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Fertilizer Policy Research Program for Tropical Africa

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International Fertilizer Development Center (IFDC)

and

International Food Policy Research Institute (IFPRI)

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Abbreviations and Acronymns

APCC	Agricultural Policy Coordination Committee, Ghana
BNDA	Banque Nationale de Développement Agricole, Mali
CGIAR	Consultative Group on International Agricultural Research
CMDT	Compagnie Malienne pour le Developpement des Textiles, Mali
CNRA	Comité National de la Recherche Agronomique, Mali
COMADIS	Comptoir Malien de Distribution, Mali
DAP	Diammonium phosphate
DRAM	Direction Régionale de l'Agriculture, Mopti, Mali
ERP	Economic Reforms Programme, Ghana
FAO	Food and Agriculture Organization of the United Nations
FCFA	Franc de la Communauté Financiere Africaine
FPRG	Fertilizer Policy Research Group
GDP	Gross Domestic Product
IER	Institut d'Economie Rurale, Ministry of Agriculture, Livestock and Environment, Mali
IFDC	International Fertilizer Development Center
IFPRI	International Food Policy Research Institute
IMC	Inter-Ministerial Council, Ghana
ISSER	Institute for Statistical, Social, and Economic Research, University of Ghana, Ghana
K_2O	Potash
N	Nitrogen
NARES	National Agricultural Research and Extension System, Ghana
NFPU	National Fertilizer Policy Unit
NPK	$N + P_2O_5 + K_2O$
ODR	Opération du Développement Rurale, Mali
OHV	Opération Haute Vallée, Mali
ON	Office du Niger, Mali
ORM	Opération Riz Mopti, Mali
P_2O_5	Phosphate
SAP	Structural Adjustment Program
SCAER	Société de Crédit Agricole et Equipment Rural, Mali
TPR	Tilemsi phosphate rock
USAID	U.S. Agency for International Development
WAMU	West African Monetary Union

1. Foreword

In most countries in sub-Saharan Africa, over 75% of the population is involved in agricultural activities. The product of these activities accounts for a lion's share of gross domestic product and of foreign exchange earnings. But the predominantly subsistence nature of the agricultural systems severely limits the ability of these countries to meet present and future food requirements. At a time of increasing population pressure, decreasing per capita arable land, and shortened fallow periods, maintenance of soil fertility and the prevention of soil loss through better management practices have become the greatest challenges facing farmers and agricultural policymakers alike. It is widely accepted throughout sub-Saharan Africa that fertilizer is a key input in the restoration and maintenance of soil fertility, the increase in agricultural production to ensure food security, and the successful technological transformation and commercialization of subsistence agriculture. In a period of rapid population growth, marked by declining and in some cases negative rates of growth of per capita agricultural and food production, any hope to reverse the trend must necessarily be based on the adoption of appropriate policies for tackling the most severe constraints on the growth of fertilizer use.

The causes underlying the poor growth performance of agricultural and food production in sub-Saharan Africa are diverse and complex. Whatever these causes may be, solutions must be based on the creation of an environment conducive to increased agricultural and food production. To achieve this goal, national governments must adopt pricing, credit, marketing, supply, and other policies that provide sufficient incentives for smallholder and commercial farmers to produce over and above subsistence requirements through efficient, equitable, and environmentally safe use of modern farm inputs such as

fertilizers and improved seeds. This observation encouraged the International Fertilizer Development Center (IFDC) and the International Food Policy Research Institute (IFPRI) in 1987 to address the fundamental question of which policy framework was needed to promote, in a stable and long-term manner, the use of fertilizers and other agricultural inputs. It was accepted that this framework should aim at (1) encouraging the use of fertilizers on food and export crops, (2) reducing the divergence between the recommended fertilizer doses and those effectively used, (3) accelerating the fertilization of new lands, (4) promoting the distribution of fertilizers among the small-scale farmers and in less endowed agricultural areas, (5) improving the technical skills of farmers, and (6) increasing the economic efficiency of fertilizer use. It was in search of such a policy framework that this fertilizer project was initiated with assistance from the United States Agency for International Development (USAID).

2. Acknowledgment

This research project initiated by the International Fertilizer Development Center (IFDC) and the International Food Policy Research Institute (IFPRI) was generously funded by the United States Agency for International Development (USAID). The implementation of this project also involved many national research centers in sub-Saharan Africa. All these research centers express their deep gratitude to USAID.

This project has benefitted from the comments and support of many people in government, academic, and other research centers in both sub-Saharan Africa and the United States. IFDC and IFPRI also wish to extend their appreciation to these people.

3. Introduction

Since the 1970s, the per capita food and agricultural production in most of Africa has been worsening. High population growth is increasing the pressure on land in many areas of Africa, leading to overexploitation of land and subsequent fall in soil fertility and desertification. To reverse this trend, agricultural production technology for increasing and maintaining land productivity must be adopted. The adoption of such a technology involving the widespread use of improved inputs and farm management practices requires policies and action programs on agricultural research, extension, and services.

Agricultural producers are increasingly coming up against land constraints; thus, in some regions, expanding crop area is no longer a feasible policy prescription. Technological change that brings about incremental growth in land productivity is a necessary condition for increased agricultural production and economic development of the sub-Saharan region. The key role of fertilizers to increase and maintain land productivity and promote agricultural production and development in developing countries of Asia and Africa is well documented in a number of studies.[1]

Research in the humid tropics of Africa has shown that the use of fertilizers with appropriate soil management increases land and labor productivity, stabilizes crop yields, and enhances employment of farm labor. Also, an evaluation based on fertilizer trials and world market data indicates that substantial foreign exchange savings are obtained by using limited foreign exchange resources to import (and use) fertilizers rather than food.

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[1]See FAO, *Fertilizer Review* (Rome, 1983) and World Bank, *Accelerated Development in Sub-Saharan Africa: An Agenda for Action* (Washington, D.C., 1981) for details.

In the late 1960s, there was a consensus in Asia that food production has to be increased through yield-increasing technological innovations. In this connection, policies to sustain large-scale diffusion of fertilizers, high-yielding varieties, and irrigation were formulated and implemented in a number of Asian countries. The use of these land-augmenting, labor-using technologies was also seen as a way of improving labor employment and productivity. This large-scale technological change has also prompted the development of related industrial activities and services in most of these countries, with all the beneficial backward and forward linkages.[2]

Despite the recognized value of fertilizer as a key input for agricultural development, the fertilizer sector in tropical Africa is the least developed of any in the developing regions of the world. Chemical fertilizer use in 1990 in this region averaged a low of 8 kg/ha, compared with 118 kg/ha in Asia and 46 kg/ha in Latin America. Organic fertilizer use data are scarce or nonexistent in most countries. Chemical fertilizer production facilities in the region are virtually nonexistent, and of those in place many are underutilized or mothballed. With fertilizer use primarily dependent on imports, tropical African countries face fluctuating international supply situations, poor to nonexistent national supply routes, and a weak purchasing power in addition to a general lack of knowledge regarding the role of fertilizers in increasing crop production and the income of the rural poor. Even if fertilizer is imported, these countries generally lack the marketing system and extension program to reach the farmer.

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[2]S. Wanmali, *Service Provision and Rural Development in India: A Study of Miryalguda Tuluka*, IFPRI Research Report 37, Washington, D.C., 1983.

With these limitations, the emergence of a fertilizer sector will often require the establishment of new policies that will remove the constraints to fertilizer use. Such policies generally are linked to a shift in budgetary priorities in the country and thus need to be based on sound information and policy analysis.

Currently, the ability of policymakers in most African countries to devise appropriate policies is largely constrained by the lack of knowledge about how key policies affect the availability and use of fertilizers and other technology-carrying inputs. The lack of policy information was singled out by the Consultative Group on International Agricultural Research (CGIAR) as the key constraint to policy formulation. Hence, research on fertilizer policy is needed to (a) identify key variables affecting the fertilizer sector operations and their impact on fertilizer use and (b) evaluate various fertilizer policies that may be adopted to increase the use of fertilizers by farmers in terms of the economic and social benefits and costs that such policies can have for the country. On the supply side, policies to be considered may involve import strategies and the allocation of hard currencies and credit, institution building and private sector development, infrastructure development, and pricing policies. On the demand side, consideration must be given to policies on fertilizer and crop pricing, research and extension, and farm-level credit. In addition, in those countries endowed with natural resources suitable for use as fertilizers or fertilizer raw materials, policies on their exploitation will need to be established.

