KENYA
FERTILIZER
ASSESSMENT

Kenya Fertilizer Assessment

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The African Fertilizer and Agribusiness Partnership

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June 2012

Acknowledgements

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Acronyms

AFAP	African Fertilizer and Agribusiness Partnership
AGMARK	Agricultural Market Development Trust
AGRA	Alliance for a Green Revolution in Africa
ASDS	Agricultural Sector Development Strategy
AU	African Union
CAADP	Comprehensive Africa Agriculture Development Program
CAN	Calcium Ammonium Nitrate
CERES	Crop Environment Resource Synthesis
c.i.f.	Cost, Insurance and Freight
CIP	Country Investment Plan
CFS	Container Freight Services
CSM	Cropping System Model
DAP	Diammonium Phosphate
DSSAT	Decision Support System for Agrotechnology Transfer
EAC	East African Community
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GIS	Geographic Information System
GoK	Government of Kenya
GVW	Gross Vehicular Weight
ha	hectare
ICASA	International Consortium for Agricultural Systems Applications
IFDC	International Fertilizer Development Center
ISFM	Integrated Soil Fertility Management
K	Potassium
KES	Kenyan Shilling
km	kilometer
km^2	square kilometer
KPA	Kenya Port Authority
MAP	Monoammonium Phosphate
MDG	Millennium Development Goal
MDS	Minimum Data Set
mt	metric ton
MTIP	Medium Term Investment Plan
N	Nitrogen

NAAIAP	National Accelerated Agricultural Input Access Program
NCPB	National Cereals and Produce Board
NEPAD	New Partnership for Africa's Development
P	Phosphorus
SSA	Sub-Saharan Africa
SWS	Single Window System
USAID	United States Agency for International Development

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Executive Summary

The purpose of this assessment is to estimate fertilizer required to achieve the agricultural growth objectives articulated in the country investment plan and analyze a range of potential policy options to ensure the supply of this fertilizer. A number of institutions, both local and international,[1] are involved in the implementation of projects and programs aimed at improving food security in Sub-Saharan Africa (SSA). Typically within the Comprehensive Africa Agriculture Development Program (CAADP) framework, these activities assume that yields and production will increase, driven by the correct use of quality inputs and therefore higher productivity. A key constraint of these assumptions is the limited agricultural data and market information available for making the necessary decisions to achieve these goals. Further, although some of these players may be working in the same geographic areas or toward similar goals, a lack of information flow hinders coordination of their efforts and blocks the creation and capture of synergies.

It is therefore important to estimate the gaps between expected results and the current reality of input use (optimal versus real), the policy constraints being faced and where information gaps hinder decision-making, and then to gather and analyze relevant information to fill these gaps. This study reveals that, under appropriate assumptions, Kenyan fertilizer consumption will need to nearly double from 0.5 to 0.9 million metric tons (mt) to meet the agricultural growth targets set in the CAADP country investment plans. This increased fertilizer consumption has implications for development of each node of the fertilizer value chain as each evolves to meet the pressure resulting from these increased volumes.

On the supply side, the port of entry must handle significantly more cargo and will require either increased efficiency of existing operations, expansion of its infrastructure to handle

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[1] Such institutions and partners include the African Union (AU/NEPAD/CAADP), the Alliance for a Green Revolution in Africa (AGRA), the United States Agency for International Development (USAID), AGMARK and the International Fertilizer Development Center (IFDC), among others; the African Fertilizer and Agribusiness Partnership (AFAP) is a product of partnerships between these institutions.

the increase in cargo, or both. However, this study does not detail the exact nature of port modifications required. Such information will require a detailed separate study of port operations by logistics experts. As a general observation, it may be possible for the port to increase its efficiency without changing the 'hard' infrastructure, by engaging additional labor to compensate for scarce equipment, increasing its hours of operation and improving its online cargo clearing system to reduce delays. The inland transport system from port warehouses to various destinations will require increased private sector investment to handle the storage, handling and movement of the cargo. Increased storage facilities will be required both at the port and inland locations with the expectation that these will be funded mostly by the private sector. The trucking system providing much of the inland transport and storage will require significant adjustments to meet these requirements as well. While there are some opportunities for increased efficiencies (e.g., use of modern inventory control systems, 24-hour staffing at warehouses during peak season, identification of backhauls), additional trucks and improved infrastructure will be required. Finally, on the supply side, a private sector-driven agro-dealer network that supplies inputs to farmers at the local level in a timely manner is typically the key to a functioning supply chain that identifies and responds directly to farmers' needs. On the demand side, the challenges are equal or greater. Farmers must be motivated to adopt intensive agricultural practices and fertilizer rates that promote maximum economic yield for the crop of interest. The primary incentive will come from farmers' access to viable markets that can absorb the production. Development of output markets is crucial because it produces the economic benefits that allow farmers to increase the use of mineral and organic fertilizers, as well as complementary inputs such as improved seeds, farm equipment and irrigation. In support of output market development, farmers must be exposed to the benefits of best management practices and use of fertilizer. These informative trainings provided by either public (Ministry of Agriculture) or private sector-based extension must be accompanied by farmers' increased knowledge of tools (e.g., soil testing) that enable them to identify the most efficient fertilizer products and application rates tailored to both crop and soil conditions in order to maximize economic returns.

Some factors that cut across the whole value chain include financial constraints and policy interventions that negatively affect private sector investments in the industry. Since

agricultural investments are subject to higher risk compared to industrial ventures, banks are more reluctant to finance this sector. A number of approaches show promise for generating investment funds, including arrangements in which public-private partnerships share the risks and cushion banks from losses resulting from defaults. Another approach employs peer-group pressure by lending to a group of farmers or other stakeholders that are self-selected and act as each other's guarantee in case of defaults, therefore ensuring that the lender will be paid. This is an area in which AFAP can play an important role.

An important overall aspect that cuts across the chain is the existence of an enabling environment for businesses to increase their investment without uncertainty or increased risks. Uncertainty usually comes in the form of state intervention in markets. The government's participation in a subsidy program that targets the same farmers as the private traders, but at subsidized prices, is clearly not conducive to businesses and private sector development.

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1.0 Contribution of Agriculture to GDP

The Kenya agricultural sector is an important segment of the national economy generating employment, outputs and incomes. Currently, agriculture directly represents 26 percent of the gross domestic product (GDP) and another 25 percent indirectly through its linkages with manufacturing, distribution and service industries (GoK, 2010, ASDS). It accounts for 65 percent of national exports and provides 70 percent of informal and approximately 18 percent of formal employment.

Approximately 80 percent of the population, consisting of 3.5 million farm-family households, lives in rural areas and owns an average of 4 hectares (ha) of land. Seventy percent of cultivated land is cropped by smallholder farmers, 42 percent of whom are net buyers of maize (i.e., they buy more than they sell to the market). Twenty percent are self-sufficient while 38 percent are net sellers, selling more than they buy from the markets (Nyoro, 2007).

Food crops (maize, sorghum, millet, wheat, etc.) make up 34 percent of agricultural GDP. Population pressure, poor weather and low input use have led to an increased focus on agriculture in order to raise production and contribute to increased access to food. Looking at the overall agricultural sector, Kenya has not met the minimum budget allocation of 10 percent of GDP as recommended in the Comprehensive Africa Agriculture Development Program (CAADP) Compact. Due to the significant contribution of the agricultural sector to the overall economic growth, it is important to invest commensurately in order to meet the targeted growth rate of 6 percent per year. The Government of Kenya (GoK) has embarked on such a plan focusing on raising investments to spur agricultural growth.

1.1 Agricultural Investment Priorities and Targets

Kenya's Medium Term Investment Plan (MTIP, 2010-2015) identifies proposed interventions to achieve the objectives of the Vision 2030, the Agricultural Sector Development Strategy (GoK, 2010, ASDS) and the CAADP goals of attaining robust sector growth and

reduction of food insecurity sufficient to meet the Millennium Development Goal (MDG) for poverty and hunger in Kenya. The overall goal is to achieve an average growth rate of 7 percent per year for the agricultural sector in order to reduce unemployment and poverty by investing US $3 billion in the following broad areas:

1. Increase productivity, commercialization and competitiveness of agricultural commodities and enterprises (36 percent).

2. Divest from state agencies and encourage private sector participation (13 percent).

3. Promote land and natural resources management (42 percent). A key thrust of MTIP, as reflected in the budget allocations, is to increase the productivity of Kenya's arid and semi-arid lands.

4. Streamline services such as in research, extension, training and regulatory institutions to make them effective and efficient (aligned to CAADP Pillar 4).

5. Strengthen market access and trade by developing farmer organizations and agribusinesses (aligned to CAADP Pillar 2).

Of the US $3 billion investment budget, the agricultural investments will be funded by development partners (31 percent), government (65 percent) and the private sector (1 percent) (GoK, 2010). As of 2010, the projected government funding under this framework was 4.6 percent of the national budget, which is below the 10 percent target recommended under CAADP (African Union, 2010). The CAADP agenda is designed to work with African states toward increasing agricultural production and lowering poverty rates to meet MDGs. To achieve this, states are encouraged to raise investments in agriculture (to at least 10 percent of the national budget) and target agricultural growth rates of at least 6 percent.

The following are the targets to be achieved by 2015 for the agricultural sector as indicated in the MTIP plan (Table 1).

Table 1. Agricultural Growth Targets in MTIP (2010-2015)

Indicator	Target
GDP growth rate (%)	10
Agricultural growth rate (%)	*7[a]*
Poverty rate – MDG 1 to reduce number below the poverty line (%)	25
Reduction in food insecurity: This surpasses MDG goal (%)	30
Divestiture in state corporations dealing with production, processing and marketing	All
Reforming and streamlining agricultural services	All

a. This aggregate rate is translated into detailed crop yield targets as explained in discussion under crop production.

Source: Government of Kenya. 2010. Agricultural Sector Development Strategy (ASDS)/Medium Term Investment Plan (MTIP).

Low productivity in the agricultural sector is a key challenge to increasing overall production in the sector. While low productivity in the agricultural sector can be attributed to a broad range of factors (limited adoption of improved technologies including agro-inputs, bad weather, poor farm management skills, policy, etc.), the consensus from a number of stakeholders is that using integrated soil fertility management (ISFM) systems to overcome low production is an important component of any agricultural intensification approach. Use of inorganic fertilizer is central to this approach and a key element in a number of policy efforts in Africa that seek to promote fertilizer use through subsidies and other investments to raise agricultural production. Though there are no comprehensive studies on the yield response to fertilizer for various crops in Africa, Figure 1 shows that there is a positive relationship between total fertilizer use and total cereal production in Kenya.
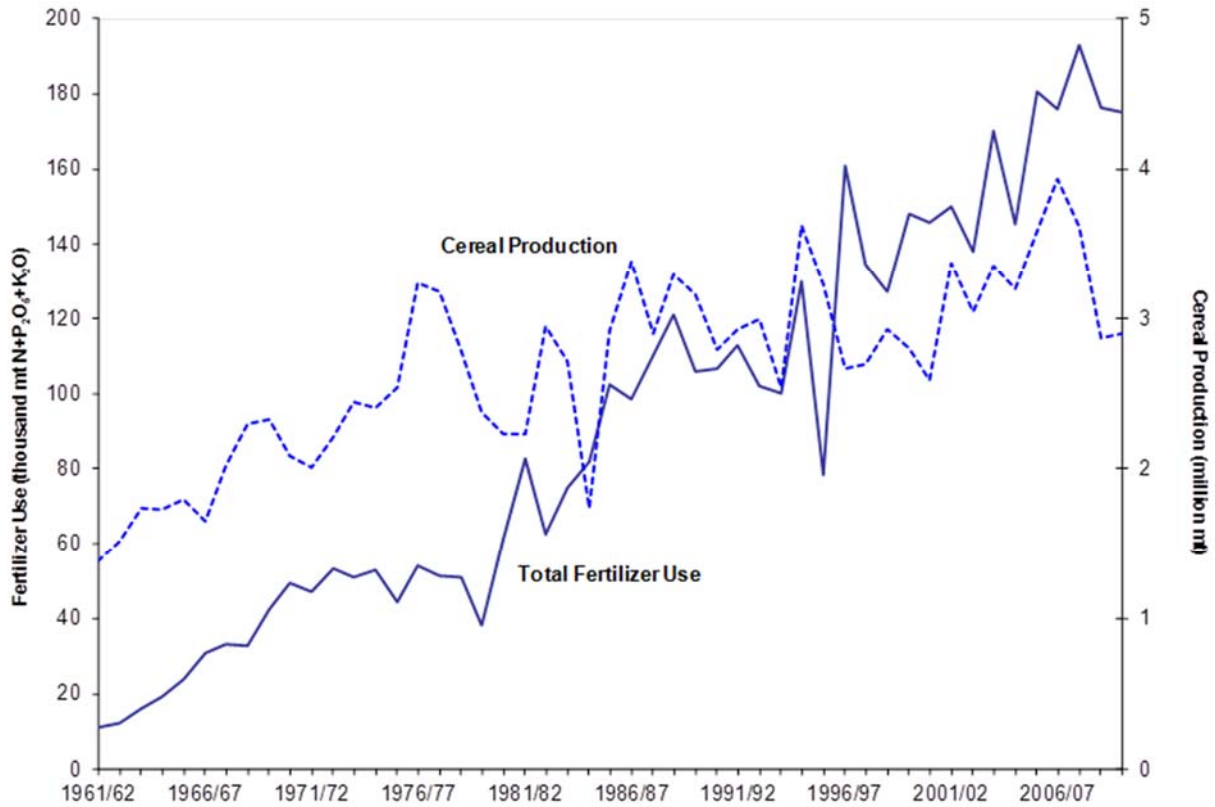
Figure 1. Kenya: Total Cereal Production and Total Fertilizer Use, 1961/62-2009/10

This study's main objective is to estimate fertilizer requirements that will meet the agricultural growth targets as articulated in the Kenya national development plans under the CAADP compact agenda. These estimates will have implications for tackling existing challenges in fertilizer value chains in order to meet the estimated increased volumes of fertilizer. The study also looks at the effect of policy on private sector investments, investments that will be required to support increased fertilizer use. The Kenya agricultural investment plan targets a growth rate of 40 percent in yields by 2015. This study provides insights into how much fertilizer will be required to achieve these production targets in order to aid planning and provide important information to stakeholders.

2.0 The Conceptual Approach: A Framework for Linking Inputs to Outputs

This study is based on a framework that captures some aspects of general and partial equilibrium models and subsector analysis. For agricultural growth to take place, a complex number of elements have to coalesce and markets need to clear (i.e., demand equates to supply). This study also utilizes value chain analysis to understand the linkages between input and output markets. This approach avoids complex modeling and takes a generalized approach in part due to data and time limitations. To address the question of procuring and distributing enough fertilizer to meet the CAADP targets, a value chain framework was adopted as the core methodology.

