

Factors Driving the Increase in Fertilizer Use by Smallholder Farmers in Kenya, 1990-2007

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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 rapid private-sector investment in fertilizer retailing and maize marketing, which in turn has increased farmers' use of fertilizer on maize. Panel survey data on 1260 smallholder farms show 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. The paper describes the public investments and reforms adopted in both maize and fertilizer markets which contributed to these improvements in smallholder maize productivity. Panel survey data is also used to examine factors influencing farmers' decisions to purchase fertilizer and the quantity of fertilizer applied per acre of maize. The study shows that geographic differences in agro-ecological potential are the fundamental factor influencing whether farmers use fertilizer or not. In the high-potential areas of western Kenya, fertilizer use rates per acre of maize are comparable to that of Asia. By contrast, in semi-arid areas the use of fertilizer is very risky and often unprofitable for farmers unless highly subsidized. Fertilizer price levels, household resource endowments, and education also influence producers' decisions on fertilizer use. The study's findings indicate that the Kenyan Government's policy environment and public investments in support of input market development over the 1990-2007 period have been successful in raising fertilizer use and productivity of smallholder maize production. However, recent events in Kenya have created uncertainty about the sustainability of the progress achieved in the period under study. A number of crises have recently hit Kenya, including post-election political violence of 2007/2008, the general rise in world input prices starting in 2007, global economic downturn, and drought in 2009 that led to poor harvests. These crises have at least temporarily impeded the progress over the 1990-2007 period as documented in this report.

1. Introduction

Fertilizer use is notably lower in most of Africa than in other developing regions. Too little irrigation and varieties unresponsive to fertiliser may explain this to some degree. But more often the finger is pointed at lack of credit, long distances between farmers and the nearest fertilizer retailer, weak market infrastructure, and the withdrawal of state input subsidies and food price supports associated with market liberalization. Indeed, in many countries the withdrawal of state input delivery systems has seen fertiliser use fall as commercial distribution systems compete with subsidized government programs.

Kenya, however, stands as a notable departure from this common narrative. In the early 1990s fertiliser markets were liberalised, government price controls and import licensing quotas were eliminated, and fertilizer donations by external donor agencies were phased out. Subsequently fertiliser use has almost doubled over the 15-year period from 1992 to 2007, with much of the increase registered on smallholder farms. In the productive farming areas of western Kenya, rates of fertiliser application on maize compare well with those seen in Asia and Latin America.

This study identifies the factors responsible for the growth in fertilizer use in Kenya since market liberalization in the early 1990s. Using national consumption figures, prior research has been unable to show whether small farmers or large farms and estates are driving this growth, whether the increased fertilizer consumption is being devoted to smallholder food crops or mainly industrial crops such as tea and sugarcane. Our study sheds light on both of these issues. Moreover, by identifying the farmer characteristics and geographic factors associated with commercial fertilizer purchase for use on maize, the major food security crop in the country, policy makers can refine the targeting criteria for possible fertilizer subsidy programs to efficiently increase national fertilizer use and to minimize the crowding out of commercial fertilizer demand.

The study tracks trends in fertilizer use among 1260 small-scale farm households surveyed by Egerton University's Tegemeo Institute in 1997, 2000, 2004, and 2007. The paper also compares fertilizer use rates in this data set with those of other recent surveys in Kenya to assess comparability. We also examine the correlation between household fertilizer use and indicators of welfare such as wealth and landholding size. In addition, we use fixed effects fertilizer market participation models to identify household and community factors associated with fertilizer use. Lastly, the study considers alternative policy strategies for maintaining smallholders' access to fertilizer in the current context of substantially higher world fertilizer prices.

1.1 Background

Kenya's economy is predominantly agrarian with over seventy percent of its people dependent on agriculture-related farm and off-farm activities for livelihoods. Food security is a concern for a significant proportion of the population living below the one-dollar-a-day poverty line. The national absolute poverty declined from 55.5% in 2000 to 47% in 2005/6 (Kenya National Bureau of Statistics (KNBS, 2009). However, poverty rates may have increased following the post-election violence of 2008, drought of 2009, and the recent global economic downturn. Kenya's GDP grew by 7.1% in 2007 and dropped to 1.7% in 2008 (KNBS, 2009; World Bank, 2010).

Maize accounts for the largest share (about 56%) of cultivated land in Kenya. About 98% of the 3.5 million small-scale farmers in Kenya are engaged in maize production. The small- and medium-scale sector produces about 75 percent of the nation's maize crop, while the large-scale sector (farms over 25 acres) produce the other 25%. On average,

1.5 million hectares are planted to maize annually, with annual production ranging between 16.6 and 34.8 million bags (1.5 and 3.1 million MT) depending on weather and market conditions (Food and Agriculture Organization, Ministry of Agriculture Annual Report -2008, Kenya National Bureau of Statistics-2009). National maize consumption is about 37 million bags (2.9 million MT) annually. The shortfall in production is met through imports from Uganda, Tanzania, and the world market.

Maize marketing and trade policy in Kenya has been dominated by two major challenges. The first challenge concerns the classic food price dilemma: how to keep farm prices high enough to provide production incentives for farmers while at the same time keeping them low enough to ensure poor consumers' access to food. The second major challenge has been how to effectively deal with food price instability, which is frequently identified as a major impediment to smallholder productivity growth and food security. Redressing these causes of low farm productivity and food insecurity are major challenges facing Kenyan policy makers.

During the pre-1990 years the state attempted to address these challenges by direct participation in input and output markets for national "strategic" crops through state-run agencies that set prices at pan-territorial levels or through the creation of ostensibly farmer-run organizations that were managed to varying degrees by state-connected political agents or their surrogates. For coffee, the government helped enact laws that created Coffee Board of Kenya (CBK) and Kenya Planters Cooperative Union (KPCU), for pyrethrum flowers it was the Pyrethrum Board of Kenya (PBK), for milk the Kenya Cooperative Creameries (KCC), for tea the Kenya Tea Development Agency (KTDA), and for maize, the National Cereals and Produce Board (NCPB). During its heydays, NCPB generally bought maize grain from farmers at higher-than-market prices and sold maize to industrial maize millers at prices below market prices. For instance, good rains in Eastern Kenya during the short season in 2010 saw a bumper harvest in March-April that led to NCPB maize purchases at artificially high prices (\$355 per metric ton²) compared to market prices of \$230 per ton of maize grain (World Bank, 2010). Though NCPB generally buys from less than 5% of producers (who tend to be the larger maize selling farms in the country), its operations have a significant effect on market prices (Jayne, Myers, and Nyoro, 2008) and therefore affect prices received by other farmers selling to private traders as well as prices paid by consumers (World Bank, 2010).

On the input side, the 1970s and 1980s saw the formation of state-run Kenya National Trading Corporation (KNTC) and Kenya Grain Growers Cooperative Union (KGGCU) which became Kenya Farmers Association (KFA) working together with the above output organizations which doubled in input provision services as well.

An analysis of all these crop systems and their attendant state intervention in form of agencies, policies, regulations and performance is beyond the scope of this study. For

² We use exchange rate of 1 US\$=73 Kenya Shillings

this study we focus on maize due to the strategic importance that maize plays in Kenya both politically and economically. Historically, not only in Kenya but throughout the entire region, policy makers have been most concerned with raising fertilizer use on maize, the main food security crop in the region.

For a number of reasons to be explored below, state efforts in the 1980s to improve food security through increased production and incomes did not produce desired results. This led to a number of reform measures aimed at attempting to achieve these objectives in a more efficient way, in the lines of a *laissez faire* or competitive markets dogma. The following section describes the reform process for fertilizer and maize markets.

1.2. Fertilizer and Maize Market Reforms in Kenya

The period before market reforms begun in earnest in the early 1990s was characterized by a predictable pattern involving the participation of state-run agencies or private farmer organizations (with heavy state intervention in their management) in input and output markets from import and export, distribution to retailing. Though these state agencies kept re-inventing themselves under different names particularly when they came under scrutiny for corruption and unsustainable budgets, their re-incarnations followed the same general *modus operandi* and eventually failed to achieve their goal of improving smallholder livelihoods. The following discussion provides details that put the above scenario into perspective.

Agricultural policy in Kenya has gone through a number of key phases characterized by an unpredictable shelf-life. In the immediate post-independence period (late 1960s) agricultural policy was concerned with supporting a smooth transfer of prime land from white settlers to indigenous Kenyans with help from state-supported agencies in the production and marketing of produce (NCPB for maize) and inputs were marketed through the Kenya Farmers Association (KFA) and credit provided through the Agricultural Finance Corporation (AFC).

In the 1960s KFA, a farmers union with lot of political connections, imported and distributed fertilizer to large producers who received credit from AFC and delivered produce to NCPB. The KFA could for instance offer inputs on credit (through AFC) to select farmers who will repay KFA after harvesting the crop and delivering to relevant marketing agencies like NCPB (that then deducted the loans on behalf of KFA and AFC). In order to deal with high prices and a weak distribution network for smallholder farmers, fertilizer subsidies were introduced through these agencies (Ariga, Jayne, Nyoro 2006). This conflict of interest across interlinked agencies generated widespread corruption and bureaucratic costs that led to a policy change in 1972 in favor of introducing another agency Kenya National Trading Corporation(KNTC) whose job was to import fertilizer and KFA was to be the distributor. Though this was a move to raise competition, it did not succeed in keeping fertilizer prices at low levels, falling into the

same bureaucracy and corruption since these agencies were influenced by state-organs. On the output side, the NCPB controlled maize prices at all levels of the market chain (Nyoro, Kiiru, and Jayne 1999). By setting fixed pan-territorial prices for all market participants, these entities stifled private trade by removing arbitrage opportunities. Private traders were required to apply for movement permits to let them transport grain across district boundaries.

