Global Bureau, Office of Agriculture and Food Security

U.S. Agency for International Development

POLICY SYNTHESIS

for USAID - Bureau for Africa
Office of Sustainable Development

Office of Sustainable Development

Number 32 February 1998

FERTILIZER IN SUB-SAHARAN AFRICA: Breaking the Vicious Circle of High Prices and Low Demand

By

Valerie Kelly, Thomas Reardon, David Yanggen, and Anwar Naseem

Food Security II Cooperative Agreement between U.S. Agency for International Development, Global Bureau, Economic Growth Center, Office of Agriculture and Food Security and Department of Agricultural Economics, Michigan State University

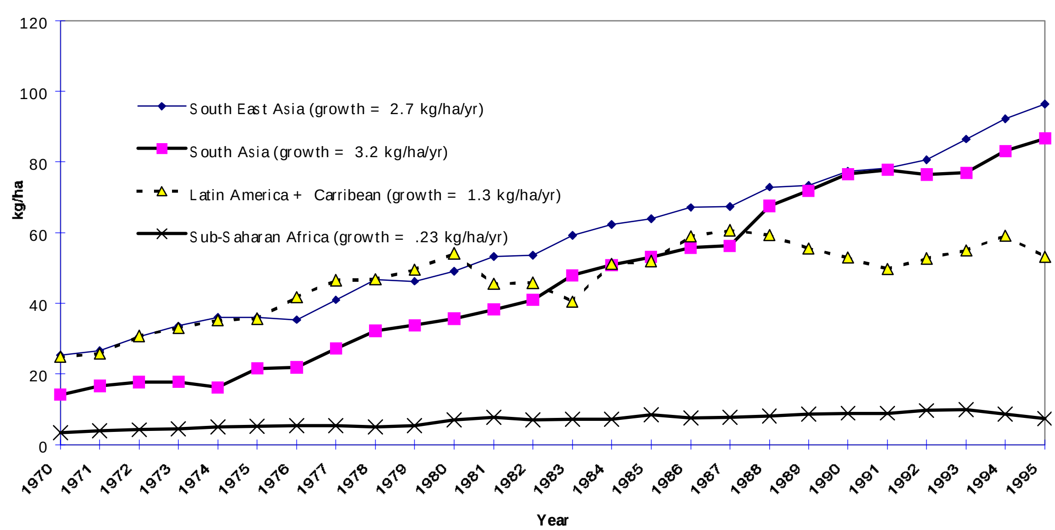
BACKGROUND: To increase rural incomes and meet growing food demands Sub-Saharan Africa (SSA) must improve agricultural productivity. SSA is the only developing region where per capita food production has been declining; the region now has the largest cereal deficits in the world. If there is no change in productivity, deficits will more than triple by 2020.

Fertilizer is a powerful productivity-enhancing input, but SSA uses very little. Historical trends are abysmal (Figure 1). In 1970, SSA used <5kg/ha while other developing regions used >15 kg/ha. In the 25 years from 1970 to 1995 fertilizer consumption grew only .23 kg/ha/year. Current use is only 9 kg/ha, down from highs of 11-12. This contrasts sharply with >50 kg/ha used in Latin America and >80 kg/ha in Asia.

Economists estimate that SSA agricultural production must grow by 4% per annum during the next decade to stimulate a satisfactory level of general economic development. This is faster than recent rates of 1-2%. Experience elsewhere has shown that fertilizer can provide a substantial productivity boost. A third of the increase in cereal production worldwide and 50% of the increase in India's grain production has been attributed to fertilizer-related factors.

OBJECTIVES AND METHODS: The research

Figure 1: Regional Trends in Fertilizer Consumption



summarized here addresses two questions: Why is fertilizer not yet fulfilling its potential as a major stimulus to agricultural productivity in SSA? What can be done to improve the situation? Our answers are based on an extensive review of fertilizer-response, profitability, and policy literature as well as some analysis of crop budgets and aggregate national statistics on fertilizer consumption.[1]

FINDINGS: Much of the debate about fertilizer use in SSA focuses on two issues: whether the profit *incentive* is adequate and, if so, whether farmers have the *capacity* to access and use it.