There is an important link between output and input markets, with price signals influencing farmers' decisions to invest in their soil and thus their likelihood to invest in fertilizers. An analysis of the amount of fertilizer needed and the capacity of the existing fertilizer distribution system to supply those needs requires an assessment of the nodes, associated stakeholders within each node and commodity flows along two interlinked value chains: (1) the input (fertilizer) value chain, spanning fertilizer production, trade and consumption by farmers[2] and (2) the output value chain, spanning crop production by farmers, transformation and marketing and consumption by consumers, either domestic or external. Figure 2 provides a simplified illustration of what are, in reality, complex interactions among a vast array of actors along this set of dual, integrated value chains.
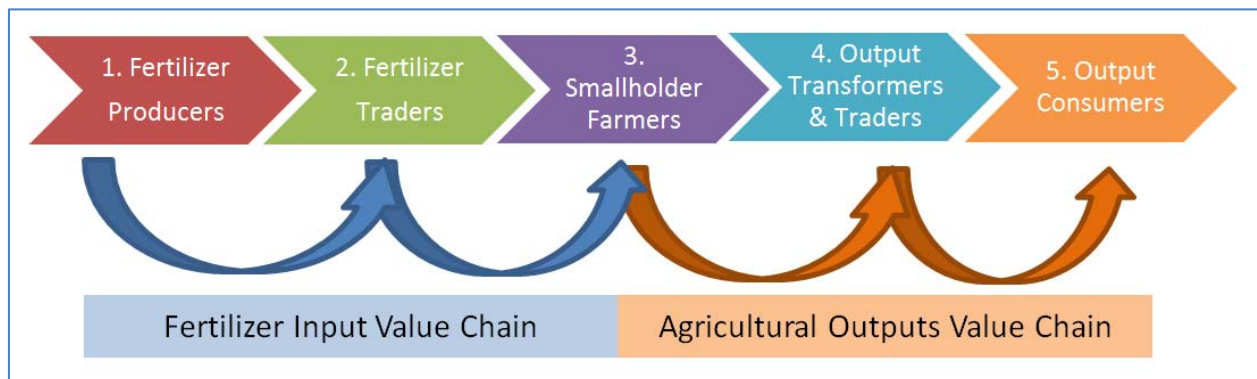
Figure 2. The Double Value Chain

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[2] Although we present the value chain for mineral fertilizers, we acknowledge that their effectiveness is determined by interactions with other inputs including organic fertilizers, improved seed varieties, water and traction equipment and management skills, i.e., the ISFM package.

For the purposes of this analysis, we start at the right-hand node (5) and work left, extending the classic fork to farm analysis beyond the smallholder farmer (3), further down the soil nutrients value chain to the different types of traders (2) and fertilizer producers (1). To analyze how much nutrient input is needed in order to reach the CAADP output targets and what measures are needed to get that quantity through the existing fertilizer distribution system, the following simplifying assumptions were made:

1. The CAADP crop production targets accurately reflect the quantities needed to achieve the domestic contribution to national food security, agricultural growth targets, national storage and transformation capacity, people's food preferences, etc. Note that output produced at farm level is higher than consumption at Node 5; the latter does not account for post-harvest losses, which can be significant.

2. Markets will be well-developed in order to absorb the increased levels of crop production. This output will either be domestically consumed or exported. The analysis also assumes that the agents involved in Node 4 have the capacity to store, process, transport and market the increased output.

3. Since prices will vary depending on the levels of supply and demand, the analysis assumes that the fertilizer quantities estimated by this study will remain profitable so that farmers have the incentive to use. Specifically, it is assumed that even if crop prices fall (possibly driven down by increased supply), either the price of fertilizer or the returns to fertilizer will compensate for the reduced price. Otherwise, farmers will find it unprofitable to use fertilizers.

4. Given that Kenya does not currently have the capacity to produce significant quantities of mineral fertilizers, the analysis assumes that all fertilizers (or their components) are imported (Node 2) and that Kenya is a price taker and thus does not influence international prices.

These assumptions allow for simplification of the analysis of the output value chain and an increased focus on the input value chain to address the following question: *What quantities of fertilizer are required to produce (Node 3) economically viable crop outputs targeted in the national CAADP strategy (Node 5)?*

Ideally, this estimate is generated for each crop using a crop simulation model that brings together the best available information on agronomic and climatic conditions with information on crop areas, production and yields to provide estimates of the levels of nitrogen (N), phosphorus (P) and potassium (K) needed to achieve the economically viable target for each crop in the CAADP strategy. The results of the analysis are aggregated to the zonal and national level. Details on the specifics of this study in terms of the agronomic model, the data and the analysis are presented in Section 3.0.

Next, the study assesses the capacity of the current fertilizer system (Node 2) to procure, import, store, transport and distribute that quantity to farmers (Node 3) in time for the growing season. We ask the question: *What investments and policy changes will be necessary to ensure the smooth flow of increased quantities of fertilizer through the chain to smallholders?*

The study models the fertilizer distribution system depicted by zeroing in on the numerous sub-nodes and players involved in what is globally summarized as 'fertilizer traders' in Node 2 of Figure 2. The key steps and players include:

1. *Importation* – Importers, bankers, shipping companies, port service providers (labor and equipment), revenue authorities, quality inspectors, transporters and blending and bagging agents.
2. *Wholesale Distribution* – Importers or independent wholesalers, bankers, quality inspectors and transporters.
3. *Retail Distribution* – Agro-dealers/stockists and financial service providers.
4. *Consumers* – Cereal and cash crop farmers, both large and small.

The assessment looks at the possible actions of value chain participants in light of increased fertilizer use and the role of the support structure in the value or supply chain, including the effects of policy on value chain players. For each node, we examine the physical, human, institutional and financial capacity of these players and identify investments and policy changes needed to ensure the right quantities of the nutrients flow on time through the supply chain to the variety of different end users. Additional details on the supply chain framework, the data and the analysis are presented in the sections that follow.

In summary, the study assumes some relationship between crop production and fertilizer use, generating an equivalent quantity of fertilizer to satisfy the level of agricultural production; it then uses value chain analysis to identify what needs to change to accommodate the increase in fertilizer consumption throughout the chain. The study uses simple tabular, graphic and descriptive analysis to capture the results.

3.0 Capturing Agronomic Aspects: Description of the DSSAT Model

The Decision Support System for Agrotechnology Transfer (DSSAT) model plays an important role in generating the fertilizer estimates needed to meet the CAADP crop targets. DSSAT[3] evaluates the impact of technology adoption and environmental shocks over a range of crop production outcomes. The model combines crop, soil and weather databases with over 28 crop[4] simulation models to simulate multi-year outcomes of various crop management strategies on crop growth, development and yields. It allows users to appraise new crops, products and practices for adoption.

DSSAT has been applied for more than 20 years by researchers, educators, consultants, extension agents, growers and policy- and decision-makers in over 100 countries worldwide. Using this tool, these users ask 'what if' questions by conducting simulation experiments on a computer rather than in the field. The Cropping System Model (CSM) incorporates components from different disciplines which can be modified depending on the particular needs and context. DSSAT is structured to compare the simulated outputs from the crop model with real-world observations, thus allowing validation and improved calibration.

The Minimum Data Set (MDS) for DSSAT includes weather (site-specific daily solar radiation; minimum and maximum temperatures and rainfall), soil (depth; percent sand, silt and

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[3] DSSAT was developed through collaboration among scientists at the University of Florida, University of Georgia, University of Guelph, University of Hawaii, IFDC, USDA-Agricultural Research Service, Universidad Politecnica de Madrid, Washington State University, and other scientists associated with the International Consortium for Agricultural Systems Applications (ICASA) (Hoogenboom et al., 2010; Jones et al., 2003).
[4] These crop models have evolved from previous CROPGRO and Crop Environment Resource Synthesis (CERES) models.

clay; carbon; pH; density) and crop management information (planting date; density and depth; row spacing; crop variety).

3.1 Applying DSSAT to Estimate Fertilizer Requirements

To estimate fertilizer recommendations for this study, the DSSAT model was used to generate the N, P and K requirements to increase the yields of the priority CAADP crops from their current levels to their economically viable levels, where the latter is defined as a production level that is profitable to farmers.[5]

The MDS requirements are quite extensive, and a consistent set of reasonably up-to-date figures are seldom available in the African context. Furthermore, to the extent that such data are available, it takes considerable time and expertise to attribute the data to mapping units, which do not align with more traditional agro-climatological or administrative zones.

For the analysis, the following data and information were used:

1. A single improved seed variety for all locations.
2. A 30-minute by 30-minute mapping unit (polygons) representing a unique climate and combination of soils. This grid is equivalent to 55 square kilometers (km^2) on the ground, or 302,500 ha. For Sub-Saharan Africa (SSA), this has been derived from the World Harmonized Soil Database to generate the proportion of a given soil within a mapping unit. Available digitized soil databases were utilized for this estimation. For the rainfed potential yield simulation (see Figure 3), soil data from the HarvestChoice project were used. Each of the mapping units (polygons) contains from one to 15 soil profiles.
3. Unique combinations of soils and weather inputs that link crop simulation models to a geographic information system (GIS). Weather data are derived from many sources, but MarkSim was used to develop the work presented in Figure 3. This is a tool created to generate simulated weather data for crop modeling and risk assessment. Climate files

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[5] It is technically feasible to integrate the CAADP yield targets into the DSSAT model but would take considerable effort to recalibrate the model. The current formulation somewhat overshoots the CAADP target but maintains basic conditions of economic viability. A qualitatively determined correction coefficient was used to adjust the DSSAT fertilizer estimates downward to better align with the CAADP targets.

generated spatially for each mapping unit are then used by the crop simulation models in DSSAT to generate daily weather data as inputs to the model.

4. Predicting grain yields under varying management conditions ranging from rainfed potential yields to yields constrained by N, P and K status. The rainfed potential yield is dependent on variety, rainfall, solar radiation, temperature and soil physical attributes. Soil fertility, soil toxicity (pH, aluminum status, etc.), pest and disease control and other management conditions are assumed to be at ideal conditions for non-stressed crop growth.

5. Comparing simulated yields obtained under a wide range of management conditions with observed yields. The reliability of fertilizer recommendations will be dependent on thorough validation of the model's prediction with observations from research stations, district-level yields and unique input data (soils and weather) from the districts (locations).

6. Collating economics data for inputs and produce (grains and stover).

7. Using the validated/calibrated models, long-term weather data and economics data to determine maximum net returns and efficient (optimum) N, P and K fertilizer recommendations.

8. The N, P and K recommendations can also be determined based on target yields, which may be lower than the optimum yields described above (7).

To generate recommendations for a given country, the experimental files are generated for each polygon (mapping unit), where a base experiment (e.g., N:P:K response) is used as a template for testing every combination of soil profile and climate file. All biophysical output can be mapped, along with the most economically efficient treatment (created by a net return analysis coupled with Mean-Gini analysis), driven by a localized cost-price file. The efficient treatments (recommendations) for each polygon are based on the dominant soil in terms of total production. All other biophysical variables, such as optimal planting date, grain yield, nutrient uptake, etc., can be given as a weighted mean of the soils present in the polygon. Apparent discrepancies may appear in some mapping units between recommendations (based on dominant soil) and yields (based on weighted mean), if the dominant soil represents a small area (< 30 percent). A ground-truth procedure is thus critical to ensure that constraints in the smallholder farms and model assumptions are valid.

Figure 3 portrays the results from rainfed potential yield driven by climatic factors, soil water-holding properties, planting date and variety for maize planted in early March. All other soil fertility status and management conditions were assumed to be non-limiting, and the potential yields range from 0-500 to 10,000-12,000 kg/ha. These results already indicate areas that are not suitable for maize production and areas with low yield potential that should have lower fertilizer recommendation rates than regions with higher yield potential. Similar information can be generated for September planting and for crops such as millet, sorghum, rice and beans.

3.2 Data Collection Methodology

Two methods were applied in collecting data and information for this study: (1) secondary data and (2) empirical data collection through interviews with key players in the government and private sector (Ministry of Agriculture, importers, CAADP focal points, research institutes, etc.). The study derived most of the data from existing or secondary literature or reports on fertilizer issues in Kenya by various organizations and research institutes, including IFDC. This data exercise covered several areas:

- National country investment plan (CIP) targets from country development plans and CAADP documents.
- Agricultural production data: crops, area cultivated, production.
- Fertilizer: imports, consumption, application rates per hectare, percentage of farmers applying by crop and region.
- Agro-ecological zone data: weather, soils.