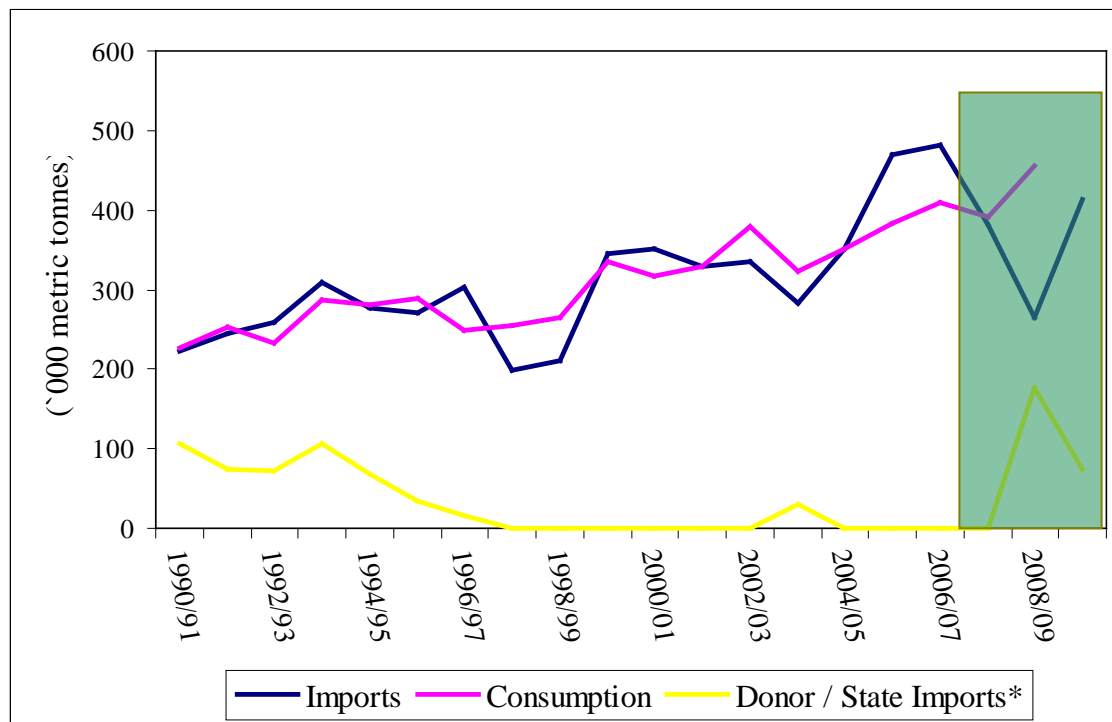
In the 1980s the government started relaxing its monopoly and letting the private sector compete with state agencies albeit under uncertain state rules. Fertilizer traders were to adhere to official prices and the state influenced competition through strict trade licensing requirements and the control of the allocation of scarce foreign exchange to importers. Licensing and allocation of foreign exchange provided rent-seeking opportunities for public sector officials (Kimuyu 1994). While the controlled pricing structure was designed to improve farmers' access to fertilizer, it had the opposite effect in the more remote areas. The controlled prices were too low for fertilizer retailers to recover the costs of transporting fertilizer from district towns to remote areas. Hence, distances travelled by farmers to procure fertilizer were relatively high in the 1980s and early 1990s.

State agencies also imposed a heavy burden on public resources contributing to deficits and inflation in the 1980s. A decline in the budgetary support to the agricultural sector over time probably contributed to the subsequent decline in agricultural growth as did the mismanagement of agricultural institutions, ad-hoc reform agenda, withholding of donor funds over disagreements about democracy and governance, and depreciation of the Kenya shilling that raised input prices (Kodhek 2004). In the late 1980s and early 1990s the state began easing trade restrictions in the fertiliser and maize markets. From January 1990 the government started removing some import quota restrictions followed by the abolition of licensing requirements of fertilizer imports in 1992 and the general liberalization of the economy.

In a major policy change, the government liberalized the fertilizer sub-sector in 1993 to allow the participation of the private sector in imports and local trading and distribution of fertilizer. Coupled with the freeing of the foreign exchange regime in 1992, these changes in the policy environment led to a significant new entry of private sector firms in importing, wholesaling, distribution, and retailing of fertilizer (Wanzala 2002). Government price controls and import licensing quotas were ultimately eliminated, and fertilizer donations by external donor agencies were phased out. Maize movement controls were relaxed in early 1990s to allow private traders to transport a few bags across districts with permission from government officials which led to rent-seeking behavior and increased cost to businesses (Kimuyu, 1994). The NCPB still continued to buy mostly from large producers at prices above the market and during shortages sold to consumers at subsidized prices, a situation that helped stabilize maize prices (Jayne, Myers, and Nyoro 2008).

With the participation of stakeholders from all facets of society in the 1990s and 2000s a number of government policy papers enunciated a multi-sectoral approach to rural development including private-public synergies in development. By 1996 there were 12 major importers, 500 wholesalers, and roughly 5,000 retailers distributing fertilizer in Kenya (Allgood and Kilungo 1996). The number of retailers was estimated to have risen to between 7,000 and 8,000 by 2000 (IFDC, 2001). However, these are estimates as there is no comprehensive business registry or database covering all types of businesses in Kenya. Even with easing of trade restriction, high costs of upland transportation and logistical problems at the port of Mombasa (Wanzala, 2002; Ariga and Jayne, 2009) add to cost of fertilizer and reduce effective demand. Though markups are less than 11% of the farm-gate price of fertilizer in Western Kenya (Jayne et al., 2003), in a number of farming areas no fertilizer is applied due to the risk from markets, poor rainfall, and agro-conditions. However, in other areas application rates rival those of Asia and clearly fertilizer is profitable. The trend in national consumption of fertilizer has followed a steady growth path since 1990 with the government imports declining and private sector role increasing.

Figure 1: Trends in fertilizer consumption, commercial imports, and donor imports, 1990–2009, with projections for 2010



Source: Estimated from Ministry of Agriculture (MoA) data by Authors: In 2004 and 2008 NCPB imported approximately third and 40 percent of national needs (MoA). The estimates for year 2010 are projections for both private and government imports. The years under the color-box cover the time period after 2006/07 when government imports / subsidies re-started partly as a reaction to deficits in maize production and post-election violence disruptions of agricultural activities (this period is not covered in detail in this study).

Since 2007, a major escalation in the world price of fertilizers has led to increased government involvement in fertilizer marketing. The post-2007 period has been marked by uncertain policy regimes after a fairly stable and transparent policy since 1993. In a move to bolster production after a disputed presidential election that led to disruption of farm activities, NCPB imported fertilizer in 2008 but delivered it late which contributed to a poor crop. This in turn created pressure from some farmer lobby groups and activists for increased subsidization of inputs (fertilizer and seed) to raise productivity of maize to counter an expected increase in hunger in 2009. In 2009 the GoK imported substantial amounts of fertilizer through NCPB to be distributed through its branches and select private retailers at subsidized prices (40% subsidy). For early 2010, newspaper reports indicated that the government will import 1.5 million bags (75,000 tonnes) of fertilizer (Nation Newspaper, 04/10/2010). The following table details some key points in the liberalization process of the maize sector especially by modifying the role played by NCPB, the main grain-marketing state agency.

Table 1. Evolution of maize and fertilizer market policy reforms starting in 1988

State Marketing Agency	Maize Market Policy	Fertilizer Market Policy
1988 NCPB faces deficits and is 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. State sets all prices for grain and flour.	Pre-1990 KGGCU / KFA and KNTC main input agencies. Mismanagement and deficits common. Heavy government control. Imports poorly coordinated leading to surplus / deficits. Late 1980s saw controlled licensing of private trade but under pan-territorial pricing. State agencies financially weak.
Early 1990s NCPB narrows its margins. Private trade finds it unprofitable to reach remote areas.	1991 Local and International pressure for reforms builds up. Further relaxation of inter-district trade.	
	1992 Kenya moves from one party politics to a multi-party state. Restrictions on maize trade across districts re-imposed. NCPB unable to defend ceiling prices. In 1993 maize and maize meal prices deregulated. Import tariff abolished. No subsidies to registered millers.	1992 Foreign exchange regime liberalized. Fertilizer import restrictions relaxed. In 1993 fertilizer market liberalized. Private traders allowed to import and distribute. State and donor imports declined dramatically. In 1994 custom duty and VAT removed.
1995 Donor pressure leads to NCPB being restricted to limited buyer and seller of last resort role. NCPB market share declines to 10-20% of marketed	1995 Full liberalization of internal maize and maize meal trade. Maize import tariff re-imposed to 30%. In 1996 export ban imposed after poor harvest. In	1996 Entry estimates of 12 major importers, 500 wholesalers, and roughly 5,000 retailers (Wanzala and others)

maize trade. NCPB operations confined mainly to high-potential areas of western Kenya.	1997 import tariff imposed after poor harvest	
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.	1997 –2005: External trade and tariff rate levels change frequently and become difficult to predict. NCPB producer prices normally set above import parity levels	
	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.	
2008 High world food prices. NCPB asked to sell subsidized grain to millers who then could lower prices to consumers. Difficult for state to enforce and monitor at millers’ end due to unknown milling costs. Allegations of corruption emerge.	2008 Post election violence. African Centre for Open Governance (AFRICOG) estimated 3.5 million bags destroyed. NCPB imports began late 2008 from US and South Africa. Estimated 5 million bags arrive (AFRICOG).	2008 High world prices for fertilizer exacerbate food crisis from election violence. Prices more than doubled. Petrol and transport costs also go up.
2009 Briefcase firms and NCPB employees took advantage of crisis and subsidy arrangements to favor some firms for kickbacks. Weaknesses in disaster preparedness, institutions, and food policy are revealed. NCPB top management and some MOA officials sent home due to corruption during the crisis.	2009 Imports continue but maize production better than expected. Claims of monopoly at port (grain handling: one large grain handler—Grain Bulk Handlers Limited (GBHL) and milling but not substantiated (AFRICOG).	2009 NCPB imports state subsidized fertilizer to aid in recovery from post election violence. Distributed through private trader networks.
2010 NCPB allocated funds to buy maize from short rains in eastern Kenya.	2010 Short rains season does very well but farmers’ claim poor prices from private traders.	2010 State imports over 30,000 tonnes of fertilizer and distributes to vulnerable farmers. Distribution done through NGOs.

