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Enhancing Access and Utilization of Quality Seed for improved Food Security in Kenya

By

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Abstract

Increasing agricultural productivity is central to accelerating economic growth and improving the wellbeing of both rural and urban people in Kenya. In deed, the Kenya's Strategy for Revitalization of Agriculture (SRA) stresses the need to improve access to quality inputs and financial services. Seed is among the most important productive resources that greatly affect productivity. The challenge in Kenya today is to develop seed production and delivery systems that encourage wider use of quality seed throughout the marketing chain. While both the informal and informal seed systems exist in Kenya, evidence shows that vast majority of farmers rely on the informal seed system for seed and planting material for most agricultural commodities, and often continue to recycle seed that has been exhausted through generations of cultivation. The result has been persistently low yields.

The overall objective of the study is to enhance seed access and utilization in Kenya. The specific objectives were thus to: (1) assess the structure of the seed system in Kenya and estimate the magnitude of the informal seed source; (2) assess the role of the informal seed systems in improved seed access and utilization and how they can be integrated into the formal seed programs; and, (3) review the seed industry regulatory and legislative framework and propose policy options to improve availability, access and utilization of improved seed. Data for the study is drawn from the Tegemeo Rural household panel data, the stockist interviews and discussions with key stakeholders.

Findings of the study indicate that the informal seed system is an important source of seed for farmers. The study identifies some successful approaches to seed access among farmers, including positive selection, contract farming, community-based and marker-led approaches to seed access and utilization. The study also analyses the returns to use of improved seed for a number of crops and its implication on seed use. The seed industry and regulatory framework is reviewed to examine bottlenecks facing private sector investment in seed production and distribution. Policies options to establish a seed market with an effective demand large enough to induce the needed investment and create the competition required to establish a viable and efficient seed industry are explored.

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ACRONYMS

ADC	Agricultural Development Corporation
ADRA	Adventist Development and Relief Agency
AGMARK	Agricultural Marketing Trust of Kenya
ALRMP	Arid Lands Resource Management Programme
ARZ	Agro-regional Zone
ASAL	Arid and Semi Arid Lands
CB	Cereal Bank
CBSP	Community Based Seed Production
CIMMYT	International Maize and Wheat Improvement Centre
CIP	International Potato Centre
COMESA	Common Market for Eastern and Southern Africa
CRS	Catholic Relief Services
EAC	East African Community
EUREPGAP	European Retail Producer Group-Good Agricultural practices
FAO	United Nations' Food and Agriculture Organization
GOK	Government of Kenya
GTZ	German Technical Cooperation
HCDA	Horticultural Crop Development Authority
ICRISAT	International Crops Research Institute for Semi Arid Tropics
IFAD	International Fund for Agricultural Development
ISTA	International Seed Testing Association
KARI	Kenya Agricultural Research Institute
KSC	Kenya Seed Company Limited
KSU	KARI Seed Unit
KENFAP	Kenya National Federation of Agricultural Producers
KEPHIS	Kenya Plant Health Inspectorate Services
MOA	Ministry of Agriculture
NGO	Non-Governmental Organization
NMK	*Njaa Marufuku* Kenya
OPV	Open Pollinated Variety
QDS	Quality Declared Seed
SANSOR	South Africa National Seed Organization
SRA	Strategy for Revitalization of Agriculture
STAK	Seed Trade Association of Kenya
SVT	Seed Variety Trials
TRIPS	Trade-Related Aspects of Intellectual Property
UPOV	Union for the Protection of New Varieties
WTO	World Trade Organization

1.0 Introduction

1.1 Background Information

Seed and planting materials are no doubt the most important inputs in agricultural production. However much a farmer puts to use other productive inputs (land, fertilizer, labor etc), seed still determines whether an output will be realized or not. The government of Kenya has been pursuing strategies aimed at increasing agricultural productivity as this has been seen to be central to accelerating economic growth and improving the wellbeing of both rural and urban people in Kenya. Seed has been recognized as a core component to realizing this strategy. Compared to other agricultural inputs, seed has been shown to have the greatest potential to increase on-farm productivity and enhance food security (Muyanga et al, 2005). Improved seed thus plays pivotal role in increasing agricultural productivity and thereby reduces production costs inherent in our production systems

Two seed systems exist in Kenya, the formal and informal seed systems. While the formal seed system is an important source of high quality certified seed, it is not able to meet the farmers' demand. Majority of farmers therefore rely on the informal seed system for seed and planting material for most agricultural commodities, and often recycle seed that has been exhausted through generations of cultivation. The result has been persistently low yields. The challenge in the Kenyan agriculture today is to develop seed production and delivery systems that encourage wider use of quality seed throughout the marketing chain. In deed, one of the six fast-track activities for Kenya's Strategy for Revitalization of Agriculture (SRA) is to improve access to quality inputs and financial services (Republic of Kenya, 2004).

A well-functioning seed system is one that uses the appropriate combination of formal, informal, market and non-market channels to efficiently meet farmers' demands for quality seeds. While the seed industry in Kenya is better developed compared to other countries within the region, high cost of seed relative to other purchased inputs, coupled with the inability of the formal seed system to meet the demand by farmers have been cited as bottlenecks to the seed industry (Nyoro and Ariga, 2004). Moreover, local and international seed companies find it unprofitable to make the investment required to provide the quantity, quality and variety of seed needed to support an expanding agricultural base.

In addition, poor legislative and regulatory framework in the seed industry has adversely affected access to improved seed and planting materials by farmers. Since the liberalization of the seed industry in 1996, private sector participation has increased, with a number of private seed companies being registered to produce seed, thus reducing the monopoly that the Kenya Seed Company has enjoyed for a long time. While it was widely expected that this would lead to improved accessibility to quality seed and hence increased efficiency, agricultural productivity has generally been low and shown declining trends. In addition, mechanisms to protect farmers from malpractices by the seed producers and traders have not been adequately put in place. Farmers, therefore have no fallback position when faces with seed crisis. Poor accessibility to information regarding demand, supply and general performance in seed the market, were also among other constraints identified (Kamau, 2002).

The Kenya Plant Health Inspectorate Services (KEPHIS), which is charged with the regulation of the seed industry, has also been viewed by key stakeholders to impede the release of improved varieties from breeding programs to seed producers and eventually to farmers. This has often worked against private sector investment in the seed sector. A study by Tegemeo in 2002 showed that the regulatory environment and restrictions in the maize seed industry was prominent and breeders lacked incentives from seed industry for investment.

This study takes a look at the seed industry in Kenya with a view to understanding the approaches that have been used to access seed by farmers in the face of an ineffective formal seed system. The study proposes policies to help establish a seed market with an effective demand large enough to induce the needed investment and create the competition required to establish a viable and efficient seed industry.

1.2 Research Questions:

The study seeks to answer the following questions:

1) What proportion of farmers use improved seed for key commodities groups, and what constraints face improved seed access and utilization in Kenya?

2) What seed distribution systems are working in Kenya, and why are working? What is the role of community-based seed systems in seed production and distribution? Specifically, how can the informal seed systems be integrated into the formal seed system in order to enhance the availability of improved seed at the farm level?

3) What are the seed cost buildups for various commodity groups in Kenya? And, how can the industry attract additional private investment to infuse competition that ultimately creates conditions for reduction in seed prices?

4) What should the role of KEPHIS be in the seed industry so as to encourage private-public sector partnership in seed development, production and distribution?

1.3 Objectives of the study

The overall objective of the study is to enhance seed access and utilization in Kenya. The specific objectives are thus:

1) To assess the structure of the seed system in Kenya and estimate the magnitude of the informal seed source;

2) To assess the role of the informal seed systems in improved seed access and utilization and how they can be integrated into the formal seed programs;

3) To review the seed industry regulatory and legislative framework and propose policy options to improve availability, access and utilization of improved seed

1.4 Data and Methods

Data for the study consisted of the Tegemeo Rural Household data, the stockist interviews and discussions with key stakeholders including farmers. Key stakeholders were interviewed using an interview checklist. Focused group discussions were carried out with community organizations involved in seed and plant material production. Methods included descriptive and econometric analysis, and sub sector methods to analyze performance of and constraints facing the Kenya seed industry.

1.5 Organization of the Paper

The working paper is organized into four sections. Section 1 (the present section) has presented an overview of the seed sector in Kenya, and addresses the pertinent issues in Kenya's seed sector. The section has discussed the two seed systems prevalent and their importance and laid out key research questions, objectives, data and methods adopted in the rest of the paper. Section 2 provides an assessment of the Kenyan seed industry structure, and provides alternative measures to the important seed sources for farmers. The section also discusses the improved seed adoption, and examines factors that affect the adoption. The section concludes with an analysis of the returns to improves seed, to establish how profitable it is to use improved seed for various crops.

Section 3 turns the focus to the theme of this paper, namely, examining what is working in the seed industry with regard to access and utilization. The section provide examples of initiatives that farmers use to access fairly clean seeds and planting materials for different groups of commodities, and also some food security-related initiatives to seed access. Section 4, the final section, looks at key policy implications and lessons for the Kenyan seed sector.

2.0 Structure of the Seed Industry in Kenya

Seed industry in Kenya, like any other economy, is divided into the formal and informal systems[1]. The two systems vary in their magnitude and importance depending on the commodities they support. Evidence shows that commodities that have been supported by massive research efforts tend to have more formal than informal seed system, while those regarded as orphan crops have more informal than formal seed system. This section takes a closer examination of the seed system in Kenya to assess their importance in seed access.

2.1 The Kenya Seed System

Table 1 below shows the proportion of seed that passes through the formal and informal systems for selected commodities. Approximately four-fifths (78%) of all seed used in Kenya comes from the informal sector. Despite this, the importance of the informal seed system has been largely underplayed and unappreciated as a distinct and expanding presence. With the exception of maize and rice, seed for other commodities are mainly sourced from the informal sector. For maize, about 40% of the seed comes from public seed companies, while another 20% coming from the private seed companies. For rice about 80% of the seed is sourced from the public seed sector. Notably, maize has been supported by massive national research network both locally and internationally. For most other commodities, informal seed system, especially farm-saved seed is the key source for seed.

