is 2.52; to the use of fertilizers is 1.87. For the use of fertilizers, the odd ratio to the use of oxen/tractors is 0.58.
Source: Primary data.

The following pairs of technology were more likely to be adopted simultaneously; hybrid maize and new crops, pesticides/insecticides and animal draft power, and pesticides/insecticides and fertilizers. The decision to adopt new crops and fertilizers, animal draft power and fertilizers, as well as hybrid maize and fertilizers were made more independent. Deciding to adopt hybrid maize, new crops, pesticides, animal draft power/tractors, and fertilizers simultaneously imply that farmers in the study area respond to extension services available in the region. Evidence of simultaneity also underscores the need to design integrated development programmes.

Validation data results analysed in relation to objective 3 of the study, that is, identification of the determinants to adoption of new agricultural technology in the study area, were as follows:

Validation data Probit Maximum Likelihood analysis:

The results (Table 4.7) show that with $\propto = 0.05$, Farm income (FARMINCO) and use of fertilizers (PURCHFER) had significant influence on smallholder farmers' adoption of new agricultural technologies in the study area. The interpretation was that farmers with high income from the farm enterprises were more likely to use fertilizers and therefore achieve food security status than those who did not.

Table 4.7. Probit Maximum Likelihood Estimates of the Adoption of Fertilizers, improved Seeds, and Cultivation with Oxen (Mouldboard plough) in South Western Kenya.

Variable	Normalized coefficient	Standard error	B/st.Er	Elasticity of:	
				Adoption index (P[|z|>z])	Expected level of use intensity
Constant	-1.589	2.257	-.704	.482	.232
TOTHHOLD	.001	.002	.343	.731	.535
MAIQUAN	.0003	.0005	.660	.509	.259
FARMINCO	**.0004**	**.0001**	**3.043**	**.002**	**.000005**
PURCHSEE	3.070	1.715	1.790	.074	.540
PURCHFER	**3.384**	**1.463**	**2.313**	**.021**	**.043**
MOULDBOA	-3.234	2.377	-1.360	.174	.030
YRSINFRM	-.056	.033	-1.700	.090	.008
MEDICALE	.002	.001	1.840	.066	.004

Source: Primary data .

4.4: Impact of the Returns to Adoption of Agricultural Technology

Maize is staple crop for many people in Kenya. Its level of production can signal hard times ahead or vulnerability to food insecurity to many, particularly in the rural areas. The vulnerability assessment can be done on the basis of the World Bank determined threshold of 440 kg an equivalent of 4.89 (90 kg bags) of maize per capita required by an adult per year for normal livelihood and the 270 kg which translates into 3 (90 kg bags) of maize per capita per year (FAO, 1998). Use of improved seeds for production purposes can increase chances of higher yields for the farmer and therefore increase the likelihood of food security achievement. Vulnerability classification range from Extremely food insecure, that is, producing less than 270 kg or 3 (90 kg) bags of maize per capita per year, to Food secure status, that is, producing over 699 kg equivalent to 7.77 (90 kg bags) of maize per capita. Table 4.8 below show agricultural technology adoption as a determinant of smallholder farmers' household food security status in southwestern Kenya, by region. Respondents who were classified as food secure (category 4) were all from Rongo region and all had adopted improve seeds in production. However, 92 percent of those who were extremely food insecure had adopted improved seeds and only 8 percent did not use improved seeds. All farmers who were moderately to highly food insecure from both Kendu Bay and Oyugis regions had all adopted the use of improved seeds for crop production. Therefore, the results did not give a clear picture to associated adoption of new agricultural technologies with attainment of food security status.

Table 4.8: Agricultural technology adoption impact on smallholder farmer household food security in South-Western Kenya, by region, November 20007.

Technology category		Oyugis (Degree of food security)				
		1*	2	3	4	Total
Improved Seeds Adoption (0)	Frequency	11	0	0		11
	Percent within technology category	100.0	.0	.0		100.0
	Percent within food security category	44.0	.0	.0		36.7
Adopted (1)	Frequency	14	4	1		19
	Percent within technology category	73.7	21.1	5.3		100.0
	Percent within food security category	56.0	100.0	100.0		63.3
	Total	25	4	1		30
		Kendu Bay (Degree of food security)				
Improved Seeds Adoption (0)	Frequency	-	-	-	-	
	Percent within technology category	-	-	-	-	
	Percent within food security category	-	-	-	-	
Adopted (1)	Frequency	12	3	1		16
	Percent within technology category	75.0	18.8	6.3		100.0
	Percent within food security category	100.0	100.0	100.0		100.0
	Total	12	3	1		16
		Rongo (Degree of food security)				
Improved seeds Adoption (0)	Frequency	2	2		0	4
	Percent within technology category	50.0	50.0		.0	100.0
	Percent within food security category	8.3	50.0		.0	13.3
Adopted (1)	Frequency	22	2		2	26
	Percent within technology category	84.6	7.7		7.7	100.0
	Percent within food security category	91.7	50.0		100.0	86.7
	Total	24	4		2	30

Source: Primary data from the study area.

Key: *1= Extremely food insecure (less 3 bags = 270 kg of maize per capita per year); **2= Highly food insecure** (between 3-to-4.88 bags); **3= Moderately food insecure** (between 4.89-to-7.77 bags); **4= Food secure** (grater than 7.77 bags per capita)

4.4.1: Current Vulnerability Assessment analysis; Kenyan Population Groups, The Case of Nyanza Province

The results of the analysis of the vulnerability status of population groups based on the Maize Equivalent are presented in the following tables. Table 4.9 illustrates the maize equivalent ranking based on major food crops produced in the study area. The districts with three (3) stars, i.e. *** indicate those districts with a maize equivalent less than 3, while the districts with ** depict those districts with a Maize Equivalent value between 3.01 and 4.88 and district with * represent Maize Equivalent value between 4.88 and 7.77. The results indicated that no district in the sample was food secure.

Table 4.9: Maize Equivalent Ranking, by all Food crops, Nyanza Province, 2001

	Food crop								
District	Bean	casv	Cowp	grng	Maiz	Milt	sorg	swpt	**MZEQ**
Bondo***	.22	.28	.02	.00	.48	.00	.14	.13	**1.27**
Gucha**	.73	.02	.02	.04	2.07	.17	.03	.10	**3.18**
Homa Bay**	.68	.53	.04	.01	1.30	.01	.26	.74	**3.57**
Kisii**	.33	.29	.03	.02	1.19	.27	.01	1.80	**3.94**
Kisumu*	.09	4.21	.02	.01	.31	.00	.18	.27	**5.09**
Kuria*	.46	1.27	.00	.02	1.62	.47	.31	1.93	**6.08**
Migori**	.41	.02	.13	.00	1.54	.04	.17	1.13	**3.44**
Nyamira***	.40	.05	.00	.01	1.79	.06	.00	.11	**2.42**
Nyando***	.03	.33	.00	.00	.85	.00	.26	.55	**2.02**
Rachuonyo***	.27	.13	.00	.00	.83	.00	.35	.35	**1.93**
Siaya***	.51	.00	.00	.00	1.00	.01	.33	.11	**1.96**
Suba***	.66	.00	.00	.00	1.11	.02	.29	.00	**2.08**
Aggregate	**4.79**	**7.13**	**.26**	**.11**	**14.09**	**1.05**	**2.33**	**7.22**	36.98

Source: calculations based on secondary data

Key: * Districts that are relatively food-insecure; ** Districts that are moderately food-insecure; *** Districts that are extremely food-insecure

4.4.2: Smallholder Farm Household Current Vulnerability Assessment

The income accounting model was applied to the study area's CVA analysis. Total income for each respondent, was derived from the summation of income from all the farm enterprises and non-agricultural income during the year. Per capita income for each respondent was then expressed in terms of maize equivalent, as a measure of the ability to purchase maize and other expenditure items. The regional degree of food security is then assesses by the summation of the respondents cumulative maize equivalent and divided by the population, that is the total number of reported persons in the households in the sample for the region (Annex 9).

The results of the analysis of the vulnerability status of population groups based on the Maize Equivalent were as presented below based on major food crops produced in the study area. Table 4.10 show the maize equivalent ranking, by regional major farm enterprises in the study area.

Table 4.10: Respondents Maize Equivalent Ranking, by major Farm enterprises in South-western Kenya.

	Regional Maize equivalent			
Enterprise category	**Rongo**	**Oyugis**	**Kendu Bay**	**Aggregate**
Maize	2.14 (1.79)*	1.03 (0.83)	0.42 (0.83)	**3.59**
Sorghum	0.09 (0.31)	0.13 (0.35)	0.24 (0.13)	**0.46**
Legumes	0.18 ((0.41)	0.27 (0.27)	0.01 (0.27)	**0.46**
Groundnuts	0.16 (-)	0.39 (-)	0.33 (-)	**0.88**
Sugarcane	2.36 (6.9)	0.17 (-)	2.75 (-)	**5.28**
Dairy	0.32 (-)	0.69 (-)	- (-)	**1.01**
Cattle	6.13 (-)	1.89 (-)	1.74 (-)	**9.76**
Poultry	0.36 (-)	0.36 (-)	0.45 (-)	**1.17**
Total	**11.74**	**4.93**	**5.94**	**22.61**
Distict	**3.44**	**1.93**	**1.93**	**7.3**

Source: Primary data collected, November 2007.

CHAPTER 5

5.0: ANALYSIS AND DISCUSSION OF RESULTS

5.1: Socio-Economics

The socio-economic profile of respondents in the study area showed that a typical smallholder farmer from the study area would be described as medium aged (31 –to-45 years old) male, with primary level education, earning an annual farm income of less than ksh 30,001, and with a medium size family of between 5 and 10 persons in the household. The farmer was likely to operate less that 20 acres of land, and have over 10 years experience in farming. The implication of these results was that, socio-economic characteristics often form an important launching pad for sustainable intervention measures. This is explained by the fact that policy makers need to pay due attention to the prevailing social and economic backgrounds of the various publics they deal with. This would entail recommending interventions commensurate with the target group's social and economic domains, particularly for agricultural technology adoption purposes. For example, it would appear that any new agricultural technology with expenditure requirement might be spurned by the majority of smallholder farmers in the study area given their meagre income in the lower income category. All the other socio-economic characteristics can similarly be used as benchmarks for recommendation domains.

5.1.2: Non-Parametric Analysis

As a follow-up to the Friedman's two-way ANOVA, chi-squares were used to organize the data into groups for the Kruskal-Wallis one-way ANOVA which tries to find out whether there were any significant differences in the patterns of responses on rating of perceived benefits from different information sources, respondents' opinion about the adoption of various agricultural technologies, and respondents' degree of agreement with four statements on extension services in the country. Opinion about adoption of various agricultural technologies as a variable did not generate adequate chi-squares to warrant further analysis.

Table 5.1 show that Daily newspapers had a high chi-square value to merit significant difference in the pattern of response on the rating of perceived benefits of sources of agricultural information based on the number of years of experience of work in the field. This means that respondents' opinion about perceived benefits associated with daily newspapers as a source of agricultural information differed significantly along years of experience at work.

Table 5.1: Kruskal-Wallis Analysis of Respondents' Perception of Benefits Associated with Information Sources in South Western Kenya by Years of Experience.

Source of information	Chi-Square	Significant
Farm magazine	4.2805	0.2327*
Local farm newspapers	1.6756	0.6424
Daily newspaper	7.3729	0.0609**
Farm radio/television Program	3.5622	0.3128*
Extension officers	0.2895	0.8652
Government Sponsored Agencies	2.2264	0.5268*
Non-Governmental Organizations	2.8444	0.4162*
Commodity associations	2.7739	0.4278*
Neighbour/friend/family	2.9307	0.4024*
Others	2.7000	0.2592*

Note: * Significant difference in the pattern of response with α 0.5.
** Significant difference in the pattern of response with α 0.05

The Mann-Whitney U-test was then applied to all possible pairs of contrasts. Alpha was set at 0.01 or less in accordance with the post-factum analysis procedure. The analysis is used to determine whether there is a significant difference in the way two groups rate the independent variables, for example, beneficial sources of agricultural information, statements on extension services, and adoption rates of new technology available in the study area. The results are shown in Table 5.2. Mean ranks, Z-scores, Chi-squares were used to organize the data into groups in order to show the significant differences in the relative order of ratings, patterns of responses, and rating patterns within different categories of the variables studied.