There is an urgent need in tropical Africa to provide assistance in fertilizer policy analysis to national programs and donors alike. The principal objective of the IFDC/IFPRI Fertilizer Policy Research Project was to generate information about the benefits, costs, and income distribution effects of various policies that could be adopted by governments of

tropical African countries to increase food production, generate income for the rural poor, and promote agricultural development while preserving the natural resource base through the judicious use of organic and/or chemical fertilizers. Such information will facilitate the decisionmaking process in these countries and promote the adoption of more effective policies to achieve economic and rural development and expand the availability of food.

4. Project Activities, 1987-90

The formulation of a coherent policy framework requires, at the outset, a profound knowledge of the technical, economic, sociological, and institutional variables affecting the supply of and demand for fertilizers. It was from this perspective that a workshop was organized in April 1988, with the aim of gathering views and recommendations on what African policymakers and analysts considered at that time to be the major constraints to the development of the fertilizer sector in their respective countries.[3] Those countries represented included Benin, Cameroon, Côte d'Ivoire, Kenya, Malawi, Nigeria, Senegal, Togo, Zambia, and Zimbabwe. This workshop made specific recommendations on different areas that needed attention if fertilizer use is to be promoted in sub-Saharan Africa. These areas include the information sector, fertilizer supply, fertilizer use, and the institutional structures.

On the basis of these recommendations, a research agenda was developed and studies were planned in the areas of fertilizer supply, fertilizer use, and policy reforms. Little attention was given during this time to information management. In the area of institutional reforms, the work was planned only for Cameroon. The workshop also helped to identify the group of countries to be studied. These countries were selected on the basis of some of the following criteria: population density, level of fertilizer use, the implementation of economic policy reforms, and the geographical position of the country in relation to the sea.

The main objective of this phase of the project (1987-90) was to identify the constraints on fertilizer sector development in sub-Saharan Africa and suggest policy

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[3]T. B. Tshibaka and C. A. Baanante (eds.), *Fertilizer Policy in Tropical Africa: Workshop Proceedings*, IFDC and IFPRI (1990).

measures to alleviate such constraints. To this end, various themes were examined within broad aspects of the fertilizer sector development in sub-Saharan Africa including (1) impacts of policy changes on the fertilizer sector; (2) analysis of potential and effective fertilizer demand; and (3) indigenous fertilizer production constraints in sub-Saharan Africa.

The main findings obtained from the completed studies during the 1987-90 subperiod are summarized below. In The Gambia, it was found that in the past much emphasis was laid on improving crop yields per unit of area, especially for rice. Although increased yield per hectare is desirable, the real issue in The Gambia is to focus on total productivity, and on labor productivity in particular. Technologies for improving overall productivity—through area extension and intensification—are known and are available in The Gambia to a limited extent. The key is to promote the relevant technologies on the appropriate scale in the various agroclimatic environments.

With regard to fertilizers, use of this input was found to be profitable in 1984 and 1985 even when subsidies were removed. Gambian farmers were found to use fertilizers on both cash and food crops. A high proportion of fertilizers was used on cereals. Fertilizer use per hectare was still far below the recommended levels and had dropped significantly since 1984. The exception was the rice project area, where fertilizer was more available and accessible. The limited availability and accessibility of this input were identified as the main constraints to its use. Fertilizer aid proved to be the key factor affecting fertilizer supply in The Gambia. The study stresses that fertilizers, seeds, and crop protection are

complementary components of a strategy to vitalize growth in agriculture. They all require increased attention from public policymakers.[4]

In the case of Rwanda, the preliminary analysis indicated that yield-increasing technologies–fertilizers, high-yielding seeds, and pesticides–were the only options left for Rwanda to increase its agricultural production and productivity. In this context, a survey was conducted to assess the quality of land resources in the four study zones located in the southern part of the country. It was found that more than 90% of the farmland in the study areas was prone to erosion or loss of topsoil once the natural cover was removed. In addition, the analysis indicated that, for the study area as a whole, 11.2% of the farmland is considered by farmers to exhibit a low fertility level, 52.5% a medium fertility level, and 36.3% a high fertility level. On the basis of this information, the fertility of 63.7% of the farmland in the study zone needs to be enhanced if this land is to be intensively and productively cropped.[5] Fertilizers and anti-erosion measures are essential inputs for the restoration of the fertility of these lands.

The study on Zambia concentrated on farmers' practices and behavior with regard to fertilizers.[6] First, the study found that maize was very responsive to fertilizer use, and this is true of hybrid and local varieties in the Eastern Province of Zambia. These responses

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[4]J. von Braun, "Structural Adjustment, Agriculture and Nutrition: Policy Options in The Gambia," IFPRI Working Paper No. 4, Washington, D.C., 1990.

[5]V. Rutunga and T. Tshibaka, "La Fertilité de Quelques Sols du Rwanda," IFPRI Draft Paper, 1989.

[6]D. N. Jha and B. Hojjati, "Fertilizer Use on Smallholder Farms in the Eastern Province, Zambia," IFPRI Draft Paper, 1991.

are stable over a range of weather conditions. Cotton and beans also respond well to fertilizer application.

Important gaps in research were identified with regard to establishing fertilizer response relations at different sites within the Plateau and Valley zones, nutrient balance in fertilizer recommendations, and evaluation of response under mixed cropping. Increased efficiency of fertilizer use was found to assume high importance if fertilizer use and output growth are to be maintained. Pricing of fertilizer mixtures and ensuring a judicious combination, as well as strengthening the focus on technical efficiency of fertilizer use in the extension program, were identified as important actions to take in this regard. It was found that it is important to examine the relative price structure with respect to crops other than maize. Neglecting this will impede the diffusion of fertilizer use on other crops as well as the diversification of the crop base. Domination by a single crop, maize, makes agriculture highly vulnerable. Furthermore, the study notes that fertilizer use triggers the transition of agriculture from a subsistence-oriented sector to a modern, market-oriented sector. The Eastern Province experience clearly shows that, under favorable circumstances, yield-increasing technologies offer viable opportunities even in land-surplus regions.

A study conducted by Gandhi and Desai of IFPRI indicates that in the Gazaland District of Zimbabwe, only one-third of the sampled smallholder households are fertilizer users.[7] Of the two-thirds of households that are nonusers, 43% do not even know about fertilizers. Among the users, most do not seem to use fertilizers to the full extent of their cultivated area. The level of crop response is of great importance to farmers. Maize is the

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[7]"Fertilizer Use in Zimbabwe: An Analysis of Effective Demand," IFPRI Draft Paper, 1990.

most fertilized crop, followed by wheat, tomato, beans, and cotton. The first three crops are perceived by farmers to be the most profitable. In this regard, food crops seem to lead nonfood crops by a large margin.

Lack of information is a major problem in that 43% of the nonusers do not even know about fertilizers. This highlights the great importance of extension. The availability of credit was identified as an important constraint by the users. The need for infrastructure and services was also stressed.

Finally, the findings obtained from all these studies indicate that the following areas are of critical importance and need special attention: crop response level; price environment; crop marketing and input distribution; use of animal traction; and investments in infrastructure, education, research and extension, and credit institutions.

5. Project Activities, 1990-92

During the first 3 years of the Fertilizer Policy Research Project (1987-90), research work focused on a number of issues relating to the fertilizer sector development in sub-Saharan Africa. Examination of the various issues over this vastly diverse geographical region confirmed prior established facts about the countries studied, i.e., these countries are characterized by (1) limited capacity to anticipate the impact of sectoral or economy-wide policies on the availability and use of fertilizers and other agricultural inputs and (2) weak institutional structures to handle these specified areas related to fertilizer sector development. After 3 years it was apparent that the efforts were too diffuse and that, if a visible impact was to be made in a given country, a reorientation of the Policy Project was necessary. Thus, Ghana, Malawi, and Mali were chosen as impact countries for initiation of institution and capacity building work and for research on selected fertilizer policy issues.