(i) The Formal Seed System

The formal seed sector in Kenya comprises of both the public and private sector agencies and characterized by a clear chain of activities starting with plant breeding, variety release and certification, seed multiplication, production, distribution and marketing system. The Formal seed system is especially important in crop production for commercial purposes (for example export or further food processing). Currently, the formal seed sector comprises of 5 public (including 4 KARI seed units) and 50 registered private seed companies. The formal system is governed by strict regulations in order to maintain variety identity and purity as well as to guarantee physical, physiological and sanitary quality. Seed produced through this system is distributed through officially-recognized seed outlets, which must obtain registration and certification from KEPHIS. Some of the formal seed is distributed through the national

[1] The "informal system is sometimes also referred to as 'local', 'farmer', or 'traditional' seed systems.

agricultural research systems (mainly KARI Seed Unit KSU) and even through relief seed programs.

Table 1: Proportion of seed made available from different sources in Kenya

	Informal System		Formal System				
Crop	Farm-saved seed[2]	Community-based schemes	Public companies/ Parastatals	Private local companies	Private foreign companies	Government distribution schemes	Donors/ NGOs
Bananas	80	0	20	0	0	0	0
Beans	80	0	5	0	10	0	5
Cassava	93	2	5	0	0	0	0
Cow-pea	75	8	10	2	0	0	5
Ground-nut	80	3	0	10	0	0	7
Maize	32	2	40	15	5	5	1
Millet	90	3	1	2	0	0	4
Pigeon-pea	80	0	6	4	0	0	10
Rice	15	0	85	0	0	0	0
Sorghum	87	0	4	5	0	2	2
Soy-bean	99	1	0	0	0	0	0
Sweet potato	96	3	1	0	0	0	0
Overall	**76**	**2**	**15**	**3**	**1**	**1**	**3**

Source: Authors' analysis of Sector interviews; Ministry of Agriculture; KEPHIS; Seed Companies; STAK

(ii) The Informal Seed System

Most farmers produce for subsistence reasons and hence seed-related activities tend to be integrated and locally organized, coming from informal seed system. The informal system embraces most of the ways in which farmers themselves produce, disseminate and procure seed: directly from their own harvest, through barter among friends, neighbors and relatives, and through local grain markets or traders. The same general steps take place in the informal system as in the formal but as integral parts of farmers' grain production rather than as discrete activities. Local technical knowledge and standards guide informal seed system performance, including the prevailing market forces. Perhaps because of its local specificity to needs and preferences the informal system provides most of the seed farmers use, worldwide between 80% and 90% of stocks. The important exception concerns hybrid maize.

[2] Farm-saved seed includes retrained seed, seed purchased from neighbors or local markets but which has not undergone any certification to verify its quality

2.2 Seed Sources for Farmers

Two seed sources exist, namely, informal and formal seed sources. The informal seed sources include retained seed and purchases made through informal markets, including the local markets and neighbors. Seed purchased from these sources mainly comprises the local varieties and their quality has not been verified. Formal seed purchases, on the other hand, are those made from the stockists and outlets through which certified seed are sold.

2.3 Seed Channels used by Farmers in Kenya

An assessment of the important seed sources for farmers is critical for policy purposes. Different approaches can be used to do this. One approach is to look at the proportion of farmers using a particular seed source. Alternatively, one can compare the value shares of the seed passing through various seed sources. In both approaches, seed types are categorized into retained seed, informal seed purchases and formal seed purchases. Table 2 shows the alternatives measures of importance of the various types of seed used by farmers in Kenya. From the Table, it is evident that households tend to use all the three types of seeds. Almost Nearly all households (99%) use retained seed while 86% and 83% use seed from informal and formal purchases, respectively. This classification includes all crops that a household plants during a production period. It however fall short of explaining the importance of a seed source since it does not attempt to estimate the quantities of seed that farmers acquire from each source, nor does it give the value of the seed and therefore may be misleading.

A realistic way of gauging the importance of the type of seed used by farmers is to estimate the proportion of all seed transactions made by the farmer. According to this classification, the most frequently used source of seed by farmers is the retained seed, accounting for nearly two-thirds (63%) of seed transactions made by farmers. Informal and formal seed purchases account for 19% and 18% respectively. Thus, the most frequent source of seed used by households in the country is retained production, while formal sector seed purchases are least frequent. This may to some extent explain the low yields experienced in the country. This classification, however, still does not clearly show the real importance of seed source, since it is estimated at household level.

Table 2: Alternative Measures of Importance of Seed Channels in Kenya

Source of Seed	% Of Households using seed source	% Of all seed "transactions"[3]
Retained	99	63
Informal Purchases	86	19
Formal Purchases	83	18

Source: Tegemeo Household Survey 2004, Authors' Calculations

(i) Value share of seed sources used

In terms of policy, the above estimates would be inadequate to explain the important seed sources for farmers and more global estimates such as regional and national estimates would be quite appropriate. This can be clearly understood by estimating the value of seed by type as well as by crop production in the country. Table 3 estimates the value share of seed sources used by farmers in Kenya. Two measures are used here: (i) share of total value of seed used in the country, and (ii) share of total value of crop production in the country. Se now turn to these measures to understand the important seed sources. Using these two measures, the value share of seed purchases from the formal sources is higher than seed from either informal or retained sources.

Table 3: Value share of seed sources used by farmers in Kenya, 2004

Source of Seed	Share of total value of seed used nationally (%)	Share of total value of crop production in country (%)
Retained	40	42
Informal Purchases	8	10
Formal Purchases	52	48

Source: Tegemeo Household Survey 2004, Authors' Calculations

In terms of value shares, formal seed sources account for more than half (52%) of all seed used in the country, compared to 40% from retained sources and only 8% from the informal seed purchases. The wide disparity in shares could be explained by the high prices of seeds from formal sources compared to those from the informal purchases. For example, certified

[3] This estimate computes the value of each source as a proportion of the total value of seed used by the household in a given production period

seed maize retails at Ksh 120 (could be as high as Ksh 175 for imported seed) a kilo, while seed maize purchased from informal sources is sold at Ksh 25 for the same quantity.

The same pattern is exhibited when we consider the seed source by value of crop production. Most of the crop production (48%), by value, is derived from using formal seed sources, compared to informal seed purchases (10%) or retained seed (42%). This may imply that farmers producing for commercial purposes would tend to use the formal seed sources for maximum benefits while those producing for subsistence purposes would tend to rely on seed from retained production or informal sources.

(ii) Value share of seed source by commodity group

The information presented so far has considered all crops in all regions of the country. This tends to mask a lot of information, since there are differences in crops and regions in terms of seed sources and use. Table 4 breaks the value share of seed used by crop type. The crops are grouped into cereals and pulses, tubers, vegetables and non-tree fruits, tree crops and fodder.

Table 4: Value shares of seed channels in Kenya by crop category

Crop category	Retained Seed	Informal Purchases	Formal Purchases
	------ % Of Total Value of Seed ------		
Cereals and Pulses	34	14	52
Of which: Maize	***10***	***3***	***87***
others	***58***	***24***	***17***
Tubers	84	16	0
Vegetables & non-tree fruits	43	34	22
Industrial Crops	1	0	99
Tree Crops	93	7	0
Fodder	98	1	1
Overall	40	8	52

Source: Tegemeo Household Survey 2004, Authors' Calculations

The formal seed source is dominated by cereals and pulses and the industrial crops. Among the cereals and pulses, more than half (52%) of the seed by value is from formal seed purchases, while another one-third (34%) of the seed is farm-retained. But even among the cereals and pulses, maize dominates the formal seed purchases (87%) of seed used for cereal and pulses production. Other cereals and pulses are mainly from farm-saved seed (58%). Vegetables and other non-tree fruits are also mainly grown from retained seed sources (43%) and informal sources (34%), while the tree fruits are mainly produced from retained seedlings.

Industrial crops (sugarcane, tea, coffee) are predominantly grown from formal seed sources while tubers are mainly grown from farmer-saved (84%) and informal seed sources (16%). A unique feature for industrial crops is that they tend to be supported by well-established research system and output markets. The respective sub-sectors provide inputs including seeds and planting materials to their farmers, often on credit, to be recovered when the farmers deliver the produce to them. This helps the farmers to get around the constraints to using high quality seed posed by lack of finances. The organizations also provide extension services to the farmers thereby promoting good use of the inputs.

(iii) Value share of seed source by agro-regional region

Finally, Table 6 takes a look at the share values for the various seed channels in Kenya in 2004 categorized by the agro-regional zone. In terms of value, formal seed sources are important for all agro-regional zones, except in the Eastern and Coastal Lowlands. Over 40% of all seed purchases from the formal channels are for maize in the high potential maize zone. But retained seed use is spread over wider geographical area and more crops. Four-fifths of all seed used in Eastern Lowlands by value is retained seed. This may be attributed to the fact that the Eastern and Coastal lowlands are generally arid and semi arid areas.

Table 5: Value shares of seed channels, by agro-regional zone in Kenya

Zone	Retained Seed	Informal Purchases	Formal Purchases
		----- % Of value in the region -----	
Central Highlands	49	10	41
High Potential Maize Zone	31	7	**61**
Eastern Lowlands	**80**	11	9
Western Lowlands	45	7	48
Western Transitional	11	4	**85**
Western Highlands	35	6	**60**
Coastal Lowlands	55	26	19

Source: Tegemeo Household Survey 2004, Authors' Calculations

(iv) Value share of seed source by household income

Income is hypothesized to influence the use of formal or informal seed systems (Table 6). There is evidence that in terms of income quintiles, both the formal and informal seed channels are important. In terms of overall value seed shares, more than half (52%) all seed used by households while retained seed is valued at 40%. Higher income households' seed

value is 5 to 6 times that of lower income households, meaning higher income households are able to access quality seed more than the lower income households.

Table 6: Value share of seed channels by household income quintiles in Kenya

Income Quintile	Retained Seed	Seed purchases from informal sector	Seed purchases from formal sector	Mean total value of seed used (Ksh)
	---- % of seed value for each quintile -----			
1 (Lowest)	35	12	53	5,136
2	44	10	46	7,864
3	48	10	42	11,717
4	41	8	51	15,165
5 (Highest)	36	7	57	29,976
Overall	**40**	**8**	**52**	

Source: Tegemeo Household Survey 2004, Authors' calculations

From the above, the basic patterns in seed access show that that the seed sector in Kenya is highly diversified and that nearly all households rely on all the three types of seed. Retained seed is important across all income levels. Also among households, high shares of seed are retained as compared to what is purchased. This has implication on the productivity of the crops, since recycling of seed leads to reduction in seed vitality and hence yields. With the exception of vegetables and non-tree fruits, the share of purchased seed form the informal sector among households is low. The formal sector seems to primarily serve the higher income households and is heavily focused on maize, especially in the high potential zone.