Table 5.2: Pairwise Contrasts of Respondents' Rating of the Perceived Benefits of Sources of Agricultural Information in Southwestern Kenya by Number of Years of Work Experience.

Daily Newspapers

Less than 1 Year*	1-to-5 Years	6-to-11 Years	>12 Years
39.50**	22.71	17.67	21.06
X	X		
	X	X	
		X	X

Note: * The Number of Years Worked in the Field with common underlines did not differ significantly in their response pattern.
** Friedman's mean rank.

There were significant differences in the rating patterns by those respondents who had worked as Agricultural Officers for less than 5 years as opposed to those who had worked for 6-to-11 years. These results indicated the latter perceived the benefits from Daily newspapers more favourably than the former. The other categories of years of work experience did not indicate any significant differences in the pattern of responses among themselves. However, those with work experience of five or less years, together rated daily newspapers less strongly on the issue of perceived benefits.

The implication of these results to policy makers, particularly in the sphere of extension services, was that interpersonal modes of communication, for example, extension officers, neighbors/friends, and Non-Governmental Organizations, were perceived as being more beneficial than mass media modes of communication, for example, daily newspapers, farm magazines, and local farm newspapers. This was an important finding in the face of the current trend, which has put emphasis on interactive modes of communication in the wake of retrenchment in the public sector.

5.1.3 Empirical Results Descriptive Analysis

In order to ascertain whether the estimated equation met the-three-stage least squares conditions, as specified in Chapter 3, autocorrelation was tested. According to Diagne (2000) the absence of autocorrelation can be accepted if the Durban Watson (DW) statistics is sufficiently close to 2. Alternatively, values of DW that are close to zero or 4, suggests the presence of autocorrelation. This is corroborated by Byerlee (1998) that if from the sample data the DW statistics is approximately 2, we accept the absence of autocorrelation in the function. Since the DW statistics were all close to 2, as shown in Tables 5.3 and 5.4, we deduce the absence of autocorrelation. This indicated that there were more direct relationships among the variables considered in the study. Table 5.3 below show the 3-stage least squares 'statistical test results.

Table5.3: Three-Stage Least Squares Statistical Tests for Maize Production in South Western Kenya: 1993

Equations	Constant	R^2	R^{-2}	F	D.W
1st-stage					
1	-3623.2	0.65	0.62	74	2.3
2	-110.7	0.42	0.36	74	2.0
3	4.4	0.17	0.08	74	1.6
4	1.1	0.33	0.27	74	2.1
5	204.8	0.14	0.06	74	1.6
2nd-stage					
1	-3861.0	0.24	0.20	0.01	1.8
2	-548.2	-1.22	-1.33	029	1.9
3	2.8	0.13	0.08	0.15	1.6
4	3.9	0.09	0.07	0.95	2.0
5	118.3	0.04	-0.01	0.90	1.7

As shown in Table 5.3 above, only the adjusted R^2, that is R^{-2} values, of 0.62 and 0.36 for equation 1 and 2 in the 1st-stage of the 3-SLS' regression on maize productivity indicated that the power of our model to explain the variations in our dependent variable (Y) were reasonably high. However, the R^{-2} values in the rest of the equations were quite low. Indicating that the other equations could not explain much in terms of factors influencing maize productivity in the study area. Table 5.4 show the 3-SLS statistical test results for sorghum production in South Western Kenya. The negative signs indicated inverse relationship between the explanatory variables and the dependent variable.

Table 5.4: **Three-Stage Least Squares Statistical Tests for Sorghum Production in South Western Kenya.**

Equations	Constant	R^2	R^{-2}	F	D.W
1st-stage					
1	3218.7	0.89	0.87	53	2.0
2	-386.8	0.86	0.84	53	2.1
3	-0.9	0.30	0.21	53	2.2
4	7.0	0.51	0.44	53	2.5
5	32.1	0.31	0.22	53	1.9
2nd-stage					
1	1769.1	0.84	0.83	56	2.2
2	-4697.1	-3.2	-3.4	57	2.2
3	-9.8	-1.9	-2.1	56	2.3
4	22.6	0.09	0.06	58	2.2
5	235.4	0.25	0.20	56	1.8

In the 3-SLS (1-st stage regression) on sorghum productivity, equation 1, 2, and 4 had high R^{-2} values as well as equation 1 in the 2nd-stage as shown in Table 5.4 above. This meant the three equations adequately explained factors influencing sorghum productivity in the study area. We therefore conclude that these equations were relevant for variations explanation of our dependent variable.

The F-test was performed to assess the overall significance of the regression using the variance ratio. In performing the F-test, the null hypothesis;

$H_o : \beta_1 = \beta_2 = \beta_3 = ... \beta_n = 0$ (5.1)

was tested against the alternative hypothesis;

$H_a : \beta_1 \# \beta_2 \# \beta_3 ... \beta_n \# 0.$ (5.2)

From the summary of the 3-SLS' regression results for maize and sorghum production as shown in Appendices 3 and 4, the calculated F values were 74, 53, 56 etc.., while the tabular F value was 10.14 and since the calculated F values 74, 53, 56, etc.. were greater than the tabular F value of 10.14, we reject H^o in favour of H^a at the 5% level of significance. The result of the F-test shows that under the linear equation analysis the combined influence of all explanatory variables on agricultural productivity (as measured by Net-cash farm income) was significant.

In order to ascertain the significance of the individual coefficients, the students 't' was employed to test the null-hypothesis;

$H_o = ß_1 = 0$, against the alternative; (5.3)

$H_a : ß_1 \# 0.$ (5.4)

The results shows that the coefficients of the following variables were significant;

X_1, X_2, and X_7 in various equations, we conclude that not all coefficients were insignificant and therefore accept $H_a : ß^1 \# 0$

Principally we are interested in assessing how the algebraic signs of our estimated coefficients tally with or deviate from the a priori expectations. Our a priori assumption of signs are as listed in chapter 3.

Focusing on the 2nd-stage of the regression results, the coefficient of the variable X_1, the annual total yield'07 had the expected sign. Yields of 2007 therefore, had a positive influence on the income of 2007. The implication is that, farmers who obtained higher yields in 2007 were more likely to receive higher net incomes at the end of 2007.

The coefficient of the variable X_2, the number of cattle owned by the farmer in 2007 had the expected sign. Thus, the number of cattle owned positively influenced the income of 2007. The interpretation was that farmers with large herds had the possibility of selling the livestock, if need be, in order to purchase agricultural inputs used to increase productivity, hence the higher net income.

The coefficient of the variable X_3, the number of labourers (both family and hired) of a farmer had an unexpected sign. Thus, the number of labourers a farmer had, negatively influenced the income of 2007. This implied that there was an optimal level of labour usage beyond which an extra labour unit was not economical as decreasing returns abound.

The coefficient of the variable X_4, the quantity of fertilizers used for the major crop in 2007 had the unexpected sign. That is, the quantity of fertilizers used negatively influenced the income of 2007. This finding probably underscores the optimal application of fertilizer as an input as was that case with labour. The coefficient of the variable X_5, the total expenses on insecticides/pesticides for 2007 had the expected sign. Hence the total expenses on pesticides/insecticides for 2007 positively influenced income of 2007. Therefore, farmers who had higher expenditures on insecticides and pesticides were more likely to obtain higher yields and by implication, higher net income.

The coefficient of the variable X_6, the quantity of improved seed of major crop planted in 2007 had the expected sign. This means that the quantity of improved seed for major crop of 2007 positively influence on income of 2007. This indicated that the quantity of improved seeds used had a positive increase in yields which lead to higher net income at the end of the year.

The coefficient of the variable X_7, the income of 2006 had the expected sign. That is, the income of 2006 had a positive influence on income of 2007. A possible interpretation was that the previous year's income, that is, 2006 enabled the farmer to purchase agricultural inputs for the next year enhancing productivity and by extension net income in 2007.

The coefficient of the variable X_8, number of years of education had the predicted sign. Thus, the number of years of education positively influenced the income of 2007. The implication was that, farmers with more years of education tend to be more responsive towards change hence adoption of new agricultural technologies which spur productivity leading to higher net income.

The coefficient of the variable X_9, the family size in 2007 had the expected sign. That is, family size negatively affected income of 2007. Hence, farmers who had larger families probably spend resources on family subsistence instead of farm inputs leading to low productivity and incomes.

5.2: Returns to Adoption of New Agricultural Technology

When farmers use new farm inputs, they are expected to achieve higher production levels and therefore higher income from the farm. It therefore follows that with increased income from the farm, the farmer's purchasing power will be increased and ultimately attain a level of food security. A farmer is then said to be food secure either if they are able to produce enough for subsistence or when they have the purchasing power to acquire the needed supply. Food security can be measured in terms of maize equivalent which estimates that 270 kg of maize, that is, 3 (90 kg bags) per capita is the border line for hardcore poverty (FAO, 1998). Thus persons who cannot produce or afford that amount of maize in a year would fall under the hardcore poverty line. By the same token, 440 kg, which translates to 4.89 (90 kg bags) of maize is the minimum amount required per capita per year for a person to be food secure, or enjoy normal livelihood. The returns to adoption of new agricultural technology in the study area were therefore assessed using the threshold production requirements for food security. The mean estimated maize, and sorghum production level for the sample respondents during the year was 1274.4 kg, and 744.3 kg, respectively (Annex 9).

Since use of improved seeds was considered as one of the most widely adopted technologies by smallholder farmers in the study area, and given the integral part the variable plays in crop production, its adoption was thought to impact positively on increased chances of attaining the food security threshold. Table 4.4 show the returns to adoption of new agricultural technology in south-western Kenya, by region/food security. In terms of food security category, all respondents from Kendu Bay region who produced maize and were food secure, that is, produce amounts above the 440 kg threshold, had all adopted improved seeds. In Rongo region of those who produced maize and were food secure, 85 percent had adopted improved seeds and only 15 percent did not use improved seeds. A similar picture is repeated in Oyugis region where 70 percent of those who produced maize and were food secure had adopted improved seeds and only 30 per cent did not use improved seeds. Although the results showed there were non-adopters who were food secure, based on the maize equivalent estimates, overall, farmers who adopted farm inputs, for example, improved seeds were more likely to reap higher yields and therefore be highly food secure than those who did not adopt.

5.3: Determinants of Adoption of New Agricultural Technology

5.3.2: Simultaneity of Technological Choices (Estimation of Relationships)

Due to the simultaneity nature of some of the decisions to adopt the technologies presented in Table 4.6, a combination of instrumental variables were used. A full description of the variables used in this analysis is provided in Annex 6, and the results of the probit maximum likelihood estimates were summarized in Table 5.5.

The following relationships within the equations were statistically significant. The income of (previous year before the study) the financial remittance during the year of study 2007, and regional disparity, significantly influenced the use of fertilizers. Farmers who received higher remittance during the year were more likely to use fertilizers than those who received less remittance. Farmers from relatively high potential regions were not likely to use fertilizers as those from relatively low potential regions. Thus, farmers from Oyugis and Rongo regions were less likely to use fertilizers than those from the Kendu Bay, Rangwe, and Homa Bay regions.

Table 5.5: Probit Maximum Likelihood Estimates of the Adoption of Fertilizers, Hybrid Maize, Improved Seeds, Pesticides and Cultivation with Oxen/Tractors in South Western Kenya.

	USEFERT		MEANLAP		USEIMPRSE		PESTUSE		NEWCROP	
Variable	Coef.	t-rat.[a]	Coef.	t-rat.	Coef.	t-rat.	Coef.	t-rat.	Coef.	t-rat.
EDCT	-0.06	0.01	-0.01	-1.27	-0.02	0.01	-1.00	0.28	0.01	1.91
INC91	0.00	-5.10[b]	0.00	-0.00	0.00	-2.40[b]	0.00	3.69[b]	0.00	-6.60
YLD91	0.00	0.00	0.00	0.04	0.00	0.40	-0.00	7.56[b]	0.00	0.00
LABAN	0.08	-0.06	-0.01	--	-0.00	-0.04	0.03	0.39	-0.01	-0.04
FINREM	0.00	8.77[b]	0.00	-0.00	0.00	2.30[b]	0.00	-1.30	0.00	-3.70
RSPST	0.12	-0.27	0.04	0.79	0.04	-0.26	-0.12	0.29	0.06	-0.19
AG	0.32	-0.05	0.08	0.29	0.94	0.00	0.32	0.03	0.63	-0.02
REGN	0.00	2.61[b]	0.96	-0.14	0.97	-0.03	0.19	0.70	0.19	-1.01
CONSTAN	0.52	-2.48[b]	0.22	-13.48[b]	0.75	1.25	0.01	-8.13[b]	0.87	-10.89[b]
T	33.57*		--		14.01		--		11.60	

Note: *The sample consisted of 240 households for USEFERT, MEANLAP, USEIMPRSE, PESTUSE, and NEWCROP.*

a = Absolute value of t-ratio.
b = Indicate significant levels at 5 percent.
c = Coefficient value of the variable.
** = Chi-square values in the last row.*

Source: Primary data.

