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## MACRO-MICRO LINKAGES: STRUCTURAL ADJUSTMENT AND FERTILIZER POLICY IN SUB-SAHARAN AFRICA

by

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## RÉSUMÉ

Considéré comme allant de soi pendant les années 60, le principe de subvention des intrants agricoles a été remis en cause dans le cadre des Plans d'Ajustement Structurel, au profit d'une libéralisation de ce secteur. Mais, étant donné que la consommation d'engrais en Afrique sub-saharienne, est la plus faible du monde, l'accélération du développement agricole de l'Afrique sub-saharienne impliquera un accroissement de cette consommation.

Une large diffusion des pratiques agricoles modernes est donc un impératif absolu pour les politiques agricoles. Or l'arrêt des subventions s'est toujours traduit par une chute de la consommation des engrais. Ceci s'explique par les particularités de la demande privée d'intrants agricoles, extrêmement sensible au facteur-risque associé à l'utilisation des engrais. Les utilisateurs doivent donc être protégés contre les aléas économiques consécutifs à l'emploi d'intrants modernes, ce qui suppose le maintien d'un schéma de subvention.

Associée à une hausse des prix versés aux producteurs pour leurs produits, une telle politique assurera une augmentation de la production et une intensification des méthodes de production.

## SUMMARY

In the 1960s, the principle of subsidies for agricultural inputs was unquestioned. The advent of Structural Adjustment Plans led however to a re-examination of this principle, as preference moved towards liberalisation of the agricultural sector. Given the very low consumption of fertilizers in sub-Saharan Africa — a consumption level which is currently the lowest for all world regions — its agricultural development calls imperatively for an increase in the use of fertilizers.

Widespread diffusion of the most modern agricultural practices is therefore a *sine quo non* for agricultural policies in this region. Hitherto, the cessation of subsidies has always resulted in reduced use of fertilizers. This is due to the specific nature of private demand for agricultural inputs, which is particularly sensitive to the risk factor associated with the use of fertilizers. Users must accordingly be protected against the economic hazards consequent upon the introduction of modern inputs; it follows that a subsidy framework must be maintained.

Such a policy, allied to a rise in the prices paid to producers for their products, will assure not only higher production, but also production by more highly intensified methods.

## PREFACE

In developing countries, structural adjustment and trade liberalisation are matters of immediate and profound concern. Research carried out within the OECD Development Centre programme on Developing Country Agriculture and International Economic Trends aims to provide fresh perspectives which may facilitate the reform process.

The Centre's research on agriculture incorporates several components: a conceptual component to provide analytical guidance to the broader issues; a global general equilibrium model to analyse the overall trends and policy consequences; country case studies to look at the reform options and their implications for individual representative countries; and a component to analyse the links between economic reform and technological change in agriculture.

This study is an element in the first component: it provides an analytical and empirical framework for examination of the interaction between the macroeconomic changes associated with structural adjustment and the microeconomics of fertilizer use.

The considerable attention which has been devoted to the analysis of structural adjustment may be contrasted with the relative neglect of its impact on the ground. While it is widely acknowledged that the supply and use of agricultural inputs has been distorted, little is known of the possible implications of substitution of new economic rules. In particular, the possible negative consequences for smaller and poorer farmers of the removal of structures which facilitated input use and reduced risk should be examined.

The focus of this study on structural adjustment and fertilizer use in sub-Saharan Africa is particularly welcome. This timely examination of an important, but neglected issue points to the need for a more considered and long-term understanding of the impact of structural adjustment. Existing policies are shown to be inadequately founded. Much more caution is needed in order that the effects of policies be understood. This study highlights the analytical issues, assembles the available evidence and offers clear policy conclusions. It thus provides a major contribution to our understanding of the interaction of macroeconomic adjustment and microeconomic reforms in agriculture.

Louis Emmerij  
President, OECD Development Centre  
November 1991

## INTRODUCTION

### 1. *The General Context*

Since the publication of the "Berg Report" in 1981, attention has been drawn to the agricultural problems of sub-Saharan countries, and policy recommendations have been oriented toward a restoration of the productive potential of agriculture in exports and food crops.

The diagnosis of agricultural crisis has focused on the counter-productive effects of state intervention, both as regards pricing policies and rigidities and as regards inefficiencies resulting from public intervention in agriculture. Marketing Boards and *Caisses de Stabilisation Agricoles* (CAISTABS) were blamed for levying a surplus on export crops and keeping prices paid to domestic producers below world prices, thus discouraging production, and for controlling centrally the commercial networks, thus introducing rigidities, market distortions and keeping more efficient private operators out. The misallocation of funds earned by Marketing Boards and CAISTABS was also seen as inducing inefficiencies in the allocation of public funds which hit mainly the agricultural sector.

Structural Adjustment Policies (SAPs) have therefore been increasingly concerned with the reform of the agricultural sectors, with the general objective of increasing producer prices and diminishing state intervention (Norton, 1987, Guillaumont, 1990b). However, since SAPs do tend not merely to restore the productive potential of agriculture but also to influence the overall macroeconomic environment, the place of agricultural policy within the SAP framework suffers from some ambiguities.

### 2. *Relation between Stabilisation and Adjustment Policies*

One general ambiguity stems from the interferences between the policy objectives of stabilisation and structural adjustment. Classically, stabilisation is brought about by demand-management instruments, such as a reduction in the level of public expenditures and budget deficits, and a tight monetary and credit policy. The reduction of public expenditures in agriculture, and especially the reduction of subsidies, is thus part of the stabilisation strategy. Structural adjustment on the other hand aims at increasing the efficiency of productive sectors through supply-side measures and as such is more concerned with micro-level and sectorial policy measures. One important objective of these measures is to induce expenditure-switching effects which will result in a reallocation of productive resources. Based on the general diagnosis that structural disequilibria result from misleading incentive structures and from market distortions, the structural adjustment philosophy sees the restoration of market mechanisms as the prime mover of reallocation.

Although in theory both sets of measures are not contradictory, since stabilisation instruments are supposed to cure basic disequilibria and install a "sound" economic environment which will spontaneously mature into structural adjustment (Fontaine, 1989), in practice requisites of stabilisation and structural adjustment can prove quite contradictory.

One first general contradiction comes from the fact that stabilisation will often prove more difficult to achieve than expected so that stabilisation episodes can drag on for some time. Repeated attempts to stabilise the economy will generate uncertainties regarding the future course of policy (e.g. on budget, credit, rate of exchange and so on) and generally disturb the environment in a way which is unfavourable to adjustment.

Second, macroeconomic requirements of stabilisation and adjustment can prove contradictory in a more fundamental way, for instance on fiscal and monetary issues. Adjustment will require a low tax base (e.g. on foreign-trade profits) and an easy credit situation, while stabilisation will require increased government revenue and a tight monetary policy.

A third element of contradiction, more relevant here, is that expenditure-switching, reallocation of resources and increases in productivity may require some public intervention in the form of subsidies, especially when markets do not operate smoothly. The incentive structure resulting from market prices will not necessarily ensure a proper mobilisation of resources, and subsidy schemes may prove necessary to reinforce the potency of incentives. If the budget situation is tight, there will be a trade-off between the stabilisation and the adjustment objectives. Depending on the relative importance attached to these two objectives, adjustment may be sacrificed to stabilisation.

Finally, adjustment in itself may prove self-contradictory. This will be the case if the liberalisation of markets induces domestic instability. In such a case, the indications provided by the structure of price incentives may change abruptly from year to year, and disconcert private producers.

### ***3. Structural Adjustment and Agriculture***

There are essentially three reasons why the conflicts between policy objectives will prove particularly acute in the case of agricultural reform.

The first is that agriculture is customarily the best candidate for state intervention and protection, i.e. the sector where arguments for protection and state intervention carry the heaviest weight (Sarris, 1987).

The second, which concerns especially African agriculture, is that the discrepancy between short-term and long-term factors is higher in agriculture than in other sectors: short-term economy-wide imbalances tend not to originate from the agricultural sector, where crises generally result from long-lasting imbalances materialising only gradually elsewhere. Conversely, reforms intended to restore a



policy environment favourable to agriculture need time to take effect (Norton, 1987). The contradiction between short-term stabilisation and long-term adjustment is accordingly strongest in agriculture. In particular, obsession with the restoration of budget equilibrium through curtailment of transfers and subsidies to agriculture may prove particularly harmful.

The third reason is that, thanks to the numerical predominance of small-holders and to structural complexity, as exemplified by the emergence of numerous middlemen both official and unofficial, the existence of a wide variety of soils and cultivation practices etc., African agriculture is extremely heterogeneous. Thus behaviour does not correspond to "market rationality"; diffusion of information proceeds slowly along a great variety of channels; and adoption of new attitudes and practices takes a long time to be measured, in terms of generations rather than of years. The structural adjustment philosophy which depends on short-term reactions to changes in market signals is here most probably inadequate.

Finally, since policy change is often associated with uncertainty, and since risk-aversion is a characteristic feature of small-holder agriculture, it is clear that there is an essential trade-off to be struck between bringing about reform of the policy environment towards greater efficiency and the need for achieving stability in the economic environment.

This report, organised in five chapters, examines the impact of structural adjustment and liberalisation proposals upon fertilizer supply and demand.

Chapter I retraces the evolution of views regarding fertilizer policy and delineates the problem.

Chapter II examines the place of fertilizer demand and utilisation in the strategy of agricultural intensification in sub-Saharan Africa.

Chapter III examines the determinants of demand for fertilizer and stresses the impact of attitudes toward risk.

Chapter IV analyses the impact of alternative domestic pricing policies upon demand for fertilizer.

The final Chapter draws conclusions and outlines policy implications.

## I. VARIOUS SCHOOLS OF THOUGHT IN PAST AND PRESENT FERTILIZER POLICY

### 1. *An Outline Review of the Past Three-and-a-half Decades*

Starting from the notion that fertilizers should be made available to most farmers at cheap prices, it was originally admitted, in the mid-1950s, that fertilizers should be subsidised, and distributed through official channels.

The reasons for subsidy of fertilizer were based on the "infant-industry" type of arguments, and subsidies were considered as an educational device. Subsidy was seen as inducing a high consumption of fertilizers which would gradually increase the scale of utilisation and make producers familiar with these inputs. In the future, once benefits had become apparent to all, subsidies could eventually be removed without inducing a fall in demand.

Clearly, an adequate time-span would be indispensable for such "maturation". The example of Malaysia, often quoted as an example of successful phasing-out of subsidies after achieving educational aims, shows that such a time-span needs to be measured in terms of generations<sup>1</sup>.

Subsidy can alternatively be viewed as a means for exploiting externalities or compensating some particular kind of distortions<sup>2</sup> (which result in under-consumption), or compensating for time-imperfections in the allocation process (connected with "imperfections" in credit availability or demand).