2.4 Adoption of Improved Seed in Kenya

We now turn the discussion to adoption of seed, and investigate key factors that affect household adoption of improved seed. An understanding of this helps in charting out policy options that can lead to access and high adoption of improved seed thereby resulting in increased productivity. We first take a look at the factors affecting access to the seed and then discuss the level of adoption of improved seed.

2.4.1 Factors affecting access and use of improved seed

A number of factors can explain the patterns of seed adoption in Kenya. Some of these are system related while others are farmer-based or economic in nature. Discussed below are some key factors that influence the type of seed farmers use.

(i) Input supply systems

While there exists effective demand for productivity-enhancing inputs by farmers, this is often not matched with an effective input supply system that makes the inputs available when and where they are needed and affordably.

Table 7 shows the seed demand and supply situation in Kenya in 2005. Maize seed is the most produced and traded seed in Kenya. On average 25,000 mt of seed maize is produced annually. Apart from maize, beans, sorghum, rice, cowpea and pigeon pea are other important crops. Free seed is normally distributed to smallholder farmers as an emergency response following disasters such as drought or hunger, and therefore is not an annual event. The crops normally included in the relief seed program are maize, beans and sorghum. Inadequate formal seed supply systems dampen, or even preclude the diffusion of new crop varieties.

Table 7: Seed demand and supply situation for selected crops in Kenya (2005)

Crop	Acreage planted (ha)	Total seed demand (mt)	Formal seed supply (mt)	Proportion of formal: total seed (%)
Beans	1,034,477	62,069	1,030	2%
Cow-pea	72,654	2,034	565	28%
Maize	1,760,618	44,015	27,500	62%
Millet	92,430	739	175	24%
Pigeon-pea	180,240	5,047	19	0%
Rice	15,940	1,275	300	24%
Sorghum	122,368	1,224	433	35%

Source: Authors' analysis of Sector interviews; Ministry of Agriculture; KEPHIS; Seed Companies

(ii) Lack of credit

At the retail and wholesale levels, stockists lack the credit facilities to assist in making the inputs available. They therefore order less stock which make their operational costs are high. These costs are often passed on to the farmer resulting in higher input costs. In semi-arid areas, there is even more tendency for farmers to recycle their seed, since most varieties are open pollinated (OPVs) that still perform relatively well after several generations unlike hybrids.

(iii) Distance to stockist

Distance to the stockists is equally an important determinant of fertilizer adoption. Evidence exists that farmers do not necessarily purchase inputs from the nearest stockist (Table 8). Farmers would travel an average of 7 km to purchase fertilizer and hybrid seed, even though the distances to nearest stockist are shorter (4 km). The reason is that farmers tend to purchase seed and fertilizer at the same time and from the same stockists. Thus use of hybrid seed is highly correlated with use of hybrid seed. The difference between where farmers purchase inputs and the nearest input seller are significant. Where distances to stockists are longer, hybrid use tends to be low and vice versa (Table 9). For example, distance between stockists and farmers tend to be shorter in the high potential areas (Western and Central highlands). The farmers often travel longer distances to purchase inputs mainly to take advantage of lower prices. Thus while a stockist may be located near a farmer, the farmer would opt to travel longer distances to buy inputs if he/she is convinced that doing so would be cost-effective.

Table 8: Distances to agricultural inputs stockists

	Mean Distances (Km) to			
Agro-regional zones	**Where farmer buys fertilizer**	**Nearest fertilizer seller**	**Where farmer buys hybrid maize**	**Nearest hybrid maize seller**
Coastal Lowlands	25.5	18.5	21.3	18.7
Eastern Lowlands	7.8	4.3	8.1	3.9
Western Lowlands	10.7	7.3	9.3	5.3
Western Transitional	5.4	2.8	5.2	2.7
High Potential Maize	10.4	3.0	9.7	3.0
Western Highlands	3.2	1.4	3.5	1.6
Central Highlands	3.4	1.4	3.6	1.5
Marginal Rain Shadow	9.5	6.2	11.1	5.2
Average	**7.1**	**4.1**	**7.3**	**3.9**

Source: Tegemeo Household Survey 2004, Authors' Calculations

(iv) Land size

The use of improved seed varies across the country, being highest in the High Potential Maize zone (90%) and lowest in Coastal Lowlands with small landholders using substantially less even in high potential zones (Table 9). This seems consistent with the argument put above with regard to distance: the longer the distance to the stockist, the lower the adoption of improved seed. Overall, only 53% of farmers were using improved maize seed in 2005, meaning that nearly half of the seed maize used in the country comes from local varieties sources.

About half of farmers owning less than 2 acres use hybrid maize seed compared to over 60% of the farmers in the larger farm categories of more than 5 acres. Again use is highest in the high potential maize and western transitional and highland zones, suggesting the importance of well functioning input distribution system.

Table 9: Farmers using improved maize seed in Kenya by farm size in 2004

	Farm size (acres)			
Agro-regional zone	**Less than 2 (N=313)**	**2 to 5 (N=556)**	**More than 5 (N=528)**	**Total (N=1397)**
	------% of farmers using improved seed-------			
Coastal Lowlands	0	0	0	0
Eastern Lowlands	18	12	14	13
Western Lowlands	6	11	21	12
Western Transitional	31	63	73	64
High Potential Maize Zone	85	93	90	90
Western Highlands	54	70	90	64
Central Highlands	52	56	45	52
Marginal Rain Shadow	71	70	56	66
Total	***48***	***50***	***61***	***53***

Source: Tegemeo Institute Household Survey 2004, Authors' computation

(v) Regulatory and legislative issues

The seed sector in Kenya was fully liberalized in 1996. With the liberalization the government was obliged to make the required policy and legal reforms to enhance seed production and trade. This saw the increase in private sector participation in the production and marketing of seed. Kenyan seed system is governed by the Seed and Planting Materials Act (CAP 326). The Kenya Plant Health Inspectorate Services (KEPHIS) is mandated by the Act to regulate the production of certified seed in order to ensure that high quality seed standards are maintained.

A critical component of the formal seed system is the requirement that the KEPHIS be involved at every stage in the development, release and production of the seed and in licensing the distributors of the seed categorized under Schedule II[4] of the Act. They conduct field inspections, seed testing and certification before the seed can be distributed to seed merchants. In addition, KEPHIS is charged with ensuring seed quality through collaboration with the seed companies and KARI. Despite this requirement, most of the crops in the Schedule do not have well-established breeding programs or even varietal maintenance

[4] Schedule II crops must undergo mandatory seed certification and include cereals (maize, wheat, barley, sorghum, millet, oats, and Triticale), legumes (beans, peas, cowpeas, pigeon peas), oil crops (sunflower, oil-seed rape, linseed, soya bean and sesame), grasses, pasture legumes and root crops (Irish potatoes).

programs. As a result, a large share of the seed used in Kenya is technically "illegal" since it has not been certified. Yet, the informal system is much wider and important to just be branded illegal. Clearly, such a situation is not conducive to improving seed quality for all Kenyans; a necessary condition for developing more formalized approaches to providing improved seed to farmers has as a necessary condition that the broad informal system in Kenya have a legally recognized space in which to operate.

With regard to international trade, KEPHIS also ensures that imported planting material is disease-free and adaptable to the country's agro-climatic conditions. As a result, all imported seed and planting material must be accompanied by a phytosanitary certificate and an international orange certificate of the International Seed Testing Association (ISTA), and must meet the Kenyan quarantine requirements as set out in the Plant Protection Act (Cap 324). However, there are complaints that seed importations are subjected to looser regulations than the local seed. Some seeds imported into the country and already in the market are of questionable quality, yet the development and release of new varieties takes too long. According to the Seed and Plant Varieties Act (Cap 326), Regulation 10(1)) 'Only cultivars officially released by the Minister (for Agriculture) and ***advanced breeder's lines which have potential for release*** shall be eligible for certification.' Currently, only the first part of the section is operational; advanced breeder's lines are not being certified or released. This tends to give undue advantage to seed importers, who will then take a shorter time to have their seed certified.

The essence of the liberalization was twofold: (i) to encourage local and foreign investment in the seed sector on a level ground thereby not discriminating in any way and stimulate growth in Breeding, production and marketing; and (ii) encourage self-regulation i.e. investing in trust with the Private sector. These measures would impact directly in making new technologies accessible to farmers resulting in increased productivity, a path to a green revolution and eradication of poverty. Additionally, the government of Kenya is signatory to various International Trade Agreements like the World Trade Organization (WTO), Trade-Related Aspects of Intellectual Property (TRIPS), regional treaties such as the Common Market for Eastern And Central Africa (COMESA) and the East African Community (EAC) as well as International protocol agreements like Union for the Protection of new Varieties (UPOV) and the Cartagena Protocol. Despite these provisions, the seed sector still is overregulated.

Over regulation in the sector does not affect only the informal system; the formal private sector has complained of the way KEPHIS has adopted an attitude of 'policing' the industry and exercising regulatory monopoly powers over the private sector rather than providing services, co-ordination and leadership in the seed industry. They specifically suggest that over-regulation is hindering production and release of new certified seed varieties, especially by local breeders

2.4.2 Seed Adoption

Table 10 shows summary results of three linear probability regressions (Logit model) attempting to explain the factors associated with the adoption of formal seed – purchased hybrids or OPVs[5]. Full results including all coefficient estimates and significance levels are presented in Annex 1. Data for the analysis was obtained from the Tegemeo 2004 household survey. Industrial crops were dropped from the analysis because the use of improved seeds in these crops is associated with the vertically integrated organization of the crops' supply chains, and thus holds less policy interest for this paper. For all other crops, we first ran the regression on all crops in all fields, then ran separate regressions for maize, non-maize cereals and pulses (not reported in summary table), and vegetables. In all cases, we controlled for agro-regional zone. Also in the overall regression we additionally controlled for crop type, while in the non-maize cereals and pulses and the vegetable regressions we controlled for specific crops within those groups.

