The Relative Importance of Transaction Costs in the Adoption of Certified Maize Seed: A Case of Moist Transitional(MT) Zone in Embu

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DECLARATION AND RECOMMENDATION

Declaration

I hereby declare that this thesis is my original work and has not been presented for a degree in any other university.

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DEDICATION

This thesis is dedicated to My God and Lord, my beloved parents, Grace and Simon Munyua, the rest of the family and the memory my late brother Henry. Your unconditional love, unwavering support, prayers and understanding has made it possible to complete this study

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ABSTRACT

The rising world prices for major tradable staples such as maize have been a concern of many Sub-Saharan African countries also in Kenya. Kenya is a maize deficit country and has to meet domestic demand through maize imports. Maize is a major staple food for over 80 percent of Kenya's population. It contributes up to 40 percent of the dietary energy supply and the country is accordingly searching for ways to increase maize productivity. History has shown that growth in productivity and functional input and commodity marketing systems are intimately tied with gains in agricultural production. Maize productivity has been rising in the last decade mainly as a result of the use of improved germplasm and fertilizer. However, the proportion of farmers using these technologies is low and the aggregate productivity in maize is still low compared to other countries and its potential. Many adoption studies have been carried out in Kenya and recommendations given, but the problem of low adoption rates for improved germplasm persists. This thus necessitates re-looking at the problem of technology diffusion from a different perspective. Previous studies have often assumed the existence of perfect input and product markets, tending to ignore the important but significant role played by institutions as well as the role of transaction costs associated with market exchange. The analysis detailed in this thesis makes use of qualitative information from institutions and actors in seed input value chains as well as quantitative information collected from a sample of 150 representative small-scale farmers in the Moist Transitional Maize Zones of Embu in Kenya. A two stage regression model was applied to analyze determinants of adoption and factors affecting degree of adoption of certified improved maize seed. The results indicate that factors such as Experience in years of using certified maize seed, Distance to motor-able road, Access to credit, Age of the head, education level of the head, Degree of market participation, size of cultivated acreage and fourth wealth. play an important role in the decision of whether or not to use certified seed and on what proportion of maize area to allocate to certified seeds. By introducing elements of transaction costs this study found that as farmers adopt certified seeds, they incur higher transaction costs than non-adopters. However, the only category of transaction costs found significant were costs related to seed search costs.

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LIST OF ABBREVIATIONS

ADC	Agricultural Development Corporation
AEZ	Agro-Ecological Zones
AFC	Agricultural Finance Corporation
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center)
DES	Dietary Energy Supply
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
HYV	High Yielding Varieties
KEPHIS	Kenya Plant Health Inspectorate Service
KFA	Kenya Farmers Association
KGGCU	Kenya Grain Growers Cooperative Union
KSC	Kenya Seed Company
MASL	Metres above Sea Level
MOA	Ministry of Agriculture
NIE	New Institutional Economics
TCE	Transaction Cost Economics

CHAPTER 1

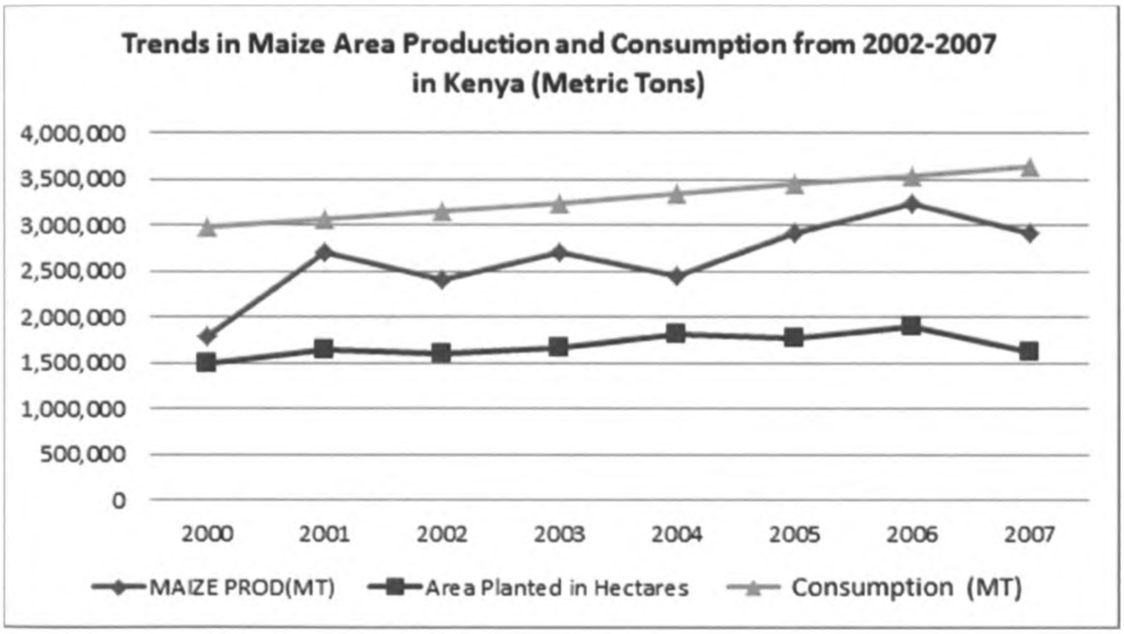
Introduction

Increasing agricultural productivity and hence production using improved agricultural technologies has been identified as a precondition for achieving food security (Langyintuo et al., 2000). As long as farmers continue to use traditional or low yielding crop varieties, agricultural productivity will remain low. Small-scale farmers depending especially on subsistence agriculture have the potential to increase their welfare and food security situation if they adopt improved production technologies. This is especially true for staple food crops such as maize cultivated by the majority of farmers in Kenya.

Maize is the most important staple food for Kenya. The crop supplies 40 to 45 percent and 35 to 40 percent of the calories and proteins respectively, consumed by an average Kenyan (GoK 2003). Maize is produced by over 90 percent of rural households accounting for more than 20 percent of all agricultural production and 25 percent of agricultural employment (MoA 2004). Small scale farmers account for 65 percent of total maize production which mainly goes to subsistence consumption, while large scale farmers contribute the largest share of marketed surplus (MoA 2004). The area under maize has stabilized at around 1.5 million hectares, producing about 26 million bags (23 million metric tonnes) of maize per annum (Ibid.).

Maize per capita consumption in Kenya is estimated at 98 kilograms which translates to approximately 27 to 31 million metric tons (30-34 million 90 kilogram bags) per year, Maize is also important as it accounts for 28 percent of gross farm output (Jayne et al., 2001). The domestic supply for maize has been on average 30 million bags annually. The demand, however, has been on the increase, and outstrips domestic supply, making the country a net maize importer. With the country's population projected to reach 43.1 million by 2020 (Jayne et al., 2001), this implies that the country will increasingly be relying on imports to meet the deficits. Figure 1 presents the trends in maize area, production and consumption figures where it can be seen that consumption is rising and area under maize is stagnant.

Figure 1 Trends in Maize Area Production and Consumption from 2002-2007 in Kenya (Metric tons per year)



Source: Ministry of Agriculture, Economic Surveys and National cereals and produce board.

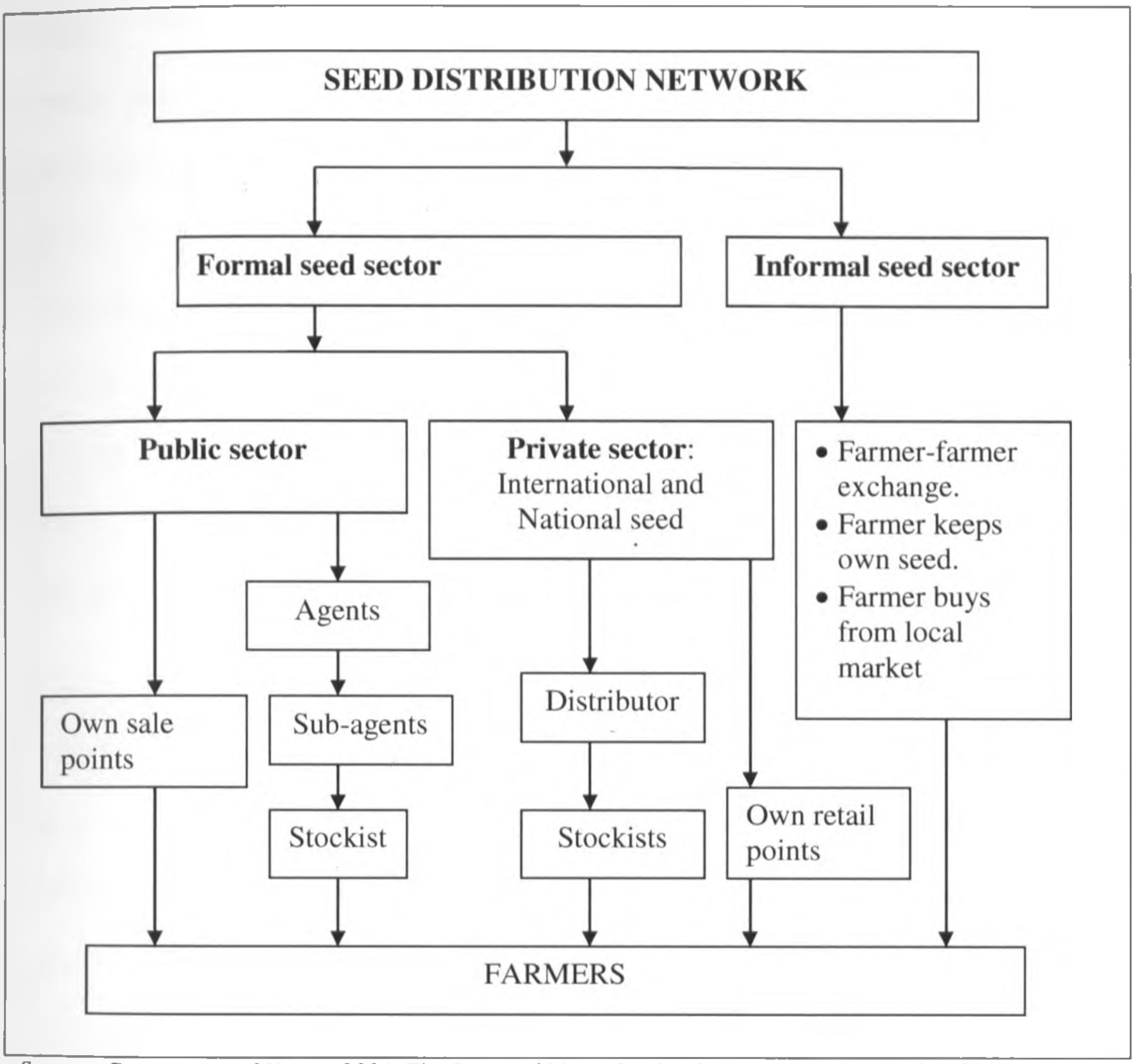
Whereas maize production has been generally fluctuating averaging 2 percent over the five years between 2001 and 2005, the marginal growth in production is driven more by use of productivity-enhancing technologies, than by increase in acreage (Smale and Jayne 2003, MoA 2004). Among agricultural inputs, seed is recognized to have the greatest ability of increasing on-farm productivity since seed determines the upper limit of crop yields and the productivity of all other agricultural inputs (MoA 2004). This means that to sustain as well as increase production volumes, it will be critical to find mechanisms that guarantee farmers access to high yielding certified seed varieties. Moreover, such a mechanism is paramount for successful variety improvement for sustainable agriculture (Hellin 2007)

The rising food and input prices in the world markets will further increase the import bill which has serious implications for food security and the country's balance of payments. This underscores the importance of investing in use of high performance certified maize seed as well as increased use of yield-enhancing inputs such as fertilizer in maize production so as to boost the domestic maize output. Due to the dominant role of maize to Kenya's agriculture and overall food security, the government has been keen to develop the maize subsector in order to contribute to the wider goals of national food and nutrition security policies (Muhammad, 2003).

Maize Seed Industry Structure and Trends in Certified Seed Use

Emphasis on the availability and dissemination of appropriate certified seed varieties and technologies to the smallholder farmers is an issue of concern to researchers, development practitioners and policy makers. Seed distribution channels play an important role in the diffusion of improved germplasm to farmers. These seed maize channels comprise actors, both the public and private sectors. There are also formal and informal seed channels. Maize improvement and research activities are carried out by Kenya Agricultural Research Institute (KARI), international research institutions such as International Maize and Wheat Improvement Center (CIMMYT) and private national and multinational seed companies. Germplasm from public research institutions is then released to seed breeding companies both public and private such as Kenya Seed Company (KSC). The seed breeders' contract large scale farmers and the state owned Agricultural Development Corporation (ADC) farms to multiply the seed under strict regulation by Kenya Plant Health Inspectorate Service (KEPHIS) which has the mandate to ensure quality control and certification of seed before it is released to the market. Multinational companies have also been importing certified seed into the country. Distribution is done by the respective seed companies through their established agents, distributors and agro-dealers s. The structure of the seed industry in Kenya is presented in Figure 2.

Figure 2 Structure of the Seed Industry in Kenya



Source: Government of Kenya, 2004. The Status of Maize Seed Industry in Kenya: A Value Chain Analysis. Ministry Of Agriculture

The seed industry in Kenya has been undergoing structural changes in the certified seed supply chains. The industry experienced phenomenal expansion in the areas of varietal improvement from the 1970s following the establishment of several maize research programs. According to the Ministry of Agriculture, by the year 2004, twenty modern maize varieties had been developed by government supported maize breeding programs. A recent study in 2008 put the number of improved maize varieties in the market at 41

(Langyintuo et al., 2008). Efforts have also been made towards developing seed varieties suitable to different agro-ecological zones. These include the 6-series for the highlands, 5-series suited for early maturity, Dry Hybrids (DH) series for dry lowlands and other composites for low lying areas. However, in spite of these advances, studies show that by the year 2002 up to 30 percent of total area under maize country-wide was under indigenous varieties (MoA 2004). Use of certified maize seed is lowest in eastern lowlands and coastal lowlands of Kenya (Table 1) where it was found to be 9 percent and 19 percent respectively (Ayieko and Tschirley, 2006). This indicates that the full potential to productivity increase from use of certified maize seed is yet to be realized in marginal areas and nationally.

A study comparing sales volumes for improved seed between 1997 and 2007 for countries in Eastern and Southern African countries indicated that there was a decline in the amount of seed sold. The countries reporting a decline included Angola (-7%), Zimbabwe (-2%) Kenya (-1%) while Mozambique, Malawi, Ethiopia, Tanzania, Uganda and Zambia reported increased improved seed sales ranging from 2 – 50 percent (Langyintuo et al., 2008). The unmet need for improved maize seed is met by recycling grain as seed. According to Pixley and Banziger 2001 when farmers recycle grain they are faced by risk of declined yields of between 5 percent for open pollinated varieties (OPV) and 30 percent for hybrids.

Substantial resources and efforts have been employed by international non-governmental, local public and private institutions towards the research and development of improved crop technologies. These high yielding varieties (HYV) are geared towards productivity increase given a set of complementary inputs such as fertilizers and other chemicals.

Prior to liberalization of the seed industry the Kenya Seed Company (KSC) had legal monopoly to grow, process and distribute certified maize seed. It had a well-developed, extensive and elaborate network of seed marketing that together with a committed agricultural extension staff has been credited with the rapid diffusion of hybrid and composite seed- also known as open pollinated varieties (OPVs) to farmers across Kenya.