Source: Adapted from Ariga and Jayne 2008 and updated for this report.

Though the increased participation of government in these market was expected to be short-lived and not significant enough to disrupt private sector investments, unforeseen events (like poor rains) may mean that the next few years will witness more state subsidies in an attempt to meet national food requirements as political pressure builds up. If recent indications are reliable, government subsidies will probably decline after a few years as they become unsustainable unless international partners continue to

shoulder some of the responsibility. The last two years have witnessed increased fertilizer subsidies organized by the Ministry of Agriculture (MoA) but funded by both state and donor funds using a voucher redemption system. Some of these funds were used to build capacity of agro-dealers or traders to facilitate the redemption of vouchers by poor or vulnerable producers. If the international funding continues, subsidies to vulnerable groups will probably be sustained for a while.

The next section describes the data we will use for this study followed by details of the performance indicators that show the effect of fertilizer and maize reforms over the period of the panel survey.

2.0 Data

We will use household survey data and secondary sources to analyze the effects of policy reforms on fertilizer and maize markets during this period by looking at a number of indicators. The panel data consists of a nationwide rural household panel survey data covering the 1996/97, 1999/2000, 2003/04, and 2006/07 crop seasons. The panel household survey was designed and implemented under the Tegemeo Agricultural Monitoring and Policy Analysis Project (TAMPA), implemented by Egerton University / Tegemeo Institute, with support from Michigan State University. Out of the national sample we select a balanced panel of 899 households interviewed all the four periods. Other data is obtained from various Kenyan government ministries such as monthly maize price levels and NCPB maize purchases and sales.

The survey sample has been classified into zones for analytical convenience based on agro-ecological characteristics, districts, and agricultural production potential. Further, these agro-ecological zones have been split into two broader categories³ (High Potential and Low Potential Regions) based on soils, rainfall, yield potential, and fertilizer use.

3.0 The Effect of Reforms in Fertilizer and Maize Markets

This section utilizes descriptive results from analysis of Tegemeo Institute's balanced household panel data and existing literature. We delineate any differences between the two regions mentioned above. The High Potential region consists of West and Middle Kenya while the Low Potential region contains coastal and eastern lowlands which are relatively drier. We first provide an overview of the processes leading to increase

³ High Potential region has higher productive potential and covers the following agro-zones: Western and Central Highlands, High Maize Potential, and Western transition areas. This includes the following districts: Trans Nzoia, Uasin Gishu, Kakamega, Vihiga, Bungoma, Narok, Nakuru, Bomet, Nyeri, Muranga, Kisii, and Meru. Low Potential region consists of the lowland zones of the coast, east, and west of the country (generally dry and poorer soils). This covers the following districts: Kilifi, Kwale, Taita Taveta, Kitui, Machakos, Makueni, Mwingi, Kisumu, and Siaya

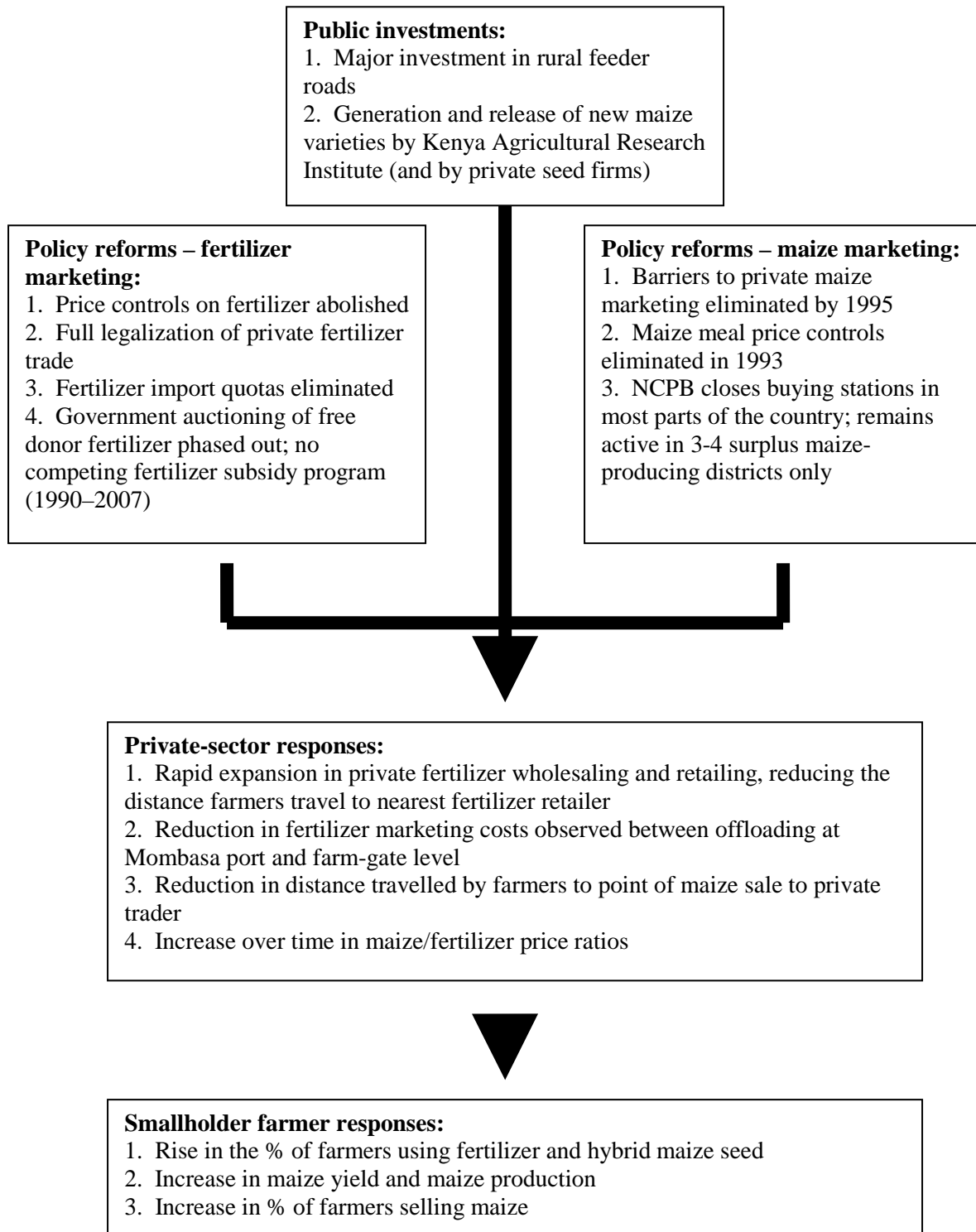
fertilizer use and maize yields on smallholder farms and then examine each of the processes in more depth.

3.1. Summary of the Processes Leading to the Growth in Smallholder Fertilizer Use and Maize Yields

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. There are some 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.

However, as explained in subsequent sections, not all producers sustained increased yields over this period. There is great heterogeneity across households, years, and regions within the country based on agro-conditions, input constraints, differences in agronomic practices, and endowments or resources across farmers. Therefore, general indicators may not reflect specific differences across years and regions.

