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IFPRI Discussion Paper 00921

November 2009

Private Sector Responses to Public Investments and Policy Reforms

The Case of Fertilizer and Maize Market Development in Kenya

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2020 Vision Initiative

This paper has been prepared for the project on
Millions Fed: Proven Successes in Agricultural Development
(www.ifpri.org/millionsfed)

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ACKNOWLEDGEMENTS

This study was commissioned by the Millions Fed Program led by the International Food Policy Research Institute, Washington D.C. The study builds upon and is made possible by over a decade of sustained data collection, capacity building, and policy analysis conducted under the Tegemeo Agricultural Monitoring and Policy Analysis (TAMPA) project, a joint collaboration between Egerton University and Michigan State University, funded by USAID/Kenya. The authors also acknowledge the Bill and Melinda Gates Foundation for its support of research and capacity building activities on agricultural markets in Africa through an agreement between Egerton University and Michigan State University.

ABSTRACT

This paper documents the factors driving the impressive growth in fertilizer use and maize productivity in Kenya since the early 1990s up to 2007. The basic story is one of synergies between liberalization of input and maize markets and public investments in support of smallholder agriculture, leading to tangible private-sector investment in fertilizer retailing and maize marketing, which in turn has resulted in a 34 percent increase in smallholder fertilizer use per hectare of maize cultivated and an 18 percent increase in maize yields over the 1997–2007 period. There is also evidence of a reduction in maize marketing margins during this period. These developments have improved the welfare of rural and urban maize consumers, who constitute roughly 80 percent of Kenya's population. While certain aspects of liberalization have also benefited maize-selling smallholder farmers, many other developments in the Kenyan agricultural sector have not. Events since 2007 call into question the sustainability of Kenya's achievements in improving smallholders' access to maize and fertilizer markets over the 1990–2007 period.

Keywords: Millions Fed, Food Security, Fertilizer, Maize, Kenya, Liberalization market

1. INTRODUCTION

Overview of Interventions in Kenya's Fertilizer and Maize Marketing Systems

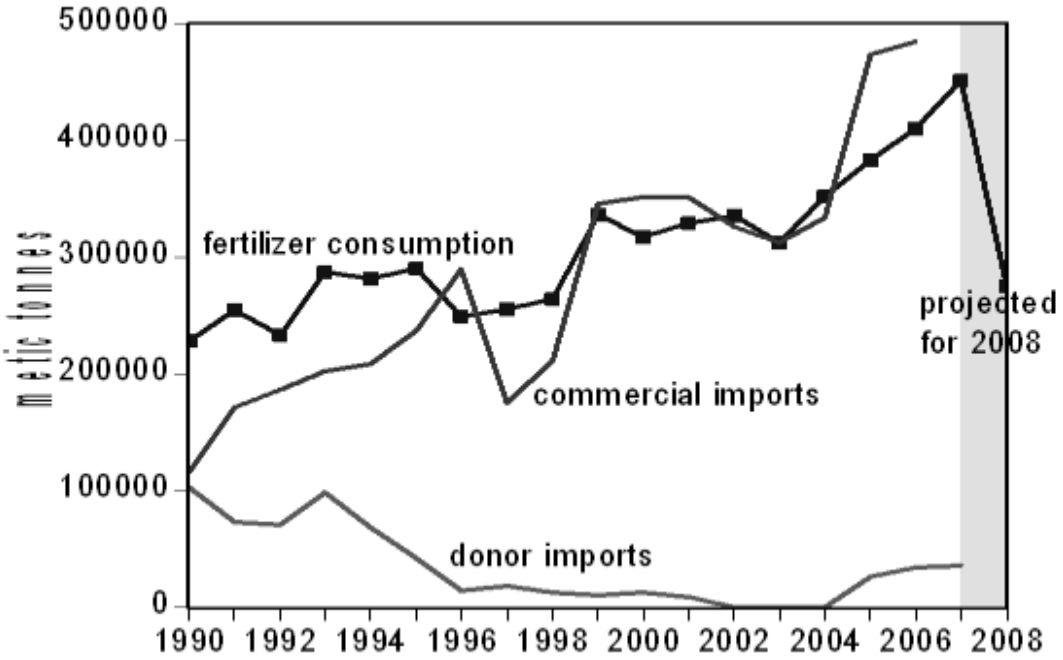
A range of policy reforms initiated in the early 1990s combined with complementary public investments induced substantial response by the private sector in input and maize markets, resulting in measurable improvements over the 1997 to 2007 period in smallholder maize productivity and rural farm incomes in Kenya. The essential features of this success story were the interaction of public investments in seed research and infrastructure with liberalization of the fertilizer and maize markets. These government actions led to the following responses by the private sector: (1) a major expansion in the number of fertilizer importers, wholesalers, and retailers operating in Kenya; (2) a substantial decline in the margins charged between the cost of fertilizer in world markets and observed fertilizer prices paid by Kenyan farmers, reflecting increased competition and efficiency in domestic fertilizer distribution; (3) a decline in the distance traveled by farmers to the point of maize sale, again reflecting improved functioning of maize assembly; and (4) the maintenance of roughly constant maize/fertilizer price ratios over the 15 years since liberalization, despite a reduction in the real price of maize due to the partial withdrawal of government marketing board interventions. These private-sector responses to public investments and market liberalization reduced farmers' transaction costs of accessing fertilizer and selling maize; raised fertilizer use and maize yields by smallholder farmers in Kenya; and contributed to growth in smallholder farm incomes and consumer welfare.

The period of this success story is from the early 1990s to at least 2007. National fertilizer use has doubled over this period (Figure 1). Total consumption has risen from a mean of roughly 180,000 tons per year during the 1980s, to 250,000 tons per year during the early 1990s, to over 325,000 tons in the 2000–03 periods, to over 400,000 tons in 2006 and 2007. According to nationwide farm survey data, smallholders' use of fertilizer per cultivated hectare of maize has grown by 33 percent in the past 10 years. This growth in fertilizer use has contributed to improved maize yields, smallholder incomes, and national food security. However, national government statistics show little improvement in maize yields over the past 20 years; this paper explains the likely reasons for this discrepancy. A combination of widespread postelection violence in 2008, drought and world market instability in both 2008 and 2009, and changes in the input marketing policy environment has disrupted the positive trends in fertilizer use and maize productivity achieved in the 1990–2007 period and has jeopardized the sustainability of these achievements.

Therefore, this success story is a fragile one. Its continuation will depend on the return to at least a minimum threshold of political stability, renewed clarity and transparency about the operations of the state in input markets, and sustained public investments in support of market development and smallholder welfare.

Kenya's case, in which the liberalization of input and maize markets has contributed to smallholder farm productivity growth and national food security, stands in contrast to many other analyses of the impacts of market liberalization elsewhere in Africa. The concluding section of this paper addresses why Kenya's efforts have proved relatively successful and the degree to which their success could be replicated more broadly elsewhere in Africa.

Figure 1. Trends in fertilizer consumption, commercial imports, and donor imports, 1990-2007, with projections for 2008



Source: Ministry of Agriculture, 1990–2007; 2008 projections from interviews of fertilizer importers.

2. POLITICAL CONTEXT OF THE REFORMS

Kenya's process of reform in the agricultural sector and the overall economy began in earnest in the early 1990s. The push for reforms in these markets was set in motion both by contemporary economic ideas of the time (see, for example, World Bank 1981; Bates 1981; Williamson 1997; de Soto, 2000) and by financial crises. The rising tide of worldwide support for market liberalization during the 1980s and early 1990s was based on the belief that greater reliance on markets would encourage competition and lower marketing costs, to the benefit of both farmers and consumers. The aspect of liberalization that was perhaps most persuasive to Kenyans was the general disappointment with state interventions and the belief that government was not managing taxpayers' funds well, as corruption and patronage became widespread (Bates 1981; 1989).

Though a number of sectors were targets of reforms, none had the elevated attention that has always been bestowed on maize. Maize is the staple food in Kenya, and more than 90 percent of rural households grow maize. Maize accounts for the single largest share of cultivated land in Kenya and nationwide farm surveys indicate that more than 40 percent of fertilizer use is applied on maize fields (Ariga et al. 2008).

In Kenya as in most of Africa in the early 1990s, the key agricultural policy challenges revolved around the classic "food price dilemma": how to keep food prices at tolerable levels for consumers while at the same time keeping adequate incentives for producers to feed the nation and raise farm incomes. Kenyan policymakers had for many years attempted to strike a balance between these two competing objectives through controlling maize and maize meal prices. The National Cereals and Produce Board (NCPB) generally offered maize prices higher than those prevailing in parallel markets and sold to industrial maize millers below prevailing market prices in urban areas. By narrowing the margin between its purchase and sale price, the NCPB was able to maintain its dominant market position and retard the development of parallel maize markets during the 1980s. However, the NCPB marketing margin was insufficient to cover its costs and it consequently incurred massive deficits during the 1980s (Jayne and Jones 1997). Hence, fiscal pressure was a major contributing factor leading to maize market reform in Kenya. There was also growing public recognition that parallel markets were becoming in many cases the preferred channels for many farmers and consumers in response to the bureaucratic inefficiencies of the state and charges of outright corruption within the NCPB. Regarding input markets, the impetus for reform grew after it became increasingly recognized that the government's controlled pricing structure did not ensure adequate margins for retailers to supply the relatively distant rural areas. While the controlled fertilizer pricing structure was designed to improve farmers' access to fertilizer, it had the opposite effect in the more remote areas (Kimuyu 1994).

Starting in the early 1990s, pressure from the private sector, civil society, and development partners plus the unsustainable costs of maintaining bureaucracies led the government to slowly relinquish its hold on both maize and fertilizer markets. Transitioning from state control policies to a freer trade regime involved the participation of a number of players. Key players in the reform process included (1) donor countries who pushed for liberalized markets as a condition for provision of bi(multi)lateral financial assistance, (2) Kenya firms involved in grain and fertilizer importation, (3) currency traders who found the fixed exchange rate costly in international dealings, (4) consumer groups that were against trade restrictions and commodity movement controls that artificially raised food prices, (5) local researchers whose analysis generally was sympathetic to policy reform, and (6) some legislators, representing areas primarily containing net food buyers who were adversely affected by a high-food price regime as well as those seeking to reduce government budget deficits.

It is important to put in perspective the role of agitation for political pluralism in Kenya on economic reforms. The perception of excessive government control and suppression of free speech engendered a growing anti-government sentiment among the populace, which pushed for free political association and the formation of competing political parties. Kenya's constitution at that time allowed for only one political party, but by 1992, under intense pressure from the masses, a few dissenting legislators,

and donors, it was amended to allow for alternative political parties. The economic reforms took off in an environment of renewed interest in "people-power;" that is, the view that paternalism was for the most part no longer appreciated and that ordinary citizens were capable of running their own affairs without excessive government oversight.

A number of additional events helped accelerate the push for reform of Kenya's maize and fertilizer markets. During the colonial period and following independence in 1963, a substantial number of Kenya's middle and upper classes morphed into an elite group with power or connections to centers of influence. Many of them over time became successful in business and commerce. The fear that government withdrawal from the maize or input markets could leave a void that would harm producers and consumers was quickly dispelled when this elite group started investing in retailing, importation, storage, distribution, and related activities; this was accelerated when the exchange rate regimes and foreign trade impediments were eased, leading to an infusion of foreign funds that led to partnerships between Kenyan and foreign entrepreneurs. For instance, the two largest fertilizer dealers in the country, while being domestic companies, have substantial foreign ownership and investment.

To conclude, the main factors contributing to policy reform in Kenya's fertilizer and maize markets were prevailing world economic ideology, growing local dissatisfaction with perceived corruption and paternalism of the state, fiscal deficits and associated pressure for reform from international financial institutions, articulation by local and international analysts that reform could bring important benefits to broad segments of the Kenyan population, and by entrepreneurial local elites who were well positioned to gain from the retreat of the state from these markets.

3. DATA USED IN THE STUDY

Many of the conclusions of this study are based on nationwide surveys of 1,260 smallholder farm households in 24 districts, surveyed 1997, 2000, 2004, and 2007. The panel household survey was designed and implemented under the Tegemeo Agricultural Monitoring and Policy Analysis Project (TAMPA), implemented by Egerton University's Tegemeo Institute, Kenya, with support from Michigan State University.

The sample frame was developed by Tegemeo Institute in consultation with the government's Central Bureau of Statistics, now the Kenya National Bureau of Statistics[1] Twenty-four districts were purposively chosen to represent the broad range of agroecological zones (AEZs) and agricultural production systems in Kenya. Next, all nonurban divisions in the selected districts were assigned to one or more AEZs based on agronomic information from secondary data. Third, proportional to population across AEZs, divisions were selected from each AEZ. Fourth, within each division, villages and households in that order were randomly selected. A total of 1,500 households were selected in 1997 in 106 villages covering 24 districts within the country's eight agriculturally oriented provinces. We excluded large farms with more than 20 acres and pastoral areas.

The attrition rate during the period 1997–2007 is 16 percent. The survey results reported in this paper are of the balanced panel of 1,260 smallholder households consistently interviewed in all four years. The sample was not rotated to account for life cycle effects. Details of the sampling procedure, geographic coverage, attrition bias, and questions asked are presented in Ariga et al. (2008).

The survey sample has been classified into zones for analytical convenience, based on agroecological characteristics, districts, and agricultural production potential (Table 1).

Table 1. Sampled districts in agroecological zones

Agroecological zone	District	Categorization	Number of households
Coastal Lowlands	Kilifi, Kwale	Low potential	70
Eastern Lowlands	Machakos, Mwingi, Makueni, Kitui, Taita-Taveta	Low potential	143
Western Lowlands	Kisumu, Siaya	Low potential	149
Western Transitional	Bungoma (lower elevation), Kakamega (lower elevation)	Medium potential	148
Western Highlands	Vihiga, Kisii	High potential	128
Central Highlands	Nyeri, Muranga, Meru	High potential	240
High-Potential Maize Zone	Kakamega (upper elevation), Bungoma (upper elevation), Trans Nzoia, Uasin Gishu, Bomet, Nakuru, Narok	High potential	345
Marginal Rain Shadow	Laikipia	Low/medium potential	37
Overall sample			**1,260**

Source: Tegemeo Household Survey data 1997, 2000, 2004, 2007.