Besides their educational purposes, subsidies were also implemented for a number of reasons: to offset disincentives caused by taxation of output as in Tanzania and Nigeria (World Bank memorandum July 1986, quoted by Lele, 1989a); to stabilise or increase incomes of poorer farmers or to redistribute income across regions as in the case of North Nigeria (Lele & Oyejide, 1989). Another motive was to substitute for poor planning capacities: subsidy was expected to make the fertilizer available to all, thus compensating for deficiencies in the planning and extension network (Srinivasan 1986). In keeping with this philosophy, fertilizer was supplied through public networks.

This corresponds to the notions prevalent in the 1960s and 1970s including favoured state involvement in agriculture. It is equally consistent with subsidy in that it allows the reconciliation of two opposing price movements: fertilizer subsidy was to compensate for implicit taxation of agricultural output. The supply of fertilizer through a public network also facilitated the administration and management of subsidy schemes. Finally, since large parts of agriculture were either included in integrated projects, or faced only one buyer (Marketing Boards), the problems of credit recovery were also made simpler if fertilizers were distributed through official channels.

One notable exception concerns Kenya, where state intervention in agriculture has generally been kept quite low, and fertilizer distribution both largely private and unsubsidised.

A shift in opinion occurred during the 1980s, based on two kinds of criticism. One concerned the failure of the subsidy scheme to "mature" into efficient behaviour. The second concerned the budgetary costs of fertilizer subsidy schemes.

This shift was accentuated by the general growing concern about short-term or allocative efficiency, which viewed interference with market forces in general, and subsidies in particular, as aggravating the tendencies to misallocation of resources. The general atmosphere of liberalisation equally resulted in growing mistrust of state involvement, direct or indirect.

With a view to assisting in the re-evaluation of such criticisms, the two following sections provide information on rates of utilisation of fertilizer and on budgetary costs of subsidy.

## ***2. Fertilizer Consumption in Sub-Saharan Africa (SSA).***

In spite of subsidy, the utilisation of fertilizers in SSA has lagged well behind that of other continents, as shown in Table 1 below.

**Table 1**  
**Fertilizer Consumption in Selected Countries**

(Kgs of nutrient/Ha of arable land)				
Countries/regions	1970-71	1987-88	Absolute Increase	<u>87-88</u> <u>70-71</u>
Low-Income Countries	17.1	70.6	53.5	4.12
Middle-Income	33.0	64.8	31.8	1.96
Sub-Saharan Africa	-3.3	8.5	5.2	2.5
East Asia	-38.0	132.6	94.6	3.5
South Asia	-13.5	58.6	45.1	4.3
Lat. America, Caribbean	-17.6	45.1	27.5	1.56
Cameroon*	-3.4	7.1	3.7	2.08
Kenya*	-23.8	42.1	18.3	1.76
Malawi*	5.2	20.3	15.1	3.9
Nigeria*	-0.2	9.4	9.2	47.0
Senegal*	-1.7	4.0	2.3	2.35
Tanzania*	-3.1	9.2	6.1	2.96
Burkina Faso	-0.3	5.7	5.4	19.0
Côte d'Ivoire	-7.4	9.0	1.6	1.2
Ghana	-1.3	3.8	2.5	2.9
Madagascar	-6.1	2.1	-4.0	0.34
Mali	-3.1	5.9	2.8	1.9
Zimbabwe	-44.6	50.0	5.4	1.12
Bangladesh	15.7	77.0	61.3	4.9
India	-13.7	51.7	38.0	3.7
Sri Lanka	-55.5	109.4	53.9	1.97
China	-41.0	236.1	195.1	5.7
Indonesia	-13.3	106.8	93.5	8.0
Malaysia	-48.9	159.6	110.7	3.26
Colombia	-28.7	94.5	65.8	3.3

Source: FAO, Fertilizer Yearbook, 1988.

Notes: \* countries of the MADIA studies; cf. note 3 following Table 3 below.

The first conclusion to be drawn from Table 1 is that the rate of utilisation of fertilizers in SSA is still extremely low, although it has significantly increased over the last twenty years.

In 1987-88 SSA consumed on average half the amount of fertilizer consumed by low-income countries in 1970-71. Only two countries, namely Kenya and Zimbabwe, equal the consumption level of Latin America.

Even taking into account the fact that learning effects are very slow to materialise, and judging the evolution in terms of rates of growth of utilisation, SSA countries are still seen to lag behind the performance of the "low-income" group, and are well below that of the Asian countries (See Table 2).

**Table 2**  
**Past and Projected Rates of Growth of Fertilizer Needs and Demand**

AT 2000	AT 2000				FAO/UNIDO World Bank 1987-99
	(%)	1961-75	1975-80	1980-85	
All LDCs	12.4	7.1	5.7	4.7	3.3
Africa	11.9	5.8	3.1	6.4	4.4
Middle East	12.5	7.8	6.8	5.4	4.3
Asia (exc.China)	12.7	9.3	8.4	4.3	4.4
Latin America	12.1	3.2	0.6	4.6	2.6

Source: Norse, 1990.

Notes: the "AT 2000" estimates up to for 1983-2000 refer to *projected needs*, while the estimates based on FAO/UNIDO/World Bank refer to *projected demand*.

SSA countries achieve a higher rate of growth than Latin America, but remain at a much lower level. Over the last ten years, demand in SSA has notably slowed down to almost half of the rate of growth for all LDCs. Concerning *needs*, SSA countries will face the highest rate of growth of all LDCs, while *demand* (last column) is expected to grow at roughly the same rhythm as in Asia or in the Middle East. Discrepancy between needs and actual demands is then expected to increase in the case of SSA. Policies should therefore be aimed at increasing fertilizer supply and use.

### 3. Budgetary Costs and Effectiveness of Subsidy Programmes

The budgetary cost of subsidy is very difficult to ascertain. Uma Lele (1989a) has produced estimates for six African countries. Although the rate of subsidy has not increased over time, budgetary costs have increased (Nigeria, Tanzania) except where policies to curb subsidies have been implemented. The increased use of fertilizers is thus seen to bear directly upon the government budget.

**Table 3**  
**Rate of Explicit Subsidy and Budgetary Cost**

Year	Cameroon		Senegal		Nigeria		Malawi		Tanzania	
	Rate	% Budget	Rate	% Budget	Rate	% Budget	Rate	% Budget	Rate	%
77	61	NA	63	NA	85	NA	NA	NA	NA	NA
78	48	NA	52	2.4	85	NA	NA	NA	50	2.9
79	54	NA	48	1.2	85	NA	NA	NA	NA	3.3
80	53	NA	54	2.6	85	NA	NA	NA	NA	2.3
81	58	NA	61	1.3	85	1.1	NA	NA	60	2.0
82	48	0.5	46	NA	85	1.7	NA	NA	60	3.2
83	NA	1.0	NA	NA	83	1.0	25	NA	60	3.4
84	NA	NA	NA	NA	50	3.8	28.6	3.2	NA	NA
85	NA	NA	NA	NA	34	3.7	23.4	1.3	NA	NA
86	NA	NA	0	..	28	NA	22.6	1.0	NA	NA
87	65	0.9	0	..	82	NA	22	0.7	NA	NA

Notes: **Rate**: rate of explicit subsidy (excludes implicit subsidy through overvaluation of currency or multiple exchange rates);  
**% Budget**: fertilizer subsidies as per cent of total budget.  
**Tanzania** abolished subsidy in 1984, but implicit and explicit subsidy remain because of overvaluation and below-cost pricing to farmers. Combined effect estimated at 60-66% in 1988/89.  
**Senegal**, since 1986, has stopped subsidising fertilizers, although a limited subsidy has been provided by USAID.  
**Kenya** not included, since it has no fertilizer subsidy programme.

Source: Lele *et al.*, 1989, pp.19-20

Among the six MADIA<sup>3</sup> countries analysed by Lele, the highest consumption is achieved by the only country without an explicit subsidy scheme, i.e. Kenya, although the rate of growth is rather moderate: utilisation increased 1.76 times over the period, against an average of 2.5 for SSA as a whole. However, very little can be inferred from that feature, and generalisation is impossible due to the specificity of Kenyan agriculture, which is more thoroughly monetised than that of other African countries.

Leaving Kenya aside, subsidy schemes seem on the whole to have influenced positively the utilisation of fertilizers.

With the lowest average explicit subsidy rate in the sample, Malawi is second to Kenya in terms of absolute values, and to Nigeria in terms of rate of growth. This low average subsidy-rate is however misleading, since subsidy programmes are targeted to small farmers who increased their consumption by 11.7 per cent per annum between 1972/73 and 1987/88 — against +4.5 per cent for the estate sector — which is considerable, even when allowing for leakages to estates<sup>4</sup>.

Nigeria and Tanzania, both applying high rates of subsidy, rank high in terms both of utilisation/ha (3rd and 4th) and of rate of increase (1st and 2nd). Finally, of the two countries which display the lower rates of utilisation or growth, Senegal and Cameroon, the first has been subjected to quite abrupt changes in policy during the 1980s, including abolition of subsidy in 1986<sup>5</sup>, while Cameroon suffers from chronic "network" deficiencies (lack of integrated rural policy, transport, credit, cash availability) with parastatals supplying most of the fertilizer through integrated programmes.

More generally, Couston (1984) noted a positive impact of fertilizer subsidy plans on consumption. On a sample of thirty-nine sub-Saharan African countries, fertilizer use increased by 16.2 per cent in the thirty-four countries with fertilizer subsidy plans, against 8.9 per cent in the five countries without.

The first conclusion is accordingly that fertilizer subsidy has exerted a positive impact on fertilizer utilisation in SSA countries, although rates of utilisation remain extremely low. Together with evidence of under-consumption noted in Table 1, this would tend to signal subsidy programmes as an important ingredient in agricultural policies, unless subsidy abolition is to be substituted for by some more effective demand-inducing policy.

This seems to contradict the results established by Cleaver (1984) — who probably helped the swing in opinion away from subsidy or public involvement. He found a negative correlation between the degree of public involvement in farm input supply and the rate of growth of agriculture (Cross-Section analysis, 31 SSA countries, period 1970-81).

However, his conclusions should be read very carefully, since they do not allow any inference regarding effectiveness of subsidy. For instance he listed Nigeria, Malawi, Madagascar, Cameroon and Côte d'Ivoire among countries relatively free from state interference regarding agricultural input supply, while all of them ran important input subsidy schemes at the time (and in most cases still do)<sup>6</sup>. The explanation here is that, although these countries ran subsidy programmes, private operators operated in the input supply network.

#### **4. Price Factors and Network Organisation**

This brings out an important distinction between pricing policies and principles of organisation of distribution, to which we will refer generically as "network" factors. These include a great variety of problems, starting with ensuring physical availability of fertilizers where and when needed, channels of distribution of rural credit, import regulations and so on.