Table 5.6 below shows significant variables determining the adoption of agricultural technology in South Western Kenya. The variable for the previous year's, that is, 2006 income carried an unexpected sign. A somewhat different set of interrelationships occurred in the equation for the means of land preparation. The educational level of the head of the household was negatively linked to cultivation techniques. The regional differences that were so strong in the equation for the use of fertilizers did not occur in the equation for the means of land preparation.

Table 5.6: Significant Variables Determining the Adoption of Agricultural Technology in South Western Kenya.

	Technology Option				
Variable	Cultivation with Oxen	Fertilizer Use	Hybrid Maize	Pesticide Use	New crop
EDCT	(-)				(+)
INC91		(-)	(-)	(+)	
YLD91				(+)	
LABAN					
FINREM		(+)	(+)	(-)	(+)
RSPST					
AG					
REGN		(+)			(+)

Source: Primary data.

Income of the previous year, and the financial remittance during the year of significantly influenced the decision to adopt hybrid maize. The higher the remittance during the year, the more likely the adoption of hybrid maize. The income of the previous year had an unexpected sign indicating a negative influence.

Yield of the previous year, and income of the previous year, both strongly influenced positively the decision to use pesticides while the remittance during the year was negatively related to the use of pesticides. Higher yields and income of the previous year allowed farmers to positively decide on the use of pesticides as opposed to lower yields and income of the previous year.

A zero (0) and one (1), that is, 0/1 Logit/Probit equation was applied on the decision to use improved seeds of various crops prevalent in the study area to estimate the impact of the various variables included in the previous equations. Better-educated farmers were more likely than their less educated compatriots to adopt use of improved seeds, and farmers who received higher financial remittance during the year were more likely than those who received lower remittance to adopt use of improved seeds. Similarly, farmers from the high potential regions were more likely to adopt improved seeds than those from the low potential regions.

However, several very strong and interesting relationships carry through across equations. Remittance during the year tends to influence the use of fertilizers, adoption of hybrid maize, improved seeds of various crops, but not use of pesticides. The educational level of the respondents was negatively related to the cultivation techniques used for cultivation but positively influenced the adoption of improved seeds. Regional disparities also tended to influence use of fertilizers and improved seeds. This finding disapproved the a-priori expectation that farmers from the low potential regions were more likely to adopt use of fertilizers given the low potential of their land and more likely to adopt use of improved seeds given the harsh conditions of their agro-ecological zones. In addition, farmers with better education would be expected to have higher propensity for change and adoption of new cultivation techniques unlike their less educated counterparts.

The decision to adopt new crops and fertilizers, animal draft power and fertilizers, as well as hybrid maize and fertilizers were made more independently. Deciding to adopt hybrid maize, new crops, pesticides, animal draft power/tractors, and fertilizers simultaneously imply that farmers in the study area respond to extension services available in the region. Evidence of simultaneity also underscores the need to design integrated development programs. Furthermore, the results indicate that, the decision to adopt more than one technology at the same time could be influenced by several social and economic variables, such as income, educational level, and regional disparity, of individual farmers at any point in time.

5.4: Impact of the Returns to Technology Adoption on Farm Household Food Security

The results of the analysis of the vulnerability status of the population groups based on Maize Equivalent ranking which was calculated from all sources of income from the major food crops in the study area (Table 4.11). On the basis of the data generated, at individual district level, Kuria, Kisumu, and Kisii districts were the most moderately food insecure secure districts in Nyanza province in that order, with Kuria* having a rank of 6.08 well above Kisumu* (5.09) and Kisii (3.94). The Extremely and Highly food insecure districts in Nyanza province were Bondo, Rachuonyo, and Siaya, in that order, with Bondo being the most extremely and highly food insecure district with a ranking of 1.27, followed by Rachuonyo (1.93), and Siaya (1.96). Looking at individual food crop production and their ranking in the maize equivalent method, there was no crop with a food secure ranking, that is, more than 7.77 (90 kg bags) of maize had the best ranking among the cereals with a score of 2.07 in Gucha, followed by Nyamira (1.79), and Kuria (1.76). However, all these were within the extremely and highly food insecure ranking category. Only cassava had a respectable score of 4.21 in the moderately food insecure category among the tuber crops. In reflection of the socio-economic farming systems classifications, the Mixed farming high potential districts of Kisii, Gucha, and Nyamira had relatively better rankings falling within the moderately food insecure ranking category. However, the best performing districts were from the High potential cereal and dairy farming systems group where Kuria and Kisumu were the most outstanding with scores of 6.08 and 5.09 placing the two in the moderately food secure districts category in the province. Among the marginal semi-arid farming systems category, the majority of the districts in this category had the worst performance with Bondo, Lower Rachuonyo, and Siaya scoring well below the 3.01 mark in the Extremely and highly food insecure ranking. However, it was surprising that Homa Bay district grouped in this category of farming systems had a relatively good score of 3.18, which places the district among the moderately insecure ranking category. These results should be interpreted with a caution since population was a major factor in the calculation of the per capita maize equivalent score. Hence, districts, which ordinarily would have been expected to perform well in the High potential cereal and dairy farming systems such as Migori and Kisii ended up with unexpected performance.

Results of the current vulnerability assessment based on the validation data collected over November/December 2007 (Table 4.12), show that at the regional level, although Rongo area respondents collectively registered the highest MEQ status of being food secure, there were unexpected results at the individual enterprise MEQ rankings with Kendu Bay area posting better MEQ ranking in sugarcane and even dairy enterprises than both Oyugis and Rongo sub-regions. The validation data analysed for MEQ rankings contradicted the earlier findings which showed the whole region of study classified as an extremely to highly food insecure districts for Rachuonyo and Migori respectively. This can be explained by the fact that data collated at the official regional level, for example at the District Reports, would be more reliable and authoritative those derived from individual research questionnaires.

CHAPTER 6

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1: Summary

In Kenya, there is an understanding that good research has been done and that beneficial new agricultural technologies have been identified. What remains unclear is the extent of adoption and the returns that accrue to the adoption of new agricultural technologies particularly among the smallholder farming systems. The main objective of this thesis was to identify the determinants of adoption and the returns associated with new agricultural technologies and then assess their impact on the smallholder farm household food security in the study area. A socio-economic profile of the smallholder farm household in the study area would be described as typically middle aged resource poor male farmer, with primary level of education and a medium size family of between 5 and 10 persons in the household.

Respondents' rating of perceived benefits from the different information sources showed a preference for interpersonal sources of communication than mass media type. This was an important finding despite the current trend with emphasis on interactive modes of communication in the wake of retrenchment in the public sector.

The returns to adoption of new agricultural technology in the study area were assessed using the threshold production requirements for food security. The results indicated farmers who adopted farm inputs, for example, improved seeds were more likely receive higher yields and be more food secure than those who did not adopt. Evidence of simultaneity of technology choices imply that farmers in the study area respond extension services available in the region and this also underscores the need to design integrated development programmes.

The Current Vulnerability Assessment (CVA) based on the maize equivalent estimates at the Regional level indicated that no district in the sample was food secure. For individual smallholder farmers in the study sample, Rongo zone reported the highest MEQ ranking of 11.74 above the threshold minimum of 7.77 (90 kg bags) of maize required for normal livelihood, or enjoyment of food security. Both Kendu Bay (5.94) and Oyugis (4.93) regions recorded MEQ rankings within a range classified as moderately food insecure, that is between 4.89 and 7.77 (90 kg bags) of maize per capita.

6.2: Conclusions

Socio-economic profile of respondents is important for identifying recommendation domains and organization of farm household food security assessment. Interpersonal sources of agricultural information were more preferred than the mass media, implying caution on retrenchment in sectors providing public services such as agricultural extension. Evidence of simultaneity of adoption implied that farmers in the study area respond to extension services available in the region and underscores the need to design integrated development programmes. Regional data analyzed for current vulnerability assessment indicated existence of moderate, to high and extreme food insecurity in the study area.

6.3: Recommendations

1. Given the current official policy of retrenchment in the public service and emphasis on interactive modes of communication, it would be important to investigate this apparent contradiction between public policy and needs of the people who require public services.

2. Simultaneity of adoption indicated that farmers in the study area responds to extension services available in the region. This underscore need to design integrated (package) approach to agricultural development.

3. Need for a more in-depth analysis of the food insecurity status of the region as this may have far reaching policy implications.

7.0: BIBLIOGRAPHY

Abdoulaye, T.A. 2002. Farm Level Analysis of Agricultural technology Change: Inorganic Fertilizer Use on Dryland in Western Niger. Unpublished Ph.D. Thesis. West Lafaytte: Department of Agricultural Economics, Purdue University.

Adams, D.W. 2002. *Filling the Deposit Gap in Micro-finance*. Park City, Utah. USA

Andrew, C. and M. Flores. April 2008. Vulnerability to Hunger: Improving Food Crisis Responses in Fragile States. United Nations University – World Institute for Development Economic Research. Wa. DC.

Baidu-Forson. 1999. Factors Influencing adoption of Land-enhancing technology in the Sahel: Lessons from case study in Niger.

Benin, S. and S. Mugarura. 2006. Determinants of Change in Household-level Consumption and Poverty in Uganda, 2007/93-1999/00. IFPRI DSDG Discussion Papers. Wa. DC.

Byerlee, D. 1998. "The Search for a New Paradigm for the Development of National Agricultural Research Systems." *World Development* 26 (6): 1049-1055.

Center on Hunger (n.d.). Food Security Measurement-Concept and Definition. Retrieved on September 15th, 2008, from **htt:/ www.centeronhunger.org**

Diagne, A., M. Zeller, and M. Sharma. 2000. Empirical Measurement of Households' Access to Credit and Credit Constraints in Developing Countries: Methodological Issues and Evidence. IFPRI Discussion Paper No. 9 . Washington D.C.

Diagne, A., and M. Zeller. 2001. Access to credit and its impact on welfare in Malawi. Research Report No 116. Washington, D.C.: International Food Policy Research Institute.

Demographic Surveillance Systems (DSS). Latest Update, June 2008. INDEPTH Network: An International Network for the Continuous Demographic Evaluation of Populations and Their Health in Developing Countries. **www.indepth_network.net**

Eicher, C.K. 2003. "Flashback: Fifty Years of Donor Aid to African Agriculture." Paper presented at an International Policy Conference "successes in African Agriculture: Building for the Future", sponsored by InWent, IFPRI, NEPAD and CTA, Pretoria, South Africa, December 1-3, 2003.

Food and Agricultural Organization (FAO) of the United Nations (UN). 2007. Farm Management Publications: Farm Business Performance Analysis; a guide to the use of benchmarking – a history of farming systems research.

Food and Agricultural Organization (FAO). 2006. Annual Report: The State of food Insecurity in the World. Rome.

Food and Agricultural Organization (FAO) of the United Nations (UN). 1998. Handbook for Defining and Setting up a food Security Information and Early Warning System (FSIEWS). Rome.

Gabre-Madhin, E.Z. and S. Haggblade. 2003. "Successes in African Agriculture: Results of an Expert Survey". Paper presented at the InWEnt, IFPRI, NEPAD, and CTA Conference "Successes in African Agriculture" Pretoria December 1-3, 2003

International Fund for Agricultural Development (IFAD). 2007. Monitoring of technology transfer, adoption and impact in the low-rainfall areas of the West Asia and North Africa (WANA) Region.

International Fund for Agricultural Development (IFAD). 2007. Dimensions of Rural Poverty in Kenya.