Other data are obtained from the Ministry of Agriculture (MoA), such as monthly maize price levels, annual fertilizer consumption, and fertilizer prices at the port of Mombasa and at Nakuru. The NCPB provided data on its annual maize purchases, sales, and price levels. We also compare results on fertilizer use with other available household surveys, such as the 1992 and 2002 farm surveys

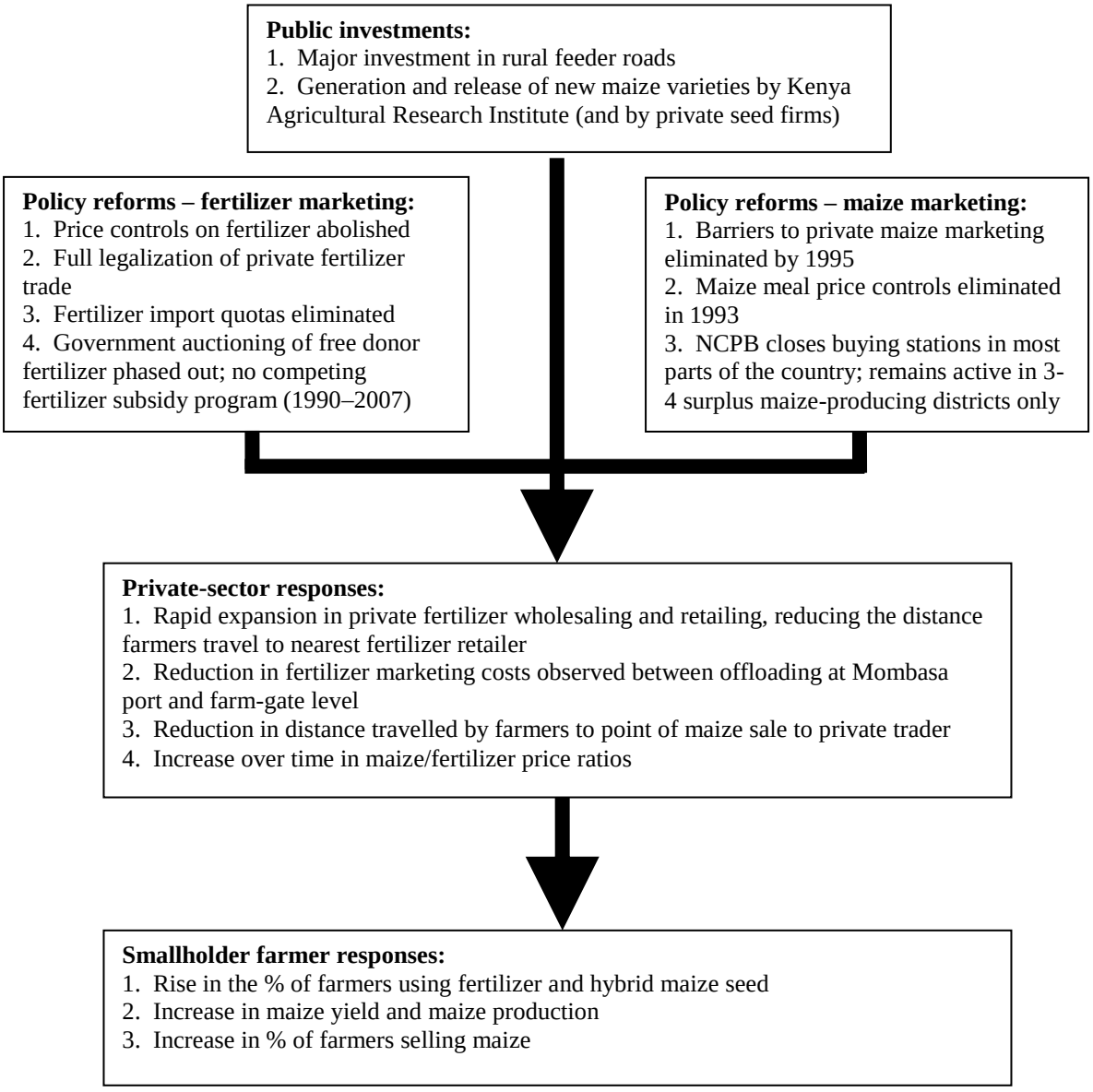
[1] See Kodhek et al. 1998, for details on the sample design.

implemented jointly by International Maize and Wheat Improvement Center (CIMMYT) and the Kenyan Agricultural Research Institute (KARI), the 2005 Rockefeller-funded household survey in Western Kenya, and the government's nationally representative Kenya Integrated Household and Budget Survey, undertaken in 2005.

4. DESCRIPTION OF THE INTERVENTIONS

Figure 2 provides a schematic description of how public investments in market infrastructure and policy reform of the fertilizer and maize markets generated specific responses from the private sector, which then generated particular changes in smallholder farm behavior. The basic story is one of synergies between liberalization of input and maize markets and public investments in support of smallholder agriculture, leading to substantial private-sector investment in fertilizer retailing and maize marketing, which in turn resulted in an impressive increase in smallholder fertilizer use and maize yields on smallholder farms over the 1997–2007 period.

Figure 2. Synergies between public goods investments, policies, and private-sector response in promoting fertilizer use and maize yield improvements by smallholder farmers



Fertilizer Market Reforms

Before Kenya's independence from the British in 1963, fertilizer use and availability was confined mainly to export crops such as coffee, tea, and sugarcane. These were basically grown on large-scale farms which were at the time supplied with fertilizers through a monopoly, the Kenya Farmers Association (KFA), which was a farmers union formed in the early 1920s. In 1972, a government commissioned study concluded that the KFA and the few private importers were acting as a cartel and were engaged in corruption, leading to unfair increases in domestic prices for farmers. The government's policy response was to introduce import quotas and subsidies and to channel imports through the Kenya National Trading Corporation (KNTC), a state-run corporation. This led to a 30 percent drop in farm-gate fertilizer prices. This forced some private companies to exit the business as they could not compete against a government parastatal offering subsidized prices. The role of KFA was redefined to be sole distributor of donor-funded fertilizer.

This monopolistic market structure was later viewed as an impediment to the development of the fertilizer market, and during the rest of the 1980s, the government of Kenya tried to encourage private firms to enter the market in competition with KNTC and KFA, albeit under uncertain state rules. Fertilizer traders were to adhere to official prices set at 54 market centers throughout the country. The government determined which firms were allowed to operate by applying strict licensing requirements and controlling the allocation of scarce foreign exchange to importers. Kimuyu (1994) concluded that the licensing process provided rent-seeking opportunities for public-sector officials, the costs of which had to be absorbed by trading firms who were mandated to operate within the trading margins afforded by the control price structure. Donor fertilizer aid, accounting for over half of total imports during the late 1980s, was poorly coordinated with commercial imports, leading to frequent oversupply and deficit. Moreover, the government increasingly recognized that its controlled pricing structure did not ensure adequate margins for retailers to supply the relatively distant rural areas. While the controlled pricing structure was designed to improve farmers' access to fertilizer, it had the opposite effect in the more remote areas.

These concerns led the government to reform its fertilizer marketing system. It was becoming increasingly difficult to maintain state-run agencies, and by late 1980 this posed a challenge to economic stability, contributing significantly to the budget deficit and inflation. A decline in the budgetary support to the agricultural sector from 13 percent in 1983 to less than 5 percent by the late 1990s probably contributed to the subsequent decline in agricultural growth, as did the mismanagement of agricultural institutions (Kodhek 2004).

The government initiated a number of policy changes affecting fertilizer marketing in the early 1990s. In January 1990 the government started removing import quota restrictions, followed by the abolition of licensing requirements for fertilizer imports in 1992 and general liberalization of the economy. In a major policy change, the government liberalized the fertilizer subsector in 1993 to allow participation of the private sector in imports and local trading and distribution of fertilizer. Before liberalization of the subsector, the importation and distribution of fertilizer was arranged by government-controlled organizations at panterritorial fixed prices. In 1994, customs duties and value-added tax (VAT) imposed on fertilizer imports were removed by the government as a policy measure to further spur agricultural productivity by encouraging farmers to use fertilizer. By 1993, donor imports dwindled to 5 percent of total consumption, and small-scale farmers relied exclusively on the private sector and cooperatives for fertilizer.

Coupled with the freeing of the foreign exchange regime in 1992, these changes in the policy environment led to substantial new entry of private-sector firms in importing, wholesaling, distribution, and retailing of fertilizer, as is shown below. Some of the largest importers were cooperatives and estate firms supplying their members, most of whom were small-scale farmers participating in tea, coffee, and sugarcane outgrower schemes. Most of the retail expansion is accounted for by independent rural shops selling fertilizer along with a variety of other retail goods to smallholder farmers.

Maize Market Reforms

The importance attached to maize by policymakers in Kenya can be inferred from the emphasis laid on maize in current and past national food policies. Food security has generally been taken to be synonymous with maize self-sufficiency by policymakers and other segments of society. This is because maize is not only the main staple food but also the most common crop grown by rural poor households for food (Nyoro, Kiiru, and Jayne 1999).

Up until the late 1980s, the government determined the price of maize paid by farmers, the buying and selling prices applying to millers and retailers, as well as the retail price of maize meal to consumers. These controlled prices were panterritorial and panseasonal, adjusted once per year at the beginning of the planting season. The government marketing board, NCPB, had a longstanding monopoly on internal and external trade. Informal private trade across district boundaries was illegal, as was cross-border trade. Traders were required to apply for movement permits to allow them to transport grain across district boundaries. Despite government attempts to suppress it, private maize trade occurred in Kenya even before the liberalization process began in the late 1980s.

The Cereal Sector Reform Program began in 1987/88 in response to political pressures for liberalization, as mentioned earlier. The European Union supported the program as part of the country's overarching structural adjustment policies. At first, the Kenyan government legalized interdistrict maize trade, with the maximum volume of maize trade to be progressively raised over time. The reform agreement also called for the NCPB to reduce its market share maize purchased as a proportion of total maize traded) over time, by widening the margin between its maize purchase and selling price, which would have provided greater scope for the private sector to operate. In fact, the NCPB did the opposite by narrowing its trading margin in the early 1990s, which made it unprofitable for the private sector to engage in many types of marketing activities, especially long-distance trade. This and other actions by the NCPB clearly impeded the private sector's ability to respond to liberalization.

The reform process intensified in late 1993, when, under pressure from international lenders, the government eliminated movement and price controls on maize trading, deregulated maize and maize meal prices, and eliminated direct subsidies on maize sold to registered millers (Jayne and Argwings-Kodhek 1997). By 1995, private traders were officially allowed to transport maize across districts without hindrance. Starting in the 1995/96 marketing year, and under pressure from external donors, the government dramatically reduced the NCPB's operating budget. Less than 4 percent of smallholder households sold maize directly to the NCPB, according to the nationwide Tegemeo/Egerton farm surveys in 2000, 2004, and 2007. Most of the maize purchased by the NCPB now appears to come from large-scale farmers in the maize surplus parts of the country, where unit procurement costs are low due to scale economies. While the NCPB's purchases now account for less than a third of the maize sold by Kenyan farmers, its operations still significantly affect market prices. A recent study found that the NCPB purchase and sale operations tend to raise market prices, particularly during good harvest years, and therefore protect against downward price risk (Jayne, Myers, and Nyoro 2008).

The market reforms were expected to raise competition by encouraging more private-sector participation in the market, thereby reducing costs in the marketing system. In practice, the implementation of the reforms has exacerbated some risks and costs of private- sector investment. This is because the reforms have been marked by frequent and usually unanticipated changes in trade tariffs, quantity restrictions, and regulatory changes facing private traders. The discretionary policy tools used by the government to influence market prices and supplies included: (1) frequent and unannounced changes in maize import tariff rates; (2) export bans; and (3) unpredictable operations of the NCPB, in particular changes in the prices it set for maize purchase and sale, its policy toward leasing storage facilities to private traders, and changes in funds allocated to NCPB by the Treasury for buying maize, which determined the extent to which the NCPB could affect the overall market (Ariga and Jayne 2008).

In addition to these sources of uncertainty, the liberalization process in Kenya has created additional risks for private investment associated with the uncertainty over the eventual dispensation of NCPB assets. Private investment in dedicated capital outlays, such as storage facilities, has been impeded

by the high degree of uncertainty over the disposition of the NCPB's storage facilities and other assets. New private investment in storage facilities could be vulnerable to huge losses if the NCPB continued to be a major player in the market offering panseasonal prices, or if its assets were sold off at highly discounted prices to competing firms, which could change the cost structure of certain stages in the marketing system.

However, since 2005 Kenya has complied with regional initiatives under the Common Market for Eastern and Southern Africa (COMESA) and the East African Community (EAC) to eliminate cross-border tariffs within the region and harmonize regional and international trade policies. Since January 2005, the tariff on maize imported into Kenya from Tanzania and Uganda has been limited to a 2.75 percent government levy. Imports of maize grain from Mombasa vary and are a source of uncertainty for private traders. A recent vector autoregression (VAR) analysis indicates that the maize import tariff over the 1995–2004 period raised mean domestic prices by roughly 4 percent, although in several particular years, the import tariff raised domestic price levels by well over 10 percent (Jayne, Myers, and Nyoro 2008).

In summary, the maize marketing and trade policy reforms adopted in Kenya over the 1990 to 2005 period had mixed effects on maize market development. On the one hand, the reforms legalized private trade, which no longer had to operate covertly. Tariff barriers to trade with neighboring countries were removed starting in 2005 and some regulations have been streamlined. On the other hand, the liberalization process, especially in its early years, was marked by policy unpredictability, vacillation, and perceptions of state resources being channeled to particular firms, giving them a competitive advantage in the market. Events in 2008 have shown that the maize market is still vulnerable to such problems (Jayne, Myers, and Nyoro 2008). In spite of these continuing policy-related risks, there is concrete evidence of private-sector response and smallholder satisfaction with the liberalization process in Kenya as will be described in Section 5. Table 2 gives a tabular chronology of policy events in the maize market.

Table 2. Evolution of maize marketing and pricing policy reforms starting in 1988

State Marketing Agency	Market Regulation and Pricing Policy
1988 NCPB financially restructured. Phased closure of NCPB depots. NCPB debts written-off; crop purchase fund established but not replenished.	1988 Cereal Sector Reform Program envisages widening of NCPB price margin. In fact, margin narrows. Proportion of grain that millers are obliged to buy from NCPB declines. Limited unlicensed maize trade allowed.
	1991 Further relaxation of interdistrict trade.
	1992 Restrictions on maize trade across districts re-imposed. NCPB unable to defend ceiling prices
	1993 Maize meal prices deregulated. Import tariff abolished.
1995 NCPB restricted to limited buyer and seller of last resort role. NCPB market share declines to 10-20% of marketed maize trade. NCPB operations confined mainly to high-potential areas of western Kenya.	1995 Full liberalization of internal maize and maize meal trade; maize import tariff re-imposed to 30%.
	1996 Export ban imposed after poor harvest.
	1997 Import tariff imposed after poor harvest
	1997 –onward: External trade and tariff rate levels change frequently and become difficult to predict. NCPB producer prices normally set above import parity levels
2000 –onward: NCPB provided with funds to purchase a greater volume of maize. NCPB's share of total maize trade rises to 25-35% of total marketed maize.	
	2005 –onward: The government withdraws the maize import tariff from maize entering Kenya from EAC member countries. An official 2.75% duty is still assessed. Variable import duty still assessed on maize entering through Mombasa port.

Source: Adapted from Ariga and Jayne 2008.

Public and Private Investment in Improved Maize Seed Technology

The release and dissemination of improved maize seed varieties has been another important dimension of Kenya's success in input intensification. Suri (2007) documents the release of at least 10 new maize hybrid or open pollinating varieties released since 1995. Several of these new varieties were released by KARI. Seed market liberalization has also allowed private entry into maize seed development and distribution in Kenya. Hassan, Mekuria, and Mwangi (2001) show a five-fold increase in the number of private seed companies between 1992 and 1996. However, as contended by Karanja (1996), the recent wave of new hybrids offers smaller yield advantages over previous varieties than the earlier wave of new releases.