Incentives. Contrary to conventional wisdom, there are examples of fertilizer response and profitability in SSA that compare favorably to those in other parts of the world. Table 1 presents information about the relative importance of fertilizer consumption for seven SSA crops and synthesizes findings concerning three ratios measuring profit incentives. O/N (output/nutrient) ratios show how many kgs of additional output a farmer can obtain from a kg of fertilizing nutrient; ratios ≥ 10 are considered efficient. An I/O (input/output price) ratio shows the number of kgs of production a farmer needs to purchase one kg of fertilizer; the lower the ratio, the higher the incentive. V/C (value/cost) ratios are rudimentary profit indicators that compare the gross income attributable to fertilizer with the costs of the input. Conventional wisdom holds that a V/C ratio must be ≥ 2 before a farmer will consider financial incentives adequate; many hold that in high-risk production environments the minimum V/C for adoption is 3 or 4.[2]

Among the cereal crops covered, maize (SSA's most important fertilizer consumer) and irrigated rice exhibit the strongest incentives. O/N and V/C ratios equal or exceed standard benchmarks. The maize ratios exceed those for Latin America, while the rice ratios are comparable to the Asian examples. Yields per hectare are high: 2-4 tons for maize and 4-6 tons for rice. On the down side, maize profitability is threatened by high yield variability (across sites and seasons) and by unfavorable I/O price ratios. These factors discourage fertilizer use for the vast majority of maize farmers. High irrigation costs represent a negative for rice that can result in low overall profitability, canceling out fertilizer benefits.

Sorghum and millet exhibit poor incentives compared with maize and rice – not surprising given that sorghum and millet are grown in difficult agroclimates (poor soils, low rainfall). Using fertilizer in combination with crop residues, manure, or water and erosion control measures considerably increases the yield response, but aggregate output is usually <1 ton/ha.

Among the export crops covered, only tea – a crop whose production is limited to a few areas in SSA – exhibits good indicators. SSA's second largest fertilizer consumer--cotton--has relatively poor yield response and mediocre profitability (minimum V/C very low, with maximums at acceptable but not outstanding levels) despite extremely favorable I/O ratios (an apparent paradox discussed below).

In sum, (1) high-productivity maize and rice technologies are available, but more basic research and extension work is needed to adapt them to diverse smallholder production environments; (2) sorghum and millet technologies are not yet highly productive and more basic research is clearly needed, focusing on the use of fertilizer with complementary inputs; and (3) there is substantial room for improving technologies for export crops. For all crops and zones, major improvements in profitability could be realized by reducing SSA's I/O price ratios, which are among the highest in the world.

V/C ratios reported include fertilizer subsidies if they existed at the time of the analysis. Because fertilizer subsidies have been phased out and replaced with market development initiatives that have not yet reduced fertilizer costs, more recent ratios rarely approach the maximum V/C values in Table 1. Farm-level fertilizer prices in SSA are among the highest in the world. In 1991/92 SSA prices per ton ranged from \$232 to \$487 for urea and phosphates while the Asian equivalents ranged from \$68 to \$201. Unfavorable I/O price ratios confirm that the negative impact of high fertilizer prices is not offset by high producer prices.

[1] For sources of particular points of view summarized here and a complete list of documents consulted, refer to the reports listed on the last page of this document.

[2] V/C = (kg output attributable to fertilizer * output price) / cost of fertilizer. Most analyses include only the cost of fertilizer in the denominator; more thorough work includes other related costs (e.g., labor for application and additional weeding or harvesting).