Institution and Capacity Building

"It has become increasingly evident that not nearly enough local skills and institutions are being systematically built, technologies are not being transferred effectively, and lasting indigenous capacities are not being developed."[8] Recognizing that the urgency to develop institutions and build capacities in African countries is stronger now than ever before, especially with many countries being compelled to undergo structural adjustment reforms, the Policy Project, working in close and equal partnership with national systems, has taken two key steps to give initial impetus to institution and capacity building work in Ghana and Mali.

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[8]World Bank, *The African Capacity Building Initiative*, Washington, D.C., 1991, p. 5.

First, a Fertilizer Policy Research Group (FPRG) has been established in Ghana, at the Institute of Statistical, Social, and Economic Research (ISSER), University of Ghana, Legon, and in Mali, at the Institut d'Economie Rurale (IER) in the Ministère de l'Agriculture, de l'Elévage, et de l'Environnement, to institutionalize the policy analysis process in each country. Efforts were made to ensure that the FPRGs were located somewhere central to the government's policymaking apparatus. These FPRGs function within relevant ministries or have direct access to individual units with responsibility for high-level policymaking. The FPRGs will thus be mechanisms for the transmission of policy recommendations to the policy-determining entity for timely and effective policy action.

In Mali, for example, the IER has direct access to the Comité National de la Recherche Agronomique (CNRA), a broad-based, multidisciplinary council comprising representatives from various government ministries, the private sector, nongovernmental organizations, and donor agencies. The CNRA is, therefore, a group of individuals with responsibility for high-level decisionmaking and with great potential for influencing in important ways the agricultural sector development in Mali in the 1990s and beyond. IER's location in relation to the CNRA, together with the fact that the Director-General of IER is the Vice-President of the CNRA, will likely facilitate the transmission of the FPRG's research findings and policy recommendations to the CNRA for action.

In Ghana at a meeting with the Secretary for Agriculture, it was decided that the FPRGs would report to the Agricultural Policy Coordinating Committee (APCC), which is an Inter-Ministerial Council (IMC) chaired by the Secretary for Finance and Economic Planning. The link between the FPRG, IMC, and the National Agricultural Research and Extension Systems (NARES) is not yet clarified.

Second, initial steps have been taken to install policy data bases and to train national personnel to use modern data and information management technology in support of the FPRGs in Ghana and Mali. This aspect of capacity building is based on the premise that existence of a sound data and information base is a necessary condition for meaningful analysis to provide timely and accurate advice to policymakers and governments. The ultimate goal of institution and capacity building is to achieve national long-term self-reliance in fertilizer and other agricultural inputs policy analysis, formulation, coordination, and implementation.

It should be noted that efforts to establish a fertilizer policy unit in Malawi were not successful. Efforts should be continued to establish a fertilizer policy unit for strengthening fertilizer policy research and implementation capacity in Malawi, because the fertilizer sector plays an important role in sustaining food security and agricultural growth in the country.

Fertilizer Policy Research

Fertilizer policy research has progressed at different stages in each impact country. The research agenda centered on five main policy themes, namely, (1) Food Security and Fertilizer Use; (2) Agronomic Potential of Fertilizer Use; (3) Agroeconomic Potential and Constraints on Fertilizer Use; (4) Policy Environment and Fertilizer Sector Development; and (5) Structural Constraints and Maize Marketing Efficiency in Ghana: Implications for Increased Fertilizer Use. The members of FPRGs in Ghana and Mali are actively collaborating with IFDC/IFPRI staff in conducting research on these themes.

The project aims/activities and project outputs/results are summarized in Table 1. What follows is a brief description of the policy research issues being addressed and an indication of the content of the forthcoming research reports.

1. **Food Security and Fertilizer Use**—The objectives of this activity are (1) to study comparative advantages in Ghanaian and Malian agriculture; (2) to analyze their evolution over time and identify the role played by potential determinants; (3) to determine the past and potential future role of fertilizer; and (4) to investigate the relationships between fertilizer use and food availability and consumption. The major focus is on the role of fertilizer in shaping crop comparative advantages and sustaining agricultural production in Ghana and Mali, with special emphasis on links between fertilizer use and long-term food security.

2. **Agronomic Potential of Fertilizer Use**—The agronomic potential of fertilizer use is evaluated for Ghana and Mali. This exercise considers key food crops and nonfood crops across different agroclimatic and ecological zones or regions using results from experiments conducted during several cropping seasons. Influential factors including cultural practices, risk, and level of technology are explicitly taken into account.

3. **Agroeconomic Potential and Constraints on Fertilizer Use**—Some of the fundamental questions policymakers and analysts are confronted with are these: "What are the determinants of agroeconomic potential of fertilizers?" and "What should be done to take advantage of this potential in such a way that the use of fertilizer is promoted without price manipulations?" The study of agroeconomic potential of fertilizer use in Ghana is set to examine these issues and to advance some policy recommendations.

The report examines the economic constraints that limit the use of fertilizers on different crops in the various agroecological zones or regions of Ghana. Specifically, the report evaluates the level of fertilizer use and estimates the returns to fertilizer use for selected crops in various agroecological zones. It also analyzes both price and nonprice factors that affect the returns to fertilizers as well as the level of fertilizer use in Ghana.

4. **The Policy Environment and Fertilizer Sector Development**—The main objective of this activity is to establish a framework for assessing the potential impact of fertilizer, agricultural, and economic policy reforms on the fertilizer sector operations in Ghana and Mali. A justification for studying the policy environment is the urgent need to evaluate and redesign existing policies with respect to their effectiveness in promoting equitable, efficient, and environmentally sound growth in the use of inorganic and organic fertilizers. The study analyzes and assesses the impact of the following policies on the fertilizer sector operations in each country: (1) Macroeconomic Policy, (2) Pricing and Subsidy Policy, (3) Credit Policy, (4) Supply Policy, (5) Organizational Policy, (6) Environmental Policy, and (7) Research and Extension Policy.

5. **Structural Constraints and Maize Marketing Efficiency in Ghana: Implications for Increased Fertilizer Use**—The observed increase in maize output due to increased fertilizer use in some areas of Ghana has led to disruptions in the maize market in those areas, leading to a sharp decline in maize producer price. This appears to suggest that the maize market cannot absorb a sudden and substantial increase in marketable surplus without a significant decline in the price of maize. This has a negative impact on farm revenue and profitability of fertilizer use and tends to

discourage the widespread use of fertilizers and other modern inputs. In this connection, this study attempts to examine the structure, conduct, and performance of the maize market. Research findings facilitate the development of policy recommendations on appropriate government actions to prevent severe maize price declines resulting from increased, fertilizer-induced maize output.

6. **Economic Policy Reforms and Fertilizer Use in Smallholder Agriculture in Malawi**–The policy reforms initiated since the 1970s in Malawi aimed at improving the country's food security and at diversifying its agricultural export base. These twin objectives were to be achieved through widespread use of fertilizers, high-yielding maize varieties, and other improved farm inputs and practices and through the reallocation of farmland between food and export crops. In this connection, the study examines whether the country has recorded some success toward achieving the above objectives. More clearly, the study assesses the effects of these policy reforms on the use of fertilizers and hybrid maize variety.

Ultimately, the study seeks to propose appropriate policy and institutional reforms required to improve agricultural productivity within the smallholder farming subsector. This is done through increases in crop response to fertilizer and other input use, reduction in inputs prices, and reforms on nonprice factors such as accessibility to farm credit, liberalization and privatization of input and product markets, and development of adequate infrastructure for efficient movement of goods and services.

6. Fertilizer Policy Research

Main findings and recommendations of the fertilizer policy research undertaken in each impact country are summarized below. It should be stressed that many of these findings are preliminary and require further work. In Phase II, these findings will be further refined and articulated into sound policy measures.[9]

Ghana

Fertilizer policy research in Ghana focused on the following five broad themes:

1. Food security and fertilizer use.
2. Agronomic potential of fertilizer use.
3. Farm-level constraints on fertilizer use.
4. The policy environment and fertilizer sector development.
5. Structural constraints and maize marketing efficiency in Ghana: Implications for increased fertilizer use.

