Egerton University

Tegemeo Institute Of Agricultural Policy And Development

Tegemeo Working paper 10

COMPETITIVENESS OF KENYAN AND UGANDAN MAIZE PRODUCTION: CHALLENGES FOR THE FUTURE

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Support for this research has been provided by the Tegemeo Agricultural Monitoring and Policy Analysis Project (TAMPA) between Tegemeo Insitute/Egerton University and the Department of Agricultural Economics at Michigan State University. Financial support for this project is provided by the Kenya Mission of the United States Agency for International Development. Additional support is also provided by MSU through resources from the Food Security III Cooperative Agreement.

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1. Introduction

Maize is the main staple food in Kenya for a large proportion of the population in both urban and rural areas. Maize consumption is estimated at 98 kilograms per person per year, which translates to roughly 30 to 34 million bags (2.7 to 3.1 million metric tons) per year. Maize is also important in Kenya's crop production patterns, accounting for roughly 28 percent of gross farm output from the small-scale farming sector (Jayne et al., 2001).

Kenyan policy makers have been confronted by the classic "food price dilemma." On the one hand, policy makers are under pressure to ensure that maize producers receive adequate incentives to produce and sell the crop. Rural livelihoods in many areas depend on the viability of maize production as a commercial crop. On the other hand, the food security of the growing urban population and many rural households who are net buyers of maize depends on keeping maize prices at tolerable levels. For many years, policy makers have attempted to strike a balance between these two competing objectives – how to ensure adequate returns for domestic maize production while keeping costs as low as possible for consumers. Maize marketing and trade policy has been at the center of debates over this food price dilemma, including discussions over the appropriateness of trade barriers and the role of government in ensuring adequate returns to maize production.

Improving the competitiveness of Kenyan maize production is also a primary means of resolving the food price dilemma. The ability to reduce the costs of maize production can ensure greater profitability to producers at lower prices while simultaneously improving poor consumers' access to food. Achieving lower production costs also allows domestic producers to compete more effectively with imports from other countries.

The purpose of this study is to assess the costs of maize production in Kenya and Uganda. We start from the fact that there is no single "cost of production" for maize.

Cost of production varies according to region, the type of technology package employed, farmers' management practices, and the weather. In light of this, the study disaggregates cost of production into seven region/technology categories, five in Kenya and two in eastern Uganda, in order to compare the relative competitiveness of maize among these regions and technology packages. Variations in cost of production within each region/technology category reflect differences in farmer management practices and micro-variability in soils and rainfall. Therefore, within each region/technology category, we present costs of maize production estimates for three terciles: low-, medium- and high-cost producers. The results hold important implications for who will benefit and lose from the removal of regulatory and informal trade barriers between Uganda and Kenya (see RATES, 2003).

The paper is organized as follows: Section 2 presents background statistics and trends in Kenya's maize subsector, and provides the policy context for the ensuing analysis. Section 3 describes the methods and data used in the analysis. Section 4 provides the main results of the paper concerning relative costs of maize production in the various regions. Even within a given region, the costs of maize production vary greatly among farmers. We identify the attributes of household production practices associated with low vs. high costs within each particular region. In Section 5, we consider the implications for current production costs in the light of regional trade agreements. Section 6 contains conclusions and policy issues.

2. Characteristics of the Maize Sub-Sector in Kenya

Aggregate Trends

Table 1 presents national trends in the maize subsector from 1975/76 to 2002/03. There is some variance in the national production statistics from the Government of Kenya (GOK), and these internal discrepancies are yet again different from FAO statistics, which are ostensibly based on government statistics. Despite these discrepancies, a consistent picture emerges that Kenyan maize production peaked during the mid- to late-1980s, and has since stagnated. Maize production has varied since 1990 between 24 and 33 million bags (2.1 to 3.0 million tons) per year, and has averaged 2.4

million tons in the 13 years between 1990/91 and 2002/03. During the last five years of the 1980s, maize production averaged 2.8 million tons per year according to this particular GOK source, and 2.7 million tons per year according to the FAO. Area under cultivation has slowly trended upward (column C). The main source of production decline over time has been declining yields (column D). Yields declined from 1.84 tons per hectare in the five years between 1985/86 to 1989/90, to 1.71 tons between 1990/91 and 1994/95, to 1.58 tons per hectare in the eight years since the 1995/96 season. The average national yields nonetheless disguise wide variations in yields in different agro-ecological zones. According to household survey data collected by the Tegemeo Institute, most farmers in the high potential maize zones are able to achieve between 15 and 30 bags per acre (3.4 to 5.8 tons per hectare), while those in agro-ecologically less favorable zones typically obtain less than 5 bags per acre (1.1 tons per hectare).

Over time, national maize production has not kept pace with consumption. Production has not increased as fast as demand driven mainly by population growth. Currently maize consumption is estimated to be in excess of 30 million bags per year. To bridge the ever-increasing gap between maize supply and demand, Kenya has been importing maize formally and informally across the border from Uganda and Tanzania in addition to large offshore imports from as far as South Africa, Malawi, United States of America and other Southern America countries like Brazil and Argentina (Nyoro et al, 1999). Columns F and G (Table 1) show Kenya's transition in official trade from net exporter to net importer during the early 1990s. However, only official trade statistics are reported, and it is likely that total imports are generally larger than those reported because of informal trade inflows from Uganda and Tanzania, estimated by one source at 150,000 tons per year during the early 1990s.[1] Between the 1992/93 and 2002/2003 seasons, the production deficits ranged between 2 to 6 million bags. Imported maize, particularly from neighboring countries, is apparently cheaper than that produced domestically, thereby exacerbating the "food price dilemma" discussed earlier. Under pressure from politically influential maize farmers, the previous KANU government often resorted to maize import tariffs and regulatory barriers to restrict maize inflows. More recently, RATES (2003) and Awuor (2003) have documented the continued existence of

[1] REDSO-funded cross border trade study for Kenya, Ackello-Ogutu et al.

Table 1. Total Maize production, Marketed Production, Exports, Imports, and producer Prices, 1975/76 to 1995/96.

YEAR	TOTAL OUTPUT	TOTAL OUTPUT	AREA HARVESTED	YIELD	NCPB MAIZE PURCHASES	OFFICIAL EXPORTS	OFFICIAL IMPORTS	NCPB PRODUCER PRICE	
	(000 MT) GOK (A)	(000 MT) FAO (B)	(000 HA) (C)	(MT / HA) (D)	(000 MT) (E)	(000 MT) (F)	(000 MT) (G)	KSH/ 90KG BAG (H)	US$ / TON (I)
1975/76	1375	1960	1450	1.35		121	0	70	105
1976/77	1597	2600	1590	1.64		113	0	77	103
1977/78	1671	2553	1570	1.63		8	0	88	117
1978/79	1620	2169	1490	1.46		23	0	89	129
1979/80	1607	1755	1350	1.30	134	120	0	77	114
1980/81	1888	1620	1350	1.20	406	0	224	95	142
1981/82	2560	1768	1120	1.58	705	1	77	100	121
1982/83	2450	2502	1208	2.07	636	1	89	107	108
1983/84	2215	2300	1300	1.77	509	123	0	154	127
1984/85	1500	1422	985	1.44	376	47	405	156	119
1985/86	2440	2430	1411	1.72	832	18	125	175	118
1986/87	2870	2898	1425	2.03	727	228	1	188	128
1987/88	2400	2416	1407	1.72	480	248	0	209	141
1988/89	3140	2761	1451	1.90	643	167	0	214	133
1989/90	3030	2631	1420	1.85	551	110	0	223	120
1990/91	2890	2290	1449	1.58	233	160	0	264	126
1991/92	2253	2340	1471	1.59	316	19	0	287	116
1992/93	2205	2430	1407	1.73	489	0.42	415	239	83
1993/94	1698	2089	1308	1.60	490	0.11	13	810	158
1994/95	2621	3060	1500	2.04	535	1.7	650	950	188
1995/96	2370	2699	1380	1.96	100	154	12	665	145
1996/97	2052	2160	1489	1.45	108	221	15	1127	227
1997/98	1887	2214	1505	1.47	60	9	1104	1162	206
1998/99		2400	1500	1.60	150	13	371	1009	181
1999/00		2322	1567	1.48	34	37	75	1200	176
2000/01		2160	1500	1.44	175	7	417	1250	177
2001/02		2776	1640	1.69	186	6	324	1000	141
2002/03		2340	1500	1.56	92				

Source: Govt. Kenya, *Statistical Abstract*, various issues (columns A, E, F, G). National Cereals and Produce Board (as reported in Odhiambo, 1997, till 1995/96; thereafter as reported in RATES, 2003) (column H). Authors' calculations using exchange rates from Central Bureau of Statistics (column I). FAO AgriStat website (columns B, C, and D).

regulatory barriers and high transaction costs that impede maize trade between Uganda and Kenya.

Importance of Maize in Small Farmer Incomes

Across all agro-ecological zones, most rural households in Kenya produce maize. However, incomes of rural households are diversified in terms of the sources contributing to household income. Results in Table 2 indicate that while crop income accounts for an average of 47% of total gross income (including home consumption) over the entire sample, non-farm activities and livestock are also important income sources and together exceed crop production nationwide. Across zones, small-scale farm households derive between 23% and 70% of their income from non-farm sources.