There is a significant amount of data that is not available from literature sources, which therefore required the study team to travel to the countries and meet with key stakeholder representatives to collect necessary information and opinions from industry players.
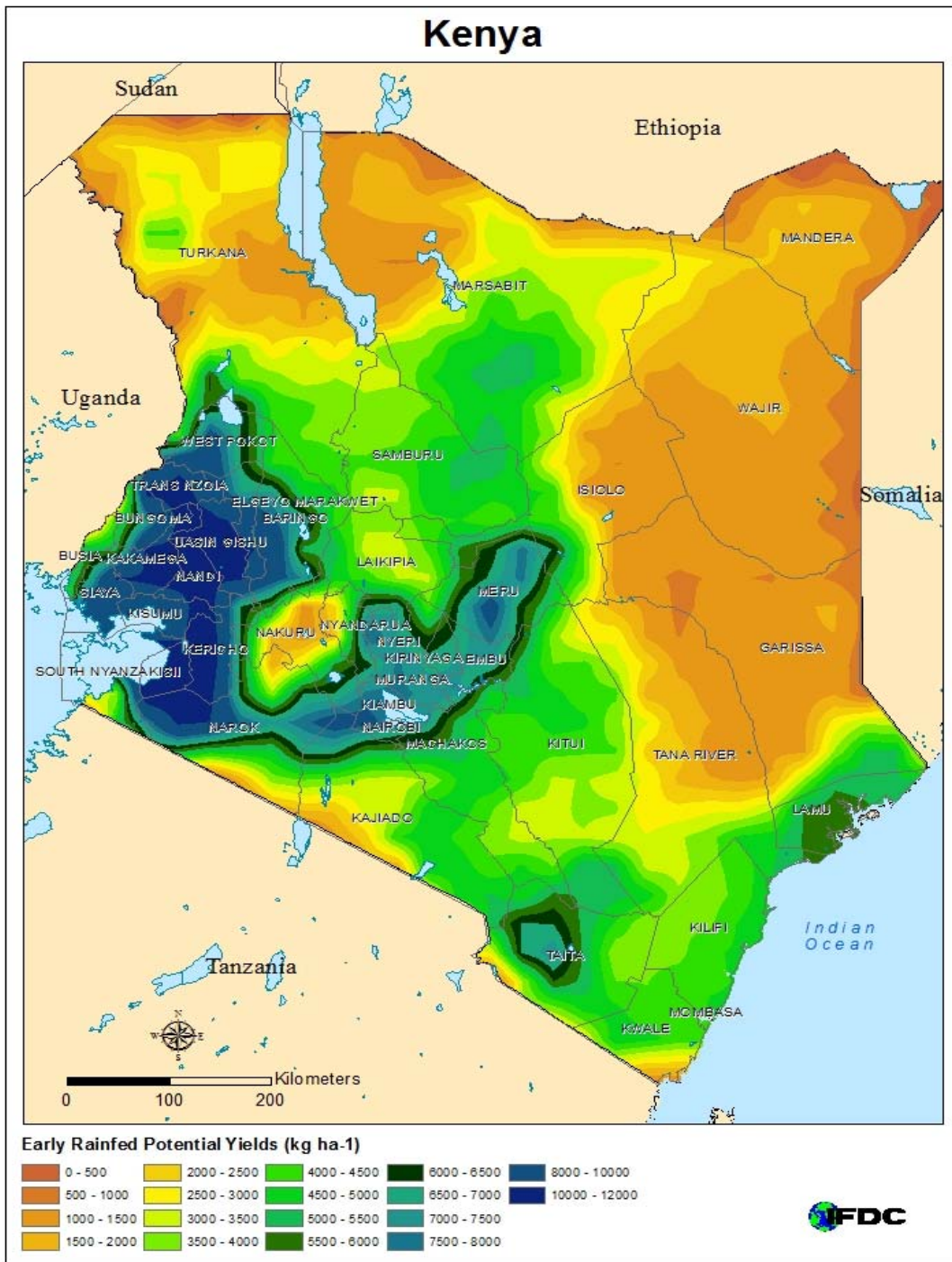
Figure 3. Mean Potential Rainfed Production (kg/ha) of Maize in Kenya for Early Planting Date (March-April)

Some desired data were not available or accessible, including:

1. Disaggregated data on application rates per hectare by crop.

2. Percentage of farmers using fertilizer by crop and region.

3. Quantity of fertilizer products for each crop; fertilizer consumption in many countries (including Kenya) is reported at the national level and with quantities not being allocated by crops or regions.

4. Soil profiles are outdated (last updated in the 1970s) and not readily available in digital format.

3.3 Description of Data

The following section provides information collected on area of arable land, its allocation to different activities, crop-specific areas and production and yields across different agro-ecological zones.

3.3.1 Allocation of Kenya's Arable Land and Area Under Crops

Fifty percent of Kenya's population lives in areas that receive relatively high rainfall, which represent 11 percent of the country's land area. In most of these areas, population pressure is resulting in small plots that are unsustainable even for subsistence farming. Kenya's landmass covers 59.7 million ha, consisting of 1.1 million ha of lakes, rivers and other water features. Of the land area, 48.4 million ha are classified as arid and semi-arid lands, of which 9.3 million ha (16 percent) are arable. The arable land is classified further in Table 2.

Table 2. Arable Land Resource Use in Kenya

Category	Million Hectares
Cropland	2.9
Grazing	2.8
Forest	2.0
Other – parks, cities, roads, etc.	1.6

Source: Agricultural Sector Development Strategy 2010-2020 (Government of Kenya).

Of the 9.3 million ha of arable land (Table 2), more than 4.1 million ha[6] are planted with crops (Table 3). This is more than the area allocated to crops in Table 2, which implies that some of the grazing and/or forest land may be under crops in some places. However, this does not mean that all cropland in Table 2 is utilized. Figure 4 illustrates the spatial location of the provincial administrative units used in the tables that follow.

Table 3. Area Under Select Crops by Region ('000 ha)

Province	Maize	Beans[a]	Sorghum	Coffee & Tea	Wheat	Irish Potatoes	Millet	Cassava	Rice
NE	5		3						
Coast	69	3	3				1	22	3
Central	115	106	1		9	54		1	10
Nyanza	245	155	62			2		6	5
Western	192	118	24			5	5	24	1
Eastern	493	26	120		15	17	65	8	
R Valley	542	281	14		132	54	19	1	
Total	1,661	689	227	310	156	132	90	62	19

a. As explained in the footnote, bean area may be overestimated due to intercropping with maize. These estimates are based on the average for the period 2000-2006. Total area under all crops is approximately 4.1 million ha.

Note: Numbers may not add due to rounding.

Source: Ministry of Agriculture National and Provincial Reports, Tea Board of Kenya.

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[6] It is important to note that over 90 percent of smallholder maize growers intercrop (mix crop) maize with beans, peas or other minor crops on the same plots (Figure 5 reflects how maize and bean areas dovetail each other). Therefore, some of the area under beans may be double-counted under maize. The combined area under beans and peas is approximately 1.2 million ha. Assuming that 1 million of this 1.2 million ha is intercropped with maize or other crops, then the effective area under crops is 3.1 million, which is slightly above the available cropland area of 2.9 million ha (Table 2).

Figure 4. Map of Kenya Showing Administrative Provinces

The information on area under crops *vis-a-vis* available national land resources (Table 3) and Figure 5 indicate that any short- to medium-term increases in production will be driven by input intensification rather than expansion in cultivated area. There is limited land for expansion unless the less productive land areas are enhanced through soil improvement measures and irrigation infrastructure, some of which is planned under the current MTIP.
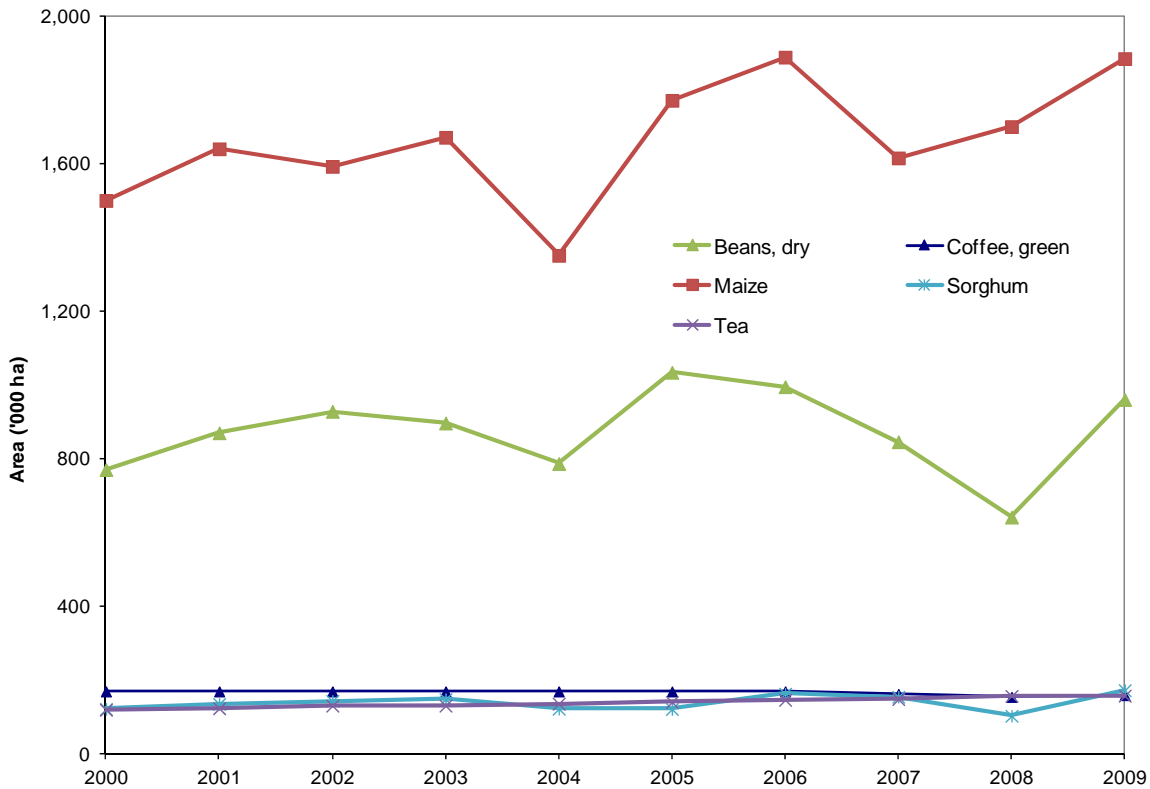
Figure 5. Area Under Top Five Crops Based on Average Area for the 2000-2009 Period

Maize is grown in all agro-climatic zones but cash crops like tea and coffee are grown primarily in the central and western highland zones. Sorghum, millet and, to some extent, cassava are mostly grown in the drier agro-ecological zone of Eastern and Nyanza provinces.

The largest area is under maize (1.6 million ha), followed by beans (approximately 0.7 million ha), with coffee, tea and sorghum together accounting for slightly more than 0.5 million ha. The area under maize accounts for approximately 50 percent of total area under crops (Table 3) while the cereal crop group (including maize) accounts for over 70 percent of the area.

Area under tea, coffee and sorghum shows no significant variation over time, remaining relatively constant. For maize and beans, there have been some movements indicating some slight increase in area for maize. Maize and beans are closely related in area dynamics because they are intercropped in most parts of the country.

3.3.2 Production and Yield Trends for Crops

For the industrial crops, tea and sugarcane have increased production (Table 4) by 4 percent, on average, while coffee has declined in recent years. Maize and wheat production has increased at a moderate rate of 2-3 percent per year. The largest increase in production trends has been for cassava, sorghum, millet and bananas, with a combined average of over 10 percent.

Table 4. Production Trends for Food and Cash Crops ('000 mt)

	2004	2005	2006	2007	2008	2009	Mean % Growth
Food Crops							
Maize	2,607	2,906	3,247	2,929	2,367	2,439	2%
Wheat	379	369	329	322	337	219	3%
Sorghum	70	150	131	147	54	99	16%
Millet	50	53	79	120	38	54	12%
Cassava	643	348	657	398	751	820	19%
Rice, paddy	49	63	65	47	22	42	4%
Potatoes	1,084	980	784	850	600	400	-1%
Sweet potatoes	571	231	725	812	895	931	22%
Bananas	600	600	619	593	843	843	6%
Beans, dry	278	382	532	430	265	465	10%
Cash Crops							
Tea	325	329	311	370	346	314	4%
Coffee, green	48	45	48	53	42	54	-4%
Sugarcane	4,661	4,801	4,933	5,204	5,112	5,611	4%

Source: FAO data.

Typically, crop yields associated with smallholder farms are comparatively lower than for commercial farms. Smallholder maize yields range from 0.5 to 1.5 metric tons (mt)/ha due to no or low fertilizer use, poor weed control and lack of quality seeds. Under appropriate agronomic practices and improved technologies, yields are significantly higher at 3.0-6.0 mt/ha.
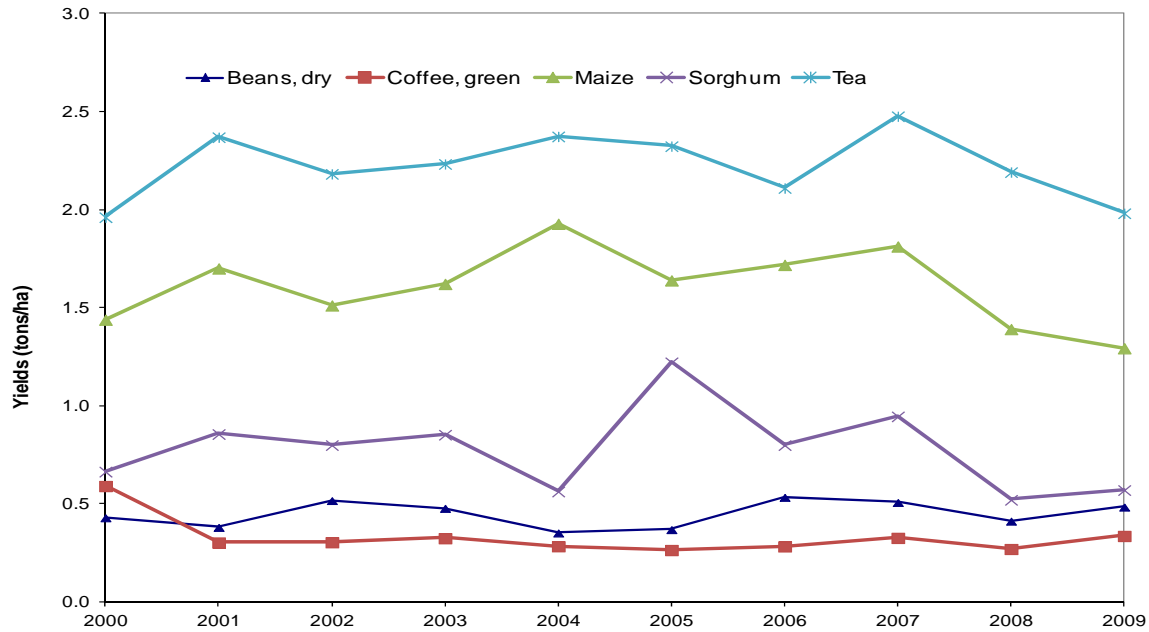
Figure 6. Yields per Hectare for Top Five Crops Based on Average Area for the 2000-2009 Period

Maize yields are fairly constant over time but show some signs of decline in recent years that may be attributed to less favorable weather patterns, declining soil fertility and market conditions. Figure 7 exhibits yield variability for maize across different provinces in Kenya with the high potential regions in the west and higher yields in Rift Valley.
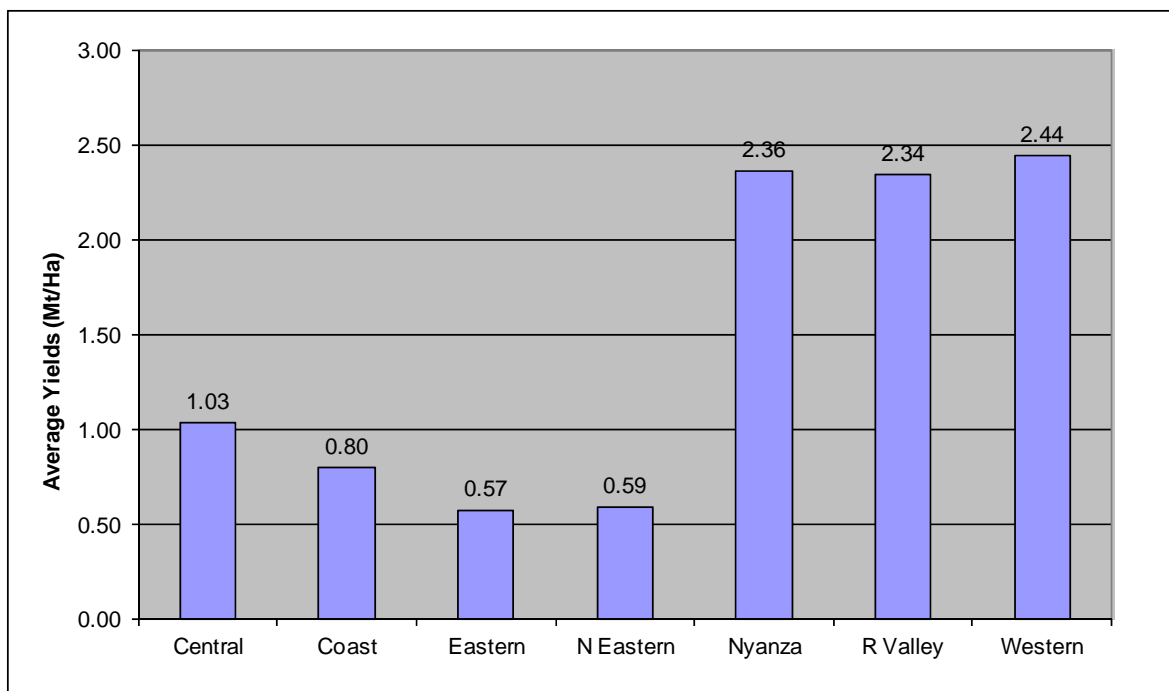
Source: FAO data.