Although the price issue has been more often investigated, especially regarding the respective roles of output price and input subsidy, network factors are prerequisites to any successful fertilizer policy, for the simple reason that whatever policy is devised regarding prices, it will be ineffectual unless the fertilizers are physically present where and when needed. From that point of view, one obvious policy objective will have to be to reinforce distribution networks; these must be made more reliable, and perhaps even more important, more robust, i.e. less sensitive to whatever shocks may affect supply.

*"Network" elements* cover extension, transport, but also adequacy and reliability of supply. They will generally cover the "non-price" elements and will concern factors commanding physical availability of inputs, such as transport infrastructure but also the whole supply network (including the question of whether it should be private or public) and extension services. It opens a number of questions regarding comparative efficiency, cost and reliability of various intermediaries: public supply, private traders, farmers' organisations, co-operatives and so on (Sindzingre, 1991).

*Incentive elements* cover mainly *pricing policies*. Behavioural factors represent here an important point, since incentives cannot work unless they correspond to expectations and are consistent with habits, customs, organisation of labour and so on. Behavioural factors equally command the adoption of improved practices which depends on incentives but also on "network" factors, which will make the technical alternatives physically available to the farmer by means of diffusion of know-how, education, extension etc..

In other words, there is a intricate relationship between behavioural factors, effectiveness of incentive schemes and diffusion of best practices. Attitudes toward innovation, especially innovations requiring the acquisition of priced inputs on a market, constitute a particularly delicate segment in the overall sequence of diffusion, which may act as a bottleneck unless properly addressed.

Although these two sets of factors largely intersect (for instance, pricing policy, cash availability and credit, or import regulations and domestic prices of fertilizers or of substitutes to locally produced food products, etc..) they will be separated in this report which will concentrate on pricing policy, assuming that "network" factors adapt to physical requirements.

One reason why these issues should be kept separate is that the impact of liberalisation on both sets of factors will be markedly dissimilar. Even assuming that some form of subsidy programmes should be maintained (which means moving back



from liberalisation tendencies), liberalisation — in the form of greater reliance upon private operators, or co-operatives — will prove useful as a reform mechanism on some segments of "networks". Thus the principle of this distinction is not solely academic or analytical, but also relevant to the formulation of policy recommendations.

## **5. Policy Recommendations**

Present-day attitudes increasingly tend toward the removal of subsidies and privatisation of distribution networks. Such proposals were part of agricultural reform programmes in many African countries, such as Senegal, Cameroon, Nigeria or Ghana.

The general philosophy of the World Bank on this issue as expounded in various documents<sup>7</sup> appears as a relatively simple and straightforward application of theoretical microeconomics<sup>8</sup>.

One should note that the issue has not been very deeply investigated in the World Bank's long-term perspective of SSA (World Bank 1989b), where only distribution factors are briefly examined, and there is hardly any mention of the issue in Harrison's "Long-Term Perspective Study of Agriculture in SSA" (1990). If it were not for the inclusion of fertilizer distribution and subsidy reform in SAPs, and for the MADIA studies (Lele *et al.*, 1989a, Lele 1988), one would have the feeling that, in spite of the need for further research stressed in World Bank 1989a (pp.101ff.), the issue is considered as resolved, and that overall liberalisation based upon theoretical microeconomic analysis is considered to be the proper answer to fertilizer policy.

At all events, what remains clear is that, as seen in Table 1 above, SSA is the World region where fertilizer consumption is lowest, and where plans to increase utilisation are most required.

## **6. Complexity of the Issue**

Even within the realm of microeconomics, liberalisation of fertilizer supply still poses a number of intricate questions upon which very little is known. This section lists some of these.

### *a. The demand for inputs is a derived demand*

The role played by fertilizers (i.e. the demand evinced for them and the efficiency of the use to which they are put) in price-based regulation models is problematic. Fertilizers are an input, and factors governing input demand or utilisation are more difficult to ascertain and quantify than behaviour of output or final demand. Because the demand for an input is derived from the demand for the final product, it enters into and is mediated by the production function. Basic microeconomics make it possible to derive such demands in the case of an optimising agent with good knowledge of productive relations. This exercise requires exploring a somewhat lengthy chain of "derivations", implying a few crucial assumptions (leaving aside market imperfections) regarding at least knowledge of production functions by the

user, profit-maximising attitudes and behavioural patterns, and degree of uncertainty regarding the outcome<sup>9</sup>.

Impact of price movements is more problematic in the case of agricultural goods in general than in manufacturing activity, and derivations are even more hazardous in the case of agricultural inputs. Difficulties increase when one considers the case of Third World agriculture, particularly that of African agricultural systems, especially when small-holders are producers and (potential) demanders for and users of fertilizer.

#### *b. Economic behaviour of small-scale producers*

Concerning problems raised by behaviour, one can quote (a) attitudes towards risk (which induce under-consumption of inputs); (b) complexity of households (especially in Africa) which administer not one but many budgets, thus preventing the identification of a simple "budget constraint" — which results in under-consumption of marketed inputs — and; (c) general shortage of cash or credit — which prevents efficient allocation over time. Coexistence of various actors with various attitudes, especially regarding risk aversion and access to credit, compounds analytical difficulties with the possibility of substitution of demands between these various categories in the face of price variations.

#### *c. Productive impact of fertilizers*

The impact of fertilizer utilisation on production is not well known, that is, it is known only in experimental conditions (i.e. for a given fertilizer, applied to a given crop in a given environment and for given agricultural practices). This makes any generalisation very difficult. Consequently, when one wants to estimate the impact of fertilizer utilisation in practice, one has to rely on broad approximations. Actual productive impact of fertilizer is estimated to stand at about 60 per cent of the level achieved in experimental utilisation (Falusi 1987). If one adds that fertilizers are not a homogeneous input, since productive impact varies as between different crops, actors, ecological zones and types of lands, and that intercropping is very common, any approach demanding sound knowledge of production functions has to be used with extreme caution.

There is therefore little chance of achieving more than "a minimum quantitative analysis using broad ranges for the relevant elasticities" (World Bank, 1989a, p.102).

#### *d. The determination of output prices*

A third difficulty stems from the fact that many output prices govern demand. Fertilizers are used on a great variety of crops whose numerous price, and price variations, command the "derivation" of demand. The situation will necessarily be different when one considers domestic food crops or export crops.

In the case of *domestic food crops*, output-price variations will basically respond to domestic supply and demand conditions. World prices will exert their influence indirectly, through substitution between home-produced or imported food. These substitutions obey rather complicated patterns. Even for tradable food products which are in principle comparable, and should be perfect substitutes — e.g. rice and maize — substitution can be quite imperfect, depending for instance on the peculiar brand — e.g. white or yellow maize. If one brings in various food crops with various income and price elasticities — superior or inferior goods, e.g. wheat and manioc — then the pattern according to which various prices will respond to liberalisation measures (e.g. import tariff reforms) becomes extremely complicated (Hibou, 1990). And of course, devaluation policies have to be taken into account.

In the case of *export crops*, the pricing policy for export goods is supposed to determine the domestic price. This depends upon the institutional reforms of CAISTABS and Marketing Boards (which is a policy decision and can be considered as a datum), but also on the mechanism whereby prices offered by Marketing Boards or CAISTABS are actually translated into farmgate prices. This in turn depends on the structure of intermediation between Boards or CAISTABS and the producer, which will vary according to the strategies developed by middlemen. Although the situation varies from country to country, and within the same country from region to region, or from village to village, this transmission mechanism is known to be very imperfect (Azam et Bonjean, 1991).

#### *e. Rate-of-exchange policies*

The rate-of-exchange policy of course influences prices paid domestically to producers of export goods. Even assuming that Boards pass on a fixed proportion of the world price at the current rate of exchange, the translation of the CIF export price into producer price will still depend on the behaviour of the intermediaries.

Domestic prices of food crops will also depend on the rate of exchange which will determine the domestic price of substitutes available on the world market. This introduces further complications in the pattern of determination of food products.

The domestic procurement price of fertilizers (either imported, or produced locally from partly imported inputs) will equally depend on rate-of-exchange policies, as well as on world prices.

Thus the rate of exchange will directly influence the overall profitability of fertilizer utilisation, as well as its relative profitability between export and food crops, thus possibly inducing shifts in utilisation.

#### *f. Uncertainty*

Policy reforms will normally introduce some uncertainty in price determination, firstly since reforms disrupt habits, and secondly since liberalisation of markets and fixation of prices by market mechanisms can by themselves destabilise the price-formation mechanism. In the case of export crops, if CAISTABS and Boards are

abolished or reformed and producer prices are linked to world prices, they will reflect the instability of world prices of primary commodities. In the case of food crops there is also a possibility that reforms of "*Caisses de compensation*" and other price stabilising mechanisms will increase the instability of producer prices.

*g. Network factors*

Finally, in so far as adjustment and liberalisation will reform the network supplying fertilizers and will modify the credit policy, they will modify both the conditions of physical availability of fertilizers, and the terms upon which they can be purchased. Since the physical availability of fertilizers is a prerequisite to any policy, reforms should primarily aim at increasing the regularity and predictability of supply. Whether the supply network should be private or public is a question of compared efficiency and reliability. However, since a number of long-term factors must be taken into account, and since subsidy schemes should be kept in operation, a conflict of policy objectives may arise. If one assumes that private organisation of supply will reduce X-inefficiency, one should also wonder whether the organisation of fertilizer supplied and distribution will be consistent with the attainment of policy objectives other than delivery.

## **7. Conclusion to Chapter I**

Since the SSA is characterised by a very marked under-consumption of fertilizer, a major policy aim must be to reduce, phase-out or cut subsidies, accompanied by price increases on output.

As well as having productive effects, such policies will increase the role of market forces in a region where agriculture is relatively less moulded by monetary exchange. One important consequence of such a policy course could be to increase social differentiation, since layers or groups of peasants are unequally integrated into, and unequally familiar with, the mechanisms of monetary exchange. This could weaken an important asset of agriculture, viz. their limited degree of social differentiation respectively to other regions and continents (Lipton 1989) — an asset which currently enhances their resilience to shocks and their ability to survive such shocks.

The analysis of any proposed policy course should therefore be supplemented by an investigation of its effects upon social differentiations and risks of marginalisation. This risk is probably quite high in the case of reforms of fertilizer programmes: fertilizers draw upon the scarcest resource, and one which commands social differentiation, namely cash. Moreover, cash also commands productivity increases, which constitute the key to economic survival.