Within the crop income category, maize is tied with horticultural crops as an aggregate (including vegetables, fruits, and flowers) for 14% of total household income, across the national sample. Coffee and tea account for a combined 5.6% of total gross income. However, only in four of the 22 districts covered (Nakuru, Trans Nzoia, Uasin Gishu, and Machakos) was maize the leading or even the second most important cash crop. As an aggregate, cash crops such as coffee, tea, sugarcane, and horticultural crops account for more than 20% of household income.

Over time, evidence suggests that there has been a moderate shift away from maize cultivation into other crops. Earlier national survey data from the mid-1970s indicate that maize at that time accounted for about 35% of the value of total crop production (Greer and Thorbecke 1988). According to the Tegemeo household surveys from 22 districts in the late 1990s, maize now accounts for 28% of the value of total crop production. While the data sets are not strictly comparable, they include many of the same areas, and the decline in income share from maize would appear to be too large to be explained simply by sampling differences.

[2] REDSO-funded cross border trade study for Kenya, Ackello-Ogutu et al.

Table 2. Shares of total household incomes, by source of income, 1996/97 & 1999/00 season.

	Off farm income	Livestock income	Crop income	Crop income from		
				maize	other crops	cash crops
Coastal Lowlands	70	8	22	7	5	10
Eastern Lowlands	50	14	36	9	9	18
Western Lowland	41	14	45	17	19	9
Western Transitional	23	16	61	13	12	36
High-Potential Maize Zone	26	35	49	25	14	10
Western Highlands	26	17	57	16	9	32
Central Highlands	29	21	50	5	7	38
Total	**35**	**18**	**47**	**14**	**11**	**23**

Notes: [1] "other crops" include dry beans and peas, other grains, roots and tubers. [2] "cash crops" includes coffee, tea, sugar cane and horticulture.
Source: Tegemeo Household Surveys, 1996/97 and 1999/00.

Maize Prices and Small Farmer Welfare

Kenya has for a long time pursued the goal of attaining self-sufficiency in maize and other crops. Under this policy, most households were commonly viewed to be net maize sellers who derived their benefits largely from high grain prices. However, it is now clear that the proportion of rural households that are net buyers of maize is much higher than previously thought. In nationwide household surveys, Tegemeo Institute has documented the proportion of rural households that are buyers and sellers of maize. Table 3 shows that a large number of the farmers -- who are conventionally understood to be protected by the policy of restricting maize imports -- happen to be net maize buyers and are actually directly hurt by higher maize prices. For example, in the districts surveyed in the Western Lowlands (Kisumu and Siaya) and Eastern Lowlands (Kitui, Machakos, Makueni, and Mwingi), 82 and 66 percent respectively, of the small-scale farm households surveyed were net buyers of maize. They purchased, on average, 540 and 290 kgs per household per year. The proportion of maize purchasing households is in the range of 50 to 62 percent in the districts comprising Western Highlands (Kisii and Vihiga), Western Transitional (Bungoma and lower elevation divisions of Kakamega), and Central

Highlands (Muranga, Nyeri, Meru, and Laikipia). While direct welfare effects are not implied, there are strong signs that the benefits derived from restricting cheaper maize imports are enjoyed by a relatively small proportion of rural Kenyans.

The main region where higher maize prices clearly help small-scale farmers is in the High-Potential Maize Zone (districts such as Trans Nzoia, Uasin Gishu, Nakuru, Bomet, and the upper elevation divisions of Kakamega). In this region, roughly 70 percent of households sell maize; mean household sales are in the range of 3 tons. Even in this zone, however, about 20 percent of small-scale households only purchase maize, or purchase more maize than they sell.[3] When aggregating up across all 22 districts, we find that while almost all of the households surveyed grow maize for consumption, it is generally insufficient for household requirements and they therefore use income derived from their non-farm and cash crop activities to buy much of their food.

According to the Tegemeo surveys, there are clear income differences between the groups of small-scale households that sell vs. buy maize. The households that are sellers of maize have annual per capita incomes that are nearly double that of maize buying households (Ksh 30,396 vs. Ksh 17,450). The poorest 25 percent of rural households spend a larger proportion of their income on food (71%) than the wealthiest 25 percent of households (59%). Maize purchases amounted to 28 percent of annual household income for the poorest quartile of farmers. Indirect effects on wage labor and multiplier effects make it overly simplistic to deduce welfare effects from higher maize prices based simply on households' position as either maize buyers or sellers. However, policies contributing to relatively high maize prices involve a direct transfer of income from low-income rural households and urban consumers to relatively non-poor farm households located primarily in the North Rift Valley.

The finding that a large proportion of rural households enter the maize market as buyers rather than sellers is reinforced by an earlier national maize survey implemented by KARI in the early 1990s. According to the KARI survey, 41 percent of the small farmers nationwide sold maize (Table 4). This figure was as high as 69 percent in the "Highlands" area, and as low as 14-38 percent in the lowlands, dry mid-altitude, moist mid-altitude, and dry transitional regions.

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[3] The proportion of small-scale households that both sold and purchased maize in the same year was found to be 8 percent.

Table 3. Household Characteristics from Tegemeo Household Surveys, 1996/97 and 1997/98: Percentage of Households that are Sellers and Buyers of Maize and Quantity of Sales and Purchases.

Zone	Number of Sampled Households	Per Capita Income	Cropped Land size	Maize Marketing Position			Household Maize Sales [7]		
				Net Seller	Autarky	Net Buyer	Net Seller	Autarky	Net Buyer
		-Ksh-	-acres-	----------- percent ----------			----------- kgs ------------		
Western Lowlands[1]	170	10920	2.95	5	13	82	315	0	-540
Eastern Lowlands [2]	150	19355	5.36	23	11	66	564	0	-290
High-Potential Maize Zone [3]	332	29922	7.73	68	10	22	3022	0	-595
Western Highlands [4]	180	14055	2.96	23	19	58	580	0	-399
Western Transitional [5]	150	16578	5.31	23	15	62	1166	0	-694
Central Highlands [6]	242	28010	2.8	16	21	53	413	0	-316
Total	1,224	21647	4.81	32	16	52	2028	0	-462

Source: Tegemeo Institute/Egerton University/KARI//MSU Rural Household Survey, 1996/97, and 1997/98.
[1] Kisumu and Siaya. [2] Kitui, Mwingi, Machakos, and Makueni. [3] Trans-Nzoia, Uasin Gishu, Bomet, Nakuru, and upper elevation divisions within Kakamega. [4] Kisii and Vihiga. [5] Bungoma and lower elevation divisions of Kakamega. [6] Muranga, Nyeri, Meru,and Laikipia.
[7] negative figures indicate quantity of maize and maize meal purchased.

Table 4. Maize Production, Consumption and Marketing by Agro-ecological Zone, Kenya Maize Impact Study (KARI), 1992/93

	---------- Marginal Agroecological Zones ----------				Favored Agroecological Zones		
	Lowlands	Dry Midaltitude	Moist Midaltitude	Dry Transition	Moist Transition	Highlands	All Zones
% Net Sellers of Maize:							
Small Farm	14	28	38	22	49	69	41
Large Farm	0	33	38	-	94	94	70
Proportion of Maize Sold (%):							
Small Farm	0	12	15	12	28	31	20
Large Farm	0	21	29	-	80	75	57
Maize Selling Price, Ksh/Kg:							
Small Farm	13.50	9.45	14.05	14.25	10.40	10.05	11.50
Large Farm	13.80	11.55	14.30	-	9.80	10.00	11.05
Maize Purchase Price, Ksh/Kg:							
Small Farm	18.65	14.25	17.70	17.50	13.90	14.20	15.55
Large Farm	15.90	14.45	17.90	-	11.50	10.90	12.75

Source: Kenya Maize Impact Study, KARI, as reported in Karanja and Renkow (2003).

The biggest challenge facing Kenya's maize sub-sector (as well as the overall agricultural sector) is therefore to continuously strive to raise productivity through reducing production and marketing costs. This strategy would raise net incomes of surplus maize producers and promote household food security. It would allow greater returns from maize production without forcing consumers to incur higher costs, thereby reducing the magnitude of the food price dilemma. Improved farm technology, farm management skills, and input systems to efficiently deliver these technologies and skills are critical components of this strategy. Therefore, there is a pressing need to study actual farmer behavior to understand why some are able to achieve high levels of productivity (low costs per bag of maize produced) while other farmers in the same area are achieving much lower productivity (i.e., higher costs per bag of maize produced). By identifying certain practices and technology uses that contribute to productivity growth, such findings would be important for extension and outreach programs targeted to small farmers. The remainder of this study is devoted toward that end.

3. Data and Methods

Data

Production cost data used in this paper are based on a single-visit survey of 581 rural Kenyan and Ugandan households in April-May 2003. Out of the total sample, 447 households were Kenyan while the remaining 134 were Ugandan. The survey was designed and implemented by the Tegemeo Institute of Egerton University, in collaboration with Michigan State University.