Figure 7. Average Yields for Maize in Different Provinces (mt/ha)

Table 5 shows the current and target yields for some crops under the national development plans with a target of 7 percent annual agricultural growth. It provides a comparison of CAADP and current production for different crops. The maize gap between the current production and the target production is estimated at 1 million mt.

Table 5. Production Gap for Major Crops: Current and MTIP Targets

	Yield		
	Current	MTIP Target[a]	Production Gap
	(mt/ha)		(million mt)
Maize	1.6	2.2	1.00
Sorghum	0.8	1.1	0.07
Wheat	2.2	3.1	0.12
Millet	0.6	0.8	0.02
Cassava	9.2	12.9	0.23
Rice, paddy	3	4.2	0.02
Potatoes	7	9.8	0.37
Beans, dry	0.4	0.6	0.17
Coffee, green	0.3	0.4	0.02
Tea	2.2	3.1	0.14
Sweet potatoes	10.4	14.6	0.33
Sugarcane	83.9	117.5	2.22
Bananas	15.8	22.1	0.22

a. This is based on MTIP target of 7 percent agricultural growth (and 40 percent increase in crop yields within the period)

Source: Ministry of Agriculture, FAO data and authors' estimates.

4.0 Kenya's Fertilizer Market: Evolution and Recent Developments

4.1 Overview of Fertilizer Consumption Patterns

FAO data indicate that SSA produces 0.1 percent of the world's fertilizer nutrients, consumes 0.9 percent, accounts for 2.2 percent of imports and 0.2 percent of global exports. The small share of global market is a reflection of decreasing soil fertility, low application rates, unfavorable input-output price ratios and constraints to input and output market development (Gregory and Bumb, 2006; Ariga and Jayne, 2009).

Kenya is a rapidly growing market for fertilizer with transit fertilizer through Mombasa Port going to other East African Community (EAC) countries. Like most SSA countries, Kenya depends on the international markets for its fertilizers as local production is non-existent or limited. There is some local blending by Mea Ltd. and Athi River Mining Ltd., which formulate blends for various crops and soils. There has been considerable interest and some efforts by

several governments to encourage local or regional manufacturing in hopes of improving accessibility and productivity while simultaneously reducing pricing by avoiding international price fluctuations and saving on foreign exchange. Even though Tanzania, Rwanda and Uganda have some phosphate and/or natural gas resources, the regional fertilizer market is not sufficient to justify investment for a production facility, in part because exports of locally produced fertilizers cannot compete with cheaper Arab Gulf products at current prices (Gregory and Bumb, 2006). However, detailed feasibility studies that consider all aspects of potential manufacturing capabilities in the region are limited.

Currently, the larger share of fertilizer products sold is purchased by commercial farmers who have markets for their farm outputs rather than smallholder farmers, many of whom are engaged in subsistence production. However, 70 percent of Kenya's cultivated land is occupied by non-commercial, smallholder farmers growing crops primarily to feed their families and only participating in the output market when they have excess production. Nationwide farm surveys indicate that more than 40 percent of fertilizer used is applied on maize fields (Ariga et al., 2008). The fertilizer products applied at planting include diammonium phosphate (DAP), monoammonium phosphate (MAP) and NPKs (mainly 23:23:0 and 20:20:0), while calcium ammonium nitrate (CAN) and urea are typically used for topdressing. For tea and coffee, NPK blends are commonly used, including NPK (25:5:5:5s) for tea and NPK (17:17:17) for coffee. Specialty fertilizers (e.g., fertilizers containing secondary and micronutrients) are mostly used for horticultural crops.

Figure 8 shows the usage trend for various fertilizer products over the last few years, revealing a general increase in total quantities and products since 2006/07. Noticeable variations in products used year to year were primarily associated with the NPKs used for tea and coffee.
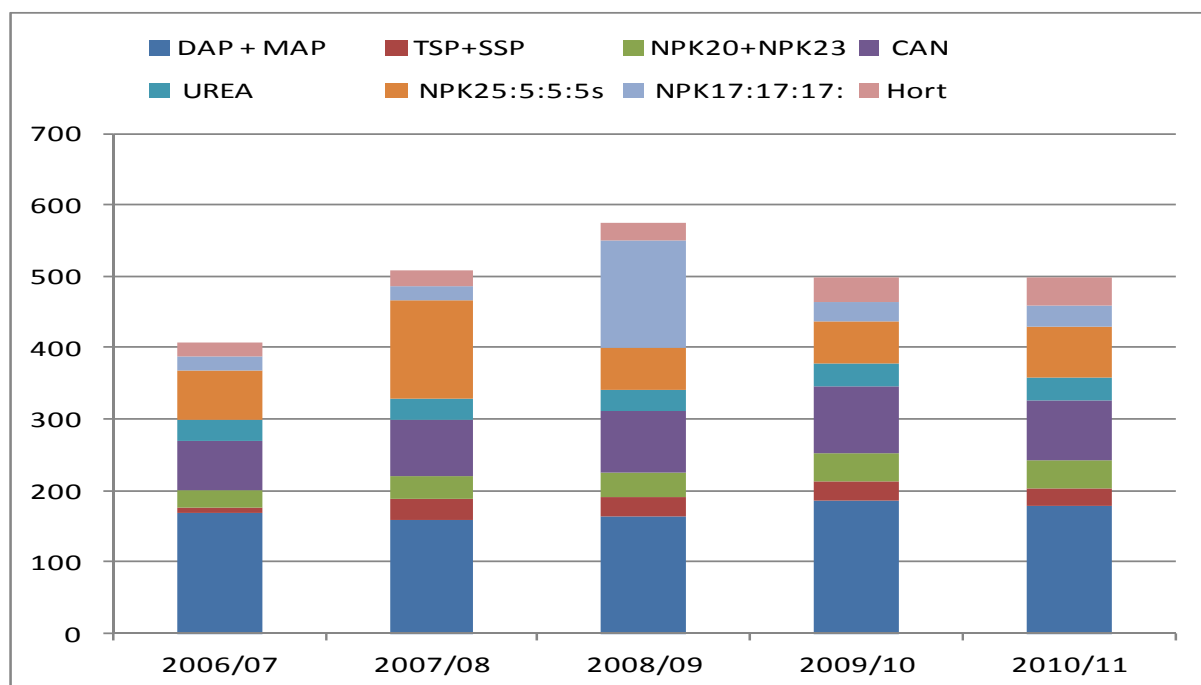
Figure 8. Trends in Usage of Various Fertilizer Products

Adoption and application rates vary across agro-ecological zones and crops. Fertilizer adoption rates vary from 4 percent (Coast Province) to a high of 90 percent of households in the high-potential maize zones. Cereals (maize, wheat, rice, sorghum, millet and others), tea and coffee account for 75 percent, 13 percent and 6 percent of the national consumption of fertilizer products in Kenya, respectively (i.e., over 90 percent of all inorganic fertilizers) (Table 6).

Table 6. Estimated Average Fertilizer Use by Crop Category (2008/09-2010/11)

Crop Group	Metric Tons	As % of Total Use
Cereals	365,357	74.7%
Tea	63,023	12.9%
Coffee	26,902	5.5%
Tobacco	542	0.1%
Horticulture	32,979	6.7%
Total	488,803	100.00%

Note: The totals and percentages are based on estimates from annual averages of the period 2005/06 to 2010/11 (six years). Current annual national consumption is approximately 500,000 mt.

Source: Ministry of Agriculture, 2011.

The tea subsector has an interlinked input-output market in which farmers receive fertilizer on credit and deliver their product to the input supplier who then deducts the cost of inputs after selling the tea on behalf of farmers. The coffee subsector used to have a centralized selling system with inputs provided (similar to the tea subsector), but this was liberalized and farmers are now given the choice of selling their coffee in a competitive market. While the potential exists to increase fertilizer use on these cash crops (tea and coffee), there is a significantly greater opportunity to increase fertilizer use on cereal crops, which are currently under-fertilized. Increased use on these crops would have a greater impact on food security since cereals are grown by over 90 percent of all farmers.

4.2 The Evolution and Effect of Policy on Investments in the Fertilizer Sector

Kenya's fertilizer market was liberalized during the early 1990s when price and marketing controls, licensing arrangements and import permits and quotas were eliminated. These reforms led to increased entry and investment of private sector participants in the markets. This more *laissez faire* environment promoted the growth in fertilizer use from less than 200,000 mt in 1990 to over 450,000 mt of product in 2009. The upsurge in fertilizer use following the liberalization of the subsector in the early 1990s was partly due to the GoK maintaining a stable fertilizer policy by eliminating import licensing quotas, foreign exchange controls and not interjecting market uncertainties through the introduction of large-scale subsidy programs until 2007 (Figure 9). The stable business environment led to increased private investment in fertilizer distribution (10 importers, 500 wholesalers and over 6,000 retailers).
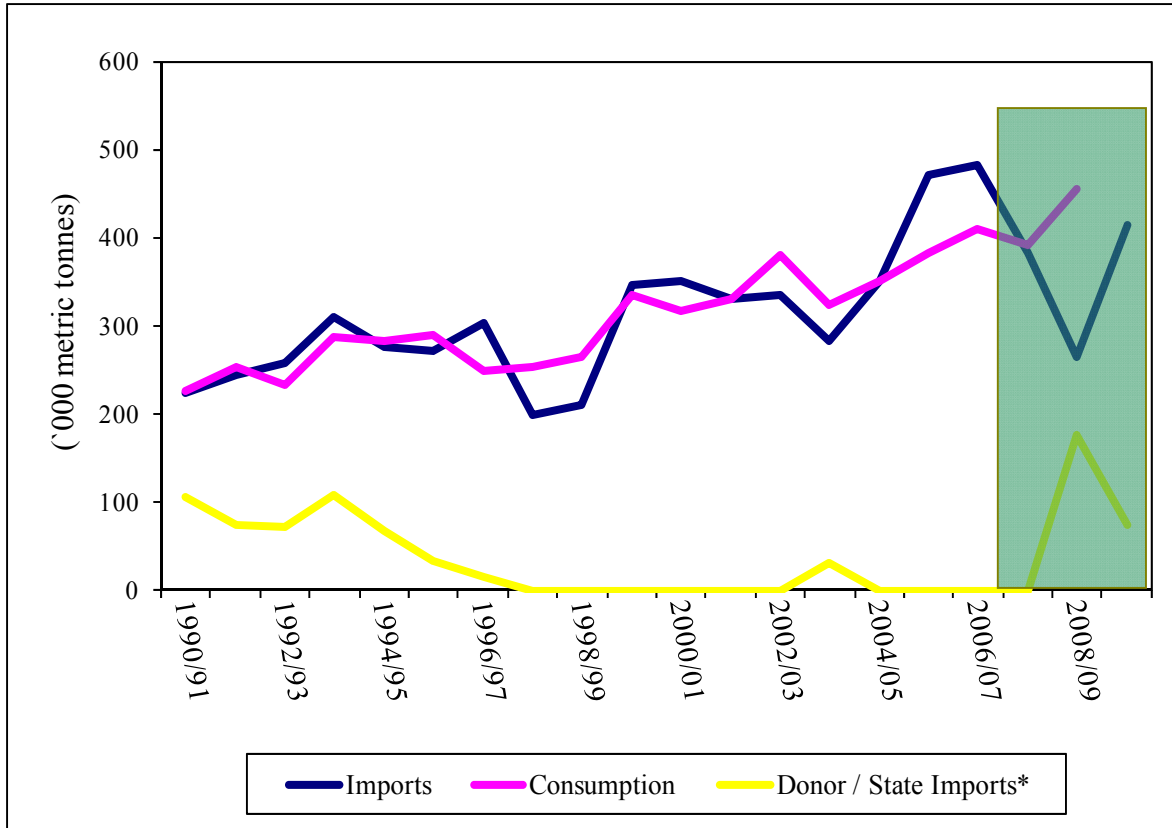
Figure 9. Trend in Kenya's Fertilizer Imports and Consumption (1990/91-2009/10)

The expansion in retailing outlets and investments in roads led to a reduction in the distance of farmers to the nearest fertilizer seller, while increased competition between importers and wholesalers led to reduced marketing costs, which reduced market margins (Figure 10).
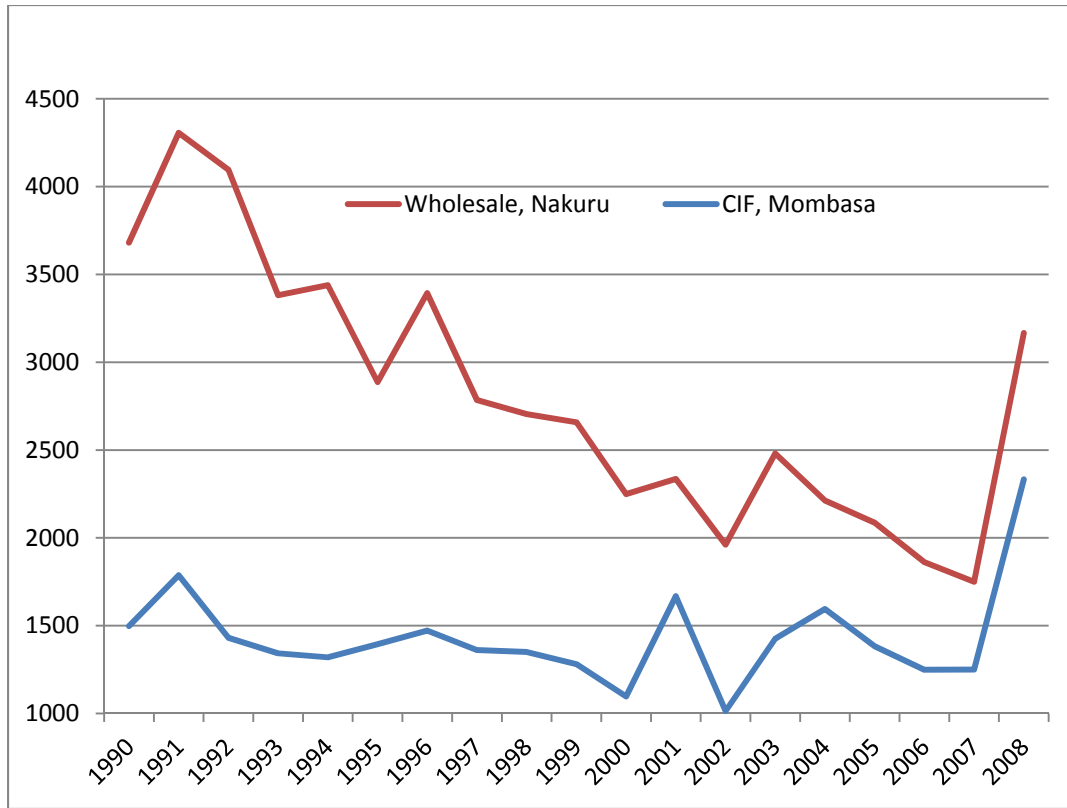
Figure 10. Price of DAP in Mombasa and Nakuru (Constant 2007 Kenyan Shillings per 50-kg Bag)

It is clear that the inflation-adjusted prices have been declining over this period, and the margin between cost, insurance and freight (c.i.f.) and Nakuru wholesale prices (Figure 10) has also decreased.