International Food Policy Research Institute (IFPRI) .2001. Agricultural research and poverty reduction: 2020 Vision Briefs from the International Food.

International Farming Systems Association (IFSA). 2008. Empowerment of the rural actors; a renewal of Farming Systems perspective. Eight (8^{th}) European International Farming Systems Association (IFSA) Symposium, 6 to 10 July 2008, Clermont-Ferrand (France).

International Monetary Fund (IMF) & International Development Association (IDA). 2005. Update on the Assessment of Implementation of Action Plans to Strengthen Capacity of Heavily Indebted Poor Countries to Track Poverty Reduction Public spending. Wa. DC.

Institute of Policy Analysis and Research (IPAR). 2004. District Focus for Rural Development in Kenya: Its Limitations as a Decentralization and Participatory Planning Strategy and Prospects for the Future. Policy Brief Vol 10, Issue No 9/2004.

Isinika, A.C, A. Pagoulatos, and D. Debertin. 1998. Returns to Research and Extension Investments in Crop Production in Tanzania. *Journal of Agricultural Economics and Development* (A regional journal for Eastern and Southern Africa). Sokoine University, Tanzania. Vol 2 (p13-24).

Jayne, T.S. 2007. Under appreciated Facts about African Agriculture: Implications for poverty reduction and Agricultural growth strategies. Michigan State University. U.S.A.

Jeffrey D. S. 2005. *The End of Poverty: Economic Possibilities for Our Time*. Penguin Books

Kelly, V., Adesina, A.A. and A. Gordon. 2003. "Expanding Access to Agricultural Inputs in Africa: A Review of Recent Market Development Experience." *Food Policy* 28: 379-404.

Kimuyu, P. and J. Omiti. 2000. Institutional Impediments to Access to Credit by Micro and Small scale Entrepreneurs in Kenya. IPAR Discussion Paper Series. Discussion Paper No. 026/2000.

Kutner, M., Christopher Nachtsheim, John Neter, and William Li. 2004. Applied Linear Statistics. Amazon Prime Publishers.

Lipton, M., S. Sinah and R. Blackman in FAOSTAT. 2001. Reconnecting Agricultural Technology to Human Development. Poverty Research Unit at Sussex (PRUS), Sussex University, U.K.

MacKinnon, James and Davidson, Russell. 2004. *Econometric Theory and Methods.* New York: Oxford University Press.

Makokha, M., Odera, H. , Maritim, H.K., Okalebo, J.R., and D. M. Iruria.1999.Farmers' perceptions and adoption of soil management. *African Crop Science Journal, Vol. 7. No. 4, pp. 549-558.*

Mavrotas, G. and A. Shorrocks. (2007). *Advancing Development: Core Themes in Global Develoment*. Palgrave Macmillan.

Ministry of Agriculture (MoA). 2008. Strategic Plan 2006-2010: Strategy for revitalizing Agriculture. G.O.K. Publication.

Ministry of State for Planning, National Development, and Vision 2030 (MSPNDV). 2008. Kenya Vision 2030: Ministry's Re-branding and Strategic Plan.

Nerlove, M., S. Vosti, and W.Basel.1996. "Role of Farm-Level Diversification in the Adoption of Modern Technology in Brazil," IFPRI Research Report 104.

Ndjeunga, J., Freeman, H.A., Gerard, B., Bationo, A., Tabo, R., Zarafi, M.A. and D. Marchal. 2003. Assessing the Diffusion of Point Application of Mineral Fertilizers in Niger. Patancheru, Andhra Pradesh, India: International Crops Research Institute for the Semi-arid Tropics.

Nekesa, P., Maritim, H.K., Okalebo, J.R. and Woomer, P.L. 1999. Economic analysis of maize-bean production using a soil fertility replenishment product (PREP-PAC) in western Kenya. *African Crop Science Journal* 7:585-590.

Nina, L. and J. Dixson. 2008. Responding to the Challenges on Impact Assessment of Participatory Research and Gender Analysis. Mexico, DF, Mexico.

Omiti, J., W. Owino, W. Otieno, and P. Odundo. 2002. Poverty Reduction Efforts in Kenya: Institutions, Capacity, and Policy. IPAR Discussion Paper Series. Discussion Paper No. 0033/2002.

Onyuma, S. O. 2008. Assumptions about Microenterprise Lending as a Precondition for Development: A Critical Review. *Eastern Africa Social Science Research Review - Volume 24, Number 1, pp. 109-134*

Patrick, M. 2005. Empirical measurement of credit rationing in agriculture: a methodological survey. *The Journal of International Association of Agricultural Economists Volume 33 Issue 2, Pages 191 – 203.*

Persaran, M.H., and A. Timmermann. 2000. Recursive Modelling Approach to Predicting U.K. Stock Returns, *Economic Journal, 110, pp 159-191*.

Republic of Kenya (RoK). 2007. Kenya Vision 2030.

Republic of Kenya (RoK). 2003. Interim Poverty Reduction Strategy Papers (I-PRSP): Interim Poverty Reduction Strategy Papers 2000-2003: Sector Policies and Priorities. Government of Kenya Publications.

Republic of Kenya (RoK). 2000. National Development Plan: 2000-2008. Government Printers

Rukuni, M., Blackie, M. J. and C.K. Eicher. 1998. "Crafting Smallholder-driven Agricultural Research Systems in Southern Africa." *World Development* 26 (6): 1073-1087.

Simtowe, F. and Zeller, M. 2006. The impact of Access to Credit on the Adoption of hybrid maize in Malawi: An Empirical test of an Agricultural Household model under credit market failure. Unpublished.

Sharma, M. and M. Zeller. 2000. Factors Affecting Repayment Rates in Group-Based Lending: Findings from Bangladesh and Madagascar. Rural Financial Policies for Food Security of the Poor. Policy Brief No. 9. July 2000.

Shenggen F. and M.W. Rosegrant. 2008. Investing in Agriculture to Overcome the World Food Crisis and Reduce Poverty and Hunger. IFPRI, Policy Brief No. 3.

Sibale, P.K, Chirembo, A.M., and Saka, A.R. 2001. "Food Production and Security." Targeted Inputs Programme (TIP) 2000-01 Evaluation Programme. Lilongwe: Ministry of Agriculture and Irrigation.

Thritle, C., and L. Beyers, Y. Ismael, J. Piesse. 2003. Can GM-Technologies Help the Poor? The Impact of Bt Cotton in Makhathini Flats, KwaZulu-Natal. S.A.

Todaro, M.P. 2000. World Economic Development: Economic growth, policies, theories, and income distribution. Reading, MA (USA).

United Nations Development Programme (UNDP-Kenya). 2007. Millennium Development Goals in Kenya: Briefing Note on Millennium Development Goals (MDGs), New Partnership for Africa Development (NEPAD), World Summit on Sustainable Development (WSSD) and united Nations Development Assistance Framework (UNDAF).

Vogel, R.C. and D.W. Adams. 1999. Old and New Paradigms in Development Finance: Should Direct Credit be resuscitated? Briefing Notes for Consulting Assistance on Economic Reform II, discussion Paper No. 2.

von Braun, J.; Swaminathan, M. S.; Rosegrant, Mark W. 2004. Agriculture, food security, nutrition and the Millenium Development Goals (Annual Report Essay) Washington, D.C.: International Food Policy Research Institute (IFPRI)

Walker B.H., and D. Salt. 2006. Resilience thinking: Sustaining ecosystems and people in a changing world. Island Press, USA.

World Bank. 2000. Entering the 21st Century: World Development Report 199/2000. Wa. DC.

World Resources Institute. 2002. World Resources 2000-2001: People and Ecosystems: The Fraying Web of Life. Washington, D.C.: World Resources Institute.

Zeller, M., and M. Sharma. 2000. Many borrow, more save, and all insure: implications for food and micro-finance policy. International Food Policy Research Institute (IFPRI), 2033 K Street, NW Washington, DC 20006, USA

7.1: Additional Sources of Information on Food Security

Organization	Website
Action Against Hunger	www.aah-usa.org
Beta Sigma Phi	www.betasigmaphi.org/index.shtm
Bread for the World	www..bread.org
Capital One	www.capitalone.com/index.htm
Centre for Studies in Food Security	www.ryerson.ca/~foodsec/
Centre for Sustainable Community Development	www.sfu.ca/cscd/default.htm
Center on Hunger	www.centeronhunger.org
Community Food Security Coalition	www.foodsecurity.0rg/
UN Millennium Project	www.unmillenniumproject.org/who/index.htm

8. APPENDICES

Appendix 1: The Correlation Matrix I

	INC91	Y91	INC92	Y92	SD92	FT92	PI92	LBR92	CTL	NCT	FSN	EDY	AGE	ML	FL	
INC91	1.0000															
Y91	.5217**	1.0000														
INC92	.7774**	.7161**	.0538	1.0000												
Y92	.6124**	.9024**	.0842	.8125**	1.0000											
SD92	.0417**	.4400**	.2475	.4023**	.4460	1.0000										
FT92	.3019**	.4136**	-.0458	.2749*	.3868**	.3171**	1.0000									
PI92	.2911**	.1121	.0758	.2249	.1063	.1854	.2548	1.0000								
LBR92	.1210	.2188	.1207	.1811	.1833	.1357	.1211	.1746	.1239	1.0000						
CTL	.1251	.3045*	-.1063	.3121*	.2835*	.3920**	.1428	.0909	-.0837	.2484	1.0000					
NCT	.2470	.0064	.1038	.0679	.0300	.2667*	.1828	.5857**	.1186	.0161	.1091	1.0000				
FSN	-.0400	.2135	.2514	.1124	.1011	.0425	-.1359	-.0368	.2682*	.3469**	.1739	-.2347	1.0000			
EDY	.2822*	3099*	.0087	.3095*	.2850*	.1867	.2776*	.1897	.0003	.2102	.1075	.1695	.0878	1.0000		
AGE	-.3130**	-.0555	-.1235	-.1768	-.0418	-.1817	-.1279	-.1123	-.1080	-.1457	-.0934	-.1477	-.0363	-.3547**	1.0000	
ML	.0455	.1964	.0624	.0959	.2097	.1460	.1203	-.0458	.0892	.1375	.0978	-.0150	.0111	.0561	.5325**	1.0000
FL	.0455	.1964	.0624	.0959	.2097	.1460	.1203	-.0458	.0892	.1375	.0978	-.0150	.0111	.0561	.5325**	-1.000

Appendix 2: The Correlation Matrix (II)

	INC91	Y91	INC92	Y92	SD92	FT92	PI92	LBR92	CTL	FSN	EDY		
INC91	1.0000												
Y91	.5208	1.0000											
INC92	.7789**	.7078**	.0482	1.0000									
Y92	.6090**	.9032**	.0763	.8047**	1.0000								
SD92	.3899**	.4343**	.2482	.3923**	.4442**	1.0000							
FT92	.2991*	.4004*	-.0433	.2742**	.3779**	.3132	1.0000						
PI92	.3044*	.1411	.0640	.2366	.1032	.1623	.2547	1.0000					
LBR92	.1285	.2326	.1110	.1217	.1934	.1330	.1157	.1798	.1147	1.0000			
CTL	.2330	.3253*	-.1226	.3165*	.2939**	.3636**	.1300	.1266	-.0999	.2672*	1.0000		
FSN	-.0340	.2301	.2404	.1121	.1154	.0454	-.1408	-.0353	.2576*	.3557*	.1921	1.0000	
EDY	.2889*	.3023*	.0052	.3155*	.2776	.1742	.2781*	.2077	-.0032	.2097	.1189	.0827	1.0000

Appendix 3: Respondent Smallholder farmers' socio-economic characteristics in South-western Kenya, by region, November 2007.