## II. AGRICULTURAL INTENSIFICATION STRATEGY

### 1. *The Need for Agricultural Intensification*

Formerly considered a continent with excess land-supply and virtually inexhaustible production potential, Africa nowadays displays the highest population growth rate in the world (3.2 per cent in 1980-88, against 2 per cent for all low-income countries), with mounting food deficits and population pressure on land. By 1988, food production per head in SSA had fallen to 94 per cent of the 1980 level while rising to 112 per cent for all low-income countries, to 117 per cent for China and India, and to 123 per cent for East Asia (WDR 1990). Consequently, the self-sufficiency and the food security of SSA have seriously deteriorated. The other two regions where self-sufficiency ratios are falling are North Africa and West Asia, i.e. countries where industrial development is on its way, and which benefit — unlike SSA — from alternative resources, especially oil exports (Table 4).

**Table 4**

**Self-sufficiency Ratios in Basic Grains  
Regional Averages 1974 and 1984**

	1974	1984
North Africa	66.1	49.1
Sub-Saharan Africa	83.6	68.0
Latin America	78.4	81.0
West Asia	63.6	33.9
South & East Asia	88.1	94.2

*Source:* Norton 1987, p.24, based on FAO data files for the "Agriculture toward 2000" project.

Countries with high agricultural potential are located in Central Africa (Zaire, Congo, Central African Republic), humid West Africa (excluding Nigeria) and Southern Africa. Countries with immediate problems lie mainly in the Sahel, in mountainous East Africa, and along with the dry belt stretching from the coast of Angola through Botswana, Lesotho and Southern Zimbabwe to Southern Mozambique. Ten countries will have reached a critical state by the year 2010, even assuming they have also reached an intermediate level of inputs: Mauritania, Niger, Somalia, Burundi, Rwanda, Kenya, Lesotho, Swaziland, Comorros and Mauritius. A tight situation is also expected in Senegal, Nigeria, Ethiopia and Uganda (FAO 1986).

While Africa is still seen as a land-surplus continent, carrying capacity is progressively being reached. If Africa at large has still a land reserve which is about the size of total cultivated land (197 million hectares cultivated and a reserve of potential suitable land of 199 million hectares, FAO 1986), this varies from region to

region. In Sudan-Sahelian Africa, suitable reserves represent only 0.6 per cent of currently cultivated area, and in humid and sub-humid West Africa, 12 per cent of lands cultivated is already considered as only "marginally suitable"<sup>10</sup>.

Paradoxically, growing land scarcity and population pressure do not result in a generalised labour surplus. Urban migrations draw mainly men away from the countryside, and seasonal shortages of labour represent a major problem. Different kinds of innovations make varying demands upon labour. Herbicides save labour by shortening the work of weeding; pesticides and fertilizers, on the other hand, require additional labour. But since labour shortages are essentially seasonal, pesticides and fertilizers will not exert important effects upon labour shortage, which is most acute at the harvesting season. One important set of labour-saving innovations concerns the work of women. Improvements which reduce the time spent at domestic tasks, such as fetching wood and water and milling grain, will indirectly improve labour availability for agriculturally productive purposes.

Consequently, increases in production will have to come essentially from increases in yields (See Table 5).

**Table 5**  
**Sources of Projected Agricultural Output Growth (%)**

Increase intensity	Increase in yields per hectare	Increase in cultivated area	in
All LDCs	63	22	15
SSA	57	26	17
Middle East/ North Africa	77	0	22
Asia(excl. China)	59	11	20
Latin America	49	39	12

*Source AT 2000.* Increase in yields corresponds to improved agricultural techniques and encompasses notably use of fertilizers, chemicals and improved varieties, while increase in intensity refers to shortening of fallow periods and irrigation.

Roughly speaking, one-quarter of the increase in agricultural output in SSA countries will result from an increase in cultivated areas — which is slightly more than average for all LDCs — and one-fifth from intensification. Increase in yield per hectare will be the most important source of growth. It is also the source which depends most on the utilisation of modern inputs which then appear as a major problem.

The need for improving the average level of technology and modern input-utilisation in particular has been illustrated by Kawagoe, Hayami & Ruttan who ranked factors influencing positively differences in labour productivity between LDCs and DCs. The first factor explaining differences in labour productivity is utilisation of

technical inputs (which explain 27 per cent of the difference in labour productivity between developed and developing countries), among which fertilizers alone account for 16 per cent of the difference. This ranks them as the second factor after educational level (19 per cent).

## **2. Strategy for Intensification: Technological Breakthrough or Diffusion?**

The choice of an appropriate strategy for intensification and use of fertilizers depends on prospects for improving technical efficiency or allocative efficiency.

As regards allocative efficiency, since Schultz's (1964) "Poor but Efficient" hypothesis, it is an accepted view that farmers master rules of allocative efficiency, i.e. that, within a given set of technological alternatives and prices (or non-prices costs), they come reasonably close to effecting the best allocation of resources. On this hypothesis, the two main sources of expected agricultural progress lie in:

a) improvements in technology and b) improvement of price signals, properly translating social-opportunity costs to farmers who then adapt decisions to nation-wide constraints.

Regarding the first point, there do not seem to be, for Africa, any large prospects for a rapid technological breakthrough.

Although introduction of modern crop varieties in Africa has lagged behind that in other continents (improved maize is really significant in only two countries, namely Kenya and Zimbabwe; is marginal in Malawi; and hardly significant elsewhere), generalisation of high-yield varieties (HYVs) is not a ready prospect. As a result of ecological conditions and the specific nature of food crops, there is no ready HYV-strategy "on tap" for Africa (Lipton 1987, 1990). The main prospect for improving productivity in agriculture lies in the dissemination of "best practices", which could gradually lead to a phased technological revolution. Such a scheme has been proposed by Harrison (1987 and 1990) and is summarised in Box 1.

**PHASED GREEN REVOLUTION FOR AFRICA, ACCORDING TO  
HARRISON  
(1987 and 1990)**

Harrison (1987 and 1990) presents a scenario where Agricultural Development would undergo 4 Phases of transformation.

*General prerequisites* include improved incentives, market liberalisation through abolition of state monopolies, securing land tenure, integration and co-ordination of research along clear priorities, and reinforcement of extension network, using pyramid training. Extension network, and later input and credit supply, are to be administered by farmers' groups.

Main action in *Phase One* (which should extend over 5 years) is dissemination of low-cash-cost technologies presenting low risk. The technology which will be disseminated will be adapted from the practices of the best 10 per cent of farmers. Few extra imports should be needed. Soil fertility will be improved by rotation (nitrogen fixation by legumes) and mulching. Small-scale irrigation technology is to be adopted (earth dams, hand-dug wells). In this phase, output is expected to increase by 10 to 20 per cent.

*Phase Two* (5 to 10 years) is characterised by introduction of low-cost techniques, nationwide supply services, small-cash investment by farmers and increased imports. Soil fertility is to be increased by using simple phosphate fertilizers and crop variety improved by adoption of open-pollinated varieties. Irrigation remains small scale and non-mechanised (hand-operated pumps, cheap well technology, scooped ponds).

In *Phases Three and Four* (extending over 20 years), agriculture would gradually use the full complement of chemical inputs, hybrid seeds, and gradual mechanisation. This supposes adaptation of moderate-cost technologies involving nationwide distribution services, higher cash investments, and imports. In this phase, hybrid seeds are introduced as well as more elaborate fertilizers: adapted Nitrogen, Phosphorus, Potassium (NPK) fertilizers, with doses gradually increasing. Selective mechanisation of labour bottlenecks will improve labour availability, and irrigation will be progressively mechanised, with the introduction of motorized pumps.



The lack of prospects for a technological breakthrough in African agriculture pleads in favour of a phased revolution in Africa. If fully implemented, the impact of such a diffusion strategy would amount to a low-cost shift of the production function through a generalised move to the upper boundary.

However, Phase One as defined by Harrison is somewhat misleading on the point of fertilizers, and chemical inputs more generally, which do not appear as a priority before Phase two or three.

### **3. Prospects for Future Fertilizer Utilisation**

It seems clear that the present minimal level of utilisation will have to be at least maintained. Moreover, the diffusion of best existing practices will entail generalising the higher levels of fertilizer consumption achieved by the most efficient farmers. In fact, greater fertilizer use and diffusion of best existing brands on existing varieties are part of the diffusion strategy aimed at achieving a widespread and significant enhancement of average performance in the field of agricultural productivity.

For instance, although he does not fully address the point, Harrison's predictions rely on the assumption of an "intermediate use of inputs (at) roughly the level of present-day Sri Lanka or Colombia" (1990 p.51), which stand around a 100 kg. of nutrient per arable ha. (respectively 109.4 and 94.5 kg/ar.ha). This would imply a doubling of the highest level attained anywhere in any African country (Zimbabwe: 50 kg/ar.ha, Kenya 42.1 kg/ar.ha) and a twelvefold increase over the present-day average SSA consumption (8.5 kg/ar.ha) (see Table 1).

The need for increased utilisation of fertilizer is even greater than suggested above since intensification of culture without proper technological improvements has resulted in an exhaustion of lands and indeed *decreased* productivity. Fast rotation of crops, extension of arable lands, and shorter fallows induced an over-exploitation of soils. Natural fertilizing elements lack the time for spontaneous reproduction. This is known as "soil mining" or "extraction" of fertilizing elements, and calls for increased use of properly designed mineral fertilizers. Fertilizer use must in fact respond to two major but counterpoised preoccupations: a preoccupation with productivity, whereby fertilizers are expected to increase yields per hectare, and a conservation preoccupation, whereby the use of fertilizers is expected to restore the mineral potential of soils.

This "extraction" phenomenon not only reduces overall yields, but, when coupled with misutilisation, also reduces responsiveness of cultures to fertilizers. Table 6 illustrates this phenomenon in the case of Malawi.

**Table 6**  
**Maize in Malawi**  
**Evolution of Yields (Kg/Ha) and Response to Fertilizer Use (Kgs/Kg of fertilizer)**

Location	Yields (Kg/Ha) 1957-62	Yields (Kg/Ha) 1985-87	Response to Fertilizer 1956-67	Response to Fertilizer 1982-85
Lilongwe	1760	1100	23	13
Kasungu	1867	1120	24	18
Salima	1693	1060	25	17
Mzuzu	1535	775	32	18
Average	1714	1014	25.1	16.5

*Source:* Twyford, 1988.

Consequently, in all LDCs as well in SSA countries, increase in yields is seen as the most important factor which will contribute to increases in agricultural output. Although SSA has an above-average potential for output increase in areas under cultivation, more than half of the increases in output are expected to come from increased yields/ha (see Table 5, above). This, of course, is the operation which requires the greatest use of modern inputs, i.e. fertilizers, pesticides, herbicides and modern varieties of seeds.

In spite of their potential adverse effects on the environment, chemical fertilizers seem to be the only adequate input.

Chemical fertilizers are potentially dangerous for the soil. If injudiciously used, they can increase soil acidity and accelerate loss of fertility, unless some relatively complex operations are conducted<sup>11</sup>. Consequently, prospects for mulching, manure and organic fertilization seem appealing. One advantage is ecological and safety of use: the risk of misuse resulting in soil degradation is much smaller, since these organic products have a lesser toxicity and acidity.