Due to increases in energy and raw material prices and growth in demand from emerging markets and the biofuel sector in USA and Europe, global fertilizer prices increased rapidly in 2007 and skyrocketed in 2008. The prices of urea and DAP increased more than four-fold between August 2007 and October 2008 (Figure 11). The government responded to this 'mismatch' between world and domestic fertilizer prices by enacting 'emergency' measures to deal with the high prices and encouraging fertilizer use by introducing subsidies in 2009 (Figure 9). GOK imported 140,000 mt of fertilizer and distributed it at below market price. This parallel market created competition that impacted private sector investments negatively. This intervention on price and marketing has introduced risk and uncertainty in the market because

GOK has not formulated a clear exit strategy from this intervention, creating uncertainty for private market participants. An additional problem with this scenario is that late delivery of the government-subsidized fertilizers results in farmers planting late. Late planting results in lower yields, but farmers are willing to take the risk of waiting for subsidized fertilizers even when private sector stocks are available (at higher prices).

**Fertilizer Prices
(FOB, bulk)
Monthly Averages
January 2005 - March 2012**

1. Derived from *Green Markets*.   2. Derived from *FMB Weekly Report*.
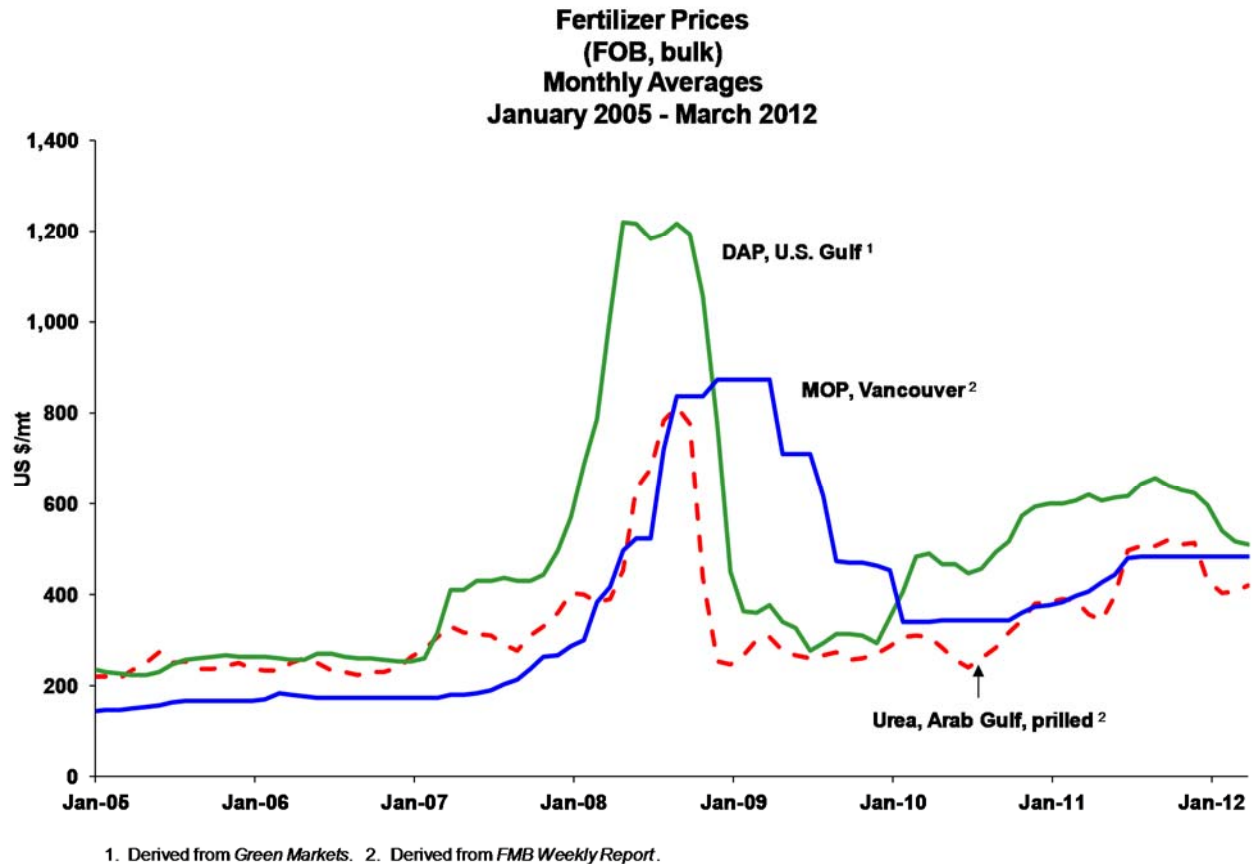
Figure 11. Recent Global Fertilizer Price Trends (2005-2012)

The sharp run-up in international fertilizer prices could not be sustained due to a decrease in consumption and increased financing needs. Beginning in November 2008, prices for urea and DAP decreased rapidly through March 2009. The major decrease in fertilizer prices in the global

market was not matched by a corresponding fall in local prices in Kenya due to significant carryover stocks bought at high prices during previous periods.

Increased fertilizer use is also hampered by the previously noted outdated fertilizer recommendations based on work that was done in the 1970s and early 1980s. Today, it is common to find farms using the same fertilizer product and rate each season every year, regardless of crop. In addition, the inherent soil fertility levels have degraded over the years due to nutrient depletion resulting from soil erosion, reduced fallow periods, fewer rotations and under-fertilization. Finally, farmers' access to information on fertilizer use and best management practices is limited because extension services are financially strained. Currently, the farmer-extension agent ratios are as high as 2,500 to 1.

Table 7 provides some understanding of the current policy environment in the fertilizer market and how this impacts the value chain stakeholders.

Table 7. Summary of Key Policy Issues in Fertilizer Markets

Policy	Description	Effect
Regulation	Fertilizer Bill drafted but not enacted. Kenya Bureau of Standards (KEBS) to regulate quality at all levels in the chain. Regional harmonization.	Weak quality control at retail end. Capacity of KEBS limited. Selling from open bags, some underweight bags and mislabeling.
Subsidy Smart versus distribution by the state	Combination of smart (50% price at private agro-dealer) and subsidized fertilizers distributed directly to all farmers by GoK (emergency).	GoK imports are ad-hoc and disruptive to private sector sales. Late delivery to farmers. Farmers in remote areas not accessed by limited GoK retail stores/depots.
Macroeconomic Exchange rate and monetary policy	Free Foreign Exchange regime since 1993. In 2011 to early 2012, increased devaluation of currency against dollar.	Imports more expensive (fertilizer). However, world prices transmitted well to local markets. More difficult for smaller importers to access foreign currency (large amounts and lack of international links).

Policy	Description	Effect
Trade Tariffs on imports and/or exports. Non-tariff barriers (NTBs)	No tariffs on fertilizer. However, port costs are high and there is a reimbursable value-added tax (VAT) on services and transport. NTBs exist across borders.	Recovery time of VAT on services significant for importers (hidden cost).
Price and Market Controls	No price fixation by GoK. However, GoK tries to influence price through pan-territorial price subsidies. No restrictions on market entry.	Private sector is competitive. GoK direct imports affect smaller players.
Credit/Finance	Competitive banking sector. Collateral requirements. GoK, AGRA and Equity Bank created a risk-sharing partnership through credit guarantee schemes.	Lower interest rates with credit guarantee. Generally rates are high in market, and banks are risk-averse to agriculture, limiting use of credit by small-scale participants.
Extension and Training	Extension agents and farmers not well-versed in different fertilizer technologies.	Use less efficient fertilizers based on out-of-date recommendations. Soil acidity increased from overusing some N fertilizers in some areas without liming. Low yields due to nutrient imbalance and depletion.

4.3 Major Fertilizer Supply Chains in Kenya and Effect of Subsidy

Some key supply chains for Kenya fertilizer are depicted in Figure 12, symbolized as systems (S) 1-3. The diagram focuses on domestic participants and does not include international players (manufacturers, shippers and others). S-1 and S-2 are private sector-driven value chains, while S-3 is a government or state import distribution chain.

S-1: Private Importers

S-2: Private Importers

S-3: Government Imports: NCPB

Wholesalers / distributors or Estate Crops

Export Crop Company: e.g. KTDA distribution network for tea

State agency's distribution system e.g. NCPB stores across the country

Agro-dealers / Retailers

All Farmers: at full market prices

Target poor farmers: At subsidized prices (vouchers system)

Outgrower farmers growing for export

Target all farmers: At subsidized prices (no vouchers)

Note: Adapted and modified from Wanzala et al. (2009) by authors.

Figure 12. Major Fertilizer Supply Chains in Kenya

Supply chain S-1 is the most common, with most fertilizer distributed through its system of importers, wholesalers and retailers. Importers buy directly from international suppliers and deliver them to their own distribution or wholesale points or to other firms in the chain, who then transmit the products to agro-dealers from whom farmers purchase fertilizers. This is the supply chain that the government uses to implement its targeted subsidy program using vouchers, which are redeemed by recipients at private retail/agro-dealer stores across the country. The implementation of this subsidy through private sector channels (often called 'smart' subsidy) is meant to minimize negative effects on private sector investments. This chain also includes imports of specialized formulations made specifically for the horticultural industry by private firms. Supply chain S-2 captures the case for specific high-value crops mostly grown for exports (tea, coffee, sugar in Kenya; tobacco in Malawi; cotton in West Africa) in which procurement is directly from international sources or through local importers by a collective crop agency on behalf of all farmers. This has developed into an input-output interlinked market arrangement in which inputs are supplied on credit to farmers and costs are recovered after the agency sells the output.

Supply chain S-3 is a state-driven chain involving direct procurement or procurement by tender and then local distribution by public agencies mostly covering subsidy programs. This is the case in Kenya in which the National Cereals and Produce Board (NCPB), a government agency, imports fertilizer and distributes through its network of stores or depots across the country at subsidized prices. This is the parallel system that creates uncertainty for private sector players for three main reasons:

1. Unlike the voucher system embedded in the private sector distribution S-1, this subsidy is available to all farmers without restrictions. This is in direct competition with the S-1 system.

2. Information on amounts of fertilizer and timing of imports is often not available to the private sector. This has implications for private sector decisions on purchases.

3. Unlike the vouchers or coupons that are targeted to poor farmers through S-1, this subsidy covers all farmers. Even though the government does not meet the targets it sets for quantities of imports, farmers would prefer to purchase the cheaper fertilizer before they resort to purchasing it from the private sector at higher market prices. An additional problem is that the government competes for scarce foreign exchange with the private sector in the importation of fertilizers.

At the import level in Kenya, there are about 10 competitors who may also be involved in wholesaling and distribution. Some of the factors that limit entry include the small size of the market, financial requirements and logistics and management constraints in handling bulky products. A 20,000-mt container of DAP at current free on board (f.o.b.) prices will cost US $12 million to purchase at source. Considering the capitalization of most SSA firms, this is a major hurdle unless they have links to relatively cheaper international sources of finance. Some smaller importers engage in strategic alliances with larger competitors to make joint import procurement to gain scale economies.

At the wholesale and retail levels, there are relatively more participants compared with the import level; their margins are relatively low, relying on volumes to increase business. However, the small number of players at the import level does not necessarily imply oligopoly, and some indicators imply the existence of competition (Figure 10). Some importers brand their products with their company name to differentiate themselves from competitors.

The fertilizer industry in Kenya is regulated by the Fertilizer and Animal Foodstuffs Act (Cap 345). The Act regulates the importation, manufacture and sale of agricultural fertilizers and animal foodstuffs. The Act provides for approval of fertilizers and licensing of sterilizing plants; inspection of fertilizers and records by authorized inspectors; analysis of samples taken by inspectors; financing of the regulatory program through licensing fees and administration; and enforcement and assessment of penalties. A new bill has been drafted to replace and address areas not covered in the current Act, but it is awaiting parliamentary vote and presidential assent.

4.4 A Breakdown of Domestic Fertilizer Distribution Costs

In pursuing avenues to raise fertilizer consumption in Kenya, it is important to analyze domestic costs of distributing fertilizer from the port to the farm-gate. This provides information that will guide decisions on specific areas to be targeted in order to mitigate costs so that retail prices are reduced. The supply chain costs consist of three major items (transport, transaction costs and trade margins). Of these three categories, transport costs generate the most interest; it is important to note that estimating business margins and transaction costs is not easy due to lack of information and data on the individual elements (confidentiality and the difficulty of measurement).