Socio-economic category frequency and percentage			Region			
			Oyugis	Kendu Bay	Rongo	Total
Gender	Female	Count	13	8	12	33
		% within gender of the respondent	39.4	24.2	36.4	100.0
		% within region	43.3	50.0	40.0	43.4
	Male	Count	17	8	18	43
		% within gender of the respondent	39.5	18.6	41.9	100.0
		% within region	56.7	50.0	60.0	56.6
	Total	Count	30	16	30	76
Age (Yrs)	Less than 31	Count	7	4	2	13
		% within age category	53.8	30.8	15.4	100.0
		% within region %	23.3	25.0	6.7	17.1
	31-to-49	Count	12	9	14	35
		% within age category	34.3	25.7	40.0	100.0
		% within region	40.0	56.3	46.7	46.1
	More than 49	Count	11	3	14	28
		% within age category	39.3	10.7	50.0	100.0
		% within region	36.7	18.8	46.7	36.8
Total	Count		30	16	30	76
Household size (Number of persons)	Less than 5 (**small size family**)	Count	9	0	0	9
		% within household category/size	100.0	.0	.0	100.0
		% within region	47.4	.0	.0	13.8
	5-to-10 (**medium size family**)	Count	10	0	26	36
		% within household category	27.8	.0	72.2	100.0
		% within region	52.6	.0	86.7	55.4
	More than 10 (**large size family**)	Count	0	16	4	20

		% within household category	.0	80.0	20.0	100.0
		% within region	.0	100.0	13.3	30.8
Total	Count		19	16	30	65
Farm size (acres)	Less than 10	Count	25	16	29	70
		% within farm size (acres)	35.7	22.9	41.4	100.0
		% within region	83.3	100.0	96.7	92.1
	10-to-20 acres	Count	5	0	1	6
		% within farm size (acres)	83.3	.0	16.7	100.0
		% within region	16.7	.0	3.3	7.9
Total	Count		30	16	30	76
Average annual farm income (Ksh)	Less than 30000	Count	15	9	21	45
		% within average farm income category	33.3	20.0	46.7	100.0
		% within region	71.4	60.0	75.0	70.3
	30001-to-60000	Count	3	3	3	9
		% within average farm income category	33.3	33.3	33.3	100.0
		% within region	14.3	20.0	10.7	14.1
	More than 60000	Count	3	3	4	10
		% within average farm income category	30.0	30.0	40.0	100.0
		% within region	14.3	20.0	14.3	15.6
Total	Count		21	15	28	64
Average annual income from all sources (Ksh)	Less than 30000	Count	16	7	17	40
		% within income from all sources category	40.0	17.5	42.5	100.0
		% within region	53.3	43.8	56.7	52.6
	30001-to-60000	Count	5	3	5	13

		% within income from all sources category	38.5	23.1	38.5	100.0
		% within region	16.7	18.8	16.7	17.1
	More than 60000	Count	9	6	8	23
		% within income from all sources category	39.1	26.1	34.8	100.0
		% within region	30.0	37.5	26.7	30.3
Total	Count		30	16	30	76
Experience in farming (Years)	Less than 10	Count	10	10	6	26
		% within years of experience category	38.5	38.5	23.1	100.0
		% within region	33.3	66.7	20.0	34.7
	More than 10	Count	20	5	24	49
		% within years of experience category	40.8	10.2	49.0	100.0
		% within region	66.7	33.3	80.0	65.3
Total	Count		30	15	30	75
Highest level of formal education	None	Count	1	0	5	6
		% within highest level of formal education	16.7	.0	83.3	100.0
		% within region	3.3	.0	16.7	7.9
	Primary	Count	9	8	12	29
		% within highest level of formal education	31.0	27.6	41.4	100.0
		% within region	30.0	50.0	40.0	38.2
	Secondary	Count	9	6	4	19
		% within highest level of formal education	47.4	31.6	21.1	100.0
		% within region	30.0	37.5	13.3	25.0
	Post secondary	Count	11	2	9	22
		% within highest level of formal education	50.0	9.1	40.9	100.0
		% within region	36.7	12.5	30.0	28.9
Total	Count		30	16	30	76

Appendix 4: Respondents' Staff Position in Agricultural and Livestock Development in South Western Kenya: 1993

Designation	Frequency	Percentage
Frontline	13	33
Divisional	14	30
District	4	9
Others*	13	28

Note: * = other designations such as Research Officers, and Subject matter specialists.
Source: Primary data, September 1994.

Appendix 5: Staff Years of Experience in Agricultural and Livestock Development in South Western Kenya: 1993

Number of years	Frequency	Percentage
Less than 1 year	1	2
1-to-5 years	12	26
6-to-11 years	12	26
Over 12 years	19	43
Missing*	2	4

Note: * = Number of respondents with inadequate information on variable "years of experience".
Source: Primary data, September 1994.

Appendix 6: Description of Variables Used in Estimation of Probit Maximum Likelihood Estimates of Adoption of New Agricultural Technologies in South Western Kenya.

Variable	Explanation
USEFERT	Quantity of fertilizers used in 2007 (Kg)
MEANLAP	Means of land preparation
USEIMPRSE	Quantity of improved seed used in 2007 (Kg)
PESTEXP	Total expenditure on pesticides and insecticides in 2007 (Ksh)
NEWCROP	Number of new (improved) crop varieties cultivated in 2007 (Num)
EDCT	Level of education (Years)
INC91	Yield obtained from major crop in 2007 (Kg)
YLD91	Net farm income received in 2006 (Ksh)
LABAV	Number of persons employed in the farm in 2007 (Num)
FINREM	Financial remittance (assistance) received in 2007 (Ksh)
RSPST	Respondent's gender identity (Status)
AG	Age of respondent (Years)
REGN	Region of residence

Note: Kg = Kilograms, Ksh = Kenya shillings, Num = Number, Stu = Status.

Appendix 7: New agricultural technology adoption in South-western Kenya, by region, November 2007.

Agricultural technology category		Region			
		Oyugis	Kendu Bay	Rongo	Total
Improved Seeds Adoption (0)	Frequency	11	0	4	15
	Percent within the category	73.3	.0	26.7	100.0
	Percent within region	36.7	.0	13.3	19.7
Adopted (1)	Frequency	19	16	26	61
	Percent within the category	31.1	26.2	42.6	100.0
	Percent within region	63.3	100.0	86.7	80.3
	Total	30	16	30	76
Fertilizer Adoption (0)	Frequency	6	16	9	31
	Percent within the category	19.4	51.6	29.0	100.0
	Percent within region	20.0	100.0	30.0	40.8
Adopted (1)	Frequency	24	0	21	45
	Percent within the category	53.3	.0	46.7	100.0
	Percent within region	80.0	.0	70.0	59.2
	Total	30	16	30	76
Pesticides Adoption (0)	Frequency	27	15	29	71
	Percent within the category	38.0	21.1	40.8	100.0
	Percent within region	90.0	93.8	96.7	93.4
Adopted (1)	Frequency	3	1	1	5
	Percent within the category	60.0	20.0	20.0	100.0
	Percent within region	10.0	6.3	3.3	6.6
	Total	30	16	30	76

Tractor land preparation adoption (0)	Frequency	28	16	26	70
	Percent within the category	40.0	22.9	37.1	100.0
	Percent within region	93.3	100.0	86.7	92.1
Adopted (1)	Frequency	2	0	4	6
	Percent within the category	33.3	.0	66.7	100.0
	Percent within region	6.7	.0	13.3	7.9
	Total	30	16	30	76
Mould-board land preparation Adoption (0)	Frequency	7	0	1	8
	Percent within the category	87.5	.0	12.5	100.0
	Percent within region	23.3	.0	3.3	10.5
Adopted (1)	Frequency	23	16	29	68
	Percent within the category	33.8	23.5	42.6	100.0
	Percent within region	76.7	100.0	96.7	89.5
	Total	30	16	30	76
Cattle veterinary services Adoption (0)	Frequency	7	5	3	15
	Percent within the category	46.7	33.3	20.0	100.0
	Percent within region	23.3	31.3	10.0	19.7
Adopted (1)	Frequency	23	11	27	61
	Percent within the category	37.7	18.0	44.3	100.0
	Percent within region	76.7	68.8	90.0	80.3
	Total	30	16	30	76
Cattle feeds Adoption (0)	Frequency	17	15	10	42
	Percent within the category	40.5	35.7	23.8	100.0
	Percent within region	56.7	93.8	33.3	55.3
Adopted (1)	Frequency	13	1	20	34
	Percent within the category	38.2	2.9	58.8	100.0
	Percent within region	43.3	6.3	66.7	44.7
	Total	30	16	30	76

Cattle Dipping Adoption (0)	Frequency	8	13	3	24
	Percent within the category	33.3	54.2	12.5	100.0
	Percent within region	26.7	81.3	10.0	31.6
Adopted (1)	Frequency	22	3	27	52
	Percent within the category	42.3	5.8	51.9	100.0
	Percent within region	73.3	18.8	90.0	68.4
	Total	30	16	30	76
Poultry veterinary services Adoption (0)	Frequency	17	2	9	28
	Percent within the category	60.7	7.1	32.1	100.0
	Percent within region	56.7	12.5	30.0	36.8
Adopted (1)	Frequency	13	14	21	48
	Percent within the category	27.1	29.2	43.8	100.0
	Percent within region	43.3	87.5	70.0	63.2
	Total	30	16	30	76
Poultry Feeds Adoption (0)	Frequency	17	13	10	40
	Percent within the category	42.5	32.5	25.0	100.0
	Percent within region	56.7	81.3	33.3	52.6
Adopted (1)	Frequency	13	3	20	36
	Percent within the category	36.1	8.3	55.6	100.0
	Percent within region	43.3	18.8	66.7	47.4
	Total	30	16	30	76

Source: Primary data

Note: O = none adopter; 1 = Adopter

Appendix 8: Basic Data for calculating the Maize Equivalent for South-Western Kenya- Rongo region, August 2007.

Qn	farmincm	offfincm	incmallsr	numhh	mzoutpt	mzcrmpr	mzcvalue	mzoutpcpt	farincpct	allincpcpt	mzpr97	mzeqallin	alinq90kg	mzmzeq	mmq90kg
1	3200	10000	13200	0	1800	12	21600	0	0	0	9	1466.667	5.432099	2400	8.888889
2	18100	800	18900	0	1260	12	15120	0	0	0	9	2100	7.777778	1680	6.222222
3	57140	45000	102140	0	1911	12	22932	0	0	0	9	11348.89	42.03292	2548	9.437037
4	2400	0	2400	0	600	12	7200	0	0	0	9	266.6667	0.987654	800	2.962963
5	200	0	200	0	0	12	0	0	0	0	9	22.22222	0.082305	0	0
6	0	0	0	0	364	12	4368	0	0	0	9	0	0	485.3333	1.797531
7	20360	4800	25160	0	2000	12	24000	0	0	0	9	2795.556	10.35391	2666.667	9.876543
8	91300	3600	94900	0	455	12	5460	0	0	0	9	10544.44	39.0535	606.6667	2.246914
9	2000	10000	12000	0	455	12	5460	0	0	0	9	1333.333	4.938272	606.6667	2.246914
10	7800	60000	67800	0	280	12	3360	0	0	0	9	7533.333	27.90123	373.3333	1.382716
11	0	0	0	0	637	12	7644	0	0	0	9	0	0	849.3333	3.145679
12	0	120000	120000	1	1001	12	12012	1001	0	120000	9	13333.33	49.38272	1334.667	4.94321
13	0	3000	3000	1	0	12	0	0	0	3000	9	333.3333	1.234568	0	0
14	16000	10000	26000	2	910	12	10920	455	8000	13000	9	2888.889	10.69959	1213.333	4.493827
15	0	0	0	3	821	12	9852	273.6667	0	0	9	0	0	1094.667	4.054321
16	0	4000	4000	4	651	12	7812	162.75	0	1000	9	444.4444	1.646091	868	3.214815
17	0	120000	120000	4	2548	12	30576	637	0	30000	9	13333.33	49.38272	3397.333	12.58272
18	61200	0	61200	4	1440	12	17280	360	15300	15300	9	6800	25.18519	1920	7.111111
19	9000	20000	29000	4	641	12	7692	160.25	2250	7250	9	3222.222	11.93416	854.6667	3.165432
20	5070	10000	15070	4	184	12	2208	46	1267.5	3767.5	9	1674.444	6.201646	245.3333	0.908642
21	11800	30000	41800	5	1001	12	12012	200.2	2360	8360	9	4644.444	17.20165	1334.667	4.94321
22	32240	50000	82240	5	3458	12	41496	691.6	6448	16448	9	9137.778	33.84362	4610.667	17.07654
23	10000	20000	30000	5	1001	12	12012	200.2	2000	6000	9	3333.333	12.34568	1334.667	4.94321
24	37000	40000	77000	5	2002	12	24024	400.4	7400	15400	9	8555.556	31.68724	2669.333	9.88642
25	12460	30000	42460	6	1001	12	12012	166.8333	2076.667	7076.667	9	4717.778	17.47325	1334.667	4.94321
26	87881	60000	147881	6	5096	12	61152	849.3333	14646.83	24646.83	9	16431.22	60.85638	6794.667	25.16543
27	18870	35000	53870	7	637	12	7644	91	2695.714	7695.714	9	5985.556	22.16872	849.3333	3.145679
28	0	10000	10000	7	1456	12	17472	208	0	1428.571	9	1111.111	4.115226	1941.333	7.190123
29	0	60000	60000	7	3185	12	38220	455	0	8571.429	9	6666.667	24.69136	4246.667	15.7284
30	23200	10000	33200	7	912	12	10944	130.2857	3314.286	4742.857	9	3688.889	13.66255	1216	4.503704
	527221	**766200**	**1293421**	**87**	**37707**		**452484**	**6488.519**	**67759**	**293687.6**		**143713.4**	**532.272**	**50276**	**186.2074**