Today the seed industry has been liberalized attracting many actors who deal in locally produced seed as well as imported germplasm. The seed industry is still characterized by a high degree of concentration in terms of market share. However, by 2004 there were 13 registered seed companies dealing with about 50 seed varieties (MoA 2004). The Ministry of Agriculture notes that despite the increased activities of the seed companies, there has been a decline in use of certified hybrid seeds whereas the use of recycled hybrids, indigenous varieties and open pollinated varieties which have low genetic potential have continued to increase among smallholders. As a result farmers have continued to have declining yield and a reversal or slowing down/stagnation of productivity gains.

Kenya Farmers Association (KFA) was the major distributor of certified maize seed across the country until the early 1990s. Inevitable privatization saw seed distribution taken up by mainly private seed agents, sub-agents and agro-dealers/stokists. These certified seed output chains are supposed to ensure that maize seed is available in various parts of the country in as far as the marketing margins cover the distribution costs and profits. However, several bottlenecks impede the realization of increased access to certified seed, e.g. distribution of seed is hindered by poor road networks in rural areas (Langyintuo et al., 2008). It has also been observed that access to grain markets with predictable and fair prices for grain output is an important factor in farmers' decisions to invest in farm inputs such as seed (Langyintuo et al., 2004, Muhammad et al., 2003).

The government and indeed the international community continue to address the prospects for food security. CIMMYT is currently involved in a study on *Developing and disseminating stress tolerant maize for sustainable food security in East and Central Africa.* The project aims to increase the availability of breeder and foundation seed of stress tolerant, nutritionally enhanced maize varieties, scale up certified seed production especially in stress prone-environments, and identify the policy recommendations required to increase maize seed availability in stress-prone environments.

The introduction of many new technologies has been met with only partial success, as measured by observed rates of adoption. The benefits from technology development can only be realized if innovation diffusion will be successful and that farmers put to use these technologies on farm. Adesina and Zinnah (1993) observed that various institutional, economic, psychological and social factors are important in determining the adoption of improved crop technologies. They also postulate that farmers are more likely to adopt a given technology if the expected benefits are seen to outweigh those of existing alternatives.

In spite of the efforts by various players many farmers in Kenya are still not using improved seeds. Table 1 shows seed type usage by agro-regional zones in Kenya. Western transitional, High-potential maize zones and Western highlands lead in proportionate certified seed use. The marginal areas of eastern lowlands and coastal areas reported the lowest adoption rates of certified seed.

Table 1 Maize Seed Type Usage by Agro-Regional Zones in Kenya

Agro Regional Zone	*Certified seed*	*Indigenous seed/Retained seed*
	- percent of usage in the region-	
Central highlands	41	59
High potential maize zones	61	39
Eastern lowlands	9	91
Western lowlands	48	52
Western transitional	85	15
Western highlands	60	40
Coastal lowlands	19	81

Source: Ayieko 2006, Tegemeo Household Survey 2004

Other studies specific to Kenya found that extension services, yield difference between improved and local varieties, and geographical characteristics significantly influenced the adoption process of improved maize seeds and inorganic fertilizers (Kaliba et al., 2000). Suri, (2006) in her study of comparative advantage of technology adoption found that access and infrastructure constraints impede even those farmers whose returns from hybrid maize would be extremely high. Winter-Nelson et al.,, 2005 attributed the muted production response in export crops in Tanzania after liberalization to the failure of policy reforms to address the provision of agrochemicals, extension advice and finance

Many development projects have sought to remove some of these constraints by introducing facilities to provide credit, information, the orderly supply of necessary complementary inputs, infrastructure investments, marketing networks, etc. Expectations that removal of these constraints would result in the adoption of improved practices have been only partially realized. As past experience shows, immediate and uniform adoption of innovations in agriculture is quite rare (Feder et al., 1985), In a synthesis of 22 adoption studies in Eastern Africa, availability of information on the technology and profitability of the technology, were identified as the main obstacles to technology adoption (Doss et al., 2003). It was found that farmers did not appear resistant to using improved varieties and fertilizer in the region, however, much of the improved varieties were of recycled hybrids and from earlier varieties especially in Tanzania and Ethiopia (Doss et al., 2003). Due to this phenomenon the review concluded that although farmers gain some benefits from recycled varieties, they do not obtain all the agronomic benefits from improved varieties. Using newly purchased seed would presumably increase output albeit at some additional cost. Further, the study highlighted a weakness that the absence of a standardized definition of adoption across the reviewed studies, where many studies treated recycled seed from improved varieties the same as newly purchased seed.

Statement of the Problem

The global maize productions trends show that although 68 percent of the global maize area is in the developing world (Pingali and Pandey 2001). This notwithstanding, only 46 percent of the world's maize production is grown there. Adoption of New or improved technologies such as certified seeds and complementary inputs have been identified as an integral step towards bridging the yield differential between developed and developing world.

Past studies on technology adoption studies have assumed costless market exchange and zero transaction costs. Transaction Costs School argues that market exchange is not costless as has been assumed by neoclassical economists. Transaction costs in the market for farm inputs such as certified seeds and productivity increasing inputs such as fertilizers may affect the decisions made by the farmer whereas transaction costs in output markets may influence the supply response as well as demand for inputs. This implies that high transaction costs in input and output markets for maize inputs and grains may constrain participation of smallholder farmers in maize production and marketing activities. There is, therefore, a need to study the relative importance of transaction costs on the adoption and intensity of certified maize seed adoption.

From the fore-going, the issue of transaction costs implication has gained importance both locally and internationally. This study was conceived in part to investigate the determinants of adoption for certified maize seeds as well as to complement CIMMYT's work of looking into institutions, actors in the input supply chains so to build up an understanding of the different actors in the maize seed input and grain output chains; along with finding out the relative importance of transaction costs involved in market exchange of certified maize seed.

Overall Objective

The main purpose of this study was establish relative importance of transaction costs in certified seed adoption among small scale farmers in Moist Transitional maize zone of Nembure division of Embu District.

Specific objectives

The specific objectives for the study are as follows:

1. To establish the role played by various institutions and actors in the supply of maize seed, and

2. To analyze the relative importance of transaction costs
3. To analyze the determinants of adoption of certified maize seeds by smallholder maize farmers

Hypothesis

The study tested the following hypothesis

1. Transaction costs have no effect on small-scale farmers' adoption of certified maize seeds.

Justification and Significance of the Study

With maize occupying such a central position in the diets and livelihoods of the Kenyans, it is imperative that ways and means of improving maize productivity be sought. Recent evidence show that annual maize yields and area planted have stagnated at below two metric tons per hectare and 1.5 million hectares respectively. This means that the potential for maize production increase will rely more on yield improvement than area expansion. Therefore this study will contribute to greater understanding of technology adoption by adding to the body of knowledge on technology adoption. This in turn can lead to better agricultural policy formulation.

By studying the constraints to the adoption of certified maize seed, this study will shed more light on the factors that inhibit adoption of certified seed and identify opportunities for the use of improved germplasm which has been recognized to have significant yield improvement.

There have been very few studies on the role of institutions and transaction costs along the input and output market value chains in Kenya. Transaction Cost Economics (TCE) seeks to bring to the fore how costs of searching information, contracting as well as enforcement of contracts bear on the resultant marketing arrangements. In light of this, this study sought to highlight the relative importance of transaction costs on the use of certified maize seed.

Several studies on technology adoption in general as well as the adoption of improved maize germplasm have been carried out in Kenya as well as in Sub-Saharan Africa, but they have tended to ignore the important role that institutions in the input value chains play in technology adoption. Previous studies have also assumed frictionless market exchange, they therefore miss the effect that transaction costs have on the use of technology and intensity of use. This study therefore plays a vital role in identifying institutional innovations that will promote technology adoption as well as to contribute to policy formulation that will seek to address the transaction costs that impede technology adoption among small-scale farmers in Moist Transitional Maize Zone of Kenya.

CHAPTER 2

Literature Review

This chapter presents a review of some of the studies on technology adoption with respect to maize. A critical examination of objectives, methodologies applied and the findings from these studies. The theoretical basis for the study is also presented. The chapter ends by looking at transaction costs and the role of institutions in input and output product markets and consequently in the adoption of certified seed.

The continuing importance of agriculture in the economies of developing countries is reflected in the association between growth in agriculture and of the economy as a whole (Bank 1982). In Kenya this hypothesis is underscored by the strong correlation between the agricultural sector Gross Domestic Product (GDP) and the overall GDP (Jayne et al., 2005). Literature shows that agricultural productivity growth arises from the changes in availability of biological and physical capital, improvements in human capital, institutional innovation and technological change (Bonen and Eicher, 1987).

Low average yields in the developing world are responsible for this wide gap between global share of area and share of production. The average maize yield in developed countries is 8 tons per hectare while that of developing countries is below 3 tons per hectare. Disparities in climatic conditions as well as farming technologies account for the 5 tons per hectare yield differential between developed and developing world (Pingali and Pandey, 2001).

The role played by seed and other productivity-enhancing inputs in increasing productivity is without doubt a significant one. Worldwide the success of the Asian green revolution has been credited to policies that promoted increased use of high yielding seed and fertilizer technologies. Many African governments have been promoting increased use of similar use of similar technologies for more than three decades (Crawford et al., 2003). There is evidence that policies that promoted comprehensive agricultural support led to success of the Asian Green Revolution --e.g. improved germplasm, fixed prices, fertilizer subsidies and credit subsidies-- (Hellin 2007).

Adoption Studies on Certified Maize Seed

Past studies on innovation diffusion sought to investigate the factors that promote or stifle adoption of improved crop technologies. Conventional wisdom is that constraints to rapid technology adoption at the household level include factors such as lack of capital, limited access to information, risk aversion, small and fragmented land holding and inadequate incentives associated with tenure arrangements (Feder et al., 1985). They further observe that insufficient human capital, absence of equipment that affects timeliness of production, untimely supply of complementary inputs and inappropriate transportation infrastructure among others constrain adoption.

Kaliba et al., 2000 argue that production increases in maize can be achieved through expansion in area planted, yield gains, or some combination of the two. However, diminishing arable land in the least developed countries often rules out the possibility of further expansion on area planted unless maize is grown in place of other crops. This suggests that future production growth will depend mainly on the yield gains brought about by productivity enhancing technologies. One of such technology is improved germplasm contained in the certified maize varieties.

Rapid uptake of improved maize seed technology in Africa has involved a complex interaction between farmer characteristics, technological, institutional, and policy innovations (Smale and Jayne 2003). They propose that technical change needs to be evaluated in the context of an institutional and policy environment. Nyoro (2002) observed that incentives and ability of farmers to invest in productivity-enhancing inputs and methods depend on reduction of transaction costs and risks of exchange across inputs, credit and output markets. However, adoption studies in the past were not explicit on the relative importance of transaction costs on the technology adoption.

Technical change leads to increased output by poor farming households which in turn may lead to higher disposable incomes where the households can sell off the surplus. The direct consumption effect of increased productivity and high income is an increase in the level of food consumption and therefore a possibility of improved nutrition, consequently, a reduction in food insecurity, of the adopting households. Besides increased household consumption from own production, higher cash income from new technology is also associated with increased expenditure on purchases of basic food staples as well as fruits and other high value products(Ahmed and Bouis 2002).

Karanja et al., (2003) noted that technologies developed for high potential regions are likely to have more profound aggregate impacts on maize production and lead to greater reductions in export demand (if prices are controlled) or maize prices (if maize prices are flexible). Technology adoption in high potential regions is likely to have substantially greater positive impacts on aggregate real incomes, but inferior income distributional outcomes compared to technology adoption in marginal regions. It is important to investigate the determinant of certified maize seed use for different agro ecological zones so as to address the inter-regional income distributional effects.

According to a survey done in Kenya in 1992, there were high adoption rates of improved maize varieties in the high potential areas (85 percent of the farmers), less than 20 percent in the low potential areas (Coast and Dry transitional), and around 50 percent in the mid-altitudes (Hassan et al., 1998) the country-wide average being 73.6 percent. These results are consistent with the other findings by Ayieko, (2005) shown in table 1, and Wekesa et al., (2003), in which the adoption rate of improved maize varieties in the coastal lowlands was only 40 percent. Adoption rates for fertilizer were lowest as only 4.5 percent of the respondents used inorganic fertilizers.

Langyintuo et al., (2005) highlighted the following as the challenges limiting maize technology adoption by small-scale farmers in Southern Africa. High cost of improved maize seed and related inputs such as fertilizer, long distances to input and output markets, limited input credit in the rural settings, poor infrastructure for technology dissemination, natural hazards such as drought which makes technologies unprofitable, inappropriateness of technologies (e.g. hybrids which farmers want to recycle), reduced contact between farmer and extension worker, limited knowledge on technology attributed on the farmers' part to weak linkages among stake holders that stifle dissemination of technology.

Owuor (2000) and Karanja (1999) found that small-scale farmers using 'improved seed' and those using other inputs on maize experienced high yields per unit area as compared to those not using improved seed and fertilizer. Karanja (1999), found that farmers using hybrid seed also used more fertilizer, however, this effect varied with agro-regional zone.

Besides inputs, other factors found to affect productivity include 'non-conventional inputs' such as infrastructure, price of inputs and contact with extension officers The household characteristics that were significant to maize productivity were level of education, family labor and off-farm income. Land size, value of assets, gender, size of family, and age-composition of the family had no significant impact on use of inputs (Ibid). Karanja (1999) also observed that fertilizer use was more pronounced in zones that are wetter and the rains are more reliable which he attributed to production risk associated with inadequate rainfall. Where rainfall is adequate, most crops will respond to fertilizer, and it becomes worthwhile to adopt better crop varieties bred specifically to respond to fertilizer, this gives impetus to investing in the search for stress tolerant maize varieties better suited to marginal areas. This study will shed light on the role played by institutions in the seed supply chain.

Modeling Technology Adoption Studies

The rate of adoption of any agricultural innovation can be measured in two ways: in terms of the number of farmers who adopt the innovation, or in terms of the total area on which the innovation is adopted (Morris 1998). The decision to adopt hybrid maize is influenced by a complex and highly variable set of factors. Depending on the context, these can include demographic characteristics of the household (e.g., size, age and gender composition, wealth, education level of the household head), the expected profitability and/or perceived risk of the technology, farmers' consumption preferences, and the availability and cost of inputs, especially seed.

In general a range of factors have been hypothesized to influence the adoption of agricultural technologies (Feder et al., 1985; Zeller, 2000 Fernandez-Cornejo et al., 1994;). This includes the farm size, tenure, and household characteristics such as household size, age, education and farming experience of the head, incomes earned by the household, access to credit, location factors of the farm which include the soil fertility, climate, pest infestation, irrigation, the source and availability of information on technology to the household. The survey carried out in Embu collected data on selected characteristics from the above as well as various categories of transaction costs.

Literature on modeling dichotomous technology adoption decisions shows adoption decisions are modeled following a sequential adoption process (Karanja et al., 1999). First choosing from two basic types of maize varieties, grouped into certified maize seeds and non-certified seed (e.g. retained seed and indigenous varieties), and then the farmer independently deciding on how much area to allocate to certified maize, subject to household resources and spatial constraints.

