

**IMPROVING THE EFFECTIVENESS, EFFICIENCY AND SUSTAINABILITY OF  
FERTILIZER USE IN SUB-SAHARAN AFRICA**

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## EXECUTIVE SUMMARY

Fertilizer had been part of the technological trinity (improved seed, irrigation, and fertilizer) responsible for bringing about the Green Revolution of Latin America and Asia. Its adequate and efficient use should, therefore, be a main ingredient in achieving food security in Sub-Saharan Africa (SSA). At present, average fertilizer use intensity in SSA is the lowest compared to anywhere in the world and the region needs to take affirmative action to improve the situation.

The reasons for the dismal fertilizer use intensity in SSA are many and varied, and could be analyzed with respect to response rate (effectiveness), profitability (efficiency) and sustainability of use. That is what this research sought to do in order to present fertilizer related agricultural policy experiences of SSA countries and lessons learnt over the years to the region's policy makers, politicians and other stakeholders, in a form that will interest them and will be understood by them.

SSA countries' fertilizer policies have, over the years, followed a general trend of state interventions and subsidies in the 1960s and 1970s, liberalized markets and removal of subsidies in the 1980s and 1990s and a return to moderate state interventions in recent years. Responses to the fertilizer policies have, however, varied widely ranging from Kenya's largely successful market reform policies to Malawi's debatable 'successful' state intervention and subsidy policies.

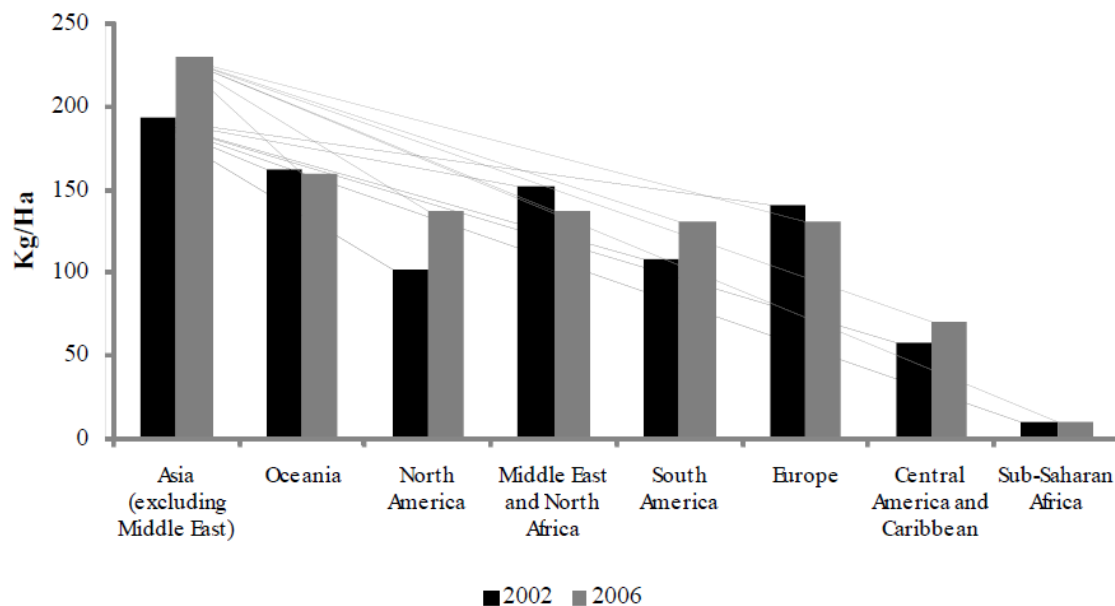
There continues to be low crop response to fertilizer application in SSA mainly because of poor fertilizer management by farmers; fertilizer unavailability at the time it is needed; lack of complementary inputs, such as improved seeds and irrigation. There has also been low profitability from fertilizer use mainly due to the low response, high fertilizer prices and low and unstable product prices. The low and inefficient use of fertilizers has hindered the growth in agricultural productivity and to some extent jeopardized the long term sustainability of African soil.

Based on the study, the main recommendations are: (1) Farmers' knowledge and skills in sustainable crop and soil management practices should be improved through well-informed and effective capacity building and extension services (2) Fertilizer distribution private sector should be developed and governments should establish supporting policy environments to attract investments into the fertilizer production and distribution sectors of the countries. In particular, transportation and market infrastructure should be significantly improved (3) Present fertilizer subsidy programs in SSA countries should be nurtured to maturity by effective targeting and by fine-tuning them in terms of organization and legislation to ensure transparency and accountability of all actors.

## I. INTRODUCTION

Increased use of fertilizer is one of the main ingredients in achieving food security in SSA. Numerous studies show that substantial agricultural productivity gains can be achieved in SSA by increasing the use of fertilizer and the efficiency of its utilization (Eicher, 1994; Ersado et al., 2004; Tomich et al., 1995; Maiangwa, 2007; Wanzala, 2001). Experiences outside Africa also highlight fertilizer's key role in boosting agricultural productivity. Fertilizer was an integral part of the technological trinity - improved seed, irrigation, and fertilizer – responsible for bringing about the Green Revolution in Latin America and Asia, and it contributed as much as 50 percent of crop yield growth in the regions (Bumb & Baanante, 1996; Duflo et al., 2003; Kikuchi et al., 1990; Mujeri et al., 2012; Viyas, 1983). Despite the growing evidence, farmers in SSA still lag far behind in fertilizer use. The average fertilizer use intensity in SSA is still the lowest at around 10 kg/Ha whereas it has reached 222 kg/ha in Asia, 160 kg/ha in Oceania and 138 kg/ha in South America (Figure 1). Even when compared with countries and crops in similar agro-ecological zone areas, fertilizer use intensity is much lower in SSA than in other developing regions, and crop yields are correspondingly lower (Liverpool-Tasie et al., 2010).

*Figure 1: Fertilizer Use Intensity By Region, 2002 and 2006*



Source: Hernandez & Torero, 2011

Fertilizer use is low in SSA for varied reasons, including unattractive crop price/fertilizer price relationship, inadequate credit availability for both farmers and dealers, poor distribution facilities, limited irrigated agriculture, continued use of local crop varieties by most farmers and low incentive in investing in land-saving technologies given the relatively low population densities (Crawford et al., 2006; Demeke et al., 1998; Kaliba et al., 2000; Kherellah et al., 2002; Zerfu & Larson, 2010). The challenge with fertilizer is not limited to its low usage. Most African farmers get low response rate from fertilizer application, i.e. relatively low production from every ton of fertilizer applied, due to inefficiency in application and/or the poor soil fertility condition (Gregory & Bumb, 2006; Mwangi, 1996). The low response rate, coupled with high

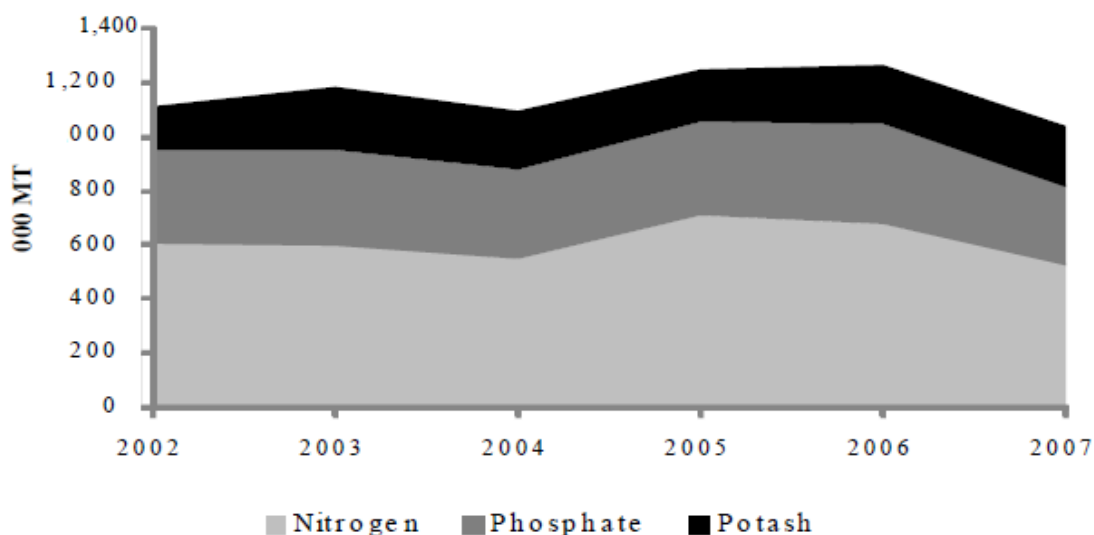
fertilizer price and fluctuating crop price, has limited the profitability of fertilizer use and hence, the demand for it by smallholder farmers. In semi-arid areas where variable rainfall causes highly variable returns to fertilizer use, the sub-optimal response rates contribute even further to lower demand (Piha, 1993). The non-optimal use of fertilizer has also deteriorated the soil quality on farmlands to such an extent that a recent World Bank study claims that SSA faces “an escalating soil fertility crisis” (Morris et al., 2007). Therefore, low and inefficient use of fertilizer are not only hindering the growth in agricultural productivity but also jeopardizing the long term sustainability of African soil and thereby, gravely undermining the prospects for ending chronic poverty and food insecurity in the region.

The striking contrast between the limited use of fertilizer in SSA and the much more extensive use of fertilizer in other developing regions has stimulated considerable policy initiatives. During the Africa Fertilizer Summit in 2006, African leaders made a unanimous commitment to take immediate actions to solve Africa’s fertilizer crisis (African Union, 2006). At country level, the fertilizer policy has been extremely dynamic over the years but the policymakers are still far from finding the best set of policies. Given this scenario, there is a need to examine the policies and actions with regards to fertilizer use in SSA countries. This study is carried out to suggest practical ways of improving the use of fertilizer. The study analyzes the effectiveness, efficiency and sustainability of fertilizer use, and also presents fertilizer related agricultural policy experiences of SSA countries and lessons learnt over the years to the region’s policy makers, politicians and other stakeholders, in a form that will interest them and will be understood by them. It is based on reviews and analyses of information contained in leading journals, reports of institutions such as the World Bank, IFPRI and FAO, agricultural/fertilizer policy documents, unpublished and published research materials from local sources such as ministries, research institutions, universities, NGOs, and through discussions with farmers, policy makers and politicians.