Another one is low cost, and especially low cost in cash. In principle (and subject to what is said below), these are largely home-produced, require small investment and few marketed inputs. Optimal size is small, which allows location of production site at the village level, and which simplifies transport problems with carts proving quite adapted<sup>12</sup>.

However, these natural fertilizers do not yet offer an adequate alternative. Their productive potential is too limited, as illustrated by the case of China where, in spite of a very efficient recycling network and production of manure at village level, agricultural production has been shown to be very dependent upon chemicals from 1975 onwards (Von Vexhull and Dowdle, 1989). Alternative techniques for biological fixation of nitrogen by legumes are extremely promising, but as things stand now these

techniques cannot replace chemical fertilizers. For one thing, the productive effect is not large enough. Biological fixation of nitrogen will certainly preserve the mineral potential of soils, i.e. oppose "soil-mining" thus improving medium and long-term conservation problems, but the impact on immediate productivity, which commands yields and adoption by farmers, may be small. While these techniques efficiently restore mineral elements to the soil, they do not always increase fixation of nitrogen by crops<sup>13</sup>. Moreover, utilisation is delicate, and efficiency depends crucially on appropriate adaptation to local conditions. Finally, they entail some modern operations ("inoculation") which require production of an artificial input — the "inoculum", at present mostly produced in developed countries. This has to be bought, which makes it a marketed input, and adapted to African conditions. Until local production of "inocula" is fully developed, prospects will remain limited (Saint-Macary, 1990 and *Afrique Agriculture* N°173).

#### 4. Efficiency Differentials and Diffusion of Best Practices.

The scope for generalisation of best practices in SSA agriculture is generally recognised. Table 7 illustrates this potential in the case of cotton growing in Tanzania.

**Table 7**

**Distribution of Technical Efficiency Scores  
among Tanzanian Cotton Farms**

Technical Efficiency Scores <sup>o</sup>	Number of Farms
0.23-0.38	3
0.38-0.54	12
0.54-0.69	6
0.69-0.85	6
0.85-1.00	10
Total	37

*Source:* Shapiro (1983).

Note: <sup>o</sup>Technical Efficiency scores are ratios of actual output to predicted output. Predicted output was calculated by using a Cobb-Douglas based upon the best practices found in the set. A ratio of 1.00 denotes best practice.

The average level of technical efficiency was 0.663, and Shapiro estimates that if all farmers were to modify their operations so as to operate on the outer-bound production function without using more inputs, output would increase by 51 per cent for the sample as a whole. Furthermore, in the sample of 37 farms analysed by Shapiro, very few used any additional inputs at all (9 used artificial fertilizer, 4 used manure, and 11 insecticides). Generalisation of best practices together with increased use of inputs would push the outer-bound production function even further out.

The most likely intensification strategy is then one of diffusion of both best practices and limited low-cost technological improvements which will in any case require a very substantial increase in the overall consumption of fertilizers.



One crucial point concerns the means by which this diffusion will come about.

They depend upon "network" elements (which will not be examined here) and on incentive manipulation and pricing policies. These in turn depend on behavioural factors which will be examined in the next chapter.

### III. THE ALLOCATIVE EFFICIENCY ISSUE

This chapter examines the behaviour of farmers regarding demand for fertilizers. It starts from the classical hypothesis that farmers allocate resources reasonably efficiently, and shows that this hypothesis does not apply to modern inputs. The notion of "restricted allocative efficiency" is then presented, and behavioural factors explaining this restriction are examined. Policy implications are drawn in the last section.

#### 1 *The "Poor but Efficient" Hypothesis*

If farmers are "rational" in the "*homo economicus*" sense, they will be responsive to prices, both as regards supply of products and utilisation of inputs.

On the question of rationality of supply behaviours, M Nerlove (1958) and E Dean (1966) show that response of supply to prices is positive (i.e. that supply curves slope upwards as they should). The alternative possibility is that supply responses are nil or negative. The behavioural implications are immediate: if farmers have a "fixed income" rather than a "revenue maximisation" objective function, then increases in prices bring about a decrease in supply<sup>14</sup>.

Regarding utilisation of inputs, "rationality" implies that productive resources should be allocated in such a way as to roughly equate marginal productivities and marginal costs. For a given set of inputs, output will then be maximised, and actual practices will bring the productive system onto, or quite near, the production possibility frontier. However allocation possibilities as well as choice of inputs are constrained by technology, or more precisely, by the farmers' knowledge of technological alternatives. This leads to a slightly weaker proposition about farmers' "rationality": if "rational", farmers will spontaneously move towards their visible production possibility frontier, i.e. the production possibility frontier which corresponds to their actual knowledge of techniques. In point of fact, the proposition has to be weakened even further: when it comes to modern inputs, knowledge of the existence of the technology has to be supplemented by know-how as to their proper utilisation.

Verification of this hypothesis was attempted by T. Schultz (1964) who calculated, within the available technology, the ratio of value produced by an input to the cost of this input. Finding that this ratio (popularised under the appellation of "Value-Cost Ratio", or VCR for short) stood in the vicinity of 1<sup>15</sup>, Schultz concluded that allocative efficiency prevailed.

This result, known as the "Poor but Efficient" hypothesis, although it quite soon came under heavy questioning (see below), constituted the basis for policy recommendations in the 1980s.

The policy implications are straightforward. With a fixed technology, increases in productivity will follow diffusion of knowledge, which will push the production possibility frontier upwards. Once knowledge has been acquired (e.g. knowledge of the existence and productivity of modern inputs and know-how regarding their proper utilisation), the farmers will adopt these techniques if required inputs are physically available. In so far as farmers are "rational", they will use these inputs efficiently, unless the terms on which they are offered (viz. prices) distort their decisions. In this case the inputs will be misallocated, and the productive system will move away from the production possibility frontier. Since input subsidies distort prices, they should be removed. When both output prices and input prices are distorted by government intervention (subsidies to inputs, and administered prices for output), removal of distortions on both the input and the output side will restore conditions of economic efficiency and proper allocation of and demand for inputs.

Although the principle of positive reaction to prices as regards both output supply and input demand is established, the actual reactions of output and input allocation to prices are weak, in the case of small farmers, especially in Africa. First, price elasticities of output are low (typically in the 0.1-0.4 bracket) (Askari & Cummings, 1976 and 1977, Bond, 1983, Fontaine, 1987a). Second, reactions of input demand to prices proves a rather complicated matter, especially when it comes to modern inputs.

Concerning inputs, a crucial distinction is to be drawn between inputs which are either home-produced or acquired through transactions not involving monetary expenditures (e.g. exchange of labour or services between households), and marketed inputs, which have to be bought for money. Even if one accepts Schultz's "Poor but Efficient" hypothesis as a rough approximation as regards non-marketed inputs, i.e. those where Value-Cost Ratios do not differ too much from 1, it certainly does not hold for marketed inputs, which display VCRs well above 1.

This has been demonstrated in many contexts. To quote but a few authors (See Table 8), VCRs superior to 1 for marketed inputs were found for seeds in Nigeria rice planting (Welsch 1965) and land (Hopper, 1966); fertilizers (Sahota 1968) in Indian agriculture; and all marketed inputs, including land and capital, in Kenya (Wolgin, 1975). It also is a commonplace in innumerable FAO studies, which estimate the minimal norm for Value-Cost Ratios<sup>16</sup> on modern inputs (pesticides, fertilizers and so on) to lie somewhere between 2 and 2.5 (see for instance communications presented at meetings: FAO/FIAC, Nairobi, 1986, FAO, Dakar, 1988, FAO, Arusha, 1989).

**Table 8****Selected Benefit-Cost Ratios and Value-Cost Ratios for Fertilizer Use**

Table 8a: Marginal Value Product/Price: Kenya 1969-1970 (Wolgin, 1975)

Input/ Crop	LMa	HMa	CFb	CFc	HMc	LMd	Average
Land	3.8	5.3	3.5	2.75	2.15	0.72	3.01
Hired Labour	2	na	0.6	2.56	na	1.24	1.6
Purch.Input	1.44	3.27	4.3	1.37	2.78	2.57	2.62
Capital	10.2	15.8	na	na	21	5.0	13.00

Notes: Purch.Input: purchased inputs (includes fertilizers); LM: local maize, HM: Hybrid Maize, CF: Coffee. Small letters refer to ecological zones: a: balanced mixed farming, b: kikuyu grass; c: star grass; d: grass plains, savannah, coastal belt.

Table 8b: Marginal Value Products/ Marginal Factor Cost, Various Sources (Shapiro,1983)

Study/Input Fertilizer	Land	Labour	Seed	Capital	
Hopper	2.29	1.25	na	na	na
Welsch	1.74	0.4	4.8	na	na
Chennareddy	1.54	0.83	na	0.01	na
Sahota	na	1.11	0.77	0.99	3.61

Note the values for Land, Seeds and Fertilizers, i.e. marketed inputs or capital, as computed with those of Labour and Capital, largely home-produced.

Table 8c: Value Cost Ratios for Fertilizer use on Maize (FAO sources)

Author/ Country	Lesotho	Burkina	Rwanda
Coursier (1981)	2.4	3.2	"
Blas (1984)	"	"	2.7

This leads to a notion of "*restricted allocative efficiency*", where Schultz's hypothesis would be restricted to non-priced inputs alone. In so far as it holds<sup>17</sup>, this hypothesis does not then apply to modern inputs, which have to be treated separately.

The important point here is that high VCRs indicate not only high marginal productivity of marketed inputs, but also under-utilisation of these inputs, or — to put things in proper perspective — reluctance on the part of farmers to adopt them. Hence proper understanding of the reasons for this reluctance is vital in designing an input policy for SSA agriculture.



## **2. Restricted Allocative Efficiency**

There are probably three sets of factors explaining the limited responsiveness of peasants to price movements (low-supply elasticities, under-consumption) and reluctance to use marketed inputs.

The first set comprises general attitudes towards cash; the second, actual availability of cash; and the third, attitudes towards risk. They will be briefly examined in turn.

*Attitudes towards cash* stem from the fact that African households very seldom run one budget in terms of money, but more typically run many budgets, some in kind, some in cash. Distribution of activities between subsistence and market-oriented activities, and between male and female activities are such that the "*homo economicus*" assumption — of allocation of *one* aggregate set of resources, by *one* integrated household decision-making process, to globally *competing ends* — simply does not apply (Adam, 1980, Folbre, 1986). Various budgets have specific objectives and substitution between them is very imperfect, since it often implies renegotiation of positions between men and women, male and female productive activities, especially when cash is concerned (Lassailly-Jacob, 1986). For instance, money accumulated for the house, even if it was earned in production for the market, will not easily be ploughed back into production. Mobilisation of inputs in kind poses no such problem: it draws on a vast tank of natural resources which can be increased through mutual obligations within the neighbourhood. If one had to trace the circulation of money, one would have to start from the assumption that there is not one single structure of scarcity, but many; and that the kind of scarcity which translates into money is extremely specific, and somehow more acute and binding than others. To the economist doing calculations from outside, all productive resources are seen as substitutable, and all ends are seen to compete whereas for households, expenditures involving outlays in money do not easily substitute for expenditures involving mobilisation in kind, but obey much more complicated patterns<sup>18</sup>. The behavioural assumption underlying allocative efficiency at household level does not hold, and allocation of money-income between alternative uses is hampered by rigidities. This explains why supply elasticities with regard to price are low, and why marketed inputs are in such small demand.