Research documents on these themes are included in Appendix A. Important findings and conclusions of each research document are summarized below.

1. **Food Security and Fertilizer Use**

The importance of (increased) fertilizer use as a major determinant of long-term crop comparative advantage and agricultural growth arises from the need for sustained cost-reducing technological advances and the fertilizer-dependent character of most modern agricultural technologies. The adoption of improved crop varieties

[9]The views expressed in the research documents summarized below are those of researchers involved in conducting the research and are not necessarily those of the institutions with which they are associated.

and the viability of improved cropping techniques usually require the availability and application of appropriate quantities of fertilizer.

Cereals and tubers are the main foods consumed in Ghana. Expenditures on these items, together with other food products, account for a significant portion of expenditures by both poor and wealthier households in Ghana. Along with other agricultural activities, food production employs a large share of the labor force in the country.

However, yields in the food and agricultural sector of Ghana have not increased significantly over the past two decades. For almost all crops, yields have tended to be stagnant while fluctuating significantly from 1970 to 1990. Fertilizer and other improved inputs would greatly contribute to short- and long-term food security in the country by raising the level of performance in the food and agricultural sector. In fact, the use of fertilizer in Ghana's food and agricultural sector is very low and has not shown any significant upward trend since the early 1970s. Moreover, the restricted amounts of fertilizer that are applied seem to be heavily concentrated on one single crop, maize, and to a lesser extent on rice. Other crops that are less commercialized, but that play a significant role in household food intake, receive insignificant amounts of fertilizer. Furthermore, it appears that more than 80% of Ghanaian farmers do not use fertilizer at all. The bias in distribution and use of fertilizer in favor of maize and against non-maize-growing areas can have serious effects on the exploitation of the country's comparative advantages, the long-term growth potential in its agricultural sector, and food security.

The price environment that prevailed throughout the study period could not contribute to increasing fertilizer consumption. It has been characterized by falling or at best stagnating real producer prices and high levels of variability in the real costs of fertilizer across all major crops. In fact, Ghana could use trading on regional markets to some extent to even out fluctuations on its local markets, stabilize food consumption, and reduce risk in its domestic agricultural sector. All this would raise performance in the agricultural sector and raise food security in the short and longer run.

Ghana shows some degree of specialization in trade and production vis-à-vis other West African countries, which suggests a potential for intercountry trade in food and other agricultural commodities. Fertilizer use in Ghana is, however, lagging significantly behind the observed levels in its main potential competitors for regional markets, namely Cameroon, Côte d'Ivoire, and Nigeria.

2. **Agronomic Potential of Fertilizer Use**

Agronomic potential is assessed by using the results from experiments conducted at experimental stations and on-farm trials for selected food and cash crops, across geographical and agroecological regions during several cropping seasons. Agronomic indicators and fertilizer response estimators are developed, considering biophysical constraints represented by crops, soil fertility, crop and fertilizer management, and rainfall or climate.

The land area in Ghana totaling 23.9 million ha, including the forest and savanna soils, can be divided into six main agroecological zones: Rain Forest, Semideciduous Forest, Transitional, Coastal Savanna, Guinea Savanna, and Sudan

Savanna. The last two regions are also referred to as Northern Savanna. The rainfall distribution is bimodal in the forest zone and generally unimodal in the savanna. There are two important factors that characterize the Ghanian soils. These are the low fertility and low water-holding capacity.

Results from 200 fertilizer response experiments done in Ghana during the period 1960-90 were analyzed by statistical procedures involving regression analyses. Eighty percent of the experiments showed response to nitrogen, while 70% and 50% showed responses to phosphorus and potassium, respectively. An attempt was made to relate fertilizer and crop management practices with soil fertility and crop response across agroecological regions and agricultural districts. An average increase in yield per hectare from fertilizer applications ranged from 60% to more than 100% in most of the crops. Improved varieties were highly responsive to fertilizer applications. Average crop response to fertilizer applications in most agricultural areas in Ghana could be summarized as follows.

Maize response to fertilizer applications across agroecological zones varied from 7.6 kg grain yield per kilogram NPK in the Upper East region of the Interior Savanna Zone to 18.6 kg in the Volta region located in the Semideciduous Forest. The maximum maize grain yield was 3,160 kg/ha obtained with 90 kg/ha of nitrogen, 50 kg/ha of P_2O_5, and 30 kg/ha K_2O in the Volta region. The highest average cotton response was obtained in the Volta region of the Transitional Zone. Applications of 80 kg/ha of nitrogen combined with 60 kg/ha of P_2O_5 and 10 kg/ha of K_2O produced about 1,000 kg/ha, and the fertilizer efficiency was about 6.6 kg seed yield per kilogram of NPK.

Cassava and yams, the principal tuber crops grown in Semideciduous and Transitional regions of Ghana, were highly responsive to nitrogen and K_2O applications. Groundnut responded to P_2O_5 and K_2O in the Volta region. Sorghum response was very consistent across the Northern Savanna regions with about 10 kg of grain per kilogram of NPK. Lowland and upland rice grown principally in the Volta and Northern regions was highly responsive to nitrogen applications. Soybean and cowpeas significantly responded to phosphate fertilizer applications.

3. **Farm-Level Constraints on Fertilizer Use**

The study examined various aspects of fertilizer use in all six agroecological zones that form the country. Most of the fertilizer used in the country is used on cereals, mainly maize, rice, and sorghum. The production of these crops is located largely in the northern half of the country, comprising Guinea Savanna, Sudan Savanna, and Transitional zones. About 69.2% of the fertilized land area surveyed was located in these zones, which also accounted for approximately 76.3% of the volume of fertilizer nutrients used in Ghana in the 1991 crop year.

A comparison of the rates of fertilizer nutrient application per acre of fertilized land area with the recommended rates for selected crops reveals a gap in most instances. In the Rain Forest, Semideciduous Forest, and Coastal Savanna zones, maize on continuously cropped land received only 58.4%, 42.0%, and 67.9% of the recommended rates, respectively. In the Transitional, Guinea Savanna, and Sudan Savanna zones, the amount of fertilizer nutrients applied to maize per acre of fertilized land was 66.2%, 106.6%, and 82.6% of the recommended amounts, respectively.

About 15 different types of fertilizer products were used in the 1991 crop season, ranging from 3 in the Rain Forest to 8 in the Sudan Savanna. However, 85% of the nutrients used were supplied by NPKs (15-15-15 and 20-20-0) and ammonium sulfate.

The study analyzed the agroeconomic potential of fertilizer use, this potential being the highest level of returns to fertilizer use that can be obtained under the ideal technical and economic conditions. The agroeconomic potential of fertilizer use could be approximated to the highest returns that can be derived from fertilizer use given the prevailing technical and economic conditions. These returns are a function of the crop response to fertilizer and the farm-level fertilizer-crop price ratio.

The cost of fertilizer use, expressed in terms of crop output needed to purchase a kilogram of fertilizer nutrients, varies from 1.5 kg to 3.9 kg for maize. These costs appear to increase from south to north. For rice, costs vary from 1.0 kg to about 1.8 kg. For sorghum, the farm-level terms of trade between fertilizer and the crop vary from 1.6 kg to 2.9 kg. Costs of fertilizer use in the north are lower for sorghum than for maize.

Based on average crop response, fertilizer use on maize, rice, and sorghum is significantly profitable in the agroecological zones where they are produced. Because the crop responses to fertilizer and the fertilizer-crop terms of trade are the key determinants of the level of agroeconomic potential, efforts need to be deployed in order to improve these parameters. First, actions must be taken to increase crop responses to fertilizers through widespread use of appropriate fertilizer use practices and other agricultural techniques. For these objectives to be achieved, it is necessary

to improve the quality of both research and extension services. Second, measures are to be initiated to rationalize fertilizer imports, to improve fertilizer and crop marketing, and to expand credit markets and other related services.