## II. FERTILIZER CONSUMPTION AND PRODUCTION IN SSA

Fertilizer consumption in SSA is the lowest in the world, making up only 2 percent of the 2002 world supply and expected to rise to only 3 percent by 2011/12 (Camara & Heinemann, 2006). In recent years SSA's fertilizer consumption has fluctuated and ultimately decreased to 1,041,000 MT of nutrients in 2007, as compared with 1,113,000 MT in 2002 (Figure 2). Nitrogen has accounted for more than half of the total consumption in the region. From 2002 to 2007, nitrogen accounted for 53 percent of the almost 7 million MT of nutrients consumed in SSA, phosphate accounted for 29 percent, and potash accounted for the remaining 18 percent (Hernandez & Torero, 2011).

*Figure 2: Consumption of fertilizer by macronutrient, 2002–07*



Source: Hernandez & Torero, 2011

Despite the relatively dismal aggregate trends in fertilizer use in SSA, great variability in fertilizer use has been observed within the region. Several SSA countries are still at a low level of fertilizer intensity, but about half of them have registered rapid positive growth in fertilizer intensity and a few have experienced negative growth in fertilizer use, indicating that the region has the potential to boost its fertilizer consumption (Table 1).

Table 1: Fertilizer Use Intensity and growth in Fertilizer Use Intensity, By Country

Intensity of fertilizer use, 1996-2002	% growth in fertilizer use intensity (kg/ha cultivated) (mean 1996-2002 / mean 1990-95)	
	< +30%	> +30%
< 25 kg/ha	<p>Angola (0.7, -69%)                      Burkina Faso (5.9, -28%)                      Burundi (2.3, -6%)                      DRC (0.5, -47%)                      Gambia (5.2, +15%)                      Guinea (2.0, -4%)                      Madagascar (2.9, -8%)                      Mali (9.0, +7%)                      Mauritania (4.0, -64%)                      Niger (0.9, +5%)                      Nigeria (5.6, -73%)                      Tanzania (4.8, -47%)                      Zambia (8.4, -34%)</p>	<p>Benin (17.6, +76%)                      Botswana (11.8, +294%)                      Ethiopia (14.4, +71%)                      Cameroon (5.9, +77%)                      Chad (4.3, +93%)                      Cote d'Ivoire (11.8, +53%)                      Ghana (3.6, +68%)                      Lesotho (23.2, +35%)                      Mozambique (3.2, +142%)                      Rwanda (1.8, +89%)                      Senegal (13.2, +67%)                      Togo (7.0, +30%)                      Uganda (0.6, +237%)</p>
> 25 kg/ha	<p>Malawi (30.8, +9%)                      Swaziland (30.5, -40%)                      Zimbabwe (48.3, +9%)</p>	<p>Kenya (31.8, +33%)</p>

**Notes:** Fertilizer use intensity is defined as kg of fertilizer applied per hectare cultivated to annual and permanent crops. Growth in fertilizer use intensity is defined as the percentage increase in mean fertilizer use intensity between the 1996-2002 period and the 1990-1995 period. Numbers in parentheses are mean fertilizer use intensity for 1996-2002, and the percentage increase in fertilizer use intensity as defined above.

Source: Crawford et al., 2005

Within each country fertilizer application has varied widely based on crop type, farm size, climate, and irrigation availability (FAO, 2006). For instance, fertilizer application throughout SSA mainly concentrated on maize and sorghum. Oil crops, such as groundnuts and cotton, which play major role as cash crops for smallholder farmers, also received significant amounts of fertilizer whereas roots and tubers that generally respond well to medium fertilizer application received slight fertilization (Table 2).

Table 2: Fertilizer Use by Crop in Selected SSA Countries\*

Crop	Fertilizer Use (1000 tonnes N + P <sub>2</sub> O <sub>5</sub> + K <sub>2</sub> O)	Percent
<b>Cereals</b>		
Barley	24.7	4.0
Maize	160.5	26.0
Rice	49.7	8.0
Sorghum and millet	107.8	17.4
Wheat	42.4	6.9
<b>Roots and Tubers</b>		
Cassava, taro, yam	32.3	5.3
Potato	18.9	3.1
Pulses	25.5	4.1
<b>Oil Crops</b>		
Groundnuts	11.0	1.8
Oil palm	2.8	0.5
Soybean	2.5	0.4
Fruit crops	17.1	2.8
<b>Beverages and Sugar</b>		
Sugar Cane	7.0	1.1
Coffee	17.8	2.9
Tea	9.0	1.5
Fibres: Cotton	35.1	5.7
Vegetables	26.4	4.3
Tobacco	19.8	3.2
Others	7.6	1.2

\* Ethiopia, Ghana, Guinea, Kenya, Madagascar, Malawi, Mauritania, Nigeria, Togo, United Republic of Tanzania, and Zambia (Based on data from 2002).

Source: FAO, 2006

As opposed to the global pattern, fertilizer production in SSA has shown a downward trend. Total production in the region decreased at an annual rate of 7.3 percent from 2002 to 2007, totaling 111,000 MT of nutrients at the end of the period. Out of the total 829,000 MT of nutrients produced during this period, nitrogen accounted for 54 percent and phosphate for 43 percent. Due to the limited availability of raw materials and inadequate infrastructure, the production of nutrients in the region has been concentrated in four countries: Zimbabwe, Senegal, Nigeria, and Mauritius. The amount of nutrients consumed in the region is approximately 10 times the amount produced in the region and therefore, many SSA countries tend to be highly dependent on fertilizer importation (Hernandez & Torero, 2011).

SSA exhibits the lowest levels of consumption and production in the world. Some SSA countries with low fertilizer intensity have registered rapid positive growth whereas others have experienced further decline in fertilizer consumption. The low domestic production has not been able to meet even the small fertilizer consumption demand and therefore, caused several

countries to heavily rely on importation. It is now imperative for SSA countries to make effective, efficient, and sustainable use of the limited fertilizer available to them and also to expand the domestic production capacity.

### **III. FERTILIZER POLICIES IN SSA COUNTRIES AND THEIR IMPLEMENTATIONS**

Fertilizer policy in SSA has been extremely dynamic over the last forty years. In the 1970s and early 1980s, most SSA countries were dependent on fertilizer subsidy and adopted state-led fertilizer supply policies, where governments were heavily involved in fertilizer distribution and procurement schemes via public agencies (Yamano & Arai, 2010). During this period, fertilizer use increased significantly, along with increased adoption of improved seeds, thereby raising hopes for some countries to follow the path of the Asian Green Revolution (Byerlee & Eicher, 1997). Then in the late 1980s and 1990s during the structural adjustment period, many governments adopted market reform policies, although the degree of how thoroughly these were implemented varied from country to country. Following the liberalization of most economies in the wake of several adjustments policies, government's role in the fertilizer sector became limited and subsidization of fertilizer became a "no-go" area. However, in recent times rising food security concerns have again increased the need for state involvement and already caused the emergence of innovative fertilizer promotion programs along with fertilizer subsidy in SSA's agriculture strategy realm.

Although most SSA countries have followed a general trend in terms of fertilizer policy, transitioning from enormous levels of intervention in the 1960s and 1970s to liberalization of markets of the 1980s and 1990s followed more recently by moderate interventions, there have been considerable differences in their approaches reflecting the diversity that exists within the region in terms of social, political, economical, agro-ecological and climatic aspects (Cagley & Gugerty, 2009). Consequently, the responses to the fertilizer policies have been widely varied. Few countries, such as Kenya, succeeded in implementing fertilizer market reform policy whereas other countries, such as Ethiopia and Nigeria, did not make a smooth transition and still continue to rely heavily on state intervention. On the other hand, some state interventions, such as Malawi's voucher program and Ethiopia's credit scheme, initially had significant positive effect on fertilizer consumption but over time they faced difficulty in being sustainable.

Kenya is one of the few SSA countries that has thoroughly and successfully implemented fertilizer market reform policy and experienced substantial increment in total fertilizer consumption (Freeman & Kaguongo, 2003; Omamo & Mose, 2001; Yamano & Arai, 2010). From the mid-1980s the government encouraged private firms to enter the market while initially maintaining tight controls over the market (Jayne et al., 2003; Yamano & Arai, 2010). In 1993 the government completely withdrew from the fertilizer market and abandoned price controls, and ushered the successful market reform. Several factors came into play behind Kenya's successful market reform. First, before the market reform period, the state-led fertilizer policies were successful in increasing the fertilizer use among smallholders and so many farmers easily learned about new technologies that involved high-yielding varieties and inorganic fertilizers.

Second, before and during the market reform period, Kenya had a strong cash crop sector and the sector maintained a high and stable level of demand for fertilizer. Thus, fertilizer importers and distributors in the country were willing to make initial investments in facilities to import and store large amount of fertilizers, that then reduced retail prices of fertilizer for smallholder farmers. Third, farmers who planted cash crops received fertilizer credit from cooperatives and processing firms to apply fertilizer on cash crops (Jayne et al., 2004; Yamano & Arai, 2010). The prompt response of the private-sector to public investments and market liberalization helped Kenya to make a smooth transition from the state-led fertilizer system to a market-oriented fertilizer system that ultimately led to higher fertilizer consumption.