Kenyan households were selected from 8 districts within 3 maize growing regions namely, Kitale, Kakamega and Embu, with assistance from the Kenya Agricultural Research Institute (KARI). Kitale, in Trans Nzoia District, covers the main commercial growing areas in the country and is considered to be Kenya's 'granary'. Kakamega covers Western province and parts of Nyanza district. This region is prone to striga. Both Trans-Nzoia and Kakamega are prone to moderate drought. Maize is grown both commercially and for subsistence purposes. The Embu region covers districts distributed within Eastern and Central province with maize production being concentrated in UM2 (main coffee) and UM3 (marginal coffee) zones.

Enumerators surveyed households in detail about management practices and inputs used on fields on which maize was grown. The data collected included land size holding, area planted to maize and intercrop (owned and rented), crop output and prices, quantity of family labor, quantity and cost of hired labor, quantity and prices of material inputs (seeds, chemicals, fertilizer), and quantity and costs of tractor and draught inputs. The data was recorded separately for the maize monocrop and intercrop fields.

Derivation of Maize Production Technology Categories

Maize in Kenya and Uganda is produced under a variety of farming practices. While farmers in some areas commonly use tractors and/or oxen for land preparation and plant maize as a monocrop (pure stand), most small farmers in most parts of both countries use hand implements like the hoe. Among such farmers, maize is commonly intercropped with other crops, predominantly beans. Labor used is generally a mix of family and hired labor. Maize crop is usually grown on own land but some farmers grow it on rented land.

All maize fields under the survey were classified into different production technology categories (PTC) based on various criteria. First, households were divided into two broad categories depending on whether they grew maize as a monocrop or intercropped it with beans. Further stratification within these two categories was based on agro-ecological zone, farm size, type of seed used, intensity of fertilizer use, and land preparation technology.

Three production regions were identified, two for Kenya and one for Uganda. The *High potential maize-western Kenya (HPM-western)* region includes Trans-Nzoia, Kakamega, Lugari and Bungoma districts while the *Central Highlands-Kenya* region consists of Embu, Meru Central and Nyeri districts. The three districts surveyed in Eastern Uganda (Iganga, Sironko and Kapchorwa) formed the *Uganda region*. Farm sizes were categorized into two groups based on amount of land cultivated. The small-scale group had 0-10 acres of land under cultivation while medium/large scale group had above 10 acres of cultivated land. Two types of seed varieties were used namely, hybrid and open pollinated varieties (OPV). Some households used purely hybrid seeds (81.1%); others used purely OPV seeds (18%), while a small proportion (0.9%) used both types of seed. Very few farmers reported using recycled hybrids.

Maize fields were also classified based on intensity of fertilizer use. Producers using 40 kilogrammes or less of fertilizer per acre were classified as low input users, while those who used more than 40 kilogrammes per acre, were regarded as high input users. Land preparation technology was defined based on the number of land preparation stages (passes) and type of equipment used. Two passes were defined where the farmer carried out first and second land preparation stages. In most cases, the type of equipment used in the second land preparation stage was the same as in the first stage.

After creating variables representing production regions, farm size, type of seed used, intensity of fertilizer use, and land preparation technology, all possible combinations of these variables were used to define different maize production technology categories (PTC). Small sample sizes in most cases warrant caution in generalizing confidently. Seven production categories were identified for the monocrop system and 6 for the intercrop maize system. Tables 5 and 6 show the number of households in each production category for both systems.

Producers in the monocrop system used predominantly purchased maize hybrid seeds (75%), some used purchased OPV seeds (11%), 8% used recycled OPV, and a few used recycled hybrid seeds (6%). Over 85% of producers in categories 1, 2 and 3 used purchased hybrid seeds while in PTC 4, 50%, 30% and 15% used purchased hybrid, recycled OPV and recycled hybrid, respectively. In PTC 5, 75% used purchased hybrid, 17% recycled OPV and 4% recycled hybrid seeds. Purchased OPV seeds were predominant in PTC 6 (64%), while 29% and 7% of producers recycled OPV and purchased hybrid, respectively. In the seventh PTC, almost equal numbers of producers used purchased OPV (48%) and purchased hybrid (44%), while an equal but smaller number used recycled OPV (4%) and recycled hybrid (4%).

There is also variation in maize seed types used in the intercrop system. In PTC 1, 71% of producers used purchased hybrid while 20% used recycled hybrid seeds. Purchased hybrid seeds are predominant in PTC 2 (90%) while in PTC 3, 81% of farmers purchased hybrid seeds, 9% purchased OPV and 9% recycled hybrid seeds. For PTC 4, 63% purchased hybrid, 16% recycled OPV and another 16% recycled hybrid seeds. Production category 5 had 85%, 10% and 5% of producers using purchased hybrid, recycled OPV and recycled hybrid, respectively. A larger proportion of farmers (54%) in PTC 6 used recycled OPV, nearly half of this (29%) used purchased OPV, while 17% used purchased hybrid seeds.

Within each PTC, households were ranked according to maize production costs per bag and then stratified into 3 equal terciles: the lowest production cost, medium production cost and highest production cost farmer terciles.

Table 5. Production Technology Categories (PTC) for Monocrop Maize Systems

PTC	Description of Production technology category	Number of households
1	High potential maize - Western Kenya, small scale, 1 pass, high fertilizer intensity	14
2	High-potential maize - Western Kenya, small scale, 2 passes, high fertilizer intensity	53
3	High potential maize - Western Kenya, medium/large scale, 2 passes, high fertilizer intensity	60
4	Central-highlands Kenya, small scale, 1 pass, low fertilizer intensity	20
5	Central-highlands Kenya, small scale, 1 pass, high fertilizer intensity	24
6	Uganda region small scale, 2 passes, no fertilizer	14
7	Uganda region small scale, 2 passes, high fertilizer intensity	27
Total		212

Source: Tegemeo Maize Production Cost Survey data, 2003.

Table 6. Production Technology Categories (PTC) for Intercrop Maize Systems

PTC	Description Production technology categories	Number of households
1	High potential maize-western Kenya, small scale, 1 pass, high fertilizer intensity	35
2	High-potential-western Kenya, small scale, 2 passes, high fertilizer intensity	94
3	High potential-western Kenya, medium/large scale, 2 passes, high fertilizer intensity	21
4	Central-highlands Kenya, small scale, 1 pass, low fertilizer intensity	19
5	Central-highlands Kenya, small scale, 1 pass, high fertilizer intensity	20
6	Uganda region, small scale, 2 passes, no fertilizer	41
Total		230

Source: Tegemeo Maize Production Cost Survey data, 2003.

Production costs

Production costs per acre were determined based on information on family and hired labor usage for all reported labor activities, land rental rates, land preparation costs, cash input costs such as fertilizer and purchased seed. Costs for land rent, family labor, hired oxen and hired tractor were valued at their respective median levels in the district. Information on costs of storage bags and marketing was also computed and used in selected runs to examine the extent to which results change when these costs are included.

The method used to determine costs of maize production on intercropped fields was as follows. Production costs per acre were determined as for monocrop maize, but the harvested value of bean output was converted into maize equivalent units using the relative maize/bean price ratios in each respective district. In this way, the total output on each intercropped field can be expressed in an equivalent value of maize output, which is then converted into cost per 90kg bag. Thus, total maize production per acre for the intercrop system was then given by the sum of reported maize bags per acre and the equivalent bags of maize per acre, based on quantity of beans harvested on the intercropped field and median maize/bean price ratio in the district. This figure was used to compute production costs per bag for the intercrop system.

Production in Trans-Nzoia district was adjusted upwards by a factor of 1.2 because the harvest in this particular district was very poor in the 2002 season. Choice of this factor was found to be most reasonable based on information on typical yields in this district.

Four percent of total field-level observations were dropped from the analysis because of probable data entry errors, with maize yields recorded either under 2 bags per acre or over 40 bags per acre. Land preparation costs consist of expenditure on all activities involved in getting fields ready for planting. Activities include land clearing, ploughing and harrowing carried out by tractors, draught power or hand hoe. Labor costs are defined as a sum of all expenses incurred in carrying out all other farm operations except land preparation. Mean district-level fertilizer prices for each type of fertilizer purchased were multiplied by quantities used on each field to derive fertilizer costs per field. Costs for seed and chemicals are computed in a similar way.

4. Results

Data analysis focused on estimating production costs per bag and per acre for defined production technology categories. Tables 7 and 8 show mean production costs per acre by component and PTC for monocrop and intercrop systems, respectively.

Land preparation costs vary across PTC but differences are less pronounced for the intercrop system. These costs are highest for PTC 2 and 3 in the monocrop system and for 3 and 6 in the intercrop system. These are areas where most farmers use tractors and oxen for land preparation and carry out first and second tillage. Labor costs also show variation across categories. They are highest in Central highlands category for both production systems and are relatively lower in Ugandan and HPM-western production categories. Fertilizer costs are, as expected, higher in areas with higher fertilizer intensity. However, they are consistently higher in PTC 1, 2 and 3 for both mono-and intercrop-systems.