Oyugis Region															
31	170800	24000	194800	7	1340	14	18760	191.4286	24400	27828.57	12	16233.33	60.12346	1563.333	5.790123
32	15	24000	24015	7	1530	14	21420	218.5714	2.142857	3430.714	12	2001.25	7.412037	1785	6.611111
33	14410	0	14410	8	2880	14	40320	360	1801.25	1801.25	12	1200.833	4.447531	3360	12.44444
34	3170	12000	15170	8	810	14	11340	101.25	396.25	1896.25	12	1264.167	4.682099	945	3.5
35	0	15000	15000	8	647	14	9058	80.875	0	1875	12	1250	4.62963	754.8333	2.795679
36	11100	180000	191100	8	1260	14	17640	157.5	1387.5	23887.5	12	15925	58.98148	1470	5.444444
37	33780	0	33780	8	1355	14	18970	169.375	4222.5	4222.5	12	2815	10.42593	1580.833	5.854938
38	42035	0	42035	8	2340	14	32760	292.5	5254.375	5254.375	12	3502.917	12.97377	2730	10.11111
39	2400	2400	4800	9	540	14	7560	60	266.6667	533.3333	12	400	1.481481	630	2.333333
40	12200	7800	20000	9	1790	14	25060	198.8889	1355.556	2222.222	12	1666.667	6.17284	2088.333	7.734568
41	6800	0	6800	9	16000	14	224000	1777.778	755.5556	755.5556	12	566.6667	2.098765	18666.67	69.1358
42	11840	36000	47840	9	650	14	9100	72.22222	1315.556	5315.556	12	3986.667	14.76543	758.3333	2.808642
43	49650	0	49650	9	3460	14	48440	384.4444	5516.667	5516.667	12	4137.5	15.32407	4036.667	14.95062
44	11600	0	11600	9	630	14	8820	70	1288.889	1288.889	12	966.6667	3.580247	735	2.722222
45	9860	12000	21860	9	1090	14	15260	121.1111	1095.556	2428.889	12	1821.667	6.746914	1271.667	4.709877
46	11290	0	11290	9	1470	14	20580	163.3333	1254.444	1254.444	12	940.8333	3.484568	1715	6.351852
47	74330	0	74330	9	1560	14	21840	173.3333	8258.889	8258.889	12	6194.167	22.94136	1820	6.740741
48	21000	5000	26000	9	1980	14	27720	220	2333.333	2888.889	12	2166.667	8.024691	2310	8.555556
49	98500	0	98500	9	4020	14	56280	446.6667	10944.44	10944.44	12	8208.333	30.40123	4690	17.37037
50	4520	0	4520	9	2510	14	35140	278.8889	502.2222	502.2222	12	376.6667	1.395062	2928.333	10.84568
51	10940	60000	70940	10	2070	14	28980	207	1094	7094	12	5911.667	21.89506	2415	8.944444
52	2603	3600	6203	10	1210	14	16940	121	260.3	620.3	12	516.9167	1.914506	1411.667	5.228395
53	20116	7200	27316	10	1810	14	25340	181	2011.6	2731.6	12	2276.333	8.430864	2111.667	7.820988
54	3400	6000	9400	10	540	14	7560	54	340	940	12	783.3333	2.901235	630	2.333333
55	26520	0	26520	10	2780	14	38920	278	2652	2652	12	2210	8.185185	3243.333	12.01235
56	131722	60000	191722	10	1640	14	22960	164	13172.2	19172.2	12	15976.83	59.17346	1913.333	7.08642
57	4300	192000	196300	11	3693	14	51702	335.7273	390.9091	17845.45	12	16358.33	60.58642	4308.5	15.95741
58	0	60000	60000	11	540	14	7560	49.09091	0	5454.545	12	5000	18.51852	630	2.333333
59	4274	0	4274	11	1080	14	15120	98.18182	388.5455	388.5455	12	356.1667	1.319136	1260	4.666667
60	13597	84000	97597	11	1810	14	25340	164.5455	1236.091	8872.455	12	8133.083	30.12253	2111.667	7.820988
	806772	**791000**	**1597772**	**274**	**65035**		**910490**	**7190.712**	**93897.44**	**177877.3**		**133147.7**	**493.1395**	**75874.17**	**281.0154**
														276.913	**1.025604**

Kendu Bay Region															
61	0	0	0	11	0	14	0	0	0	0	12	0	0	0	0
62	18875	56000	74875	12	2170	14	30380	180.8333	1572.917	6239.583	12	6239.583	23.10957	2531.667	9.376543
63	88900	5500	94400	12	3000	14	42000	250	7408.333	7866.667	12	7866.667	29.1358	3500	12.96296
64	7600	12000	19600	12	540	14	7560	45	633.3333	1633.333	12	1633.333	6.049383	630	2.333333
65	52500	6000	58500	12	720	14	10080	60	4375	4875	12	4875	18.05556	840	3.111111
66	15000	4500	19500	12	1800	14	25200	150	1250	1625	12	1625	6.018519	2100	7.777778
67	9810	1500	11310	13	320	14	4480	24.61538	754.6154	870	12	942.5	3.490741	373.3333	1.382716
68	115360	8000	123360	14	1800	14	25200	128.5714	8240	8811.429	12	10280	38.07407	2100	7.777778
69	49600	18000	67600	14	1800	14	25200	128.5714	3542.857	4828.571	12	5633.333	20.8642	2100	7.777778
70	12400	16500	28900	15	720	14	10080	48	826.6667	1926.667	12	2408.333	8.919753	840	3.111111
71	21568	120000	141568	15	1800	14	25200	120	1437.867	9437.867	12	11797.33	43.69383	2100	7.777778
72	23650	8000	31650	16	720	14	10080	45	1478.125	1978.125	12	2637.5	9.768519	840	3.111111
73	9040	4000	13040	16	800	14	11200	50	565	815	12	1086.667	4.024691	933.3333	3.45679
74	38800	8000	46800	17	900	14	12600	52.94118	2282.353	2752.941	12	3900	14.44444	1050	3.888889
75	12300	3000	15300	17	1800	14	25200	105.8824	723.5294	900	12	1275	4.722222	2100	7.777778
76	64800	60000	124800	18	3060	14	42840	170	3600	6933.333	12	10400	38.51852	3570	13.22222
	540203	**331000**	**871203**	**226**	**21950**		**307300**	**1559.415**	**38690.6**	**61493.52**		**72600.25**	**268.8898**	**25608.33**	**94.84568**
														113.3112	**0.419671**

Descriptive Statistics

Appendix 9: Farm Enterprise Production Levels, in South-Western Kenya, November, 2007

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Division	76	2	1	3	2.00	.894
Age (yrs) of respondent	76	60	20	80	45.17	14.828
Number of years of formal education	51	15	2	17	10.24	4.203
Number of female orphans households	29	7	1	8	2.83	1.929
Number of male orphans households	26	7	1	8	1.96	1.587
Total number of female households	62	13	1	14	5.48	2.856
Total number of male households	56	9	1	10	4.41	2.222
Total number of households	65	17	1	18	9.03	3.885
Land size	76	10	10	20	10.79	2.714
Total output of maize (Kg)	73	17992	8	18000	1274.40	2967.833
Total output of sorghum/millet (Kg)	41	8355	45	8400	744.27	1753.479
Total output of horticultural crops (Kg)	11	1360	80	1440	485.91	495.736
Total output of cotton (Kg)	9	5970	30	6000	1416.67	2347.254
Total output of sugar can (tons)	27	200	0	200	44.83	45.360
Total output of pasture (Kg)	21	7985	15	8000	561.67	1711.321
Total output of cassava (Kg)	4	1008	72	1080	408.00	454.946
Total output of s/potato (Kg)	9	3550	50	3600	905.56	1168.002
Total output of banana (Kg)	2	125	125	250	187.50	88.388
Maize revenue (Kshs.)	39	49400	600	50000	8102.56	9420.910
Legumes revenue (Kshs.)	21	18840	60	18900	2488.57	4273.699
Groundnuts revenue (Kshs.)	43	44740	260	45000	8552.56	9816.183
Cotton revenue (Kshs.)	6	3030	330	3360	1548.33	1122.006
Sorghum/millet revenue (Kshs.)	20	35820	180	36000	6082.75	9062.259
Tomatoes revenue (Kshs.)	3	5970	30	6000	2080.00	3396.012
Kales revenue (Kshs.)	12	13760	240	14000	4178.00	4325.357
Onions revenue (Kshs.)	2	1190	10	1200	605.00	841.457
Revenue (Kshs.) from cattle sales	23	58000	2000	60000	23391.30	16707.345
Revenue (Kshs.) from poultry sales	43	8320	180	8500	2018.26	1969.420
Revenue (Kshs.) from dairy-milk sales	17	98486	14	98500	7416.29	23728.132
Revenue (Kshs.) from goat-milk sales	2	1665	15	1680	847.50	1177.333
Eggs quantity	76	400.00	.00	400.00	15.2500	48.79648
Revenue (Kshs.) eggs sales	13	34410	150	34560	3116.77	9454.116
Valid N (listwise)	0					

Descriptive Statistics

Appendix 10: Farm Production Cost Levels in South-Western Kenya, November 2007.

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Division	76	2	1	3	2.00	.894
Land preparation cost of maize/legumes entrp (ksh/unit)	74	5700	300	6000	1898.11	1318.356
Weeding cost of maize/legumes entrp (ksh/unit)	74	6800	200	7000	1780.27	1263.718
Cost of maize/legumes seeds purchased (ksh/unit)	61	2798	2	2800	495.26	644.578
Imprseedadoption	76	1	0	1	.80	.401
Fertilizer cost purchased for maize/legumes entrp (ksh/unit)	45	4950	50	5000	1259.11	1239.268
Manure cost purchased for maize/legumes entrp (ksh/unit)	33	1498	2	1500	336.61	332.481
Pesticides cost purchased for maize/legumes entrp (ksh/unit)	5	1400	100	1500	616.00	564.163
Harvesting cost of maize/legumes entrp (ksh/unit)	66	16985	15	17000	1092.95	2152.840
Total maize/legumes production cost (Ksh)	74	18110	890	19000	6018.84	4114.143
Land preparation cost of sorghum/millet entrp (ksh/unit)	36	3900	100	4000	1199.44	845.161
Weeding cost of sorghum/millet entrp (ksh/unit)	35	7030	50	7080	1242.29	1336.444
Cost of sorghum/millet seeds purchased (ksh/unit)	30	699	1	700	171.07	206.470
Fertilizer cost purchased for sorghum/millet entrp (ksh/unit)	17	1000	200	1200	431.76	247.922
Manure cost purchased for sorghum/millet entrp (ksh/unit)	16	580	20	600	239.38	177.706
Pesticides cost purchased for sorghum/millet entrp (ksh/unit)	2	190	50	240	145.00	134.350
Harvesting cost of sorghum/millet entrp (ksh/unit)	29	1960	40	2000	535.86	528.113
Total sorghum production cost (Ksh)	39	11690	60	11750	3045.95	2361.957
Total production cost for all enterprises incurred	76	86740	2250	88990	19765.69	18941.179
Valid N (listwise)	1					

Appendix BI:

QUESTIONNAIRE (I)

An analysis of the Economic Impact of new technology and farming practices on small farming systems in South Nyanza

Conducted by

Christopher Obel Gor
Department of Agricultural Economics
University of Nairobi
January, 1993

PART I

Background information:

Q1 (a) Name of Head of Farm-family ----------------------------------
(b) Administrative Division --
(c) Sub-division --------------------- Location ----------------------
(d) Date completed ------------- Respondent No. ----- Age ------

(e) Relationship to the Farm-family (circle a number please)
1. Father 2. Mother 3. Son 4. Daughter 5. Other, please specify ----------------

Utilization of new technology

New technology and farming practices are used here to refer to: use of animal draft power, or tractor for land preparation; use of improved seed varieties, improved animal breeds; use of fertilizers, insecticides/pesticides, vaccines for animals, accaricides, dipping, and artificial insemination. Others are: tree planting, rotation, mulching, terracing, and alley cropping.