Mozambique, on the other hand, tried to make a similar transition but faced difficulty in improving fertilizer consumption among most of the farmers. After the end of the civil war in 1992, they liberalized prices and trade, and privatized state enterprises. By the end of the 1990s, all the agricultural input markets were entirely privatized. The government phased out price controls and minimum producer prices for agricultural goods. The state marketing enterprise was restructured and mandated to only act as a buyer of last resort and the agricultural marketing system transitioned into the private sector. However, their agricultural policies focused research, extension services, and marketing only on the export crop sectors, specifically cotton and cashew (Schneider & Gugerty, 2009). The heavy focus on cash crops and the limited access to fertilizer by non-cash crop farmers restricted Mozambique's market reform to thrive like Kenya's.

Ethiopia, unlike Kenya and Mozambique, returned to state-led fertilizer marketing, after a brief liberalization of the fertilizer market. The market was liberalized in 1992 with the creation of a multi-channel distribution system. The private sector initially responded rapidly and several private wholesalers and retailers emerged. However, these private wholesalers and retailers quickly exited the market and were replaced by "private" holding companies with strong ties to government throughout the 1990s and early 2000s (Yamano & Arai, 2010). For many years regional governments intervened in fertilizer supply, initiating a 100 percent credit guarantee scheme on farmers' fertilizer purchase (Spielman et al., 2010). Currently, about 90 percent of fertilizer is delivered on credit at below-market interest rates or even at zero interest rate (Yamano & Arai, 2010). From 2007 onwards fertilizer imports were again controlled by a government parastatal and cooperatives. These state-led policies appeared successful in increasing fertilizer use until recent years and some concerns have been raised about the state-led policies. First, it is not clear how long the government can assist the farmers through expensive programs, such as the fertilizer credit programs. Second, the state-led policies have crowded out the private firms from the fertilizer market (Jayne et al., 2003). Third, the increased fertilizer use coupled with the use of improved seeds has not necessarily achieved high technical efficiency and profits. Spielman et al. (2010) argue that the low technical efficiency is largely due to the application of standard packages to vastly diverse environments and also claim that the state-dominated inputs supply and credit systems failed to deal with the timeliness and quality of fertilizer supply. Despite trying both state-led and market-led policies, the Ethiopian government faced difficulty in establishing an efficient fertilizer marketing and distribution system.

Nigeria repeatedly struggled with state-led interventions but still continue to work with state-led interventions to improve agricultural productivity. Over the years the Nigerian government has intervened in several ways, including the promotion of state monopoly for fertilizer import and

distribution, implementation of price controls and subsidies at the fertilizer retail markets, provision of credit to farmers for the purchase of fertilizer, institution of import tariffs, decentralization of procurement and distribution, and deregulation of markets (Liverpool-Tasie et al., 2010). Despite all these interventions, there has not been any significant success. Moreover, the heavy emphasis on price subsidization to the detriment of other approaches, such as complementary actions to improve farmers' fertilizer-use techniques (e.g., extension programs), seeking lower transactions costs (e.g., better regulatory environment), or reduced risk (e.g., fertilizer quality control) has hampered market development in Nigeria (Yanggen et al., 1998). The frequent changes in fertilizer policies and promotion of a dual fertilizer market (subsidized and free-market) prevented the required response from the private sector in taking over the role played by the public sector. In addition, problems with fertilizer quality, arbitrage, and timeliness of fertilizer distribution persisted throughout most of the period (Liverpool-Tasie et al., 2010). Therefore, like Ethiopia, Nigeria's attempt at a Green Revolution has so far failed because of too much reliance on state intervention.

Uganda took a completely different path from other SSA countries discussed above. When the governments of other SSA countries were heavily involved in the fertilizer distribution in the 1970s and early 1980s, the Ugandan government was deeply involved in civil conflicts and was unable to implement any meaningful agricultural policies. By the time the new government took over in 1986, the structural adjustment programs had started in other African countries, and so the Ugandan government quickly adopted such policies. However, due to the lack of basic market structure to build upon, the scale of fertilizer market never became large enough to capture any scale economies (Yamano & Arai, 2010). Omamo (2003) show that the fertilizer market structure was dominated by smallholder trade, high prices, and low net margins. This was due to the poor transportation infrastructure and the country's remoteness from the major ports. There has been no sign of expansion of the fertilizer market for decades and still now the total fertilizer consumption (nitrogen fertilizer) is at a low level, about 5 percent of the Kenyan fertilizer consumption and 12 percent of the Ethiopian fertilizer consumption (FAOSTAT, 2010). Therefore, Uganda is now left at a crossroad as to which approach they should take in formulating future fertilizer policies.

Like Kenya, Malawi is cited regularly as a symbol of how an effective fertilizer policy lifted a country out of low productivity even though their approach to the fertilizer crisis has been radically different. Malawi eliminated universal fertilizer subsidies for smallholders in the mid-1990s, but reintroduced limited subsidies in 1998 through the Starter Pack program, which gave all farmers 10 to 15 kg of fertilizers and enough improved seeds to plant 0.1 of a hectare. In 2000, the program was converted into the Targeted Input Program (TIP), which distributed the packs to a targeted group of farmers. Later in 2005, the program was again redesigned as the Agricultural Inputs Subsidy Program (AISP), a voucher-based universal subsidy program that allows farmers to buy 100 kg of fertilizer at about one-fifth of the market price, thus dramatically increasing both the quantity of fertilizer being subsidized and the fiscal cost of the subsidy (Minot & Benson, 2009). The consistent effort of the Malawian government in adapting their subsidy program to the needs of the farmers led to significant increases in maize production and productivity and ultimately, contributed to 'increased food availability', higher real wages, wider economic growth and poverty reduction (Chirwa & Doward, 2011). Nonetheless, the 'success' of the subsidy programs repeatedly came under attack for its high burden on government's budget

and questioned for its sustainability and long-term impact on smallholder welfare. In 2008/09 the cost of subsidy to the government was about 16% of the total government budget (Wiggins & Brooks, 2010). Then again the subsidy helped the government to avoid making any costly food imports as it had to in the years immediately preceding the subsidy (Chirwa & Doward, 2011). Moreover, in Malawi 75% of the country's 2.4 million smallholders are subsistence farmers with an average of less than one hectare of land and for many years have suffered serious food deficits as they cultivated on the same plot of land year after year with no restoration of nutrients and the subsidy has indeed prevented widespread hunger.

Successes and failures of the policy reforms in various SSA countries have been thoroughly studied by researchers (Kherallah et al., 2000, Jayne et al., 2003; Jayne et al., 2004; Spielman et al., 2010; Yamano & Arai, 2010). Unfortunately, the results of the various studies show inconclusiveness regarding the impact of various fertilizer policies on agricultural production and productivity. However, they do indicate that the fertilizer policy formulation in SSA has always been trial and error and/or "bandwagon" type. The policies were not always based on critical agronomic and economic analyses of the advantages, disadvantages, opportunities, challenges and the very dynamic nature of the agricultural industry. Several challenges, such as high fiscal and administrative costs, insufficient capacity to implement fertilizer policy effectively, disproportionately targeted subsidies and reliance on "one-size-fits-all" philosophy that failed to recognize the diversity of production systems and the range of farmers' needs, have hampered the formulation of effective fertilizer policies in the region (Morris et al., 2007).

## **IV. EFFECTIVENESS, EFFICIENCY AND SUSTAINABILITY OF FERTILIZER USE IN SUB-SAHARAN AFRICA**

### **4.1 Preamble**

The bottom line of the arguments on how to achieve better use of fertilizer revolves around the effectiveness, efficiency and sustainability of fertilizer use. By effectiveness the question that is being addressed is: Is fertilizer achieving the full agronomic purpose for which it is applied? This question is not a simple situation of yields in the short term. It involves long term effects on the soil and use or non-use of complementary inputs. With regard to efficiency, the main question is whether fertilizer use by the numerous African small farmers is profitable. Are the returns significantly greater than the cost of fertilizer use? This is also not a simple matter of costs and returns in the short term. It will also involve crop response rates, price movements of fertilizers and crops, as well as production risk and credit availability. In the case of sustainability, we are interested in whether fertilizer use will ensure that agricultural production and productivity be better or at the least not worse in the long term. The questions to address are: How can fertilizer use ensure that production and productivity will improve in the long term? Can fertilizer use increase production and productivity and still guarantee that the resource base of the African continent will be protected for future generations?

## 4.2 Effectiveness

Between 1962 and 2008, average cereal yields in South Asia and East Asia increased from 1 to 2.6t/ha and from 1.5 to 5.4t/ha respectively, but in SSA it only increased from 0.8 to 1.5 t/ha, causing cereals (and aggregate crop) output per person to fall substantially (Hunt, 2011). Low and inefficient use of fertilizer were two key factors behind low crop yields in SSA. Several studies show that the crop response to fertilizer on farmers' fields, even when farmers use recommended rates, are much lower than the potential (experimental) yields found in on-station and on-field fertilizer trials all over Africa (Fisher et al., 2009; Evenson & Gollin, 2003; Suri, 2007; Titttonell et al., 2008). The low crop response rate to fertilizer is not inevitable. Based on the results of a large number of trials and demonstrations carried out in the context of the FAO Fertilizer Program, it is found out that the response of crops to fertilizers in Africa is comparable with that of other regions (FAO, 1989). Table 3, containing the ranges of productivity indices, actually indicate that Africa has generally higher indices for maize, pulses and oil crops and there are no marked differences for rice and cotton.