Form the table it is generally observed that, with the exception of education of the household head and regional indicator variables, results for maize and vegetables are quite similar, suggesting that the same set of factors drive the adoption of hybrids and purchased OPVs across these crops. Because hybrid use is so low among non-maize cereals and pulses (less than 2%), results for that regression (in Annex 1) are less comparable. Female headed households are less likely to use formal seed, especially on maize. This result persists despite controlling for other variables (see below) that could be correlated with female headedness, such as household assets, education of the household head, and household size. We therefore consider this a strong result. Education of the household head has significant positive effects for maize. Household-head's education does not seem to affect adoption of formal vegetable

[5] Note that about 93% of all purchased seed is of hybrids – purchases of OPVs are relatively rare – so that this analysis primarily reflects the factors associated with purchase of hybrid seed.

seed or cereals other than maize. These results seem to be consistent with other finding in Africa that returns to education are much lower in agriculture than in non-farm enterprise (Michaelowa 2000; Joliffe 1998; Joliffe 2004).

Results on total household land area are positive and very strong in all regressions. Land area's effect is especially strong on non-maize cereals and pulses (see Annex 1) and vegetables. Use of fertilizer is clearly associated with use of hybrid seed in maize, and those with more years of using fertilizer are consistently more likely to use hybrid seed than those with less. In vegetables, it appears that having *some* experience helps, but having *more* experience does not help any more. Surprisingly, we find little effect of distance to a motorable road (or other variables measuring distance to transport and economic infrastructure). In the "all crops" regression, the 20% of households most distant from such a road are somewhat less likely to use formal seed, but otherwise no consistent pattern is found. Results on household assets suggest that the most asset poor households are least likely to use improved seed; yet for each individual crop group, households with the most assets are not much more likely than others (except the very poorest) to use such seed.

Regional variables show that, controlling for all other variables (including crop) farmers in the Eastern Lowlands are always the least likely to use improved seed, while those in the High Potential Maize zone are, with the exception of vegetables, always the most likely to use such seed. Results for Western Lowlands are quite variable:- they are less likely than farmers in the Coastal Lowlands (the omitted dummy) to use improved maize seed, but are the most likely to use formal vegetable seed.

Table 10: Summary results on factors associated with use of purchased seed in Kenya

Variable	All Crops	Maize	Vegetables
Household is female-headed	Female-headed households are 25% less likely to adopt	Female-headed households are 24% less likely to adopt	Female-headed households are 14% less likely to adopt
Education of household head	Some education increases adoption, but more does not continue to increase it (those with no formal schooling adopt less, otherwise no effect)	Some education increases adoption, and more (past 8 yrs) increases it more	No apparent effect
Size of land holdings	Steady increase in adoption as total land holding size increases	Steady increase in adoption as total land holding size increases	Steady increase in adoption as total land holding size increases
Household size	Steady increase in adoption as total household size increases	Steady increase in adoption as total household size increases	Only the largest 20% of households show higher adoption rates
Years using fertilizer	Those with some experience, even small, are more likely to adopt than those with none (those with none are less likely to adopt)	Steady increase in adoption as experience with fertilizer increases	Those with some experience, even small, are more likely to adopt than those with none (those with none are less likely to adopt)
Distance to motorable road (km)	The most distant 20% are less likely to adopt; otherwise no apparent effect	Inconsistent pattern	No apparent effect
Value of household assets	Steady increase in adoption as total value of household assets increases	Some increase in adoption as total value of household assets increases	The 20% of households with the lowest value of assets is less likely to adopt; otherwise no effect
Crop type	Maize and vegetables most associated with adoption; non-maize cereals and pulses least associated	----------	----------
Type of vegetable	----------	----------	Carrot, French bean, cabbage among most likely to use; onion and cucumber among least likely
Regional variables	Eastern Lowlands much less likely to adopt; HPMZ much more likely.	Eastern & Western Lowlands much less likely to adopt; HPMZ much more likely.	Eastern Lowlands and Central Highlands much less likely to adopt; Western Lowlands much more likely.

2.5 Returns to improved seed use in Kenya

In previous sections, we examined the structure of the seed sector in Kenya, and analyzed who tends to use the various seed channels – retained, purchased informal, and purchased formal. The question that begs answer is whether it pays for a Kenyan farmer to spend cash income for formal or informal seed, rather than retaining it on the farm. In this section, we present an analysis of the returns to use of formal seed.

We used a linear regression approach to examine this question, the results of which are displayed in Table 11. We ran separate linear regressions for 13 crops that had sufficient observations in the 2004 Tegemeo Household Survey dataset to give robust results. The data points used in each regression were each planting of the given crop on a specific field; for example, if one household planted one crop on each of two fields, plus two other crops each on one field, we would use four data points from that household in the analysis (assuming each crop was among those we chose for the analysis).

Each regression controlled for the size of the field, the amount of fertilizer used (with manure and inorganic fertilizers separated), whether a field was prepared manually, with oxen, or with a tractor, the number of additional crops on the field, agro-regional zone, and a series of household variables: household size, whether it is headed by a female, education of the household head, years of experience planting hybrids, and the value of assets. Here we report only the focus of interest in this analysis: whether it pays for a household to purchase informal or formal seed, rather than retaining seed from its own production. In interpreting the results, any return above Ksh 1 indicates that, on average for that crop, households increase net earnings if they purchase formal or informal seed, rather than using retained production.[6]

Overall, results suggest that purchasing formally certified seed in Kenya – rather than retaining seed or purchasing informal seed -- pays off in terms of net returns to the cropping activity. In six of the nine crops for which we had sufficient observations on purchases of formal seed, returns to this seed were positive, larger than Ksh 1 (so that net earnings rose for the average farmer), and statistically significant.

[6] The regression results should not be interpreted as the marginal product of each type of seed in each crop, because we have not estimated fully specified production functions. However, the large sample size and the ability to control for many relevant variables means that the results should provide a solid basis for assessing whether and to what extent it pays for farmers to invest in formal seed in the country.

Table 11: Regression results on returns to use of formal and informal seed in Kenya

Crop	N	% Purchasing formal seed	% Purchasing informal seed	Ksh earned from using 1 Ksh of retained seed	***Additional*** Ksh earned from purchasing 1 Ksh of:	
					Informal Seed (Ksh)	Formal Seed (Ksh)
Maize	4,769	54.0	8.6	2.95***	0.20	**5.78*** **
Dry beans	3,922	0.3	44.3	1.46***	0.07	**3.37*** **
Sorghum	727	2.1	28.9	1.81***	-0.04	**1.86*** **
Irish potato	1,678	0.0	54.7	1.95***	**0.91*** **	----
Groundnut	249	1.2	68.0	3.20***	**3.09*** **	----
Sweet potato	1,434	0.0	6.3	3.66***	0.15	----
Tomato	805	60.0	24.2	-5.96	**23.56*** **	9.8
Sukuma wiki	1,865	47.2	38.1	0.45	0.41	**4.26*** **
Spinach	500	37.3	46.5	1.32	-0.66	**2.09** **
Pumpkin	1,217	0.0	10.5	40.00***	**-13.28*** **	----
Cabbage	674	78.5	19.4	42.16	-38.27	-35.30
Carrots	330	97.3	2.4	4.88	-8.69	-3.03
Onion	1,186	15.4	31.1	0.07	-0.02	**9.08*** **

Key: * Significant at 10% level; ** significant at 5% level; ***significant at 1% level.
Source: Tegemeo Household survey 2004, Authors' calculations

We do not find evidence of positive returns to formal seed (or informal seed) in cabbage and carrots, but this statistical result may be driven by the very large shares of households already using formal seed for these crops – 79% and 97%, respectively; given this pattern, it appears quite likely that most farmers of cabbage and carrots are improving their returns by purchasing formal seed. Informal seed appears to generate a positive net return, on average, in groundnuts, while Irish potato farmers who purchase informal seed, rather than retaining from their harvest, appear approximately to break even, increasing gross earnings by Ksh 0.91 for every Ksh 1 that they spend.

Two potentially anomalous results should be interpreted with caution. First, the 10.5% of pumpkin growers that purchases informal pumpkin seed appear to have earned significantly *lower* returns than those that used retained seed. For those interested in this crop, the result bears investigation in the field to determine if there are serious problems with the informal pumpkin seed that is sold in rural areas. Second, informal tomato seed appears to generate substantially *higher* returns than does formal tomato seed. Given the importance of tomato cultivation for many Kenyan farmers, this result may bear special attention.

One possible explanation would be that most small-scale farmers do not prepare tomato seed nurseries and would buy tomato transplants from the vendors in the informal market. Thus the seed may have come from originally from the formal system but the fact that they are

transplant makes it difficult to discern whether they are formal or not. The question then is: are there highly effective programs in place for producing and trading informal tomato seed? Note that about a quarter of all tomato growers purchased informal seed, and we find no statistical outliers in the data, so that these results appear to be reasonably robust in a statistical sense; further investigation would be needed to confirm that these results indicate actual superiority of informal tomato seed.

3.0 Seed Access and Utilization in Kenya: working innovations?

A key question that ought to e answered with regard to seed access and utilization is, what seed system is working for the various commodity groups and why are they working. The answer to this question holds key to the enhanced use of improved seed. This section describes some cases of seed distribution systems. The commodities are categorized into four groups: horticultural crops, grains and pulses, commercial/industrial crops, and fruit trees.

3.1 Horticultural crops

Horticulture in Kenya has been cited by various studies as a success story (Minot et al, 2002, Nyoro et al, 2004). The sub-sector is important both for foreign exchange as well as domestic consumption. In 2005, it was ranked the highest foreign exchange earner, bringing to the economy some Ksh 45 billion in foreign exchange, and Ksh 44.3 million from internal trade (GoK, 2005). More than 400,000 hectares was put to horticultural production in 2005. For the commodities destined for export market, the stringent market conditions require the use of high quality seed and other agronomic practices. Farmers producing for the European market, for example are required to adhere to the EUREPGAP conditions.

Seed system for horticultural crops is heavily oriented towards the formal seed purchases. The crops are high-value in nature and therefore, farmers who grow them tend to do so for commercial purposes. Commercial farmers normally use improved seed, while a large proportion of those producing for subsistence use seed from local sources, often retained. Most of the horticultural crops produced for local market are produced using local varieties which are not certified, while those commodities destined for the export market (baby corn, French beans, snow peas) tend to be grown using mostly certified seed (Table 12). In many of the cases, marketer (exporter) supplies the farmers with seed and specifies the importer's requirements of the eventual produce. For these crops, the exporters dictate the varieties to be grown and even the source of seed. Where necessary, the exporters import the seeds on behalf of the farmers.