The weight of the research evidence in Kenya is that there are large and statistically significant increases in maize yields from using fertilizer on farming areas of at least medium potential in Kenya (de Groote et al. 2005; Suri 2007; Ariga et al. 2006; Ariga et al. 2008; Marenya and Barrett 2009).[2] Strong research evidence reviewed by Suri (2007) also indicates that the marginal product of fertilizer is heightened by the use of improved modern seed varieties. Therefore, improvements in the generation, release, and adoption of improved maize seed technologies are likely to have played an important role in the observed uptake of fertilizer use by smallholder farmers in Kenya and the associated gains in maize productivity.

Public Investments in Support of Market Development

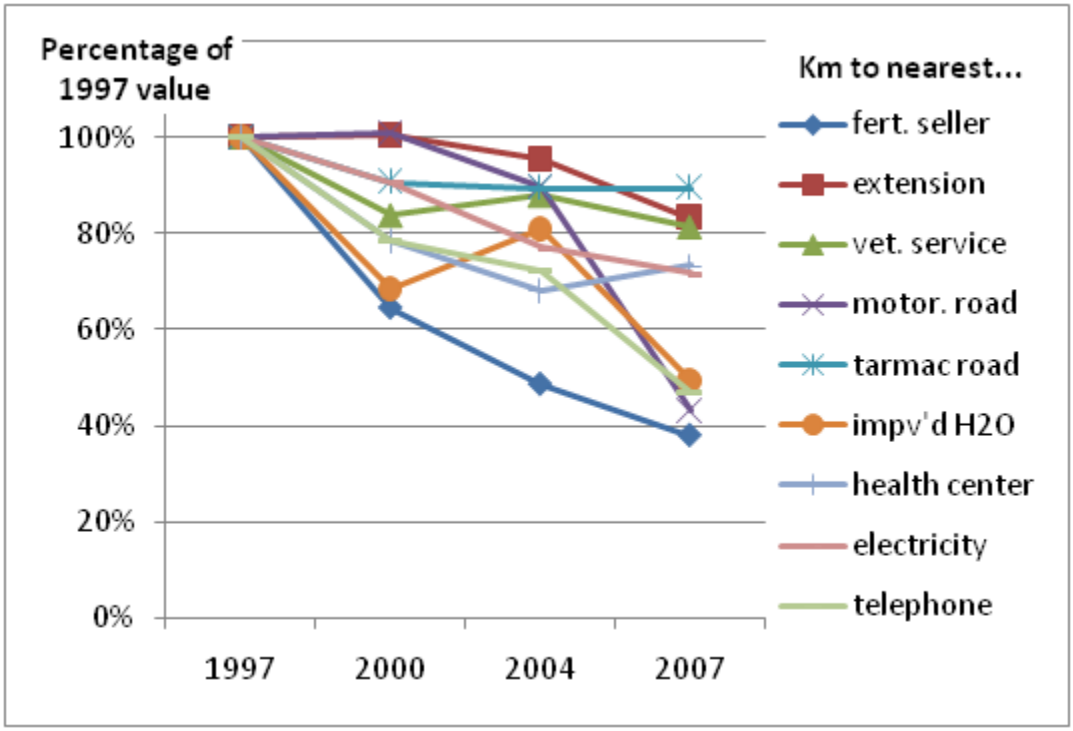
The Tegemeo farm household panel surveys collected information from respondents in each wave on access to markets, infrastructure, and services. This enables us to track changes over time in these "access" variables. Some of these indicators show changes in private-sector investment, such as the distance from the farm to the nearest fertilizer retailer and, in some cases, extension services. Other indicators are measures of public goods investments, such as distance from the farm to the nearest motorable road, tarmac road, clean water supply, health facility, and electricity grid. The indicators "distance to nearest telephone" and "distance to nearest veterinary service," while important measures of access to markets and information, represent a combination of both public- and private-sector coordination.

Figure 3 shows changes over the 1997–2007 period in mean household distance from the farm to these public- and private-sector services. Results are plotted as a percentage of the initial 1997 survey values. For virtually every indicator, there is a clear reduction in the distance traveled by households to markets and services. There is an especially substantial reduction in the mean distance to a clean water supply, telephone, motorable road, and fertilizer retailer. Smallholders' purchases of fertilizer over the sample period were all from private retailers. Therefore, the expansion of geographical coverage and improved proximity to fertilizer sellers may be interpreted as the expanding discovery and response to opportunities for fertilizer sales.

The greatest improvements in many of these infrastructure and service variables occurred between 2004 and 2007, such as the reduction in distance to a motorable road, water supply, and veterinary services. Mean distance from farm to motorable road fell in half between 2004 and 2007. The Constituency Development Fund (CDF), under which local authorities were given increased control of budget resources for local development, was established in 2003/04. All the 210 constituencies in Kenya are allocated 2.5 percent of the total government revenue for CDF funding. The sharp reduction in the distance to motorable roads and clean water between the 2004 and 2007 surveys is associated with this administrative reform, although causality cannot be inferred.

[2] However, Karanja, Renkow, and Crawford (2003) show that adoption of technologies in high potential areas is associated with higher gain in yield and profitability, compared to those in marginal areas.

Figure 3. Relative changes in indicators of access to markets and services, indexed to 1997



Source: Tegemeo Household Survey data 1997, 2000, 2004, 2007

Cell phone ownership has also mushroomed in Kenya over the past 15 years. The percentage of rural smallholder households owning a phone has moved from 0.9 percent in 1997 to 55 percent in 2007 (Table 3). The greatest increase in cell phone ownership over the past decade has occurred between 2004 and 2007. If this trend continues, close to 80 percent of smallholder households will own cell phones by 2010. When considering the various ways in which cell phone connection is likely to improve households' access to information, market opportunities, and farm sales options, it is hard to escape the conclusion that smallholders' access to markets are experiencing a major improvement in Kenya.

Table 3. Share of households that own a phone by agricultural zone over time

	Share of households that own a phone (%)			
Agroecological Zone	**1997**	**2000**	**2004**	**2007**
Coastal Lowlands	4.0	0.0	16.0	61.3
Eastern Lowlands	1.4	1.4	18.6	52.4
Western Lowlands	0.0	.7	17.0	41.2
Western Transitional	0.0	0.0	10.1	37.8
High-Potential Maize Zone	0.6	1.2	22.0	60.4
Western Highlands	0.0	0.8	14.0	50.4
Central Highlands	1.2	3.7	19.4	66.5
Marginal Rain Shadow	2.7	0.0	18.9	67.6
Total sample	0.9	1.3	17.9	55.0

Source: Tegemeo Household Survey data 1997, 2000, 2004, 2007

In summary, the nationwide household panel data provide strong evidence of a marked public investment in infrastructure and services, especially since 2004, which has stimulated private investment in retail input and output markets and also improved smallholders' access to information and services of various kinds (Chamberlin and Jayne 2009). Some of these investments, especially the private sector ones, could not have occurred without prior changes in the input and commodity market policy environment (mentioned in earlier sections), which provided incentives for private-sector investment in response to these opportunities. Figure 2 presents schematically the synergistic interactions between policy liberalization in the input, maize, and foreign exchange markets; public investments in support of rural development; and private investment response in input and maize markets, leading to tangible benefits for smallholder farmers and consumers.

5. OUTCOMES OF THE INTERVENTIONS

This section provides evidence of the synergistic effects of public and private investments and policy reforms on a number of outcomes measured at the farm level and in price relationships. Several of these outcomes represent investment response by the private sector and benefits from competition, for example, (1) increased private-sector investment in fertilizer wholesaling and retailing, (2) a reduction over time in the distance traveled by farmers to the nearest fertilizer retailer, (3) a decline in fertilizer marketing margins between Mombasa and upland markets, (4) improved maize–fertilizer price ratios facing farmers, and (5) a decline in the distance traveled by farmers to the point of maize sale.

Other outcomes detected in household panel survey data point to (1) a rise in the percentage of farmers using fertilizer, (2) increasing maize yields over time, and (3) an increase in the percentage of farmers relating to markets as sellers.

Increased Number of Private Fertilizer Wholesaling and Retailing Firms

As described in Section 4, the major policy changes affecting fertilizer markets included abolishing foreign exchange controls in 1992, elimination of fertilizer import quotas, import licensing requirements, and retail price controls, the removal of customs duties and VAT imposed on fertilizer imports, and the phasing out of noncommercial fertilizer distribution channels. By 1993, donor imports dwindled to 5 percent of total consumption, and small-scale farmers relied exclusively on the private sector and cooperatives for fertilizer.

These changes in the policy environment led to a significant new entry of private-sector firms in importing, wholesaling, distribution, and retailing of fertilizer (Kimuyu 1994; Wanzala et al 2002). Allgood and Kilungo (1996) report that by 1996, there were 12 major importers, 500 wholesalers, and roughly 5,000 retailers distributing fertilizer in the country. IFDC (2001) estimates that the number of retailers rose to between 7,000 and 8,000 by 2000. Some of the largest importers were cooperatives and estate firms supplying their members, most of whom were small-scale farmers participating in tea, coffee, and sugarcane outgrower schemes. Evidence of private-sector response in input and maize markets is revealed in the farm panel survey data through changes in proximity of households to markets and services (in the subsequent three sections).[3]

Progressive Reduction in the Distance Traveled by Farmers to Source Inputs

The rapid expansion in the number of input retailers in Kenya is also detected in the nationwide household panel survey data. The mean distance of small farmers to the nearest fertilizer retailer has declined from 8.1 kilometers (km) to 3.4 km between 1997 and 2007 (Table 4). A similar trend is observed in the distance to the nearest seller of hybrid maize seed, which declined from 5.6 km in 2000 to 3.4 km in 2007. Both the expansion in the number of rural fertilizer and hybrid seed retailers as well as accelerated public investment in road infrastructure since 2003 have expanded small farmers' access to fertilizer, reduced their transactions costs, and worked synergistically to raise the demand for modern inputs and the productivity of smallholder maize production, other factors held constant. Therefore, the reduction in distance traveled to access fertilizer and improved seed is likely to be an important factor behind increased fertilizer use by smallholders as seen in the longitudinal survey data.

[3] Since the sample is a stationary set of households that do not change from year to year, changes in distance to markets and services cannot reflect migration or other causes of household relocation.

Table 4. Mean distance to fertilizer and hybrid maize seed retailer

Zone	Distance to fertilizer seller				Distance to hybrid maize seed retailer		
	1997	2000	2004	2007	2000	2004	2007
Coastal Lowlands	30.6	24.3	18.4	11.3	21.8	18.7	9.5
Eastern Lowlands	9.8	5.4	4.2	2.7	6.4	3.7	3.0
Western Lowlands	16.0	11.6	7.5	3.8	9.1	5.4	3.8
Western Transitional	6.3	4.6	2.8	3.6	4.2	2.7	3.7
High-Potential Maize Zone	5.0	4.0	3.0	3.6	4.5	3.0	3.7
Western Highlands	3.3	2.2	1.4	2.4	2.6	1.6	2.4
Central Highlands	2.7	1.5	1.4	1.3	1.9	1.5	1.5
Marginal Rain Shadow	26.2	5.8	5.4	2.3	5.2	4.3	2.3
National sample	**8.1**	**5.7**	**4.1**	**3.4**	**5.6**	**3.9**	**3.4**

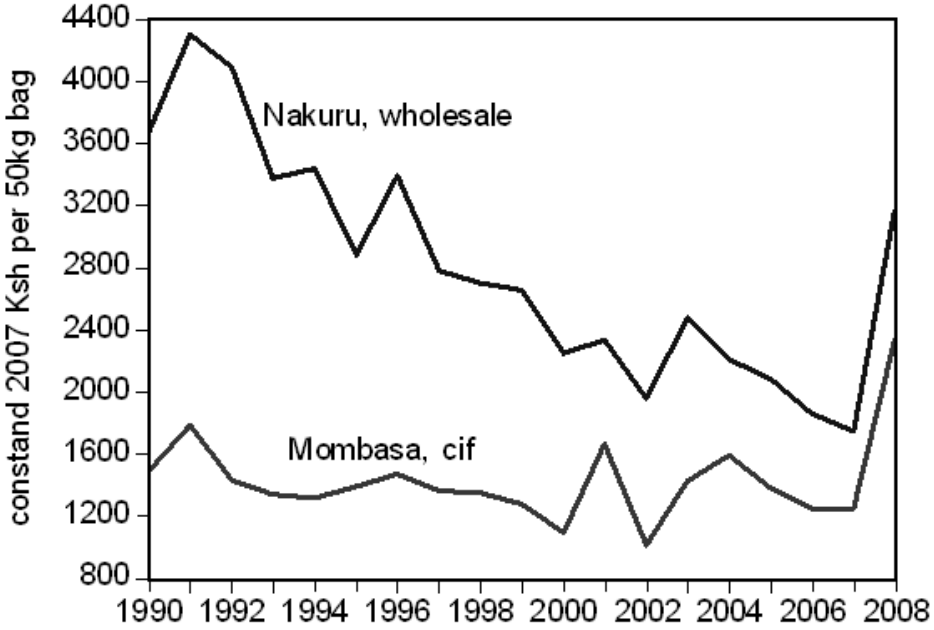
Source: Tegemeo Institute/Egerton University household surveys, 1997, 2000, 2004, and 2007.

Decline in Fertilizer Marketing Margins between Mombasa and Upland Markets

Figure 4 plots trends in real c.i.f. prices of diammonium phosphate (DAP) fertilizer ex Mombasa and the real wholesale price of DAP in wholesale Nakuru markets in western Kenya. Both price series are collected annually by the Ministry of Agriculture. DAP is the main basal fertilizer applied at planting on maize in Kenya. The Mombasa prices are a reflection of world DAP prices plus port charges and duties, which were reduced in 2003. The difference between the Nakuru and Mombasa prices thus reflects domestic fertilizer marketing costs. Nominal Kenyan shilling (Ksh) prices were deflated by the Kenyan consumer price index.

Figure 4 shows that while world prices, c.i.f. Mombasa, have stayed roughly constant over the 1990 to 2007 period, real DAP prices at Nakuru have declined substantially, from roughly Ksh 3,800 per 50 kilograms (kg) to Ksh 2,000 in constant 2007 shillings. While both import prices and upcountry prices have shot up in 2008, in relation to the general price index, DAP prices in 2008 are in real terms about equal to where they stood in the mid-1990s, about the time that the substantial decline in marketing costs began. Prices of urea show a similar pattern. Clearly there have been some positive developments in Kenya's fertilizer marketing system that have accounted for this cost reduction.

Figure 4. Price of diammonium phosphate (DAP) in Mombasa and Nakuru (constant 2007 Kenyan shillings per 50-kg bag)



Source: Ministry of Agriculture. FMB weekly fertilizer reports for c.i.f. Mombasa.
Note: Nakuru is a maize-producing area in the Rift Valley of Kenya, 400 miles (645 km) by road from the port of Mombasa.