*Table 3: Fertilizer productivity on selected crops in Africa, Asia and Latin America*

Crop	Africa	Asia	Latin America
	Fertilizer productivity index		
Wheat	4 – 8	8 – 12	4 – 8
Rice	8 – 12	8 – 12	8 – 12
Maize	8 – 12	4 – 8	4 – 8
Sorghum	4 – 8**	8	< 12*
Pulses	4 – 8	< 4	< 4
Oil crops	8	4 - 8	4 – 8
Cotton	4	< 4*	< 4*

\*Brazil only

\*\*Africa: including millet

Source: FAO, 1989

The fertilizer response rate can be increased through the selection of crops which are more responsive to fertilizer application such as maize and rice, the selection of areas with more reliable rainfall patterns and soils which are more responsive to fertilizer application. The effectiveness of fertilizer use improved significantly when farmers shifted from groundnut to irrigated rice and horticulture in Senegal; from maize to tobacco in Malawi; and from millet and sorghum to improved maize varieties in northern Ghana, Burkina Faso and Mali. Despite such measures, fertilizers are not fully effective (Merteens, 2005). Fertilizer's full agronomic potential is often unrealized because of (a) poor soil fertility caused by mismanagement of fertilizer at the farm level (b) failure of the extension service to inform farmers about appropriate technology (c) poor availability of fertilizer (d) lack of complementary inputs. However, it must be noted identifying the factors responsible for low effectiveness of fertilizer at the macro level is a difficult task as fertilizer response are best analyzed at the micro level for specific agro-ecological and market situations and by taking into account the individual farmer's resource constraints and risk preferences.

### *Fertilizer Mismanagement*

Survey data on crop response to fertilizer commonly indicate that the contribution of fertilizers to food grain yields varies tremendously across farms even within same villages (Xu et al., 2009). The difference in effectiveness most likely reflects differences in farmer's management ability and knowledge about appropriate fertilizer application rates. Crop management practices, such as manure application, crop rotations, intercropping, reduced tillage, and improved fallows that improve soil fertility, are still not widely practiced across the region and in turn have limited crops' responses to fertilizer. In most circumstances, farmers have either completely ignored fertilizer recommendations or relied only on the "one-size-fits-all" recommendations provided through the extension services (Spielman et al., 2010). Heterogeneous soil conditions and differing crop needs throughout the region made proper fertilizer management even more challenging (Tittonell et al., 2005; Zingore et al., 2008; Barrett & Marenya, 2009a).

### *Poor Extension Services*

Lack of relevant agronomic information, researchers and extension personnel prevent farmers from attaining better crop responses and jeopardize the long term sustainability of the soil. The current extension services in SSA countries are not sufficient to equip farmers with the knowledge and decision making skills needed to manage fertilizer through approaches that take into account the heterogeneity of the crops and soils. Still now the traditional top-down extension approaches that were designed for delivering standardized recommendations to all farmers are used throughout region. Not only are most recommendations the same for decades but they are the same for all parts of the countries. That for sure is scientifically impossible given the degree of nutrient mining that has characterized African agriculture and the diversity in ecologies within countries. A field study by Duflo et al. (2003) in western Kenya came to a conclusion that fertilizer is a profitable investment even under actual conditions on the farmers' farms but "it appears official package recommended by the Ministry of Agriculture is actually more risky, and less profitable on average". But the problem goes far beyond the poor performance of the agricultural extension services in the region. Other factors behind the agricultural extension not working well include: (i) the inability of technical and social scientists to effectively communicate consistent and financially sound recommendations to the extension agents (ii) poor strategy for targeting research recommendations and extension messages to farmers in specific agro-ecological and socio-economic zones (iii) limited effort to disseminate information beyond farmers participating in research trials or extension demonstrations (iv) lack of a system to monitor and evaluate the diffusion process, which limits people's understanding about the adoption and adaptation processes and farm-level impacts and (v) inconsistency in agricultural policies (especially relating to credit, price and subsidy), which makes it difficult for farmers to assess benefits and sustain fertilizer adoption (Kelly, 2005). In order to maximize the potential of the extension services it also important to increase farmers' capacity to learn, evaluate, adopt, and adapt the most appropriate technologies for their situations from a pool of available ones. Consequently, extension agents, both public and private, should be provided with training in farm management and marketing analysis and in more participatory extension methods than have been used in the past. One approach that has proved to be particularly effective in building farmers' confidence in their ability to use fertilizer properly involves the use of demonstration plots. Demonstrations have been scaled up and used effectively in Malawi and Kenya, largely in

conjunction with NGO programs to build agro-dealer supply networks (Phiri, 2004; Blackie & Albright, 2005). Farmer field schools are also proving to be an effective forum for farmer experimentation and direct learning within the local community (Friis-Hansen et al., 2004).

### *Fertilizer Unavailability*

Fertilizer is often unavailable at the right time and place. Factors limiting supply include unfavorable business environment, poor transport and communications infrastructure. Unavailability in some areas stems from policy uncertainty associated with government activity in the market. In some villages of Malawi and Zambia there have been inadequate and/or late supplies because suppliers were unwilling to risk investing in imports when there is a chance that government or donor programs will also import and sell at subsidized prices (Xu et al., 2009). Moreover, the absence of fertilizers and high fertilizer prices cause farmers to seek for low-analysis fertilizers that enter the markets through unofficial channels or are intentionally or unintentionally distributed after re-bagging fertilizers into smaller packages (Turuka & Kilasaru, 2002).

### *Lack of Complementary Inputs*

Fertilizer is only one aspect of the crop production process. Complementary factors such as use of improved seed, irrigation, and weeding are highly important for increasing crop yield and in SSA these factors face constraints (Duflo et al., 2009; Kherallah, 2002; Morris et al., 2007). Water availability has become a serious problem in many countries, particularly in southern and eastern Africa. In Sub-Saharan Africa, only 4.3 percent of arable land is irrigated, compared with a world average of 19 percent (Shapouri, 1999). Enough existing evidences show that fertilizer responds better (and farmers are more likely to adopt it) in zones where rainfall exceeds 700 mm per year or in other words where there is better soil moisture supply (Lele & Stone, 1989; Matlon, 1990; Jha & Hojjati, 1993; Thompson, 1987). In Burkina Faso, combining tied ridges with moderate levels of inorganic fertilizer increased sorghum yields by 90 to 440% (Sanders et al., 1996). Improvements in the generation, release, and adoption of improved maize seed technologies are likely to improve the uptake of fertilizer use by smallholder farmers and the associated gains in crop productivity (Suri, 2007). Hence, it is essential to make investment in drought-mitigating and water-harvesting techniques that could allow farmers to manage production risks more effectively by adopting new and improved plant varieties that are drought resistant, pest resistant, and tailored to a rain-fed environment.

Maximizing the agronomic efficiency of the applied nutrients and thereby, improving crop productivity should be high priority for all the SSA countries. Projections estimate that more cereal grain will be required by 2050 to feed the growing population in SSA and that will require increased use of fertilizer with higher effectiveness (Ladha et al., 2005). Furthermore, the increase in crop response to fertilizer will increase farmers' profitability and accelerate the adoption of fertilizer.

### 4.3 Efficiency

Profitability of fertilizer use in SSA is lower than those observed elsewhere in the developing world, reflecting the low crop response to fertilizer, the region's poorly developed marketing systems and its difficult production environment. Studies, using Value Cost Ratio (VCR) i.e. ratio of the technical response to fertilizer use and the nutrient/output price, clearly indicate that low profitability is observed throughout the region (Jayne et al., 2003; Wanzala et al., 2001, Yanggen et al., 1998). Table 4, containing VCRs for the main fertilized crops in some selected SSA countries, shows that generally the VCR ranges between 3 and 2, but there are some SSA countries, such as Malawi, Zambia and Tanzania, with VCRs even below 2<sup>1</sup> (Kelly et al., 2005).

*Table 4: Value Cost Ratios (VCRs) for fertilized crops in some SSA countries*

Country	Crop-Fertilizer	VCR during early 2000s
Benin	Cotton-NPKSB	3.2
Cote D'Ivoire	Rice-Urea	2.3
	Cotton-NPKSB	2.7
Mali	Rice-Urea	3.3
	Cotton-NPKSB	3.0
Burkina Faso	Cotton-NPKSB	2.2
Ghana	Maize-AS	2.2
Senegal	Groundnuts-Mixed Fertilizers	3.0
Ethiopia	Maize-Urea	2.3
Togo	Cotton-NPKSB	3.0
Kenya	Maize-Urea	2.8
Cameroun	Cotton-NPKSB	1.7
Zimbabwe	Maize-Urea	2.6
Malawi	Maize-Urea	1.3
Nigeria	Maize-Nitrogen	3.1
Zambia	Maize-Nitrogen	1.1
Tanzania	Maize-Nitrogen	1.1

Source: Kelly et al., 2005

More recent studies confirm that low profitability is still an issue in SSA. Bumb et al. (2006) calculate VCR in West Africa and report that in all crops (except groundnut) the average VCR is less than 3 (Table 5). Similarly, Guo et al. (2009) estimate VCRs in selected East African countries under different market access scenario and conclude that VCR is around 2 (Table 6). Jayne et al. (2008) show that in Malawi 55 kg of nutrient per hectare applied to local maize gives a 750 kg/ha increase in yield over unfertilized local maize and gives a VCR of 1.23 while Xu et al. (2009) illustrate that in the more remote areas of Zambia, where farmers face nitrogen-maize price ratios that are 20 percent higher than elsewhere, fertilizer use is profitable only for a minority of farmers.