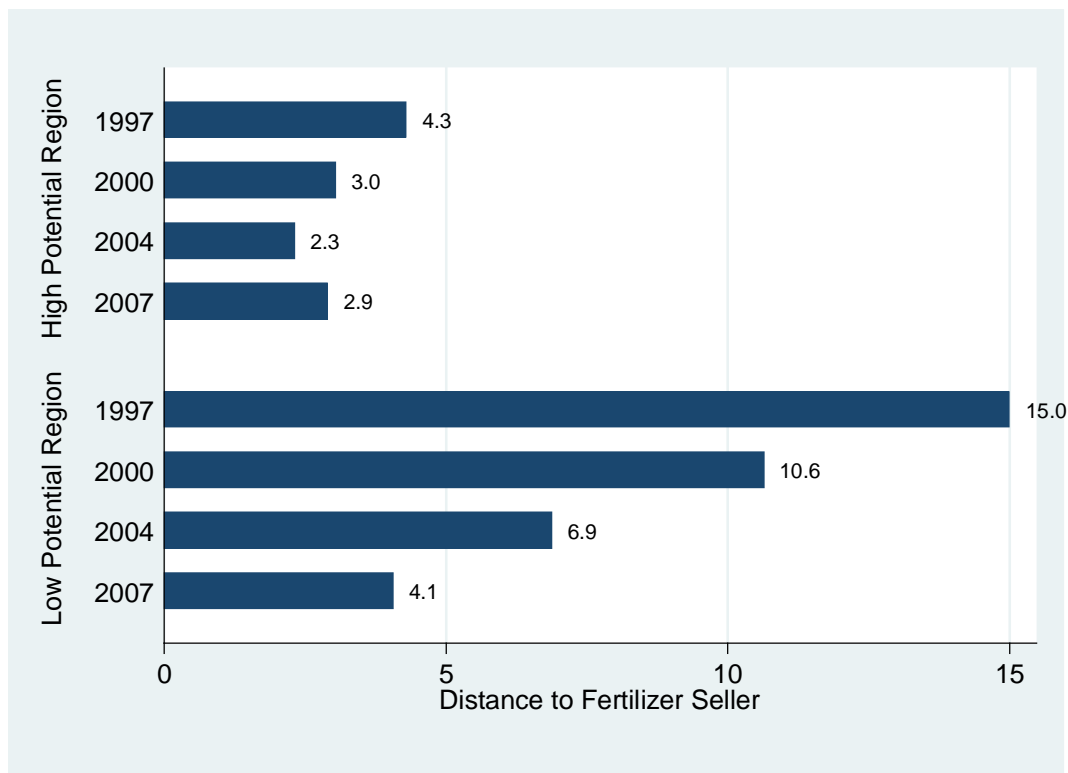
Figure 2. Synergies between public goods investments, policies, and private-sector response in promoting fertilizer use and maize yield improvements by smallholder farmers



3.2. Distance from Farm to Fertilizer Seller

One indicator of how reforms have contributed towards making fertilizer available is how far farmers travel to buy fertilizer compared to the pre-reform period. The survey collected data on distance (kilometers) from farm to fertilizer seller or retail store for each of the panel years. This variable is a measure of increased private sector competition leading to more investment into expansion of retail services closer to producers by i) retailers opening stores in new catchment areas that were hitherto not serviced by the government-run input system ii) retailers spreading out stores in existing areas in order to capture more business. The figure below shows how distance has declined over the survey period:

Figure 3. Declining Distance (kilometers) from Farm to Fertilizer Seller



Source: Estimated from Tegemeo Institute/Egerton University household surveys, 1997, 2000, 2004, and 2007 by Authors. Note: High Potential region consists of the following districts: Trans Nzoia, Uasin Gishu, Kakamega, Vihiga, Bungoma, Narok, Nakuru, Bomet, Nyeri, Muranga, Kisii, and Meru. Low Potential has the following districts: Kilifi, Kwale, Taita Taveta, Kitui, Machakos, Makueni, Mwingi, Kisumu, and Siaya

In general, distances in Low Potential region are longer than those in High Potential region, which is one reason why we split the sample into two broad groups for this analysis. For High Potential region, distance to fertilizer seller has decreased from 4.3 in 1997 to 2.9 kilometers in 2007 while for Low Potential region this is 15 and 4.1 kilometers respectively. The private sector investment in fertilizer trade has expanded

rapidly after the state allowed competition and removed trade restrictions. Though absolute distances are generally higher for the Low Potential area, the rate at which distances have declined is generally higher for this region. However, as we will see below, the consumption of fertilizer has not followed the same pattern for this region, implying the presence of other constraints. The Low Potential area is characterized by agro-ecological conditions that have less rainfall and poor soils compared to the High Potential region. We now examine whether these reforms that allowed market competition led to more households using fertilizer over the years.

3.3. Increasing Proportion of Households Using Fertilizer

Using a balanced panel, the percentage of households using fertilizer on at least one farm plot has risen from 59% in 1997 to approximately 72% for the national sample. However, there is heterogeneity in growth across agro-ecological zones and the two broad regions of interest. For the High Potential region, which had a relatively higher proportion of fertilizer users in 1997, the increase was from 77% of the households to 91% while for the Low Potential region it was 12% in 1997 and 26% in 2007. Though the growth rate in the proportion of users grew faster for this region during this period, the proportions themselves are significantly smaller than those in the High Potential area, which has a most of its households using fertilizer.

Table 2. Percentage of maize-growing households using fertilizer (by region and zone)

High Potential region:	1997	2000	2004	2007
Western Transitional	41%	65%	71%	81%
High Potential	84%	89%	89%	92%
Western Highlands	78%	90%	91%	95%
Central Highlands	90%	91%	91%	93%
Sub Total	77%	85%	86%	91%
Low Potential region:				
Coastal Lowland	4%	4%	5%	11%
Eastern Lowland	26%	27%	47%	48%
Western Lowland	2%	5%	7%	13%
Sub Total	12%	14%	23%	26%
GrandTotal	59%	65%	68%	72%

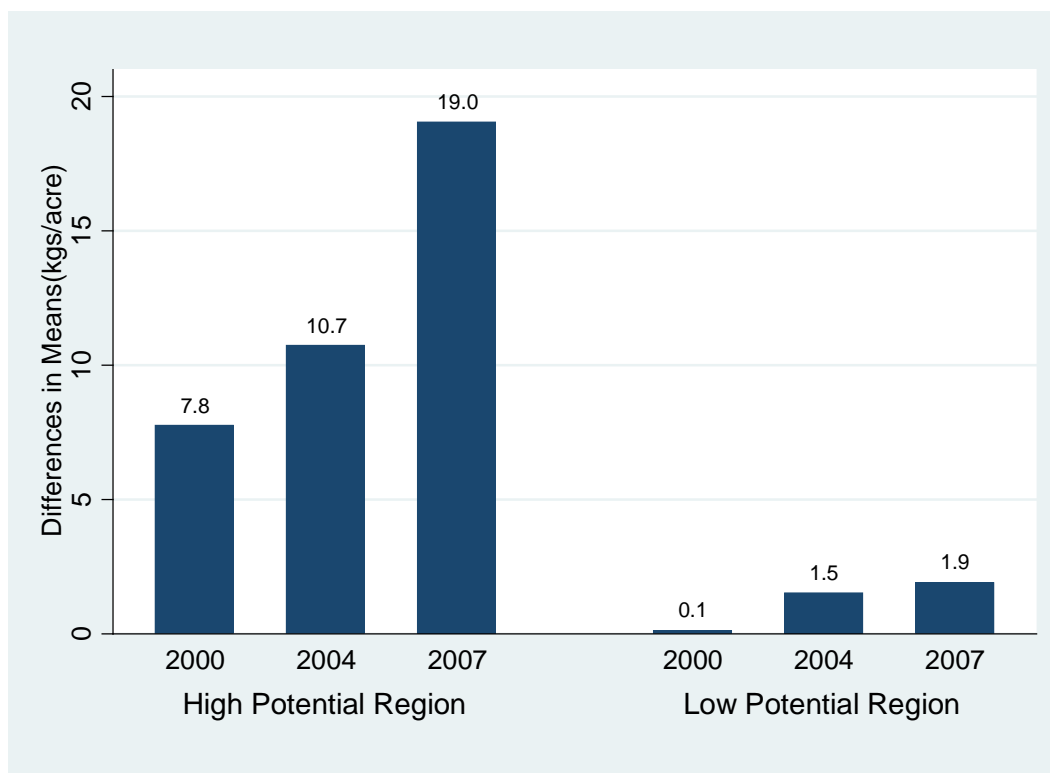
Source: Estimated from Tegemeo Institute/Egerton University household surveys, 1997, 2000, 2004, and 2007 by Authors. This sample consists of a balanced panel of 899 households interviewed all the four periods. Note: High Potential region consists of the following districts: Trans Nzoia, Uasin Gishu, Kakamega, Vihiga, Bungoma, Narok, Nakuru, Bomet, Nyeri, Muranga, Kisii, and Meru. Low Potential has the following districts: Kilifi, Kwale, Taita Taveta, Kitui, Machakos, Makueni, Mwingi, Kisumu, and Siaya

We next look at application rates for those households using fertilizer and for the whole sample of households including non-users in order to understand the trend in intensity (kilogram per acre of maize) since the inception of fertilizer reforms in the 1990s.

3.4. Dynamics of Fertilizer Application Rates

For comparison at the household level, we aggregate by summing plot level application rates using plot area (acres) as weights⁴. First, for each region we compare the differences between the weighted mean household application rates (kgs per acre) for the years 2000, 2004, and 2007 from the rates prevailing in 1997. This will help reveal whether there were any increases, decreases, or no changes in application rates for subsequent years when compared to the base period of 1997. The bar graph below shows the trend in this indicator from the base year 1997.

Figure 4. Differences in means household fertilizer application rates on maize from 1997 levels



Source: Estimated from Tegemeo Institute/Egerton University household surveys, 1997, 2000, 2004, and 2007 by Authors. Note: High Potential region consists of the following districts: Trans Nzoia, Uasin Gishu,

⁴ We sum the product of plot fertilizer application rates and ratio of plot size (acres) to total acres for all plots in the household. This procedure gives more weight to application rates in bigger plots in determining aggregate household application rates. $Rate = \sum (\text{plot rate} * \text{plot area} / \text{Total household cropped area})$.