Recent interviews of key informants in Kenya's fertilizer sector undertaken for this study identify four factors responsible for the declining fertilizer marketing costs observed in Kenya: (1) exploiting the potential for cheaper backhaul transportation, taking greater advantage of trucks transporting cargo from Rwanda and Congo to the port of Mombasa; (2) private importers are increasingly using international connections to source credit at lower interest and financing costs than are available in the domestic economy; (3) mergers between local and international firms in which knowledge and economies of scope enable cost savings in local distribution; and (4) increased competition among local importers and wholesalers given the expansion of firms engaged in fertilizer marketing since the early 1990s. In fact, it is likely that the fourth factor–increased competition–has stimulated firms to exploit the other cost-reducing innovations identified in order to maintain their market position. Intense competition has caused some shake-out in fertilizer importation, as firms that did not innovate quickly enough soon found themselves uncompetitive and lacking sufficient volume to continue in the business.

With the skyrocketing of world fertilizer prices in 2008, maize–fertilizer price ratios have plunged, contributing to a drop in fertilizer use by Kenyan farmers in 2008, though these have been mitigated by cost reductions achieved over the past decade in Kenya's fertilizer distribution system.

Rise in the Percentage of Farmers Using Fertilizer and Hybrid Maize Seed

The proportion of sampled smallholder farmers using fertilizer on maize in the main season has grown from 56 percent in 1996 to 70 percent in 2007 (Table 5). These rates vary considerably throughout the country, ranging from less than 10 percent of households surveyed in the drier lowland areas to up to 95 percent of small farmers in Central Province and the maize surplus areas of Western Kenya. The largest shares of smallholders using fertilizer are in Central Highlands, High-Potential Maize, and Western

Highlands zones, where more than 80 percent of all maize-growing smallholders apply fertilizer on maize.

Table 5. Percent of farm households using fertilizer on maize

Agroregional zone	1996	1997	2000	2004	2007
	% of households using fertilizer on maize				
Coastal Lowlands	0	0	3	4	14
Eastern Lowlands	21	27	25	47	43
Western Lowlands	2	1	5	5	13
Western Transitional	39	41	70	71	81
High-Potential Maize Zone	85	84	90	87	91
Western Highlands	81	75	91	91	95
Central Highlands	88	90	90	91	93
Marginal Rain Shadow	6	6	12	11	16
Total sample	**56**	**58**	**64**	**66**	**70**

Source: Tegemeo Institute/Egerton University household surveys, 1997, 2000, 2004, and 2007.

Table 6 presents trends in fertilizer dose rates, defined as the quantity of fertilizer applied to fields receiving fertilizer. Overall, fertilizer dose rates on maize fields have not increased appreciably. The mean dose rate was 56 kg per acre in 1997, rising to only 59 kg in 2007. Dose rates even appear to be declining somewhat in the lowland zones, while they are increasing in the moderate- and high-potential areas.

Table 6. Fertilizer dose rates (kg applied on maize fields receiving fertilizer, main season)

Agroregional zone	1997	2000	2004	2007
	Dose rate (kg/acre) on fertilized maize fields			
Coastal Lowlands	11	5	3	7
Eastern Lowlands	10	18	15	16
Western Lowlands	24	14	10	12
Western Transitional	54	48	62	71
High-Potential Maize Zone	65	67	74	75
Western Highlands	31	36	46	47
Central Highlands	68	64	64	58
Marginal Rain Shadow	12	15	43	43
National sample	**56**	**55**	**60**	**59**

Source: Tegemeo Institute/Egerton University household surveys, 1997, 2000, 2004, and 2007.

The percentage of households using fertilizer is much lower in the drier areas such as Eastern Lowlands (43 percent in 2007), Western Lowlands (13 percent in 2007) and Marginal Rain Shadow (16 percent in 2007). However, the percentage of farmers using fertilizer has increased in all zones between 1997 and 2007.

Mean dose rates in the six districts sampled in the High-Potential Maize Zone in 2007 were 75 kg per acre (187 kg per hectare), comparable to or higher than post-Green Revolution dose rates on rain-fed grain crops in the relatively productive areas of South and East Asia. In the drier lowlands by contrast, dose rates are low, but it is unclear whether economically optimal dose rates in such areas are much higher than observed here (further analysis is needed on this question). Overall, Kenya's agricultural

extension system recommends that farmers should apply 100 kg of fertilizer per acre of maize, but this recommendation may be based on high-potential rainfall and soil conditions and may therefore not be appropriate for the drier regions in the country, nor may it be appropriate given postliberalization maize/fertilizer price ratios.

The household panel data also reveal a general increasing trend in the proportion of households planting hybrid maize seed over the period 1997–2007, from 70 percent in 1997 to 74 percent in 2007. Analysis by zone reveals the greatest increase in the lowland and mid-altitude zones where particular progress has been made in the release of improved varieties by Western Seed Company, Monsanto, and the Kenya Agricultural Research Institute. The percentage of smallholders using maize hybrids rose in the Western Transitional Zone from 74 percent in 1997 to 87 percent in 2007 and in the Western Lowlands Zone from 14 percent in 1997 to 32 percent in 2007. However, other zones such as the Central Highlands and Marginal Rain Shadow have experienced a decline in hybrid adoption levels. The overall rise in the use of improved maize seed as observed in the survey data is consistent with official national estimates that the quantity of improved maize seed used rose from 45,000 tons in 1996/97 to 51,000 tons in 2006/07[4], a 13 percent increase (Ministry of Agriculture 2008).

The findings reported in Tables 5 and 6 from the nationwide Tegemeo survey data are largely consistent with those of other available studies. For example, a 2007 Rockefeller Foundation-funded study using different farm survey data in four districts of Western Kenya reports either a similar or higher proportion of small-scale farmers using inorganic fertilizer on maize than this study (Tegemeo Institute 2007). The mean district-level fertilizer application rates on fields receiving fertilizer are slightly higher in the Rockefeller-funded study than in the Tegemeo survey for comparable districts.

Another recent study by Marenya and Barrett (2008) of fertilizer use patterns in Vihiga and South Nandi district in 2005 found that 88 percent of the 260 farmers used fertilizer in the 2004 main crop season, compared to 78 percent in the Tegemeo sample in Vihiga District (South Nandi district was not included in the Tegemeo sample). In their study of Nakuru District, Obare et al. (2003) found more than 90 percent of farmers using fertilizer on maize. Nakuru District is also included in the Tegemeo sample, and we find that the proportion of households using fertilizer on maize in Nakuru varied between 83 and 91 percent, averaging 87 percent over the four years. Based on available corroborating evidence, we conclude that the findings reported in Tables 5 and 6 are comparable, and if anything, may underestimate the extent of fertilizer use, compared with other studies.

Trends in Fertilizer Application Rates for Monocropped and Intercropped Maize Fields

Tables 7 and 8 present fertilizer use rates and doses per acre for different kinds of maize fields: pure stand maize fields, maize fields intercropped with less than four other crops, and maize fields intercropped with four or more other crops. Some interesting insights emerge. First, note that of the total maize area in the sample (2,260 acres), roughly two-thirds of this area was in maize fields intercropped with less than four other crops in 1996/97 (usually maize–bean), but over time, an increasingly higher proportion of maize area has been under the third category, maize fields intercropped with four or more other crops (Table 7). By 2006/07, 1,049 acres in the total nationwide sample were devoted to maize intercropped with four or more other crops (usually beans and/or other legumes, potatoes, and/or a horticultural crop), while 790 acres were maize intercropped with less than four other crops, followed by only 473 acres under monocrop maize. In both of the intercropped maize categories, the proportion of maize area under fertilization has risen dramatically (from 63 to 85 percent of the area with less than four other crops and from 21 to 55 percent of the area with four or more other crops). By contrast, the percentage of area under maize pure stand receiving fertilizer has risen only slightly, from 74 percent in 1997 to 80 percent in 2007.

[4] In this paper, all tons are metric tons.

Table 7. Proportion of smallholder maize area fertilized, 1996/97–2006/07 (%)

	% of maize area receiving fertilizer (total acres in sample)			
Category of maize field	**1996/97**	**1999/2000**	**2003/04**	**2006/07**
Maize pure stand fields	74% (518)	73% (429)	76% (332)	80% (473)
Maize fields intercropped with < four other crops	63% (1,432)	71% (1,012)	70% (1,057)	85% (790)
Maize fields intercropped with > =four other crops	21% (310)	53% (1,118)	49% (894)	55% (1,049)
All maize fields in sample	60% (2,260)	63% (2,560)	63% (2,283)	70% (2,312)
% of total maize area under maize pure stand	22.9%	16.8%	14.5%	20.4%

Source: Tegemeo Institute/Egerton University household surveys, 1997, 2000, 2004, and 2007.

Table 8 presents trends over time in the intensity of fertilizer application on different categories of maize fields. The intensity of fertilizer application has increased dramatically on the intercropped fields. For example, on the maize fields intercropped with less than four other crops, mean dose rates rose from 60.9 kg/acre in 1997 to 74.2 kg/acre in 2007. When counting all fields, both fertilized and unfertilized fields in this category of maize field, mean application rates rose from 36.1 kg/acre in 1997 to 59.4 kg/acre in 2007 (Table 8, second row), a 65 percent increase. The dose rates on fertilized monocropped maize fields were roughly constant over the 10-year period at just over 70 kg per acre, but when accounting for the increased proportion of pure-stand fields receiving fertilizer over time, the overall increase in application rates on maize pure-stand fields has risen steadily over the decade, from 37.9 to 53.7 kg per acre (Table 8, first row).

Table 8. Fertilizer use rates per acre of maize cultivated by smallholder farmers and dose rates on fertilized maize fields, 1996/97, 1999/2000, 2003/04, and 2006/07 (kg/acre)

	Mean fertilizer use rates on all maize fields, both fertilized and unfertilized (Mean dose rates refer to fertilized maize fields only)			
Category of maize field	**1996/07**	**1999/2000**	**2003/04**	**2006/07**
Maize pure-stand fields	37.9 (72.6)	36.4 (64.2)	49.3 (71.0)	53.7 (74.1)
Maize fields intercropped with < four other crops	36.1 (60.9)	37.5 (61.9)	46.7 (66.4)	59.4 (74.2)
Maize fields intercropped with > four other crops	13.5 (42.1)	30.7 (60.7)	32.2 (58.0)	33.3 (56.1)
All maize fields in sample	33.6 (61.3)	34.2 (61.6)	41.1 (64.1)	44.7 (63.5)

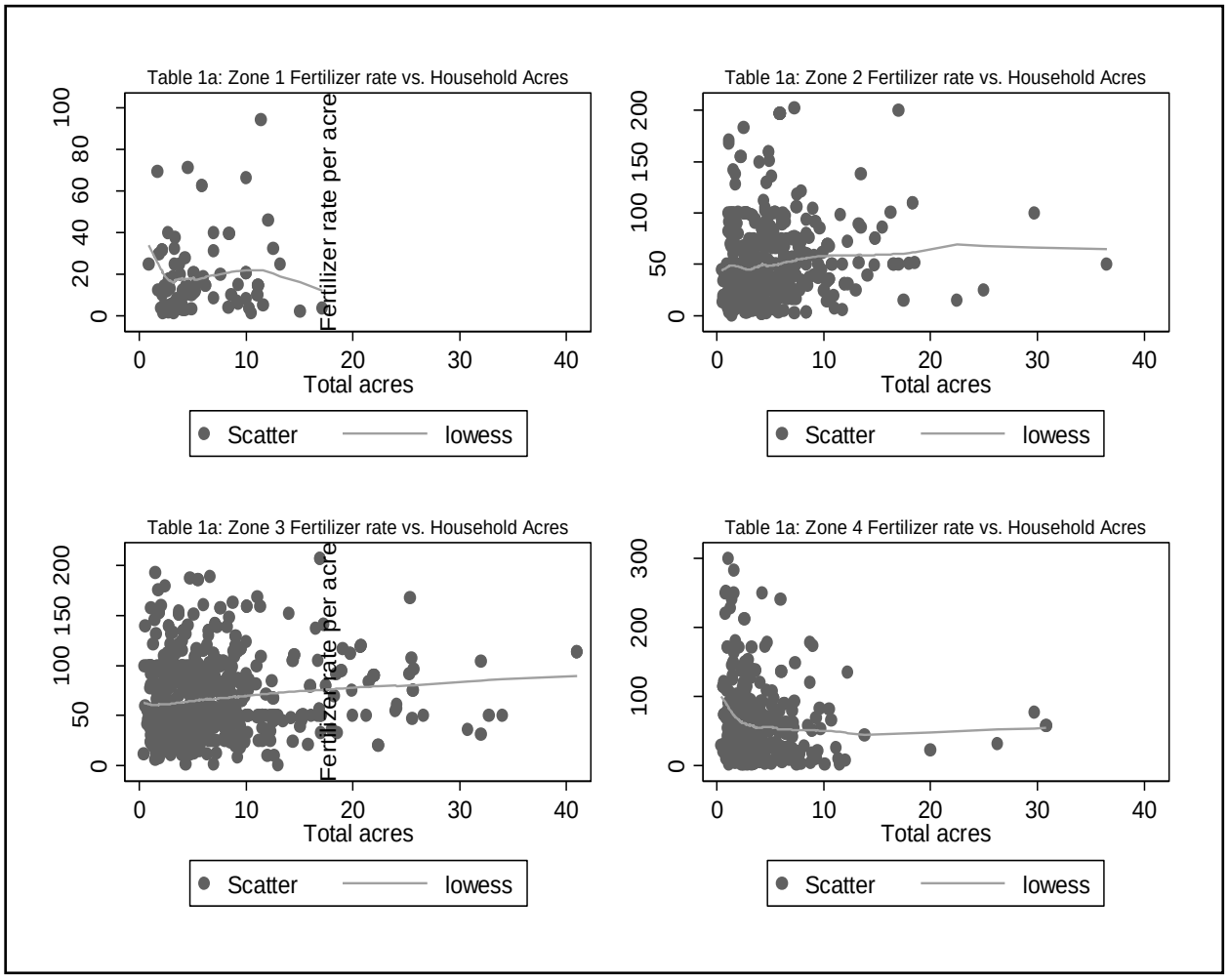
Source: Tegemeo Institute/Egerton University household surveys, 1997, 2000, 2004, and 2007.

Relationship between Household Farm Size and Fertilizer Use Rates

A common worry is that the poor cannot afford to purchase fertilizer and that even if fertilizer use rates are increasing in Kenya, this may not have much impact on poverty if the poor cannot afford to purchase this key input. To assess this, we examine the relationship between farm size and fertilizer use. Landholding size is one of the most important indicators of wealth in Kenya. Across the 1997, 2000, and 2004 surveys, the majority of all households had 75 to 100 percent of the value of their total assets in land (Burke et al. 2007).