*Cash availability.* Whatever the attitudes toward cash, it cannot be spent if it is not available. Since marketed inputs require cash, all factors commanding cash availability will immediately influence demand for inputs, and especially fertilizers. This is a well-known factor holding consumption of fertilizers back, and has been illustrated for instance in the case of Senegal (Kelly, 1988). While cash availability could seem to be increased by a greater involvement in market-relations — which would result in greater monetisation of peasant economies — or by greater use of credit, none of these solutions can be easily implemented because involvement in money relations increases risk.

*The impact of risk aversion* upon peasant "rationality", and especially upon attitudes to marketed inputs, was introduced into the debate by Lipton (1968) and has since then become a major theme of research and preoccupation. There are many sources of risk.

Natural sources of uncertainty concern the climate and more generally natural phenomena (droughts, locusts, pests and so on). Avoidance of natural risks has generated a number of different responses. One of those consists of varying cultivation practices — mixed-cropping, cultivation of various species which mature at different times of year, planting tubers which operate as an underground storehouse and so on. Another resides in certain social practices — lineage solidarity, exchange of land and labour, common management of grain reserves etc. — designed to minimise uncertainty (see contributions to Eldin and Milleville, 1989, Part 2, pp.179-409.). Such risk-averting cultivation practices can have a negative bearing on the use of inputs and fertilizers<sup>19</sup>.

### **3. Risk Aversion and Allocative Efficiency**

Risk associated with economic phenomena, which is increasing and becoming one main risk factor in African agriculture (Labonne, 1989), brings in other considerations. This risk mainly concerns the evolution of prices of both inputs and outputs.

Risk-averting peasants will tend to produce at lower than optimal levels (Boussard, 1990). Production entails costs which can only be recovered through sale of the output. If sale receipts are below expectations (because physical volume of production, collection capacities or prices fall short of expectations), the outlay (costs of production) will be only partially recouped, thus entailing a loss. The rational decision minimising the expected loss (e.g. maximising mathematical expectation of gain) will be to reduce outlays in the form of costs of production, i.e. to reduce the level of production (Fellner, 1948; McPherson, 1986).

Sub-optimality directly follows, with inputs allocated so as to equate *expected values* of marginal product (and *not* marginal product) to price. The greater the (perceived) risk, the greater the difference between marginal product and price (or the higher the VCR) of an input (Shahabuddin and Mestelman, 1986). This result holds when alternative approaches to risk are used, such as the "Safety First" (Roy, 1952) or "Disaster Avoidance" (Roumasset, Boussart and Singh, 1976).

Indeed the result holds in the case of all inputs (marketed inputs and inputs in kind); all crops (subsistence or cash-crops); and touches all farmers (large, small, efficient, inefficient). The extent of risk aversion varies however significantly as between inputs, crops and classes of farmers. Thus it is more pronounced on cash-crops than on subsistence crops (Wolgin, 1975). Again, high-yielding varieties (HYV, referred to as "modern crops") — for which yield depends heavily on weather conditions, especially rainfall — are more risky than traditional cultures (Schutjer and Van der Veen, 1977), and are certainly perceived as more risky, if only for lack of familiarity (Lipton, 1978).

The general principle that risk aversion declines with income (Arrow, 1971) also applies to farming (Lipton, 1978 p. 323 ff.). This can be intuitively understood in a "Safety First" or "Disaster Avoidance" perspective: the richer the farmer, the less probable is disaster. Risk aversion also probably declines with the diversification of incomes in the household. When income from cultivation is supplemented by non-farm income, i.e. when one or more member of the household earns a regular wage, agricultural risk is tempered by the regularity of wage income. For a given level of income, diversification of income sources makes it possible to take more risk in agriculture (Fontaine 1987b and literature quoted). Since off-farm employment opportunities depend on the educational level, higher education will induce greater use of modern production techniques, and especially fertilizers.

Finally, marketed inputs in general, and fertilizers in particular, carry greater risk aversion than home-produced inputs and inputs in kind. Significantly, most examples illustrating risk-aversion attitude on inputs concern fertilizers (e.g. Ellis, 88, Ch.5, pp. 84 ff.), because utilisation of marketed inputs is seen as carrying the higher risk. It involves outlays in cash, it is more subjected to weather hazards than other inputs (the importance of rainfall is higher), and economic uncertainty bears on the price at output.

In other words, fertilizers are in a sense a veritable symbol of most forms of risk, both natural and economic. Moreover, risk aversion corresponds to most features accounting for social differentiation: wealth, size of land tenure, and education. Consequently, expenditures on fertilizers will vary widely among farmers, better-off farmers spending more on fertilizers than poor farmers<sup>20</sup>. This was noted by Rao (1975) in the case of Indian agriculture, but seems equally true in Africa. An illustration in the case of Kenya is given below (Table 9) where the proportion of farms using no fertilizer at all stands in the 86-91 per cent range for smaller farms (1ha. or less) and falls below 70 per cent when the size of 5ha. is reached.

Introduction of credit, considered here as a device spreading risk over time, does not significantly alter the situation: credit is unevenly distributed between farmers, for the same reasons as risk aversion (Lipton, 1977). For one thing, credit is considered a risky business. Repayments will depend on future income, so that economic uncertainty is extended into the future. For another, credit often requires collateral, which of course favours wealthier farmers over poor ones. In other words, although generally considered in the economic literature as lowering uncertainty by making it possible to spread risk over time, credit is most probably not seen as a mechanism decreasing risk by most farmers — unless of course credit schemes are specifically devised to minimise risk.

Table 9

**Kenya. Annual Expenditures on Fertilizer in Shillings  
Number and Per Cent of Holdings Grouped by Size and Expenditure on  
Fertilizer, 1974/75**

Size/Exp.	0	0-100	101-200	250+	Total
0.5 ha. 205840 (%)	187952 (91.4)	9004 (4.4)	4019 (1.9)	4865 (2.3)	(100)
0.5-1.0 ha. 265816 (%)	228677 (86)	21566 (8.1)	4550 (1.7)	11023 (4.1)	(100)
1-2 ha. 400371 (%)	294202 (73)	55482 (14)	29405 (7.4)	21282 (5.3)	(100)
2-3 ha. 224072 (%)	176625 (79)	20428 (9)	15390 (6.8)	11629 (5.2)	(100)
3-4 ha 131916 (%)	106146 (81)	13483 (10.2)	2575 (1.9)	9712 (7.3)	(100)
4-5 ha. 107031 (%)	76033 (71)	3551 (3.3)	3708 (3.5)	23739 (22.2)	(100)
5-8 ha. 96386 (%)	56584 (61)	16478 (17.1)	10306 (10.7)	13018 (13.5)	(100)
over 8 ha. 51464 (%)	34824 (67)	3889 (7.5)	4810 (9.3)	7941 (15.5)	(100)

Kenya: *Source.* Computed from J.C.Abbott 1983, p.21.

#### **4. Policy Implications of Attitudes Toward Risk**

One of the policy implications of risk aversion concerns the *strategy of diffusion of "best practices"*. As noted by McPherson (1986), efficiency differentials witnessed by Shapiro (1983) can prove quite rational from the farmers' point of view if risk aversion is taken into account. This reinforces the case made by Wolgin (1975) who argued that a generalised risk-compensating scheme would allow overall production to increase, especially by increasing allocative efficiency. If one adds that risk aversion affects more heavily marketed inputs than inputs in kind, policies compensating for risk will exert a direct and marked effect on the consumption of

fertilizers — and more generally all "modern" inputs. Now, beyond adoption of "best practices", the introduction of new techniques is seen as an even riskier business. Consequently, whatever strategy is devised to bring about a "Green Revolution" at some point of time in Africa, it will have to be supplemented by a policy taking risk into account.

The other point concerns *social differentiation* and the spread of "best practices" and new technologies. Since risk aversion is unevenly distributed among peasants, farm size, and more generally wealth, as well as educational levels, will play a significant role. The better-off farmers will adopt new techniques and inputs more easily and more quickly than small, illiterate, credit-constrained ones. Thus a policy which fails to take risk into account will in effect favour larger over smaller farmers. This will have important social implications, since one of the positive assets in African agriculture is its relatively limited differentiation as compared to other continents (Lipton, 1989).

Turning to purely productive considerations, strategies disregarding attitudes toward risk will slow down diffusion of technologies. Since large farms adopt new techniques before small ones do, disregard of risk would restrict the adoption of new techniques to large farms, and further slow down the diffusion to small farms who typically lag behind (Feder and O'Mara, 1981).

*Credit policy* will prove extremely important in that respect. Since it introduces intertemporal flexibility in choices and constraints, it is considered by economic theory as a device minimising risk. On this basis, credit availability will directly command the adoption of new techniques and the demand for fertilizers. One immediate policy implication is that, if the demand for fertilizer is to be increased, then credit must be made easily available to rural producers. However, the form under which credit is made available will also prove crucial. First of all, if intensification of agriculture is to result from diffusion, credit should be made available to all producers, and credit schemes devised accordingly. The question of collateral will prove important, since it is an important potential source of discrimination. Second, credit can increase risk. This will depend on two sets of factors: the rate of interest, and the conditions of repayment. The reaction to the rate of interest is typically very strong, for the same reasons that the demand for priced inputs is very sensitive to prices. Cheap credit is then a necessary ingredient of a successful fertilizer policy.

Repayment conditions can also introduce uncertainty, especially when output prices are unstable. If they are, the expected instability of future prices will make credit a risky enterprise for the farmer, and the financing of fertilizer demand by credit will compound risky operations. The most reassuring forms of credit should then be favoured, perhaps along "credit-in-kind" lines, with repayment in kind, or at predetermined prices, occurring at harvest period. This naturally has far-reaching implications in terms of "network reforms", since private schemes of fertilizer supply and credit management might then prove extremely complicated. On the other hand, "integrated programmes" — where one and the same agent supplies both inputs and credit, and commercialises output — simplify matters, and seem to have favoured the utilisation of fertilizers. Some form of monopoly can be, from that point of view point,

commendable<sup>21</sup>.