Table 1. Fertilizer Incentives: Summary of Key Indicators by Crop and Region

		Yield Response (O/N Ratio)			Price Incentives (I/O Price Ratio)			Profit Incentives (V/C Ratio)		Observations on patterns and incentives
Crop	Region	Typical	Min	Max	Typical	Min	Max	Min	Max	
Maize	E/S Af.	17	2	52	5-7	3.9	13.9	1	15	Maize consumes about 25% of fertilizer used in SSA but a high percent of maize production receives no fertilizer at all.
	W. Af.	15	0	54	2-4	1.9	5.1	.69	26	
	L.A.	10	5	18	1-3	.01	7.1	1.2	5.3	
Cotton	E/S Af.	5.8	0	7	1.8	.07	4.6	.00	3.1	Accounts for about 17% of SSA fertilizer use; a very large percent of cultivated cotton area is fertilized.
	W. Af.	5	2	12	1.9	.09	3.7	.61	3.7	
Rice (irr.)	W. Af.	12	7	16	2	.2	4.5	1.6	3.97	Accounts for only 4% of SSA fertilizer consumption. Total SSA area in rice is small % of total cultivated area.
	Asia	11	7.7	33.6	2.5	1.4	5	1.5	3.1	
Sorghum	E/S Af.	10	4	21	6	3.2	9.3	1.5	2.6	Accounts for 8% of fertilizer used in SSA; very small portion of total sorghum area is fertilized.
	W. Af.	7	3	14	2-4	1.4	4.9	1	18	
	Asia	7	2.8	21	2	1.7	2.6			
Millet	W. Af.	7	2.8	21				.5	39	Accounts for 3% of fertilizer used in SSA; very small portion of total millet area is fertilized.
	Asia	20	3	27				<1		
Ground-nuts	W. Af.	9	4	21	3	.3	4.2	1.5	5.8	Accounts for 1% of fertilizer used in SSA although a major cash crop in many countries.
	Asia	6.5	6	17	1	.7	1.2			
Coffee	E. Af.	8.5	5	10						Accounts for <1% of fertilizer used.
	W. Af.	4	2	6						
Tea	E. Af.	14	8	35						Accounts for <1% of fertilizer used.

Source: Compiled by authors from extensive literature review.
Notes: Information on V/C ratios was sparce and costs used in calculating ratios poorly documented, hence no attempt was made to generalize about 'typical' V/C ratios. Three crops which use a large share of SSA fertilizer (wheat, 14%; sugarcane, 11%; and tobbaco, 5%) are not covered because they are important crops in only a few countries and very little information about 'incentives' for these crops was found.

Subsidies are one way of keeping fertilizer prices low. Proponents note that subsidies promoted rapid growth in fertilizer use and agricultural productivity in China, India, Mexico, Nigeria, Turkey, and Venezuela. Opponents point out that unless subsidies are accompanied by a clear program to rectify the underlying problems they are compensating for (e.g., inefficient markets, poor infrastructure) their demands on the budget grow rapidly, reducing the ability of government to make other agricultural investments.

For many reasons, *fertilizer market development* programs have not yet had the desired impact on fertilizer prices and demand. In some cases subsidy removal and devaluation reduced already low effective demand (Ghana and Senegal). In others, a lack of complementary actions to improve farmers' fertilizer techniques (e.g., extension programs), lower transactions costs (e.g., better regulatory environment), or reduce risk (e.g., fertilizer quality control) hampered market development. Inadequate access to foreign exchange and credit for dealers has also been a constraint (Ethiopia). Government's continued involvement in the distribution of fertilizer aid has also discouraged some private sector initiative. Another shortcoming noted was the failure to train private sector operators in product promotion skills (Kenya).

Some *output market development* programs have contributed to fertilizer profitability by reducing farmers' risks and transactions costs. Market information systems have reduced price differences between deficit and surplus zones (e.g., Mali). Liberalization of cereal exports and imports has stabilized prices at the national level (e.g., Kenya and Ethiopia). Expansion of market infrastructure has reduced farmers' marketing costs and increased profitability, thereby promoting smallholder use of fertilizer (e.g., Zimbabwe and Zambia in the 1980s).

Table 2. Correlations between Fertilizer Use and "Determinants"

	Coefficients by period					
"Determinant"	1970-4	75-9	79-83	80-4	85-9	90-4
Rainfall index	.55*	.57*	n. a.	.62*	.54*	.32+
Road density/ha	.63*	.33*	.73*	.21	.21	.20
Ag. researchers/ha	n.a.	n.a.	.44*	n.a.	n.a.	n.a.
Primary schooling	.37*	n.a.	n.a.	n.a.	n.a.	.36*
Secondary schooling	.68*	n.a.	n.a.	n.a.	n.a.	.60*

Source: Estimated by authors using FAO and World Bank data bases.
Notes: * = significant at 95% level of confidence; + = significant at 90% level of confidence

Some measures improve *fertilizer and output market efficiency* simultaneously. The best documented evidence concerns reductions in marketing margins realized by reducing official and unofficial road taxes on goods transported within national boundaries (e.g., Mali and Senegal). Another example is infrastructure, particularly roads but also communications. There is a strong correlation between fertilizer use and kilometers of roads per hectare in SSA (Table 2).