Kakamega, Vihiga, bungoma, Narok, Nakuru, Bomet, Nyeri, Muranga, Kisii, and Meru. Low Potential has the following districts: Kilifi, Kwale, Taita Taveta, Kitui, Machakos, Makueni, Mwingi, Kisumu, and Siaya

Clearly, weighted mean household application rates have increased relative to those in 1997 (and also from one year to the next) for each region. For High Potential region, these increases were 8, 11, and 19 kilograms per acre respectively from 1997 to 2000, 2004, and 2007. It is also obvious that in absolute terms, differences are relatively much smaller in the Low Potential region probably as a result of lower application rates (Table 3) and lower proportion of fertilizer users (Table 2).

Table 3 supplies information on application rates (kilos per acre) for two sets of households; for the whole sample and a subset consisting of only those households that used non-zero amounts of fertilizer (only users). When estimating for the whole set of households we include “zeros” for those not using fertilizer which makes these rates lower or equal to those for users only (depending on presence of non-users).

Table 3. Fertilizer application rates (kilograms per acre) for maize-growing households (by region and zone)

	Fertilizer Users PLUS Non-Users (zeros Included)				Fertilizer Users Only			
	1997	2000	2004	2007	1997	2000	2004	2007
High Potential region								
Western Transitional	23.0	47.1	46.5	57.3	57.5	73.0	63.8	71.8
High Potential Maize Zone	53.1	58.5	60.9	65.4	63.7	66.5	70.4	73.3
Western Highlands	26.9	40.6	49.6	48.4	36.3	45.4	54.0	51.7
Central Highlands	62.2	68.4	73.4	67.2	68.8	77.9	84.2	74.1
<i>Sub Sample</i>	46.3	56.1	59.5	61.6	60.6	66.7	70.0	69.6
Low Potential Region								
Coastal Lowland	0.4	0.8	0.1	1.6	10.4	19.6	2.1	13.9
Eastern Lowland	3.1	5.7	8.3	9.6	12.1	24.8	19.7	23.9
Western Lowland	0.4	0.5	0.9	2.3	21.3	16.4	19.4	18.6
<i>Sub Sample</i>	1.4	2.8	4.0	5.3	12.7	23.6	19.1	22.0
Grand Total	33.3	38.0	43.1	45.0	58.0	63.8	65.2	64.7

Source: Estimated from Tegemeo Institute/Egerton University household surveys, 1997, 2000, 2004, and 2007 by Authors. Note: High Potential region consists of the following districts: Trans Nzoia, Uasin Gishu, Kakamega, Vihiga, bungoma, Narok, Nakuru, Bomet, Nyeri, Muranga, Kisii, and Meru. Low Potential has the following districts: Kilifi, Kwale, Taita Taveta, Kitui, Machakos, Makueni, Mwingi, Kisumu, and Siaya

Application rates have increased from their 1997 levels for all regions and agro-zones across the years. For both regions taken together, application rates increased from 33.3 (58.0) to 45.0(64.7) kilograms per acre for whole sample (users only) respectively. Though intensities differ across regions and agro-zones, the general dynamics is an upward tick in application rates from the 1990s. The High Potential Maize Zone (HPMZ),

which includes Trans Nzoia and Uasin Gishu, and Central Highland zone have some of the highest application rates in the sample. For example, the HPMZ's rates for fertilizer users only in 1997 and 2007 are 157.3 and 181.1 per hectare, which rivals those in Asia which benefited from the Green Revolution and is considered to have one of the highest fertilizer application rates in the world.

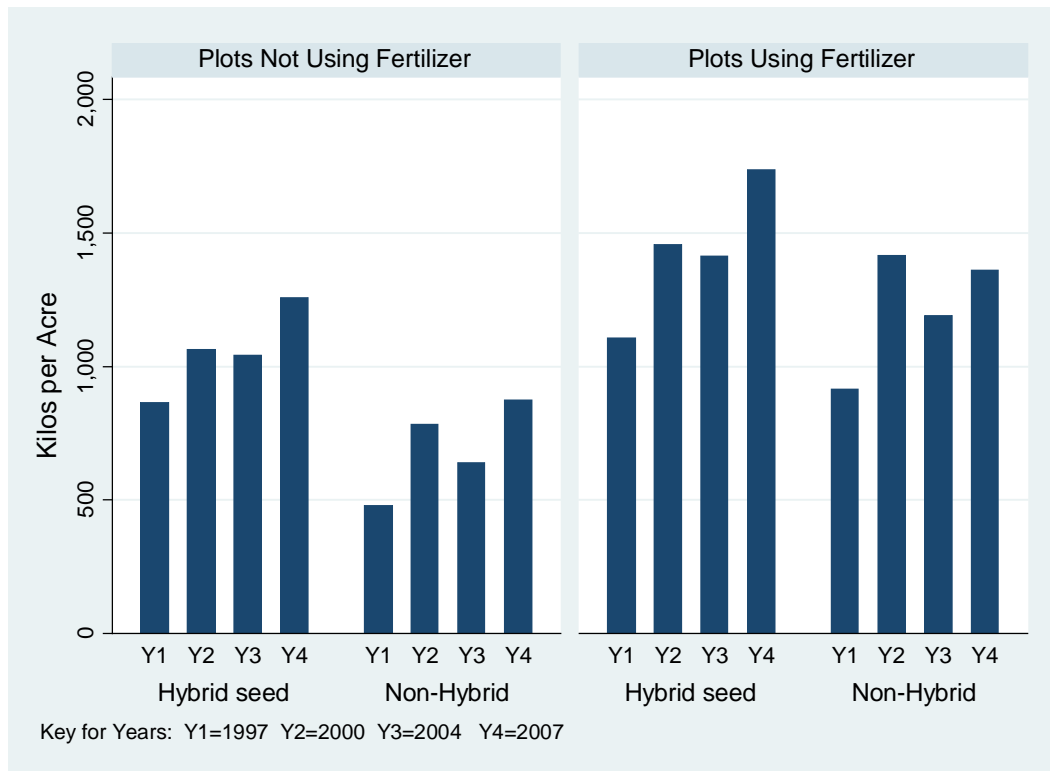
3.5. Trend in Maize Yields for (un)Fertilized Plots and Different Seed Technologies

Next we compare the performance of maize yields over this period of time noting the differences in yields for fertilized and non-fertilized plots for various maize seed technologies across the two regions. As shown in Figure 3 and Table 3, there has been significant increase in fertilizer application since the reforms of the 1990s when markets were opened up to competition. The question for this section is whether the reforms and the rise in consumption of fertilizer, partially due to increased retail investment (Figure 2), had an effect on maize production. First we look at the dynamics of maize yields for plots that received fertilizer and those that did not across the years and for different seed types (the following bar graph).

First, for all plots (fertilized and unfertilized), yields have generally increased from 1997 to 2007. Secondly, irrespective of fertilization, yields for hybrid seed plots are higher than those for non-hybrid plots. Thirdly, for each seed technology, yields for fertilized fields are higher than those for unfertilized fields. Finally, yields for plots that receive fertilizer and use hybrid seeds are the highest for each year in this period⁵.

⁵ Note that "hybrid" stands for purchased hybrid seed and Open Pollinated Varieties (OPV) and "non-hybrid" consists of re-cycled or re-planted hybrid and some "traditional" seed types of unknown source.

Figure 5. Trend in maize yields (kgs/acre) in fertilized and non-fertilized plots for different seed technologies.

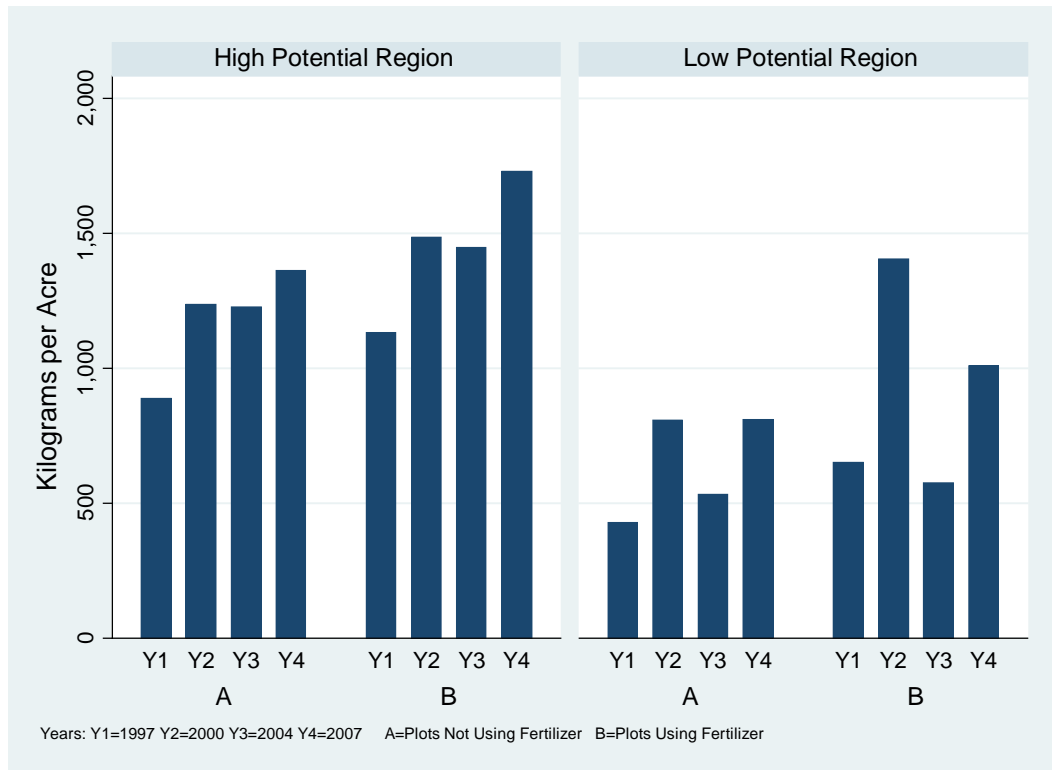


Source: Estimated from Tegemeo Institute/Egerton University household surveys, 1997, 2000, 2004, and 2007 by Authors. § note that these bivariate findings do not control for differences in rainfall, soils, unobserved farmer skills, etc.