## IV. DOMESTIC PRICING POLICIES

This Chapter examines the impact of domestic pricing policies upon the demand for and utilisation of fertilizers. The analysis is restricted to domestic food crops, and the influences of devaluation and of uncertainty of prices are not taken into account. Elements for adapting the argument to export crops, and considering the impact of devaluation and uncertainty, will be given in the concluding Chapter.

### 1. *Various Pricing Principles*

Precisely because of their low degree of utilisation<sup>22</sup>, the productive potential of fertilizers is particularly high in SSA. Under-consumption thus harbours an important potential source of output growth, which could be tapped by measures increasing fertilizer utilisation. The question is one of devising a proper policy to tap this potential. Since price mechanisms are an essential lever for resource mobilisation, attention will be focused on pricing policies.

Basically, two main policy courses can be envisaged. One of these directly stimulates demand for fertilizers by influencing input prices — typically through a subsidy scheme — while the other seeks to increase production through a rise in output price, thus indirectly increasing demand for fertilizer. These two options will be referred to as *Subsidy-Push*, denoting a direct increase in demand for fertilizer brought about by subsidy, and *Price-Pull*, if fertilizer demand is "indirectly" increased following a rise in output prices.

In principle, both options lead to equivalent results. Under a "rational entrepreneur" assumption, lowering the price of an input or increasing the price of the output will both result in increased production and increased use of the input. Supply reaction will push output up if output price increases, thus inducing a greater demand for inputs. Conversely, if the price of an input is lowered, the demand for that input will increase and, assuming that substitution between inputs is restricted, output will increase.

The liberal recommendations, as expounded by Tolley *et al.* (1982) typically rely on *Pull* mechanisms.

Sections 2 to 4 will review some of the elements permitting a comparison between these two broad options. Section 2 examines the question of output-supply and input-demand elasticities, Section 3 attempts to explain the high level of input-demand elasticities, and Section 4 expounds two policy options based on the comparison between these various elasticities.

The following Sections (5 to 7) examine the workings of price increases or subsidy removal under various assumptions. Section 5 analyses the CAISTABS — which guarantee purchase of production at a fixed price — and examines the consequences on both output expansion and intensification of production, Section 6 evaluates the potential for increasing input demand through output-price increases,

and Section 7 is an account of some experiments in subsidy removal. Section 8 presents conclusions.

## **2. Pricing Principles and Values of Elasticities**

In a perfect Price-Pull model, the demand for fertilizer will follow from increases in the price of output. This is however an induced demand, which depends on a transmission mechanism whereby increased profitability of production will translate, via marginal value products, into greater actual demand for inputs. With VCRs (Value Cost Ratios) constantly above 1 (see above, Part 1 Section 5), the argument will require some further refinement. On the contrary, in a pure Subsidy-Push model, lowering the price of fertilizer will immediately generate an increased demand for inputs.

The key factor commanding reactions to Subsidy-Push or Price-Pull policies is the differential reactivity of both output supply and fertilizer demand to changes in prices offered for output or charged on inputs. The values of various elasticities are therefore a crucial element of judgement.

Before presenting any estimates, a word of caution regarding data is called for. The author has been unable so far to find a consistent set of adequate estimates for SSA countries. This Section accordingly relies on data from other continents, complemented with extremely rough estimates aiming at checking that figures in SSA countries would fall somewhere within the rather broad intervals found elsewhere.

From what we know of them, input-demand elasticities concerning price are large when compared with elasticities of supply concerning price (see Table 10).

Estimates of price elasticities for fertilizer demand ( $\epsilon_{i,p_i}$  in that Table) vary widely, but very seldom fall below 0.4. Excluding extreme values<sup>23</sup>, we will rely on the hypothesis that they remain within the range [0.3;0.7]. This compares with a range for output supply-price elasticities ( $\epsilon_{s,p}$ ) of [0.05;0.3]. A rough but convenient convention will then be to consider fertilizer demand-price elasticities to be about twice as high as output supply-price elasticities.

Such values for demand elasticities for fertilizer are quite high — higher at least than would be expected from microeconomic analysis. They imply an output response to a fertilizer price decrease (output elasticity with respect to fertilizer price, noted  $\epsilon_{s,p_i}$ ) of about the same order of magnitude as output supply-price elasticities ( $\epsilon_{s,p}$ )<sup>24</sup>.



Table 10

Short-run Demand & Production Elasticities of Fertilizer  
and Short-run Price Elasticities of Output

Source	Period or Country	Country or product	$\epsilon_i, \pi_i$	$\epsilon_s, i$	$\epsilon_s, p$
Timmer	1949-71	Brazil	-1.12		
	1953-68	India	-0.31		
		idem	-0.53		
		India	-1.2		
	1958-64	India	-1.2		
	1960-72	Korea	-0.17		
	1971	idem	-0.7		
	1958-72	Philippines	-0.59		
	1950-66	Taiwan	-0.55		
idem		-2.03			
Barker & Hayami	Philippines		-0.5	0.1	0.3
Sidhu & Sidhu	India	rice	-0.5	0.2	0.2
	idem	wheat	-0.4	0.3	0.2
Pichitkul	Thailand	N	-0.53		
	idem	P <sub>2</sub> O <sub>5</sub>	-0.32		
	idem	K <sub>2</sub> O	-0.55		
Kawagoe, Hayami & Ruttan	inter-	OLS <sup>a</sup>		0.10	
	country	PCR <sup>a</sup>		0.30	
idem	LDCs	OLS <sup>a</sup>		0.09	
		PCR <sup>a</sup>		0.16	
Sobhti	India-Wheat: Traditl.		0.26 <sup>b</sup>		
	idem	HYV		0.63 <sup>b</sup>	
Bond <sup>c</sup>	1963-81	Ghana		0.20	
	1966-80	Kenya		0.10	
	1969-78	Côte d'Ivoire		0.13	
	1968-81	Madagascar		0.10	
	1970-79	Senegal		0.17	
	1972-81	Tanzania		0.03	
	1968-78	Uganda		0.05	
	1964-80	Burkina Faso		0.22	
		Average on sample		0.12	
Own estimates	SSA <sup>d</sup>	low		0.125	
		high		0.55	

Symbols:  $\epsilon_i, \pi_i$ : price elasticity of fertilizer demand;  $\epsilon_s, i$ : output elasticity of fertilizer;  $\epsilon_s, p$ : price elasticity of output. A blank denotes missing coefficient.

Notes: a. OLS; Ordinary Least Square, PCR; Principal Component Regression;  
b. own calculations from figures presented in source.  
c. aggregate supply response to real producer price.  
d. see Note 23.

This is higher than expectations based on microeconomic analysis presented by Tolley *et al.* (1982). Assuming producer equilibrium, i.e. equalization of marginal costs and revenues, they show that the overall effect on production exerted by an increase in the price of output will necessarily be larger than that exerted by a fall in the price of fertilizer<sup>25</sup>. The output elasticity with respect to own price should be larger than the elasticity of output with respect to fertilizer price.

Consequently, the equality between supply elasticities of output with respect to output price *and* input price shows that demand elasticity for fertilizer with respect to fertilizer price is higher than predicted by theoretical microeconomic analysis.

In other words, demand for fertilizer over-reacts to changes in fertilizer prices. The next section attempts to explain this feature.

### **3. Reasons for High Demand Elasticities**

In his analysis of determinants of fertilizer demand, Segura (1986) lists four factors influencing positively the demand elasticity for inputs. These are:

- a) high substitutability with other inputs (the less essential the fertilizer is, the higher its demand elasticity);
- b) high-demand elasticity of output with respect to own price;
- c) high-supply elasticity of other inputs; and
- d) high share of fertilizer in total cost.

Points *b)* *c)* and *d)* do not apply to SSA agricultures. Demands for export goods are typically price inelastic on the world market, while demand for domestically produced foodcrops is typically inelastic. The supply of other inputs (capital and labour) is equally inelastic (capital because of credit constraints, labour because of its scarcity in peak periods). The supply of land is probably more elastic than that of capital and labour, although, when not scarce, arable land is available only after clearing. Finally (see Table 11) fertilizer represents a small part of cost, typically in the 15-30 per cent bracket of priced inputs alone, which means a much smaller proportion of total cost (if land, labour and animals are included in the calculation).

**Table 11****Expenditure on Fertilizer as a percentage of Priced Inputs  
Various crops, 1983**

	Wheat	Rice	Maize	Millet	Sorghum
Ethiopia	18		30		
Kenya	43		45		
Madagascar		21			
Nigeria		56	50.5	40	18
Zaire			9		
Malawi			45		
Zimbabwe			33		
Tanzania			15	14	20
Mali				30	
Niger				6.6	8
Senegal				25	
Burkina Faso				10	35
Chad				11.6	
Burundi					14
Rwanda					8
Somalia					14
Averages	30.5	35.5	32.5	19.5	16.7

Computed from "AT 2000."

The relatively high level of elasticities would then correspond to one of two alternatives. The first of these is point *a*) identified above, i.e. substitutability for other inputs, especially non-marketed — this could equally correspond to attitudes toward risk, a factor omitted both by Tolley *et al.* and Segura. In the second (more likely) alternative, the correspondence would be to a combination of substitutability among inputs and to risk aversion, with risk aversion on the priced input inducing a high degree of substitutability of non-priced for priced inputs. In this event, the high value of demand price elasticity for inputs means that an increase in the price of fertilizer will lower the consumption of fertilizer while increasing that of other inputs.

Such a substitution will most probably be inefficient and move production away from the production frontier, since, as seen above, non-marketed inputs have generally reached VCRs close to 1, while fertilizers have not. Substitution away from fertilizers accordingly means reducing the use of the inputs with highest marginal productivity<sup>25</sup>.

Such substitutions thus appear irrational — unless, again, risk aversion is at

work. In that case the substitution away from fertilizer in case of price increase should be interpreted as a strategy to minimise monetary outlays in an uncertain situation. On this hypothesis, a subsidy on inputs would help restore allocative efficiency: by decreasing monetary outlays of the producer, it would compensate for risk aversion and allow demand for fertilizer to move closer to optimality.

#### **4. Policy Implications: The Output Price-Support Versus Input-Subsidy Issue**

Differences between producers' response to output-price and input-price variations introduce some asymmetry between the behaviours of output supply and input demand. High-demand elasticities for fertilizer thus open the possibility of a policy sequence in which the volume of agricultural production is *pushed* by increased consumption of fertilizer consumption induced by subsidy of input rather than being *pulled* by output-price increase.

The two options are not strictly equivalent since a given increase in total production can result from a *shift along the existing production curve*, if producer prices are increased, or from a *shift of the production curve* to the right, if fertilizer utilisation is enhanced by subsidy.

Comparisons between these two policy options have been carried out by Barker and Hayami (1976) in the case of Philippines, by Tolley *et al.* (1982) in a general theoretic fashion illustrated by figures from Bangladesh, by Sidhu and Sidhu (1985) for India; and a rough adaptation to Sub-Saharan Africa was attempted in Fontaine (1987a). D.McCarthy and L.Taylor (1980) applied an alternative formulation of this argument to Pakistan<sup>27</sup>. These comparisons were made in a food self-sufficiency perspective, and concern domestic food crops only. Elements for adapting the argument to export crops will be presented in the next chapter.