Results show that seed costs are relatively low in Uganda, primarily because of greater reliance on OPVs. For Kenyan households, seed costs are comparable in categories 1, 2 and 3 in both systems but tend to be lower in categories 4 and 5 for producers engaged in the monocrop system compared to those in the intercrop system. In particular, PTC 4 in the monocrop system has much lower seed costs than other Kenyan production categories. This is not surprising since in this category only 50% of producers purchased hybrid seeds. The rest (30% and 15%, respectively) used recycled OPV and recycled hybrid seeds, which are relatively cheaper. Chemical application is on a much higher scale in the monocrop system relative to the intercrop system. Land rental rates for areas suitable to grow maize show variation across production regions, being highest for *high potential maize-western Kenya* and lowest for *Uganda* region, irrespective of maize production system.

Table 7. Mean Production Cost per Acre by Component and Production Technology Category for Monocrop System

	HPM-western Kenya, s/scale, 1 pass, high fertilizer (PTC 1)	HPM-western Kenya, s/scale, 2 passes, high fertilizer (PTC 2)	HPM-western Kenya, m/l scale, 2 passes, high fertilizer (PTC 3)	Central highlands Kenya, s/scale, 1 pass, low fertilizer (PTC 4)	Central highlands Kenya, s/scale, 1 pass, high fertilizer (PTC 5)	Uganda zone, s/scale, 2 passes, no fertilizer (PTC 6)	Uganda zone, s/scale, 2 passes, high fertilizer (PTC 7)
Land preparation	1,363	2,820	4,240	750	829	2,115	2,521
Labor[1]	1,914	1,195	514	3,487	4,590	2,415	908
Fertilizer	2,551	2,636	2,868	593	1,801	0	2,666
Seed	1,280	1,378	1,200	459	951	405	891
Chemicals	226	667	539	366	542	97	367
Land rental	2,888	2,888	2,888	1,923	1,923	1,277	1,277

Source: Tegemeo Maize Production Cost Survey data, 2003. Labor[1]: Labor costs for all activities excluding land preparation.

Table 8. Mean Production Cost per Acre by Component and Production Technology Category for Intercrop System

	HPM-western Kenya, s/scale, 1 pass, high fertilizer (PTC 1)	HPM-western Kenya, s/scale, 2 passes, high fertilizer (PTC 2)	HPM-western Kenya, m/l scale, 2 passes, high fertilizer (PTC 3)	Central highlands Kenya, s/scale, 1 pass, low fertilizer (PTC 4)	Central highlands Kenya, s/scale, 1 pass, high fertilizer (PTC 5)	Uganda zone, s/scale, 2 passes, no fertilizer (PTC 6)	Uganda zone, s/scale, 2 passes, high fertilizer (PTC 7)
Land preparation	1,337	2,162	2,845	1,546	1,553	2,453	n/a
Labor[1]	4,256	3,008	1,774	5,527	5,822	3,757	
Fertilizer	2,384	2,687	2,651	606	1,979	0	
Seed	1,293	1,582	1,411	1,605	1,368	776	
Chemicals	143	205	320	380	483	203	
Land rental	2,685	2,685	2,685	2,062	2,062	1,170	

Source: Tegemeo Maize Production Cost Survey data, 2003. n/a : not applicable because intercrop was found to be scarcely used in this agricultural system.
Labor[1]: Labor costs for all activities excluding land preparation.

Production Costs per Bag for Monocrop Maize System

Farmers in each PTC were classified into three groups ranked by production costs per 90-kg bag of maize produced. Analysis was done at two levels; one including a year's rental value of own land (opportunity cost of own land) as a production cost and the other excluding this cost component. This discussion is based on the results where rental value was not counted in as a production cost.

Components of production costs per acre by tercile for the monocrop system are summarized in Figure 1. These are calculated at mean values for all production categories. Labor, fertilizer and land preparation costs are a significant portion of maize production costs for all types of farmers. However, labor and land preparation costs are the main source of the difference between high- and low-cost producers. High cost farmers also incur relatively lower chemical costs per acre.

Results in Table 9 indicate that production costs differ greatly across production technology categories. Overall, PTC production costs range from a low of Ksh. 514 per bag in PTC 7 (Uganda small-scale, high fertilizer use intensity, and two land preparation passes) to a high of Ksh. 1,230 per bag in PTC 3 (Western Kenya, medium/large scale, high fertilizer use intensity, and two land preparation passes) when land rental costs are excluded. The difference becomes even wider when the higher costs of land rental in Western Kenya are included. The cost of tractor land preparation technology in Western Kenya is a major source of the production cost differences in these two regions. Households in eastern Uganda in general achieve lower costs of maize production than their Kenyan counterparts.

Among least-cost producers, PTC 1 and PTC 2 have very similar costs of maize production. PTC 1 and 2 represent small-scale producers in high-potential areas of Western Kenya, using high fertilizer doses, with the only difference being that PTC 2 uses 2-tillage passes unlike PTC 1, which uses only 1 pass. The higher costs of land preparation, labor and seed in PTC 2 are compensated by the 15% higher yields obtained by farmers in PTC 2. However, among the high-cost tercile of producers, a second pass in land preparation accounts for 27% reduction in maize production costs per bag in PTC 2. A two-fold increase in yield between the two production categories in the high-cost tercile outweighs the increase in seed, chemicals, fertilizer and land preparation costs. Thus on average, a second-tillage pass seems to lead to lower production costs per bag in this region.

Fig 1: Cost Structure by Tercile for Monocrop System

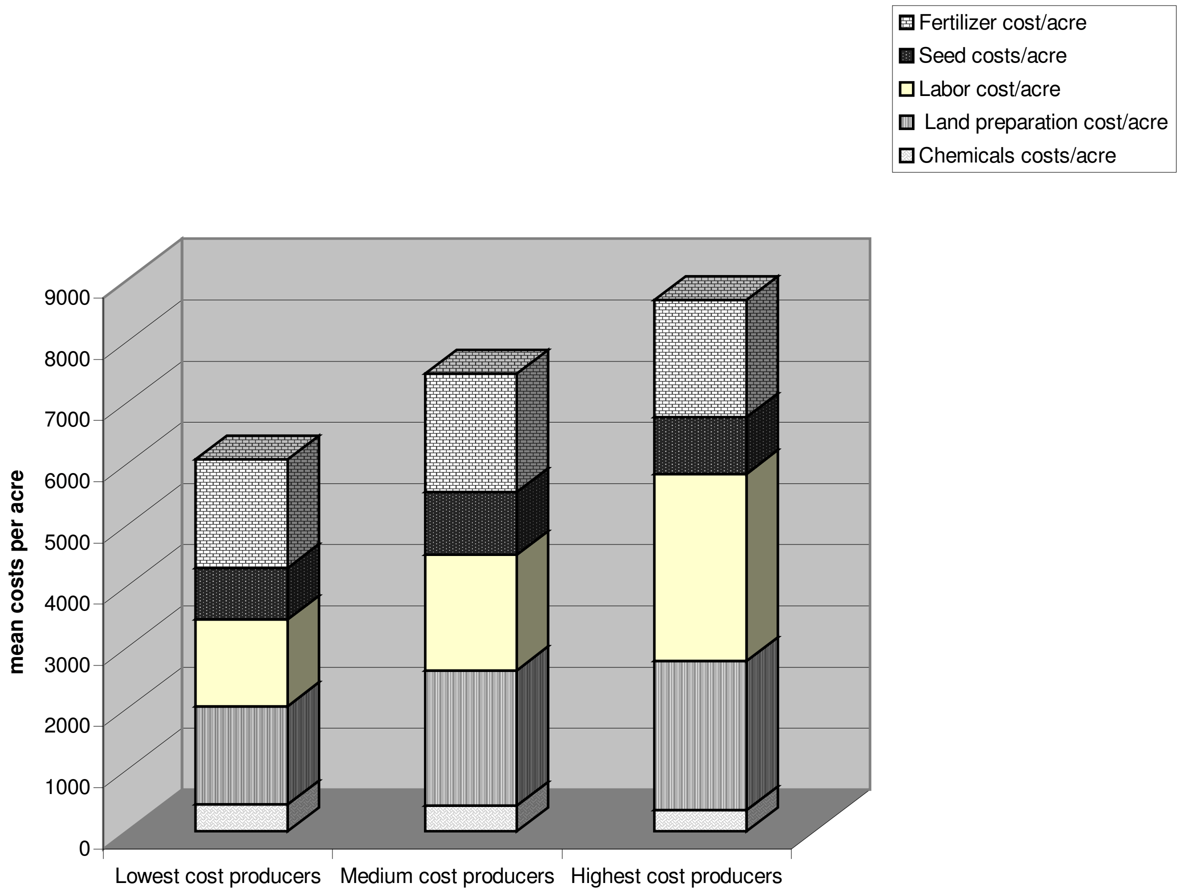


Table 9: Mean Characteristics of Maize Monocrop System, According to Level of Production Costs per Bag and Production Technology Category