Figures 13 and 14 illustrate the key domestic costs from the port to key cities in Kenya (Nairobi). The international freight, insurance and product costs are excluded from Figure 14, because these are out of the control of individual countries and set by international market forces. This study focuses on internal costs that can be influenced by policy or other public-private activities geared to reducing such costs. The contributions of these individual costs are compared to the total domestic costs. For instance, domestic transport costs account for 33 percent of all the domestic costs of moving fertilizer from the port (Mombasa to Nairobi). Port charges and internal transport costs take a relatively high proportion of domestic costs.
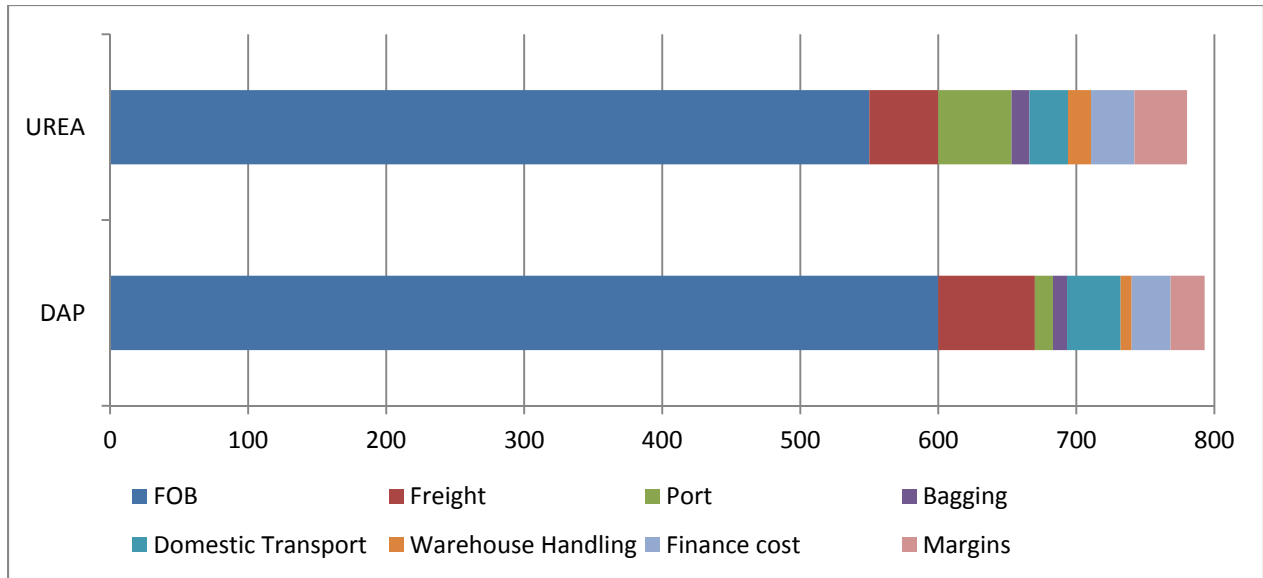
Figure 13. Cost Buildup for DAP and Urea
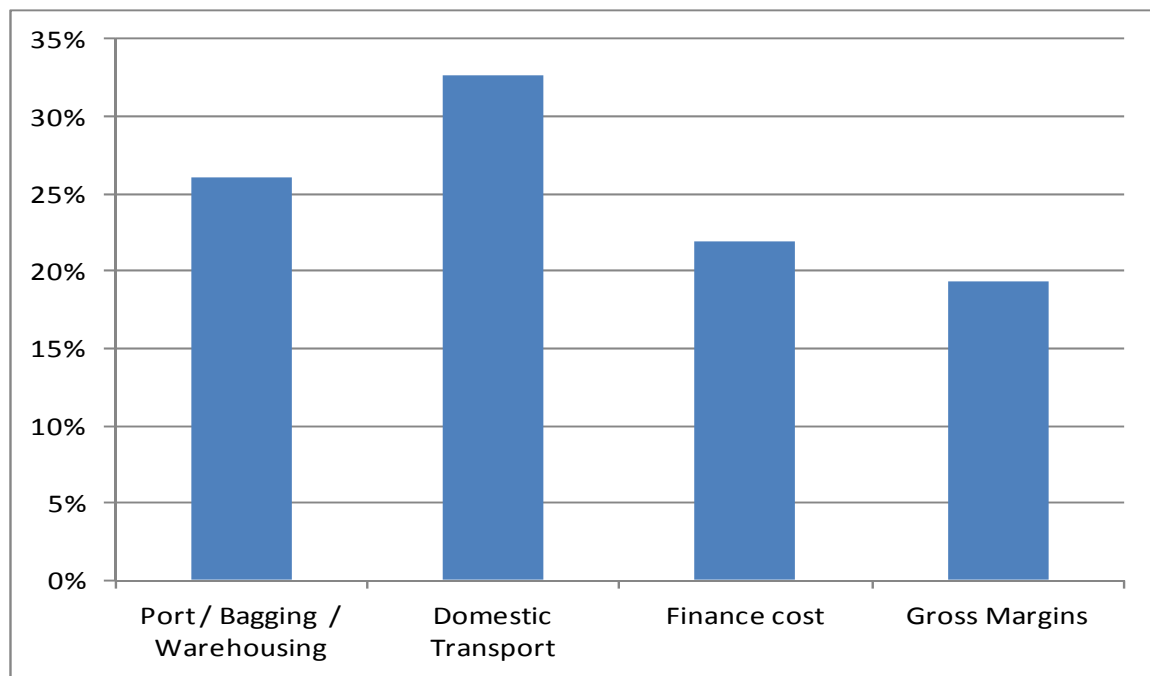
Figure 14. Domestic Fertilizer Costs for Kenya

Inland transport costs also add a significant part of the cost of fertilizer. It has been documented that it costs more to move a container from Mombasa to Kampala than to ship it from Tokyo to Mombasa (JICA, 2009). The margins are 'gross' (i.e., the internal costs incurred

by the businesses related to the fertilizer activity, including labor, capital and overhead, are part of these margins); therefore, the 'net' margins are lower than what is reflected here, depending on the respective costs for these firms.

Clearly, these costs create a challenge to improving the flow of fertilizers to farmers at attractive prices. Efforts toward increasing fertilizer consumption in Kenya will have to design ways to reduce these costs at various points on the supply chain. The following sections examine ways to reduce port charges and transport costs by tackling domestic infrastructure constraints, particularly in light of estimates of increased fertilizer required for reaching CAADP or MTIP targets.

5.0 Estimating Fertilizer Requirements

As indicated in the framework for linking inputs to outputs outlined in Section 3, the ideal way to estimate fertilizer requirements is to account for relationships between inputs and the market dynamics generated by significant changes in markets for inputs and agricultural commodities. While the DSSAT model allows us to impose the condition that the increases in fertilizer use must be both agronomically feasible and economically profitable at current input and output price levels, it does not incorporate all the power of a *general equilibrium analysis*, in which prices and quantities in all input and output markets are simultaneously determined.

Likewise, the existing DSSAT modules were not sufficiently refined (or set up) to allow analysis of some of the CAADP target crops nor locally relevant seasonal dynamics. In addition, we were not able to obtain complete data sets for production and fertilizer use by crop for each agricultural region over time and updated soil profiles. To use the above methods requires extensive data and time.

However, sometimes a reasonable answer furnished rapidly is more useful than a more precise answer furnished too late in the planning period. In this and the following sections, we conduct fairly simple analyses, ground-truthed in agronomic realities and based on available techniques and data. These estimates are intended to identify the basic issues that emerge as the

Kenyan public and private sector lay out the priorities underlying a realistic program for meeting the CAADP targets. We assume that as that process unfolds, interested parties will contribute information and momentum to the analysis.

To provide a robust and reasonable range of estimates for the quantities of fertilizer required to achieve the CAADP targets, we first analyze the gap between current and target production levels (Table 8). We then adopt two different approaches to filling that gap. First, we calculate the minimum level of fertilizer needed to close the gap using the simple approach of extrapolating current best practices to the entire country. We then, for purposes of comparison, employ the more complex DSSAT model described above to derive a more refined set of initial conditions and estimates of production potentials.

Table 8.   Yield and Production Differences Between Current and CAADP Targets

		Yield		Total Production		Production Gap (MTIP *less* Current)	
	Area	Current	MTIP Target	Current	MTIP Target		As % of Current Production
	('000 ha)	(mt/ha)		(million mt)		(million mt)	
Cereals							
Maize	1,660	1.6	2.2	2.7	3.7	1.00	37
Sorghum	226	0.8	1.1	0.2	0.2	0.07	35
Wheat	156	2.2	3.1	0.3	0.4	0.12	40
Millet	90	0.6	0.8	0.1	0.1	0.02	20
Cassava	62	9.2	12.9	0.6	0.8	0.23	38
Rice, paddy	20	3	4.2	0.1	0.1	0.02	20
Others							
Potatoes	131	7	9.8	0.9	1.3	0.37	41
Beans, dry	689	0.4	0.6	0.3	0.5	0.17	57
Coffee, green	160	0.3	0.4	0.0	0.1	0.02	
Tea	158	2.2	3.1	0.3	0.5	0.14	47
Sweet potatoes	78	10.4	14.6	0.8	1.1	0.33	41
Sugarcane	66	83.9	117.5	5.5	7.8	2.22	40
Bananas	35	15.8	22.1	0.6	0.8	0.22	37

Source: Ministry of Agriculture and authors' calculations. MTIP and CAADP targets are used in this study interchangeably. The maize gap is estimated at 1 million mt.

Table 8 reveals the gaps between the CAADP targets and current production and sets the stage for the discussion below. These CAADP targets are discussed in the national country investment plans for the period 2010-2015.

Maize is targeted for analysis for several reasons including: (1) there is more data available on fertilizer use for maize than any other cereal crops, mostly because of the importance of maize as a staple food crop; (2) maize accounts for nearly 40 percent of all fertilizers applied to cereal crops; and (3) the DSSAT model would require more specialized configuration and data to deal with the other crops than what was available during this study period. Therefore, a number of broad assumptions are made about the estimates for the non-maize target crops to attempt to account for these challenges.

5.1 Scenario 1: Extending Current Best Practices

Scenario 1 assumes changes in cereal fertilizer use while holding constant fertilizer use in industrial crops (crops such as tea have relatively high application rates, especially in the large or estate sector and therefore are close to optimal applications). The changes in maize fertilizer application come from extending the average rates from those already using fertilizer to the entire cultivated maize area. One way to estimate fertilizer requirements for the CAADP targets is to assume that those targets can be met by greatly increasing the productivity and profitability of cereal production in those areas not currently applying fertilizers. Using this approach, we note that fertilizer rates and crop yields differ greatly between zones (reflecting a variety of factors) and that within any given zone, only a portion of each crop is fertilized. This scenario then considers how much fertilizer it would take to fertilize the entire zone at the average rate found on the fertilized portions of the zone. Assumptions can be summarized as:

- The existing average rates on fertilized areas are technically and economically optimal in the respective zones.
- The currently unfertilized areas in each zone could be as productive as the fertilized areas, with sufficient fertilizer being available.

The study then proceeds to:

- Identify total maize area by region.

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- Identify yields and fertilizer use rates on the fertilized portions of the maize area in each region.

- Compute total crop production and fertilizer use assuming that the current rates of fertilizer use were applied throughout each region.

Ideally, one would do this for each crop targeted by CAADP. However at this stage, the analysis is limited to maize and the combination of all other cereal and non-cereal crops.

Data from the Food and Agriculture Organization of the United Nations (FAO) and the Ministry of Agriculture indicate that Kenya's cultivated maize area is approximately 1.66 million ha (Table 9). Only a third of that (approximately 0.58 million ha) is fertilized, mostly in the high-potential maize zones in the Rift Valley and Western Highlands. Focusing on the fertilized area under maize and multiplying the average application rate by the total hectares that are fertilized gives us 129,000 mt as the total estimated amount of fertilizer currently used on maize. [7] Extending this application rate to the total area under maize (fertilized and unfertilized) gives a total of 303,000 mt of fertilizer product required today if all cultivated area under maize were to be fertilized at the current rate of fertilized land. This is a significant assumption, as indicated above, assuming that: (1) productivity and profitability are the same, even in areas where farmer behavior indicates it probably is not; and (2) fertilizer in high-potential zones is already applied at optimal levels. Furthermore, the study makes no assumptions on investments in soil fertility measures (including organic fertilizer use) and water for irrigation. Nevertheless, these computations allow the creation of a boundary for these estimates.

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[7] No reliable estimates exist on the quantity of fertilizers (DAP, CAN, urea, etc.) used specifically on maize out of the national annual consumption of 0.5 million mt covering all crops in Kenya. We estimate that maize consumes approximately 40 percent of the total amount of fertilizer intended for cereals; based on Table 6, this is 145,000 mt, a number that is close to the estimate of 129,000 mt for this study.

Table 9. Current Fertilizer Use on Fertilized and Total Cultivated Maize Area (Average 2008-2010)

Agricultural Zone	Fertilized Maize Area		Current Maize Yield	Total Maize Area	
		Total Fertilizer Use			Total Fertilizer Use
	('000 ha)	('000 mt)	(mt/ha)	('000 ha)	('000 mt)
Western Transitional	67	16.00	2.44	193	47
High-Potential Maize Zone	245	68.00	2.34	543	152
Western Highlands	111	23.00	2.36	246	51
Central Highlands	60	17.00	1.03	115	33
Coastal Lowland	5	0.04	0.80	69	1
Eastern Lowland	96	4.00	0.57	494	20
Total	584	128.04	1.67	1,660	303

Note: Numbers may not add due to rounding. The total (national) yield is an area-weighted average of the zone yields.

Source: Area and fertilizer use data from Ministry of Agriculture, FAO Database and estimates by authors

Using the estimate of 303,000 mt for all cultivated land under maize (if all cultivated land were fertilized at the rate applied on currently fertilized maize), the total fertilizer consumed by all cereals, including maize, would be approximately 539,000 mt (303,000 plus 236,000 mt), based on Table 6. To estimate the lower bound, we assume that the other four major crop categories (tea, coffee, tobacco and horticulture) consume fertilizer at their current average levels (Table 6); therefore, the total fertilizer requirement for cereals and non-cereals is 662,000 mt.

Assuming that the average yield on the fertilized maize field of 1.67 mt/ha (0.7 mt/acre) is maintained under these circumstances, then total maize production will be 2.77 million mt. This is the lower bound considering that we have assumed that seed, other inputs and management practices remain the same; this back-of-the-envelope estimate does not account for many other factors, such as changes in consumption for crops other than maize and changes in prices, which will create a new set of incentives; in addition, the average rate used in computing fertilizer requirements is much lower than some of the high rates in these regions that are comparable to Asia. But it provides a rough gauge of the expectations under minimal requirements. The following analysis controls for more factors, and therefore we expect the

estimates of production to be higher under this robust environment in which fixed factors in Scenario 1 are now allowed to change.

5.2 Scenario 2: Estimating Economically Viable Fertilizer Use on Maize Crop

Scenario 2 assumes economically optimal maize yields and generates the fertilizer requirements to achieve this for the entire area (Table 10), assuming that fertilizer use on other cereal and industrial crops will continue to grow at the current average rates. Unlike the analysis in Scenario 1, this method uses the DSSAT model to estimate the levels of N, P and K needed to achieve the highest economically viable yields under the agro-climatic/soil conditions of each region.