<sup>1</sup> A ratio equal to two is generally considered as the minimum requirement for a farmer to adopt fertilizer and a ratio of three to four to be necessary when production or price risk is high

*Table 5: Typical Value-Cost Ratios (VCR) of Fertilizer Use in West Africa*

Crop	Typical VCR	Minimum VCR
Maize	2.8	1.5
Rice	2.4	1.6
Sorghum	1.9	1.1
Millet	2.9	0.6
Cotton	1.5	0.6
Groundnut	3.4	1.5

Source: Bumb, 2011

*Table 6: Value-Cost Ratio with 35 Kg N/Ha Application in some East African Countries*

Country	Market Access			
	High	Medium	Low	Average
Burundi	2.5	2.0	2.0	2.25
Kenya	2.75	2.25	1.5	2.25
Rwanda	2.0	1.5	1.5	1.75
Tanzania	3.25	2.75	1.25	2.5
Uganda	3.0	2.0	1.75	2.0
Total	2.75	2.25	1.5	2.25

Source: Guo et. al., 2009

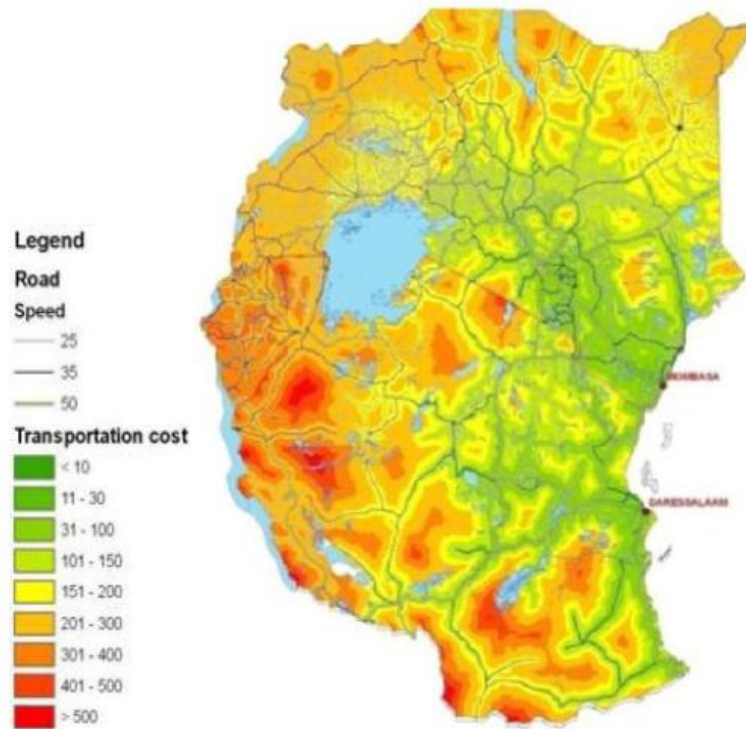
Profitability, as measured by VCR, mainly depends on three factors: crop price, fertilizer price and response of the crop to fertilizer application. Response rate is a parameter that changes from farmer to farmer, with farmers who have better farming skills or those living in higher potential zones using fertilizer more effectively and therefore obtaining higher response. As discussed earlier in SSA, the response rates are not very satisfactory and significant improvements are needed. It can be increased by the selection of the most appropriate type of fertilizer (percentages and types of nutrients), the use of the most efficient application method (type, number and timing of applications), improved water control (e.g. smallholder irrigation) and through a better management of the fertilized crop involved (timely weeding, adequate pest control, timely harvest and proper post-harvest techniques). Fertilizer prices as well as crop prices also vary significantly across space that even within the same region fertilizer profitability differ. The crop price can even vary from one household to another depending on whether that household is a net seller of the crop, a net buyer, or neither. These complexities and dynamic nature make it difficult for categorical statements to be made with respect to the profitability of fertilizer use in any particular location.

### *Fertilizer Price*

Fertilizer prices in SSA are generally high because of low volumes of production, poor infrastructure, low population densities, inadequate and costly financial services. Distance itself is a major cause of high marketing costs for some countries, where farms are very far from the nearest port (Guo et al., 2009). Figure 3, based on a paper using GIS data, show how fertilizer

transport costs vary across East Africa as a result of distance, transport, road conditions, and slope of the roads. Policy uncertainty and structural problems also keep transportation, handling, and port clearance costs unnecessarily high. There are a number of other problems that inflate costs. The first is poor security that leads to high losses from the theft of fertilizer in transit and storage. Second, poor-quality warehouses and long storage periods in humid climates lead to substantial losses from fertilizer caking. Third, limited port capacity adds further to costs since large shipments face delays and high demurrage charges. Fourth, national regulations that require distribution by domestic transporters sometimes necessitate an additional round of offloading and loading, which adds to costs and increases security problems. Fifth, importation of low analysis fertilizers increases the transport cost per kilogram of fertilizing nutrient and results in farmers often paying more for less. Landlocked countries may also face levies imposed by countries through which the fertilizer travels. In a number of countries, war and internal strife have damaged railways and trunk roads and, for some landlocked countries, have resulted in the closure of the most direct route from a seaport (e.g., the case of Mali following disturbances in Côte d'Ivoire). The end result of these deficiencies is that often more than half the price that SSA farmers pay for fertilizer comprises costs incurred between the port and the point of retail sale (Kelly & Crawford, 2007).

Figure 3: Fertilizer Transport Cost Across East Africa



p. 8, cost in USD/metric ton

Source: Guo et al., 2009

Typically SSA countries introduce subsidies to reduce fertilizer price but because of its opportunity cost in terms of investments foregone in infrastructure, crop science technology, extension, management practices, output and financial market development, alternative approaches are recommended. Reduction in the cost of fertilizer manufacture and/or importation

as well as the improvement in infrastructure can lower prices of fertilizers and costs of delivery. Published estimates suggest that cost reductions of 10-20 percent from transportation improvements of this type are possible (Jayne et al., 2003; IFDC, 2005; Wanzala, 2003). The farmgate fertilizer price can be lowered through the following: (i) Reduction in the costs of port clearance (ii) Reduction in the costs of transportation and distribution (iii) Pooling of import transactions across countries (iv) Selection of fertilizer types with high nutrient contents (v) Better access of private traders to market and finance information (vi) Collective farmer action in fertilizer purchase via farmer associations or cooperatives (Kelly et al., 2005), the use of fertilizer subsidies and the provision of fertilizers on credit at low interest rates. Additional cost savings could also be realized by improvements in governance and general operational efficiency that stem from broad economic development and better controls on corruption.

### *Output price*

While prices of fertilizers tend to be generally stable, those of outputs are generally very unstable even within the same season for some crops leading to high uncertainty with regard to profitability. Fertilizer/output price ratios for SSA as compared to Asia and Latin America have been less favorable for most of the principal crops (Yanggen et al., 1998). Comparison of fertilizer-crop price ratios over time indicated that the ratio more than doubled in Benin, Ghana, Nigeria and Tanzania and increased by about 50% in Malawi, Senegal and Zambia. It however decreased in Ethiopia, Kenya and Zimbabwe (Kherallah et al., 2002). The policies and actions that aim at keeping food prices low as a result of increased production, without decrease in cost of production per unit output, will only result in drastic decreases in farmers' profitability and general instability of the agricultural industry. Hence, government policies should thus consider as very important the existence of stable product pricing regimes.

Even if the farmers achieve VCRs above two or even three to four, still there is no guarantee that farmers will start applying fertilizers in their fields. Highly volatile output prices from one season to another and production risk make it very difficult for farmers to assess the eventual benefit of fertilizer use. Yields and output prices vary so widely on a year-to-year basis that farmers fear that in any given year their crop income will not be high enough to cover their fertilizer costs. Profitable use of fertilizer during a season with good rainfall can be followed by a season with even a negative effect of fertilizer application due to several prolonged dry spells (Wallace and Knausenberger, 1997). Improvements in the collection and dissemination of market information, coupled with training of farmers in how to use the information, could reduce some of the price risk associated with fertilizer use (Kelly & Crawford, 2007). Private firms have few incentives to provide market information services as they cannot easily prevent buyers of their services from re-selling the information to others. Public investment in the collection and distribution of market information is necessary and in the long-run the public funding for market information services can be supplemented by private funding, as is now happening in Mali (Sansoni 2002; World Bank 2004). Interventions that directly address the production risk in profitability, such as improving and expanding extension activities to disseminate appropriate fertilizer recommendations, agricultural research to develop crop varieties that are responsive to fertilizer, and investments in complementary technologies like irrigation, would also lead to increased demand for fertilizer. The development of commercial risk mitigating instruments is in its infancy in Africa and not broadly supported as a feasible option in the short-run. Reliance on

non-discretionary and objectively verifiable indicators such as a rainfall index can substantially reduce opportunities for farmers to misrepresent crop losses and gain unjustified compensation (Ibarra, 2005).

Poorly functioning financial markets for input credit constrain farm-level demand for fertilizer across the continent. During the reform period there were clear declines in fertilizer use in Zimbabwe, Tanzania, Malawi, and Senegal following the tightening of credit programs or their dissolution due to high default rates (Eicher and Kupfuma, 1997; Kelly, 1988). The key constraint in the development of credit markets is information asymmetry and there are no institutions to help lenders assess the borrowers' creditworthiness. This problem is further exacerbated by the relatively large cash requirements for inputs compared to net farm incomes, high output price risks, the high administrative costs of developing credit services for smallholder farmers, smallholder farmers' lack of acceptable collateral, the culture of strategic default fostered by the prior state systems, and the near impossibility of lenders obtaining legal redress in the event of default (Crawford & Kelly, 2007).

Therefore, by reducing fertilizer costs and risk, increasing or stabilizing producer prices and improving fertilizer use effectiveness, profitability of fertilizer use can be improved in SSA, which is also the underlying driving force for expanding fertilizer adoption.

#### 4.4 Sustainability

African soils have inherent difficulties for agriculture, in terms of fertility, acidity, and drainage. Land use practices and harsh climatic conditions over the years have further degraded the soil through nutrient mining by crops, leaching, and inadequate erosion control (Buresh et al., 1997; Scherr, 1999; Smaling et al., 1997; Stoorvogel & Smaling, 1990; Sanchez et al., 1997; UNEP, 1997; Weight & Kelly, 1999). The deterioration of the soil quality is now of such an extent that a recent World Bank study claims that SSA faces “an escalating soil fertility crisis” (Morris et al., 2007). Henao and Baanante (2006) estimate that in 2002–04 as much as 85 percent of African countries had nutrient mining rates of more than 30 kg per hectare of nutrients per year, and 40 percent had rates greater than 60 kg per hectare per year (Table 7). The rapid soil nutrient depletion and likely degradation have already affected agricultural productivity and are partly responsible for decreasing crop yield and per capita food production in SSA (Henao and Baanante, 2006).