A Tobit model could be used to investigate the probability of adoption as well as the intensity of application (Kaliba et al., 2000). These models are also known as censored or truncated regression models. These models are called truncated if the observations outside the specified range are totally lost and censored if one can at least observe the exogenous variable. To estimate the determinants of intensity of use the study adopted a two stage model.

Two stage models have been applied in several studies where it is assumed that the decision to use and the application rate are made sequentially and where the decision to use the input and how much to use may be affected by different factors (Winter-Nelson and Temu 2002). A two stage model was applied using Heckman's sample selection procedure where a probit is used to describe the participation decision and to generate the inverse mill ratio Inverse mills ratio is the ratio of the probability density function to the cumulative distribution function of a distribution. This ratio is used in the second stage to correct for possible selection bias in regression to explain the intensity of use among users (Heckman 1976).

The first element in the selection model is the probit equation to predict participation in the certified maize seed markets. By making assumptions about the probability density of the residuals, the modeler can choose between several different binomial choice model formulations. Two types of binomial choice models are most common and found in practice: the logit and the probit models. The logit model assumes a logistic distribution of errors, and the probit model assumes a normal distributed errors.

Transaction Costs and Role of Institutions in Input and Product Markets

Following the structural reforms in many agricultural sectors in Kenya and other sub-Saharan African countries, it has been observed that the reforms have been more successful in improving output prices than in improving actual output (Kherallah et al., 2000). The muted production response seen in traditional export crops as well as in staple production has been attributed to failure in policy reforms to adequately address the provision of inputs like certified seeds, agrochemicals, extension advice and finance (Winter-Nelson et al.,, 2004). The input supply markets in Kenya saw the reduction of the level of activity, withdrawal or collapse of marketing and agricultural finance parastatals and other farmer organizations such as Kenya Farmers Association (KFA), Kenya Grain Growers Cooperative Union (KGGCU) and Agricultural Finance Corporation (AFC).

The withdrawal of the state from direct retail marketing was intended to allow more efficient provision of marketing services by private traders and farmer organizations (Dorward 2001). However, capacity constraints have hindered the entry of private sector players into produce markets where larger investments are required, or in the provision of crop input supply services in remote areas (Poulton et al., 1998). Dorward (2001) observes that costs in input provision may have increased due to the presence of multiple marketers and long supply chains, increase in quality control costs and collapse of crop secured credit schemes due to presence of multiple output buyers. The spatial distribution of input suppliers may also raise the travel costs that farmers face while buying inputs (Winter-Nelson et al, 2004).

Transaction Costs Economics School of economics argues that market exchange is not costless as has been assumed in the neoclassical economists. Bromley (1991) defines transaction costs as the costs of searching and gathering information on agents, goods and services, bargaining and negotiating a contract, monitoring and enforcing a contract.

Transaction costs are defined here as costs related exclusively to the coordination of exchange among market actors, distinct from the physical costs or 'production costs' of transferring goods, such as transport, handling, and storage costs. Factor that affect the severity or incidence of transaction costs include frequency of transactions (i.e. volume/number of transactions per time period), uncertainty in the environment surrounding the transaction - such as environmental, political, social or economic risk surrounding a transaction. Other aspects include bounded rationality, opportunism between the actors, asset specificity and information asymmetry (Kherallah and Kirsten 2001).

New Institutional Economics (NIE) postulates that neoclassical economics takes institutions as a given i.e. there is an assumption that institutions have no influence on aspects and outcomes of economic activity. This view is in contrast to that of NIE that seeks to indigenize institutions by attempting to analyze the functional characteristics of institutions so as to understand markets and how exchange transactions are coordinated.

This implies that high transaction costs may influence the participation of smallholder farmers in production and marketing activities. Transaction costs in the market for farm inputs such as certified seeds and productivity-increasing input such as fertilizers may affect the use decisions of the farmers whereas transaction costs in output markets may influence the supply response as well as the input demands. It is therefore necessary to study the relative importance of transaction costs in the use of inputs especially certified maize seeds.

Several studies in supply response show that transaction costs in output markets influence crop choice and marketed supply response (Goetz, 1992). Winter-Nelson (2004), in a study of coffee farmers in Tanzania, observed that transaction costs in input markets imposed constraints on intensification of input application. He also observed that coffee farmers faced higher transaction costs in input markets as compared to output markets since product buyers are present in the villages while input distributors were concentrated in major towns implying different travel costs for inputs and outputs.

Renkow 2004, in a study on infrastructure, transaction costs and market participation in Kenya for maize farmers observed that infrastructure investments can enhance return to household resources by lowering transaction costs of market exchange; they can boost net return to agricultural production, lead to greater availability (at lower cost) of necessary agricultural inputs such as fertilizers and chemicals, and thus improve welfare by increasing agricultural productivity. However, this study only addressed transaction costs in the output markets and not in input supply chains or how the transaction costs affect adoption of technology.

Modeling Transaction Costs

Because transacting is not free transaction costs refer to costs other that money price that are incurred in trading or exchange of a good or a service (Kherallah and Kirsten 2001). Before a transaction takes place a farmer will need to identify the stockist/agro-vet from where to purchase assured quality certified seed. This involves opportunity costs in terms of time energy and money. As such the certified seed purchase transactions entail 1) searching and information collection costs, 2) bargaining and negotiation costs and 3) monitoring and enforcement of agreements costs. This study therefore is an attempt to quantify transaction costs incurred in certified maize seed acquisition and examine their relative importance on farmers' decisions to adopt certified maize seed technology.

To arrive at the total transaction cost to the farmer, data on transaction costs (costs in terms of time and effort it requires to find out which of the various seed products farmers prefer) was collected, value of time spent for maize field days and demonstrations activities--, the cost of traveling from farmer's house to the seed agro-dealers and back, the time spent waiting in line, and the effort of the paying itself; (the costs above and beyond the cost of the seed are the transaction costs). To get the time monetary equivalent of time spent in the procurement of certified seed, the time spent in the above activities was then multiplied with the mean daily wage rate for the sub-location.

CHAPTER 3

METHODOLOGY

This chapter gives an overview of the study area, the research methodology applied and the data collection methods. The chapter then concludes with the data sampling procedure.

Conceptual Framework

To analyze the determinants of use of certified seed and the relative importance of transaction costs, a static model of an agricultural household is applied. Here the decisions of a farmer in a given period are assumed to be derived from maximization of expected utility or expected profit subject to land availability, credit and other constraints (Feder et al., 1985, Winter-Nelson and Temu 2005). Utility is a function of net revenue and the household objective is to;

$$MAX(U) = U(PQ - C_i I_i)$$

Subject to $.g(Q, I_i; Z) = 0, production\ function$

Where P is the output price, Q the volume of output, I_i and C_i represent the quantity and unit cost of input i and Z is a vector of household characteristics.

Profit is a function of the farmer's choices of crops and technology in each time period. It therefore depends on his discrete selection of a technology from a technology mix. In this study the farmer is assumed to maximize his utility from the maize enterprise by choosing between traditional technology (local and recycled seed) and modern technology (certified maize seed). Since the utility is unobservable, the observed choice between the two choices of technology reveals which one provides the greater utility.

Hence the farmer's choice of either variety is modeled based on a binary random variable.

Theoretical Framework

Many approaches to modeling adoption on seed demand and seed adoption use static analysis that relates the degree of adoption to the factors affecting it (Feder et.al, 1985). These studies assume separability between household production and consumption decisions. One approach has been to characterize the problem as one that a farmer has to choose between two technologies: the traditional technology and a modern technology such as use of HYVs. This approach then investigates how much land is allocated to modern technologies relative to other traditional varieties.

The solution to the temporal optimization problem at the beginning of each period will determine the choice of technology that the farmer will use in the period, his allocation of land among crops and his use of variable inputs. Most adoption studies assume that the amount of land available to the farmer is fixed per given period and that he will maximize his expected utility subject to land availability. Credit and labour constraints may also affect farmers' choice.

Two measures have been used in studying adoption of improved technologies: 1) the number of farmers who adopt the innovation; and, 2) the total area in which the innovation is adopted. The two measures may yield similar outcomes but disparities in access to productive resources such as land may yield results where the proportion of farmers adopting may differ significantly from the proportion of the total cultivated area that is affected by the innovation (Morris et al., 1999). The proportion of households adopting an innovation measures the number of farmers who have adopted an innovation, whereas the proportion of the area that is under improved technology alludes to the potential aggregate economic benefits attributable to adoption.

Determinants of Adoption for Certified Maize Seed

To estimate the determinants of adoption of certified maize and the relative influence of transaction costs. A two stage Heckman selection model was specified, the first stage of Heckman involves a probit model used to estimate the determinants of certified maize seed adoption. The second stage of the model is a censored regression used to estimate the determinants of intensity of use. Probit models have been used to study use of inputs in developing countries such as improved seed, fertilizers, insecticides (Hattink, 1998, Kaliba et al., 2000) and influence of transaction costs on input use in coffee (Winter-Nelson et al.,, 2004). These models include the Linear Probability Model, the binary choice model and the binary logit model. The Linear Probability Model is the regression model applied to a binary dependent variable which has the general form as shown in equation 1:

$$\boldsymbol{Y_i} = \propto \ + \boldsymbol{\beta x_i} + \boldsymbol{\varepsilon_i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . \textbf{(1)}$$

Where x_i is a vector of values for the ith observation, β is a vector of parameters to be estimated, α is the intercept and $\mathcal{E}$ is the error term. The dependent variable $\boldsymbol{Y}$ is a discrete variable that represents a choice, or category, from a set of mutually exclusive choices or categories. $\boldsymbol{Y}$=1 when there is adoption of certified maize seed, and $\boldsymbol{Y}$ =0 when there is no adoption.

The functional form of the Linear Probability Model is linear which means that a unit increase in x_k results in a constant change of β_k in the probability of an event, holding all other variables constant. By making assumptions about the probability density of the residuals, the modeler can choose between several different binomial choice model formulations. Two types of binomial choice models are most common and found in practice: the logit and the probit models. The logit model assumes a logistic distribution of errors, and the probit model assumes a normal distributed errors. These models, however, are not practical for cases when there are more than two choices.

Choice models involve a response Y with various levels (a set of choices or classification), and a set of x_i's that reflect important attributes of the choice decision or classification. Usually the choice or classification of Y is a modeled as a linear function or combination of the x_i's. However since the dependent variable is unobserved, the model cannot be estimated with OLS. Instead, Maximum likelihood methods are employed to solve for the coefficients in choice models

The first stage of the Heckman selection model (probit) is specified as follows:

$$\boldsymbol{Prob(purchased\ seed\ use} = \mathbf{1}) = \mathbf{1} - \boldsymbol{F}(-\propto \boldsymbol{X}) + \boldsymbol{u}, \boldsymbol{u} \sim \boldsymbol{N}(\mathbf{0}, \mathbf{1}) \ldots\ldots (2)$$

Where purchased seed use takes the value of 1 if farmers used and 0 otherwise. X is a vector of explanatory variables; $\propto$ is a vector of coefficients to be estimated. The explanatory variables included in the model were drawn from previous studies and literature on adoption and transaction costs.

Intensity of use of certified maize seed

The certified seed use rate in the second equation is measured by the proportion of area under certified to total area under maize. The second equation estimating the use rate is specified as follows;

$$\boldsymbol{Certified\ seed\ use\ rate} = \boldsymbol{\beta_1 X_2} + \boldsymbol{B_2 \lambda} + \boldsymbol{\varepsilon}, \boldsymbol{\varepsilon} \sim \boldsymbol{N(0, \sigma^2)} \ldots\ldots\ldots\ldots\ldots (3)$$

Where $\boldsymbol{\lambda}$ represents inverse mills ratio calculated from equation (2) the inverse mills ratio is calculated to ensure that the error term has zero expectation. (Savadogo et al., 1995). The explanatory variables in equation (3) include factors affecting improved maize technology adoption, measures of output price, transaction costs[1], factors mitigating transaction costs and environmental factors affecting input responsiveness and farm and farmer characteristics influencing certified seed use.

Empirical Model

There is no firm economic theory that dictates the choices of independent variables in adoption studies. However, adoption literature suggests that farmers' decision to adopt an agricultural technology depends on the farmer's economic situation, characteristics of the technology, institutional and policy environment (Feleke and Zegeye 2006, Smale and T. Jayne 2003).

Table 2(a) presents the independent variables that were hypothesized to influence the decision of the farmer to adopt or not adopt certified maize seeds. These are the variables for the first stage (probit) model. Table 2(b) presents the independent variables

[1] computed using opportunity cost of time of searching for seed using average wage rate.

hypothesised to influence the intensity of use of certified seed. The hypothesize sign for the influence are also indicated and a justification for inclusion given in the ensuing discussion.

Table 2(a) Independent Variables in the Adoption Model (Probit)

Stage1 Variable label	Unit of measurement	Expected sign (-/+)
Transaction costs, seed information costs	Ksh	-
Transaction costs, seed search costs ***	Ksh	-
Transaction costs, production info costs	Ksh	-
Experience with certified seed years	years	+
Distance to motor-able road	kms	-
Distance to extension service	kms	-
Degree of commercialization**	%	+
Access to credit (1=Yes 0=No)**	(0,1)	+
Maize net deficit household (0,1)	(0,1)	+
Membership in farmer group (0,1)	(0,1)	+
Age of the head **	years	+
Gender of head(1=male 0=female)	(0,1)	+
Primary level education**	(0,1)	+
Secondary level education**	(0,1)	+
Tertiary level education**	(0,1)	+
Total cultivated acres**	acres	+
Wealth quintile2	(0,1)	+
Wealth quintile3	(0,1)	+
Wealth quintile4***	(0,1)	+
Wealth quintile5*	(0,1)	+

Table 3(b) Independent Variables in the Intensity of use Model

Proportion of maize area under certified seed	Unit	Expected sign
Experience with certified seed (years)	years	+
Distance to motor-able road (Km)	Km	-
Access to Credit (0,1)	(0,1)	+
Membership in farmer group (0,1)	(0,1)	+
Maize deficit household (1=Yes 0=No)	(0,1)	+
Age of the head (Years)	years	+
Gender of head(1=male 0=female)	(0,1)	+
Off-farm income (0,1)	(0,1)	+
Years of schooling	years	+
Degree of commercialization	%	+
Total Cultivated land (acres)	acres	+
Mills lambda	number	

The total transaction costs were split into three categories. Transaction costs, seed information costs are the costs that a farmer will incur in searching for information on different maize seed varieties so as to arrive at the appropriate variety for his/her area, such costs would be incurred in attending field days usually held before the planting season y seed and farming input sellers, visits to agricultural extension staff and from other sources from where the farmer would seek such information. Transaction costs for seed search costs— These are costs incurred when the farmer is looking for the desired seed varieties which includes travel time and effort to ensure that the farmer gets quality seeds, Transaction costs, production information costs this is the last category of transaction costs studied and in is the cost n time and resources expended by the farmer in search of additional information on proper maize crop husbandry, as the crop season progressed. The three categories of costs were captured on the table on section 2 of the appended questionnaire. The three categories of transaction cost were hypothesized to be a constraint to adoption and therefore exerted a negative influence.

Farmer experience with certified seed in years was included as it is expected that the longer a farmer is exposed to a technology, one is exposed to the benefits of superior technology and thus a rational farmer is more likely adopt improved technology which will maximize his objective function. The longer the duration of exposure the more the farmer acquires experience on better practices with the technology. Zinnah (1993) observed that farmers are more likely to adopt a technology if it can be demonstrated that the expected benefits outweigh the costs and superior to the existing methods.