Figure 5 shows scatter plots of fertilizer use by farm size by region. Each dot represents a household in the sample. A bivariate regression line was estimated for each figure, using locally weighted smoothed scatter plot regressions, or "lowess" (Cleveland 1979). However, Figure 5 shows that for any given zone and among landholdings under 20 acres, which account for nearly all of the sampled households, there is tremendous variation in the amount of fertilizer per acre used on maize. In Zone 1, for example, there appears to be a slight inverse relationship between farm size and intensity of fertilizer use, and mean dose rates in this semi-arid zone are in the range of 20–40 kg/acre throughout the farm size distribution. There is a slight positive relationship between farm size and fertilizer use intensity in the more productive Zones 2 and 3, but still the defining feature of Figure 5 is great variation in fertilizer use regardless of farm size, in every zone. Many small farms use fertilizer very intensively and many other farms of similar size do not. Household characteristics associated with fertilizer use are discussed below. Differences in fertilizer use appear to be greatest across the zones, with the most productive, Zone 3, achieving substantially higher mean use than Zone 1, the semi-arid lowland regions.

Figure 5. Scatter plot of household acres cultivated versus fertilizer use per acre (each dot is a household), by region



Source: Tegemeo Institute/Egerton University household surveys, 1997, 2000, 2004, and 2007.
Notes: Analysis in this section combines the eight agroecological zones into four in order to conserve degrees of freedom for the econometric analysis reported later in this section. The zonal aggregations are as follows:
Zone 1: Eastern and Western Lowlands (Kitui, Mwingi, Machakos, Makueni, Siaya, Kisumu);
Zone 2: Western Transitional and Western Highlands (Bungoma, lower elevation divisions in Kakamega, Kisii, and Vihiga)
Zone 3: High-potential maize zone (Trans-Nzoia, Uasin Gishu, Bomet, Nakuru, upper elevation divisions in Kakamega)
Zone 4: Central Highlands (Muranga, Nyeri, Meru, Laikipia).

We now examine the profitability of fertilizer and benefits accruing from use of increased amount of fertilizer per acre. Based on an earlier study that estimated production functions for maize using a translog functional form and using the same farm survey data (Ariga 2007), we generated marginal product elasticities for fertilizer and other factors including seed, labor, and controlling for semi-fixed factors. The analysis is confined to maize fields with three or fewer other crops grown on the same field. Table 9 presents the translog elasticities for fertilizer for the various zones as defined earlier. These elasticity estimates were found to be statistically significant at the 1 percent level for each zone.

Table 9. Translog elasticities on maize fields for different agroecological zones

Agro-Ecological Zone	Fertilizer rate
Zone 1 (Eastern and Western Lowlands)	0.163[a]
Zone 2 (Western Transitional and Western Highlands)	0.211[a]
Zone 3 (High-potential maize zone)	0.205[a]
Zone 4 (Central Highlands)	0.111[a]
Total	0.202 [a]

Source: Tegemeo Institute/Egerton University Rural Household Surveys (Adapted from Ariga 2007.
Note: Superscript "c"= p<0.10, "b"= p<0.05, "a"= p<0.01). The zones are defined in details in the notes attached to Figure 5 above.

Using these marginal product estimates for the four zones, we then compute value-cost ratios (VCRs) for fertilizer use on maize based on the maize–fertilizer price ratios observed in the survey data for each year. The value–cost ratio (*VCR*) divides the value of the marginal product by the price of fertilizer:

$$\text{VCR} = (MP_N \times P_{maize})/P_N$$

where MP_N is the marginal product of nitrogen fertilizer, P_{maize} is the value of the output (maize if pure stand, maize plus other crops if intercropped) and P_N is the price of nitrogen fertilizer. If the response function were known with certainty, the incentive would be to apply nitrogen to the point where the VCR is 1.0. However, there is clearly substantial weather uncertainty about the outcome of applying fertilizer. For these reasons, researchers have suggested that a VCR of 2.0 or greater is generally required for farmers to use fertilizer in appreciable amounts (Kelly 2006). Our paper adopts this convention and considers a VCR of at least 2 as an indicator that fertilizer use is likely to be profitable.

The VCRs are estimated for three groups based on amounts of fertilizer used per acre (lowest to highest). One needs to interpret with care the results in Table 10. In moving across the three columns (terciles of fertilizer use), fertilizer dose rates per acre for these households are increasing with the third tercile having the highest fertilizer dose rates. Each column has been subdivided into four (covering years 1997, 2000, 2004, and total summary for all the years) within each tercile. In each row, we report VCRs for each zone across columns, that is, as fertilizer dose rates increase. For instance, in the High-Potential Maize Zone (Zone 3) for the first tercile of users, on average, a Ksh10 investment in fertilizer contributes Ksh65 worth of maize, while the same investment contributes Ksh30 and Ksh19, respectively as fertilizer use increases through the second and third terciles. The cells in green show cases in which VCR estimates exceed 2.0. The same trend exists for the other zones implying that the greatest potential for benefits exists for households that are applying relatively moderate levels of fertilizer. An additional kilogram of fertilizer generates less additional output for households using near optimal amounts, compared with those that are using relatively less fertilizer per acre currently. This is as one would expect as expressed by the theory of diminishing marginal returns.

Therefore combining the findings that the proportion of maize area being fertilized by smallholders in Kenya is rising over time, that application rates are also rising, and that VCR estimates are generally well over 2.0 for at least the first and second terciles of fertilizer users in most zones, we can infer that increased use of fertilizer in the post-liberalization period has benefited households in most zones, particularly the medium- to high-potential zones.

Table 10. Value cost ratios for fertilizer (by terciles of fertilizer use)

		1st Tercile				2nd Tercile				3rd Tercile			
Zones		**1997**	**2000**	**2004**	**Total**	**1997**	**2000**	**2004**	**Total**	**1997**	**2000**	**2004**	**Total**
1	N	14	12	33	59	3	1	3	7			3	3
	VCR	4.25	8.79	8.58	7.60	1.59	1.77	3.83	2.58			0.74	0.74
2	N	67	77	57	201	36	47	65	148	29	23	75	127
	VCR	5.31	14.65	4.72	8.72	1.75	3.92	2.48	2.76	1.22	1.91	1.78	1.67
3	N	51	39	34	124	110	88	107	305	68	79	120	267
	VCR	6.21	4.29	9.49	6.51	2.48	2.77	3.85	3.05	1.60	2.02	1.98	1.90
4	N	45	32	42	119	22	16	17	55	40	25	39	104
	VCR	8.86	8.68	9.45	9.02	2.22	4.29	2.44	2.89	1.52	1.95	1.90	1.89
Total	Total	177	160	166	503	171	152	192	515	137	128	236	501
		6.39	10.49	7.66	8.11	2.28	3.28	3.26	2.94	1.50	2.10	1.91	1.85

Source: Tegemeo Institute/Egerton University Rural Household Surveys.
Note: N stands for sample size. The zones are the same as defined in the notes attached to Figure 5 above.

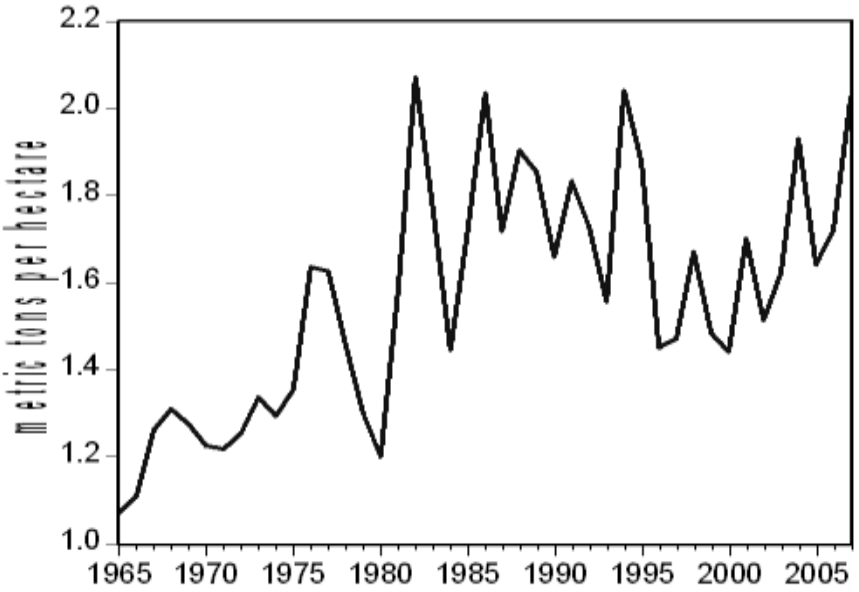
Another conclusion emerging from Table 10 is that there appear to be good reasons for observed variations in application rates across zones; the recommendation of 100 kg of fertilizer per acre in all zones would appear to be inefficient, but 100 kgs per acre may be profitable in some areas. In other areas, diminishing returns set in earlier, and hence 100 kg/acre contributes very little additional output. In such cases, application rates less than the standard 100 kgs/acre recommendation would be warranted. In the drier areas where rainfall is more erratic, such as along the coast, even very low fertilizer application rates would not provide a VCR > 2; hence the very low fertilizer use in such areas would not necessarily reflect sub-optimal utilization.

Increasing Maize Yields over Time

Particular attention has been focused on the widespread perception that maize, the primary staple, is suffering from declining yields since the 1990s when market liberalization programs were partially adopted. The perception is based on the fact that the operations of the NCPB, which were primarily designed to support maize price levels in maize-surplus areas of the country, have been scaled down since the mid-1990s. The perception that real maize prices have declined slightly over the past 15 years is indeed correct. However, we feel that the evidence of declining maize yields is not very strong, and available nationwide household panel survey data actually indicate the reverse.

National maize yield trends based on FAO statistics are presented in Figure 6. These estimates are not based on survey data; they are based on the "best guess-timates" of local agricultural extension agents and then aggregated to the district level and then to the province and national level by MoA staff. The official national estimates show that after rising impressively between 1965 and 1980, maize yields have largely stagnated over the past two decades.

Figure 6. National maize yield, Kenya, 1963–2007



Source: FAO Stat (last accessed May 31, 2009).

There are two reasons why MoA national yield estimates are likely to underestimate actual maize yield growth. First, MoA figures show that the fraction of maize area in marginal areas has increased over time. Second, and more subtle, is the fact that the proportion of maize area under intercropped land has increased dramatically since the early 1990s (Ariga et al. 2008). According to nationwide household survey data in 1997, 2000, 2004, and 2007, the proportion of total maize fields under monocrop production has declined from 22.9 percent in 1996/97 to 16.8 percent in 1999/2000 to 14.5 percent in 20003/04, before rising to 20.4 percent in 2007 (Table 7, last row). The proportion of total maize fields with four or more other crops on them has risen dramatically, from 13.7 percent in 1996/97 to 45.4 percent in 2006/07.

These survey data findings indicate that there is a general trend among Kenyan farmers to cultivate maize in more complex intercrop patterns over time.[5] However, national estimates of maize area by the MoA do not differentiate between maize area under monocrop and intercrop – they are added together informally by district agricultural officers in the computation of maize area and production. Maize yields on intercropped fields are almost certainly lower than maize yields on monocropped fields (although the total value of crop output per unit of land may be either higher or lower). Hence, due to the manner in which national area and production statistics are estimated by the MoA, the evidence of shifts in maize area from monocrop to more complex intercropping during the 1997–2004 period would downwardly bias true maize yields in more recent years, because they do not account for the fact that an increasing proportion of total maize area is under intercropped cultivation. In fact, nationwide field-level panel data indicate that both monocrop maize yields and intercrop yields have generally risen between 1997 and 2007, as shown in Table 11 and Figure 7.

[5] The reasons for the apparently dramatic shift in maize from monocrop to intercrop are due to many factors, including the retreat of NCPB from maize purchases at above-market prices in most areas of Kenya, the rise of horticulture markets (making maize intercropped with horticulture more profitable for farmers), declining farm size, and risk mitigation.

Table 11. Mean maize productivity (main season)

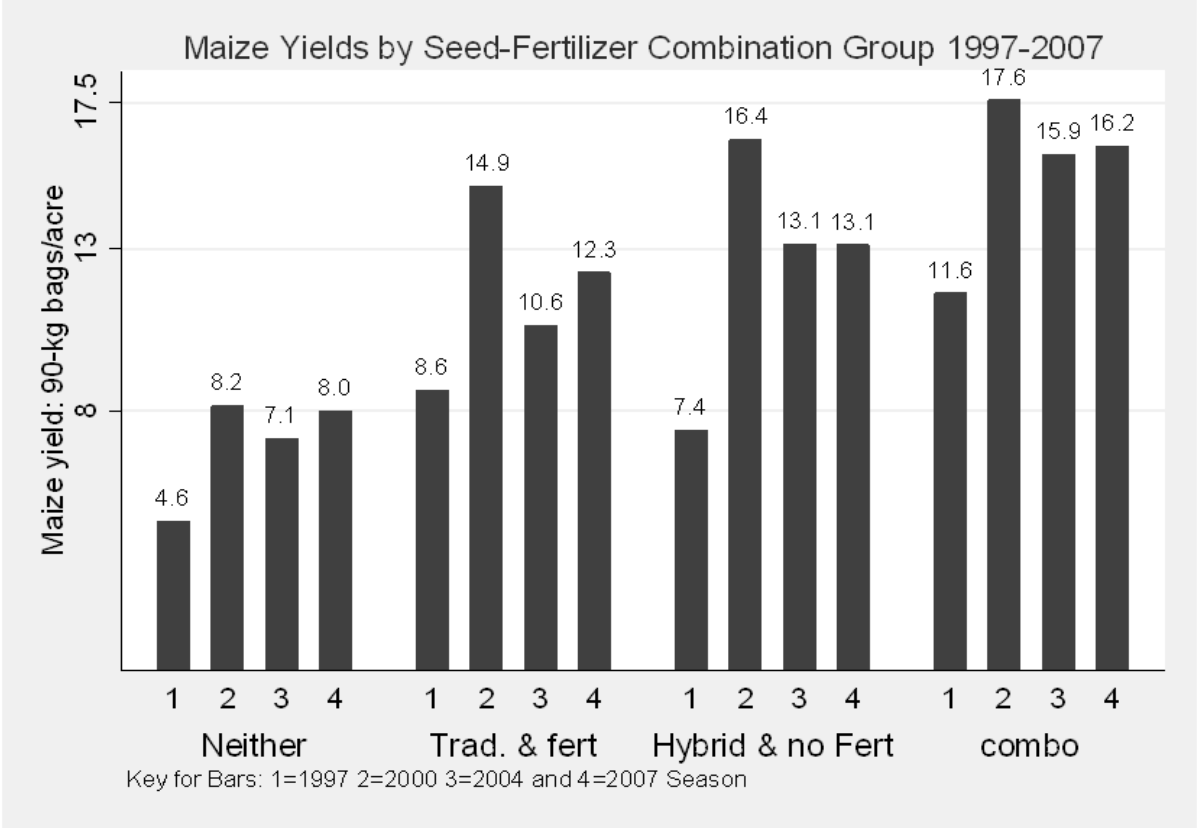
Zone	Overall maize		Pure stand maize		Intercrop maize	
	Yield (kg/acre)	Yield (bags/acre)	Yield (kg/acre)	Yield (bags/acre)	Yield (kg/acre)	Yield (bags/acre)
Coastal Lowlands						
1997	178.1	2.0	175.9	2.0	177.1	2.0
2000	361.8	4.0	470.8	5.2	359.9	4.0
2004	217.5	2.4	168.7	1.9	221.3	2.5
2007	374.0	4.2	347.5	3.9	378.4	4.2
Eastern Lowlands						
1997	206.2	2.3	437.8	4.9	161.4	1.8
2000	334.1	3.7	601.7	6.7	309.3	3.4
2004	322.6	3.6	561.7	6.2	264.4	2.9
2007	423.1	4.7	447.3	5.0	415.3	4.6
Western Lowlands						
1997	267.9	3.0	300.1	3.3	268.8	3.0
2000	233.3	2.6	600.3	6.7	230.5	2.6
2004	231.1	2.6	233.3	2.6	250.5	2.8
2007	505.8	5.6	527.9	5.9	508.3	5.6
Western Transitional						
1997	480.8	5.3	502.1	5.6	487.0	5.4
2000	677.2	7.5	926.8	10.3	675.2	7.5
2004	794.0	8.8	739.8	8.2	805.5	9.0
2007	961.0	10.7	888.8	9.9	973.7	10.8
High Potential Maize Zone						
1997	1035.5	11.5	1441.8	16.0	943.2	10.5
2000	940.0	10.4	1006.1	11.2	940.7	10.5
2004	1239.9	13.8	1443.5	16.0	1233.7	13.7
2007	1196.2	13.3	1265.3	14.1	1165.3	12.9
Western Highlands						
1997	500.4	5.6	486.4	5.4	508.2	5.6
2000	682.1	7.6	657.0	7.3	679.7	7.6
2004	597.8	6.6	1063.1	11.8	600.8	6.7
2007	795.5	8.8	622.6	6.9	797.8	8.9
Central Highlands						
1997	633.3	7.0	726.9	8.1	626.8	7.0
2000	794.4	8.8	1129.6	12.6	757.1	8.4
2004	829.2	9.2	770.1	8.6	813.7	9.0
2007	930.6	10.3	978.5	10.9	916.9	10.2
Marginal Rain Shadow						
1997	190.7	2.1		0.0	190.7	2.1
2000	79.6	0.9	240.0	2.7	65.4	0.7
2004	375.8	4.2	240.0	2.7	373.9	4.2
2007	409.7	4.6		0.0	409.7	4.6
Overall Sample						
1997	591.1	6.6	883.3	9.8	550.8	6.1
2000	644.8	7.2	861.5	9.6	635.0	7.1
2004	737.7	8.2	939.5	10.4	731.3	8.1
2007	839.1	9.3	1003.8	11.2	818.5	9.1