	Production Technology Category (PTC)						
	1	2	3	4	5	6	7
Lowest Production Cost Farmer Tercile:							
Production costs/bag[1]	413	424	472	364	452	334	268
Production costs/bag[2]	568	562	596	434	569	457	341
Yield (Bags/acre)	20	23	25	15	17	10	23
Production costs/acre	7,475	9,671	11,052	5,361	7,641	3,314	6,189
Land rental/acre	2,888	2,888	2,888	1,923	1,923	1,277	1,277
Chemicals cost/acre	341	510	475	671	840	45	170
Land prep. cost /acre	1,401	2,279	3,131	373	330	1,841	1,886
Labor cost/acre	978	1,005	628	2,447	3,264	1,205	364
Seed costs/acre	1,291	1,396	1,157	262	948	148	721
Fertilizer cost/acre	2,712	2,559	2,576	349	1,717	0	2,488
Fertilizer use (kg/acre)	119	112	114	13	63	0	78
Medium Production Cost Farmer Tercile							
Production costs/bag[1]	692	645	931	713	686	493	407
Production costs/bag[2]	923	821	1,139	971	844	558	466
Bags/acre	14	17	15	7	14	13	23
Total production costs/acre	9,383	10,978	13,854	4,690	9,594	6,185	9,338
Land rental/acre	2,888	2,888	2,888	1,923	1,923	1,277	1,277
Chemicals costs/acre	132	384	634	161	547	91	980
Land preparation cost/acre	1,479	3,003	4,431	502	848	2,567	2,636
Labor cost/acre	1,675	1,083	590	2,617	4,543	1,518	1,162
Seed costs/acre	1,598	1,370	1,202	595	963	604	900
Fertilizer cost/acre	2,855	2,522	3,159	669	1,632	0	2,667
Fertilizer use (kg/acre)	124	111	137	23	62	0	90
Highest Production Cost Farmer Tercile:							
Production costs/bag[1]	1,611	1,173	2,287	1,754	1,676	1,199	867
Production costs/bag[2]	2,350	1,468	2,702	2,226	2,088	1,368	959
Bags/acre	5	11	8	5	8	6	13
Total production costs/acre	7,746	11,784	15,463	8,388	11,209	7,002	9,776
Land rental/acre	2,888	2,888	2,888	1,923	1,923	1,277	1,277
Chemicals costs/acre	205	1,034	503	266	190	125	80
Land preparation cost/acre	1,216	3,147	5,157	1,322	1,308	1,882	3,040
Labor cost/acre	2,902	1,485	323	5,248	5,963	4,281	1,197
Seed costs/acre	954	1,369	1,241	492	941	413	1,052
Fertilizer cost/acre	2,118	2,823	2,869	725	2,054	0	2,844
Fertilizer use (kg/acre)	91	121	125	31	88	0	98
Overall:							
Production costs/bag[1] (for PTC)	940	753	1,230	973	938	670	514
Production costs/bag[2] (for PTC)	1,331	957	1,479	1,249	1,167	818	589

Source: Tegemeo Maize Production Cost Survey data, 2003. 1:excluding land rental; 2: including land rental

Comparison between PTC 2 and 3 reveals the difference in production costs between small-scale and medium/large-scale farmers using similar production technology (two land preparation passes and high fertilizer intensity). The most efficient medium/large-scale producers can almost match the production costs of their small-scale counterparts, but among the medium- and high-cost terciles, larger farms incur substantially higher production costs. Aggregating across all terciles, larger farms in PTC 3 incur an average of 63% higher production costs per bag, excluding land rental rates, and 54% higher production costs when land rental rates are included. This may be largely attributed to the higher land preparation costs and, to a lesser extent, higher fertilizer costs to a lesser extent. Ironically, there should be scale economies in both of these technologies.

Turning to Central Province in Kenya, we find tremendous intra-PTC variability in maize production costs. PTC 5 differs from PTC 4 primarily in the amount of fertilizer applied. Application of higher levels of fertilizer in PTC 5 do not provide sufficiently higher yields compared to PTC 4 among farmers in the low-cost tercile; hence production costs per bag are 24% higher in PTC 5 vs. PTC 4. Production costs are roughly similar in the medium- and high-cost production terciles in PTC 4 and 5.

The remarkable feature in these production zones, and the ones in Western Kenya as well, is the variability in production costs within each zone. For example, the most efficient third of monocrop maize producers in PTC 4 and 5 produced maize at Ksh 569 per bag or below, even including land rental costs. This converts to roughly US$84 per tonne or below, which is quite efficient by world standards. Farmers in the medium-cost monocrop tercile achieved production costs in the range of Ksh 700-950 per bag (US$104 – 140 per tonne). Farmers in the high-cost monocrop tercile obtained production costs of between Ksh 1650 and Ksh 2200 per bag, which is over $250 per bag and clearly inefficient by world standards.

Turning to eastern Uganda, we examine PTC 6 and 7. PTC 6 is characterized by no small-scale monocrop production using mainly OPVs and no fertilizer use. PTC 7 uses mainly hybrid seeds and high fertilizer use, but is similar to PTC 6 in other respects. The hybrid-fertilizer combination appears to be highly productive, and PTC 7 achieves 25-30% lower production costs on average. Higher fertilizer costs in PTC 7 are more than compensated for by yield advantages of 130%, 77% and 116% for low, medium and high cost terciles, respectively.

Among small-scale producers in the Kenyan system, Central highlands production categories incur higher production costs per bag and achieve on average, lower yields than production technology categories in Western Kenya. Even between comparable categories like PTC 1 and 5, yields are 15% lower in PTC 5. This may be attributed to lower fertilizer application (about half). Production category 5 has higher labor costs and as seen in Table 10a, PTC 1 has more mechanized land preparation operations that may augment yields as a result of better land preparation. It appears that application of insufficient fertilizer when mainly using hybrid seeds and less thorough land preparation contribute to higher production costs per bag in PTC 5.

Overall, for the monocrop system, Kenyan maize production technology categories have higher production costs per bag compared to Ugandan ones. All costs except land preparation are generally higher in Kenyan production systems than in Uganda. There are important observed differences between production technologies in the two countries that can explain the apparent differences in production costs per bag. Kenyan production categories mainly use hybrid maize varieties, more fertilizers, and are on average more mechanized (Table 10a) while Ugandan categories use open pollinated seed varieties and lower levels of chemical inputs, fertilizers in particular. The Ugandan production system achieves comparable yields even when less or no fertilizer is applied. This may be because soils in eastern Uganda are more fertile.

Table 10a: Most Frequently Used First and Second Land Preparation Technology for the Monocrop System (% within Zone)

PTC	Least-cost tercile		Medium-cost tercile		High-cost tercile	
1	Hired tractor	75	Hired tractor	100	Hired tractor	100
	None	100	None	100	None	100
2	Hired tractor	71	Hired tractor	82	Hired tractor	65
	Hired tractor	65	Hired tractor	77	Hired tractor	53
3	Own tractor	55	Hired tractor	52	Own tractor	59
	Own tractor	55	Own tractor	57	Own tractor	59
4	Own oxen	50	Hand hoe	71	Hand hoe	100
	None	100	None	100	None	100
5	Hand hoe	88	Hand hoe	62	Hand hoe	100
	None	100	None	100	None	100
6	Own oxen	100	Hired oxen	80	Hand hoe	40
	Own oxen	100	Hired oxen	80	Hand hoe	40
7	Hired oxen	56	Hired tractor	56	Hired tractor	44
	Hired oxen	56	Hired tractor	44	Hired tractor	44