A number of techniques for seed production and distribution exist for horticultural crops. In this section we discuss two of the techniques, one for the Irish potatoes and the other for horticultural crops that destined for export.

3.1.1 Positive Selection in Irish Potato

Irish potato is one of the main staple foods in Kenya today, especially in urban centres, and plays an important role in food security. There are about 500,000 potato farmers spread out in various parts of Kenya. In 2005, a total 0f 120,000 hectares were put under Irish potato production, mainly in Central, Rift Valley and Eastern provinces. The total production during the year averaged 1 million metric tonnes between 2004 and 2005.

Despite importance of Irish potato industry in Kenya, the crop faces a number of key challenges. There is inadequate supply of certified seed, to the extent that farmers almost solely rely on informal seed sources (farm-saved, local markets or neighbors) for their planting material (Table 12). In addition, the cost of certified seed and other productive inputs is out of reach of most small-scale farmers[7]. The Kenya Agricultural Research Institute (KARI) Potato Research Centre, Tigoni, produces basic seed for multiplication in high altitude farms. However, only 1% of the farmers can access this planting material, since the seed distribution network is collapsed in the early 1990s. Because of the high demand for the certified seed and its unavailability, most farmers resort to the informal system for planting material which include farmer-saved seed, exchange with neighbors and purchase of seed from unlicensed growers and seed suppliers mainly in their immediate localities (Ogolla, et al, 2002; Ayieko et al, 2005). This system exacerbates the use of poor quality seed and often that leads to spread of seed-borne disease.

To address the formal seed constraints in Irish potato production, a number of institutions have come together through private-public partnerships to assist farmers to access fairly clean planting material as a means to enhance potato production. One such initiative is a concept known as positive seed selection approach (See Box 1). In the approach, farmers are trained to identify and differentiate healthy plants to be earmarked for seed development while the crop is still in the field. These healthy plants are pegged for observation. As the crop matures, any selected plant that show slight signs of disease is unpegged. The remaining pegged plants are harvested first, to be used for seed, before the rest of the crop is harvested.

[7] A 50kg bag of seed potato is sold for Ksh 1, 900 and a farmer needs 14 to 15 bags per acre

Table 12: Seed Sources for selected Horticultural Crops

Crop	Purchase Hybrid	Retained Hybrid	OPV	Local Variety	Seedlings
Baby corn*	100	0	0	0	0
Carrots	97	0	0	0	2
French beans*	87	9	0	0	4
Cabbage	78	0	0	0	21
Snow peas*	63	0	18	15	5
Sunflower	62	3	9	18	9
Tomatoes	60	2	1	2	36
Sukuma wiki (Kales)	47	1	1	1	50
Capsicum	42	1	3	2	51
Watermelon	39	0	0	11	50
Spinach	37	1	1	0	61
Dhania	35	12	24	29	0
Brinjals/biriganya	27	0	0	8	66
Onions	15	0	0	0	84
Runner beans	7	0	13	67	13
Chili peppers	2	1	2	8	87
Green peas	2	0	53	43	1
Indigenous vegetables	2	0	18	51	28
Irish potatoes	1	0	0	0	99

* Commodities produced for the export market.

The advantage of this approach is that the potato farmers are able to obtain fairly good quality clean seed without being subjected to the stringent conditions – and high cost - of the formal seed system which require KEPHIS certification. Farmers have been able to increase their potato yields by up to 30% through use of clean seeds from positive selection. A comparison between planting materials from three different seed potato management practices (farmer practice, positive seed selection technique and the certified seed) reveal that the yields from positive seed selection compares favorably with the certified seed. Farmers have been able to realize between 5 and 7 metric tonnes per acre, up from 3 to 4.5 tonnes before the project. The concept is easy to grasp by farmers, and its cost to the farmer is minimal. Farmers can learn and train their neighbors. KARI has been giving farmers using this approach in training a technical backstopping and the initial basic seed for multiplication.

Positive selection approach stands out as a viable means to make seed available to most potato farmers. Table 13 provides certain attributes of three techniques to potato seed access, namely, the positive selection, the formal seed system, and the local seed system of making seed available to farmers. By comparison, certified seed is three times as expensive as the positive and local seed systems. In addition, quality of seed from positive selection, though not certified, is quite high. Yet yields compare favorably to those obtained by using the certified seed (between 5 to 7 metric tonnes), but almost twice yields obtained from local varieties. Positive selection technique is also easily transferable since it is done on farmer's fields. In terms of farmer reach, the positive selection, within the shorter time it has been in existence, has reached about 20,000 farmers, about four times those reached by the formal seed system.

Box 1

Positive seed selection in Irish potatoes

The production of disease-free seed tubers of high-yielding varieties is recognized as an important aspect in improving yields and controlling seed-borne diseases in farmers' fields. After years of problems with seed potato, an initiative involving KARI-, Midlands Limited (a private Irish potato seed producing company) and a joint venture by KARI, CIP, GTZ, MoA and two farmer groups in Ol-jororok (*Ol Marei* and *Eol-Enkitok)* has brought hope of farmers accessing quality seed. The initiative, dubbed the Positive Selection Approach. The aim of this initiative is to facilitate access to cheap and clean planting materials to farmers within their localities. Through support from these organizations, farmers get basic seed from KARI for multiplication and selection.

The farmer groups employ the positive seed selection technique to come up with clean and high-yielding planting materials. The farmers are trained to identify disease-free plants during active vegetative growth phase, and mark them in the field for further selection. During harvest, tubers from the marked healthy plants are first harvested before the rest of the crop is harvested. Seed tubers for the next crop season are obtained only from these plants. To be selected as seed for the next season, the marked plant must be disease free, and must have more than four tubers. These tubers are then considered as clean seed for use, and can be circulated among the group members. The technique, first tested in Bomet district to demonstrate on-farm improvement of seed tuber quality, has resulted in improved yields to farmers. To date, the approach has made available to more than 20,000 small-scale farmers, but the approach has the potential to reach up to some 100,000 farmers.

Table 13: Comparison of Positive Selection to other seed types

System attribute	Formal system	Informal system	
	Certified Seed	Local Variety	Positive Selection
Seed Cost (Ksh/kg)	38	13	13
Mean yield per acre (metric tons)	7.5	4	7.5
Seed Quality	High	Low	Relatively High
Certification	Certified	Not Certified	Not Certified
% Farmers Reached	1	95	4
Transfer of Technology	Moderate	Easy	Easy
Disease Prevalence	Disease-free	High infection	Effective against wilt than virus
Challenges:	Seed availability	Diseases; low yields	No quality verification done

3.1.2 Seed access through contract farming

As with any other export ventures, export horticulture is subject to stringent export market conditions, which, in most cases, is out of reach of most small-scale farmers. The biggest challenge facing production is lack of quality seed, high cost of inputs and lack of streamlined market (GoK, 2005). Seeds for horticultural commodities are generally very expensive and mostly imported. While Kenya Seed Company (KSC) Ltd, through its subsidiary, Simlaw Seeds, has been the only local company producing horticultural seed, the supply of these seeds has been very low.

A number of farmers producing organizations export horticulture have to some extent got around seed challenges through contract farming with some well established firms and NGOs. As part of the contracts, the contract sponsors recommend, procure and distribute many or all material inputs. An example of a successful contract farming venture in which quality seed acquisition has been an integral part of the contract is the Vegcare project in Kibwezi division of Makueni district which is financed by Care-Kenya, an NGO (Box 2). Horticultural farmers in the division have been using seeds from a number of sources for seed, ranging from farm-saved seeds, local seeds purchased from neighbours or local markets; or individual exporters. The NGO has been assisting farmers to access seed, fertilizer and irrigation equipment through the contractual arrangement.

Box 2

Contract Farming as a means to accessing quality seed

Vegcare Horticulture Company Ltd, whose key shareholders are CARE-Kenya (an NGO) and Vegpro Kenya Ltd (Horticulture Exporters), was set up with a mission of making the markets work for the smallholder horticulture farmers. The company promotes a rural agribusiness support program that targets the poor. To date, the company has contracted about 250 farmers from Makindu, Kibwezi and Mtito Andei divisions of Makueni district to produce Asian vegetables (*Okra, chilies, Karella, brinjals, Ravaya*) gourds and baby corn for export, mainly to the United Kingdom (UK). The company provides the farmers with access to export market at annual contracted volumes and prices. In addition, the company assists farmers to access affordable credit facilities for horticulture production.

As part of the contract, the company offers training and extension services to contracted horticulture smallholders. After training, farmer groups were given irrigation equipments, seeds, fertilizers and chemicals. The company secures seed from various sources and distributes the same to farmers. Most of the seed is imported and issued to farmers in form of credit. Before inputs are issued, a thorough assessment of potential farmers is done to ascertain that the farmers have the capacity to utilize the inputs productively. The company assists farmers to bulk seeds that are not readily available in the market.

A number of challenges face this approach to promoting agricultural production. First, the program targets poor farmers, who are the most vulnerable of the society. However, these farmers also tend to be the most inefficient producers. To address this challenge, the company has since shifted focus from poor farmers to working with those farmers who are willing and able to produce. Secondly, the contractual arrangement suffers from spot buyers, and this hamper s input loan recovery. Also, group dynamics are essential to the success of the project. Where a group disintegrates, the company finds it difficult to recover its loans. Third, is the problem of credit recovery. Because the company has been working with poor farmers, the program has suffered from poor recovery of input credit to the farmers. In addition, there have been problems with ownership of program facilities such as irrigation equipment, was crucial. Also, the farmer groups had no binding contract with the program and could choose to market their produce elsewhere. As a result, there have been cases of contract violation, arising from non-production.

3.2 Grains and Pulses

Grains and pulses are very important in Kenya's food security agenda. These crops tend to be low-value, and are cultivated by almost all households in most parts of the country. Compared to other commodities, these crops have a generally well established seed system throughout the country. Despite this, evidence shows that the seed distribution system for most of these crops is heavily dependent on local varieties, a large proportion of which is retained. Table 14 shows the types of seed for crops that have food security agenda, which include the grains, pulses and a number of tubers. It is evident from the table that most of maize planted in the country is hybrid (46%). Nearly one-third (30%) of the seed maize is local variety. Most of seed wheat is however retained hybrid. Other crops that are important in the food security agenda tend to be purchased from local varieties (e.g. sorghum, millet, cassava, beans cowpeas). For example, about 70% of sorghum, 67% of millet and 81% of bulrush millet are local varieties. This trend suggests the importance of informal seed system in addressing seed and food security in the country.