Though there is a general increase in yields from year-to-year, this is particularly significant for the year 2000 compared to the rest of the years. This may partly be explained by the favorable prices for maize following a poor maize crop in the 1998/99 season; as a result the fertilizer (DAP) to maize price ratio was lower at the planting season for year 2000, an incentive to farmers at the planting season in 2000 (using naive price expectations based on recent output prices).

The following graph moves away from the above discussion on aggregate trends to looking at the existence of regional differences in the yield-fertilizer nexus for the period covered by the household surveys. The “A” and “B” stand for unfertilized and fertilized plots respectively while the “Ys” denote the years 1997, 2000, 2004, and 2007.

Figure 6. Trend in maize yields (kilos/acre) for fertilized and non-fertilized plots by region §.



Source: Estimated from Tegemeo Institute/Egerton University household surveys, 1997, 2000, 2004, and 2007 by Authors. Note: High Potential region consists of the following districts: Trans Nzoia, Uasin Gishu, Kakamega, Vihiga, Bungoma, Narok, Nakuru, Bomet, Nyeri, Muranga, Kisii, and Meru. Low Potential has the following districts: Kilifi, Kwale, Taita Taveta, Kitui, Machakos, Makueni, Mwingi, Kisumu, and Siaya. § note that these bivariate findings do not control for differences in rainfall, soils, unobserved farmer skills, etc.

There is heterogeneity across regions, with High Potential area having more suitable conditions for maize production compared to the Low Potential region. This is brought out clearly when comparing yields for fertilized plots (B) in Low Potential region with those from unfertilized plots (A) in High Potential region. Even without fertilization, yields for unfertilized plots in High Potential region are generally higher than those from fertilized plots in the Low Potential region indicating that fertilizer use has varying effects depending on other restricting factors.

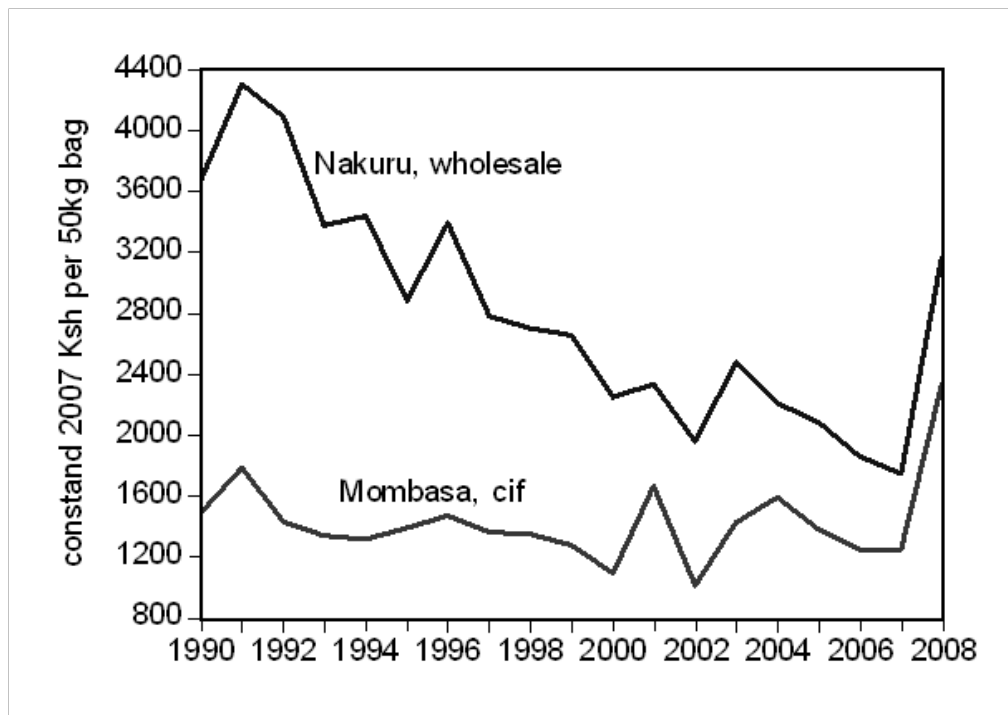
The above yield figures are based on composite yield index unlike the numbers estimated by the Ministry of Agriculture (MoA). The MoA estimates capture yields attributed to maize crop only (even where maize is intercropped in the same plot with other crops and it is difficult to apportion area or inputs use to each crop in the mix). The composite yield (i.e. the sum of the yields for maize and other crops in the same plot converted to an index using price ratio of each crop to that of maize) is obviously

different from just estimating the yields for maize only. Estimating only yield for maize, even when the plot has multiple crops whose input or resource use cannot be separated or clearly apportioned to each crop, does not reflect the true returns to inputs applied to the plot or field.

3.6. Trends in Wholesale Price Margins

Price margins can indicate the state of competition and innovations that reduce marketing costs between two points of interest by improving market efficiency. The margin between wholesale world prices (cif, ex-Mombasa port on the east coast) and hinterland town of Nakuru has been declining over the period covered by this study.

Figure 7. 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.

The world price has been fairly constant over this period but rose sharply in 2008 in relation to the general price index. This implies that marketing costs have declined and led to lower prices at Nakuru. Studies (Kimuyu 1994; Wanzala et al 2002; Allgood and Kilungo 1996; IFDC 2001) and interviews with stakeholders suggest this reduction is a result of increased competition after the 1990s reforms, economies of scope resulting from mergers, and access to competitive credit from international sources.

The following section looks at factors that influence producer decisions in the fertilizer market using panel methods.

4.0 Household and other Determinants of Fertilizer Demand

In this section we analyze fertilizer demand regression results for the two regions (high and low potential) that highlight relevant factors influencing fertilizer use or demand decisions. The preceding section condensed key indicators of the success of fertilizer and maize reforms. In this section we estimate the effects of household characteristics and geographic factors on household fertilizer use through market participation models. The variables entering the model include education, value of assets, land size, land preparation technology, gender of the household head, and geographic factors including distance to fertilizer seller, agro-ecological conditions, soil types, and market conditions. This will provide a measure of diversity or heterogeneity in demand across the country and between different households that face varied surroundings which is important in setting appropriate policy geared to achieving food security for smallholders.

We use panel regression methods including Random effects (RE), Fixed effects (FE), and Correlated Random effects (CRE) to model fertilizer demand (application rate per acre). The RE approach assumes strict exogeneity between explanatory variables and composite error term, which includes unobserved household specific heterogeneity. On the other hand FE does not assume strict exogeneity but takes the unobserved effects as constant over time and uses a differencing approach to remove these effects to generate consistent estimates. Unlike FE, the CRE method extends the RE analysis by modeling unobserved heterogeneity using the household means of time-varying variables. Therefore with CRE, we can test whether our model captures unobserved effects and use the estimates to classify households or explain differences between households (Wooldridge 2002). An additional benefit of CRE is that the estimates on the time-varying variables are the same as those in the FE estimation and unlike FE, the effect of time-constant factors (like gender, location dummies, etc) are estimated as well (not differenced away as in FE).

Using CRE, we reject the null of non-existence of unobserved heterogeneity which implies that fixed effects approach is the appropriate method over random effects which assumes exogeneity. However, CRE offers the benefits of producing the same estimates as from FE regression on time-varying variables while at the same time providing a way to model heterogeneity so as to explain differences across households based on skills and other factors we are unable to observe or get data. For these reasons we will only discuss results for the CRE method using a double hurdle approach.

The following discussion is based on Table 5 which contains CRE regressions for fertilizer market participation and demand for High and Low Potential areas. We discuss and contrast results for the two regions for the market participation and consumption or use decisions. For the double hurdle model the same variable can have different sign and magnitude in the market participation and demand equations, unlike the Tobit model which assumes same effect and magnitude in both equations.