Q2. Over the past five (5) years, which of the following farm equipment/implement have you been using for land preparation?
(Circle a number for each equipment/implement used)
1. Hand tools 2. Own-ox plough 3. Hired ox-plough
4. Own-tractor 5. Privately hired tractor
6. Government tractor hire service
7. Others, please specify ------------------------------

Q3. If you have been using hand tools, what are your reasons for not switching to other equipment/machines?
1. Lack of funds to purchase superior equipment
2. Limitations due to size of farm
3. Unavailability of labour
4. Limitations associated with skills for operations
5. Others, please specify? --------------------------

Q4. If you use your own ox-plough, which year did you acquire it?
(1) Prior to 1988 (2) 1988 (3) 1989 (4) 1990
(5) 2006 (6) 2007 (7) 1993

Q5 (a) If you have ever hired ox-plough for land preparation since 1988 which year(s) did you do this?
(1) 1988 (2) 1989 (3) 1990 (4) 2006 (5) 2007 (6) 1993

(b) If you used hired ox-plough in recent years, do you plan to continue hiring?
1. Yes, 2. No.
(i) If yes, why? --
(ii) If No, why? --

Q6 (a) If you have ever hired a tractor for land preparation since 1988, which year(s) did you do this?
(1) 1988 (2) 1989 (3) 1990 (4) 2006 (5) 2007 (6) 1993

(b) If you used hired tractor in recent years, do you plan to continue the service?
1. Yes 2. No
(i) If yes, why? --
(ii) If no, why? --

(Q7) If you use your own tractor, which year did you acquire it? (Circle a number)
(1) Prior to 1988 (2) 1988 (3) 1989 (4) 1990 (5) 2006 (6) 2007 (7) 1993

Farm practices:

(Q8) (a) Which of the following annual cropping patterns do you practice? (Circle a number)
1. Monoculture (produce only one crop)
2. Mixed cropping (produce more than one crop on different fields)
3. Intercropping (produces more than one crop on same field)
4. Other, please specify ------------------

(b) Which seed type did you use and what quantity?

Crop	Seed quantity	Type (Trad./HYV)
----------	-------------	----------------
----------	-------------	----------------
----------	-------------	----------------
----------	-------------	----------------
----------	-------------	----------------

(c) Which animal breed do you raise and their number?

Animal (type)	Number of animals	Breed(Trad./Grd)
------------	----------------	----------------
------------	----------------	----------------
------------	----------------	----------------
------------	----------------	----------------

(d) How much fertilizer was used for various crops in 2007 and at what cost?

Crop	Fertilizer (Kg)	Estimated cost (Kshs.)
-----------	--------------	------------------
-----------	--------------	------------------
-----------	--------------	------------------
-----------	--------------	------------------
-----------	--------------	------------------

(e) How much pesticide/insecticide did you use in 2007 and at what cost?

Crop	Pesticide/insecticide	Estimated cost (Kshs.)
-------------	-------------------	--------------------
-------------	-------------------	--------------------
-------------	-------------------	--------------------
-------------	-------------------	--------------------

Environmental concerns:

Q9 From an environmental point of view, tree planting, rotation, terracing, mulching and alley-cropping can harness the physical and climatic conditions that improve and sustain the agricultural productivity of a farm.

(a) Which of the above environmental practices do you use on your farm?
(1) Tree planting (2) Rotation (3) Terracing (4) Mulching
(5) Alley-Cropping (6) Other, please specify --------------------------

(b) If you practiced any of the above environmental aspects since 1988, which year(s) did you do this?

<u>Environmental Practice</u> <u>Year(s)</u>

1. ------------------------------ ------ ------ ------ ------ ------
2. ------------------------------ ------ ------ ------ ------ ------
3. ------------------------------ ------ ------ ------ ------ ------
4. ------------------------------ ------ ------ ------ ------ ------
5. ------------------------------ ------ ------ ------ ------ ------

(c) If you don't practise any of the environmental aspects above, why? ------------------------
----

(d) Of those who have adopted the environmental concerns listed (Rotation, Tree planting, Terracing, Mulching, and alley-cropping). What changes have you observed in your farm in terms of its agricultural productivity since you adopted the practise(s)?

1. The productivity has increased
2. Has decreased
3. Has remained the same.
4. Cannot tell

Q10.(a) Artificial Insemination can be used to produce superior breeds of animals in terms of productivity, resistance to diseases and other virtues such as adaptability. Have you ever employed this practice for your herds?
1. Yes 2. No.

(b) If yes, which year(s) did you use it ---

(c) If no, why? --

(d) How often do you dip your animals?
(1) Once a Week (2). Twice a Week (3). Three times in a Week
(4). Once a month (5) Twice a month (6) Never

(e) If you never dip your animals, why? ---

(f) Over the past five years, when were your animals last vaccinated and against which disease?

Animal	Year vaccinated	Disease (specify)
----------	--------------	----------------
----------	--------------	----------------
----------	--------------	----------------
----------	--------------	----------------

Economic Impact Analysis (Labour, Land use, Market, Yields, Income).

Q11. New technology here refers to: use of animal draft power, tractors; use of improved seed varieties, improved animal breeds; use of fertilizers, insecticides/pesticides, vaccines for animals, accaricides, dipping, and artificial insemination. Others are: tree planting, rotation, mulching, terracing, and alley-cropping.

(a) Labour:
What changes have occurred in labour use since you started using new technologies (e.g. tractor or animal-draft power) for farm operations?

	Before (Man days)	After
Land preparation	--------------	--------------
Weeding	--------------	--------------
Harvesting	--------------	--------------

(b) If you use new technologies and farming practises and you hire labour, how many of your hired farm labour would you categorize as immigrants from other areas (e.g. other sublocations, locations or divisions/districts) and how many are permanent residents of the area? (Circle a number on the scale).

```
+-----------------------------------+
| Number of workers in each category |
     |                 |
                |     0  1  2  3  4  5 or more |
|                       |
+-----------------------------------+
```

1. Immigrants 1 2 3 4 5 6
2. Permanent residents 1 2 3 4 5 6

(c) Since the adoption of the new technologies and farming practices for your farm operations, how would you classify the labour you use?

(Circle a number)
1. More family labour than hired labour
2. More hired labour than family labour
3. Only family labour
4. Only hired labour

Q12. **Land use:**
(a) What changes in land use have you made since you started using the new technologies (tractor, or animal draft power) for cultivation?

(Circle a number)

1. The area cultivated has been increased
2. The area cultivated has decreased
3. The area cultivated has remained about the same

(b) In terms of crop mixtures as it relates to land use what changes would you say have been made since you started using new technologies and farming practices?

1. Only one more crop was produced. 2. Two-to-three more crops were produced.
3. more than four more crops were produced. 4. Some mix as before was produced.

(c) How much land did you leave fallow? -------- acres why? ------------------------------------
----

Q13. **Market:**

(a) What changes have occurred in terms of the portion of your produce you sell in the market since you adopted the use of new technologies and farming practices? (Circle a number)

1. it has increased 2. it has decreased
3. it has remained the same 4. only produce for subsistence

(b) Over the past five years, during which year did your produce fetch the highest price in the market?

(Circle a number)

(1) 1988 (2) 1989 (3) 1990 (4) 2006 (5) 2007

Yields

Q14 (a) What effect have the adoption of new technology and farming practices had on your yields?

1. Increased 2. Decreased 3. Remained about the same

(b) In your opinion how would you describe the change in yields, since you adopted new technology and farming practices?

(Circle a number on the scale).

+--+
| Somewhat Somewhat | | Significant
Significant Insignificant Insignificant | +--
-----------+

1. Increased 1 2 3 4
2. Decreased 1 2 3 4

(c) What would you say is your major crop? .... or animal raised? -----------------

(d) For the major crop/animal referred to above what were your yields over the past five years?

Year	Crop-yield (bags, Kg)	Animal-Produce (Kg, litre, dozen)
1988	--------------------------	-----------------
1989	-------------------------	-----------------

1990 ------------------------ -----------------
2006 ------------------------ -----------------
2007 ------------------------ -----------------

Income:

Q15. (a) What was your Net Farm Income (Over the part five years)

Year	Net Farm Income
1988	Ksh ----------------------
1989	------------------------
1990	------------------------
2006	------------------------
2007	------------------------

(b) Do you have other business apart from farming?
(Circle a number)
1. Yes 2. No.
If yes, how much time do you spend on the business? ------- hrs.
If no, why? ------------ No opportunity
------------ Farm work is enough
------------ Other, please specify

(c) How many farm-family members have off-farm income? ----------
On average how much remittance per year do they make? Ksh. -----------

Constraints to adoption:

Q16. (a) What prevents you or limits you from adopting new technology and farming practices?
1. Limited land 2. Limited labour 3. Limited power (e.g. machine) input
4. Limited capital, please specify ---------------------
5. Other, please specify ----------------------

(b) If land, how much more would you need and what would you pay per acre?
------- acres -------- cost.

(c) If labour, what operations create the bottlenecks? (circle a number)
1. Land preparation 2. Planting 3. Weeding 4. Harvesting
5. Combination, please specify ------------------------------

(d) If capital, have you tried applying for credit? (Circle a number)
1. Yes 2. No, why? ----------------------------

If yes, did you get it or not?
i) Yes ii) No, If No why? --------------

(e) If you use new technology and farming practices, what is their:
Greatest shortcoming? ---------------
Greatest advantage? -----------------------------

PART II

The following questions concern the Farm-Family's Social characteristics (e.g. Family Size. Age, Gender composition, and Education)

Q17. What is the size of your family? i.e. family size (number of persons) [Circle a number]

(1) Less than two persons. (2) Two-to-four persons (3) Five-to-seven persons
(4) Eight-to-Ten persons (5) Eleven or more persons.

Q18. What is the age distribution in the farm-family? (Circle a number on the scale for each age group)

	Number of Persons					
	0	1	2	3	4	5 or more
1) Less than 15 yrs	1	2	3	4	5	6
2) 15-to-30 yrs	1	2	3	4	5	6
3) 31-to-46 yrs	1	2	3	4	5	6
4) 47-to-62 yrs	1	2	3	4	5	6
5) 63 or more yrs	1	2	3	4	5	6

Q19. What is the gender (sex) distribution in the farm-family? (Circle a number on the scale for each gender category).

	Number of persons					
	0	1	2	3	4	5 or more
1) Female	1	2	3	4	5	6
2) Male	1	2	3	4	5	6

Q20. How many members of the farm-family actually live on the farm? (circle a number please)

1. Less than two persons. 2. Two-to-five
3. Six-to-nine. 4. Ten or more.

Q21. Of those living on the farm, how many are available for farm work?

Number of persons	Number of hours per day
----------------	-----------------------
----------------	-----------------------
----------------	-----------------------
----------------	-----------------------
----------------	-----------------------

Q22. For members of the family living outside the farm, when did they leave the farm?
(circle a number)

1) Less than two years ago 2) Two-to-Four yrs.
3) Five-to-seven yrs 4) > Eight yrs

Q23. Why did they leave the farm? (circle a number)

1. In search of better income 2. Due to lack of land
3. Lack of accommodation 4. Availability of land elsewhere
5. Others, please specify ------------.

Q24. Please indicate your educational status. (Circle the number of highest educational level completed)

(1) Cannot read nor write (2) Can read and write but no formal education
(3) Attended primary school (4) Attended Secondary/High school
(5) Other, please specify --------------------.