Source: Kibaara et al. (2008), based on Tegemeo Institute rural household surveys.

To further decompose how maize yields are evolving in Kenya by technology package, we examine yields in the farm survey data according to four groups: (1) fields using both hybrid seed maize and inorganic fertilizer, (2) fields using hybrid seed but no fertilizer, (3) fields using open-pollinated varieties (OPVs) or traditional seed varieties with fertilizer, and (4) fields using traditional seed and no fertilizer.

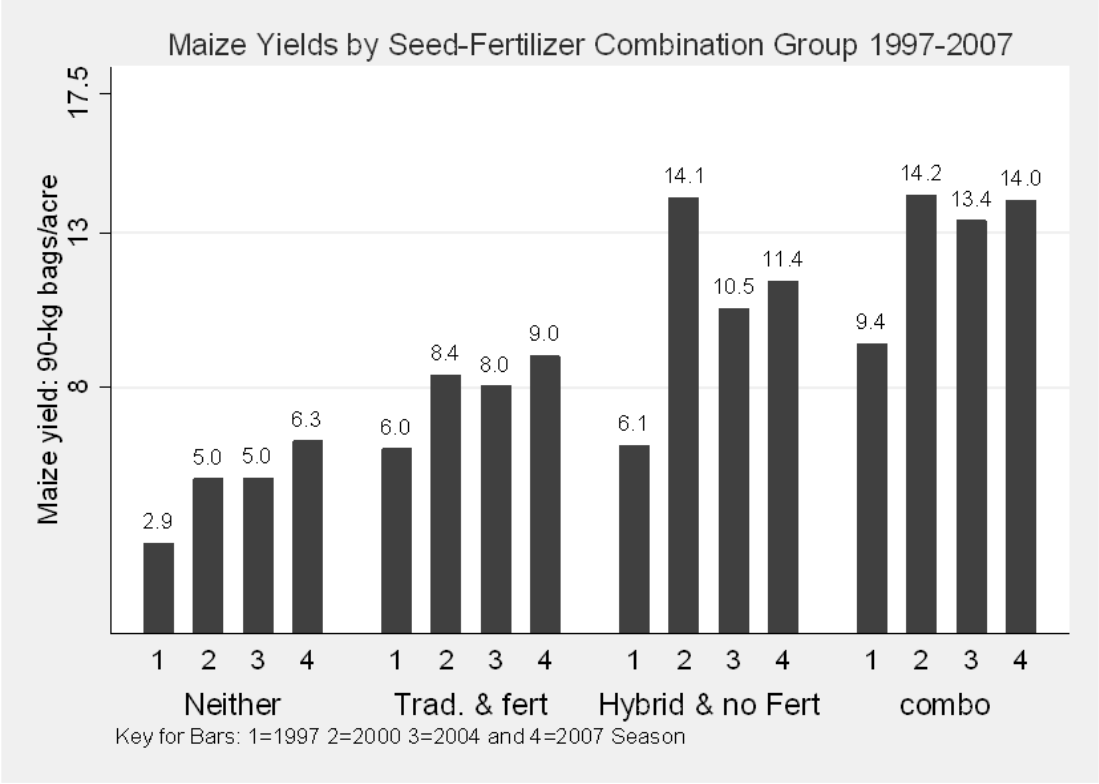
Given that the majority of maize fields in the sample are intercropped with other crops, it may be invalid to measure yields (a partial measure of land productivity) by counting the output of only one crop, especially if many other crops are harvested on the same area. For this reason, we present yields in two ways. We first count all crops harvested on the maize area, converting other crops to kilograms (kg) of maize based using relative price ratios as weights (Figure 7a). This provides a more complete picture of output per unit of land on area devoted to maize. In the second method, we ignore the production of other crops and count only the kg of maize harvested on maize fields (Figure 7b).

Figure 7a. Maize yields (converting other crops on intercropped maize fields to maize equivalents), by seed and fertilizer technology category



Source: Tegemeo Institute/Egerton University household surveys, 1997, 2000, 2004, and 2007.
Note: Yields used here are the maize-equivalent for mixed-crop fields where all of each crop's production is converted to maize, using the relative prices with maize as the numeraire.

Figure 7b. Maize yields (not converting production of other crops into maize equivalents), by seed and fertilizer technology category



Source: Tegemeo Institute/Egerton University household surveys, 1997, 2000, 2004, and 2007.

Several interesting observations come out of Figures 7a and 7b, which depict the yield outcomes for these different groups. First, maize yields generally appear to be increasing across the years from 1997 to 2007 for each of these four categories of maize fields. But the year 2000 stands out as recording the highest yields for each of these classes of technology use. Moreover, and most importantly, maize yields are consistently lowest among the "neither" category (farms using neither hybrid seed nor fertilizer) and are highest among the "combo" category, farmers using both hybrid seed and fertilizer.

The findings in Figure 7a and 7b are surprisingly similar in the story they tell. The "combo" group (users of both hybrid seed and fertilizer) has higher yields relative to all the other combinations, while the "neither" group does poorest. The stark difference between the "neither" group and the other groups for every year shows the effect of hybrid and fertilizer use on maize yields. The group that uses no fertilizer and plants traditional seed (neither) has an average yield of approximately 7 bags per acre of 90 kg each (when counting the other crops converted to maize equivalents) and only 5 bags per acre when counting only maize production. The groups that either use fertilizer with traditional seed or hybrid seed without applying fertilizer had an average yield of about 10 to 12 bags/acre (in maize equivalents, or 8 to 10 bags/acre when ignoring the other crops harvested). The group using both fertilizer and hybrid seed maize has the highest average yield of 15 bags/acre (13 when ignoring the other crops harvested). The yields for this latter group are twice as large as the group that uses neither hybrid seed nor fertilizer. Clearly, the adoption of a combination of appropriate technologies appears to be associated with smallholder productivity and therefore incomes that will raise food security status. However, as shown earlier, fertilizer use in Kenya is highest in the moderate- to high-potential areas, where maize yields are likely to be higher than in the semi-arid regions even without fertilizer. A multivariate analysis of the contribution of fertilizer to maize yield, holding geographic and other factors constant, is contained in Kibaara et al. (2008).

Decline in the Distance Traveled by Farmers to the Point of Maize Sale

The liberalization of maize trade in Kenya has been associated with increased penetration by private maize assemblers into rural areas. This is discernible from the Tegemeo household panel survey data, which provide evidence of a reduction between 1997 and 2007 in the distance traveled from the farm to the point of maize sale (Table 12). Over 90 percent of maize sales were to private traders, and in six of the seven zones covered, there has been a reduction in kilometers from the farm to the point at which the maize was transferred to private buyers. This is especially evident in the Eastern Lowlands, where the mean distance between farm and private buyer declined from 6.55 km in 1997 to 1.62 km in 2007, and in the High-Potential Maize Zone, where this distance declined from 1.80 km in 1997 to 0.40 km in 2007. Because per kilometer marketing costs tend to be highest at this stage of the marketing chain where road quality is poorest, the improved penetration of maize assemblers into rural smallholder areas has most likely brought tangible benefits to smallholder farmers.

Table 12. Mean distance from farm to maize buyer, 1997–2007

Zone	Households selling maize (n=)	Kilometers from farm to point of maize sale, by buyer type				
		Private trader	NCPB	Millers/processors	Cooperative	Consumers
Eastern Lowlands						
1997	58	6.55	...	...	...	1.27
2004	94	3.15	...	...	...	1.46
2007	88	1.62	0.00	...	...	1.28
Western Lowlands						
1997	21	1.83	...	...	...	1.00
2004	48	2.48	...	...	...	2.50
2007	50	1.04	...	...	...	0.26
Western Transitional						
1997	41	0.71	...	...	...	0.00
2004	108	0.25	...	...	4.67	0.34
2007	90	0.07	...	...	...	1.55
High Potential Maize Zone						
1997	230	1.80	12.77	29.88	2.00	0.59
2004	313	1.13	18.57	9.48	32.00	2.88
2007	312	0.40	13.50	9.75	...	2.69
Western Highlands						
1997	40	3.15	...	...	...	2.70
2004	116	2.62	...	...	...	2.24
2007	105	1.81	...	...	...	0.96
Central Highlands						
1997	82	0.94	0.00	...	...	2.07
2004	85	1.32	...	19.33	...	0.26
2007	125	0.42	0.25	24.00	...	0.50
Marginal Rain Shadow						
1997	1	...	...	0.00	...	...
2004	15	0.71	...	...	...	0.00
2007	24	0.00	...	...	...	0.20

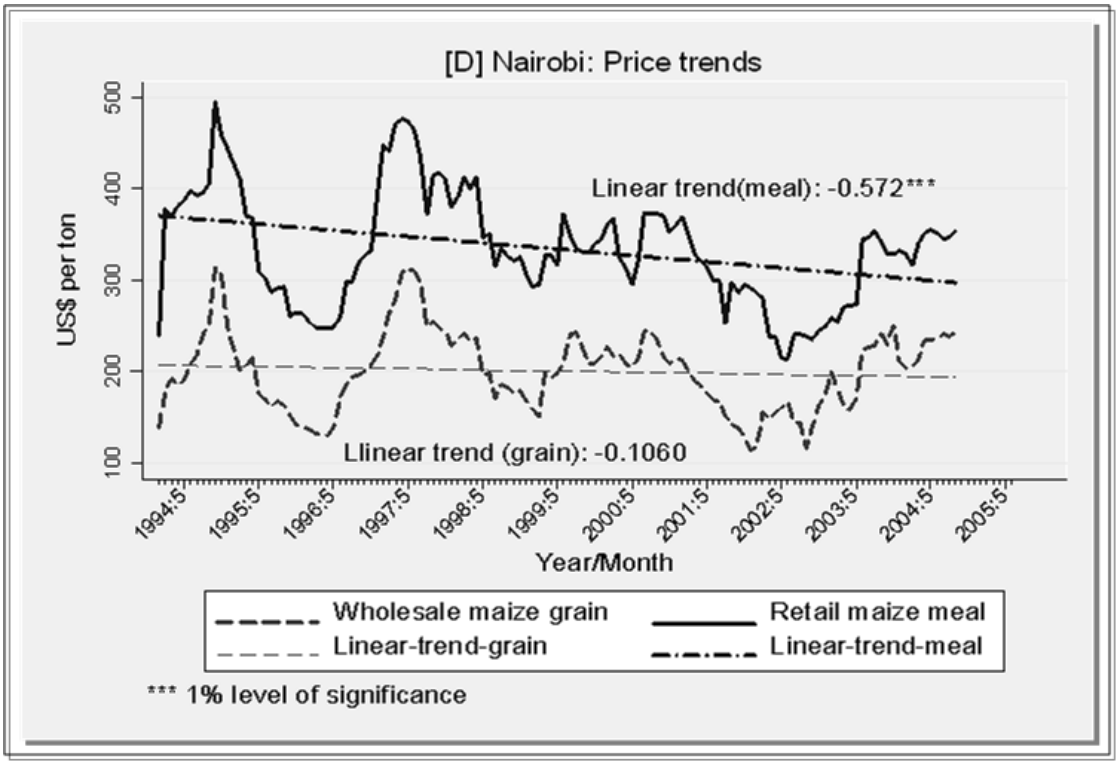
Source: Tegemeo Institute/Egerton University household surveys, 1997, 2000, 2004, and 2007.

Reduction in Marketing Margins between Maize Grain and Maize Meal Prices

Figure 8 shows that since the inception of the market reforms in the 1990s, the marketing margin between wholesale grain prices and retail maize meal prices has declined substantially. Retail maize meal prices have been declining at a trend rate of US$0.57 per year (statistically significant at the 1 percent level), while wholesale prices in Nairobi have been declining at only US$0.11 per year (not statistically different from zero trend).

The significant reduction in retail maize meal prices in Kenya mainly reflects policy changes adopted in the mid-1990s. Prior to liberalization, a few officially registered maize-processing firms had a de facto oligopsony on milling maize and supplying the retail sector. Regulations made it difficult for nonregistered millers and traders to transport grain into urban areas or acquire grain from the marketing board. Market reform opened this system to greater competition as small millers and retailers who were previously excluded from entering the market were now allowed to procure and transport grain freely across district boundaries. The marketing reforms induced rapid investment in medium- and small-scale milling and retailing networks. In response to greater competition, the registered large milling companies have reduced their margins in an attempt to regain lost market share. Increased competition at the milling and retailing stage of the maize value chain has greatly benefited low-income consumers in Kenya (Jayne and Argwings-Kodhek 1997; Ariga and Jayne2008).

Figure 8. Trends in maize grain and maize meal prices, Nairobi, 1994–2006



Source: Jayne and Chapoto 2006.