Table 4. Fertilizer market participation and demand using correlated random effects to model household heterogeneity

Equations	High Potential Region		Low Potential Region	
	Market Participation (0/1)	Consumption (kilos / acre)	Market Participation (0/1)	Consumption (kilos / acre)
Dependent Variable (units)		(Kilos / acre)		(Kilos / acre)
Price for Nitrogen (Khs / Kilo)	0.015	-0.831*	-0.009	-0.175**
Price for Maize Grain (Khs / Kilo)	-0.003	0.313	-0.003	-0.016
Age of household head (years)	-0.002**		-0.001	
Quintiles for Value of Household Assets †:				
2	0.012	0.853	-0.047	0.359*
3	0.001	1.108	0.016	0.571***
4	-0.017	-0.101	-0.001	0.401*
5	-0.012	2.454	0.021	0.897***
Quintiles for Total Cropped Land †:				
2	0.021	-3.767***	0.007	0.130
3	0.038*	-4.270***	-0.006	-0.326
4	0.068***	-3.995**	-0.007	0.058
5	0.069***	-1.594	0.006	-0.261
Categories for Education of H. Head †:				
2 1-4 years	-0.018	1.475	-0.066	-0.305
3 5-8 years	-0.017	0.546	-0.036	-0.155
4 9-12 years	0.001	5.605*	0.043	0.379
5 > 12 years	0.032	6.416*	0.100	0.133
Categories for Land Preparation Technology †:				
2 Oxen	0.101***	4.330**	-0.016	0.011
3 Tractor	0.147***	5.670***	-0.030	0.056
Categories for Land Tenure†:				
2 Own land without title	0.005	-0.088	0.027	0.068
3 Renting Land	0.054***	-1.047	0.030	-0.299
Dummy (1=Female Head of Household)	-0.023	-0.647	-0.060***	-0.281*
Categories f Soil Types †:				
2	0.007	-1.595	-0.162**	-0.479
3	0.020	-1.643		
4	0.009	-1.708	-0.008	-0.143
5	-0.094*	-7.913*	-0.083	-0.377
Agro-Zone Dummies (Dropped C Lowland and W Transitional):				

Eastern Lowlands			-0.036	-0.195
Western Lowlands			0.389***	2.324**
High Potential	0.398***	-0.435		
W Highlands	0.263***	-2.239		
Central Highlands	0.423***	19.053***		
Dummy (1=Single Crop in Plot)	-0.061***	-0.307	-0.001	-0.042
MUNDLAK – CHAMBERLAIN: TIME- AVERAGED TERMS:				
Price for Nitrogen (Khs / Kilo)	-0.064**	-1.246	-0.062	0.525
Price for Maize Grain (Khs / Kilo)	0.053***	-1.669	0.030***	0.098
Dependency Ratio (Dependants to Productive Members)	-0.001	-0.359	0.002	-0.005
Distance to Fertilizer Seller	-0.023***	0.641	-0.009***	-0.012
Duration as Head of Household (years)	0.004**		0.001	
Quintiles for Value of Household Assets †:				
2	0.015	4.074	0.096	-0.495
3	0.088**	-3.910	0.046	-0.396
4	0.111***	0.454	0.058	0.218
5	0.103**	-1.483	0.057	-0.064
Quintiles for Total Cropped Land †:				
2	-0.046	-2.737	0.190***	-1.039
3	-0.002	4.387	0.238***	-0.278
4	-0.067*	0.031	0.173***	-0.489
5	-0.007	2.099	0.178***	-0.657
Fractions of 20-day periods with <40mm of rain inn season	-0.185***	-26.845**	0.100	6.206
Observations (Plots)	4051	4051	1782	1782

Note: Standard errors are omitted to make the table more readable (full table is available from authors upon request). The stars on the t-statistics indicate significance at *** p<0.01, ** p<0.05, * p<0.1. † Quintiles range from lowest (1) to highest (5) for asset values and land sizes (compare estimates with lowest quintile which is dropped). Estimates for the rest of categories (land preparation, zones, tenure, etc) should be interpreted in relation to the omitted category (category 1). Note: High Potential region consists of the following districts: Trans Nzoia, Uasin Gishu, Kakamega, Vihiga, bungoma, Narok, Nakuru, Bomet, Nyeri, Muranga, Kisii, and Meru. Low Potential has the following districts: Kilifi, Kwale, Taita Taveta, Kitui, Machakos, Makueni, Mwingi, Kisumu, and Siaya

We discuss the above results under relevant sub-sections below; effect of fertilizer and maize prices, household resource endowments, effect of technology and gender on demand for fertilizer.

4.1. Effect of Fertilizer and Maize Prices on Demand for Fertilizer

When a household is faced with an increase in fertilizer price of approximately US\$3.8 per 50-kilogram bag, its application rate per acre declines by 4.4 kilos (High Potential region) or 1.1 kilos (Low Potential region). This translates to a response elasticity of 0.52 i.e. a 10 percent increase in fertilizer price leads to a 5.2 percent decline in application rates per acre for High Potential region. The elasticity for Low Potential region is 0.32.

From the Mundlak-Chamerlain device (Wooldridge 2002), households that face higher fertilizer prices have lower probability of participation while those facing higher maize output prices have higher probability of participation in fertilizer markets. There is a reduction in probability of market participation of 0.64 points for households facing a 10 Kenya Shillings per kilo higher fertilizer price while households facing a similar higher maize output price have higher probability of participation by 0.53 points for the High Potential region (0.30 in Low Potential region) i.e. households facing higher fertilizer prices have lower probability of market participation while those facing higher output prices have higher probability. However, the level of input and output prices has no significant effect on kilograms to apply per acre across households. This implies that price signals are important in determining farmers' decision to participate in fertilizer markets.

4.2. Effect of Household Resource Endowments on Demand for Fertilizer

We look at the effect of some measures of resource endowment (asset values, land size) on fertilizer demand. Though probability of market participation for the Low Potential region does not change with value of assets, the application rate rises with assets. Raising a household's asset from the lowest quintile to the third quintile or fifth, raises the application rates by 0.571 and 0.897 kilogram per acre respectively. But when contrasting different households in the High Potential region, those with higher value of assets have greater probability of participating in the fertilizer market.

A related measure of resources is the amount of land under crops during the season (because our data does not have total land owned for the year 2000, we use land under crop as a proxy for this variable). Though the probability of market participation rises with increase in the size of land for households in High Potential region, the amount applied per acre decreases with land size. Households with more land under crops in Low Potential region have higher probability of market participation although the rates per acre are not significantly different from those with less land under crops.

4.3. Effect of Land Tenure, Gender, Land Preparation Technology, and Mixed Cropping on Demand for Fertilizer

Households that rent land have higher probability of fertilizer market participation (by .05 points) than those who have title to their land but there is no significant difference in application rates across land tenure categories. Female headed households have lower probability of market participation (0.06) and intensity per acre (0.28) compared to male-headed households in Low Potential region. Though signs of estimates are the same as those of High Potential region, this latter's gender estimates are not significant. We find no plausible explanation why Low Potential region has gender effect while High Potential region does not.

On agro-ecological zones, households in central highland have a 0.4 point higher probability of participating in fertilizer markets than western transitional zone and 5.95 kilos more per acre. On land preparation technology there is a higher probability of market participation for households using animal draught (.1) or tractor (.14) compared to manual hoeing; fertilizer application per acre for these households also increases by 4.4 and 5.6 kilos respectively over manual technologies. Households that do inter- or mix cropping (i.e. plant maize with one or more other crops in the same plot) have a higher probability of fertilizer market involvement than those doing single maize cropping. However, application rates do not significantly differ with intensity of mixed cropping.

4.4. Effect of Distance to Fertilizer Seller, Education, and Experience on Demand for Fertilizer

Households that are further away from fertilizer sellers have lower probability of participating in the market (0.023 points per kilometer) for High Potential region (0.01 points for Low Potential region). For instance, households in High Potential region that are located 10 kilometers away from fertilizer retailers have 0.23 lower probability of participating but application rates per acre do not differ significantly. Households with head who have more years of schooling have a positive but insignificant probability of participating in the market than those who do not. The intensity of application per acre is positive with years of education (and significant for High Potential region). Age of household head in High Potential region has negative relationship with probability of participation but not the intensity of application. The number of years or duration as the head of household has a positive effect on probability of participation in market in High Potential region; experience has head of household raises chances of market participation.

5.0. 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

1. The percentage of sampled smallholders using fertilizer on maize has increased from 59 percent in 1997 to 72 percent in 2007.
2. Fertilizer application rates (which include all maize fields regardless of whether they received fertilizer or not) rose from 33 kg/acre in 1997 to 45 kg/acre in 2007, a 34 percent increase.
3. 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 26 and 41 percent, respectively, in 1997 to 48 and 81 percent in 2007.
5. 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 more on the intercropped fields and less so on monocropped fields.
6. Fertilizer marketing costs have declined substantially in constant Kenya Shillings 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.

From the household survey data we learn a number of important lessons that are relevant to policy. First, the probability of households participating in fertilizer markets declines with high fertilizer prices, a finding that may support calls to subsidize fertilizer to maintain farm production levels at such times. Households with higher value of assets and larger farm sizes are more likely to participate in fertilizer markets. Compared to household that use manual land preparation methods, households using animal draught or tractors during land preparation apply more fertilizer per acre and are more likely to buy fertilizer. Therefore, resource endowments (land, assets and access to animal power and tractors) are important factors that encourage fertilizer use. In lower potential regions female-headed households are less likely to purchase fertilizer and have lower application rates per acre of maize cultivated. This is an area that require further study to figure out the major reasons and why this does not occur in high potential region. Households whose heads have more years of schooling also are more likely to purchase fertilizer. The further away a household is from the nearest fertilizer seller, the lower the probability of purchasing fertilizer. The increased proximity of farm households to fertilizer retailers over the 1997-2007 period as a result of input market reform is one of the major factors accounting for the increased use of fertilizer among smallholder farmers in Kenya.