Distance to motor-able road and distance to extension are included in the study to capture the infrastructure access for the farmers. Infrastructure plays an important role in access to input and grain markets as well as the flow of information on new technologies. It is hypothesized that the further from infrastructure reach the less likely a farmer is to adopt or increase intensity of use of certified seeds.

Membership to an organization may indicate was hypothesized to influence adoption of certified seed positively. Members in farmer organizations may have better access to information, have increased social capital and there is a possibility of collective action in the procurement of agricultural inputs.

The distance to extension advice is included to capture access to extension service. Distance in kilometers is used as the current policy on extension is demand-driven extension service. Under this policy farmers who need service are the ones to travel to centers to seek extension advice as opposed to the earlier approach where field extension workers were given resources to visit farmers on their farms. Access to extension advise should result in households making better farming decisions, including that of adopting improved seeds (Salasya et al., 2007).

Access to credit is a dummy variable and indicates access to credit for the purchase of maize production inputs. Households that have access to credit relax their financial constraints and purchase improved seed.

Other explanatory variables farmer attributes that may explain the decision to adopt certified seed include Age, gender, education level, degree of participation in maize grain markets buying and selling, and wealth status in terms of cultivated land and household assets of the farmer are included. Older household heads have more experience in farming and therefore more likely to make better farming decisions. However younger households are less risk averse. Female headed households are hypothesized to have limited access to productive resources and information as compared to male headed households. Four categories to capture different levels for education are included i.e. no education (base case); primary, secondary and tertiary levels.

Maize deficit households are expected to intensify the production of maize to meet their subsistence needs and therefore more likely to adopt improved technology. Households who are increasingly participating in markets to off load the surplus maize are expected to adopt improved technology due to expected positive supply response from increasing maize prices. Household wealth in terms of cultivated acres and asset wealth is expected to be positively related to adoption and intensity as the wealthier household is it has access to more productive resources and thus relaxing the input cost constraint.

Area of Study

Embu district is an administrative district in the eastern province of Kenya, and the provincial headquarter for the province. The district has the following four administrative divisions and their respective household populations as per the 1999 census: Central (52,446), Kyeni (48,385), Manyatta (71,332), Nembure (41,590) and Runyenjes (64,111). Nembure Division was selected purposefully as it falls in the moist transitional (MT) maize zone. This area is suitable for maize and contrasts well with eastern lowlands agro regional zones; which are the targeted zone for the wider CIMMYT project which seeks to disseminate nutritionally enhanced and stress tolerant maize varieties. Moist Transitional (MT) between mid altitudes and highlands. The zones have high yields of more than 2.5 tonnes per hectare producing 80% of maize in Kenya and accounting for 30 percent of the area under maize (De Groote et al., 2002).

Nembure division lies between 1,000 -1,500 m above sea level and covers an area of 88 km^2 of which 65 km^2 is arable. The estimated population from 1999 census was 41,590 and population density of 472 persons per km^2. The average annual rainfall ranges from 1,200 to 1,500 mm. Rainfall is bimodal and distributed in March/April (long rains) and October/November (short rains). Soils are fertile and well drained.

Sources of Data and Collection Methods

This study made use of primary cross-sectional farm household data on farmer characteristics, maize farming practices as well as environmental and institutional characteristics relating to the households. These data covered the main maize crop season for 2007/08 cropping year. To evaluate the institutional context that influenced the functioning of maize seed markets, this study used both quantitative information as well qualitative data.

To further enrich the quality of the final data, sequencing of the study was considered important. To gain from synergies between the qualitative and quantitative data processes, the study commenced with qualitative interviews with various stakeholders so as to gain familiarity with issues under study as well as to identify the issues that needed further quantitative data. A questionnaire was then drafted taking into consideration matters arising from the qualitative study that needed further detail at the household level. The instrument was shared with the supervisors and the comments received went a long way to improve the quality of the data collected. Enumerators with a background in agriculture (first degree) were recruited, then a pilot study was carried out and more corrections on the questionnaire done to arrive at the final instrument (see annex 1)

Checklists and in-depth interviews were used in collecting qualitative data from the actors along the seed input value chains. They included farmers (8), seed agents/distributors (3), agro-dealers (5), seed distributors, Ministry of Agriculture (MoA) extension officers (2) an officer from AGMARK and a marketing manager from Kenya Seeds Limited. Key issues that came up were then followed up on for the various groups of respondents. The data collected examined the factors that influence adoption of certified seed. Linkages with other players along the chain, the volume of seed handled, varieties sold and policy issues relating to seed trade.

This information was then used to establish how the actors and institutions interact and their influence on the resultant transaction costs. It also assisted in mapping of the seed supply chains in the study area.

Sampling Procedure

A sample of 150 farmers was selected to participate in the quantitative cross-section survey. The sample size was arrived at after considering the resources available and by following literature on the appropriate sample size. According to Zeller (2000) causal studies involving probit or logit regression models should have a minimum of 100 observations. Further, he observes that where rigorous testing of the questionnaire is done the standard deviation for the variables reduced as interviewer and respondent errors are reduced (Zeller 2000).

A multistage population-proportionate random sampling procedure was applied to select 150 farmers. The selection process comprised of the following steps: First the Nembure division was purposefully selected as it fell on the moist transitional maize zone (MT). Nembure division has three administrative units namely Gaturi south, Makingi and Kithimu locations. Makengi location falls on upper mid altitude zone more suitable for tea and coffee and therefore it was left out. (Gaturi south and Kithimu) were chosen since they fall within the target Agro-Ecological Zone (AEZ). The two selected locations had three sub-locations each as can be seen from the Table 3. All sub-locations lay in MT zone except Kithegi that was in a lower altitude and thus was left out of the selection. Census data from 1999 were used to arrive at the population of households for all non-urban sub-locations in remaining two locations.

Table 4 Sample distribution

Division	Location	Sub-location	Households (1999 census)	Proportion to Population	Villages	Sampled villages
Nembure	GATURI SOUTH	ENA EAST	642	0.12	1	15
		GATUNDURI	1,145	0.22	3	27
		NEMBURE	1,006	0.19	3	23
	Sub total		2,793		7	65
	KITHIMU	ENA WEST (RUKIRA)	406	0.08	1	14
		KITHIMU	2,014	0.39	6	71
		KITHEGI	0	0	0	0
	Sub total		2420		7	85
Total			5,213	1.00	14	150

Source, Census 1999, Author

The village formed the final sampling unit. The criterion to determine the number of villages that would participate was in consideration of the following; (i) Reduction of heterogeneity within the sampling unit (ii) take into account of any variation between villages as well as to (iii) ease data collection; for this to be achieved, It was decided that each unit should have a minimum of 10 and a maximum of 15 households.

Fourteen Villages were selected as shown in Table 3. The number of villages per sub-location was proportionate to the weight of households for the sub-location to the total population of households in the study area according to 1999 household census. Villages were then random sampling from the names of villages according to the number of villages per sub-location.

The sampling frame was obtained from the Kenya National Bureau of Statistics (KNBS) pre-census village household lists for Nembure division the lists were collated in December 2007 by KNBS with the help of village elders and provincial administration.

Households were then sampled using systematic random sampling. The selected households were then notified of the impending survey with the assistance of the village elders.

Data Analysis

Data organization was carried out in SPSS program while the estimation procedures were carried out in STATA. Data cleaning and correction were carried out to check for correctness, consistency of the data and was done to check and eliminate errors that may have occurred in data collection and entry stages. This was done thorough data exploration procedures for extremes and outliers and use of scatter graphs. This was to ensure that the standard deviation was reduced so as to increase precision of estimates.

Limitations of the Study

Estimation of transaction costs is fairly new in applied economics and therefore there are no agreed means of quantification as many studies use proxy indicators. Opportunity cost of Farmers time and resources which have been used to approximate transaction costs is also prone to be under/over estimated. The precision problems arise from the difficulty apportioning time to different activities where the farmer in instances where when procuring certified seed the farmer had more than one activity. However, such errors are assumed to randomly distribute around the true mean.

Many economic variables are usually not fully independent of each other; rather they show a degree of dependence e.g. there is a correlation between the demand of a product and its price. Correlation refers to the departure of two or more random variables from independence. The Pearson correlation coefficient for the variables included in the two stages was computed and is given in appendix 2. Several variables exhibit significant correlation such as distance to extension and distance to tarmac road (.3) significant at 1 percent level of significance; Age and experience are correlated (.53) at 1 percent level of significance. However the degree of the correlation though significant in some cases is none the less strong in as none of the coefficients have a correlation of above 7 percent.

Another concern is that there is a very high level of specialization exhibited where adopting farmers have a mean area under certified seed of 93% percent. This means the second stage of the study only adds 7 percent incremental explanatory power to the study.

The study is based on recall data which has been known to have problems in precision where farmers may not recall with high degree of precision. The sample of 150 which was arrived at given to consideration on the resources available and economic theory on central measures of tendency is on the lower limit. However care was taken to screen that data for errors during collection and entry as well check for consistency in the data in order to increase precision of estimates.

CHAPTER 4

RESULTS AND DISCUSSION

The following section presents the findings and discussions on the results that emerged from the study. The section starts with descriptive statistics of the socio-economic characteristics of the surveyed households then a description of the structure of seed input value chain. The regression estimation results of the factors that affect the use of certified maize seeds and the degree of adoption from the two stage Heckman selection model are then presented followed by a discussion on the results.

General Characterization of the Respondents

The following are the household characteristics of farmers in the study area the results relate to data collected on the main season for the 2007/08 cropping year. These households were predominantly small-scale farmers with 82 percent of the respondents cultivating maize on an area less than 1.8 acres on average. The results show that more than half of the farmers (55.3%) used recycled and local varieties whereas the remaining 44.7% used certified maize seed.

The average household size in Embu was 5 members per household. The average age of the household head was high at 52.7 years (Table 4) indicating aging farming population which is a reflection of out-migration of young people from the agricultural sector. Experience with use of improved varieties showed that farmers had on average 12.5 years since they first used certified seed. This shows that farmers have been exposed to improved varieties for a long time. However, 33% of the respondents reported that they have ever had experienced the problem of adulterated certified seed.

Fertilizer adoption was high in the area with 93 percent of the households used in-organic fertilizer on maize (Table 5) in the 2007/08 cropping year. The mean application rate per acre was 31.7 kilograms per acre (Table 4). The mean yield per acre for the sampled farmers was 390.46 kg which translates to 4.3 bags per acre. This yield is nonetheless lower as compared to the average yields obtained in high potential areas of 10 bags per acre (Ariga et al., 2008). This indicates that there exists potential to improve aggregate yields if a greater number of farmers adopt improved maize seed and fertilizer technologies or more area is allocated to improved technologies.

Table 5 Descriptive Statistics for Explanatory Variables Used the Model

Variable	Observations	Mean	Std. Dev.	Min	Max
Total land holding (acres)	150	1.79	1.31	0	7.0
Acreage under crops	150	0.82	1.03	0.05	11.0
Certified seed(0,1)	150	0.47	0.50	0	1.0
Proportion of maize acres under certified seed)	150	0.44	0.48	0	1.0
Age of the head (Years)	150	52.73	16.26	20	92.0
Experience with certified seed (years)	150	12.55	12.81	0	58.0
Experience with adulterated seed(0,1)	150	0.33	0.47	0	1.0
Mean fertilizer per acre(Kg)	147	31.72	23.97	0	114.3
Yield per acre (kg/acre)	150	390.46	484.02	3.375	3207.3
Value of harvest per acre (Ksh)	150	4753.23	4523.30	178.125	27624.5
Membership in farmer group (0,1)	150	0.45	0.50	0	1.0
Household size	150	4.98	2.23	1	12.0
Gender of head(1=male 0=female)	150	0.74	0.44	0	1.0
Years of schooling for the head	150	6.45	4.86	0	23.0
Degree of commercialization	150	0.24	0.33	0	1.0
Off-farm income(0,1)	150	0.87	0.33	0	1.0
Maize deficit household (1=Yes 0=No)	150	0.44	0.50	0	1.0
Household Asset Wealth(Ksh)	150	179475.10	229208.80	10500	1809700.0
Total transaction costs	150	82.62	92.74	0	418.8
Transaction costs more information on growing	150	26.52	54.15	0	277.5
Transaction costs attributed to information on seed	150	34.36	49.71	0	228.8
Transaction costs incurred in seed search	150	21.75	32.86	0	168.8
Distance to motor-able road (Km)	150	0.41	0.41	0.001	2.0
Distance in Km from hh to nearest seller of hybrid maize seed	150	1.37	1.76	0.1	21.0
Distance to seed source	150	1.50	3.15	0	15.0
Access to credit (0,1)	150	0.23	0.42	0	1.0
Distance to extension service	149	4.15	3.29	0.2	13.0

Source, survey results

The mean household asset wealth for the surveyed households was 179,475 Ksh. However, it was skewed to the right showing a high level of in equality when compared to the median income 96,150 Ksh which is about half the mean asset value. Most of the households had at least one member engaged in off-farm income activities this indicates that there exists opportunities for households to get additional income opportunities in the area besides farming.

The mean years of schooling in the area is 6.4 years which is primary level this is a good indicator of human capital. This is a high literacy level indicating that the farmers have the capacity to grasp information on improved maize technologies. Up to 70 percent of the households are male headed,

Infrastructure plays an important role in access to input and grain markets and the flow of information on new technologies. Results indicate that the mean actual distance travelled to obtain seed (1.5 Km) is higher than the mean distance to the nearest agro-dealer (1.4 Km). This shows that besides just seed, to be assured of quality of seed bought farmers are farmers are willing to travel further to more established and reputable stockists. These established agro-dealer located in major centers as opposed to the seed agro-dealers nearest to the farmer. The mean distance to an extension service is 4.1 Km and there is a wide variation in this indicator as it ranges from 0.2 to 13 Km. This is an important indicator of access to extension information. Forty five percent of the farmers were involved in farmer groups and associations

Of the three categories of transaction costs under study the farmers incur the highest average amounts in obtaining information about different seed varieties, followed by costs related to search for information on good husbandry practices after planting. The lowest transaction cost category was on certified seed search costs.

Table 5 presents the results disaggregated by use (0, 1) of certified seed for the sampled households. The statistics are for adopters (farmers growing certified seeds), non adopters (farmers using recycled and indigenous maize seed varieties) the overall means and significance level for a test for differences in the means.

The mean age of the household head was 52 years overall, however those using certified seed were on average younger at 50 years as compared to 55 years for non adopters. The mean ages are statistically different at 10 percent level of significance. This indicates that as the household head becomes older they are less likely to be using certified seeds.

Adopters of certified seed had on average more years of schooling as compared to non adopters (8 years and 5 years respectively), this indicates that education is important in the diffusion of agricultural technologies underscoring why it is important to package information on new technologies in an easy and comprehensible way for farmers whose average level of education about 6 years of schooling (primary level).