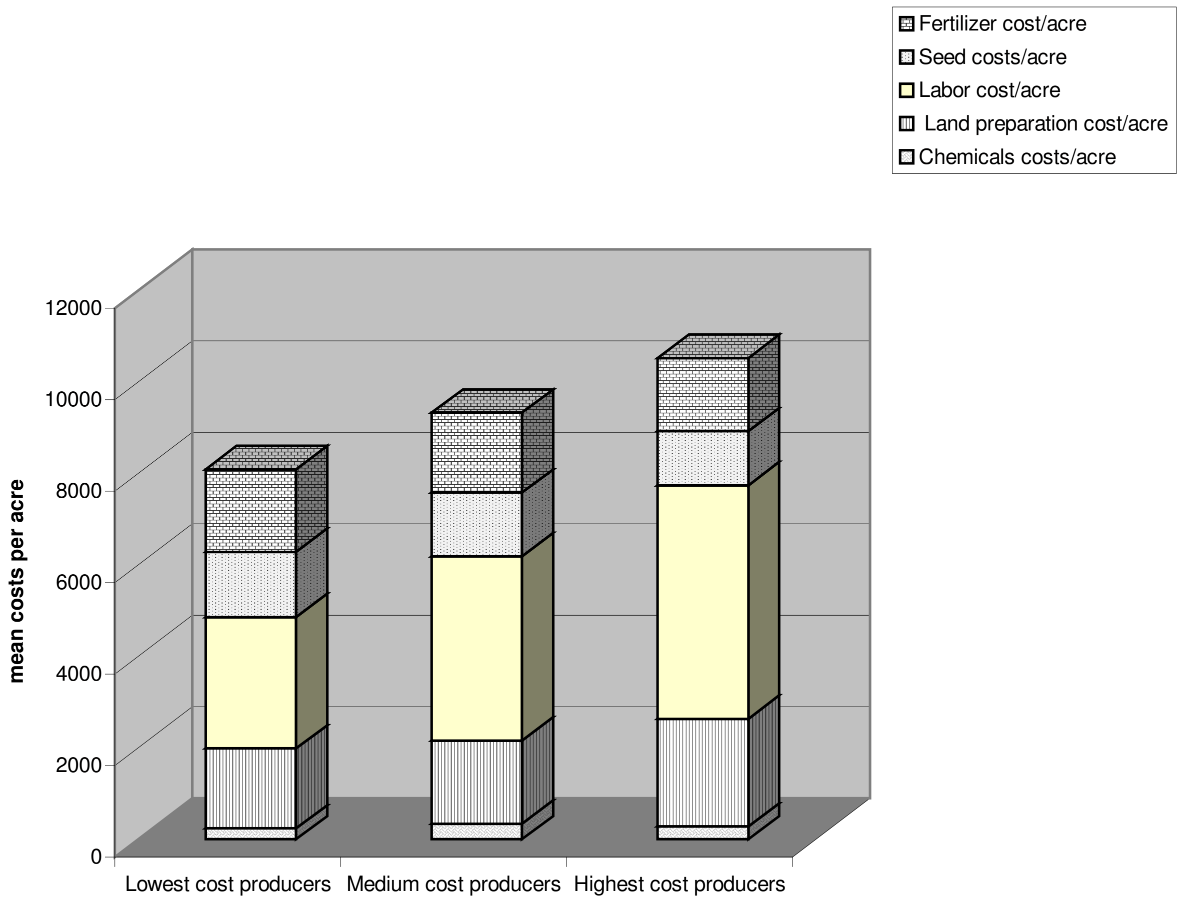
Source: Tegemeo Maize Production Cost Survey data, 2003.

Production Costs for Intercrop Maize System

We now undertake a similar comparison of production costs across PTCs for maize-bean intercrop systems. Table 6 on page 14 presents the six categories examined. A summary of components of production costs by tercile of maize producers for intercrop maize system is shown in Figure 2. There is little variation in fertilizer and chemical costs across producer groups. Labor costs are the largest component of maize production costs for all types of producers, and also account for the major source of the difference in production costs between low- and high-cost producers. Land preparation costs account for a smaller part of the difference in costs between low- and high-cost producers.

Production cost ranges from Ksh. 307 in Ugandan production category to Ksh 2,265 per bag in Central highlands, Kenya (Table 11). PTC 5 achieves the highest average production costs per bag among intercrop production categories. In the least-cost tercile, PTC 1 and 2 have equal yields but costs per bag are 5% higher in PTC 2. Labor and land preparation costs differ in these categories. Although category 1 has 1.7 times as much labor costs as category 2, the advantage of a second tillage in category 2 may be obscured by the accompanying land preparation costs. PTC 2 incurs 90% more in land preparation relative to PTC 1. However, among high-cost producers, the two categories achieve similar production costs but yields are 29% higher in PTC 2. Land preparation costs are higher in PTC 2 by a smaller margin of 58% while labor costs are 1.1 times higher in PTC 1. On average a second tillage pass in PTC 2 is associated with lower production costs per bag.

Fig 2: Cost Structure by Tercile for Intercrop System



Production category 3 has 5% higher costs per bag and 27% higher yields than category 2. Higher costs may be due to 32% and 16% increase in land preparation and fertilizer costs, respectively. In the highest cost tercile, PTC 3 still achieves higher costs but by a greater margin of 15% while yields are lower by 11%. Higher costs per bag for PTC 3 may be indicative of lack of economies of size in maize-bean intercrop production.

Yields in PTC 4 and 5 are comparable, but PTC 5 incurs 22% greater production costs per bag. Farmers in PTC 5 use nearly 4 times more fertilizer than those in PTC 4, which translates to a 287% increase in fertilizer costs per acre. A similar pattern is observed in the highest-cost tercile but production costs per bag are much higher (43% more) and fertilizer costs are 375% higher. In this case, use of more fertilizer per acre in maize-bean intercrop systems does not seem to translate into significantly higher yields. This observation may be a direct result of relatively poor land preparation (use of hand hoe for a single pass; see Table 10b).

Although no fertilizer is used in PTC 6, this category achieves the lowest production costs per bag among all production cost terciles. Comparison between PTC 6 on one hand and PTC 4 and 5 on the other hand, which have similar yields, indicates that lower costs in PTC 6 may be due to savings on fertilizer, labor and seed costs, as well as relatively fertile soils in eastern Uganda. Production category 6 uses primarily open pollinated seed varieties (83% of maize seed is OPV, 54% being recycled OPV) that provide relatively high yields even without applying fertilizer, while PTC 4 and 5 in the Central Highlands primarily use purchased hybrid seeds which are more expensive and require larger fertilizer applications. Categories 4 and 5 may be suffering a double tragedy by carrying out a single land preparation stage using the hand hoe predominantly (Table 10b). These categories incur very high labor costs and land preparation using the hoe is generally perceived to be of lower quality.

It is clear that for the maize intercrop system, Ugandan farmers and Kenyan smaller farms in high-potential maize-western region are lower cost producers while the Central Highlands production categories and the larger farmer systems of Western Kenya incur relatively higher production costs per bag. Therefore, it seems that there are no economies of scale in intercrop maize-bean production.

Table 10b. Most Frequently Used First and Second Land Preparation Technology for the Intercrop System (% Within Zone)

PTC	Least-cost tercile		Medium-cost tercile		High-cost tercile	
1	Hired tractor	73	Hired tractor	73	Hired tractor	73
	None	100	None	100	None	100
2	Hired tractor	42	Hired tractor	53	Hired tractor	58
	Hired tractor	52	Hired tractor	47	Hired tractor	42
3	Own tractor/own oxen[1]		Hired tractor	86	Own tractor	43
	Own tractor/own oxen[1]		Own tractor	57	Own tractor/own oxen[2]	
4	Hand hoe	80	Hand hoe	83	Hand hoe	80
	None	100	None	100	None	100
5	Hand hoe	67	Hand hoe	100	Hand hoe	100
	None	100	None	100	None	100
6	Hired tractor	58	Hired tractor/hired oxen[3]		Hand hoe	46
	Hired tractor	50	Hired oxen	38	Hand hoe	46

Source: Tegemeo Maize Production Cost Survey data, 2003.

1: Technologies are equally frequently used at 50% each; 2: Technologies are equally frequently used at 43% each; 3: Technologies are equally frequently used at 31% each

Table 11: Mean Characteristics of Maize Inter-crop Fields, According to Level of Production Costs per Bag and Production Technology Category

	Production Technology Category (PTC)					
	1	2	3	4	5	6
Lowest Production Cost Farmer Tercile:						
Production costs/bag[1]	465	487	516	498	607	307
Production costs/bag[2]	594	622	615	765	785	410
Yield (Bags/acre)	22	22	28	17	17	17
Production costs/acre	10,035	10,425	13,563	8,743	9,927	5,118
Land rental/acre	2,685	2,685	2,685	2,062	2,062	1,170
Chemicals cost/acre	166	216	201	167	571	120
Land prep. cost /acre	1,178	2,240	2,951	669	1,136	2,301
Labor cost/acre	3,598	2,163	2,081	4,251	4,088	1,075
Seed costs/acre	1,491	1,652	1,575	1,508	1,534	793
Fertilizer cost/acre	2,367	2,661	3,099	549	2,126	0
Fertilizer use (kg/acre)	107	111	138	22	85	0
Medium Production Cost Farmer Tercile						
Production costs/bag[1]	834	730	916	708	819	609
Production costs/bag[2]	1,033	921	1,156	874	1,017	733
Bags/acre	14	15	12	16	14	12
Total production costs/acre	11,487	10,977	10,911	11,465	11,217	7,209
Land rental/acre	2,685	2,685	2,685	2,062	2,062	1,170
Chemicals costs/acre	129	192	701	495	413	142
Land preparation cost/acre	1,344	1,928	2,237	1,936	1,218	2,251
Labor cost/acre	4,563	2,800	1,668	5,202	6,337	3,577
Seed costs/acre	1,199	1,544	1,282	2,406	1,081	852
Fertilizer cost/acre	2,491	2,923	2,373	819	1,868	0
Fertilizer use (kg/acre)	107	124	100	33	82	0
Highest Production Cost Farmer Tercile:						
Production costs/bag[1]	1,674	1,692	1,941	1,575	2,265	1,489
Production costs/bag[2]	2,121	2,042	2,430	1,762	2,985	1,624
Bags/acre	7	9	8	8	7	8
Total production costs/acre	10,522	12,315	13,628	11,267	13,107	10,601
Land rental/acre	2,685	2,685	2,685	2,062	2,062	1,170
Chemicals costs/acre	134	207	95	353	490	402
Land preparation cost/acre	1,476	2,326	3,347	1,967	2,246	2,796
Labor cost/acre	4,551	4,068	1,573	7,181	6,793	6,426
Seed costs/acre	1,207	1,551	1,377	767	1,513	683
Fertilizer cost/acre	2,294	2,468	2,481	414	1,966	0
Fertilizer use (kg/acre)	102	105	104	16	77	0
Production costs/bag[1] (for PTC)	1,006	967	1,125	916	1,261	814
Production costs/bag[2] (for PTC)	1,268	1,192	1,400	1,120	1,636	935

Source: Tegemeo Maize Production Cost Survey data, 2003. 1:excluding land rental; 2: including land rent

Summary of Findings on Maize Production Costs

Average costs of maize production vary by technology, scale of production and agro-ecological zones. The analysis in this section highlights 9 key findings:

1. Small-scale farm households in Eastern Uganda are, on average, lower-cost producers of maize for both mono- and inter-crop systems, while small-scale categories in Central highlands Kenya and large-scale farms in high-potential maize-western region incur relatively higher costs of production.