*Table 7: Countries Grouped by Average Levels of Losses of Nitrogen, Phosphorus, and Potassium (kg/ha per year), 2002-04 Cropping Seasons*

Moderate/Low Less than 30 kg/ha		Medium Between 30 and 60 kg/ha		High Greater than 60 kg/ha	
	(kg/ha)		(kg/ha)		(kg/ha)
Egypt	9	Libya	33	Tanzania	61
Mauritius	15	Swaziland	37	Mauritania	63
South Africa	23	Senegal	41	Congo Republic	64
Zambia	25	Tunisia	42	Guinea	64
Morocco	27	Burkina Faso	43	Lesotho	65
Algeria	28	Benin	44	Madagascar	65
		Cameroon	44	Liberia	66
		Sierra Leone	46	Uganda	66
		Botswana	47	Congo Democratic Rep.	68
		Sudan	47	Kenya	68
		Togo	47	Central Africa Rep.	69
		Côte d'Ivoire	48	Gabon	69
		Ethiopia	49	Angola	70
		Mali	49	Gambia	71
		Djibuti	50	Malawi	72
		Mozambique	51	Guinea Bissau	73
		Zimbabwe	53	Namibia	73
		Niger	56	Burundi	77
		Chad	57	Rwanda	77
		Nigeria	57	Equatorial Guinea	83
		Eritrea	58	Somalia	88
		Ghana	58		

Source: Henao and Baanante, 2006

Decline in soil fertility in SSA is largely attributable to poor soil management practice, which in turn is made worse by other factors such as inappropriate land use policies, insufficient commitment to investment in agricultural research, falling agricultural prices, land availability

constraints and ill defined property rights (Gruhn et al., 2000). The decision to recapitalize soils is generally a private one made by individual farmers on the basis of perceived financial returns. Farmers tend to focus on the short-run benefits of recommended technologies (e.g., the immediate returns to fertilizer) and fail to take into consideration the importance of long-term benefits from soil recapitalization, including long-term returns to fertilizer as well as those benefits that accrue to society in general, particularly future generations (e.g., more productive soils, improved food security). Moreover, under the current input/output price ratios, the fertilizer investment required to “prime the recapitalization pump” is relatively very expensive in SSA and thereby, farmers have few incentives for soil recapitalization (Weight & Kelly, 1998).

Insufficient and unbalanced fertilization of soils using chemical fertilizers as well as lack of nutrient conservation technology adoption by farmers are responsible for accelerating the rapid decline in soil fertility (Weight & Kelly, 1998). The efficient uses of both inorganic and organic fertilizers, through Integrated Nutrient Management approach, will form an important element of a holistic approach for sustainably increasing fertilizer use in most areas of SSA. Activities, including improved fertilizer management practices, general well-informed agricultural extension services as well as adoption of the most appropriate and cost-effective technologies, such as deep placement of fertilizers and the use of inhibitors or urea coatings, need to be promoted to improve the long-term fertilizer use effectiveness. Different nutrient conservation techniques have the potential to help restore soil fertility by preventing the physical loss of soil and nutrients through leaching and erosion. First, practices such as terracing, alley cropping, and low-till farming alter the local physical environment of the field and thereby prevent soil and nutrients from being carried away. Second, mulch application, cover crops, intercropping, and biological nitrogen fixation act as physical barriers to wind and water erosion and help to improve soil characteristics and structure. Organic manures such as animal and green manures also aid soil conservation by improving soil structure and replenishing secondary nutrients and micronutrients (Gruhn et al., 2000; Kumwenda et al., 1996; Omotayo, 2009). In addition, there is a great need to break free from the conventional fix of one-way technology transfer from researcher to farmer (Deugd et al., 1998). Interactive relationships should be established so that there is more cooperation and coordination between farmers and researchers to exchange information and disseminate technologies that take into account immediate farmers’ needs along with longer-term soil fertility and agricultural sustainability requirements (Gruhn et al., 2000). These should then be supported by different fertilizer policies, such as offering direct subsidy and/or improving foreign exchange access, reducing direct and indirect taxes on fertilizer imports, and by investing in infrastructure that reduces transportation costs, and promotes greater efficiency in agricultural input and output markets (Weight & Kelly, 1998).

The on-going reduction of plant nutrients may well lead to irreversible degradation and soil infertility unless concerted and committed efforts are made by actors from a variety of sectors, including the private and public sectors, scientific and policy organizations, to help intensify future agricultural production in a manner that conserves the natural resource base and prevents further degradation that has characterized African soils for generations.

## V. ASSESSMENT OF SUB-SAHARAN AFRICAN COUNTRIES' FERTILIZER SUBSIDY PROGRAMS

Fertilizer subsidy has always been central to SSA countries' fertilizer policy history as it is seen as an effective way to kick-start innovation, stimulate rapid market development both at farm-level and industry-level, and counteract the negative externalities that result from soil fertility depletion. All SSA countries implemented fertilizer subsidy schemes at some point or the other, with the level of subsidy varying from quite modest (20 percent or less) to as high as 90 percent (Morris et al., 2007). From the late 1960s till 1980s, SSA countries relied on high universal fertilizer subsidies, administered through state-owned enterprises, to improve agricultural productivity and boost food production. However, in practice the outcomes of the fertilizer subsidies have generally not been satisfactory. Empirical studies on the cost effectiveness of past subsidy programs overwhelmingly suggest that the high costs associated with them exceeded their benefits (Morris et al., 2007). The inefficient programs caused unsustainable fiscal burden on government budgets, and their administrative weaknesses resulted in pervasive problems of late delivery of fertilizers and delivery of inappropriate and/or incorrect amounts of fertilizers. In many cases the subsidy programs, which involved state monopolies in fertilizer marketing, rent-seeking activities and political manipulation led to rampant leakages and diversion of fertilizer from intended beneficiaries, and in the long run undermined the emergence of efficient, widespread private input distribution networks.

In response to the high fiscal cost and ineffective implementation of fertilizer subsidies, as well as pressure from international financial institutions, almost all SSA countries liberalized their fertilizer markets to some degree as part of structural adjustment programs carried out in the late 1980s and early 1990s. Under these reforms, governments eliminated state monopolies on fertilizer distribution and phased out universal subsidies, and subsequently experienced rises in fertilizer prices. In a case study of 10 SSA countries, Kherallah et al. (2002) show that between the early 1980s and mid-1990s fertilizer-to-crop price ratios doubled for four countries (Benin, Ghana, Nigeria, and Tanzania), increased by at least 50 percent in three more (Malawi, Senegal, and Zambia), and fell in the remaining three (Ethiopia, Kenya, and Zimbabwe)<sup>2</sup>. The scale-back or complete curtailment of fertilizer subsidy programs ultimately had evident effects on fertilizer use in SSA countries, including Ghana, Malawi, Nigeria, Tanzania, and Zambia.

In recent years due to rising food security concerns, fertilizer subsidies have re-emerged in the agricultural strategies of several SSA countries (Morris et al., 2007). The Malawian government pioneered the return to large-scale subsidies in 1998 when it started distributing free fertilizer after having discontinued similar programs in the early 1990s. The Nigerian government resumed its fertilizer subsidy programs in 1999 after halting its decades-long involvement in fertilizer subsidization, procurement, and distribution in 1997. In 2000, the Zambian government instituted a food security program, in which it distributed seeds and fertilizers to poor households. In 2003, the Tanzanian government returned to subsidizing fertilizer and later redesigned its fertilizer transport subsidy program as a voucher-based subsidy, in which farmers received vouchers for 100 kg of fertilizers, other agrochemicals, seeds, and seedlings,

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<sup>2</sup> This happened because fertilizer distribution became more efficient or output price increases under the reform programs more than compensated for the increased fertilizer prices.

redeemable at any private agro-input dealer (Banful, 2010). Fertilizer subsidies, despite their deficient past, continue to be perceived as the best choice for governments to jump-start their agriculture sector and to deliver concrete food security to the rural poor.

Fertilizer subsidies of the 21st century have gone through significant changes to address the pitfalls of the past programs. Innovative approaches, including input vouchers, demonstration packs, matching grants, credit guarantees and weather insurances, have been piloted to stimulate fertilizer use (Morris et al., 2007; Gregory and Roy, 2005; Gregory, 2006; McKean & Ostrom, 1995; van der Meer & Noordam, 2004; Kelly et al., 2003). Efforts have been made to design market-smart subsidies that not only address demand and supply constraints simultaneously but also function in a transparent and cost-effective manner. In order to address supply constraints, subsidies are administered in a manner that provides incentives for the development of commercial supply (e.g., the use of input vouchers redeemable by private sector stockists) and rural financial markets (e.g., use of vouchers that provide credit through local institutions rather than free or subsidized fertilizer). On the demand side, market-smart subsidies are used to link fertilizer use to complementary farming practices and technologies (e.g., improved seed and water conservation practices that increase fertilizer use efficiency and reduce risk) and designed to target vulnerable groups (Kelly & Crawford, 2007).

Despite the innovations, fertilizer subsidy programs that are now in practice fail to remain immune to some of the problems that plagued the subsidy programs back in the 1970s and 1980s. Some of the key problems faced by subsidy programs are:

#### *Unsustainable burden on government budgets*

Fertilizer subsidy schemes tend to have extremely high fiscal costs that make them financially unsustainable and limit the government's ability to finance long term investments in market development, agricultural research, transportation infrastructure, or other public goods. Over the years, Zambia's government has allocated up to 40 percent of the agriculture budget for fertilizer subsidies and that has left relatively little for the the long-term investments in infrastructure, research, and extension services needed to develop efficient fertilizer markets (Ariga et al., 2006). In Malawi the cost of the subsidy during 2008/09 was about 16% of the total government budget due to the program expansion and world fertilizer price hike (Wiggins & Brooks, 2010). In addition to the direct subsidy cost, the subsidy schemes when administered through state procurement and distribution systems tend to have very high administrative costs relative to what could be achieved through the private sector.