Table 6 Disaggregated Descriptive Statistics by Certified Seed Usage

		Means		T -test
Characteristic	Non adopters	Adopters	Total	significance
Transaction Costs(KES)				
Total transaction costs	63.65	106.12	82.62	***
Transaction costs incurred in seed search	12.92	32.68	21.75	***
Transaction costs more information on growing	22.60	31.37	26.52	
Transaction costs for information on seed	28.13	42.07	34.36	
Household Characteristics				
Age of the household head	54.72	50.25	52.73	
Years of schooling for the head	5.00	8.24	6.45	***
Total value of assets	138160.50	230656.00	179475.10	***
Number of Household members	4.70	5.33	4.98	
Value of crop per acre	3652.60	6116.70	4753.23	***
Technology Adoption on Maize				
Proportion area under certified maize seed (%)	0.00	0.93	0.44	***
Fertilizer adoption (%)	90%	97%	93%	
Fertilizer dosage(intensity-Kg/acre)	26.7	38.0	31.7	***
Yield per acre	330.46	464.79	390.46	
Experience with adulterated seed	0.27	0.40	0.33	
Access to credit for seed	0.18	0.30	0.23	
Farming Practices				
Total household land holding(Acre)	1.62	2.00	1.79	
Total cultivated maize acreage	1.16	1.01	1.09	
Distance extension advice(Km)	4.82	3.33	4.15	***
Total number extension contacts in the last year	0.57	0.96	0.75	
Degree of commercialization	0.19	0.30	0.24	**
Gender of household member (1- male)	0.64	0.87	0.74	***
Infrastructural Characteristics(Km)				
Distance to point of seed purchase	0.63	3.14	1.81	***
Distance to the nearest certified seed seller	1.38	1.36	1.37	
Distance to where the household bought fertilizer	2.32	2.64	2.47	
Distance to nearest fertilizer seller	1.27	1.18	1.23	
Distance to produce market	1.68	1.59	1.64	
Distance to motor-able road	0.51	0.30	0.41	***
Distance in km to tarmac road	3.76	2.26	3.05	***

*Significance level *** 1 percent , ** 5 percent

Source; survey of 150 farmers in Embu District

The mean total land holding in Embu was 1.8 acres with those using certified seed having access to more land (2 acres) as compared to 1.6 acres for non adopters. Whereas those using certified seed had access to more land as compared to non adopters, results show that they had allocated less area on average (1 acre) to maize as compared to non adopters (1.2 acres). This indicates that use of certified maize seed allows farmers to diversify into other crops besides maize as they have a larger proportion of total land holding left to allocate to other crops and livestock enterprises. Amongst those who were using certified seed, the certified seed occupied on average 93 percent of the total area under maize. This shows a very high degree of specialisation into either certified seed or non certified seeds.

Fertilizer use is complementary to the use of improved germplasm in boosting maize yields. Results show high levels of adoption in the study area at 93 percent for both adopters and non adopters. However, fertilizer dosage rate –the amount of fertilizer applied to fields receiving fertilizer-- is significantly higher for certified seeds adopters (38 Kg/acre) as compared to non adopters (26.7 Kg/acre). Other factors that influence the use of fertilisers include the distance to the fertilizer source, price and production risks associated with the agro regional zone those planting certified seed were on average closer to the fertilizer selling points.

Farmers who adopted certified maize travelled shorter distances (3.3 Km) to seek extension advice as compared to non adopting households whose mean distance was 4.8 km this means they have to travel 31.3 percent further than adopters. Adopters of certified seeds had 33 percent more contacts with extension personnel as compared to non adopters (0.9 and 0.6 respectively). This underscores the important role played by the extension service in technology diffusion.

As observed earlier that farmers are more likely to adopt a technology if it can be demonstrated that the expected benefits outweigh the costs and superior to the existing methods (Adesina and Zinnah 1993). Farmers using certified seeds obtained 56 percent higher yields as compared to non adopters (465 Kg/acre for adopters and 331 Kg/acre for non adopters). The mean yields per acre are statistically different at 10 percent level of significance. These yields of 4.5 bags per acre are however lower than national average of 10 to 12 bags indicating there is potential for improvement. The same trend is exhibited by the values of maize crop [2]per acre where those using certified seeds have a mean of Ksh 6,118 per acre as compared to Ksh 3,652 per acre which is 68 percent more.

Adopting farmers had a higher aggregate value of assets as compared to non adopters (significantly different at 5 percent level). They sold about on average 30 percent of the maize crop harvest as compared to 20 percent sold by non adopters. This indicates that improved seed technology can be used as an avenue for growing rural incomes as well as contribute to goals of rural poverty alleviation.

The distance to the point of purchase was further for adopters as compared to non-adopters. Results showed an interesting phenomenon where adopters were buying certified maize seeds and fertilizer from distant sources as opposed to buying from agro-dealers closest to them (Table 5). Other infrastructure indicators such as distance to produce markets, distance to a motor-able road and distance to tarmac road were all in favour of adopters of certified seeds as compared to non-adopters who had to travel longer distances to access these infrastructure. Infrastructure has a bearing on the resulting transaction costs of adopting certified seeds and complementary inputs since as the distance to the services increases, there is a higher incidence of transaction costs which may constrain adoption of new technologies.

[2] Valued at mean reported price at the sub-location administrative level

An analysis on the transaction costs shows that farmers who used certified seed incurred more transaction costs. This can be explained by the fact that as opposed to those farmers using local seed and recycled hybrids, adoption farmers have to travel longer distances and therefore more time. Secondly due to concern for quality of seed, farmers are willing to travel longer distances to established certified seed sources instead of buying from the periphery. A pair wise test of differences in the means for total transaction costs and transaction costs incurred in seed search showed that means were statistically different at 1 percent level of significance. For the other two subcategories of transaction costs related to information on seeds, the means are not significantly different.

Structure of Seed Value Chain and Description of the Actors

The following are the elements that form the maize seed value chain in the study area gathered from the qualitative study of actors and institutions involved in the certified seed value chain in Embu. The actors included the ministry of agriculture (MoA), Seed companies local and international, seed agents/Distributors, agro-dealers, farmers and nongovernmental organization promoting input use among farmers.

The Seed varieties found in the area were majorly from Kenya Seed Company (KSC), Pioneer seed, Seed-co Monsanto, and KARI. The multinational seed companies import the seed sold into the country. The others varieties were retained and local varieties mainly from retained seed or bought from open air market and from friends and relatives.

The Kenya Seed Company is a national quasi-government seed company that obtains germplasm from National agricultural research centers as well as from international nongovernmental seed breeders such as CIMMYT. They then multiply the seed and have a well established distribution system. The certified seeds available are mainly hybrids early maturing hybrids for lower regions and late maturing hybrids for the moist transitional areas and highlands. Open pollinated varieties were also available the most popular being Katumani variety.

Seed agents are found in major district centers where they are recruited on capacity and the desired number within the area. The distributors interviewed acted for more than one Seed company. The seed for distribution is procured in both cash and credit terms. They then sell the seed to smaller agro-dealers in rural areas that mostly travel to the district centre to get the certified seed. The transactions are mainly in cash with a few exceptions where they extend credit facilities to trusted agro-dealers. Some of the seed agents interviewed at the district level had access to Credit facilities provided by seed companies and financial institutions. The credit facility enabled the seed agents to access seed on credit from the seed companies or whereas the banks give the agents business loans. The distributors sell to both wholesale and retail customers sell in retail to farmers who chose to travel to the district centers albeit at recommended retail prices. Varieties from KSC were reported as the most popular with farmers.

AGMARK is an NGO funded by Rockefeller foundation for the program called Agricultural Input Acceleration Program. The program agro-dealers are educated about farm input use, bookkeeping, liking to financial institutions etc. this is meant to build capacity as well as enable them to pass the information to farmers as they by the products.

The Ministry of Agriculture in collaboration with AGMARK and other non-governmental organizations, and seed companies working in the area played an important role in farmer field days. The Ministry organized the field days; the seed companies provided the samples for demonstration (e.g. different maize seed varieties and some farmers volunteered their land for demonstration). AGMARK assisted in the facilitation of farmer and inviting their trained agro-dealers in the area to the meetings. Individual farmers as well as those organized in groups attended these meetings where they were exposed to different varieties as well as information on crop husbandry.

During the 2007 2008 cropping season, the government had an input subsidy program called the National Accelerated Input Access Program (NAAIAP). Under this program 500 farming households from the division were to benefit from free certified seed and other inputs for one acre. The program was to benefit resource poor households in the area. The provincial administration through use of village elders identified the poor from the community to benefit from the program. The program made use of input vouchers where beneficiaries were exchange them for seeds from selected agro-dealers. The program achieved relative success in increasing the usage of certified seed though it was dogged by the following concerns.

The beneficiary identification process was not transparent as there were publicized criteria and eventually there was leakage as even thee non poor received the subsidy. The criterion for selection of the participating agro-dealers was arbitrary and limited to only two agro-dealers whole division creating oligopoly market structure. This in turn increased transaction costs to farmers as they had to travel further use more time to obtain the subsidized inputs. Besides that it skewed the market power for the agro-dealer such that instead of adding to the gains of increased reach of agro-dealers in the periphery, only agro-dealers in established centers were selected.

There were delays in the payments to agro-dealers due to the bureaucracy of voucher verification which took long affecting the capacity of the agro-dealers, this in turn caused lateness in planting. The sustainability of the program cannot be guaranteed as the subsidy was at zero cost to the farmer thus running the risk of donor dependency.

Besides the above mentioned problems with the subsidy program here are more issues that arose from the qualitative study on the certified seed value chain. The value chain is presented on figure 3.

The selection of the seed agents and distributor at the district level was a major point of concern. Those left out of a particular channel seed brand cited that the process was not transparent especially the selection KSC seed agents whose varieties are most desired. There were only two distributors in Embu selected from a possible 5 distributors who had the capacity to act as distributors. This created uncompetitive market structure which in turn lengthened the seed value chain. The distributors out of KSC had to procure seed from those with KSC franchise this horizontal transaction for actors at the same level is otherwise unnecessary had the selection of distributors for these major varieties been open to all those who had the requisite capacity for a distributor/seed agent. The horizontal link potentially introduces more transaction costs, reduces competition, as well as profit margin for the distributor and above all leading to concentration of market power.

Figure 3 Certified Maize Seed Value Chain

Environmental and Institutional factors	**Government** • Legislation, Regulation • MoA -Government extension services, input subsidy programs) • KEPHIS –seed certification, regulation of the seed industry) • Infrastructure • Biophysical environment	**Private sector** • National/International seed companies • Seed agents/distributors at the district centers • Agro-dealers in the periphery • Seed Traders Association of Kenya(STAK) lobby group for seed companies	**Research institutions** • International governmental research institutions(CIMMYT) • National agricultural research stations(KARI) • Breeding and germplasm development	**Other institutions** • NGO's AGMARK, Catholic diocese • Agricultural extension and promotion activities • Formation of farmer groups • Demonstrations and seed fairs
Certified Seed Value Chain	Seed Companies →	Seed Agents/Distributors →	Stockists/Small-Agrodealers →	Farmers
Factor Influencing Transaction Costs	• Lengthy certification process procedure	• Barriers to entry into franchise agreements • Recruitment process not transparent • Un-necessary agent to agent transaction	• Insufficient marketing margins (pan territorial priced varieties) • Lack of credit facilities • Limited cash flow to handle seasonal demand for seed • Unsold stocks • Delays in payments by government subsidy	• Seed Adulteration • Cost of seed /expensive relative to cost of grain • Information on correct varieties • Seed viability • Seed availability • Trust for agro-dealers

Concerns over quality of certified seed led to creation of trust relationships between agro-dealers and farmers. This was demonstrated in the behavior of farmers where many opted to purchase seed from particular agro-dealers with whom they had an established trust relationships. Farmers also trusted agro-dealers in major trading centers as opposed to those at the periphery. This leads thus makes farmers travel greater distances and thus aggravating the magnitude of transaction costs incurred in certified seed procurement.

Major seed companies have adopted a pan-territorial pricing policy across the country. These prices are advertised in popular media during the planting season as the official prices and any agro-dealer selling at higher prices is deemed unscrupulous. The pan-territorial pricing creates a market failure where the costs of doing business exceed the margins set for these varieties and therefore agro-dealers in the peripheral areas have no incentive to stock certified seeds. Raising prices above advertised prices would cause mistrust by farmers, this made the agro dealers in the periphery keep minimal stocks as they are not optimistic that many farmers will be willing to shoulder the extra cost. The farmers in the periphery have to travel longer distances therefore aggravating the magnitude of transaction costs.

Lack of a policy for remaining stocks at the end of a planting season was a major concern for agro dealers. The shelf life of seed affects seed viability, losses incurred from money sunk in unsold stocks and appropriate stocking levels. Therefore the agro-dealers were compelled to stock only seed volumes that they were sure to sell by the end of the season. This increased the probability of running out seed stocks if demand increases or loss of viability for the remaining seed when demand is low. When the viability of seed is reduced it leads to erosion of trust for the agro-dealers, and the certified seed varieties and ultimately affecting adoption in certified seed. To have assurance against loss of viability farmers will tend to travel to major agro-dealers again aggravating the magnitude of transaction costs.

Determinants of certified maize seed adoption

This section presents the estimation results from the first stage of Heckman selection model (probit). The dependent variable is whether the household has adopted certified maize seed represented by 1 and 0 otherwise. The Marginal effects reported in percentage form represent the change in probability of adoption with regards to a unit change in the independent continuous (exogenous) variables (dF/dx). In case of dummies (i.e. 0 and 1) the marginal effects is the difference in probability because of belonging to a group rather than the other (difference between the benchmark compared to the other variable).

The results in Table 6 indicate that the following factors significantly affect the adoption of certified maize seeds in Moist Transitional Zones of Embu. They include; Transaction costs, seed search costs, Experience in years of using certified maize seed, Distance to motor-able road, Access to credit, Age of the head, education level of the head, Degree of market participation, size of cultivated acreage and fourth wealth. Overall goodness of fit for the regression as measured by adjusted R squared was 0.4145. This indicates that the variations in the independent variables explain 41 percent of the farmer's choice to adopt or not to adopt certified maize seeds. The R squared was significant at 1 percent.

Table 7 Determinants of Certified Maize Seed Adoption

	Marginal effects dF/dx (%)	Std. error	P>z	Coefficient
Transaction Costs				
Transaction costs, seed information costs	0%	0.001	0.89	0.000
Transaction costs, seed search costs ***	1%	0.002	0.00	0.019
Transaction costs, production info costs	0%	0.001	0.82	-0.001
Household attributes				
Experience with certified seed (years)***	2%	0.006	0.00	0.048
Age of the head (Years)**	-1%	0.005	0.05	-0.026
Gender of head(1=male 0=female)	-1%	0.147	0.95	-0.023
Primary level education**	40%	0.148	0.01	1.056
Secondary level education**	44%	0.152	0.02	1.233
Tertiary level education**	47%	0.132	0.04	1.488
Maize net deficit household (0,1)	11%	0.114	0.36	0.266
Degree of commercialization**	39%	0.200	0.05	0.987
Total cultivated acres**	-9%	0.043	0.04	-0.223
Wealth quintile2	-5%	0.148	0.73	-0.129
Wealth quintile3	-5%	0.169	0.75	-0.137
Wealth quintile4***	48%	0.132	0.01	1.388
Wealth quintile5	31%	0.1476	0.06	0.806
Institutional factors				
Access to credit (1=Yes 0=No)**	45%	0.111	0.02	1.440
Membership in farmer group (0,1)	15%	0.107	0.17	0.377
Infrastructure				
Distance to motor-able road (Kms)***	-64%	0.180	0.00	-1.617
Distance to extension service	1%	0.019	0.45	0.036
Constant		0.863	0.32	-0.863

*Significance level *** 1 % , ** 5 %

Pseudo R2 = 0.4145

Prob > chi2 = 0.0000

Source survey results

From the data collected from the three categories of transaction cost, only transaction costs relating to seed search costs were significant in the decision to adopt certified seed. This relationship is positive and it is estimated that a unit increase in the transaction costs for seed search costs increases will result in an increased probability of adoption of certified by 1 percent. Given the method used to arrive at the transaction costs it can be this positive and significant relationship between probability of adoption and seed search transaction costs means that adopters of transaction costs are willing to sacrifice time and resources to ensure that they get improved certified seed as well as be assured of seed quality. The positive sign as seen earlier can be attributed to the fact adopters spent more time to procure seed and thus had consistently higher transaction costs as compared to non adopters.