Table 10. Estimated Fertilizer Use on Fertilized and All Cultivated Maize Area (Based on Economically[8] Viable Yields for Dominant Planting Season)

Agricultural Zone	DSSAT Maize Yield	Total Maize Area	Total Fertilizer Use	Total Maize Production		
				Current	Economic (DSSAT)	MTIP
	(mt/ha)	('000 ha)	('000 mt)	('000 mt)		
Western Transitional	6.78	193	72	163	454	147
High-Potential Maize Zone	3.70	543	105	573	907	539
Western Highlands	6.70	246	88	262	744	244
Central Highlands	4.35	115	29	62	261	132
Coastal Lowland	2.86	69	11	4	14	11
Eastern Lowland	2.78	494	71	55	267	211
Total	4.53	1,660	376	1,119	2,647	1,284

Note: Numbers may not add due to rounding.

Source: Data from Ministry of Agriculture, FAO Database and fertilizer use estimates by authors using the DSSAT model.

This analysis uses conditions prevailing during the long rains or the main season in Kenya to estimate fertilizer requirements assuming that total maize area does not change in any significant way within the period covered by the CIP. Two interesting outcomes result from this

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[8] Here, economically viable estimates are based on yields per hectare that make fertilizer use profitable and beyond which the returns are not beneficial to farmers. These measures of profitability are lacking for nearly all crops and whatever is available is not based on rigorous analysis. There is need for studies in Africa to generate simple fertilizer profitability measures that will guide private and public sector decisions on fertilizer use in different regions.

analysis and also provide indications of national fertilizer requirements to achieve these economically viable yields.

First, for the DSSAT model, the average target yield for maize is 4.5 mt/ha (1.8 mt/acre), which requires a total 377,000 mt of product, or 160,000 mt of N, P and K nutrients for an area estimated at 1.66 million ha. Using the estimate of 377,000 mt of fertilizer for all cultivated land under maize (one and a half times its current level), the total fertilizer consumed by all cereals, including maize, is estimated at 707,000 mt (377,000 plus 330,000 mt[9]), based on Table 6. Here, we assume that usage in the rest of the cereals increases at the current average rate of 8 percent annually. Extending this assumption further and allowing the fertilizer consumed under the other three major crop categories (tea, coffee and horticulture) to increase at the current average rate of 7 percent (Table 6), then the total fertilizer requirements for cereals and non-cereals is approximately 900,000 mt. Fertilizer use on cereals for the second or late planting season is estimated at a third of the first period. Therefore, this estimates the requirements at close to twice the current use of 0.5 million mt.

Table 11 gives a summary of the current fertilizer use and the estimated requirements under the two scenarios above.

Table 11. Comparing Fertilizer Projection Scenarios

Crop Group	Current	Scenario 1	Scenario 2
Maize	146,143	303,000	377,000
Other cereals (excluding maize)	219,214	236,000	330,000
Tea, coffee, tobacco, horticulture	123,446	123,446	203,000
Total	488,803	662,446	910,000

Source: Authors' calculations.

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[9] We make a moderate assumption that fertilizer use for other cereals (excluding maize) increases by 8 percent annually based on the previous trend.

6.0 Key Challenges in Fertilizer Value Chains

6.1. Dealing with Challenges in Fertilizer Value Chains to Meet Agricultural Growth Targets

In the following sections, we discuss the challenges facing the fertilizer value chains and possible responses to eliminate or mitigate them so that fertilizer consumption increases to meet the goals set for the agricultural sector in national development plans. The focus will be on the main fertilizer supply chain involving the private sector, as explained above.

Already, the port and road infrastructure is under considerable stress. Delays in clearing through the port and roads are problems that increase the cost of fertilizer and also affect general business competitiveness by raising costs of goods relative to other regions in the world. Without improvements in these areas, the increased demand will overwhelm the system and raise costs for businesses and farm-gate prices.

This increased flow of fertilizers will necessitate some changes within the value chain. Two scenarios are presented and discussed at a very high level. The first scenario is that no significant changes to capacity at the port and roads infrastructure will occur, and the second approach involves making capacity investments to account for this increase.

6.1.1 Inadequate Port Infrastructure/Facilities: Reducing Port Handling Costs

A number of studies conclude that a major impediment to international trade in East Africa is the state of the ports (JICA, 2009). The major issue is that the port capacity has not been modernized and expanded to meet the increased flow of goods putting pressure on existing facilities. The inefficiency at the port of Mombasa has cost implications not only to goods destined to Kenya, but also to those goods transported to neighboring countries. The competitiveness of businesses and goods in EAC depends on the operational effectiveness of this port.

From the time the ship docks until the goods reach Nairobi or other locations in East Africa can require more than 30 days. Figure 15 compares average times spent by vessels

offloading their cargo and leaving port. A vessel through Mombasa requires an average of 23 days from its arrival to leaving port.
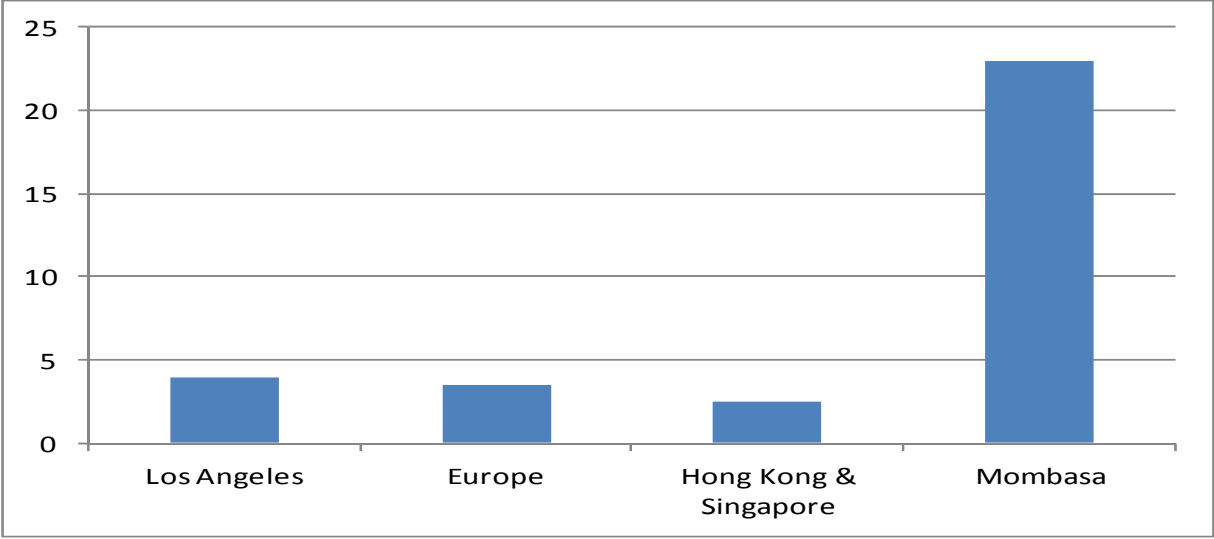
Figure 15.   Average Vessel Dwell Time at Various Ports

The slow clearance at Mombasa is not a reflection of the volume of containers that are handled at the port but rather the inadequate facilities. The two top ports in the world based on volumes (Shanghai and Singapore) handle in a week what Mombasa handles during the whole year (Figure 16).
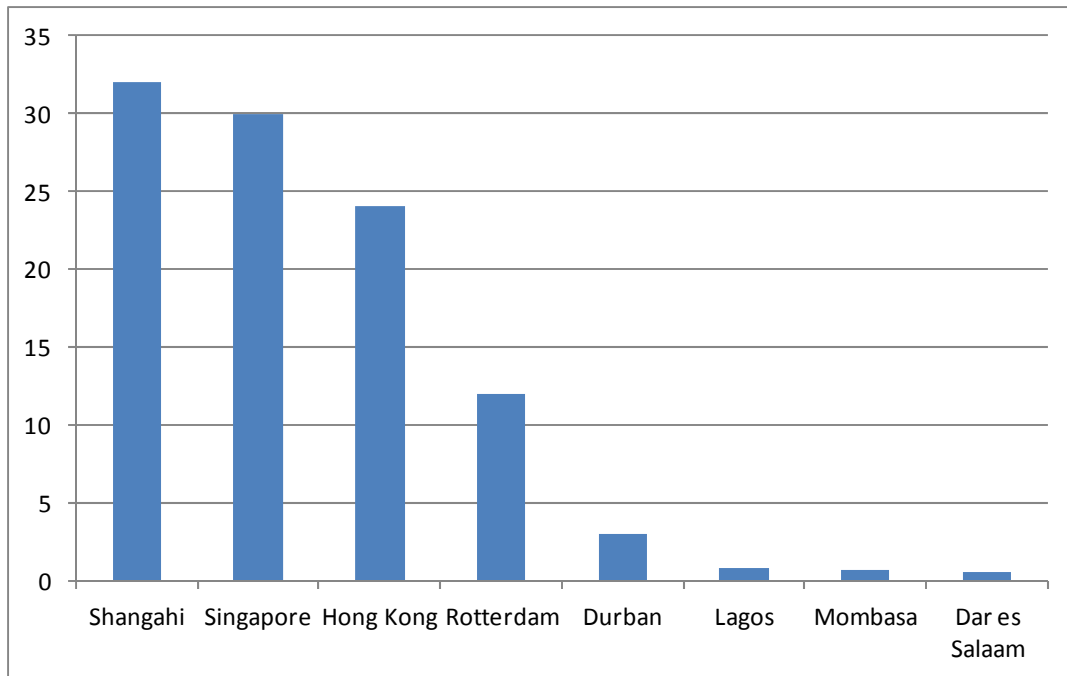
Source: World Bank (2009). Note: TEUs = 20-foot equivalent units (containers).

Figure 16. Millions of TEUs Containers Handled Annually

On arrival at Mombasa, vessels have to be allocated a berth, which may take up to seven days while the vessels 'hang' out at sea. Once berthed, offloading by the Kenya Port Authority (KPA) averages 2,000 to 3,000 mt/day. At these rates, a 20,000 mt cargo ship will take more than 10 days to get its cargo offloaded. Assuming that there is increased vessel traffic, this may require more than 10 days. Demurrage costs begin to accrue after 10 days and can rise rapidly at US $10,000/day for a 20,000 mt cargo ship. The delays lead to increased demurrage and financial costs and the risk of not meeting deliveries at various destinations.

For bulk cargo, once the ship is offloaded, the containers have to be moved to a central warehouse or Container Freight Services (CFS) Unit where they may be stored, bagged and loaded onto trucks for transport inland. The movement to CFS, which is close to the port, may take up to another 10 days. Therefore, cumulatively, a 20,000 mt bulk cargo ship may take more than 30 days to clear through the port: 10 days to get a berth, 10 days to be offloaded and another 10 days to get to a central warehouse for trucks to transport upcountry (Figure 17).

Schematic of Major Operations at Port

| 20000 t Cargo Ship Arrives | → | Ship **Berths** | → | Ship **Unloads** | → | Transport to **CFS** (storage) | → | **Inland** Transport (deport or sell) | → |

7-10 days

10 days @ 2000 t / day: Labor & Equip

10 days Poor road

Trucks, road, rail
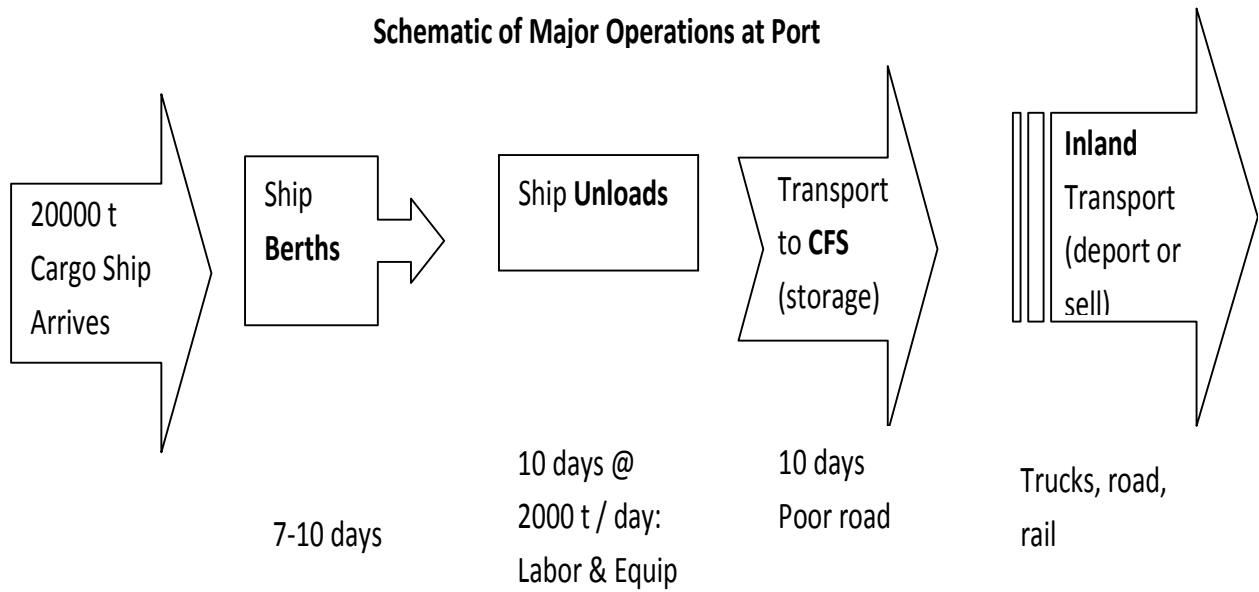
Figure 17. Schematic of Major Port Operations

To eliminate some of these bottlenecks, there are a number of measures being undertaken or planned for implementation. The construction of more Inland Container Depots to decongest the port and the introduction of 24-hour port operations, an electronic single window system and computerized cargo clearance would significantly improve operations at the ports. The government is considering utilizing public-private partnerships to increase investments at the port to ease clearance procedures, and there are ongoing discussions to allow private investors to manage some berths.

Due to the small vessel sizes that can be handled at this port, measures to raise volumes and take advantage of economies-of-scale will help to reduce costs. Some small importers are buying from large importers at the wharf to ensure that full cargoes can be imported. Large cargoes may also result from port expansion. Even if the port capacity were increased, this will not guarantee that importers will not use the smaller handy-size vessels. Using larger vessels will depend on the size of local or regional fertilizer consumption, world fertilizer price volatility (affecting local demand) and GoK interventions in the form of subsidies (which at times have left importers in a difficult position to compete with low fixed prices). In addition, it will be difficult to attract larger vessels if there are limited export opportunities. In this case, larger vessels could compound the cost problem.