2. For monocrop maize production, one-third of small-scale farmers in Western Kenya in the 2002/03 harvest season (considered slightly below normal in most areas), achieved production costs below Ksh. 500 per bag, counting land rental costs. Two thirds of these farmers achieved production costs below Ksh 700 per bag. By contrast, the least-efficient third of small-scale monocrop maize producers incurrred production costs over Ksh 1000 per bag.

3. The variation in maize production costs within production technologies (i.e. across terciles) greatly exceeds the variation in production costs across categories. This suggests that variations in management practices and husbandry skills are probably very great. Because the survey was designed to minimize differences in agro-ecology within regions, and production categories were stratified by technology type and intensity, the wide variation in production costs within production categories most likely reflects differences in management practices in the cultivation of maize. This result underscores the importance of appropriate extension messages.

4. Simply by bringing the production costs of farmers in the high production cost tercile to that of the mean in each PTC, the overall production costs would decline from Ksh 851 to 630 per bag for monocrop maize producers and from Ksh 1007 to 752 per bag for intercrop maize producers.

5. In Kenya's high-potential maize production category, use of a second land preparation pass in monocrop maize cultivation appears to be superior to just one land preparation pass. This is evident by comparing production costs for Production Technology Category 1 and 2 in Table 9.

In this area of Kenya, hired tractor ploughing was the predominant mode of land preparation. Even though this additional land preparation pass contributes Ksh 900 to 1900 additional costs per acre, this is more than compensated for by the higher yields obtained. If this finding can be corroborated by other analysis, then extension services might attempt to more widely publicize the profitability benefits of a second land preparation pass for monocrop maize. The benefits of a second tractor pass on intercropped maize-bean fields were less marked.

6. There are differences in costs of monocrop maize production between small-scale vs. medium/large-scale producers in Kenya. This is shown by comparison of Production Technology Categories 2 and 3 in Table 9 (i.e., small vs. medium/large-scale producers, both using two tractor passes for land preparation, purchased hybrid maize seed, and comparable fertilizer use intensity of 90-125 kg per acre). Mean costs of monocrop maize production by small-scale farmers under this technology system were Ksh 753 per bag compared to Ksh 1,230 per bag for medium/large scale farmers, excluding land rental costs. In this case, there seems to be no economies of size in favor of large-scale maize farmers.

7. The use of fertilizer on monocrop maize fields among small-scale farmers in Eastern Uganda appears to moderately reduce maize production costs (this is the main difference between farmers in PTC 6 and 7). Both groups enjoy substantially lower production costs than in the high-potential maize zones of western Kenya. The main source of the differences in costs between these two zones can be seen by comparing PTC 2 and 7 in Table 9. The production technologies are very similar in these two categories (high fertilizer use, two land preparation passes, and monocrop cultivation). Yields are comparable, although somewhat higher in Uganda among the middle and bottom terciles. The main difference in production costs emanates from higher land rental, land preparation, labour and seed costs in Kenya.

8. Land rental rates in the high potential maize zones of western Kenya are 126% higher than in Eastern Uganda. This implies that rental rates are a major financial cost of production for many farmers in Kenya (an opportunity cost for all farmers, even those who own their land). There is some speculation that government policies to support maize prices in Kenya have over time inflated land rental rates in the major maize surplus-producing areas such as Uasin Gishu and

Trans Nzoia. This phenomenon of cereals pricing policy affecting the price of land and production costs has been well documented in the United States.

9. Application of higher levels of fertilizer is beneficial and accompanying higher yields more than compensate for associated fertilizer costs. This is true for monocrop but not intercrop maize.

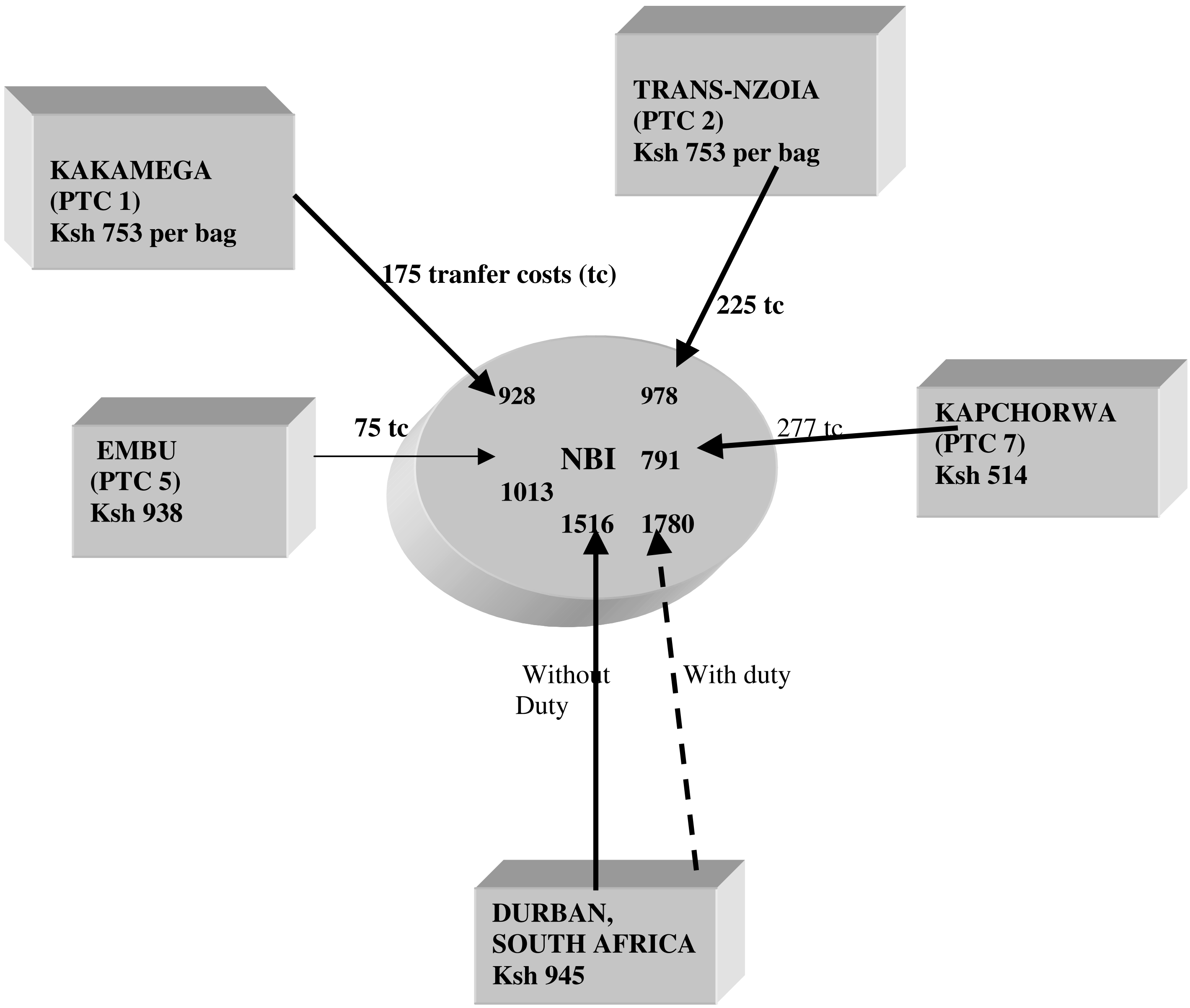
10. Labor and land preparation costs are significant components of production costs in both monocrop and intercrop systems. For small-scale farmers in Kenya, higher costs of production emanate largely from higher labor and fertilizer costs, and seed costs to a lesser extent. However, for large scale-farmers, land preparation costs form the largest portion of production costs. Among high-cost producers, labor and land preparation costs are the main source of inflated costs of production.

5. Implications for Current Production Costs vs Regional Trade Agreements

Overall Ugandan production categories have lower costs than comparable categories in Kenya. Uganda has also become an important source of maize to the Kenyan market. According to statistics from a maize market assessment and baseline study by the Regional Agricultural Trade Expansion Support Program (RATES), during 1997/98-crop season, Uganda exported a large proportion of its maize to Kenya. These imports have been increasing from about 120,000 to 150,000 bags. However the value of informal imports is often higher than official import figures. Uganda is therefore likely to remain an important source of maize for Kenya due to its close proximity to consumption areas like Kisumu and Siaya.