Table 14: Type of Seed for Grains, pulses and other crops with Food Security Agenda

Crop	Purchased Hybrid	Retained Hybrid	Open Pollinated Varieties	Local Varieties
Maize	46	5	8	39
Wheat	30	42	11	16
Oats	29	9	18	41
Rice	10	5	55	30
Bulrush millet	6	0	13	81
Soya beans	4	0	46	50
Sorghum	2	0	29	69
Millet	1	0	32	67
Groundnuts	1	0	68	31
Beans	0	0	44	55
Cowpeas	0	0	33	55

Source: Tegemeo Household Survey, 2004, Authors' Calculations

A number of models have been used to distribute seed in this category of crops. These include the formal seed system, community-based seed multiplication, relief seed, and seed vouchers and fairs. The formal seed system for grains and pulses has been through seed companies distributing the seed to stockists from where the farmers can purchase the seed. However, because of the inadequacies in the formal seed system to meet the demands for farmers for quality seed, a number of models have emerged to fill the gap. These models are supported by development agencies such as NGOs. Their strength is in the fact that they work

very closely with the farmers, and tend to be localized. They also tend not to be subject to the stringent conditions imposed by the KEPHIS. In this section we discuss, some of the more successful approaches to seed production and delivery among farmers. These include the Community-based approaches, the seed vouchers and fairs.

3.2.1 Community-Based Seed programs

Farming communities, especially those in the marginal areas, face problems with seed access and often resort to using local seeds especially for cereals and pulses. In many parts of the country, farmers face challenges with access to good quality seed which is affordable and meets their prevailing weather conditions. As a result the productivity has been low. The constraints for these farmers are wide-ranging and include persistent drought, high cost of inputs, and unavailability of the inputs. Several reasons have been cited for their use of use local seed, including: the high cost of seed, long distances to stockists, unreliable rainfall, the *striga* weed, and lack of knowledge on advanced technology. Lack of information on type of seed suitable for particular regions has often brought confusion among farmers and crop failure. In some areas of the country, there have been as many as four to five seasons' total crop failure, meaning that every time a farmer invests in purchased input (including seed), the result is sunken costs. This often discourages the farmers from purchasing the inputs.

A number of community-based approaches have been used in seed multiplication as a means to preserve seed and ensure availability to farmers. Most of the community-based approaches are embedded in the food security programs. The objective of these approaches is to help farmers preserve the local germplasm and ensure they have seed to rely on for crop production. The initiatives to bulk seed have been implemented through farmer groups with the support of the Ministry of Agriculture. Farmer groups are supplied with starter seed to multiply and distribute to other farmers. Seeds given to farmers include maize (mainly the composites), beans (Katumani Beans varieties 1 up to 9), sorghum, and millet.

These Community-based initiatives to bulk seed have received support of the donor agencies. Churches and NGOs have embarked on assisting the rural folk to address their food security problem through encouraging seed multiplication, to address the lack of improved seed. For example IFAD is promoting horticultural production and utilization of traditional food crops in Eastern province. *Njaa Marufuku* Kenya (NMK), a United Nations' Food and Agriculture

Organization's (FAO) programme to kick hunger out of Kenya, has given grants to a number of groups for purposes of seed bulking. In Machakos district, Winrock International trained and supported groups in seed bulking. Through this initiative, the groups are able to bulk seed, and in collaboration with KARI Seed Unit – Katumani, which is being distributed through a stockist in *Machakos* town.

CARE Kenya has also been working with various communities to help alleviate poverty and improve food security within the households by supporting the acquisition, and bulking of cereals, pulses (green grams, beans, cowpeas) and horticultural (okra, onions, tomatoes, mangoes, chilies) seeds. CARE facilitates groups of poor farmers in areas of their intervention to acquire seed. CARE acquires the seeds from seed companies on behalf of the farmers at cost. Whenever farmers are given the seed on credit, they are required to return double the quantities given at harvest. This kind of intervention has enabled farmers to acquire and use improved seed thus improving production on their farms. These initiatives have led to increase in improved seed use among farmers in the marginal areas.
In Homa Bay, Mbita and Kitui districts for example, the Catholic Diocese through its subsidiary the Catholic Relief Services (CRS) working with KARI and CIMMYT have embarked on efforts encourage to community seed multiplication, by promoting the bulking of groundnuts, cassava, sweet potatoes, sorghum and maize. The Adventist Development Relief Agency (ADRA), also works with organized farmer associations to improve their food security situation in assisting poor farmers in drought-prone areas to access seed. The farmers are given different agriculture skills to enable them boost their agricultural production (seed multiplication, tree production). To ensure seed accessibility to farmers, ADRA assists the farmer associations to build seed stores, and in collaboration with KARI-*Katumani*, distribute clean seed to the groups for multiplication.

The strength of community approach to seed bulking lies in the fact that the communities understand their constraints. They therefore come together to address their own problem. The groups are able to preserve the local germplasm. However, problems of group dynamics may hinder the thriving of the groups. It is worth noting that many of the groups come together because of the funding they are likely to get from the donors to support the project. Once the donors pull out, and no funding is trickling in, most groups also collapse. It is therefore imperative to mould the groups around business models so that they can be self-sustaining.

The main challenge to community-based approaches to seed production is that the production systems are not recognized by Kenya Plant Health Inspectorate Services (KEPHIS). Most of these groups cannot meet KEPHIS conditions of keeping the required isolation distances, especially maize seed. The groups cannot meet the licensing fees of a seed merchant if they want to be registered as seed merchants. And, even in situations where they are able to meet these requirements, there have been delays by KEPHIS in seed inspections. The seed therefore ends up not being certified, and so cannot be traded as commercial seed. Sometimes, the groups lose all seed to drought and have to replenish the seed, which often takes time. Box 3 provides examples of some successful community-based approaches to assist farmers to access good quality seed.

Box 3

Examples of Community Seed Multiplication Initiatives

Tuangaze Kyawango Women group (Machakos), made up of 25 farmers, began initially as a Women's Merry-go-round, to assist its members acquire household items. With time, the group identified the need to address their perennial problem of lack of quality seed. With the assistance of the Ministry of Agriculture's Extension Staff, they received training in seed bulking. They also got support from IFAD and germplasm from KARI seed unit. The group has been bulking beans, cowpeas, cassava, sweet potatoes, and sorghum. The group has been able to meet their need for quality seed for these commodities and even sell to their neighbors.

Wendano Kwa Muonga (Machakos) is a farmers group with 40 members. It started as an agricultural group leasing renting land and producing horticultural crops. The groups got training from Ministry of Agriculture extension staff on crop husbandry and seed production. It has been bulking cassava, beans, cowpeas, sorghum, millet, sweet potatoes, green grams and pigeon peas. The bulking takes place in the selected farmers' field, but the group does the operations. The members are then provided with the seed. Through this, the farmers are able to get the right seeds. Because of the success realized, the group has built a seed bank to store the bulked seed. They also intend to establish an irrigation system to ensure they are able to bulk seed even during drought.

TATRO Central Women Group, (Siaya*)* was established with the objective of improving women's conditions by involving them in agricultural development and small agribusinesses. The aim for the group is to first meet their own seed supply needs and then sell the surplus to other farmers. The group has been collaborating with CIMMYT and KARI to produce Open Pollinated Maize varieties, which are stress-tolerant and can be recycled. The group is also participating in the Rockefeller Foundations' Seed Variety Trials, which promotes crop diversification, seed production and marketing. In 2005, the group produced 4.5 tonnes of seed maize and 2 tonnes of beans, and benefited nearly 1000 small-scale farmers from the area. The group, and similar ones, could benefit from a community seed storage bank, which allows participants to deposit and withdraw seed as needed.

The community-based approaches often suffer from bad weather conditions and non-supportive government policies. Due to poor weather conditions in some parts of the country for the last four seasons, seed production and multiplication activities have been severely affected, to a point that most of the groups have lost the basic seed and need replenishment from companies and supporting organizations. Government policy that put very stringent conditions that must be met to produce seed, especially seed maize have also hampered efforts by communities trying to produce their own affordable seeds.

In addition, most of the groups lack sufficient technical know-how and equipment to enable them carry out their seed production activities effectively; they need constant extension to equip them with the necessary skills. With the ill-facilitated extension service, acquisition of these skills is not possible. Moreover, there is lack of markets for seeds produced by the community-based initiatives, since the groups must obtain merchant's licenses to be able to market their seeds outside their localities. Also, farmer communities are not well sensitized on the role of such community seed producers, from whom they can acquire clean quality seed that is disease free to plant in their farms.

Drought and high poverty levels have also contributed to the non-sustainability of these groups because some group members end up consuming the seeds. In the end such efforts might not meet the objectives of self-sustainability in clean, quality seed.

3.2.2 Market-led approaches to seed access

In a liberalized economy, agricultural inputs are a private good. If the private sector functions effectively and efficiently, it should respond to the demand for inputs from all users, including smallholders. And, if inputs are easily accessible and affordable to farmers, their utilization increases with the resultant increase in farm productivity and household incomes. Therefore, fostering sustainable commercial linkages between input supply firms and rural enterprises in the distribution chain will increase the flow of inputs, and associated product knowledge, into rural areas and farming communities. Easier access will, in turn, result in increased uptake and use of inputs by smallholder farmers leading to increased productivity and rural incomes.

Besides the commercial availability of inputs, however, there are other important constraints hampering demand for inputs by smallholders. These include: poverty; weak purchasing power among smallholders; ineffective rural savings and credit services to respond to the cash constraints; poor access to information and technologies; poor output prices; and poor market information and market access. These constraints place impediment to investments in productivity enhancing inputs.

Some interventions have recognized that the best way to increase utilization of productivity-enhancing inputs, seed included, is to approach it from the market perspective. Rockefeller Foundation, for example, has been funding interventions in Western Kenya that aim at empowering farmers through markets to get out of their poverty traps by adopting high-yielding technologies. The interventions target cereals and pulses and are formulated around the Theory of Change (ToC), which postulates that better access to markets for both the inputs and outputs leads to increased input use and adoption of improved technology. The interventions have four components, namely, cereal banking, agricultural input delivery system, market information and technology transfer through Seed Variety Trials (SVT). The Theory hypothesizes that the sum of all the interventions together should be greater than the sum of the impact of the individual interventions. Table 15 presents results of use of hybrid maize seed and fertilizers by beneficiary group to determine whether there are inherent differences between the groups in their usage of productivity-enhancing technologies.