The case for concentrating fertilizer use on cereals to the virtual neglect of other crops is becoming increasingly untenable. Agricultural diversification, which is one of the key elements of the structural adjustment program in Ghana, calls for the wider use of fertilizer and other complementary inputs on other crops. The starchy staples, namely, cassava, yam, and plantain, form the bulk of the energy consumed within Ghana. The role of these crops in food security, particularly for the poorest segments of the population, cannot be overemphasized. The analysis has shown that these starchy staples occupied 1.8% of the total fertilized area and claimed a token 0.6% of the total fertilizer nutrients during the 1991 main crop season. Even in the agroecological zones where such crops feature prominently as staples, they were planted to less than 10% of the fertilized area and claimed under 5% of the total fertilizer nutrients supplied during the study crop season.

It is important for policymakers to reassess the position of various crops in the national economy. They need to redraw the list of priorities with regard to the development and diffusion of agricultural innovations, bearing in mind the strengths and peculiarities of different agroecological zones in the country. The government of Ghana must develop a policy framework in order to promote, in a stable and long-term manner, the use of fertilizer and other agricultural inputs. Such a framework should aim at encouraging in each agroecological zone the use of fertilizer on food and export crops that have comparative advantage. Policy should also promote the

use of this input among small farmers and in areas of low agricultural potential. Improving technical skills of farmers, increasing the economic efficiency of fertilizer use, and developing agricultural commodity markets are other policy concerns requiring immediate attention.

4. The Policy Environment and Fertilizer Sector Development

Ghana's agricultural economy is passing through a developmental disequilibrium. With growth in population and income, the traditional system of shifting cultivation is inadequate to meet the growing demand for food, fiber, and fuel. Hence, a shift to intensive cultivation based on new crop technologies is required. Such technological transformation will require, among other things, increased use of organic and inorganic fertilizers.

Fertilizer use levels in Ghana are rather low. In 1990, Ghana used about 11,600 tons of nutrients. This level of nutrient use replenished only one-seventh of the nutrients removed by crops. In terms of per hectare fertilizer use, Ghana used 5 kg of plant nutrient compared with 12 kg in Nigeria, 48 kg in Kenya, and 110 kg in Indonesia.

Ghana's population increased from 6.7 million in 1960 to 14.1 million in 1990 and is projected to reach 18.7-19.5 million in the year 2000.

During the 1970s and early 1980s, Ghana experienced economic stagnation and decline. To reverse the economic decline, Ghana introduced a bold Economic Reforms Programme (ERP) in 1984. Under this program several policy and institutional changes were introduced. Major policy reforms included liberalization of trade and exchange rate policy, elimination of budget deficits, phasing out of

subsidies, and privatization of state-owned enterprises. As a result of these changes, Ghana's national income increased by 5.3%/year during the 1984-90 period. Crop production also increased significantly, although the annual growth of the agricultural gross domestic product (GDP) was lower than that of overall GDP during this period.

In spite of growth in crop production, Ghana experienced deficits in its food budget and depended on food imports. The Ministry of Agriculture estimated that, unless steps are taken to increase food production, Ghana's grain deficit will increase to 750,000 tons in the year 2000. Also, Ghana's population satisfied only about 76% of its daily nutritional requirements. Hence, to remove hunger and malnutrition, Ghana's agricultural output must increase.

Ghana's agricultural sector plays an important role in the national economy. It provides about 53% of GDP, 60% of employment, and 75% of merchandise exports. Growth in agricultural output is thus needed for both economic development and social well being.

Because increased fertilizer use will remain critical to achieve over 4.0% annual growth in crop output, the study of this theme assessed the role of the policy environment in accelerating growth in fertilizer use. The study, which covered the 1970-90 period, focused on the selected components of the seven policies, namely, macroeconomic, pricing and subsidy, supply, credit, organizational, research and extension, and environmental policies. The components having direct and indirect impact on the fertilizer sector operations were analyzed.

During the period of the study, the macroeconomic policy played an important role in constraining growth in fertilizer use. During the 1970-88 period, availability of foreign exchange was a major constraint. Consequently, Ghana depended on fertilizer aid to meet its domestic fertilizer requirement. This resulted in a supply-side constraint on fertilizer use. After 1988, excessive stocks were available in the country. By that time, however, the pricing and credit policies were relatively less favorable.

Exchange rate liberalization led to increased domestic prices of fertilizers. During the 1980-90 period, nominal fertilizer prices increased by over 25,000%. Although a part of this increase in fertilizer prices was compensated by an increase in crop prices, the real price of nutrients increased severalfold from 0.3 kg maize/kg N in 1980 to 3.5 kg maize/kg N in 1990. This reduced the relative profitability of fertilizer use and thus had a negative impact on fertilizer use in Ghana.

The policy of removing fertilizer subsidies also led to increased fertilizer prices. Under the ERP, fertilizer subsidy was reduced from 65% in 1980 to 0% in 1990. The removal of fertilizer subsidies contributed to both reduced fiscal deficits and decreased fertilizer use. Because both policies, namely, the exchange rate liberalization and the subsidy removal, were implemented simultaneously, it was not possible to separate their impact on fertilizer use. However, the joint impact of these policies was that fertilizer use decreased from about 30,000 nutrient tons in 1980-82 to about 11,000 nutrient tons in 1988-90.

During the 1970-88 period, the Ministry of Agriculture had the sole responsibility for import and marketing and distribution of fertilizers. In 1988, the private sector was allowed to distribute fertilizers in two regions—Volta and Brong

Ahafo. By 1990, private dealers were free to sell fertilizers at a government-fixed uniform price anywhere in the country. Fertilizer imports were liberalized by 1991. However, the privatization program did not achieve the desired success. The macroeconomic and price instability discouraged the private dealers from entering this market. It is clear from Ghana's experience that macroeconomic and pricing stability is necessary for the success of privatization programs. Lack of credit for farmers and fertilizer dealers also contributed to this result.

Ghana's credit policy also changed during the 1980s. Credit for agricultural operations remained subsidized until 1987. After 1988, the interest rate charged to the borrowers in the agricultural sector was no different from that charged to other borrowers. This led to decreased institutional credit for the agricultural sector. Consequently, the share of agriculture in total institutional lending decreased from 42% in 1982 to 13% in 1989. At a time when a severalfold increase in fertilizer prices led to increased credit requirements for both farmers and fertilizer dealers, interest rates for farm credit were increased. Consequently, many farmers and dealers were unable to borrow funds to buy fertilizers or benefit from the privatization program. Inadequate collateral also contributed to this problem.

Because Ghana does not have facilities for domestic manufacture of fertilizers, it depends on imports. Because of foreign exchange shortages and institutional arrangements, supply policy remained a major constraint on fertilizer use in Ghana. Private dealers should have been allowed to market and distribute fertilizers during the 1970s and early 1980s when the fertilizer market was growing. Private dealers were allowed at a time when the fertilizer market was shrinking rapidly.

From the environmental point of view, Ghana has not developed a conducive policy to prevent soil degradation and chemical pollution. In the future, relatively greater focus should be laid on developing and implementing such a policy. Ghana also lacks an integrated research and extension policy dealing with fertilizer use. The diversity of agroclimatic regions requires detailed and site-specific fertilizer recommendations. Currently, little diversity is provided in fertilizer recommendations.

Regional distribution of fertilizer use and supply suggests that measures should be instituted to prevent widening regional disparities between the south and the north. Adequate development of physical infrastructures to reduce transportation cost should receive priority in the future developmental work. Meanwhile, a safety net should be provided to the farmers in the north so that the cost of fertilizer use is not prohibitively high.

Ghana's experience of the 1980s suggests that if the growth in fertilizer use is needed to achieve socioeconomic goals like food security, environmental protection, foreign exchange savings, and balanced regional development, then the policy reform program should be introduced in phases. The simultaneous introduction of exchange rate liberalization and subsidy removal programs does not promote growth in fertilizer use nor does it encourage private sector participation. Proper sequencing and phasing should be developed for each policy, and, if needed, some safety nets should be provided to counteract the undesirable impact of certain policies. Macroeconomic and price stability is essential for successful privatization.