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 (Ariga et al 2008). The rise in smallholder use of fertilizer in the Tegemeo survey data is also consistent with official Ministry of Agriculture figures (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

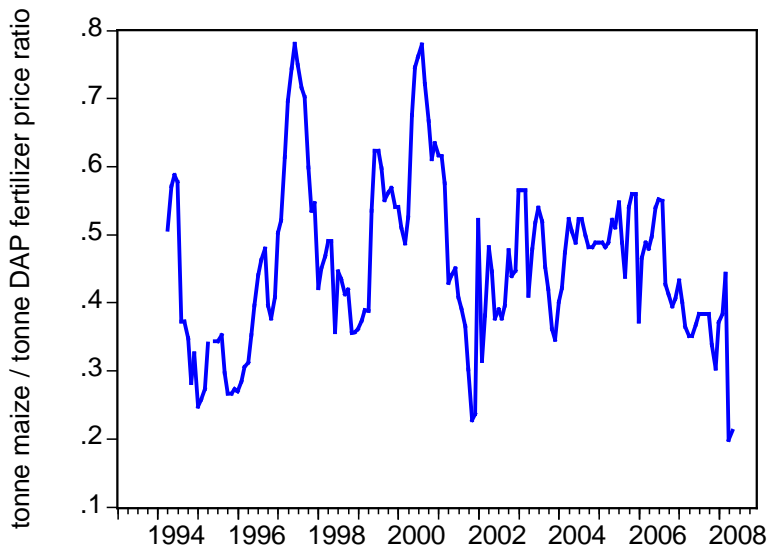
matter and moisture (Marenya and Barrett 2008). We also find that within a given agroecological zone, the decision of households to purchase fertilizer is slightly related to farm size and unrelated to household wealth. In relatively productive areas, the proportion of poorer and wealthier households 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% 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 that of fertilizer.

Figure 8. 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

2. *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.
3. *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.
4. *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 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

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

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.

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.

5. *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).
6. 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.

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 (Marenja and Barrett 2008; Kelly 2006). In some areas, improved management practices may have greater impact on yields than fertilizer alone (Haggblade and Tembo 2004).

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; 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. Even when subsidies are distributed through the private sector as in a well-designed voucher system, the degree to which vouchers are targeted to households least able to afford fertilizer determines the extent of crowding out of commercial fertilizer and hence the net contribution of the subsidy program to total fertilizer use (Ricker-Gilbert, Jayne and Chirwa, 2010).

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. Within the last two years the Government of Kenya's Kilimo Biashara scheme, through Equity Bank, has extended credit guarantees to farmers and traders letting them borrow at concessionary rates from commercial banks but backed by the state. The successes of such programs have not been studied in Kenya but earlier credit schemes of similar nature in the 1980s were abandoned when borrowers reneged on repayment and politically-connected individuals were favored in loan disbursements.

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 and its Kenya affiliate Agricultural Market Development Trust (AGMARK) agro-dealer training and credit program, and the organization of farmers into groups to facilitate their access to extension and credit services under the Kenya Market development Program (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.

6.0. References

- Allgood, J. H., and Kilungo, J. 1996. An appraisal of the fertilizer market in Kenya and recommendations for improving fertilizer use practices by smallholder farmers: A field report. Muscle Shoals, Ala., U.S.A.: International Fertilizer Development Center (IFDC).
- Ariga, J. M., Jayne, T. S., and Nyoro, J. K. 2006. Factors driving the growth in fertilizer consumption in Kenya, 1990–2005: Sustaining the momentum in Kenya and lessons for broader replicability in Sub-Saharan Africa. Working Paper 24. Tegemeo Institute. Nairobi, Kenya: Egerton University.
- Ariga, J. M., and Jayne, T. S. 2008. Maize trade and marketing policy interventions in Kenya. Paper presented at the Conference on Food Marketing and Trade Policies in Eastern and Southern Africa, EST Division, Food and Agriculture Organization of the United Nations (FAO), March 1, 2007, Rome.
- Ariga, J. M., Jayne, T. S., Kibaara, B., and Nyoro, J. K. 2008. Trends and patterns in fertilizer use by smallholder farmers in Kenya, 1997–2007. Working Paper 28. Tegemeo Institute. Nairobi, Kenya: Egerton University.
- Chapoto, A., and Jayne, T. S. 2009. Open versus closed maize border policy: A comparison of maize price instability in East and Southern Africa. International Development Working Paper. Department of Agricultural, Food, and Resource Economics, Michigan State University, East Lansing, Michigan, U.S.A.
- Dorward, A., Chirwa, E., Kelly, V., Jayne, T. S., Slater R., and Boughton D. 2008. Evaluation of the 2006/7 agricultural input supply programme, Malawi. Final report of the School of Oriental and African Studies (SOAS), Wadonda Consult, Michigan State University, and Overseas Development Institute (ODI), undertaken for the Ministry of Agriculture and Food Security, Government of Malawi.
- Food and Agriculture Organization.
<http://www.fao.org/economic/ess/countrystat/countrystathome/country-statistics/en/>
- Global Development Solutions. 2005. From laboratory to the dining table: Tracing the value chain of Kenyan maize. Prepared for the World Bank. Global Development Solutions, LLC, Reston, Virginia, U.S.A.

- Gitonga, K. T. 2004. Study on rationalization and harmonization of policies, regulations, procedures, grades, and standards in the fertilizer sub-sector in eastern Africa. Kenya Report. Kampala, Uganda: Eastern and Central Africa Program for Agricultural Policy Analysis (ECAPAPA).
- Haggblade, S., Tembo, G., and Donovan, C. 2004. Household level financial incentives to adoption of conservation agricultural technologies in Africa. Working Paper 9. Food Security Research Project, Lusaka, Zambia.
- IFDC. 2001. An assessment of fertilizer prices in Kenya and Uganda: Domestic prices vis-à-vis international market prices. International Center for Soil Fertility and Agricultural Development (IFDC), Muscle Shoals, Alabama, U.S.A. Photocopy.
- Jayne, T. S., and Argwings-Kodhek, G. 1997. Consumer response to maize market liberalization. *Food Policy* 22 (5): 447–458.
- Jayne, T. S., Yamano, T., Nyoro, J.K. 2003. Interlinked Credit and Farm Intensification: Evidence from Kenya
- Jayne, T. S., Myers, R. J., and Nyoro, J. K. 2008. The effects of government maize marketing policies on maize prices in Kenya. *Agricultural Economics* 38 (3): 313–325.
- Kelly, V. 2006. Factors affecting demand for fertilizer in Sub-Saharan Africa. *Agriculture and Rural Development Discussion Paper 23*. Washington, D.C.: World Bank.
- Kenya National Bureau of Statistics. 2009. Statistical Abstract and Economic Survey Highlights. Kenya National Bureau of Statistics (Government of Kenya), 2009
- Kimuyu, P. 1994. Evaluation of the USAID/Kenya fertilizer pricing and marketing reform program. Nairobi, Kenya: U.S. Agency for International Development/Kenya, Nairobi.
- Kodhek, G. 2004. Kenya agriculture sector brief. Food and Agriculture Organization of the United Nations (FAO. Rome
- Marenja, P. P., and Barrett, C. B. 2008. Soil quality and fertilizer use rates among smallholder farmers in western Kenya. Ithaca, N.Y., U.S.A.: Cornell University.
- Marenja, P. P., and Barrett, C. B. 2009. State-conditional fertilizer yield response on western Kenyan farms. *American Journal of Agricultural Economics* 91 (4): 991–1006.

- Mukumbu, M., and Jayne, T. S. 1994. Urban maize meal consumption patterns: Strategies for improving food access for vulnerable urban households in Kenya. Paper presented at the Symposium on Agricultural Policies and Food Security in Eastern Africa, May 19–20, 1994. Egerton University, Tegemeo Institute, Nairobi, Kenya.
- Ministry of Agriculture. 2008. Economic review of agriculture: 2008. Central Planning and Project Monitoring Unit. Nairobi, Kenya: Ministry of Agriculture.
- Nyoro, J., Kiiru, M.W., and Jayne, T.S.. 1999. Evolution of Kenya's Maize Marketing Systems in the Post Liberalization Era. Working Paper 2, Egerton University, Tegemeo Institute, Nairobi, Kenya.
- Nyoro, J., Kirimi, L., and Jayne, T. K. 2004. Competitiveness of Kenya and Ugandan maize production: Challenges for the future. Working Paper 10. Tegemeo Institute . Nairobi, Kenya: Egerton University.
- Ricker-Gilbert, J., Jayne T. K., and Chirwa, E. 2010. The Impact of Fertilizer Subsidies on Displacement & Total Fertilizer Use. Paper presented at the Agricultural Inputs Subsidy Program Workshop, Government of Malawi, Lilongwe, Malawi May 11, 2010.
- Tegemeo Institute. 2007. Enhancing market access and technology adoption among smallholders: A baseline report for evaluating agricultural interventions funded by the Rockefeller Foundation in Western Kenya. Report prepared for the Rockefeller Foundation by the Tegemeo Institute, Egerton University, Nairobi, Kenya.
- Wanzala, M., Jayne, T. S., and Staatz, J. 2002. Fertilizer markets and agricultural production incentives: Insights from Kenya. Working Paper 4. Tegemeo Institute. Nairobi, Kenya: Egerton University.
- World Bank. 2009. Still Standing: Kenya's Slow Recovery from a Quadruple Shock with a Special Focus on the Food Crisis. 2009. World Bank, Poverty Reduction and Economic Management Unit ,Africa Region, December 2009(Edition 1)
- Xu, Z., Burke, B., Jayne, T. S., and Govereh, J.. 2009. Do input subsidy programs "crowd in" or "crowd out" commercial market development? Modeling fertilizer demand in a two-channel marketing system. *Agricultural Economics* 40 (1): 79–94.