Table 15: Technology Adoption and Agricultural Input Use by Beneficiary Group

Variable	Cereal Bank Members (N=390)	Spillover Group (N=1183)	Control Group (N=106)	Total Sample (N=1682)
Level of Adoption				
Use of Hybrid Maize (%)	57.4	50.0	49.5	51.7
Use of Fertilizer (%)	84.9	76.2	77.1	78.2
Household Characteristics				
% Net Sellers	33.3	25.4	23.6	27.1
% below poverty line	69	82	86	79

Source: Rockefeller Foundation Western Kenya Baseline Survey 2005, Author's Calculations

The beneficiary groups are categorized into direct beneficiaries (cereal bank members), indirect beneficiaries (those who benefit from intervention spillovers) and non-beneficiaries (control group). There exists a wide dispersion in technology usage among beneficiary groups. Cereal bank members tend to use hybrid seeds (57.4%) and fertilizer (84.9%) than either of the other two beneficiary categories, thus confirming the Theory of Change hypothesis. Among the beneficiary groups, the CB members have lower incidences of poverty (69%) compared to the control (82% and 86% respectively). Also CB members tend to be net maize sellers (33%) compared to the other beneficiary groups.

The Rockefeller Foundation's intervention targets not only farmers but also the input stockists. This is as a realization that rural stockists face challenges such as lack of the required capital to meet the input requirements of the producers, lack of knowledge on inputs and business skills. The intervention is to provide training to stockists as well as a credit guarantee system between the commercial manufacturer of agricultural inputs and the input stockists. The intervention through the Agricultural Marketing Trust of Kenya (AGMARK), a local NGO, provides commercial linkages between private sector input suppliers and stockists to facilitate the input flow to the rural areas. The aim is to ensure continuous flow of inputs and bring the inputs within the farmers' reach. AGMARK also facilitates credit guarantee scheme, the objective of which is to improve agricultural productivity and incomes of smallholder farmers in Western Kenya. The underlying hypothesis is that if inputs are more accessible to stockists, this leads to increased purchase and use by smallholder farmers.

A significant impact of the AGMARK intervention has been increased fertilizer and hybrid seed adoption among farmers (Table 16). Fertilizer adoption rate is higher among households who purchased inputs from credit guarantee-affiliated stockists (91%) than those who purchased inputs from non-affiliated stockists (69%). Similarly, adoption of hybrid maize is higher among farmers purchasing seed from AGMARK-affiliated stockists (73%) compared to those sourcing seed from the non-affiliated stockists (48%). Mean fertilizer application rates on maize fields (both basal and top-dressing fertilizers) are also relatively higher among farmers purchasing inputs from the credit guarantee-affiliated stockists (76 kg per acre) than for the non-affiliated stockists (66 kg per acre). These trends could be attributed to the advice and input demonstration services offered by the stockists, backed up with the credit extension to the farmers.

Table 16: Fertilizer and Hybrid Maize Seed Adoption and Use in Western Kenya

	Source of Farmer's Inputs		
	AGMARK-affiliated Stockists (N=40)	Non-affiliated stockists (N=39)	Overall (N=79)
% Using Fertilizer	91	69	73
Mean fertilizer (Kg/acre)	76	66	68
% Farmers using Hybrid seed	73	48	53
Seed application rate (kg/acre)	9	9	9

Source: Tegemeo stockist survey, 2006; interviews with farmers; Authors' calculation

It is clear from these initiatives, that seed access can greatly be enhanced through market-led approaches. Thus, improved access to input and output marketing services enhances adoption of productivity-enhancing technologies by rural smallholder farmers, thereby raising their farm productivity, incomes and food security. Enhancing access to improved technologies alone is a necessary but not sufficient condition to technology adoption.

3.3 Seed access and Food Security

Most farmers are food-insecure. They tend to be net-buyers of food, implying that for the most part of they year, they rely on food purchases rather than food from own production. Poverty levels average 64% in the country. Incomes for majority of the farmers are also low, leading to usage of local varieties (Annex 2).

Therefore, to improve the productivity among farmers, a number of initiatives have been used to address the farmers' food security. Some research programs have been centered on improving the quality of the local seed varieties. For example, KARI-*Katumani* has been collecting local germplasm with the aim of coming up with seeds that are suitable to given environmental conditions. Despite these efforts, the government and other development agencies still have to come in to assist with seed distribution. Some of these interventions have been through seed relief, seed voucher and fairs and other market-led approaches. We now turn to briefly address these.

3.3.1 Seed Relief

Drought has been a persistent problem in Kenya and the incidences seem to increase in frequency. When drought occurs, farmers experience crop failure leading to famine. The response by government and the donor community has been to supply those affected by drought with food relief. This is often followed by distribution of relief seed, to help renew the crops lost during drought. Government relief seed is channelled through the Arid Lands Resource Management Programme (ALRMP), which then uses other agencies such as the Ministry of Agriculture staff, Catholic Relief Services and Anglican Churches of Kenya to distribute the seed to farmers.

Evidence shows that in some of the affected districts, up to 10% of seed used by farmers are relief seed. The seed relief distribution targets all farmers vulnerable to seed deficiencies. Each farmer ends up getting a smaller quantity of seed (often not exceeding 2kg) that does not meet the household's seed demand. Farmers have either to either buy more or use their local variety. This is therefore viewed as an ineffective way to tackle the seed problem. However, if the quantity of seed relief is sizeable, this may dampen the private sector initiatives to promote seed trade in the regions, and goes against the spirit of liberalized market. A further constraint to this initiative is that government often brings seeds not suitable to the conditions of the affected districts leading further to crop failures. Also, the timing of seed distribution is questionable as it is often distributed late after the rainy season has set in. Also the method of seed distribution is critical. The approach to seed relief should target average farmers than all the farmers. This way, they can get more seed, be more productive and then be able to feed the very poor farmers. The assumption here is that extremely poor farmers are not very good farmers.

While drought is a calamity that may strike anytime, these initiatives are not sustainable. The government needs to have strategies that are sustainable. One such strategy is to promote the drought tolerant crops e.g., sorghum, millet, cassava, and sweet potatoes. A further way to minimize seed shortages during drought is to encourage development of small irrigation schemes along the numerous streams where farmers can bulk seed and then sell to other farmers. Seed relief rarely takes cognizance of the extent of seed insecurity. Rather, the decision to distribute relief food is guided by the preceding food aid and interventions

3.3.2 Seed Vouchers and Fairs

Natural disasters often result in food crisis among farmers. The disasters come in different forms but include drought and unusual rainfall patterns, poor harvests, and continuous decline in economic conditions. In many cases, governments and development agencies respond to these calamities through the free distribution of seeds and tools, as an approach to agricultural recovery. The underlying concept behind the seed relief is that farmer seed quality is poor, and the prevailing system insists on seed certification. This is not normally the case.

Seed fairs are markets organized to empower the disaster-affected households to access seed through exchange vouchers (Bramel & Remington, 2005). The seed voucher and fairs address the problem of lack of household access of seed following a disaster and, in doing so, challenges the assumption that seed is unavailable in a community during emergency. It is a concept whereby farmers within a specific locality bring their own seeds to sell to other farmers. The objective of seed vouchers and fairs is to enhance food security and access to seeds of preferred crops as well as to provide seed security to insecure families.

Seed fairs are organized by NGOs. In Kenya, the Catholic Relief Services (CRS) and World Vision have held seed fairs in various parts of the country. In the Seed fairs, farmers are brought together to trade their local seed varieties with other farmers within the localities. The seeds are traded through seed vouchers given to farmers by the facilitating agency. Once transaction has been done, the traders then redeem the vouchers from the concerned agency. The framework involves first identifying the disaster-affected families, often in collaboration with the government officials. Once identified, the families are given a set of small-denomination vouchers to be exchanged for seed at specially organized seed fairs. The concerned agency also informs prospective seed sellers of the date, location and modalities of the seed fair. On the fair date, a fairs committee recommends sale price for different crops, registers the seed sellers, and redeems vouchers exchanged for seed at the end of the fair.

The advantage of the Seed vouchers and fairs is that it strengthens the farmer seed procurement systems. It is cost-efficient and has a multiplier effect in the community. Also, it allows commercial sector participation and provides an opportunity to promote improved varieties for farmer evaluation. However, the framework assumes that seed is available from farmer seed systems and is of good quality, but that there is problem of access.

4.0 Key Policy Lessons

The study has shown that the seed sector is highly diversified and farmers use both formal and informal seed systems to access seed. While the informal seed system is important in terms of volume of seed used, the formal seed system is important in terms of value of seed purchased. Both community-based and market-led approaches are used to avail seed to farmers and encourage utilization of improved seeds. Market-led approaches aim at enhancing competitiveness and flow of seed from the seed companies and other producers to the farmers. It has been generally shown that the formal seed system, comprising public and private seed companies, has been unable to meet demand for improved seeds, making farmers look for alternative sources of seed. And where formal seed is available, the cost has been prohibitive to most small-scale farmers. The community-based approaches therefore enhance access to seed where the formal seed system has not been effective in supplying the seed to farmers. These approaches operate with the backing of various international organizations, public and private research institutions and NGOs, a perfect example of private-public partnership

A key implication emanating from the community-based and market-led approaches is that Public-Civil society-Private sector partnerships are essential ingredient to the development and uptake of technology. This has been shown by the involvement of the government, the civil society (NGOs), the research institutions and donor communities in the production and distribution of seed among the farmers. To be effective, however, the partnerships must take cognizance of the farmer conditions and integrate this into the research agenda. For example, research institutions should work with the community-based groups to produce varieties that are suitable to the farmer conditions. Efforts should be made to strengthen collaboration among the MOA, KARI and NGOs so that their initiatives to support farmers are harnessed and used effectively. This will enhance the uptake of the technology. Also, government seed relief programs should focus on commodities that can thrive well in the affected areas, rather than promote maize as the staple food.

Second, it has been shown that farmers would be willing to use improved seed for those commodities that have markets, implying that markets are important for uptake of technology. As the Theory of Change has shown, a well-functioning output market will provide incentives for the farmer to demand productivity-enhancing inputs. Therefore, there

is need to support and strengthen the working of output markets, as a way of enhancing access and utilization of the improved seed. Seed companies, farmers and stakeholders should work together to organize field demonstrations and establish trial plots for the various seeds. Also input suppliers should be supported to take their inputs near farmers to enhance access.