Appendix B2:

QUESTIONNAIRE (II)

(Agricultural Policy-Makers and Practitioners)

An analysis of the Economic Impact of new agricultural technology and farming practices on small farming systems in South Western Kenya

Conducted by

Christopher Obel Gor
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University of Nairobi
July, 1994

PART I

(Background information about respondents)

Q1 (a) Name of Respondent ------------------------

(b) Station of duty --------------------------------

(c) Official Designation -------------------------

Q2. What is your position in the structure and administration of agricultural development in the country? (Please circle a number)

1. Frontline Extension Worker
2. Divisional Extension/Veterinary Officer
3. District Agricultural/Veterinary Officer
4. Agricultural/Research Officer
5. Others, please specify-------------------

Q3. In terms of years, what is your experience in agricultural/ livestock development ?

1. Less than one (1) year
2. One (1)-to-Five (5) years
3. Six (6)-to-Eleven (11) years
4. Greater than eleven (11) years

Q4. What is your area of interest in agricultural/livestock development ?

1. Policy formulation
2. Research
3. Adoption/Diffusion of new technology
4. Advisory role
5. Technology design
6. Others, please specify -------------------------------------

(Identification of recommended technology)

Q5 As an agricultural development policy-maker/practitioner, which are some of the latest agricultural technology or farming practices you have recommended for farm use (e.g. since 1989)?

1. Crop production technology/practices (e.g. fertilizer/crop rotation)
2. Livestock production technology/practice (e.g. vaccination/dipping of livestock)
3. Means of land preparation (e.g. animal draft power)
4. Other, please specify --

Q6. Of the technologies/practices recommended above (see Q5) what would you say was the source of the information concerning its formulation/development?

1. Public institution
2. Private commercial institution
3. Non-profit making NGO
4. Agricultural practitioners' personal intuition
5. Farmer experience
6. Others, please specify ---

Q7. Please indicate how beneficial you perceive the following sources of information to be as they relate to small-scale farming operations. (Circle a number for each source)

	Extremely Beneficial	Somewhat Beneficial	Somewhat non-beneficial	Not Beneficial
Farm Magazine	1	2	3	4
Local Farm Newspaper	1	2	3	4
Farm Radio/TV programmes	1	2	3	4
Agricultural/Veterinary extension officers	1	2	3	4
Government sponsored agencies	1	2	3	4
Non Governmental Organizations	1	2	3	4
Commodity Associations	1	2	3	4
Neighbours/Friends/Family	1	2	3	4
Other, please specify ----------------	1	2	3	4

Q8 Please indicate the degree of your agreement or disagreement with the following statements often made about extension services in the country.
(Circle a number for each statement)

	Strongly Agree	**Agree**	**Disagree**	**Strongly Disagree**
Extension services are not effective due to poor funding	1	2	3	4
Extension services are ineffective due to lack of personnel	1	2	3	4
Extension services are ineffective due to inadequate information flow	1	2	3	4
Extension services are ineffective due to negative attitude of officers	1	2	3	4

Q9. In your opinion, which of the following factors would you rank the highest as a critical constraint to adoption of recommended technology and farming practices in the study area ? (Circle only a single number which correspond to your choice)

1. Farm size 2. Land tenure 3. Labour availability
4. Farm credit 5. Social attributes 6. Economic attributes
7. Technical attributes 8. information accessibility
9. input supplies 10. Others, please specify --------------------------------

Q10. In your opinion, which of the following factors most influence farmers' decisions to seek more information and adopt new technology and farming practices?

(Circle only a single number which correspond to your choice)

1. Attributes of the technology
2. Distance of information source
3. Skills associated with the technology
4. Reduction of labour requirements
5. Farm size
6. Availability of funds
7. Others, please specify---

Technology impact

Q11. In your opinion, what would you say the adoption rate of the following agricultural inputs in your area of operations?
(Circle a number)

	High Adoption	Medium Adoption	Low Adoption	No Adoption
Fertilizer	1	2	3	4
Means of land preparation	1	2	3	4
Pesticides/Insecticides	1	2	3	4
Vaccination	1	2	3	4
Dipping	1	2	3	4
Grade livestock	1	2	3	4
Environmental friendly practices	1	2	3	4

Q12. On a likert-scale of 1-to-4 (i.e. 1 = Extremely significant, and 4 = Extremely insignificant), how would you rank the impact of new agricultural technology and farming practices adoption as they relate to the following measures of productivity in your area of operations ? (Circle a number).

	Extremely Significant	Somewhat Significant	Somewhat Insignificant	Extremely Insignificant
Annual Net-cash farm income	1	2	3	4
Crop yield per hectare	1	2	3	4
Produce (quantity) per animal	1	2	3	4
Commercialization per farm	1	2	3	4

(Constraints to practitioners' effectiveness)

Q13 What would you say is the most important limiting factor in your duty as an agent of agricultural development ?

1. Declining funding
2. Communication gap between extension and research
3. Inadequate supervision
4. Inadequate support by junior staff
5. Lack of personnel
6. Lack of continuous training
7. Inadequate cooperation by farmers
8. Inept coordination between field and headquarters
9. Lack of transport
10. Inappropriate technology
11. Other, please specify -------------------

Q14. On a likert-scale of 1-to-4, where 1 = Extremely satisfactory, and 4 = Extremely unsatisfactory, how would you rank the following interactions among researchers, extension staff, and farmers in your sphere of operation?

	Extremely Satisfactory	Somewhat Satisfactory	Somewhat Unsatisfactory	Extremely Unsatisfactory
Between Research and Extension staff	1	2	3	4
Between Research and Farmers	1	2	3	4
Between Extension staff and Farmers	1	2	3	4
Among Researchers, Extension staff, and Farmers	1	2	3	4

Q15. In your opinion, how would you describe the degree of satisfaction with the current structure and administration of agricultural extension services in the country?

1. Extremely satisfied
2. Somewhat satisfied
3. Somewhat dissatisfied
4. Extremely dissatisfied

Q16. Among the following extension service approaches, which one(s) do you often use in the diffusion/adoption process in your area of jurisdiction?

1. Individual approach
2. Group approach
3. Progressive farmer approach
4. Contract farming approach
5. Integrated (package) approach
6. Farming systems approach
7. Training and visits systems approach
8. Others, please specify ------------------------

Q17 For the field bound staff, once vital information is formulated and made available for transfer to farmers, which method (s) do you often use for information dissemination purposes?

1. Radio
2. Television
3. Newspapers
4. Demonstrations
5. Field-trips
6. Group discussions
7. Local barazas
8. Individual farmer visits
9. Others, please specify ---

Q18. As a field-staff you need a continuous flow of agricultural information to keep a breast with the changing circumstances and farmers' needs. Thus there is need for frequent in-service training sessions. In the last three (3) years (i.e. since 1990), how often have you attended such training sessions or seminars?

(Circle a number).

1. Fortnightly 2. Twice in a year 3. Every quarter of a year
4. Once every year 5. Others, please specify ------------------------------------

Q19. The current structure and administration of Extension services in the country are centralized (i.e. decisions are made at the Headquarters and passed downwards).
What is your opinion about the call to have Extension services decentralized by bringing the services under the supervision and execution of the University systems in the country? (Circle a number).
1. Strongly agree 2. Agree 3. Disagree 4. Strongly disagree.

Q20. In term of qualification, Kenya extension staff are generalists rather than specialists in their educational background. In your opinion what should be the right qualification of the field-staff? (Circle a number).
1. Generalists 2. Specialists 3. Combination of 1&2.

Q21. (a) Programme planning Process in Extension Services is important because it helps you in establishing a concise statement on why and how to initiate projects and meet set objectives. Do you subscribe to the list of those who support Programme Planning?

(Circle a number).

1. Yes 2. No

Q21. (b) If yes, would you please show us a copy of the latest Programme Plan you may have? ---

Q22. Given your experience and vision as an agricultural policy-maker or practitioner, what solutions would you propose to overcome the constraints alluded to above (see Q13).
(Circle only one number which correspond to your choice)
1. More public funding for research work
2. More funding for Extension work
3. More Farmer participation in research and extension work
4. More financial credit to farmers
5. All of the above
6. Solutions 1, 2, and 3, but not 4.

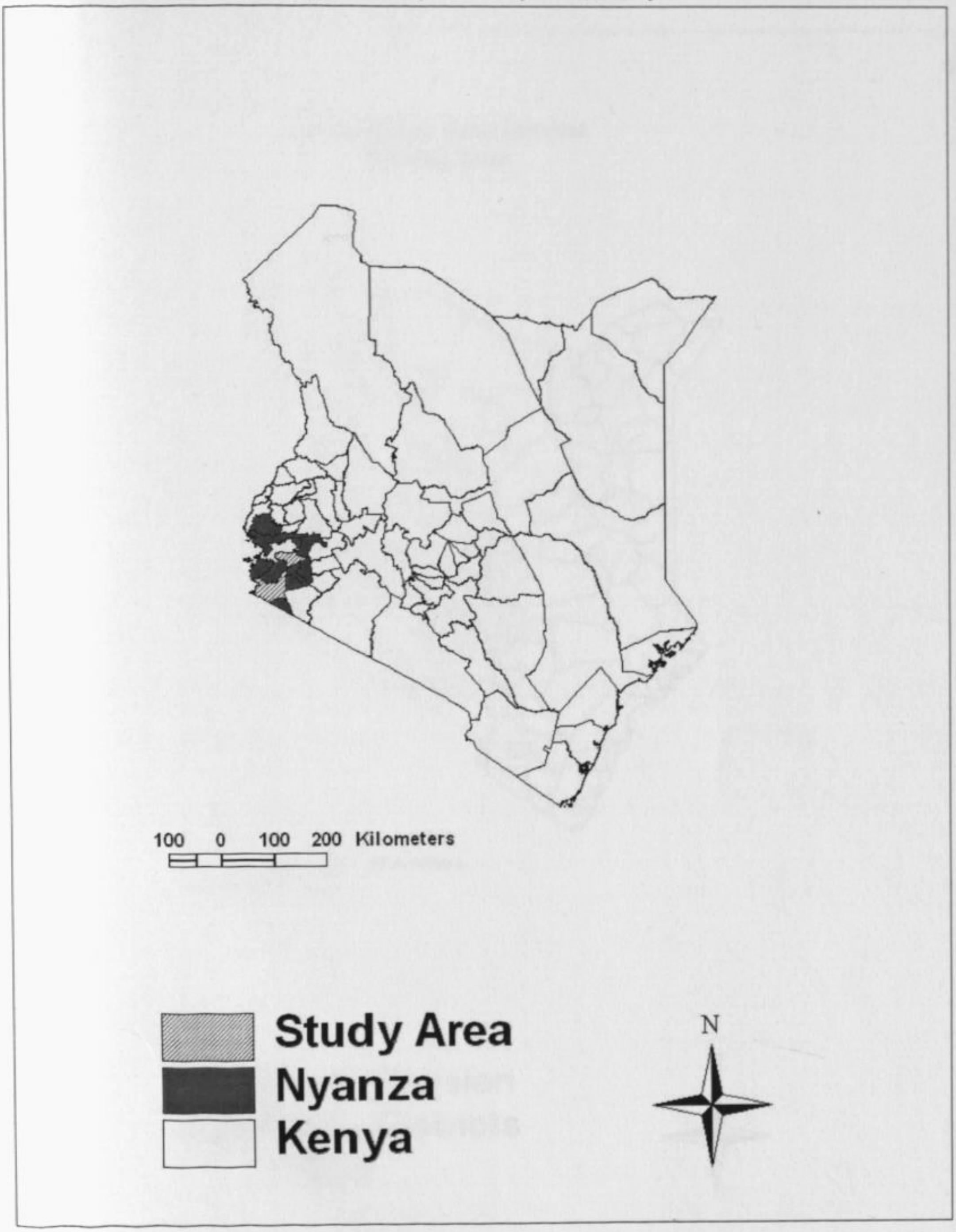
Q23. (a) What are some of the positive comments that you may have concerning new agricultural technology diffusion/adoption in Kenya ?

Q24. (b) What are some of the short-comings you may have observed concerning diffusion/adoption of new agricultural technologies in Kenya ?

ANY OTHER COMMENTS

Xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

Map-2: Study area, Nyanza, Kenya.



Map-3: Vulnerability Assessment Survey Area, Rongo and Rachuonyo Districts.