6.1.2 Inadequate Road and Rail Infrastructure: Reducing Transport Costs

According to KPA, the cargo at Mombasa has been growing at 13 percent each year, and KPA has installed additional cranes to help with unloading at the berths. But this is not sufficient to reduce congestion at the port because of the poor condition of the road and rail systems used for inland transport, which hampers transport out of the port. The rail system handles only 5 percent of the cargo, while the remaining 95 percent is handled by road. The rail network is poor and nonexistent in some areas, which leaves the road as the main mode of transport for the EAC countries. Most of the road infrastructure is in a poor state, adding to costs for truck maintenance and increasing haul times. *The limited backhaul opportunities for trucks increases the transport cost per unit of fertilizer product. The cost of transporting inputs will be cheaper if there is other cargo or output to haul as return loads. This is a problem similar to the impact of limited exports on shipping costs noted above.*

Once the cargo leaves the port for inland destinations, transport costs are another important input that raises farm-gate fertilizer prices. Road transport costs are exacerbated by numerous roadblocks and weighbridges, which provide opportunities for rent-seeking or bribery. Infrastructure, transport and non-tariff barriers (roadblocks, frequent offloading and weighbridges) have been identified as leading causes of high marketing costs (JICA, 2009).

The delays in clearing cargo through the port coupled with distributional delays resulting from numerous roadblocks and weighbridges (13 within Kenya alone) in the EAC area generate significant additional pressure for businesses to make profits under difficult logistical environments. There is a legal limit on how much trucks can carry on the roads (maximum axle loads to meet Gross Vehicular Weight [GVW] of 48 mt) to protect infrastructure from increased maintenance costs; this creates incentives for some to find ways to circumvent the axle load rules. The EAC countries are currently working on harmonizing vehicle load control laws so that they are the same across the region.

The other option to counter the slow movement of goods inland is for importers to hire more trucks instead of using a few that make several trips to clear the stock from port warehouses. Assuming availability of trucks is inelastic, this latter approach will still be costly since there will be increased competition for transport services. Most of the trucks on these roads are fairly old, implying high maintenance and replacement costs. This is an area that requires further research to identify ways of increasing truck fleets in EAC, taking into consideration the taxation system with respect to imports of trucks and other hidden costs.

6.1.3 Farm-Level, Demand-Pull Constraints

Three farm-level issues are of particular interest in their influence on demand for fertilizers, i.e., as fertilizer demand-pull factors. Soil fertility is low and declining due to insufficient use of nutrients (organic and inorganic fertilizers), particularly for smallholder farmers. There is a need to provide soil testing facilities at affordable prices to farmers so that they use the best or most suitable fertilizers and apply them at an appropriate rate. This is an

important aspect in light of the government policy to raise agricultural growth through the encouragement of the adoption of improved technologies. For farmers to use best management technologies, it is important that these technologies are relevant to the environment that exists on these farms.

There is inadequate on-farm storage for most smallholders, forcing farmers to sell their produce at harvest when prices are considerably lower. Most smallholder farmers cannot wait for better prices. These constraints restrict opportunities for value addition with surplus crop production. In addition, farm storage is closely linked to functioning output markets, which will drive the demand for inputs. If farmers are not able to sell their produce, then it is risky for them to buy inputs such as fertilizer. Interlinked input-output linkages should be harnessed, including peer-group financing opportunities, as is the case with One Acre Fund. Under this system, farmers are asked to form groups and then are financed through an arrangement in which each member takes responsibility for defaults by others. For this to happen, it is crucial that efforts are made to develop output markets for these farmers, either locally or regionally.

6.1.4 Challenges That Cut Across the Supply Chain (and Participants)
6.1.4.1 Finance or Credit

Issues associated with access to finance by farmers, retailers and importers are not new. Smallholder farmers have poor access to sources of capital to purchase improved technologies such as fertilizer. This has led to government intervention in the form of vouchers, along with training and extension efforts, to expose farmers to the cost benefits of fertilizer use. Since these farmers sell their crop immediately after harvest (when prices are low) to meet various needs, by the next planting season they lack the funds to buy fertilizers and hybrid seed. Those selling to government agencies in the hope of getting better prices have to wait an inordinate amount of time for payments, therefore incurring additional hidden costs; this latter situation leads some farmers to sell to private buyers who pay promptly though their prices may be lower than government agencies' prices. Prompt payments by NCPB (in the case of maize) and implementation of a *warehouse receipt system* may provide opportunities for improving farm incomes. This capital constraint is associated with the general *relatively higher risk* associated with agricultural investments compared to manufacturing, which reduces lending by financial

institutions. Limited access to credit results from the *high cost of credit,* with interest rates as high as 30 percent, combined with *poor knowledge* by farmers on formal credit arrangements and interacting with banks and constraints involved with *land policy and tenure*, preventing the use of land as collateral.

The financial constraint becomes particularly acute for retailers or agro-dealers that have to invest substantial amounts of money to purchase and store fertilizer stocks for relatively *low gross margins* of 2-4 percent of cost (KES 50-100/50-kg bag costing KES 3,000 or more). This results in agro-dealers confining fertilizer deliveries only to major rural centers where there is higher demand. Delivery to remote areas with additional *transport and transaction costs* reduces profits even further. In this case, there is *no incentive to develop private sector distribution in remote places due to poor demand and lack of purchasing power by farmers*. This has led to public investment by the National Accelerated Agricultural Input Access Program (NAAIAP)[10] in which farmers are organized into groups to allow for economies-of-scale in delivery of fertilizers through the voucher subsidy program (implemented through private sector distributors). But, as with most bureaucracies, this government-led effort to deliver fertilizer to those who have poor access to inputs faces the challenge of delayed voucher redemption (three months or more), accompanied by late payments to agro-dealers by the state, creating cash-flow stress to traders participating in the subsidy program.

For the large importers, the finance situation is considerably different. They have access to international finance through their multinational linkages unlike the smaller dealers, wholesalers and retailers who find collateral and high interest rates to be a major challenge. Risk-sharing arrangements like 'Kilimo Biashara' exist, in which banks give out loans at discounted rates based on guarantees from AGRA through Equity Bank to agro-dealers and farmers. This is an area in which AFAP could provide help to firms that have a good business record but require financing. Working together with development partners and governments, it is important to develop financial instruments that can be used for this purpose with appropriate oversight.

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[10] The NAAIAP subsidy program targets 2.5 million smallholders through its Kilimo Plus 'starter packs' of 50 kg of DAP/NPK, 50 kg of CAN and 10 kg of hybrid seed as a one-time supply, which is meant to introduce farmers to the benefits of using fertilizers and improved seed without encouraging dependency on prolonged subsidies.

6.1.4.2 Human Capital Development, Information

Adoption of new technology requires training on its use and information on the benefits accruing from investing in the technology. A large proportion of smallholder farmers have no knowledge of how to use fertilizer and the benefits that accrue from its use. In some places, farmers believe that using fertilizer will 'destroy' soil fertility. For fertilizer uptake to increase significantly, increased training through demonstration farms and other fora will be an important ingredient to increase adoption for farmers that are not using fertilizer and also to encourage farmers who are using fertilizer at suboptimal levels to increase their application rates.

6.1.4.3 Legal and Regulatory Framework

Kenya is using an outdated Fertilizer Act. The new draft fertilizer policy paper has not passed through parliament. It is also important to harmonize regional fertilizer policies to encourage cross-border trade and eliminate different standards across countries. Some of the delays at border posts while clearing cargo between EAC countries can be linked to problems associated with non-harmonized fertilizer standards and regulations. The EAC is currently discussing tariff and non-tariff barriers between these states, including the previously noted different requirements for truck axle loads across the states, which cause problems to transporters.

7.0 A Synthesis of Some Options for Handling Increased Fertilizer Requirements

7.1 Option 1: Assume Status Quo in Capacity at the Port

Assuming that the status quo in physical capacity remains the same at the port, the following must occur in order to meet the new requirements: (1) efficiency in utilizing available resources has to increase at the port and on roads as well – i.e., more hours per day in operation such as a 24/7 operation and more labor input to substitute for more expensive equipment to the extent possible; (2) maintaining reliable online one-shop single window system (SWS) for filling cargo clearing documents; and (3) creating incentives for increasing the number of trucks that move cargo from the port to various inland destinations, efficiently offloading the trucks for further distribution and identifying backhaul opportunities.

This scenario also makes an additional requirement of improvements in off-take of cargo from the port. Let us assume that all fertilizer will go to Kitale, which is approximately 800 km from the port of Mombasa. A round trip to Kitale (high-potential maize area) by truck takes two days. A fleet of 500 trucks, each 10 mt, will take 40 sequential trips, a total of 80 days or approximately three months. Coupled with the delays in clearing through the port, this implies that getting the estimated national consumption of 1 million mt into the country and to various destinations may take up to four months in total. This is a simplistic analysis that makes a lot of assumptions and requires further research on available transport capacity, cargo volumes (including non-fertilizers), road conditions and trip times, etc.

7.2 Option 2: Expand Port and Other Infrastructure to Meet Increased Cargo

The alternative is to expand the port by overhauling its capacity to accommodate the increased cargo necessitated by the increased volume of fertilizer and other non-fertilizer cargo. This includes increased physical capacity at the port including necessary equipment and human resources to clear goods quickly through the port, more warehouses at port and inland cargo storage facilities (there are ongoing discussions on construction of an alternative port at Lamu to the north of Mombasa to link Sudan and Ethiopia).

These two scenarios will require significant investment by the private sector in all related aspects throughout the value chain. For instance, there will be a need for increased investment in transport services (trucks, etc.), storage facilities by businesses and contracts with financial and international commodity institutions, among others.

On the other hand, existing and new businesses will have to expand their activities to handle the increased volumes of fertilizer. The major importers will utilize their linkages with multinationals to access necessary finances for imports. However, most value chain participants (small importers, wholesalers, agro-dealers and farmers) will require financing mechanisms that will support increased investments. It is important to have financing mechanisms in place to assist existing and emerging businesses that may have problems accessing the formal financial markets. To encourage competition, policies have to encourage private investment by creating

business-friendly procedures in licensing and taxation. Market information and training of farmers and agro-dealers are other aspects of a holistic approach that will help farmers gain knowledge on the profitability of fertilizers.

8.0 Conclusions and Recommendations

Kenya's fertilizer market is more developed than other fertilizer markets in SSA countries. However, the policy environment has recently been disruptive of private sector efforts in the market. Using a value chain approach for analysis, this study generates important results based on an assessment of the response by the various stakeholders to increase fertilizer consumption to match the potential growth in agricultural production.

For the value chain to accommodate an increased volume of fertilizers resulting from growth in agricultural production as per country investment plans, a number of issues have to be addressed including:

- *Poor port facilities* and inefficient operations add to the cost of fertilizer. The domestic cost of moving fertilizer from the port to farms is a significant portion of total farm-gate prices. Delays at port and warehouse facilities result in increased costs. There is a need to increase the efficiency of current operations and/or expand port capacity. This area requires further detailed research.

- *Training of farmers/dealers and input-output market development* – Estimates show that fertilizer imports have to double in order to meet the growth targets for the agricultural sector. Current fertilizer adoptions rates are in the range 30-50 percent of households, depending on the region. It is crucial that farmers that are not using fertilizer learn the benefits of using fertilizer and how to use the input (agronomy aspects); at the same time, those already using fertilizer need to be informed of the returns or benefits from intensification and encouraged to strive for maximum economic yield. Just as important will be the development of a viable output market for the increased production. Farmers cannot make investments to increase production if they are not assured of a market for their surplus production. These simultaneous efforts to create demand at the farm level and to develop the

input and output markets are the only ways that the increase in fertilizer requirements can be achieved and sustained.

- *Low import volumes* cannot take advantage of economies-of–scale. This is a direct result of the small market size in most African countries. Competition among several importers (some of whom do not collaborate in join import operations to cut costs) and a government policy that creates uncertainty, especially regarding subsidies (state subsidy programs are not transparent), often lead to confusion on the amounts to be imported, timing of these imports and prices. All of these affect import decisions for the private sector. Low import quantities are also a subject of the low port handling capacity limiting shipping to smaller vessels (handy-size). Any regional implementation of joint fertilizer procurement by several countries is likely to face a number of challenges, including inadequate capacity for offloading imported fertilizer as well as handling the imports and distribution logistics both at the country and regional level. On the other side, the consumption amounts in most countries in Africa are relatively low compared to the potential if certain demand constraints were alleviated. Thus, detailed studies identifying challenges in the consumption rate, apart from the product availability and price, will be critical. It is particularly important to recognize that demand-influencing policies should take the center stage in developing the fertilizer market in the region.

- *Farm storage or warehouse receipt system* – Most smallholder farmers sell their produce immediately after harvest at low prices because of increased supply immediately following harvests. Farmers do this to meet immediate needs such as school fees and also due to poor storage facilities at the farms where post-harvest losses can be as high as 30 percent of the output. These two actions create immediate problems: (1) farmers miss higher prices later in the season, which would be possible with storage; and (2) the low prices for output may lower the chances of these farmers buying fertilizers in the future. Higher output prices can encourage input adoption and contribute to developing sustainable output markets (domestic and regional). Encouraging financing mechanisms that link output and input markets in a peer-group setup, in which suppliers deliver inputs on credit and deduct their cost from the sale of output from farmers, can also be useful (e.g., warehouse receipt system).

- *Policy and ad-hoc state intervention* – There is general agreement, even by private sector businesses, that temporary and targeted subsidies can help increase the number of farmers

using fertilizers, which is beneficial for businesses as well. However, intervention negatively affects business when the rules for state intervention are not clearly communicated, sending wrong signals through the market. The amount of fertilizers, the timing of imports and distribution, the prices to farmers and all relevant aspects of government subsidy operations should be advertised and adhered to. In addition, subsidies should be 'smart' (i.e., targeted to those who need them the most), and they should be withdrawn/temporary so that they do not disrupt the private sector system. Examples from Africa show that prolonged subsidies are a burden to taxpayers and also disruptive to private investments and can become unsustainable. It is important to remove constraints that hinder the development of a vibrant private sector-driven fertilizer industry. Moreover, well-facilitated fertilizer trade within the region is likely to result in reduced distribution costs and ultimately spur growth in fertilizer demand. There is a need for a study to recommend ways of addressing these challenges. Other challenges come from the differences in fertilizer regulations and legislation in the region, including different tariffs and taxes and inadequate enforcement capacity.

- *A regional perspective in fertilizer marketing and trade* is therefore necessary for the region and each country to carve out a more viable fertilizer market. This will enhance the realization of economies-of-scale and efficiency gains to stakeholders.

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