Third, there is need to tackle the key factors influencing seed uptake, both from the demand and supply perspective. This includes making seed available and affordable to the farmers and strengthening extension services for farmers. The study has shown that those who use improved seed are likely to get extra income compared to those using the seed from informal sources improved seed. There is also need for better understanding the seed security of target seed systems before employing such approaches as the seed fairs.

Fourth, there is no doubt that the informal seed systems will continue to play important role in seed access and utilization in Kenya in the foreseeable future. Yet the regulations do not seem to recognize its role in the seed system. There is therefore need to provide for the informal seed system in the law. As long as the communities produce seed and sell within their localities, KEPHIS conditions should be relaxed to allow faster multiplication of seeds and improve on-farm use of improved seeds. This could be achieved through the introduction of Quality Declared Seed (QDS), which provides for different seed quality levels to meet the farmers' needs (see Kavoi, et al, 2004 for a detailed discussion of this approach).

Fifth, the role of KEPHIS should be reviewed in light of the liberalized seed sector. It is felt that the seed industry should move towards self-regulation by strengthening the roles of lobby groups, such as Seed Trade Association of Kenya (STAK) and the Kenya Federation of Agricultural Producers (KENFAP). STAK, for example should be recognized with the seed laws and strengthened to champion the course of seed traders. This happens for example in South Africa, where South Africa National Seed Organization (SANSOR), does the registration and certification of seed on behalf of the government. Under the new arrangement, KEPHIS would only come in at the most necessary stages of germination and purity tests. This move is crucial as the country moves towards the regional integration. There is also need to strengthen the farmer associations to be able to champion the interests of the farmers.

Sixth, to enhance competition in the seed industry, and enhance availability, access and utilization of improved seed by farmers, the government should ensure a level playing ground for local and foreign seed companies. There should be proper implementation of regulations governing the seed industry. Also there is need to review the seed regulations to ensure the provisions are enforceable and duly enforced. The Seeds and Plant Varieties Act (Cap 326) needs to be amended to allow for the enforcement of the various seed committees and tribunals. Equally, the role of KEPHIS needs to be revisited to allow for the seed industry to thrive. As it is currently, its role stifles the growth of the seed industry. KEPHIS also needs to build capacity to cope with the demand for its services.

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Annex 1: Regression results on factors associated with use of formal seed purchases in Kenya

Variable	All Crops			Maize			Non-mz C&P			Vegetables		
	Coef.	Sig.		Coef.	Sig.		Coef.	Sig.		Coef.	Sig.	
HH is female headed	-0.25	0.00	*	-0.24	0.02	+	-0.61	0.12		-0.14	0.14	
Head 1-8 yrs education (base is no formal ed)	0.26	0.00	*	0.42	0.00	*	-0.26	0.42		0.14	0.15	
Head 9-12 ys education	0.37	0.00	*	0.85	0.00	*	0.08	0.82		0.12	0.30	
Head has some college education	0.23	0.00	*	0.75	0.00	*	0.29	0.52		-0.10	0.45	
First land area quintile (omitted)												
Second land area quintile	0.45	0.00	*	0.43	0.00	*	0.31	0.63		0.58	0.00	*
Third land area quintile	0.43	0.00	*	-0.01	0.96		1.25	0.03	+	0.75	0.00	*
Fourth land area quintile	0.68	0.00	*	0.46	0.00	*	1.54	0.01	*	1.02	0.00	*
Fifth land area quintile (largest 20%)	0.83	0.00	*	0.61	0.00	*	2.06	0.00	*	1.08	0.00	*
First hh size quintile (omitted)												
Second hh size quintile	0.12	0.05	+	0.12	0.29		-0.17	0.70		0.19	0.06	-
Third hh size quintile	0.14	0.02	+	0.26	0.02	+	0.38	0.32		-0.03	0.75	
Fourth hh size quintile	0.16	0.01	*	0.29	0.01	*	0.21	0.58		0.15	0.12	
Fifth hh size quintile (largest 20%)	0.30	0.00	*	0.36	0.00	*	0.14	0.72		0.27	0.01	*
First quintile, yrs experience with fert (omitted)												
Second quintile, yrs experience with fert	0.72	0.00	*	0.76	0.00	*	-0.35	0.35		0.49	0.00	*
Third quintile, yrs experience with fert	0.79	0.00	*	0.99	0.00	*	-0.07	0.86		0.44	0.00	*
Fourth quintile, yrs experience with fert	0.68	0.00	*	0.97	0.00	*	-0.89	0.03	+	0.37	0.00	*
Fifth quintile, yrs experience with fert (most exp.)	0.75	0.00	*	1.26	0.00	*	-0.58	0.16		0.32	0.01	*
First quintile, distance to fert dealer (omitted)												
Second quintile, distance to fert dealer (km)	-0.04	0.51		0.05	0.61		0.01	0.97		-0.10	0.28	
Third quintile, distance to fert dealer (km)	0.03	0.64		0.04	0.73		-0.06	0.89		0.08	0.43	
Fourth quintile, distance to fert dealer (km)	0.06	0.32		-0.01	0.96		-0.03	0.95		0.20	0.05	+
Fifth quintile, distance to fert dealer (km; most dist)	0.03	0.63		-0.11	0.39		0.26	0.49		-0.03	0.75	
First quintile, distance to motorable road (omitted)												
Second quintile, distance to motorable road (km)	0.06	0.29		0.22	0.06		0.56	0.11		0.08	0.43	
Third quintile, distance to motorable road (km)	-0.04	0.49		-0.07	0.59		0.41	0.27		-0.11	0.27	

Variable	All Crops			Maize			Non-mz C&P			Vegetables		
	Coef.	Sig.		Coef.	Sig.		Coef.	Sig.		Coef.	Sig.	
Fourth quintile, distance to motorable road (km)	0.01	0.84		0.18	0.12		0.55	0.11		-0.14	0.14	
Fifth quintile, dist. to motorable road (km; most dist.)	-0.14	0.04	+	-0.22	0.10		0.04	0.92		-0.07	0.52	
First quintile, value of hh assets (omitted)												
Second quintile, value of hh assets (Ksh)	0.23	0.00	*	0.50	0.00	*	0.24	0.58		0.21	0.05	+
Third quintile, value of hh assets (Ksh)	0.27	0.00	*	0.45	0.00	*	0.26	0.56		0.16	0.13	
Fourth quintile, value of hh assets (Ksh)	0.42	0.00	*	0.73	0.00	*	0.18	0.69		0.40	0.00	*
Fifth quintile, value of hh assets (highest value)	0.43	0.00	*	0.56	0.00	*	0.32	0.47		0.23	0.04	+
Coastal Lowlands (omitted)												
Eastern Lowlands	-1.26	0.00	*	-1.66	0.00	*	-1.50	0.06	-	-0.65	0.00	*
Western Lowlands	0.14	0.22		-0.83	0.00	*	1.22	0.03	+	0.73	0.00	*
Western Transitional	0.09	0.48		0.12	0.41		-1.02	0.36		0.10	0.49	
High Potential Maize Zone	0.45	0.00	*	1.60	0.00	*	1.24	0.02	+	-0.12	0.30	
Western Highlands	0.21	0.11		.122	0.41		-1.03	0.36		0.10	0.49	
Central Highlands	0.14	0.25		0.16	0.17		0.49	0.41		-0.32	0.01	*
Marginal Rain Shadow	0.42	0.00	*	0.46	0.03	+	1.90	0.00	*	-0.09	0.67	
Tubers (omitted from overall regression)												
Maize	6.04	0.00	*									
Other cereals and pulses	1.59	0.00	*									
Vegetables	4.30	0.00	*									
Fodder	2.19	0.00	*									
Fruit trees	2.18	0.00	*									
Flowers	3.67	0.00	*									
Wheat							3.16	0.00	*			
Sunflower							5.75	0.00	*			
Other vegetables (omitted from vegetable regression)												
Carrots										8.62	0.00	*
French beans										6.91	0.00	*
Cabbage										6.20	0.00	*
Snowpea										5.60	0.00	*

Variable	All Crops			Maize			Non-mz C&P			Vegetables		
	Coef.	Sig.		Coef.	Sig.		Coef.	Sig.		Coef.	Sig.	
Tomato										5.24	0.00	*
Eggplant										5.09	0.00	*
Squash										5.45	0.00	*
Sukuma										4.79	0.00	*
Capsicum										4.54	0.00	*
Spinach										4.39	0.00	*
Bellpepper										3.81	0.00	*
Brinjal										3.89	0.00	*
Garlic										3.37	0.00	*
Onion										3.11	0.00	*
Cucumber										2.46	0.02	+
Constant	-7.47	0.00	*	-1.97	0.00	*	-7.15	0.00	*	-6.16	0.00	*
Cox & Snell R-sq	0.25			0.28			0.07			0.41		
Nagelkerke R-sq	0.40			0.38			0.42			0.62		

Data source: 2004 Tegemeo Tampa data set. Significance levels: * = 0.01 or better; + = 0.01 – 0.05; - = 0.05 – 0.10

Annex 2: Composition of Household Income, by Agro-Regional Zone

Household Characteristic	Agro-Regional Zone							Overall
	Coastal Lowland	Eastern Lowland	Western Lowland	Western Transitional	High Potential Maize	Western Highland	Central Highland	
Total Income (Ksh)	**160,837**	**174,770**	**92,187**	**120,775**	**212,083**	**105,922**	**176,318**	**160,554**
Net crop income (Ksh)	32,355	36,316	22,800	53,563	79,058	41,765	67,560	54,383
Net livestock income (Ksh)	12,291	15,235	10,685	19,148	49,948	21,138	28,670	28,028
Total Off-Farm Income (Ksh)	**116,190**	**123,219**	**58,702**	**48,064**	**83,077**	**43,018**	**80,087**	**78,143**
Business Income (Ksh)	75,089	48,647	19,412	20,396	41,473	13,718	30,519	33,844
Salaries & Remittances (Ksh)	41,101	74,572	39,290	27,667	41,604	29,300	49,569	44,299
Mean value of assets (Ksh)	156,859	157,233	105,598	70,981	341,594	71,638	255,267	164,357
Proportion of households with:								
Business Income (%)	73	59	73	55	49	53	47	56
Salaried Income (%)	62	70	66	50	48	74	62	62
HH below Poverty (%)	73	59	73	55	49	53	47	64