5. Structural Constraints and Maize Marketing Efficiency in Ghana: Implications for Increased Fertilizer Use

Ghana has comparative advantage in maize production at the farm level. This comparative advantage is, however, lost at the retail level due to high marketing costs. Therefore the overall comparative advantage (to trade) of a country depends both on its production structure and its internal marketing structure.

In the classic definition of a market, the marketing functions are buying, assembly, financing, transporting, grading and standardization, provision of market information, storage, processing, and selling. In Ghana, buying and selling are well known to most market participants as marketing functions. The supportive functions of assembly, financing, grading and standardization, and provision of market information are yet to be fully developed into the marketing system in Ghana.

The Ghanaian maize market can be classified as being efficient given the constraints. The identified constraints to increased marketing efficiency include the following.

a. Inadequate post-harvest management: use of inefficient methods for storage.

b. Insufficient marketing and trade outlets to absorb increases in supply at harvest.

c. Lack of marketing intermediary.

d. Lack of information on supply and price conditions to market participants.

e. Inadequate rural infrastructure such as feeder roads and extension services.

f. Lack of credit facilities to farmers and market participants.

This situation leads to low producer prices, high marketing costs, high retail prices and inability of the market to handle increases in marketable surplus, resulting from a widespread adoption of fertilizer-seed technology, without significant decreases in prices. Policy actions have to be initiated to remove the structural constraints outlined above.

Malawi

Because an FPRG could not be established in Malawi for unavoidable reasons, fertilizer policy research in Malawi focused on only one theme, namely, the impact of economic policy reforms on fertilizer use in smallholder agriculture. Important findings and recommendations of this research are summarized below, and the research document is included in Appendix B.

1. **Food Self-Sufficiency and Export Crop Diversification**

Malawi introduced several policy reforms even before the structural adjustment program (SAP) in 1981 to improve its food self-sufficiency and to expand its export crop base. These goals were to be achieved through intensification of maize production and through the reallocation of farmland away from maize and traditional export crops (tobacco, sugar, tea, and coffee) to new export crops. In addition, the yields of both maize and export crops were to be enhanced through a widespread use of fertilizers and hybrid maize variety. This study has concentrated on the difficulties that Malawi experiences in achieving these agricultural goals.

The study indicates that during the pre-adjustment (1971-78) period the maize yield and area increased, respectively, at an average annual rate of about 2.1% and 0.9%. During the adjustment (1979-83) period, both the yield and the area under maize crop declined, respectively, at an annual rate of 1.9% and 0.7%. The production of maize did not improve during the post-adjustment (1984-87) period. As expected from SAP, the area under maize decreased by 1.0%/year. This area contraction was accompanied by a 1.5% annual decline in maize yield. This led to 2.5% decrease in maize output per year.

The deterioration of the maize production was further compounded during the post-adjustment (1984-87) period by a reduction in land area allocated to other food crops and minor export crops, all of which fall under the smallholder sector. The yields of these crops must have declined because most of these minor food crops, which are primarily subsistence-oriented, not only attract little or no fertilizers but also tend to be cropped on poor land, and the fallow system tends to disappear as a result of population pressures on land.

Considering the export crop diversification program, the study shows that the area under predominantly smallholder export crops (groundnut and cotton) declined at a rate of 0.8%/year while the area under predominantly estate crops (tobacco, sugar, tea, and coffee) increased at an annual rate of 2.9% during the study (1970-88) period. The total area cultivated under nontraditional export crops remains negligible. It is clear from this analysis that the Government did not give smallholder farmers—who control, as a group, the bulk of the land—the needed incentives for them to expand their export crops base significantly.

The expansion of the estate sector did not improve the distribution of the increased estate income between capital and labor owners. This situation might have contributed to widespread food insecurity and malnutrition in Malawi because the wage of people working in the estate sector, most of whom are members of smallholder farming households, declined significantly during the post-adjustment (1984-88) period. The index of the real agricultural (rural) wage, which was 109.1 during the 1979-83 subperiod, declined to 76.3 during the 1984-88 subperiod.

2. Fertilizer Use and Diffusion of Hybrid Maize

A widespread use of fertilizers and hybrid seed has been regarded as the cornerstone of the policy reforms. The overall growth rate in fertilizer nutrient consumption fell from 6.4%/year during the 1972-78 period to -1.2% during the adjustment (1979-83) period and then regained its pre-adjustment level (about 6.6%/year) during the 1984-88 period. SAP reforms did not significantly improve the consumption of fertilizers.

The distribution of fertilizers among sectors was found to be biased in favor of the estate sector. Taking two major fertilizer-using crops—maize, the most important smallholder crop, and tobacco, the most important estate crop—the available data indicate that during the 1982-88 period the smallholder sector controlled 71.0% of the cropped land area under maize and tobacco combined while the estate sector claimed only 29.0%. Yet the estate sector used 48.9% of fertilizer nutrients and the smallholder sector 51.1% during the period. The diffusion of hybrid maize declined during the 1980-88 period. The share of maize area under local variety rose and that under composite and hybrid varieties fell during the period.

Conclusively, SAP reform did not affect significantly and positively the key factors influencing the use of these inputs in the smallholder sector of Malawi. These factors include, among others, the response of crops to fertilizer input, the farm-level fertilizer-crop terms of trade, information pertaining to the use of fertilizer and other improved inputs, credit and fertilizer delivery systems, and crop marketing systems.

3. Maize Response to Fertilizer Use

Data, based on the annual survey of agriculture, indicate that the degree of variability in local maize yield, as shown by the coefficient of variation, does not seem to be significantly affected by fertilizer use. The composite variety displays the same characteristic, but to a lesser extent. However, the production of hybrid maize without fertilizers leads not only to smaller yield but also to high yield variability. This implies that the availability and access to fertilizer input are some of key determinants of the adoption of hybrid maize by smallholder farmers. The development of efficient fertilizer delivery and credit systems is prerequisite to any enhanced adoption of high-yielding varieties.

The regression analysis also reveals that the response of local maize to fertilizer use is about 11.4 kg of maize per kilogram of fertilizer (N and P_2O_5) nutrients; it is 13.1 kg for composite maize, and for hybrid maize, it is 33.0 kg. The difference between the response of local maize to fertilizer use and that of composite maize is not statistically significant. Furthermore, the analysis indicates that the rates of fertilizer nutrients used by smallholder farmers are about 26.7 kg of fertilizer nutrients per hectare for local, 45.6 kg for composite, and 52.0 kg for hybrid maize.

These rates are substantially lower than the recommended rates of 39.0 kg of fertilizer nutrients per hectare for local, 92.0 kg for composite, and 132.0 kg for hybrid maize.

This analysis further indicates that the rates of fertilizer nutrients used by farmers are technically and economically appropriate. Overall, they correspond to the highest maize response that could be attained given the crop management techniques and other agricultural practices currently used by the smallholder farmers in Malawi. The recommended rates for different maize varieties are too high and make little technical and economic sense. This result contradicts some researchers who suggest that much effort is needed to encourage most smallholder farmers in Malawi to use the recommended rates of fertilizer nutrients per hectare of fertilized land area. Their conclusion appears not to be based on a rigorous analysis of the farm-level input-output data.

4. Fertilizer-Crop Terms of Trade

The fertilizer price has increased at a much faster rate than that of the smallholder prices for maize, rice, and tobacco. Consequently, the terms of trade or real price of fertilizers increased. Increases in fertilizer prices at the farm level were mostly due to increased import prices, domestic marketing costs, and external transport costs. The increases in import costs, although substantial, remain relatively much lower than the increases in the domestic marketing costs due to structural and institutional deficiencies. Furthermore, Malawi has largely relied on low-analysis fertilizers. A widespread use of high-analysis fertilizers, consistent with the ecology, will reduce costs at the farm level.

With respect to maize, the producer price of this crop is likely to fall during the process of liberalization and privatization. There is very little the Government of Malawi can do to further increase the nominal producer price of maize. The price paid to producers is already much higher than the world price. For rice and tobacco, the elimination of the export tax will help increase the prices of these crops at the smallholder farm level.