#### *Crowding out private sector*

Fertilizer subsidies may cause partial displacement of commercial fertilizer demand and hinder policy objectives to promote sustainable development of commercial input distribution systems (Xu et al., 2009; Ricker-Gilbert, Jayne & Chirwa, 2011). By lowering the prices received by suppliers of fertilizer, fertilizer subsidies undermine incentives for private firms to invest in production and marketing. Govereh et al. (2006) show that in Zambia in areas where the private sector had been active, an additional ton of fertilizer distributed under government programs resulted in a 0.12 ton reduction in total fertilizer use. The findings were also consistent with "on

the ground” feedback they received from commercial distributors in Zambia who indicated that they waited to see where government programs were operating and then arranged to distribute their fertilizer to other areas where they did not have to compete with the government programs. Empirical evidence from Malawi also show that on average 1 additional kg of subsidized fertilizer crowds out 0.22 kg of commercial fertilizer, and the crowding out ranges from 0.18 among the poorest farmers to 0.30 among relatively less-poor farmers<sup>3</sup> (Ricker-Gilbert et al., 2011).

The crowding out of the private sector is not inevitable in a subsidy regime. The use of input vouchers, which can be redeemed at local retail stores rather than direct distribution, has the potential to maintain and improve the capacity of the private sector input delivery system. The involvement of a wide range of fertilizer importers, wholesalers, and retailers in the input voucher scheme, even if it entails additional logistical costs, can attract investments in the system and lead to a less concentrated input marketing system with more competition when the input subsidy program comes to an end. But making the transition to input vouchers brings in other challenges and so, sometimes even the market smart subsidies are unable to avoid private sector displacement (Minot & Benson, 2009).

### *Targeting problems*

Fertilizer subsidies are often targeted disproportionately to better-off farmers rather than the poor households where affordability constraints are most severe, indicating that the level of social and political connections affects the fertilizer allocation process (Govereh et al., 2006; SOAS et al., 2008; Dorward et al., 2008; Jayne et al., 2003). The process of determining who will receive fertilizer subsidy is subject to a great deal of local idiosyncrasies. Numerous unofficial criteria are used in subsidy allocation, such as households’ relationship to village leaders, length of residence, and social and/or financial standing of the household in the village, and thereby, unfair distribution of subsidized fertilizer take place (Dorward et al., 2008). Holmén (2005) summarize some evidences on the biased distribution of subsidized fertilizer: Friis-Hansen (1994) mention that in Tanzania, “a politically well-connected village could receive more than it demanded of scarce input, while other villages received only a fragment of their requirements”; Bazaara and Muhereza (2003) describe that in Uganda’s agricultural programs, the main beneficiaries were politically connected people and political supporters “who had nothing to do with farming”. Banful (2009) report that in Ghana’s 2008 fertilizer subsidy program higher numbers of vouchers were targeted to districts that the ruling party had lost in the previous presidential elections and more so in districts that had been lost by a higher margin. Morris et al. (2007) discuss that in Zambia the fertilizer that did make its way to farmers often ended up being captured by wealthy farmers who least needed assistance.

### *Delivery Delays*

In situations where public agencies are responsible for fertilizer distribution, and especially in cases where fiscal constraints delay the disbursement of subsidies, procurement is often delayed, with the result that fertilizer supplies reach farmers well after the optimal fertilization period.

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<sup>3</sup> This is what we might expect, as wealthy farmers who are more likely to purchase a larger quantity of fertilizer at commercial prices are the main source of the crowding out of commercial purchases with subsidized fertilizer.

Dorward (2009) examined ten fertilizer subsidy programs in SSA and found that in nine of the ten cases, fertilizer was delivered late to substantial portions of the beneficiaries. Interestingly, the prospects of subsidized fertilizer do not give farmers the incentive to buy fertilizer from the open market and lead to lower fertilizer use. Minot and Benson (2009) report that in 2004/05, Malawian farmers held off buying fertilizer in expectation of a large subsidy, but delays in the decision making and budgeting process caused subsidized fertilizer to arrive too late for many farmers. Liverpool-Tasie et.al. (2010) indicate that in Nigeria, where the general fertilizer subsidy rates reached 87 percent, fertilizer consumption rates remained low mainly due to its unavailability at the subsidized prices as a result of late deliveries, rent-seeking activities and political manipulations.

Not a single SSA country has yet successfully adopted and implemented all the recommendations of the new fertilizer subsidy paradigm, but several have made impressive gains, at least in the formulation and design of programs. It remains to be seen if these implementation problems can be corrected as the programs mature or if they are inherent problems associated with public-sector involvement in fertilizer distribution. Nonetheless, taking into account the issues stated earlier it is very important that future fertilizer subsidy programs be more carefully designed and implemented so as to:

- (a) Target areas where applying fertilizer can actually give positive net economic benefits
- (b) Target households with little ability to afford fertilizer
- (c) Promote rather than undercut the development of a commercial fertilizer distribution system
- (d) Function in a transparent and cost-effective manner, and follow an exit strategy
- (e) Declare well in advance the allocation of fertilizer subsidy
- (f) Run in conjunction with other long term agriculture development strategies, such as investment in agriculture extension and research service and infrastructure

Lastly, fertilizer subsidy is only one factor affecting fertilizer price, and fertilizer price in turn is one of the several determinants of fertilizer use. Recent experiences from SSA countries show that fertilizer subsidy tend to be fraught with economic, institutional, and political problems. Studies, such as Economist Intelligence Unit (2008) and Fan et al. (2007), also rank fertilizer subsidies used during the Asian Green Revolution among the least effective policies in terms of benefit/cost ratio and poverty reduction. Public interventions should, therefore, not be limited to subsidy programs that influence fertilizer prices in the short run, but should expand to include a wide range of other measures, such as investing in infrastructure and complementary technologies, building rural financial markets and improving and expanding extension activities and agricultural research, that improve the profitability of fertilizer over the medium to long run by directly or indirectly influencing market prices, costs incurred, or benefits received by consumers and producers of fertilizer.

## VI. CONCLUSIONS AND RECOMMENDATIONS

### 6.1 Summary

- Fertilizer consumption levels in almost all parts of SSA are unacceptably low. The average fertilizer use intensity in SSA is at around 10 kg/Ha whereas it has reached 222 kg/ha in Asia, 160 kg/ha in Oceania and 138 kg/ha in South America.
- SSA also exhibits the lowest levels of production in the world. The low domestic production has not been able to meet even the small fertilizer consumption demand and therefore, caused several countries to heavily rely on importation. It is now imperative for SSA countries to make optimal use of the limited fertilizer available to them.
- Fertilizer use is low in SSA for varied reasons, including unattractive crop price/fertilizer price relationship, inadequate credit availability for both farmers and dealers, poor distribution facilities, limited irrigated agriculture, continued use of local crop varieties by most farmers, and low incentive in investing in land-saving technologies given the relatively low population densities.
- Fertilizer policy in SSA has been extremely dynamic over the last forty years, transitioning from enormous levels of intervention in the 1960s and 1970s to liberalization of markets of the 1980s and 1990s followed more recently by moderate interventions, there have been considerable differences in their approaches reflecting the diversity that exists within SSA countries in terms of social, political, economical, agro-ecological and climatic aspects. Consequently, the responses to the fertilizer policies have been widely varied. Few countries, such as Kenya, succeeded in implementing fertilizer market reform policy whereas other countries, such as Ethiopia and Nigeria, did not make a smooth transition and still continue to rely heavily on state intervention. On the other hand, some state interventions, such as Malawi's voucher program and Ethiopia's credit scheme, initially had significant positive effect on fertilizer consumption but over time they faced difficulty in being sustainable.
- Studies on fertilizer policies actually show inconclusiveness regarding the impact of various fertilizer policies on agricultural production and productivity. However, it does indicate that the fertilizer policy formulation in SSA has always been trial and error and/or "bandwagon" type. The policies were not always based on critical agronomic and economic analyses of the advantages, disadvantages, opportunities, challenges and the very dynamic nature of the agricultural industry. Several challenges, such as high fiscal and administrative costs, insufficient capacity to implement fertilizer policy effectively, disproportionately targeted subsidies and reliance on "one-size-fits-all" philosophy that failed to recognize the diversity of production systems and the range of farmers' needs, have hampered the formulation of effective fertilizer policies in the region.
- The bottom line of the arguments on how to achieve better use of fertilizer revolves around the effectiveness, efficiency and sustainability of fertilizer use. Most African farmers get low response rate from fertilizer application, i.e. relatively low production

from every ton of fertilizer applied, due to inefficiency in application and/or the poor soil fertility condition. The low response rate, coupled with high fertilizer price and fluctuating crop price, has limited the profitability of fertilizer use and hence, the demand for it by smallholder farmers. The non-optimal use of fertilizer is not only hindering the growth in agricultural productivity but also jeopardizing the long term sustainability of African soil and thereby, gravely undermining the prospects for ending chronic poverty and food insecurity in the region.

- The limited effectiveness of fertilizer use in SSA is due to several interacting factors: (a) poor soil fertility caused by mismanagement of fertilizer at the farm level (b) failure of the extension service to inform farmers about appropriate technology (c) unavailability of fertilizer (d) limited complementary inputs.
- Profitability of fertilizer use in SSA is lower than those observed elsewhere in the developing world, reflecting the low crop response to fertilizer, the region's poorly developed marketing systems and its difficult production environment. Studies, using Value Cost Ratio (VCR) i.e. ratio of the technical response to fertilizer use and the nutrient/output price, clearly indicate that low profitability is observed throughout the region.
- Profitability, as measured by VCR, mainly depends on three factors: crop price, fertilizer price and response of the crop to fertilizer application. Response rate is a parameter that changes from farmer to farmer, with farmers who have better farming skills or those living in higher potential zones using fertilizer more effectively and therefore obtaining higher response. In SSA, the response rates are not very satisfactory and significant improvements are needed. Fertilizer prices in SSA are generally high because of low volumes of production, poor infrastructure, low population densities, inadequate and costly financial services. Policy uncertainty and structural problems also keep transportation, handling, and port clearance costs unnecessarily high.
- While prices of fertilizers tend to be generally stable, those of outputs are generally very unstable even within the same season for some crops leading to high uncertainty with regards to profitability. Fertilizer/output price ratios for SSA as compared to Asia and Latin America have been less favorable for most of the principal crops.
- Even if the farmers achieve VCRs above two or even three to four, still there is no guarantee that farmers will start applying fertilizers in their fields. Highly volatile output prices from one season to another and production risk make it very difficult for farmers to assess the eventual benefit of fertilizer use.
- African soils have inherent difficulties for agriculture, in terms of fertility, acidity, and drainage. Land use practices and harsh climatic conditions over the years have further degraded the soil through nutrient mining by crops, leaching, and inadequate erosion control. The decline in soil fertility in SSA is largely attributable to poor soil management practice, which in turn is made worse by other factors such as inappropriate

land use policies, insufficient commitment to investment in agricultural research, falling agricultural prices, land availability constraints and ill defined property rights.