Improved Affordability of Maize Meal to Consumers

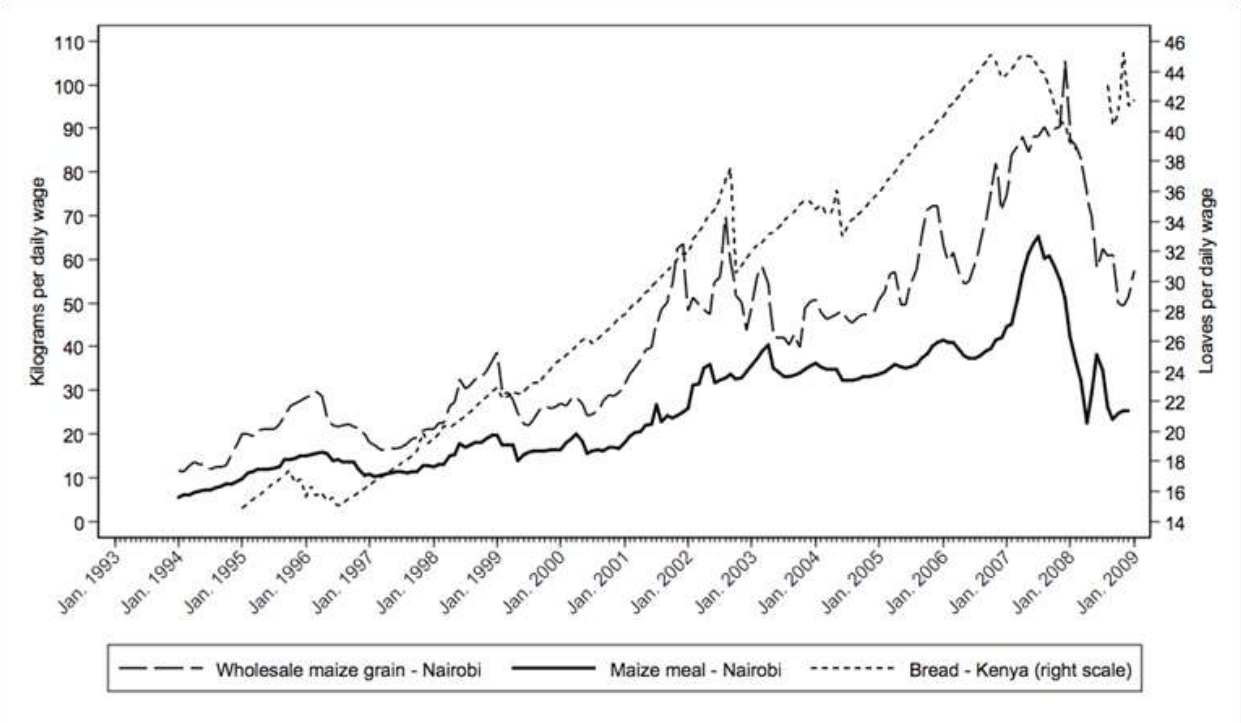
Mason et al. (2009) examined trends in wage rates relative to retail maize grain, maize meal, and wheat bread prices between 1993 and 2009 for urban consumers in Kenya. Formal-sector wages for a number of employment sectors are available for both Kenya (public and private sector, which are further subdivided

into 12 total sectors). They find a high correlation among wage rate series for various government and private-sector categories.

For all categories of wage earners, formal sector wages rose at a faster rate than maize grain, retail maize meal, and bread prices from 1994 to mid-2007, as evidenced by the upward trajectory in the quantity of these commodities affordable per daily wage (Figure 9). The average staple food quantities affordable per daily wage were approximately three times higher in the 2006/07 marketing season relative to 1995/96.

Although the recent food price crisis partially reversed this trend, the quantities of staple foods affordable per daily wage in urban Kenya during the 2008/09 marketing season were still roughly double their levels of the mid-1990s. These findings hold for formal-sector workers only. The general conclusion of improved food purchasing power over the past 15 years may not hold for a significant portion of urban workers who are employed in the informal sector.

Figure 9. Kilograms of maize meal and maize grain affordable per daily wage in Nairobi, and loaves of bread affordable per daily wage in Kenya: January 1994–January 2009



Source*:* Mason et al. 2009.
Note: Computed as mean wage rates (Ksh per day) divided by price of commodity (Ksh per kg).

Perceptions of Farmers

It would be useful to know whether the indicators of improved access to maize markets conform to the subjective impressions of smallholder households. Respondents in the Tegemeo household panel survey were asked the following two questions: (1) "The government has liberalized (soko huru) the maize market since 1992. Compared to 5–10 years ago, is it now more convenient or more difficult to sell your maize?" and (2) "Overall, would you prefer to go back to the controlled grain marketing system as it existed in the 1980s or do you prefer the current liberalized marketing system?" The first of these questions was asked only in 1997, while the second question was asked both in 1997 and in 2000. Table 13 reports respondents' perceptions.

Table 13. Household perceptions of the performance of the current marketing system compared with the controlled marketing system, Kenya, 1997 and 2000

Zone	Year	Convenience of selling grain at time of survey compared with control period			Preference for current marketing system vs. system during control period		
		Better now (e)	Better during control period (f)	No change (g)	Prefer current system (h)	Prefer control system (i)	No change (j)
Coastal Lowlands	1997	50	10	40	67	23	10
	2000				69	19	13
Western Lowlands	1997	81	14	5	52	44	4
	2000				59	40	2
Eastern Lowlands	1997	87	3	10	75	17	8
	2000				68	31	2
High-Potential Maize Zone	1997	93	5	2	61	36	3
	2000				62	37	1
Western Highlands	1997	84	11	5	53	44	3
	2000				67	31	2
Western Transitional	1997	99	1	0	37	61	2
	2000				63	36	1
Marginal Rain Shadow	1997	90	5	5	71	27	2
	2000				74	24	3
Central Highlands	1997	82	8	10	76	16	8
	2000				75	22	3
National average	1997	88	7	5	61	34	5
	2000				66	32	2

Source: Tegemeo Institute/Egerton University/KARI/Michigan State University Rural Household Survey, 1997.
Note: Districts included in each zone grouping were as follows: Coastal Lowlands (Kalifi, Kwale); Western Lowlands (Kisumu, Siaya); Eastern Lowlands (Mwingi, Makueni, Machakos, Kitui, Taita Taveta); High-Potential Maize Zone (Nakuru, Trans Nzoia, Uasin Gishu, Bungoma (Kimilili and Tongaren divisions); Kakamega (Lugari division)); Western Highlands (Vihiga, Kisii); Western Transitional (Bungoma (Kanduyi division); Kakamega (Kabras and Mumias divisions)); Marginal Rain Shadow (Laikipia); Central Highlands (Muranga, Nyeri, Meru).

Perhaps surprisingly, in spite of the fact that grain wholesale prices have declined during the post-liberalization period, the overwhelming majority of households in all regions (88 percent) stated that it was more convenient to sell grain since liberalization (even though most of them did not sell). This is because most farmers are being paid cash on the spot, unlike the NCPB, which often took months to pay, and because 70 percent of farmers now can sell their produce at the farm gate instead of moving produce to NCPB depots (Kodhek et al. 1998). Overall, 61 percent of households stated a preference for the current liberalized system in 1997, and this rose to 66 percent in 2000. The percentage of households preferring the marketing arrangements of the preliberalization period declined from 34 percent in 1997 to 32 percent in 2000. As with the previous questions, the preference for the current liberalized system was strongest in the grain-deficit areas such as Central Highlands.

Grain is now easier to purchase in deficit areas covering the drier lowlands and marginal zones due to removal of bans on across-district movement of maize. In the Western Transitional Zone (Kanduyi division of Bungoma District and the Kabras and Mumias divisions of Kakamega District), the proportion of farmers preferring the current system rose dramatically between 1997 and 2000, from 37 to 63 percent.

Interestingly, the majority of households in the High-Potential Maize Zone also stated a preference for the current system over the former control system, by a margin of almost 2 to 1. This is the zone that receives most of the subsidies in form of price supports. As mentioned earlier, NCPB delays payment though its prices are higher and farmers need to transport their produce to the depot/stores.

Also important, most households have seen that liberalization has improved the availability of maize grain in rural areas and has reduced the real price of maize meal. Since most rural households remain buyers of maize and maize meal or both, the decline in maize marketing margins and maize meal prices as shown in Figure 8 has been a major benefit to many rural households.

However, the survey data do indicate that the proportion of households that either only sell maize or are net sellers has risen progressively over the period 1997–2007, consistent with the general picture of rising maize yields over this same period. While 32 percent of the panel sample were either sellers or net sellers of maize in 1997, this figure rose to 43 percent in 2007.

6. LESSONS LEARNED, SUSTAINABILITY, AND POTENTIAL FOR REPLICABILITY

This study documents the factors driving growth in fertilizer use and maize productivity in Kenya from the early 1990s to 2007. The basic story is one of synergies between the liberalization of input and maize markets and public investments in support of smallholder agriculture, leading to tangible private-sector investment in fertilizer retailing and maize marketing, which in turn has encouraged an impressive rise in fertilizer use and maize yields on smallholder farms over the period 1997–2007. This narrative is complicated by the fact that Kenya's economy and business environment has experienced many changes during this period, both positive and negative, which have also undoubtedly affected the incentives of farmers, consumers, and private marketing agents. While these factors may not be directly linked to the fertilizer and maize markets, their influence on observed indicators cannot be analytically separated from those of the reforms highlighted in this paper. However, it is reasonable to assume that these influences outside the agricultural sector are of second-order magnitude, compared with the more direct agricultural policy reforms and investments, in explaining the behavioral responses of farmers and fertilizer and maize marketing agents, as documented in this study.

The pathways through which government actions in fertilizer and maize markets positively affected the agricultural sector and rural and urban living standards are several. As shown in Figure 2, the Government of Kenya implemented a number of policy reforms affecting the incentives for investment by private fertilizer distribution firms. The government also legalized domestic and regional maize trade, although other actions adopted by the government during the 1990s partially eroded the potential response by the private sector. In spite of the rather mixed government stance toward maize market liberalization during the 1990s and early 2000s, evidence of increased private-sector investment is tangible. Traders buying maize directly from farmers have penetrated more deeply into smallholder areas. Increased competition and efficiency in maize milling and retailing is also evident in the significant decline in maize marketing margins. There is also strong evidence of increased state investment in public goods supportive of private-sector investment, especially since the Constituency Development Fund (CDF) was instituted in 2003. The combination of supportive policy changes in the fertilizer, foreign exchange, and maize markets, coupled with improved access to markets and services made possible by public good investments appears to have stimulated investment by the private sector in both maize and fertilizer marketing. These factors have worked synergistically to bring about important gains in maize productivity and benefits to smallholder farmers and consumers in Kenya.

Evidence of increased smallholder fertilizer use and maize yields is drawn from a nationwide household panel data from four surveys between 1997 and 2007 collected by Egerton University's Tegemeo Institute. Because the data constitute a balanced nationwide panel of 1,260 households, the results provide a fairly reliable indicator of the changes in fertilizer use patterns over time, although the survey is not strictly nationally representative. The main findings are

- The percentage of sampled smallholders using fertilizer on maize has increased from 56 percent in 1996 to 70 percent in 2007.
- Fertilizer application rates (which include all maize fields regardless of whether they received fertilizer or not) rose from 34 kg/acre in 1997 to 45 kg/acre in 2007, a 34 percent increase.
- There are wide regional variations in fertilizer use on maize. More than 90 percent of smallholders use fertilizer on maize in three of the broad zones surveyed: the High Potential Maize Zone, Western Highlands, and Central Highlands. Fertilizer use is low and barely rising in most of the semi-arid regions (Coastal Lowlands, Western Lowlands, and the Marginal Rain Shadow). However, fertilizer use has risen impressively in the medium-potential Eastern Lowlands and Western Transitional Zones, where the percentage of households using fertilizer on maize has risen from 21 and 39 percent, respectively, in 1997 to 43 and 81 percent in 2007.

While the total area under maize has remained largely constant over the decade, maize yields have increased during 1997–2007 by roughly 18 percent. This yield improvement is not borne out in official government maize production statistics, which do not take into account the shift over time in the proportion of maize area grown under intercropped cultivation or the shift over time in the proportion of maize area grown in relatively semi-arid regions, which has been facilitated by the release of improved maize cultivars well suited to mid- and low-altitude areas of the country. To assess changes in maize yield, it is important to account for the gradual shift over time in the proportion of maize area under monocropped versus intercropped cultivation as well as the fact that maize area has expanded in the more semi-arid parts of the country. After stratifying between hybrid and nonhybrid users and between intercropped and monocropped maize fields, the household survey data show that maize yields on all types of field have increased over time, which reflects the influence of many factors in addition to fertilizer use. Fertilizer use and maize yields have increased especially rapidly on the intercropped fields and less so on monocropped fields.

Fertilizer marketing costs have declined substantially in constant Ksh between the mid 1990s and 2007. Interviews with key informants in Kenya's fertilizer sector identified four factors responsible for the declining fertilizer marketing costs observed in Kenya: (1) the potential for cheaper backhaul transportation has been exploited, taking greater advantage of trucks transporting cargo from Rwanda and Congo to the port of Mombasa; (2) private importers are increasingly using international connections to obtain credit at lower interest and financing costs than are available in the domestic economy; (3) local and international firms have merged, enabling shared knowledge and economies of scope that save local distribution costs; and (4) increased competition among local importers and wholesalers has expanded the number of firms engaged in fertilizer marketing since the early 1990s. It is likely that the fourth factor–increased competition–has to some extent stimulated firms to exploit the other cost-reducing innovations identified in order to maintain their market position.

To assess the robustness of the Tegemeo rural survey findings, we compared the proportion of smallholder households purchasing fertilizer with estimates based on other analyses during the same general time period. Based on three other studies that cover a subset of the same districts as the Tegemeo survey, we found that the Tegemeo survey estimates are comparable and in some cases lower than estimates of fertilizer purchases and dose rates. The rise in smallholder use of fertilizer in the Tegemeo survey data is also consistent with official Ministry of Agriculture figures (shown in Figure 1), which indicate that total fertilizer consumption in Kenya has risen 65 percent between 1997 and 2007.

The rise in fertilizer use in Kenya has not been uniform across regions. Use rates are much higher in areas where main season rainfall is relatively high and stable than they are in the drier areas. Fertilizer use is highly risky in many of the semi-arid regions, and its role in contributing to poverty alleviation and food security is likely to be limited by these environmental factors unless accompanied by actions to improve soil organic matter and moisture (Marenya and Barrett 2008). We also find that within a given agroecological zone, the decision of households to purchase fertilizer is slightly related to farm size and unrelated to household wealth. In relatively productive areas, the proportion of poorer and wealthier households applying fertilizer on maize is similar. In risky environments, only a small proportion of either poor or wealthy households apply fertilizer on maize.