This study did not find sufficient evidence to conclude that transaction costs relating to information on seed varieties and production information are a constraint to adoption of certified seed. This is notwithstanding that the mean costs for these two categories are higher than transaction costs for seed search which were found to significantly influence the decision to adopt certified seed.

As expected there is a positive and significant relationship between years of experience from using certified seed and adoption of certified seed. A unit increase in years of experience will result in a 2 percent increase in the probability of adoption of certified seed this relationship was significant at 1 percent level of significance. This implies that to increase the impact from technology diffusion interventions, the length of exposure is important in promoting technology adoption.

There is a negative and significant relationship between adoption and the age of the household head. A year increase in the age of the head results in a 3 percent less likelihood in adoption of certified maize seed. It is therefore important to look into those challenges faced by households that are headed by older farmers. These challenges may include complexity in new agricultural technologies, risk aversion and cultural beliefs associated with new technology, addressing such issues will lead to greater technology diffusion.

Another household attribute that positively and significantly affect adoption of certified seed according to this study was the degree of commercialization measured by the ratio of maize sale volume to total maize harvest, a unit increase in each of the above factors raised the probability of adoption of certified seed by 55 percent, 0.01 percent respectively.

Household asset wealth is positively related to use of certified maize seed. The bottom three wealth quintiles exhibit a negative relationship to the probability of using certified seeds. It is only the top two wealth quintiles that are positively related with use of certified seed. The fourth wealth quintile is positive and significant at 5 percent level. The highest quintile is positive but not significant.

Education is another important variable in the adoption of certified seeds. As compared to no education, Primary education increases the probability of adoption by 40 percent, secondary level education by 44% and Tertiary education by 47%. The three levels of education are all significant at 5 percent level of significance. This vindicates the importance given by the government to universal free primary education for all. The incremental potential benefit to adoption from secondary and tertiary education is a meagre cumulative 7% as compared to benefit from primary education which is 40 percent. Therefore investing in universal primary education gives the most return to investment as far as certified maize seed adoption is concerned.

Other household characteristics which were significant include Access to credit, household wealth, degree of commercialization and total cultivated acres. Access to credit to purchase input increases the probability of adoption by 45 percent, when a household is selling more to the probability increases by 39 percent. Middle incomes households (3rd wealth quintile) have are 48 percent more likely to adopt certified seed as compared to those in the lowest wealth quintile. One peculiar relationship was that of total cultivated acreage and the probability of adoption. It is inversely related where an increase by one acre of cultivated land results in a decrease by 9 percent in the probability to adopt certified maize seed. This may be indicative of resource constraint where as famers expand the area under cultivation the resources are spread more thinner thereby constraining adoption of certified maize which is capital intensive. This therefore calls for further study on this phenomenon.

Infrastructure plays a complementary role in enhancing technology diffusion through improved access to input and output markets. From the survey an increase in distance to a motorable[3] road by a kilometer diminishes the probability of adoption by 64 percent. This relationship is, statistically significant at 1 percent level (Table 6). The distance to extension service was found not significant to maize seed adoption.

Determinants of Intensity of Use for Certified Maize Seed

Table 7 presents the specification results of the use intensity model. The dependent variable in this regression is the proportion of maize area under certified maize seed. The three categories of transaction costs are also excluded as they are considered to be fixed costs as they do not vary with increase in intensity.

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[3] A motorable road referred to an all weather road usable all year

The mills lambda is positive and significant indicating that the unobserved variables in selection model are correlated with the unobservable variables the stage two of the Heckman and therefore there we would have had biased estimates without correction. Mill lambda is significant indicating that there was a statistically significant effect of selection. The rho is positive indicating that unobservable are positively correlated with each other.

Table 8 Determinants of Intensity of Use of Certified Maize Seed

Proportion of maize area under certified seed	Coefficient.	Std.	P>z
Experience with certified seed (years)**	1%	0.00	0.06
Distance to motor-able road (Km)	-1%	0.01	0.63
Access to Credit (0,1)	14%	0.14	0.32
Membership in farmer group (0,1)	5%	0.06	0.47
Maize deficit household (1=Yes 0=No)***	22%	0.07	0.00
Age of the head (Years)	0%	0.00	0.63
Gender of head(1=male 0=female)**	20%	0.09	0.02
Off-farm income (0,1)**	18%	0.09	0.04
Years of schooling	1%	0.01	0.10
Degree of commercialization***	27%	0.11	0.01
Total Cultivated land (acres)	3%	0.05	0.51
Mills lambda***	20%	0.08	0.01
Rho	0.79763		
Sigma	0.253879		
Lambda	0.202502	0.079985	
*Significant Level *** 1 % , ** 5 %			

Source: survey 150 farmers in Embu District

The following variables were found to significantly influence the intensity of certified seed adoption; Experience with certified seed, being a Maize deficit household, Gender of the head, presence of off farm income and the degree of commercialization.

Like in the first adoption estimation, an additional year of experience will increase the proportion of the area under certified maize seed by 1 percent. This underscore the role played by continued exposure of farmers to technology and therefore time of interventions geared toward technology diffusion should be considered in design of programs design to provide for adequate learning by beneficiaries.

Maize deficit households who adopt certified seed are likely to allocate a larger proportion of maize area to certified seed. A maize deficit household is likely to raise the area under certified seed by 22 percent as compared to a non deficit household. This has implication for households in Kenya and the country as a whole where many maize farming household have a net deficit in maize production. Aggressive promotion of appropriate certified in maize deficits areas yields a 22 percent propensity for area expansion.

Results from the study indicate that female headed households are more likely to have 20 percent more area under certified maize as compared their male counterparts. This has significant implications to intervention program design especially those geared towards poverty alleviation. Studies show that the incidence of poverty is disproportionately higher among female headed households. Therefore, given the higher returns from certified maize seed, this seed can be used as a tool to lift female headed households out of poverty.

Degree of commercialization was positively related to higher proportion under certified maize seed. An additional bag of maize sold will increase the proportion of area under maize by 27 percent. Therefore it is important to address the access to grain markets as the volume sold has a positive supply response. Off farm income also increases the likelihood of increasing the proportion of area under certified seed.

CHAPTER 5

CONCLUSIONS

This study assessed the factors that affect the use and intensity of certified maize seed and the relative importance of transaction cost. The study analyzed cross-sectional household data pertaining to the 2007/08 cropping year for 150 farmers in Nembure division of Embu district. This data was augmented with qualitative information from actors along the certified maize seed value chain. A Heckman selection model was used in the estimation of parameters.

Factors affecting adoption have been widely studied especially farmer, farm and environmental aspects that constrain adoption. This study sought to contribute to the knowledge on seed diffusion by expanding the study to aspects of maize seed value chains especially transaction costs of market exchange and influence of institutions along the chain. In spite of the highlighted limitation in this study, the empirical analysis of the determinants of adoption and intensity of use yielded broadly satisfactory results in terms of theory and statistical fit. The empirical results of the specification as well as qualitative survey were plausible and are summarized below.

Summary of Results

This study has shown that as farmers adopt certified seeds, they incur higher transaction costs than non adopters. Out of the three categories of transaction cost studied, only transaction costs related to search of certified seed significantly influence the decision to adopt certified seed. This study did not find sufficient evidence to conclude that transaction costs relating to information on seed varieties and production information are a constraint to adoption of certified seed.

This study found uncompetitive market structure at the seed agent level of marketing where the rules for one to qualify to be an agent were not transparent thus introducing additional transactions between agents at the same level.

The pan-territorial pricing of seed in the country does not take into consideration agro-dealers who are in more remote areas where the marketing margins are not sufficient to cover costs. This means that farmers have to travel longer to procure certified seed where the profit margin does not cover the marketing costs for agro-dealers in the periphery. The pan-territorial pricing therefore may lead to market failure and even restricting the flow of certified seed to peripheral areas.

Infrastructure was found to have a significant role in the adoption of certified seed. The distance motorable road was found to be negatively related to adoption of certified seed. The study found that those adopting certified seed travel longer distances to procure seed as opposed to expectation where one would buy seed from the nearest agro-dealer. However, this phenomenon can be explained in that due to concern for quality of seed, farmers trust more established agro-dealers s in major trading centers and thus travelled further to obtain certified seed. This has a bearing on the magnitude of transaction costs that adopting farmers incur.

Household asset wealth was found to influences the decision to purchase certified seed. Households in lower wealth quintile are less likely to be using certified seed while those in quintile 4 and above being more likely to be using certified seed.

Thos following household attributes were found to significantly influence the decision to adopt certifies seed age of the head, education level, experience with certified maize seed and degree of commercialization.

Factors that were significant in influencing the intensity of use of certified seed included Experience with certified seed, being a Maize deficit household, Gender of the head, presence of off farm income and the degree of commercialization.

Policy Implications and Recommendations

Increasing maize production and productivity remains an important goal for Kenya's agricultural policies. There are several policy instruments open to the government that may positively influence input use and maize production. The policy recommendations that can be deduced from this study are highlighted below.

Seed companies should be encouraged to establish a clear criterion for an Agro-dealer to qualify as a seed agent. This will give clarity on rules for entry to all that meet such a criterion thereby increasing the number of players and therefore competition. This would also eliminate horizontal trade between seed agents thus shortening the certified seed value chain.

The government should enforce implement strict regulation especially on seed quality, policy on remaining costs at the end of planting season and monitoring seed adulteration. This will protect the consumer from unscrupulous traders and therefore increase the trust for certified seed across the country. This would reduce the incidence of magnitude of transaction costs as farmers will not need to buy only from established agro-dealers as they are assured of quality of seed.

Policies that increase the flow of information from the extension service to farmers are proposed (e.g. increasing the number of contacts between extension and farmers through funding of field days and demonstrations).

Female headed households were seen to have a higher intensity of use of certified seed. Given the potential certified seed has in enhancing maize productivity, the innovation or technology can be used as a tool for gender empowerment.

Farmers adopting certified seed incur higher transaction costs than non-adopters. Therefore, policies that increase the availability of information on certified seed as well as those that minimize the incidence of transaction cost will reduce the burden on farmers and thus increase adoption of certified seed and eventually led to improved aggregate maize production.

REFERENCES

Adesina, A.A. & Zinnah, M.M., 1993. Technology characteristics, farmers' perceptions and adoption decisions: A Tobit model application in Sierra Leone. *Agricultural Economics*, 9, pp.297-311.

Ahmed, A.U. & Bouis, H.E., 2002. Weighing what ' s practical□: proxy means tests for targeting food subsidies in Egypt. *Food Policy*, 27, pp.519-540.

Ariga, J. et al., 2008. Tegemeo Institute of Agricultural Policy and Development Trends and Patterns in Fertilizer Use by Smallholder Farmers in Kenya , 1997-2007. *Africa*, (xx), pp.1-41.

Ayieko, M.W. & Tschirley, D.L., 2006. Tegemeo Institute of Agricultural Policy and Development Enhancing Access and Utilization of Quality Seed for improved Food Security in Kenya By. *Policy*, (27).

Bank, W., 1982. World Development Report.

Bonen, J.T. & Eicher, C.K., 1987. Agricultural Development: Transforming Human Capital, Technology and Institutions. In London: The John Hopkins University Press, pp. 271-286.

Bromley, D.J., 1991. *Environment and Economy: Property Rights and Public Policy*,

Crawford, E. et al., 2003. Input use and market development in Sub-Saharan Africa: an overview. *Food Policy*, 28(4), pp.277-292. Available at: http://www.sciencedirect.com/science/article/B6VCB-49PRGH7-1/2/6da29a314a893d1e71532e928850e46f .

Dorward, A., 2001. The Effects of Transaction Costs , Power and Risk on Contractual Arrangements□: *Journal of Agricultural Economics*, 52(2), pp.59-73.

Doss, C. et al., 2003. *Adoption of Maize and Wheat technologies in East Africa: Synthesis of the Findings of 22 Case Studies*, Mexico, D.F.: CIMMYT. Available at: http://www.cimmyt.org/english/docs /eco_wpaper/ewp03-06.pdf.

Feder, G., Just, R.E. & Zilberman, D., 1985. Adoption of Agricultural Innovations in Developing Countries: A Survey. *Economic Development and Cultural Change*, 33(2), p.255. Available at: http://www.journals.uchicago.edu/doi/abs/10.1086/451461.

Feleke, S. & Zegeye, T., 2006. Adoption of improved maize varieties in Southern Ethiopia: Factors and strategy options. *Food Policy*, 31(5), pp.442-457. Available at: http://www.sciencedirect.com/science/article/B6VCB-4J6WG1D-1/2/093c16636585d8604f19e1b11245606b.

Fernandez-cornejo, J., Beach, E.D. & Huang, W.-yuan, 1994. The Adoption of IPM Techniques By Vegetable Growers in Florida , Michigan and Texas. *Techniques*, 26(1), pp.158-172.

GoK, 2003. *A Strategy for Economic Recovery: Ministry of Planning and National Development, Government of Kenya*, Nairobi.

De Groote, H. et al., 2002. Adoption of Maize Technologies in East Africa - What Happened to Africa's Emerging Maize Revolution? Paper presented at the FASID Forum V, "Green Revolution in Asia and its Transferability to Africa". 8-10 December, Tokyo, Japan.

Hassan, R.M. et al., 1998. Adoption patterns and performance of improved maize. In Wallingford. United Kingdom: CABI Publishing.

Heckman, 1976. Sample Selection Bias as a Specification Error Author (s): James J . Heckman Published by□: The Econometric Society Stable URL□: http://www.jstor.org/stable/1912352. *Society*, 47(1), pp.153-161.

Hellin, J., 2007. *Maize value chains in East and Central Africa(ECA). A Draft background document*,

Jayne, T.S. et al., 2005. Effects of Government Maize Marketing and Trade Policies on Maize Market Prices in Kenya.

Jayne, T.S. et al., 2001. Do Farmers Really Benefit From High Food Prices? Balancing Rural Interests in Kenya's Maize Pricing and Marketing.

Kaliba, A.R.M., Verkuijl, H. & Mwangi, W, 2000. Factors Affecting Adoption of Improved Maize Seeds and Use of Inorganic Fertilizer for Maize Production in the Intermediate and Lowland Zones of Tanzania. , 32(1), pp.35-37.

Karanja, D D, Renkow, M. & Crawford, E.W., 2003. Welfare effects of maize technologies in marginal and high potential regions of Kenya. *Agricultural Economics*, 29, pp.331-341.