To reduce the farm-level terms of trade between fertilizers and maize crop, the Government of Malawi should explore the possibility of liberalizing and privatizing the domestic fertilizer delivery and maize marketing systems. For rice and tobacco, in addition to fertilizer and crop market improvement measures, trade taxes on these commodities should be phased out. Government should raise its revenue through land, income, and sales taxes, instead of through trade taxes.

5. **Returns to Fertilizer Use**

The returns to fertilizer use, expressed by the value-cost ratio based on average crop response, decreased because of the worsening of the terms of trade between fertilizers and crops. Measures to improve the farm-level fertilizer-crop terms of trade have to be pursued vigorously if the use of fertilizers in the smallholder sector is to be enhanced. In addition, efforts should also be made to improve farmers' technical skills related to appropriate fertilizer use practices.

6. Other Determinants of Fertilizer Use

In addition to the terms of trade, fertilizer use depends on a broad-based credit system. However, the distribution of formal credit is biased towards large farmers. Most smallholder farmers are left with the option of plough-back profits and dependence on relatives, friends, local traders, and traditional money lenders.

The delivery of information pertaining to the use of fertilizers and other innovations is also a key element in the process of technological transformation of the agricultural sector. Effective contact between extension staff and smallholders has been limited to a small minority of well-to-do farmers.

Research has been focused on single commodity programs located mainly on research stations; adaptive research systems for the smallholder farmers have received relatively little attention. Both research and extension have been increasingly ineffective because extension messages have not considered socioeconomic constraints facing most smallholder farmers.

Despite the heavy investments in research and extension on improved maize, tardy collation of data and weak research-extension linkages have led to blanket fertilizer recommendations, which have become increasingly uneconomical for many farmers. A number of well-researched agricultural practices are available but are not promoted by the extension staff, further illustrating weak research-extension linkage. The extension and research staff must work together in identifying farmers' needs, resources, and constraints.

Women have a major role in farming. Although more female extension assistants are needed and are being sought, the extension service should, in the

meantime, make a greater effort to involve women in direct extension contact and in training activities. The farm-home assistants should focus their messages more on farming/gardening activities and nutrition.

There is no extension service for the estate sector; although this is not particularly important for the older established managers, it is a serious constraint for managers of newly created tobacco estates who have been recently transferred from the smallholder sector. Thus, an extension service for this group of farmers is needed, but it may be more appropriate for it to be financed by the industry rather than the Government.

Mali

Fertilizer policy research in Mali focused on the following three themes:

1. Food Security and Fertilizer Use.
2. Agronomic Potential of Fertilizer Use.
3. The Policy Environment and Fertilizer Sector Development.

Research documents on these research themes are included in Appendix C. Main findings and recommendations are summarized below.

1. **Food Security and Fertilizer Use**

In Mali, cereals (millet/sorghum, maize, and rice) are the main staple food crops. They supply most of the energy requirements. Their supply of calories to the diet varies from 70% in urban areas to 80% in the rural areas. A Malian spends more than 50% of his income on food, and almost half of all food expenditures are on

cereals. Yet major increases in cereal yields have not been achieved over the last 20 years.

Mali's food sector is dominated by small-scale sorghum and millet producers. More than 80% of the sorghum and millet crop is consumed directly by farm households. Between 1980 and 1990 these two crops accounted for more than 75% of total cereal production. The share of maize was roughly 9%.

Prior to 1970, chemical fertilizers were being used almost exclusively on export crops, mainly cotton and peanuts. By 1970, fertilizer was introduced into rice cultivation both in the Office du Niger and in the controlled submersion zones. In recent years, fertilizer application has been extended to other cereal crops as well. However, the evolution of real crop prices and of the relative cost of fertilizer, and their respective levels of instability, have not been favorable to high levels of fertilizer consumption in the food sector.

Mali has the potential of becoming a major source of cereal exports to regional markets. Regional trade can contribute to national food security if intercountry commodity flows reduce price fluctuations in local food and other agricultural markets. Promoting the use of productivity-raising inputs such as fertilizer would significantly raise Mali's ability to exploit that potential. However, in terms of fertilizer use, Mali still ranks behind other major regional producers such as Cameroon, Côte d'Ivoire, Nigeria, and Senegal.

2. Agronomic Potential of Fertilizer Use

Mali is a landlocked country that lies in Saharan, Sahelian, Sudanian, and Guinean agroecological zones. Soils in the cropped areas are classed as ferruginous tropical and hydromorphic with generally low fertility and low water-holding capacity.

Increasing fertilizer use and efficiency continues to be one of the primary objectives of the Government of Mali to increase productivity per unit of land. Results from 150 experiments from experimental stations and on-farm trials located across agroecological zones were evaluated and analyzed using statistical procedures. The agronomic results showed consistent crop responses to nitrogen, phosphorus, and potassium. Of these trials, 90% showed high response to nitrogen and phosphorus while 65% showed response to potassium.

Average crop responses to fertilizer applications in agricultural areas of Mali can be summarized as follows.

Millet response of local varieties was only 2-4 kg of grain per kilogram of NPK. Responses of improved varieties were 6-8 kg of grain per kilogram of NPK. Maize response ranged from 5 to 20 kg of grain per unit of NPK in the Sikasso region using improved varieties. Sorghum response was 6-12 kg of grain per unit of NPK for improved varieties as compared with 2-4 kg of grain per unit of NPK with local varieties. Groundnut response ranged from 6 to 10 kg of grain per unit of NPK using improved varieties. Upland rice response ranged from 7 to 20 kg of grain per unit of NPK while lowland rice ranged from 10 to 24 kg of grain per unit NPK. Wheat, grown in the Sahelian zones of Mopti and Gao, showed responses ranging from 6 to 12 kg of grain per kilogram of NPK. Improved varieties of cowpea showed

increases of 2-6 kg of grain per kilogram of fertilizer and sugarcane in the Segou region, and cotton in the Sikasso showed high responses to fertilizers (NPK applications).

3. The Policy Environment and Fertilizer Sector Development

Mali's population has increased from 4.1 million in 1960 to 8.1 million in 1990 and is expected to reach 9.7 million in the year 2000. This growth in population and the expected growth in per capita income will put pressure on Mali's limited land resources to produce increasing amounts of food, fiber, and fuel to meet the growing demand. In addition, the past growth in population and the practice of shifting cultivation has created the problem of soil degradation and desertification. Unless efforts are made to control soil erosion through proper nutrient management, water harnessing, and other measures, the resource degradation will become an intractable problem. Hence, efficient and environmentally sound fertilizer use will play an important role in providing increased crop production and in preserving the resource base.

The main objective of this study is to analyze the role the policy environment has played in promoting growth in fertilizer use and supply in Mali and to identify policy-related factors constraining the fertilizer sector operations. As a corollary, the study also suggests measures to remove policy-related constraints. For the purposes of this study, the policy environment is defined as consisting of seven policies, namely macro, pricing and subsidy, credit, research and extension, environmental, organizational, and supply. Only the selected components of each policy having direct and indirect impact on the fertilizer sector operations are analyzed.

Lack of consistent and reliable data has been a major problem in the completion of this study. Developing adequate institutional arrangements for collecting, processing, and maintaining data on various facets of the fertilizer sector development should receive a high priority in the future work.

Fertilizer use grew at 17.7%/year during the 1970s and 4.9%/year during the 1980s. In absolute amounts, total fertilizer use was 2,547 nutrient tons in 1970, 14,928 nutrient tons in 1980, and 24,470 nutrient tons in 1990. Although total fertilizer use increased at 4.9%/year during the 1980s, there was little growth in per-hectare fertilizer use, which increased from 8.0 kg/ha in 1980 to 8.7 kg/ha in 1990. Thus, most of the growth in total fertilizer use was due to increase in fertilized area.

Mali's agricultural and rural development activities are designed and implemented through integrated rural development agencies known as "Opérations du Développement Rurale" (ODRs). Hence, five ODRs–namely, Compagnie Malienne pour le Developpement des textiles (CMDT), Opération Haute Vallée (OHV), Office du Niger (ON), Opération Riz Mopti (ORM), and Direction Régionale de L'Agriculture, Mopti (DRAM)–were selected to analyze the impact of the policy environment on fertilizer sector development in Mali.