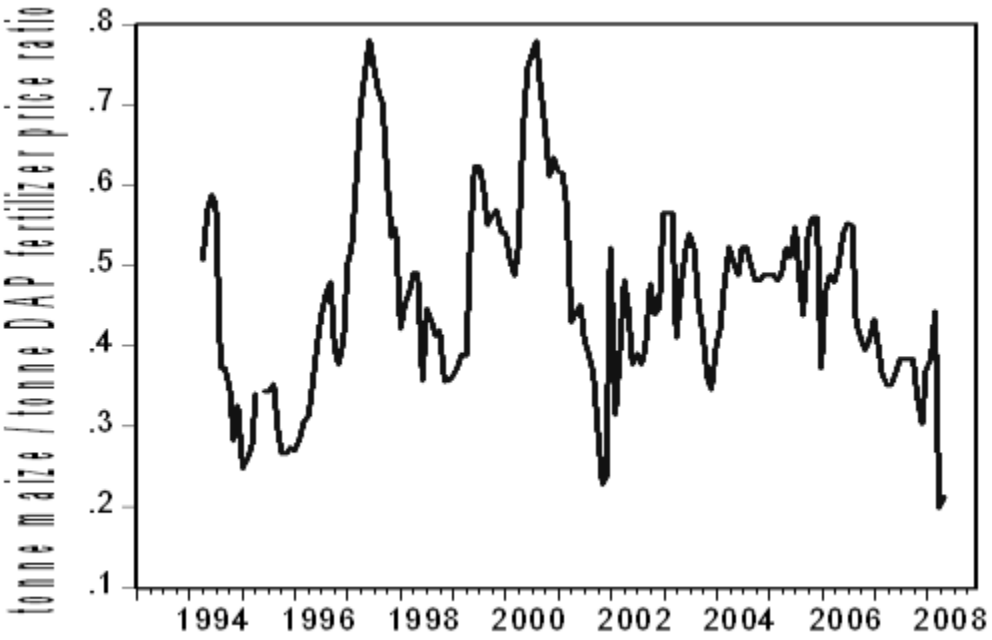
These gains in smallholder fertilizer use and maize yields have been encouraged by Kenya's decision to liberalize input and maize markets in the early 1990s. New entries and investment in fertilizer wholesaling and retailing have been massive since the early 1990s. The International Fertilizer Development Center (IFDC) estimates that more than 500 wholesalers and 7,000 retailers are operating in the country. This has led to a denser network of rural retailers and a major reduction in the distance between farms and fertilizer sellers, which has contributed to the impressive growth in fertilizer use by Kenyan smallholders from the early 1990s to 2007. Tegemeo survey data also indicate that the mean distance traveled by farmers to sell their maize to private traders has declined over the past decade; the

median distance is zero, indicating that assembly traders tend to purchase maize right from farmers' fields. Analysis of wholesale maize grain prices and retail maize meal prices indicate that the miller–retail marketing margin has declined significantly over time, conferring benefits mainly to consumers. More than 50 percent of rural farm households are either buyers or net buyers of maize, while virtually all urban households purchase maize meal each year (Mukumbu and Jayne 1994; Jayne and Argwings-Kodhek 1997).

Other signs of improvement in maize markets include farmers' level of satisfaction with the performance of maize markets from their subjective perspective. Over 65 percent of farmers surveyed in the nationwide Tegemeo Institute rural survey indicated that they prefer the current liberalized maize marketing system to the former controlled marketing system, primarily because grain is easier to sell, farmers are paid in cash at the time of sale, and maize is more reliably available for purchase.

However, in 2008, the positive trends in Kenya's maize and fertilizer markets were reversed by civil disruption, drought, and the unprecedented surge in world fertilizer prices. Early 2008 witnessed the destruction of much physical infrastructure in western Kenya, such as petrol stations and grain storage, as well as the closing of many input supply stores. Moreover, the incentives to use fertilizer in Kenya have been adversely affected both by drought and world events as maize/fertilizer price ratios plunged to their lowest level in at least 18 years. Figure 10 plots monthly wholesale maize to wholesale fertilizer price ratios per ton at Nakuru. The higher the ratio, the more profitable, and therefore the greater the incentive to apply fertilizer on maize. While this ratio has historically ranged between 0.4 and 0.6 at the time of planting, in 2008 it plunged to below 0.25. The price of maize in Kenya has not risen nearly as dramatically as fertilizer.

Figure 10. Maize / fertilizer price ratios, Nakuru, Kenya, 1994–2008



Source: Ministry of Agriculture, Market Information Bureau, Nairobi.
Note: Price ratio is defined as the wholesale market price per ton, Nakuru, divided by DAP, c.i.f. Nakuru per ton, in nominal shillings.

This brings us to consider the implications of these findings for policy options for sustaining these achievements. The main general lesson to be gained from this research is the need for a public–private relationship that encourages investment in input and output marketing services for smallholder farmers. In Kenya's case, this was achieved through a combination of public goods investments and institutional reforms supportive of liberalized marketing, even though the maize marketing reforms were at times subject to reversals. And there is room for considerable additional gains in smallholder and consumer welfare if progress could also be made in the following areas:

1. *Consider changes in government actions in the transport arena that could reduce fertilizer and grain distribution costs.* For example, because of frequent delays in offloading of commodities at the port of Mombasa and because of the erosion of the regional railway system, it is difficult to arrange for upcountry transport of a full shipload of fertilizer especially given frequent offloading delays and inefficiencies at the port. Because of this coordination problem, fertilizer importers have invested in storage facilities near the port, where fertilizer can be temporarily stored to wait until trucks arrive for loading and upcountry distribution. These investments make sense if upland transport constraints and the delays and inefficiency at the Port of Mombasa are taken as given. However, if procedures for streamlining the efficiency of off-loading at the port could be achieved (for example, by privatizing stevedore services and issuing performance contracts or by devolving wider management of port operations to professional firms), thus reducing off-loading time and the storage costs incurred at Mombasa for lack of sufficient transport, then fertilizer importing firms could avoid these extra charges. In a competitive marketing environment, these reductions in fertilizer marketing costs would then be passed along in the form of lower farm-gate prices.[6]

Reduce transaction costs associated with VAT and port operations. Currently fertilizer, as well as most other farm inputs, is zero-rated with respect to import duties. This means that no duty is charged on fertilizers, although at least until 2007, a VAT on related services was still levied. A VAT is charged, for example, on transport and services like bagging at the port of Mombasa. Although the VAT is supposed to be refunded, the process is lengthy and is a source of continuing frustration for market participants. In addition, port handling charges, Kenya Bureau of Standards (KEBS) charges, and other taxes account for 17 percent of c.i.f. (Gitonga 2004). Port fees, levies, and accessorial charges need to be rationalized and aggregated. In addition, the numerous documentation procedures need to be reduced and, if possible, provided through electronic means. Interviews with key informants in the fertilizer industry have identified numerous other potential sources of cost savings, many of which require action on the part of government to improve efficiency.

Invest in rehabilitating the eroded rail, road, and port infrastructure, which would reduce distribution costs. The farm-gate price of fertilizer in Western Kenya is roughly twice as high as the landed cost at Mombasa, and transport costs are the major component of this cost difference. High farm-gate prices of fertilizer restrict demand for its use and depress agricultural productivity. Hence, efforts to improve the efficiency of port costs and upland shipping would bring major economy-wide benefits. In particular, rail transport reduces these costs substantially and also saves government spending on road maintenance due to damage caused by shifting heavy loads from the now slower and more costly rail system to roads.

Tailor fertilizer packages to local demand conditions. This would increase demand from smaller farmers who require and are able to purchase only small packets. Repackaging of fertilizers from 50 kg packets into 25 kg, 10 kg, 2 kg, and 1 kg packets is increasingly taking place, but this is sometimes associated with fertilizer adulteration and counterfeit products. While adulteration and sales of counterfeit

[6] Some efficiency improvements in Mombasa port operations have recently been implemented, and more comprehensive reforms are currently under consideration.

products continue to be a problem, these are often isolated events rather than a well organized activity (Global Development Solutions 2005, 71).[7] Part of the wide fluctuations in the nitrogen and phosphorous concentration in fertilizers can be accounted for by the absence of effective measurement and calibration facilities. In this context, the Kenya Plant Health Inspectorate Service and the Kenya Pesticide Board should become more effective in monitoring and controlling adulteration and counterfeit products, as well as intensifying farmer and retailer awareness programs to help protect farmers from substandard products.

Raise fertilizer response rates through agronomic training of farmers. The profitability of fertilizer use could be enhanced by improving the aggregate crop yield response rates to fertilizer application. This requires making complementary investments in training for farmers on agronomic practices, soil fertility, water management, and efficient use of fertilizer and investing in crop science to generate more fertilizer-responsive seeds.[8] Emerging problems of soil acidity in the maize belt of western Kenya indicate that raising soil pH levels may be required to ensure profitable use of fertilizer in these areas. Survey data commonly indicate that the contribution of fertilizer to foodgrain yields varies tremendously across farms even within the same villages. Simply bringing fertilizer response rates among the bottom half of the distribution up to the mean would contribute substantially to household and national food security (Nyoro, Kirimi, and Jayne 2004).

Finally, *producer organizations, despite their poor track record, will increasingly be crucial for rural income growth.* Assuming that the management problems and politicization of producer organizations/cooperatives could be minimized, they might afford an important pathway for smallholders to achieve higher levels of input use and to adopt better production and marketing practices than the current separate and uncoordinated stages in the supply value chains. The role of independent producer groups would be to reduce the transaction costs and risks of private marketing firms dealing with farmers and to develop a production base through the transfer of credit, inputs, and know-how. The Farm Inputs Promotions (FIPS) and the Kenya Market Development Program (KMDP)/ Cereal Growers Association farmer training programs are examples of successful attempts by government, development partners, and NGOs to assist and train groups, to utilize farm extension knowledge, supply chain development, and fertilizer technologies.

While all of these measures can contribute to increased fertilizer use, none is likely to prove effective in isolation. Policymakers should, therefore, select strategic combinations of supply- and demand-side measures to allow supply and demand to grow in parallel—strengthening the basis for viable private sector-led commercial fertilizer markets.

The final question is about *the role of fertilizer subsidies*. The greatest scope for subsidies to promote fertilizer use is in the areas where fertilizer use may be far below its optimal levels after taking into account maize yield response to fertilizer and the riskiness of applying fertilizer, especially in semi-arid regions where crop failure is not unusual. Recent evidence indicates that crop response to fertilizer application varies widely among smallholder farmers even within the same villages due to differences in management practices, soil quality, timeliness of application, and so forth, and that there is substantial scope for raising the efficiency of fertilizer use at least for farmers who are currently getting lower response rates from fertilizer application than their more efficient neighbors (Marenya and Barrett 2009;

[7] According to Global Development Solutions (GDS 2005) nearly 3–5 percent of repackaged fertilizers are sold using counterfeit labels and packages. Specifically, fake brand name labels are used to sell inferior quality fertilizers.

[8] Research indicates that the highest crop yield response is obtained when improved seed, fertilizer and agronomic practices to raise soil organic matter are combined (Marenya and Barrett 2008; Kelly 2006). In some areas, improved management practices may have greater impact on yields than fertilizer alone (Haggblade and Tembo 2004).

Xu et al. 2009). Moreover, there is little empirical evidence to determine how prevailing levels of fertilizer application compare to optimal levels, taking into account these factors. Fertilizer use rates are clearly low in the semi-arid areas of Kenya and fertilizer subsidies in these areas would likely raise fertilizer use, but the contribution to yields and smallholder incomes may be quite limited because of the environmental riskiness and low response rates in such areas. A major question for semi-arid areas, therefore, is whether poverty reduction and food security objectives can be best achieved through fertilizer subsidies or other types of public programs and investments. Given that resources are scarce, efforts should be made to identify which types of agricultural expenditures will generate the greatest payoffs.

In the high potential areas, the large majority of farmers are already purchasing fertilizer and use rates in 2007 were quite high, although use rates are likely to have fallen since then due to the adverse conditions mentioned earlier. Fertilizer subsidies are politically attractive in that they promise increased fertilizer use and food production, but these outcomes are by no means assured. In 2009, Kenya is facing its lowest maize production level in recent history after having initiated a major fertilizer subsidy program; poor rains in 2009 have rendered the fertilizer subsidy program relatively ineffective, and the country has imported more than 1 million tons of maize since early 2009. Moreover, providing subsidized fertilizer in areas of high commercial demand will almost certainly result in a partial crowding out of commercial sales, as shown by findings in Zambia and Malawi where commercial demand for fertilizer is considerably lower than in Kenya (see Xu et al 2009; Dorward et al. 2008). Where purchase of commercial fertilizer is high, then a ton of subsidized fertilizer distributed by government is unlikely to result in an additional ton of fertilizer being applied on farmers' fields since the farmers previously purchasing fertilizer are no longer likely to buy it if they can acquire the same amount more cheaply from a government program.

In the current high price environment, the availability of seasonal loans for input purchase takes on heightened importance for maintaining farmers' effective commercial demand for fertilizer. Many Kenyan farmers have been able to finance fertilizer through the credit offered in the integrated input-output chains for crops such as tea, sugar, and coffee. These integrated marketing arrangements have also provided the means for farmers to obtain fertilizer for their food crops, since the companies can recoup their loans for other crops as well, when the farmers sell their cash crop back to the company. But in areas where fertilizer use on a particular crop is profitable, such as maize in Western Kenya and horticulture throughout the country, most farmers have achieved reasonable levels of fertilizer use without credit. Support for the development of viable credit programs may also help smallholders maintain their access to fertilizer use despite current high prices, for households in which liquidity constraints are the main problem.

The experience of Kenya demonstrates the role of a supportive policy environment that attracts local and foreign direct investment in improving smallholder farmers' access to input and commodity markets. In Kenya's case, a stable input marketing policy environment has fostered a private-sector response that supports smallholder agricultural productivity and poverty alleviation. These goals remain elusive in countries lacking a sustained commitment to the development of viable commercial input delivery systems. While the government's policy stance toward maize marketing has been prone to vacillation, the operations of the NCPB and the elimination of regional trade barriers since the inception of the EAC Custom Union in January 2005 have both promoted maize price stability (Jayne, Myers, and Nyoro 2008; Chapoto and Jayne 2009). Complementary programs to support small farmer productivity, such as the FIPS program, the CNFA agro-dealer training and credit program, and the organization of farmers into groups to facilitate their access to extension and credit services under the KMDP, have also been important factors in raising fertilizer use in Kenya.

Because mean household incomes are higher and infrastructure relatively better in Kenya than in many other African countries, the market-led growth in smallholder fertilizer use in Kenya may not be easily transferable to areas where effective demand is highly constrained. And the Kenya success story is tenuous. Sustaining the momentum will depend on continued public investment, good policy choices, the weather, and international events. Governance problems and civil disruption are jeopardizing the

sustainability of the commercially driven input distribution system and rural development more generally. Continued access to input credit for small farmers in many parts of the country will require government commitment to limit the potential for politicization and interference in the management of the interlinked crop marketing systems for sugarcane, tea, and coffee, which have provided a means for farmers to acquire additional fertilizer on credit for use on food crops. Also, new investment is needed in Kenya's eroded rail, road, and port infrastructure to maintain Kenya's competitiveness. Lastly, effective systems to improve smallholders' crop husbandry and management practices are needed to provide incentives for continued expansion of fertilizer use and productivity growth in areas where fertilizer is only marginally profitable at present.

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