- The decision to recapitalize soils is generally a private one made by individual farmers on the basis of perceived financial returns. Farmers tend to focus on the short-run benefits of recommended technologies (e.g., the immediate returns to fertilizer) and fail to take into consideration the importance of long-term benefits from soil recapitalization, including long-term returns to fertilizer as well as those benefits that accrue to society in general, particularly future generations (e.g., more productive soils, improved food security). Moreover, under the current input/output price ratios, the fertilizer investment required to “prime the recapitalization pump” is relatively very expensive in SSA and thereby, farmers have few incentives for soil recapitalization (Weight & Kelly, 1998).
- Insufficient and unbalanced fertilization of soils using chemical fertilizers as well as lack of nutrient conservation technology adoption by farmers are responsible for accelerating the rapid decline in soil fertility (Weight & Kelly, 1998). The efficient uses of both inorganic and organic fertilizers, through Integrated Nutrient Management approach, will form an important element of a holistic approach for sustainably increasing fertilizer use in most areas of SSA. Activities, including improved fertilizer management practices, general well-informed agricultural extension services as well as adoption of the most appropriate and cost-effective technologies, such as deep placement of fertilizers and the use of inhibitors or urea coatings, need to be promoted to improve the long-term fertilizer use effectiveness. Different nutrient conservation techniques have the potential to help restore soil fertility by preventing the physical loss of soil and nutrients through leaching and erosion.
- The on-going reduction of plant nutrients may well lead to irreversible degradation and soil infertility unless concerted and committed efforts are made by actors from a variety of sectors, including the private and public sectors, scientific and policy organizations, and industrialized and developing countries can help to intensify future agricultural production in a manner that conserves the natural resource base and prevents further degradation that has characterized African soils for generations.
- Fertilizer subsidy has always been central to SSA countries’ fertilizer policy history as it is seen as an effective way to kick-start innovation, stimulate rapid market development both at farm-level and industry-level and counteract the negative externalities that result from soil fertility depletion. All SSA countries implemented fertilizer subsidy schemes at some point or the other, with the level of subsidy varying from quite modest (20 percent or less) to as high as 90 percent. Empirical studies on the cost effectiveness of past subsidy programs overwhelmingly suggest that the high costs associated with them exceeded their benefits. In recent years due to rising food security concerns, fertilizer subsidies have re-emerged in the agricultural strategies of several SSA countries. Fertilizer subsidies of the 21st century have gone through significant changes to address the pitfalls of the past programs. Innovative approaches, including input vouchers, demonstration packs, matching grants, credit guarantees and weather insurances, have been piloted to stimulate fertilizer use. Despite the innovations, fertilizer subsidy

programs that are now in practice fail to remain immune to some of the problems that plagued the subsidy programs back in the 1970s and 1980s. Some of the key problems faced by current subsidy programs are: (i) Unsustainable burden on government budgets (ii) Crowding out the private sector (iii) Targeting problems (iv) Delivery delays.

- Not a single SSA country has yet successfully adopted and implemented all the recommendations of the new fertilizer subsidy paradigm, but several have made impressive gains, at least in the formulation and design of programs. It remains to be seen if these implementation problems can be corrected as the programs mature or if they are inherent problems associated with public-sector involvement in fertilizer distribution. Nonetheless, taking into account the issues stated earlier it is very important that future fertilizer subsidy programs be more carefully designed and implemented
- Fertilizer subsidy is only one factor affecting fertilizer price and fertilizer price in turn is one of the several determinants of fertilizer use. Recent experiences from SSA countries show that fertilizer subsidy tend to be fraught with economic, institutional, and political problems. Public interventions should, therefore, not be limited to subsidy programs that influence fertilizer prices in the short run, but should expand to include a wide range of other measures, such as investing in infrastructure and complementary technologies, building rural financial markets and improving and expanding extension activities and agricultural research, that improve the profitability of fertilizer over the medium to long run by directly or indirectly influencing market prices, costs incurred, or benefits received by consumers and producers of fertilizer.

## **Recommendations**

The study concludes with recommendations that indicate several areas where more focused policies are required to bring desired changes in the effectiveness, efficiency and sustainability of fertilizer use. These recommendations are general in nature having wider applicability across most countries in SSA.

- The current “same fertilizer for all soils” practice is a major contributory factor to low fertilizer use effectiveness in SSA. Appropriate mechanisms should be developed in each country to assess the location and crop specific fertilizer requirements based on soil types and agro-ecological zones considering the nutrient supplying capacity of soils. The gathered information along with crop specific recommendations should then be disseminated to the farmers via the extension agents in an effective manner.
- Improved crop management practices, such as crop rotation with legumes, changes in density and spacing patterns of seeds and placement of fertilizer and seeds at planting, improved soil organic matter, early planting, timely weeding, applying fertilizer in response to rainfall, water harvesting, and other conservation farming methods, should be promoted.
- Strengthening of extension services is needed to improve their responsiveness to the needs of farmers and to allow them to adapt with the realities of the fertilizer sector. First,

the existing extension service system needs to be well equipped and adequately staffed to cover the large number of small farmers. Second, the extension agents should receive regular training so that they are equipped to transfer appropriate location and crop specific knowledge to the farmers. Third, extension agents, both public and private, should be involved in more participatory extension methods than that have been used in the past.

- There is great need to break free from the conventional fix of one-way technology transfer from researcher to farmer. Interactive relationships should be established so that there is more cooperation and coordination between farmers and researchers to exchange information and disseminate technologies that take into account immediate farmer survival needs along with longer-term soil fertility and agricultural sustainability requirements.
- Multi-disciplinary participatory researches on fertilizer use should be stepped up to find new methods technologies that are more relevant for the farmers. National agricultural research systems should undertake more comprehensive assessments of the economics of fertilizer to assess whether there should be a switch to this kind of fertilizer, and a corresponding assessment of the price levels required to ensure on-farm profitability of their use.
- Capacity building is needed to improve the knowledge and skills of farmers and commercial actors. Key needs include basic literacy and numeracy, business management training, and knowledge of fertilizer products. The problem can be addressed by improved public education systems and through training programs that target farmers' needs.
- Fertilizer adoption requires complementary inputs, such as investment in soil and water conservation, for efficient and optimal nutrient uptake. The public and private sector should possibly go in partnership, and then engage in improving complementary inputs, such as irrigation and soil conservation and erosion control.
- Investments in transportation and market infrastructure are needed for reduction of input costs and to ensure remunerative producer prices. Investment in infrastructure will also improve the reliability of service (both timeliness of delivery and maintenance of quality of the product).
- The development of rural financial systems, market information systems, institutions for contract enforcement, and telecommunications should be nurtured to attract new investments by commodity marketing firms.
- Input credit problems should be solved through a combination of the following: (i) an expansion of contract farming opportunities that link input and output markets (ii) support for the creation and capacity building of producer associations capable of obtaining and managing input credit (iii) capacity building and incentives to draw commercial banks into the agricultural sector.

- The fertilizer distribution “private sector” needs to be adequately and urgently developed to ensure an efficient supply chain. Governments should establish supportive policy environments that attract both local and foreign direct investment.
- The selected number of fertilizer producing SSA countries should explore practical possibilities of working at their full capacities. The fertilizer companies should strategically build production plants at locations close to major consumption or input supply centers based on sound feasibility studies and adoption of logical site selection criteria. Such capacity expansion should also be supported by better storage, handling and transport facilities.
- Constraints in fertilizer availability and affordability have allowed adulterated fertilizers to penetrate the markets of SSA countries creating severe production, environment, and health consequences. This must be restricted by strengthening quality monitoring at different stages of the supply chain and by implementing laws that will take necessary actions against those involved in fertilizer adulteration.
- The present fertilizer subsidy programs in SSA countries should be nurtured to maturity. If properly implemented they can be phased out over a period of time. The programs however need considerable fine-tuning in terms of organization and legislation to ensure transparency and accountability of all actors and the imposition of stiff penalties in case of breaches of rules and regulations.
- The contribution of fertilizer subsidy programs to reducing poverty and hunger would be higher if they could be designed and implemented so as to (a) target households with little ability to afford fertilizer; (b) target areas where applying fertilizer can actually give positive net economic benefits; and (c) promote rather than undercutting the development of a commercial fertilizer distribution system.
- Before implementing fertilizer subsidy, there is need to carefully consider the objectives of the targeting and the practical feasibility and costs of implementing a targeted program, including personnel costs, time requirements and potential delays, leakage, and displacement of commercial sales by subsidized inputs.
- The fertilizer policy formulation in SSA has always been trial and error and/or “bandwagon” type. The policies were not always based on critical agronomic and economic analyses of the advantages, disadvantages, opportunities, challenges and the very dynamic nature of the agricultural industry. So it is necessary to move away from the “one-size-fits-all” philosophy and each country must implement policies that take into consideration the diversity in their agriculture production systems. Furthermore, policy uncertainty should be reduced in the region as this would help other involved actors to give proper responses to the policy changes.

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