Fertilizer use in Mali is highly concentrated in a few ODRs. In 1990, CMDT accounted for 81% of total fertilizer use. ON and OHV accounted for 13% and 3%, respectively. Thus, these three ODRs accounted for over 95% of the total fertilizer use. Although these three ODRs cover most of the highly productive area of southern Mali, efforts are needed to promote fertilizer use in other parts of the country where the resource degradation problem is serious.

CMDT's dominant position in fertilizer use is an outcome of several factors including well-developed and integrated crop and input markets, adequate research and extension, and focus on export crops. Further, farmers in the CMDT zone have an assured market and price for their produce. Such favorable conditions are generally not prevalent in other ODRs.

Mali's nutrient use is based on high-analysis fertilizers like DAP, urea, and NPKs (cotton formula). These three products accounted for over 90% of total nutrient use in 1990. In this respect, Mali is ahead of many other West African countries, including Ghana, who rely heavily on low-analysis fertilizer products.

The macroeconomic policy was not as severe a constraint on fertilizer use in Mali as it was in Ghana during the 1980s. Because Mali is a member of West African Monetary Union (WAMU), its currency is easily accepted in most of West Africa and France. Also, Mali has been importing fertilizers from Senegal and Côte d'Ivoire where the currency is FCFA as it is in Mali. Nevertheless, foreign aid has played an important role in supplying fertilizers.

Fertilizer use was subsidized in the 1970s. However, fertilizer subsidies have been phased out as a part of structural adjustment programs. Very few subsidies were in existence in 1990. Only the use of Tilemsi phosphate rock was subsidized.

Although Mali has good-quality phosphate rock (Tilemsi phosphate rock [TPR]) suitable for direct application, it has not become popular with the farmers. To promote its use, CMDT subsidizes it by 60%. Factors constraining direct application of TPR and its economic feasibility should be explored in the future research.

Nominal prices of both crops and fertilizers have increased over time. However, because of removal of subsidies and decrease in crop prices, real prices of fertilizers (terms of trade) have increased. Real prices of all nutrients were higher in 1990 than they were in 1980 for all crops except paddy rice.

Mali's pricing policy ensured subsidized and uniform prices throughout the country. This policy was changed in the 1980s. Consequently, prices differ from one zone to the other. For example, nominal and real prices of fertilizers were much lower in the CMDT zone than in other ODRs. This is mostly because CMDT benefits from the economies of scale in purchasing its fertilizer requirements.

Until 1980, the Société de Crédit Agricole et Equipment Rural (SCAER) was responsible for importing fertilizers for all ODRs. Because of mounting losses and deficits, SCAER was dissolved in 1980/81. Thereafter, all ODRs arranged for their fertilizer imports. This change in policy has created opportunities for some private agencies like the Comptoir Malien de Distribution (COMADIS) to import and distribute fertilizers. In some of the ODRs, village associations have assumed the responsibility of distributing fertilizers.

Credit for purchasing fertilizers is provided by both ODRs and the Banque Nationale de Developpement Agricole (BNDA) at an interest rate of 10%-14%/year. Because many ODRs promote trade-in-kind, i.e., exchanging fertilizers for crop produce, most of the loans for fertilizers are only for one cropping season. At the farm level in the CMDT zone, credit does not seem to be a constraint. However, further research is needed in this area.

Mali has not created any inefficient fertilizer production facilities nor has it built protective walls to safeguard and promote the use of Tilemsi phosphate rock (TPR). However, Mali should explore the possibility of using TPR in blending and compaction operations. The use of TPR should also be encouraged to restore and maintain soil fertility at reasonable levels so that soils do not become degraded. Mali's environmental policy seems to be moving in the right direction in this area.

Outside the CMDT zone, and in other parts of the country not covered by the ODRs (known as "zones diffuses"), research and extension efforts should be strengthened.

Currently, there is no policy in existence to promote the development of private sector dealer networks for fertilizer marketing and distribution. Institutional and infrastructural facilities should be developed to train dealers in fertilizer business.

7. Prospects for Further Work

The main goal of the Fertilizer Policy Research Project is to provide policymakers in sub-Saharan African countries with relevant information that would guide rational policy choices with respect to fertilizer and other agricultural input use consistent with the countries' overall economic objectives. Its immediate objective is to promote the value of a sound information base and in-depth policy analysis as a prerequisite for sound decisions through creating a National Fertilizer Policy Unit (NFPU) in each impact country to facilitate development of in-country capacity for ongoing policy evaluation, coordination, and policy implementation. Such units would function within relevant ministries or have close or direct access to individual units with responsibility for high-level policymaking. To attain this goal, further work is needed in order to continue the development and strengthening of the NFPUs in Ghana and Mali and establish similar units in Malawi and in one or two new impact countries to be chosen from a pool that includes Burkina Faso, Cameroon, and Nigeria. In close cooperation with NFPUs, the second phase of this work will develop and strengthen national capacities and institutions that will promote efficient, equitable, and environmentally safe use of fertilizers and other agricultural inputs.

Adequate training will be provided to impact country nationals to develop their capabilities for analyzing fertilizer and other agricultural input policies in the long run. Training activities will be targeted at policymakers, policy analysts, and researchers. To help the country increase its human capital stock, graduate students will be provided opportunities to gain experience and to benefit from research and training activities. The project will also (1) examine and specify the roles of the state and private sectors in the execution of tasks and the provision of services to foster the use of fertilizer and other

modern agricultural inputs, (2) provide national institutions with relevant information and analytical frameworks that will guide future research pertaining to the fertilizer sector in sub-Saharan Africa, (3) strengthen selected institutions in impact countries to enable them to carry out fertilizer studies or research on a continuous basis, and (4) strengthen advisory, coordination, and monitoring functions of related national institutions to indicate where policy changes are necessary to improve efficiency and fertilizer use.

It is, therefore, important to create a viable structure for designing policy guidelines to develop and promote institutional and infrastructural settings conducive to proper functioning of the fertilizer and other agricultural input sectors and the agricultural output sector. On the agricultural input side, the research effort will seek to examine policies and strategies that will help develop appropriate institutional arrangements for (1) the generation and dissemination of information for market development, fertilizer promotion, extension, and training; (2) input delivery, including procurement, storage, distribution, and marketing; and (3) financing, considering formal and informal credit markets for production, importation, and delivery of agricultural inputs to farmers.

On the agricultural output side, the institutional arrangements to be examined include information use and management for marketing, extension and financing, including credit for the acquisition of other agricultural inputs such as labor, seeds, and pesticides, and for distribution, storage, marketing, processing, and utilization of crop output. Another area of research will examine government regulations and controls as they affect agricultural inputs and outputs. It is important to emphasize that the development of relevant markets, institutions, infrastructures, and incentive environments for both agricultural inputs and agricultural outputs is essential to the success of agricultural modernization efforts.

Table 1. Fertilizer Policy Research Project Aims/Activities and Outputs/Results, 1991/92

Project Aims/Activities	Project Outputs/Results
I. Institution and Capacity Building 1. Creation of fertilizer policy research groups 2. Creation of database and information management system 3. Training of national personnel in policy data and information management 4. Working with national counterparts in analyzing policy data and information and in report writing	▪ Functional Fertilizer Policy Research Groups in Ghana and Mali (established in 1991) ▪ Database on fertilizer importation, consumption, stocks, aid, fertilizer and crop prices, crop production, yields, areas, macroeconomic, demographic, and other agricultural sector related data and information ▪ Trained national personnel in fertilizer data and information management and analysis.
II. Policy Research 1. Food security and fertilizer use 2. Agronomic potential of fertilizer use 3. Agroeconomic potential and constraints on fertilizer use and supply 4. Policy environment and fertilizer sector development 5. Analysis of the structure of the Ghanaian maize market 6. Diffusion of fertilizers, high-yielding varieties, pesticides, and improved practices and its economic impact in Togo	▪ Policy research reports for Ghana, Mali, and Malawi ▪ Research report on Togo ▪ Research experience to be gained by three (3) students of the University of Benin in Lomé, Togo, each of whom is using the data generated by this study to write a Master's Thesis in economics and resource management