Karanja, Daniel D., Jayne, T.S. & Strasberg, P., 1999. Maize Productivity and Impact of Market Liberalization in Kenya.pdf.

Kherallah, M. & Kirsten, J., 2001. Mssd discussion paper no . 41 the new institutional economics□: applications for agricultural policy research in by mssd discussion paper no . 41 by Mylène Kherallah and Johann Kirsten Contact□: Shirley Raymundo. , (41).

Langyintuo, A S et al., 2004. Consumer preferences for cowpea in Cameroon and Ghana. *Agricultural Economics*, 30(3), pp.203-213. Available at: F:\Literature_CIMMYT

Social Economics\Langyintuo_2004_Consumer preferences for cowpea_Cameroon and.pdf.

Langyintuo, A S et al., 2000. Farmers Strategy for Sustainable Food Security Determinants of the adoption of improved rice varieties in the inland valleys of northern Ghana. A Tobit model application.

Langyintuo, Augustine S. et al., 2008. An Analysis of the Bottlenecks Affecting the Production and Deploying of Maize Seed in Eastern and Southern Africa.

MoA, 2004. *The Status of Maize Seed Industry in Kenya: A Value Chain Analysis*, Nairobi.

Morris, M L, 1998. Maize Seed Industries in Developing Countries.

Morris, Michael L, Tripp, R. & Dankyi, A.A., 1999. Adoption and Impacts A Case Study of the of Improved Ghana Grains Maize Production Development Project Technology□: Adoption and Impacts of Improved Maize Production Technology□: A Case Study of the Ghana Grains. *Development*.

Muhammad, L et al., 2003. *The Seed Industry for Dryland Crops in Eastern Kenya*, Mexico, D.F: International Maize and Wheat Improvement Center (CIMMYT) and Kenya Agricultural Research Institute (KARI).

Muhammad, Lutta, 2003. The Seed Industry for Dryland Crops in Eastern Kenya The Seed Industry for Dryland Crops in Eastern Kenya. *Production*, (November).

Nyoro, James, 2002. Kenyas Competitiveness in Domestic Maize Production: Implications for Food Security. In *African Study Centre conference*. Leiden: University of Leiden.

Pingali, P.L. & Pandey, S., 2001. Meeting world maize needs: technological opportunities and priorities for the public sector. In Mexico, D.F.: CIMMYT.

Pixley, K. & Banziger, Marianne, 2001. Open-Pollinated Maize Varieties: A Backward Step or a Valuable Option for Farmers. In *Seventh Eastern and Southern African Maize Conference*. Harare Zimbabwe, pp. 22-28.

Poulton, C., Dorward, A. & Kydd, J., 1998. policy arena the revival of smallholder cash crops in africa□: public and private roles in the provision of finance. *Africa*, 10(1), pp.85-103.

Renkow, M., 2004. Rural infrastructure, transactions costs and market participation in Kenya. *Journal of Development Economics*, 73(1), pp.349-367. Available at: http://linkinghub.elsevier.com/retrieve/pii/S030438780300141X.

Salasya, B. et al., 2007. Factors influencing adoption of stress-tolerant maize hybrid (WH 502) in western Kenya. *Journal of Agricultural Research*, 2(October), pp.544-551.

Smale, M. & Jayne, T., 2003. *Maize in Eastern and Southern Africa: "Seeds" of Success in Retrospect.*, Washington, D.C.: IFPRI.

Suri, T., 2006. Selection and Comparative Advantage in Technology Adoption. Available at: http://ssrn.com/abstract=933124.

Wekesa, w E. et al., 2003. *Adoption of Maize Production Technologies in the Coastal Lowlands of Kenya*, Mexico, D. F.: International Maize and Wheat Improvement Center (CIMMYT) and Kenya Agricultural Research Institute (KARI). Available at: (http://www.cimmyt.org/english/docs/eco_wpaper/coastalKenya.pdf).

Winter-Nelson, A & Temu, A, 2002. Institutional adjustment and transaction costs: product and inputs markets in the Tanzanian coffee system. , 30(4), pp.561-574. Available at: F:\Literature_CIMMYT Social Economics\WinterNelson and Temu_2002_Inst Adjust and trans Costs_Tz Coffee.pdf.

Winter-Nelson, Alex & Temu, Anna, 2005. Impacts of prices and transactions costs on input usage in a liberalizing economy: evidence from Tanzanian coffee growers. *Agricultural Economics*, 33, pp.243-253. Available at: http://www.ingentaconnect.com/content/bsc/agec/2005/00000033/00000003/art00001.

Zeller, M., 2000. *Methods of Social-economic Analysis of Rural Development* 1st ed., Goetingen: Institute of Rural Development, University of Goetingen.

Appendices

Appendix 1: Pearson Correlation Coefficient Matrix for the Explanatory Variables

Pearson Correlation

	Certified	Costs of information search	Costs of seed search	Costs of more information	Experience	Distance in kms from hh to tarmac road	Distance in kms from hh to extension advice	Input credit	Maize deficit hh	Group membership	Age
Certified	1										
Costs of information search	.139	1									
Costs of seed search	.314**	.193*	1								
Costs of more information	.093	.220**	.086	1							
Experience	.161*	.038	-.019	.011	1						
Distance in kms from hh to motorable road	-.254**	.022	.131	-.050	-.032	1					
Distance in kms from hh to extension advice	-.182*	-.077	-.117	.007	-.215**	.339**	1				
Input credit	.121	.024	-.037	.146	.033	-.008	.003	1			
Maize deficit hh	.020	-.147	.065	-.025	-.152	-.029	-.089	-.015	1		
Group membership	.129	.173*	-.038	.161*	.036	-.097	-.086	.055	-.160	1	
Age	-.158	.068	-.143	.139	.528**	.105	-.008	.067	-.267**	.196*	1
Gender of household member	.288**	.033	.141	-.044	.084	-.180*	-.228**	.110	.005	.021	-.183*
Years of schooling	.340**	.077	.156	.016	-.100	-.185*	-.220**	.006	.068	.013	-.399**
Number of hh members	.165*	-.019	.074	.155	.147	-.130	-.227**	.119	.080	.123	.003
Off farm income	.000	.126	.045	-.057	-.081	.065	.086	-.041	.257**	-.096	-.155
Degree of commercialization	.182*	.185*	.096	.122	-.049	.014	.162*	-.079	-.414**	.203*	.126
Total land holdings	.133	.115	.051	.052	.329**	-.051	-.022	.030	-.398**	.117	.347**
Total value of assets	.194*	-.036	.056	-.023	.230**	-.057	.060	-.056	-.160	-.016	.133
Proportion of maize area under certified seed	.967**	.156	.332**	.080	.174*	-.229**	-.189*	.139	.054	.098	-.172*

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Pearson Correlation (*...continued)*

	gender of household member	Years of schooling	Number of hh members	Off farm income	Degree of commercialization	Total land holdings	Total value of assets	Proportion of maize area under certified seed
Gender of household member	1							
Years of schooling	.453**	1						
Number of hh members	.193*	.128	1					
Off farm income	.003	.089	-.148	1				
Degree of commercialization	.071	.087	-.222**	-.076	1			
Total land holdings	.137	.130	.056	-.119	.322**	1		
Total value of assets	.143	.216**	.067	-.023	.143	.399**	1	
Proportion of maize area under certified seed	.289**	.340**	.097	.021	.183*	.131	.206*	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

University of Nairobi/CIMMYT

Developing and disseminating stress tolerant maize for sustainable food security in East and Central Africa

Household Survey 2008

HH Name ____________________		Household No.	**HHID** ___________
Respondent(s) ____________________			**MEM** ___________
		Date:(dd/mm/yy)	**SURDATE** _______

(Instruction: Record the member number of the Respondent from the Demography table on page 10 after the survey is completed.)

Identifying Variables:

Supervisor:	__________	.**SNUM**________
Enumerator:	__________	**ENUM**________
Province:	__________	**PROV**________
District:	__________	**DIST**_________
Division:	__________	**DIV** _________
Location:	__________	**LOC** _________
Sub-Location:	__________	**SUBLOC**_______
Village:	__________	**VIL** _________

GPS coordinates :

HH1 : ______ (1=North 2=South) (_____° **DEG1**_____`` **MIN1**_____ **SEC1**)

HH2 : __East__ (_____° **DEG2**_____`` **MIN2**____ **SEC2**)

HH3 : Altitude MT. a.s.l **MASL** (_________)

SECTION 1:

CROP ENTERPRISE ANALYSIS

The relative importance of crop enterprises as ranked by the farmer

What are the five (5) most important crop enterprises to you as farmer according to their contribution to the household welfare for the last 12 months?		*Enumerator*: Then determine which of the remaining activities was the most important, second, etc.		What is the major use /importance for this crop? 1=for food consumption at home 2=for sale(edibles crops only) 3=fodder 4=industrial /cash crop 5=other specify?
cropname		Cropcode	croprank	importance
1				
2				
3				
4				
5				

SECTION 1: QUESTIONS IN THIS SECTION REFER TO THE MAIN CROP SEASON 2007/08(*Embu; NOV/DEC 2007 Machakos Jan-Mar*)

Q1.1. How many **acres** in **total land holdings** did the household **own last year (2007)**? **TACRES**_______

Q1.2.a. Did this household have any cropping activity during the **MAIN CROP Season 2007**(1 = Yes, 2 = No) **MAINCROP**______

(Embu; NOV/DEC 2007 Machakos Jan-Mar)

Q1.2.b. **If Q 1.2 a. =Yes (1), go to table below. (Enum make sure you get all details for fields with maize; for all other crops stop at tenure)**

Crop08.sav *Key Variables: hhid, harvest, field, crop:*

Crop code	Field No.	Acres	Is this field 1=owned w/ deed 2=owned w/o deed 3=rented 4=owned by parent/ relative 5=government/communal/ co-operative	Was this maize an intercrop or mono crop? 1=Yes 2=No	Hired land prep cost (Ksh)	Planting/ Seed Type 1=Purch /New Hybrid 2=Retained Hybrid 3=OPV 4=local var 7=hybrid & local var 8=hybrid purc+retained	Quantity of seed used & cost, if purchased this season				1st Fertilizer used			2nd Fertilizer used			3rd Fertilizer used			Harvest -777=not yet harvested		Sales		Price received on **largest** sale trans-action Use sale unit code	Distance to point of sale	Buyer type (**largest** sale): 1=small trader 2=large trader 5=NCPB 6=miller 7=other coop 8=NGO 9=consumer 10=Exporter
							Qty	Unit	Cost p unit	Source of funds 1=group credit (AFC) 2=other group credit 3=ROSCAS 4=own cash 5=other individual credit	Type	Qty	Unit	Type	Qty	Unit	Type	Qty	Unit	Qty	Unit	Qty	Unit		kms	
Crop	**field**	**acres**	**tenure**	**microp**	**lpcost**	**Sdtype**	**sqt**	**sunit**	**scost**	**sors**	**ft1**	**fq1**	**fu1**	**ft2**	**fq2**	**fu2**	**ft3**	**fq3**	**fu3**	**hvt**	**hunit**	**sold**	**slunit**	**Price**	**Dist**	**Buyer**

Unit codes:			Fertilizer codes:				
1=90 kg bag 11=50 kg bag 2=kgs 3=litre 4=crates	5=numbers 6=bunches 7=25kg bag 8=10kg Bag 9=gorogoro 10=tonnes 12=debe	13=grams 14=wheelbarrow 15=cart 16=canter 17=pickup 18=2kg packet(seed)	0=None 1=DAP 2=MAP 3=TSP 4=SSP	5=NPK (20:20:0) 6=NPK (17:17:0) 7=NPK (25:5:+5S) 8=CAN (26:0:0) 9=ASN (26:0:0) 10=UREA (46:0:0)	11=SA (21:0:0) 12=Other (specify)___ 13=manure 14=Foliar feeds 15=NPK (23:23:23) 16=NPK (20:10:10)	17=DAP + CAN 18=compost 19=magmax lime 20=DSP 21=NPK(23:23:0) 22=NPK(17:17:17) 23=NPK(18:14:12) 24=NPK(15:15:15)	25=Mavuno-basal 26=Kero green 27=Rock-phosphate 28=NPK 14:14:20 29=Mijingu 1100 30=UREA+CAN 31=Mavuno-top dress.

Q1.3 SHORT CROP 2007/2008 (Eastern Kenya refers to Jul-Sept 2007 harvest, Embu refers to Nov 2006-Jan 2007)

crop07.sav Key variables: hhid,harvest,field, crop. Harvest=2

Crop code	Field No.	Acres	Is this field 1=owned w/ deed 2=owned w/o deed 3=rented 4=owned by parent/ relative 5=govern ment/co mmunal/ co-operative	Was this maize an intercrop or mono crop? 1=Yes 2=No	Hired land prep cost (Ksh)	Planting/ Seed Type 1=Purch /New Hybrid 2=Retained Hybrid 3=OPV 4=local var 7=hybrid& local var 8=hybrid purc+retained	Quantity of seed used & cost, if purchased this season				1st Fertilizer used			2nd Fertilizer used			3rd Fertilizer used			Harvest -777=not yet harvested		Sales		Price received on **largest** sale trans-action Use sale unit code	Distance to point of sale	Buyer type (**largest** sale): 1=small trader 2=large trader 5=NCPB 6=miller 7=other coop 8=NGO 9=consumer 10=Exporter
							Qty	Unit	Cost p unit	Source of funds 1=group credit (AFC) 2=other group credit 3=ROSCAS 4=own cash 5=other individual credit	Type	Qty	Unit	Type	Qty	Unit	Type	Qty	Unit	Qty	Unit	Qty	Unit		kms	
Crop	**field**	**acres**	**tenure**	**microp**	**lpcost**	**sdtype**	**sqt**	**sunit**	**scost**	**sors**	**ft1**	**fq1**	**fu1**	**ft2**	**fq2**	**fu2**	**ft3**	**fq3**	**fu3**	**hvt**	**hunit**	**sold**	**slunit**	**Price**	**Dist**	**Buyer**

Unit codes: 1=90 kg bag 11=50 kg bag 2=kgs 3=litre 4=crates	5=numbers 6=bunches 7=25kg bag 8=10kg Bag 9=gorogoro 10=tonnes 12=debe	13=grams 14=wheelbarrow 15=cart 16=canter 17=pickup 18=2kg packet(seed)	Fertilizer codes: 0=None 1=DAP 2=MAP 3=TSP 4=SSP	5=NPK (20:20:0) 6=NPK (17:17:0) 7=NPK (25:5:+5S) 8=CAN (26:0:0) 9=ASN (26:0:0) 10=UREA (46:0:0)	11=SA (21:0:0) 12=Other (specify)___ 13=manure 14=Foliar feeds 15=NPK (23:23:23) 16=NPK (20:10:10)	17=DAP + CAN 18=compost 19=magmax lime 20=DSP 21=NPK(23:23:0) 22=NPK(17:17:17) 23=NPK(18:14:12) 24=NPK(15:15:15)	25=Mavuno-basal 26=Kero green 27=Rock-phosphate 28=NPK 14:14:20 29=Mijingu 1100 30=UREA+CAN 31=Mavuno-top dress.

Q 2 . Indicate the types of maize seed planted in the main and short seasons: **(Instructions:** Refer back to the crop table and copy the field numbers and seasons, where maize was planted, to this table. Then ask the questions.)