Figure 3 shows the production costs and transfer costs of maize from various places to the Nairobi market. Mean production costs in each PTC are shown inside the gray blocks while estimated transfer costs (obtained by informal interviews of traders by Tegemeo Institute) are shown next to the arrows. The figure shows that Ugandan maize is a competitive source for supplying Nairobi under normal conditions, and assuming that the transfer costs of Ksh 277 per bag are realistic. In actuality, informal trade barriers and regulatory requirements often force traders to evade formal border crossings, which entail higher transfer and transaction costs.

Figure 3: Costs of Supplying Nairobi Market from Alternative Sources



Current research by the Tegemeo Institute is attempting to measure the costs and risks associated with informal maize importation from Uganda, and their impact on maize price levels.

Outside the East African region, other sources of competition for local maize are imports from Southern Africa particularly South Africa. After adjusting the FOB maize price in Durban for various charges, the import parity price for maize at Nairobi (at an exchange rate of Ksh 75 per US dollar) was Ksh 1,780 per 90 kg bag in August 2003 (Table 12). Without imposition of 25% duty, landed cost of maize in Nairobi was still Ksh 1,516 per bag, which is beyond the range of maize prices in most seasons (generally not more than Ksh 1,500 per bag delivered at the mills in Nairobi).

Table 12. Import Parity Prices For Maize Ex Durban South Africa

	US $/Ton	Ksh/Ton	Ksh/90kg bags
FOB Durban	140	10,500	945
Freight	15	1,125	101
C& F Mombasa	155	11,625	1,046
Insurance (1% C&F)	2	116	10
Import Duty (25%)	39	2,935	264
IDF fees (2.75 of C& F	4	323	29
Stevedovering	10	735	66
KPA Shore handling	5	375	34
KARI (1% C&F)	2	116	10
KBS Analysis (0.2% C$ F)	0.31	23	2
Min of Health (0.2 of C&F)	0.31	23	2
Nagging charges	6.50	488	44
Transport to warehouse	3.00	225	20
Storage and Handling charges	1.20	90	8
Fumigation Charges	1.50	113	10
Agency fees	1.00	75	7
Incidental Charges	1.00	75	7
Landed into Store Mombasa	231	17,337	1,561
Road Haulage to Nairobi	32.5	2,438	219
Landed Nairobi with duty	**264**	**19,775**	**1,780**
Landed Nairobi Without Duty	**225**	**16,839**	**1,516**

Source: Tegemeo Institute informal interviews of maize milling and transport firms, 2003.

In the 2002/2003 season, it was estimated that Kenya produced about 21 million bags due to unfavorable weather conditions in some parts of the country, while requirements were roughly 30 million bags. This precarious maize situation puts Kenya into the typical food price dilemma discussed above. Imposition of maize tariffs to protect domestic producers will raise domestic maize prices and therefore hurt consumers. The challenge therefore is how to bridge the current production deficit without risking domestic production and also avoiding penalizing local consumers.

6. Conclusion and Policy Issues

Kenyan policy makers continue to be confronted by the classic "food price dilemma." For many years, policy makers have attempted to strike a balance between these two competing objectives – how to ensure adequate returns for domestic maize production while keeping costs as low as possible for consumers. Maize marketing and trade policy has been at the center of debates over this food price dilemma, including discussions over the appropriateness of trade barriers and the role of government in ensuring adequate returns to maize production.

This study examined the range of maize production costs achieved by small-scale and large-scale farmers in several maize producing zones in Kenya, and compared them to maize costs of production in eastern Uganda. The study is based on 581 farmers surveyed during the 2002/03 production season. The study disaggregates cost of production into seven region/technology categories, five in Kenya and two in eastern Uganda, in order to compare the relative competitiveness of maize among these regions and technology packages. Because production costs vary within each region/technology category, we present costs of maize production estimates for three terciles: low-, medium- and high-cost producers within each production technology category. The results hold important implications for who will benefit and lose from the removal of regulatory and informal trade barriers between Uganda and Kenya.

Overall, small-scale farm households in Eastern Uganda are, on average, lower-cost producers of maize for both mono- and inter-crop systems than comparable Kenyan production systems. Small-scale monocrop maize farmers in eastern Uganda achieved mean costs of Ksh 515 per bag (for a relatively high intensity technical package) to Ksh 670 per bag under an OPV/no fertilizer production technology. By contrast, small farmers in Western Kenya using hybrids and applying high fertilizer doses achieved costs in the range of Ksh 650 to 750 per bag. Mean costs of monocrop maize production by medium/large-scale farmers under a similar technology system were over Ksh 1,000 per bag, excluding land rental costs. Thus, during this particular season, Kenya's "breadbasket" incurred higher costs of production than major maize growing areas in Uganda. With open trade between Kenya and Uganda and no price support from the government of Kenya to support maize prices, competition from maize imports from Uganda will negatively affect Kenya's maize surplus areas. A way out of this political dilemma is to focus on reducing the cost of maize production in Kenya. This will enable Kenyan maize growers to compete favorably and will mitigate political dilemmas. The results of this study suggest some avenues through which maize production costs in Kenya can be reduced.

The variation in maize production costs within production technologies (i.e. across terciles) greatly exceeds the variation in production costs across categories. This suggests that variations in management practices and husbandry skills are probably very great. Because the survey was designed to minimize differences in agro-ecology within regions, and production categories were stratified by technology type and intensity, the wide variation in production costs within production categories at least partially reflects differences in management practices in the cultivation of maize. This result underscores the importance of appropriate extension messages.

Simply by bringing the production costs of farmers in the high production cost tercile to that of the mean in each PTC, the overall production costs would decline from Ksh 851 to 630 per bag for monocrop maize producers and from Ksh 1007 to 752 per bag for intercrop maize producers.

In Kenya's high-potential maize production category, use of a second land preparation pass in monocrop maize cultivation appears to be superior to just one land preparation pass. In this area of Kenya, hired tractor ploughing was the predominant mode of land preparation. If this finding can be corroborated by other analysis, then extension services might attempt to more widely publicize the profitability benefits of a second land preparation pass for monocrop maize. The benefits of a second tractor pass on intercropped maize-bean fields were less marked.

Small-scale farms in Kenya face higher labor, fertilizer, and seed costs compared to their counterparts in eastern Uganda. Land preparation costs are a significant portion of production costs for large-scale farmers. Similar findings have emerged from other studies (see RATES, 2003). It has been often argued that high costs of farm machinery have affected quality and timeliness of farm operations such as land preparation in key maize production zones. This has forced farmers to reduce quality of seedbed preparation and as we have found in this study, this compromises yield and inflates production costs. The underlying reasons for such high labor, fertilizer, and land preparation costs need to be explored and well understood if economies of size are to be realized and if meaningful recommendations can be made that will appreciably reduce production costs in Kenya.

Producers in *Central Highlands* use a significant amount of recycled hybrid. Nearly 80% of farmers surveyed in this region indicated that they used recycled seed because it is cheap. While most extension service officials and analysts contend that recycled seeds raise costs of production by reducing maize yields, this does not appear to be fully accepted by farmers in areas of Central Province. Farmers have complained that hybrid seed quality has declined over time. The challenge therefore is to encourage wider use of productive hybrids and other certified seeds through quality control and high standards throughout the marketing chain to gain back farmer's confidence in hybrid and certified seeds. Over time, this will discourage farmers from using local maize or recycled seeds. There is need to evaluate demand for and possibility of provision of fertilizer and seeds in smaller affordable packages, suited to farmers' needs, without compromising quality.

An examination of fertilizer adoption in Kenya reveals a generally widespread use by farmers in almost all agro-ecological zones. It is probably the levels and types of fertilizers used that have had greater influence in maize productivity rather than actual adoption of fertilizers or the knowledge of their existence. The biggest disparity in fertilizer use is therefore probably in quantities and types used. This again underscores the need for an effective extension program.

Despite all the constraints and challenges highlighted above, there are still some grounds of optimism for the maize sub sector in Kenya. These include:

- Following liberalization of the seed industry, there is an emergence of new maize varieties like Pioneer, Panner and Dekelb that could improve yields and raise maize productivity.
- Kenya has very high adoption rates for fertilizer and hybrid maize such that if the quality of these inputs are improved and inputs are more accessible to farmers at reasonable prices, there is good potential to increase productivity.

- With improved telecommunication and IT, production extension messages and market information can more easily be transmitted to growers and traders.
- The market for green maize is growing; supporting this sector could further improve the returns to small-scale maize production.

Therefore, Kenya, currently a high cost maize producer, needs to put more effort into maize technology generation, diffusion and quality control policies if it wishes to compete with neighboring countries. Poor crop husbandry, high cost of farm inputs and machinery, seed quality, and a weak extension system are the main contributors to the high cost of maize production. Shifting the focus from securing support prices to increasing crop productivity will go a long way toward raising living standards for Kenyan maize producers and consumers alike. A strong government commitment to crop productivity enhancement will be required to help farmers achieve these objectives.

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