V/C ratios show only whether farmers are likely to make more money than spent when using fertilizer. The ultimate decision will depend on whether farmers believe they will make more money with the fertilizer than with alternative uses of the available cash. Although *analyses of 'relative' profitability* are rare, the few cases found showed that farmers failed to adopt fertilizer with V/C ratios ≥ 2 because purchasing and fattening an animal for resale or clearing new land to expand production was more profitable. Nonfarm activities also offer stiff competition. Hence, indicators such as those used in Table 1 must be complemented with more analysis of 'relative' profitability so that programs to develop fertilizer markets consider competing activities.

Capacity. Even in cases where the absolute and relative profitability are adequate, farmers may not have the capacity to act on these incentives. Capacity is affected by zone- and farm-level variables. Zone-level variables include:
- soil quality (particularly organic matter);
- water (rainfall >700 mm/year or irrigation);
- infrastructure (roads, electricity, phones);
- credit (for farmers, traders, processors);
- human capital (farmer literacy, researchers); and
- a critical mass of commercial farming activity

Losses of organic matter and acidification are major problems in the fragile soils of SSA. Fertilizer loses its effectiveness when soil organic matter falls below minimum levels, hence zones with serious soil degradation may have low capacity for fertilizer use. Rainfall is highly correlated with fertilizer use, as is road density, although the latter variable appears to have declined in importance since 1980 (Table 2). Traders and farmers both need access to financial resources beyond their own savings and income because fertilizer is an expensive input to market (high storage and transport costs) and to purchase (largest annual input expenditure made by most SSA smallholders). The link between human capital and fertilizer use is illustrated by the positive correlations between the number of agricultural researchers, general education (percent of school-age children in school), and fertilizer use (Table 2). Commercial agriculture is a *sine qua non* for fertilizer. Three of the top fertilizer consuming countries (Zimbabwe, Kenya, and Zambia) benefitted from the establishment of large-scale commercial farms by European settlers. These farms have provided a minimum level of stable fertilizer demand that helps promote economies of scale and lower fertilizer prices. Realizing economies of scale when relying entirely on smallholders is more difficult, yet the success of SSA cotton systems shows that it can be done.

Even when zone-level factors are favorable, capacity may be limited by farm-level factors such as:
- cash constraints (own cash, credit);

- poor access to complementary inputs for which there are no markets (e.g., manure); and
- poor knowledge about adapting fertilizer to a particular production environment.

Before structural adjustment, governments administered agricultural credit programs that increased farmers' access to fertilizer. Now credit is rare and expensive. The few insights we have into what works in SSA come mainly from the cotton sector. In these vertically coordinated schemes, input, output, and credit markets are linked thereby reducing the costs and risks of administering the credit program. Credit is available to all cotton farmers, encouraging them to use fertilizer despite the low level of incentives reported in Table 1. Reimbursement of cotton credit is good because (1) there are few opportunities for farmers to sell output to anyone but the company that provided the credit, and (2) many cotton companies provide extension services and credit for food crops (e.g., Mali and Mozambique) which help farmers meet cash and food security goals. Outside the cotton sector, some post-structural adjustment initiatives to restore credit are underway, such as maize-fertilizer barter schemes run by South African companies in Zimbabwe and Zambia and distribution/credit schemes operated by local traders in Zambia. The vacuum is there and drawing in efforts, but credit demand is greater than supply.

Own-cash sources have taken on more importance with the decline of easy credit. Nonfarm income sources (e.g., wage employment, microenterprise earnings, and migration remittances) are playing an important role in financing input purchases. A problem, however, is that the bigger farmers in better agroclimates tend to have better access to credit *and* greater nonfarm earnings, which means that the capacity to buy fertilizer is becoming more skewed toward better-off households. This is a concern as it is the small, land-constrained farm that needs to intensify most by redressing current low levels of fertilizer consumption.

Access to complementary inputs (e.g., manure) is particularly important for crops and zones (e.g., millet and sorghum in the Sahel) where fertilizer response is poor without the complements. The issue will ultimately become important for all farmers because fertilizer yield response declines over time if soil organic matter is depleted. As chemical fertilizer does not add organic matter to the soil, farmers will need to increase the amount of crop residues and/or manure used. Some of this can come from increased production of crop residues obtained by using fertilizer.