Seed08.sav *(Key variables: field, season, sdvar)*

Field No.	Season 1=Main 2=Short	Crop 1=Maize 2=Green Maize	Seed **varieties** planted Use code below.	**Seed Type** 1=Purchased/New hybrid 2=Retained hybrid 3=Purchased OPV 4=Retained OPV 5=Purchased local variety 6=Retained local variety	**Source type codes:** 1=small trader 2= stockist/agent 3=large company 4=NGO /CBO 5=KFA 6=Cooperative 7=Own seed 8=Farmer /Neighbour 9=General market 10=GoK 11=Farmer group 12= Other, specify Source type	**Kms** from point of purchase to farm	How much did you incur in transporting the seed?	How did you **obtain this seed**? 1=Cash purchase 2=Credit 3=Exchange 4=Free 5=Retained seed	Reason for **Maize seed variety** selection (Use codes below) **(Maize Only)**
field	**season**	**crop**	**sdvar**	**sdtype**	**source**	**kms**	**transport**	**sdobtain**	**rseed**

Maize Seed Codes:

1=KS 614
2=KS 611
3=KS 622
4=KS 623
5=KS 625
6=KS 627
7=*KS* 628
8=KS 511
9=KS 512
10=KS 513
11=Pioneer
12=CG 4141
13=CG 5051
14=CG 5252,
15=Pan 5195
16=Pan 5355
17=Pan 5243
18=Pan 99
19=Maseno DC
20=DLC
21=DH1
22=DH2
23=DH3
24=DH4
25=Katumani
26=PH1
27=PH2
28=Coast Composite
29=Indigenous/Local type
31=Don't know
32=KS 514
33=KS 613
34=KS 626
35=KS 636
36=KS 9401
37=Kinyanya
38=Makueni
39=PH4
42=KS 612
43=Pan67
44=Monsanto
45=WS 501
46=Faida Seed 650
48=Rwanda
49=Pan 691
50=PH 1033
51=DK 8071
83=DK 3081
52=KS 629
53=KS 621
55=KS 515
56=DH 02
57=SCDUMA43
58=KH500-21A
59=KS 6213
60=KS 9201
61=WS 404
62=KS 615
63=KS 616
64=KS6 210
65=Resistant Maize (IR)/ua kayongo
66=Kakamega Synthetic
67=KSTP 94
68= Pan 612
69=Sadvil A
70=Sadvil B
71=Sadvil Composite
72=Simba
74= WS 402
75= WS 505
76= WS 403
77= WS 503
78= WS 504
79= WS 905
80= WS 909
81= WS 205
82= WS 500
40=WS 699
41=WS 904
54=WS 502
84=WS105
30=other , specify__

Reason codes

1 high yielding
2 cheaper
3 pest/disease resistant
4 freely available/own
5 Drought resistant
6 Seed promotion/donation
7 only available in the market at the time
8 Early maturing
9 No lodging/rotting
10 Striga weed resistant
11 Good for sale
12 Good for home consumption
13 On trial
14 heavy grains
15 Other specify__

TRANSACTION COSTS OF OBTAINING MAIZE SEED:

2.1 Ask the following questions for the **main seed variety** grown by the farmer.

Q 2.2. What **MAIN** maize variety did you grow (***main season***) **MAIZVAR** ______

Q 2.3a From whom did you first learn about this seed variety?. **WHFIRST**__________

1=Public Extension Agent 2= NGO agent 3=neighbour/farmer 4=market 5=traders/input dealers 6=radio /television 7=family/friend 8=newspaper/magazines 9=Farmer Organizations/cooperatives 10=field days/demonstrations 11=ASK Shows 12= Mobile phone 13=private(company agent) 14=other (specify)_______

Q 2.3b What did you do to get this information or how did you get this information?. (answer in the table below on ref q 2.3b)

Q 2.4. How did you get the seed?. **HOWGET**____

Q 2.5 What did you do to improve the information on growing this variety (answer in the table below on ref q 2.5)

TCTABLE

Ask the following questions for the main seed variety specified here; if the same activity done in different times record separately (eg, attending more than one field day)

Tcosts08.sav *(Key variables: hhid, tccat, actvity)*

Follow up questions for different incidences of Tranasaction cost	Where did you get this information from(use codes on qn2.3b)		Time spent travelling to the meeting	Kms from point of activity to farm	Cost of transport for the return journey	Time spent in the meeiting/activity hours	Cost of meals and incidental costs relating specifically to this activity
tccat	Activity		timeto	kms	trancost	durat	incidental
Ref **Q 2.3b (information search cost)**	23						
	23						
	23						
Ref **2.4** (seed search costs)	24						
Ref **Q2.5** (Subsequent Information search on improving maize ty production and management)	25						
	25						
	25						
	25						
	25						
	25						

MAIZE VARIETY CHOICE:

Q3.Questions on the main **MAIN** maize variety grown (***main season***)________(**Maizvar**). **Q 2.2 above**

List the criteria for choosing maize variety to grow? (***Reminder to enumerator:*** **prompt** the respondent with the **type** but ***do not read*** *the options* ***under criterion****, just tick the "mentioned" column, (After the farmer mentions ask the three most important properties to the by farmer)*

Type	Criterion	mentioned	Three most important? 1=Yes, (Leave blank for No)
	1=Early maturity		
1=General	2=High yield		
	3=Drought tolerance		
	4=Tolerance to Stemborer		
	5=Tolerance to other field pests		
	6=Tolerance to storage pests		
	7=Tolerance to diseases		
	8=Tolerance to Striga		
	9=lodging		
	10=Low external input demand		
	11=Rotting		
2=Tolerance	12=tolerance to Low soil fertility		
3=Storage	13=rotting of cobs in storage		
	14=Vigour		
4=Plant	15=Height		
	16=seed, low price		
	17=availability of seed		
	18=Seed size		
	19=Quality		
5=Seed			

Type	Criterion	mentioned	Three most important? 1=Yes, (Leave blank for No)
	20=cobs, number per plant		
	21=number of rows per cob (high or fixed)		
	22=cob size		
	23=cobs well filled		
6=Cob aspects	24=husk cover good		
	25=grain, large size		
7=Grain aspects	26=grain colour		
	27=Compact grain/high flour density		
	28=taste		
	29=Easy threshing		
	30=Flint		
	31=processing qualities		
	32=tolerance to weeds		
	33=Drying period		
8=Processing, cooking			
	34=Familiarity		
10=Other(Specify)			

Farming practices/ training/ - **MAIN CROP Season 2007/08**

Q4a. What seed type did you plant on the largest maize field in during **main crop season** of **2006/07** **MSEASON06**________

1=New hybrid 2=Retained hybrid 3=Purchased OPV 4=Retained OPV 5=Purchased local variety 6=Retained local variety

Q4b. Which **year** did you **first** plant **purchased hybrid maize**? (0=Never planted) **YHMZ**________

Q4c. Have you ever had an **experience with Bad/adulterated** Purchased maize seed? (0=Never planted) **(1 = Yes, 2 = No)** **BADEXP**_______

Q4d. **If yes to Q4c,** What was the problem? **(PROBPMZ)**____

Q4e. If you **didn't purchase hybrid maize,** in the MAIN CROP Season 2007/08 why not? **NFERMZ**________

0=did not plant maize 1=not profitable 2=lack of information 3=seed not available 4=not enough cash 5=too expensive 6=maize price too low 7=no money for other inputs 8= no need to use 10=other, specify__________

Q4f. If you **didn't use chemical fertilizer on maize,** why not? **NFERMZ**________

0=did not plant maize 1=not profitable 2=low response rate 3=couldn't obtain credit 4=not enough cash 5=too expensive 6=maize price too low 7=no cash when needed 8= fertilizer not available 9= no need to use 10=other, specify__________

Q4g. **Who** makes decisions on use of farm inputs (e.g. seed & fertilizers)? **NAMED**______________________ **MEM2**______*(fill later)*

Q4h. did this household purchase dry maize for home consumption in the last 12 moths? (0=Never planted) **MCONSUME**________

Q5a. Has anyone in this household attended farmer field days or farmer training school on Maize production in the last 3 years? **TRAINING** ________ (1=yes, 2=no)

Q5b. If yes, Number of days in the last 3 years: **TRAINDAYS**________

Q5c. Total number extension contacts in the last year: **CONTACT**__________

Q5d. Do you **ACTIVELY listen to** **Agricultural Programs On Radio**? **(1=Yes 2=No)** : **LISTEN** __________

Q5e. What was the average **daily wage rate** for **general farm labour** in this area in the 2007 season? (Ksh per day): **WAGERA07** __________

Q5f. For this wage, what was the **typical number** of hours **worked per day**? (Hours): **HOURS07**__________

Q5g. Over the past year (2007/ 2008 season), would you consider your agricultural production system to be reflective of a normal production year, a good production year, or a poor production year? **YR07/08**__________

1=normal year 2=good year 3=poor year

Q6a. Did any member of this household belong to a farming group/CIG during the last one year? (1 = Yes, 2 = No) **FRMGRP07**__________

Q6b. *Did any member of this household* **belong** to a **farmer cooperative or institution** dealing in **maize inputs or maize marketing**? **INSTMZ07**____________
(1 = Yes, 2 = No)

Q6c **If Q6a is No** what kind of group did the household belong to? **OTHGRP06**____________

1. None 2. Church group 3. Rotating savings group (ROSCA) 4. Other (specify)

CREDIT

Q7a. Did any household member **try to get any credit during** the 2007/08 crop year? (1=Yes) (2=No **go to Q8**) **CASHCRD** ________

Q7b. (If Yes) Did you receive the **credit** that **you tried to obtain**? (1= Yes) (2=No **go to Q7f**) **CASHRD** ________

Q7c. (If yes) How **much credit** did you receive (ksh) **CASH** ________

Q7d. For the **two** main sources of credit, what was the **source** and the **amount** that you received from each? **CSRC1** ____ **CAMT1** ________ **CSRC2** ____ **CAMT2** ________

(1= neighbor 2=farmer group 3=SACCO 4=commercial bank, specify ________ 5=relative/friend 6=NGO/MFI, specify________ 7=AFC 8= group (ROSCA) 9=Village bank 10=Shopkeeper 11=other, specify ________)

Q7e. How was the **cash credit** used (1=Agricultural purposes 2=Non agricultural purposes 3=Both) **MAINPUR** ________

Q7f. If you tried to get **cash credit but did not get** what was the reason for not getting? **NCASH** ________
(1=no collateral 2=Had outstanding loan 3= Don't Know 4= Other, specify____)

Q8 Infrastructure

Infrast07.sav

Infrastructure (Distance should be recorded in kilometers, Km)	
Q 8. Distances from your homestead	**April 2007 to March 2008**
a. What is the distance from your homestead to where you bought **hybrid maize seed**?	**SEEDSKM2** _______
b. What is the distance from your homestead to the nearest **hybrid maize seed seller**?	**NEARSEEDKM** _______
c. What is the distance from your homestead to where you bought **fertilizer**?	**FERTKM2** _______
d. What is the distance from your homestead to where the nearest fertilizer **seller**?	**NEARFERTKm**_______
e. What is the distance from your homestead to **extension advice**?	**DEXTN2** _______
f. What is the distance from your homestead to the nearest **market place** for **farm produce**?	**MKTKM2**_______
g. What is the **type of the road** from your homestead to the **farm produce market**?	**ROADTYP2**_______
h. What is the distance from your homestead to a **motorable road**?	**DTMR0D2** _______
i. What is the distance from your homestead to a **tarmac road**?	**CTMR0D2** _______

Codes for type of Road: 1=tarmac, 2=murrum/all weather, 3=dry weather, 4=foot path, -7=services not available

Q9. DEMOGRAPHIC CHARACTERISTICS OF HOUSEHOLD MEMBERS

Demog07/08.sav *(Key variables: hhid, mem)*

Reference Period: The Past 18 months -Jan 2007to June 2008

ID	Name	In which **year** was this person born?	What is the **sex** of this person? *1=male 2=female*	**Relation-ship** to **current** head *See code below*	Is this person **Currently** enrolled in formal schooling? *1 = Yes 2 = No*	What is the **highest** level of education completed? *See codes below*	Did this person receive cash from **informal /business activity?** Include **farm kibarua, dividends** between **march 2007 & march 2008?** *1=Yes 2=No*	Did this person receive income from salaried employment between **march 2007 & march 2008?** *1=Yes 2=No*
MEM	**NAME**	**yborn**	**gender**	**rshead**	**cursch**	**heduc**	**lstinf**	**curinf**
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

rshead

1= head	6= brother /sister	11=unrelated
2= spouse	7= nephew /niece	12=brother /sister-in-law
3= own child	8= son/daughter-in-law	13=parent-in-law
4= step child	9= grandchild	14=worker
5= parent	10=other relative	

Education levels (heduc)

-9=None	0=pre school	9= form 1	10 = form 2	17= college 3	18= college 4
1=std 1	2=std 2	11=form 3	12=form 4	19=univ 1	20=univ 2
3=std 3	4=std 4	13=form 5	14=form 6	21=univ 3	22=univ 4
5=std 5	6=std 6	15= college 1		23=univ 5 & above	
7=std 7	8=std 8	16= college 2			

Q10. IMPORTANCE OF INCOME SOURCES

Economic Activity		Please indicate the order of importance of each of these activities in the household's total income during the past 12 months -9=activity could not be ranked 0=did not give any income though produced 1=this activity gave the highest income 2=this activity gave the second highest income ... ...all the way to the least income -1=the household did not engage in this activity *Enumerator*: First place a -1 for all activities that the household did not engage in. Then determine which of the remaining activitie was the most important, second, etc.
ECONACT		ORDER
Crop production and sales (all crops)	1	
Livestock production and sales	2	
Farm kibarua	3	
Salaried labor	5	
Business activities	6	
Remittance	7	

Q11. Household Assets (PROMPT for each item AS LISTED BELOW)

AT PRESENT, how much/many of the following does this household own that are usable/repairable? (**Instructions**: Ask for the resale price for each asset or the current market value of the asset as it is and then add up to get total value for the asset category.)

Asset07/08.sav *Key Variables: hhid, item*

Asset	Current Quantity (2008)	Total Value (2008)	Asset	Current Quantity (2008)	Current Total Value (2008)
ITEM	QTY1	TOTVAL	ITEM	QTY1	TOTVAL
1=houses			27=posho mill		
2=stores			28=weighing machine		
3=water tanks			29=grinder		
4=radio			30=cattle dip		
5=TV			31=power saw		
6=telephone/mobile			32=spray pump		
7=solar panels			33=irrigation equipment		
8=battery			34=water pump		
9=gas cooker			35=cart		
10=bicycle			36=animal traction plough		
11=wheel barrow			37=donkey		
13=sewing/knitting machine			38=motorcycle		
14=milking equipment/shed			39=car		
15=zero-grazing units			40=truck		
16=chaff cutter			41=trailer		
17=water trough			42=tractor		
18=poultry houses			43=harrow/tiller		
19=piggery houses			44=ploughs for tractor		
21=borehole			45=planter		
22=well			46=sheller		
23=dam			47=ridger/weeder		
24=jaggery unit			48=generator		
25=cane crusher			49=boom sprayer		
26=pestle and mortar			50=Furniture (totval)		
51=Boat (rowing)			12=Beehives		
52=Motor boat/engine					

Thank you