The use of research and extension funding to adapt available fertilizer technologies to particular smallholder situations is emerging as a key tool for improving farmers' capacity to use fertilizer efficiently. A major problem has been 'pan-territorial' recommendations that fail to take into account differences in resource endowments (soil type, labor capacity, climatic risk, etc.). The situation is exacerbated by a failure to revise recommendations following dramatic changes in the I/O price ratios due to subsidy removal and devaluation (e.g., Ethiopia and Malawi). Farmers using fertilizer already experiment with doses and methods of application (few apply as recommended). There is a need for investment in research and extension programs that focus on adapting "good performers" to particular smallholder situations. The case of maize illustrates the point. Many SSA fertilizer/seed technologies for maize are "good performers," yet the vast majority of maize farmers are not yet using fertilizer. There is strong evidence from countries that have begun to focus on site-specific and adaptive research programs that this approach can have big payoffs in terms of increased fertilizer profitability and adoption (e.g., Malawi and Kenya).

CONCLUSIONS: The major findings from our literature review can be summed up in five key points.

- Declining soil fertility is a major constraint to agricultural productivity in SSA;
- More inorganic fertilizer is needed to reverse the decline (organic fertilizers are complements, not substitutes, for inorganic fertilizers);
- Contrary to the conventional wisdom of the 1980s, there are many crop/zone combinations where SSA fertilizer use is now profitable and many more where it could be profitable with minor improvements in incentives and capacity;
- The vicious circle of high fertilizer prices and low demand constrains the development of efficient distribution systems. Some combination of market, agricultural research, and extension initiatives is needed to improve incentives and capacity, thereby breaking the cycle; and

- Privatization and liberalization of fertilizer markets are necessary but not sufficient conditions for breaking this cycle; neither policy adequately addresses the fundamental problems of high transactions costs and high risks that dampen incentives and the pervasive presence of rural poverty that reduces capacity.

POLICY IMPLICATIONS: It is necessary to break the high-price, low-demand cycle by stimulating a strong increase in fertilizer demand *at the same time* that programs are implemented to improve market efficiency. The focus needs to be on the narrow issue of getting fertilizer prices down and increasing demand in a cost-effective, sustainable manner. A combination of public and private actions is needed; the objective should not be getting government out of agriculture but identifying its proper role given the situation prevailing in each country. For most countries, the following five steps will be prerequisites for developing a viable program to simultaneously stimulate fertilizer demand and supply.

1. Prepare an inventory of what is known about fertilizer response and profitability by zone and crop (Kenya and Malawi provide good examples).
2. Using the inventory, identify the crops, zones, and types of households with the greatest potential for rapid increases in fertilizer demand, taking into account demand projections for domestic and export crops. Fertilizer consumption increases most rapidly on crops with strong demand and stable prices, but such crops can stimulate fertilizer use on other crops (e.g., cotton/maize complementarities).
3. Examine potential economies of size and scale capable of reducing fertilizer prices, including economies that could be realized by regional pooling of fertilizer procurement activities.
4. Using information from step 2, identify a *combination* of market, research, and extension activities to stimulate demand for selected target groups, aiming for the level of demand required to realize the economies identified in step 3.
5. Determine which of the initiatives identified have the strongest economic justification for a particular country and period of development.

The key to developing successful programs that improve input market efficiency while increasing fertilizer use is careful analysis of the costs and benefits of the many options discussed in the 'findings' section of this synthesis, including the possibility that some type of subsidy might be an efficient way of priming the pump to get more efficient private sector involvement in the fertilizer sector. This will require careful identification and valuation of both private and social costs and benefits. A major shortcoming in the past has been the lack of attention to social costs and benefits. As concerns for the environment increase, more attention to fertilizer's environmental benefits (e.g., less production moving into marginal lands) and potential inconveniences once high levels of use are attained (e.g., soil acidification, water pollution) will be needed.

*Funding for this research was provided by the Food Security and Productivity Unit of the Productive Sector Growth and Environment Division, Office of Sustainable Development, Bureau for Africa, USAID (AFR/SD/PSGE/FSP). The research was conducted under the Food Security II Cooperative Agreement Between AID/Global Bureau, Office of Agriculture and Food Security, and the Department of Agricultural Economics at Michigan State University. The views expressed in this document are exclusively those of the authors.

Kelly is visiting associate professor, and Reardon, associate professor at Michigan State University (MSU); Yanggen and Naseem are doctoral candidates, MSU.

This paper is a summary of two reports: "Incentives for Fertilizer use in Sub-Saharan Africa" and "Macro Trends and Determinants of SSA Fertilizer Use". Copies can be obtained by writing to the authors:

Department of Agricultural Economics
Michigan State University
East Lansing, Michigan 48824-1039