Defining an adequate criterion for comparison is far from easy. In the original formulation by Barker and Hayami — which directly inspired Sidhu and Sidhu and Fontaine — both policy options entail subsidy, and the criterion for comparison is the respective budgetary costs of total subsidies. In the first option, which is to increase producer prices, subsidies will be needed to ensure that retail prices to consumers remain unchanged. In the second option, subsidies will be needed to lower the procurement price of fertilizers. Although SAPs do not favour either form of subsidy, the argument is worth examining for two reasons.

The first reason is that it illustrates the magnitude of the impact of input-subsidy schemes.

The second reason is that, although not favoured by SAP philosophy, some subsidy of domestic food crops may prove unavoidable. Price elasticities of demand for domestic food crops are typically low. The increase in supply resulting from an increase in producer prices will push market prices down. The only option to maintain

producer prices while market prices are falling is to introduce a subsidy to fill

the gap. Thus the essence of the Barker-Hayami approach may in the end prove to be more consistent with SAP philosophy than was at first apparent.

If subsidies on either input or output prices is admitted, the reasoning is quite simple. It results from the combination of three specific features:

- i)* the total expenses on fertilizers represent only a small part of total outlays;
- ii)* the demand-price elasticities for fertilizer are significantly higher than the supply-price elasticities of output; and
- iii)* fertilizers have a high-marginal productivity.

It will therefore cost less to shift the production function to the right, than it will to compensate consumers for the price increase which induced a shift along the production frontier. The difference between these two options is quite significant, with subsidies to input representing a fraction — one-half to one-third — of the compensating subsidy to consumers.

If the improvement of domestic supply is the only objective, the two policy courses lead to approximately the same result, and differ only in respect of the total amount of subsidy entailed. If however input utilisation is also taken into account, one has to compare the effects of the Price-Pull and the Subsidy-Push options. Unfortunately, no figures are available which relate the increase in fertilizer demand to the increase in production on the hypothesis of a Price-Pull; indirect evidence suggests however that the reactivity of fertilizer demand to output price is probably much lower than that of Subsidy-Push.

## **5. Price Guarantee, Extensive Cultivation and Fertilizer Utilisation**

A policy of increasing producer prices is a necessary ingredient of fertilizer policy. From a recent reconsideration of the pricing policies in the CAISTABS models (Mahieu, 1990) two features emerge with clarity.

The first is that, contrary to a commonly held opinion, the "CAISTAB" model — characterised by the triangle of fixed-pricing/guaranteed outlet/implicit taxation of agricultural production — has not exerted depressing effects on supply when consistently implemented. On the contrary, as long as they operated coherently<sup>26</sup>, guaranteed producer prices have increased supply over time, and induced over-production rather than under-production. Stability of price, and not only price level, has been a very potent incentive to increase production. However, increases in production induced by price stability resulted from an increase in cultivated areas and not from an increase in inputs (Mahieu, 1990, pp. 117-124). Labour intensity (amount of labour per hectare) did not increase. In other words, increases in output followed from extensification, and not intensification of agriculture.

This can be rephrased in theoretical terms as follows. With homogeneous production functions of degree one, maintaining a fixed price with a guarantee of purchase will indefinitely expand the scale of production<sup>29</sup> unless the price falls below average cost — which is what occurred when the combination of the overvaluation of

the CFA franc and depressed world prices forced the government of the Côte d'Ivoire to lower guaranteed prices to producers. The important implication here is that in the "classical" CAISTAB model, expansion of production operated along an unchanged production function.

Extensive plantation methods also physically hampered the utilisation of fertilizers: since plants are remote from one another, the use of fertilizers is more costly in terms of labour (more time is spent spraying the fertilizer) and less efficient in terms of returns (diffusion of nutrients from one plant to another is reduced)<sup>30</sup>.

In so far as one policy objective is to induce intensification, a positive action on output prices will be required. Theoretically, such action should induce intensification by increasing the marginal value productivity of inputs, and hence input mobilisation; this will then probably induce intensification as far as labour is concerned (Ruf, 1987), and as arable land grows scarcer, the trend should accelerate.

Accordingly, an increase in agricultural output prices will become necessary to bring about intensification. The main question is to know whether this Price-Pull intensification will also concern priced inputs and fertilizers or will be restricted to non-priced inputs alone.

## **6. Impact of Output Price Increases on Fertilizer Utilisation**

The responsiveness of fertilizer utilisation to increases in output prices is central to the policy debate. One optimistic view on that point has been clearly expounded by Tolley *et al.*, in the following terms:

"A price support provides a direct form of incentive giving producers complete flexibility to choose the least-cost combination of inputs in raising production. A subsidy on an input, however, is a more indirect incentive that achieves inefficiencies and a higher resource cost.... [We have] show[n] that the output response from a subsidy on any one input must be smaller (or at best equal to) that from a price support. A second consideration.... emphasized by Barker & Hayami is that *the use of certain inputs might not be in equilibrium*. There could be a net gain from policies that *stimulate the use of inputs not yet accepted by farmers at prevailing prices*..... [However]) a *price support policy* raises the output-fertilizer ratio and gives *added incentive* to increase fertilizer use along with traditional inputs". (p. 156, emphasis added).

The question remains will the "added incentive to increase fertilizer use along with traditional inputs" effectively induce increased utilisation? Of course, if "physical network" factors operate as constraints, neither policy will suffice unless "network obstacles" are removed.

Assuming, as previously, that "network factors" are adequate, one should next investigate the response of fertilizer demand to "direct" (i.e. subsidy) or indirect (i.e. output price) incentives.

Two problems must be distinguished here: that of reallocation of fertilizer among crops following relative prices, and that of global increase in demand for fertilizers following an increase in the average price index of agricultural goods.

There is some evidence on the first point: fertilizer is used more intensively on crops with higher price ratios. Table 12 below illustrates the phenomenon in Kenya, Malawi and Tanzania: the proportion of total fertilizer going to maize is higher in countries with higher maize/coffee price ratios.

**Table 12**

**Relative Output Prices and Share of Fertilizer Use**

	Relative Price (average on 3 Years)	Relative Share of Fertilizer Use (% of total)	
	Maize/Coffee	Coffee	Maize
Kenya (1982/83)	0.04	25.6	19.5
Tanzania (1985)	0.11	25.6	47.0
Malawi (1984)	0.13	25.6	83.5

Computed from Lele *et al.* (1989) pp. 53-54. In order to smooth out yearly variations, the price ratios presented here are averages of price ratios over the 3 years before the date of observation.

Similarly, fertilizer use is important on high value vegetables for urban markets, for instance in Cameroon (U Lele, p.28) or Senegal (interview with Magoune Gaye/DIRE-Dakar), and fertilizers seem to be reallocated between crops according to relative prices and profitability, for instance between cocoa, palm-tree and hevea in Côte d'Ivoire (interview with J.J. Pesquet/APROMA).

But these movements only concern shifts in fertilizer utilisation from crop to crop. What is really interesting is the aggregate fertilizer demand reaction to output prices. In addressing this phenomenon, one may have to face the same paradox as in supply reactions, where elasticities of aggregate agricultural production are low, even though supply elasticities of individual crops may be relatively important.

Data are scarce but theoretical expectations are that an increase in the price of output will not by itself induce optimal use of fertilizers, even if this increase is aimed at compensating the farmer for the removal of the subsidy.

This is in line with theoretical expectations based on the risk-aversion approach. In McPherson's interpretation of VCRs difference to 1 as "risk-aversion coefficients", an increase in output price will only marginally diminish the impact of risk upon decision. The relevant factor here is the amount by which an increase in output price will increase the difference between  $dU(E)$  and  $-dU(V)$  — where  $dU(E)$  stands for the increase in utility yielded by an increase in expected earnings and  $-dU(V)$  for the decrease in utility resulting from an increase of variance.

Rational behaviour yields

$$d(E) = K \cdot d(V), \text{ or } d(E)/d(V) = K$$

where  $K$  is a coefficient measuring risk aversion, and  $d(E)$  and  $d(V)$  represent increments in expected earnings and in variance of earnings. Since an increase in output prices aimed at *compensating* for the increase in the cost of fertilizer does not influence the relationship between  $d(E)$  and  $d(V)$ ,  $K$  should remain constant, and relative under-utilisation of inputs should stay in the same proportion.

Alternatively, if one assumes production functions of the Cobb-Douglas type, one would expect elasticity of demand for fertilizers with respect to own price and to output price to be equal (in absolute values), i.e.  $\epsilon_{ip} = -\epsilon_{ip}^{31}$ . In that case the direct (subsidy) and indirect (output price) incentives will be equally potent. If however input demand is in disequilibrium, and fertilizer is used below optimal level, the previous equality no longer holds, and is turned into the inequality  $\epsilon_{ip} < -\epsilon_{ip}$ , with Subsidy-Push incentive effect stronger than output-price Pull effect.

In all probability therefore, increases in production brought about by output price increases alone will correspond to moves along basically unchanged production functions. The absolute demand for fertilizer will increase only by the amount necessary to produce the additional output using unchanged techniques, i.e. will not induce intensification of fertilizer utilisation.

This is confirmed by the limited empirical information available on behaviours. As illustrated in Table 13, benefit-cost ratios (interpreted here as approximations of VCRs, i.e. as indicators of sub-utilisation) always remain high, even in countries where high output prices are supposed to compensate for unsubsidised fertilizers.



**Table 13****Benefit-Cost Ratios and Value Cost Ratios of Fertilizer/Maize**

Country	Land Quality	BCR	VCR
Kenya 1987	High	3.4-5.9	
	Medium	2.3-4.8	
	Low Potential	2.0-3.2	
Tanzania 1984	Hybrid	3.4-4.0	
Malawi 1987	Local Maize	2.0-2.6	
	Hybrid	2.6-4.6	
Burkina Faso 1981			3.2
Rwanda 1984			2.7

Sources: Lele *et al.* (1989) Table 23, except Burkina Faso (Coursier 1981) and Rwanda (Blas 1984).

Table 13 displays benefit-cost ratios of fertilizer utilisation calculated by U Lele, and VCRs for Rwanda and Burkina Faso quoted previously. The benefit-cost ratios are based upon estimated response coefficients of fertilizer utilisation and relative prices for fertilizers and products. As in the case of Value-Cost Ratios (VCRs), divergence to 1 indicates under-utilisation. The only country which, at the time, did not subsidise fertilizers was Kenya, where producer price for maize had been substantially increased from 1983 onward. Kenya is here taken as an example of "Price-Pull" policy of demand for fertilizer, i.e. as a country where fertilizer utilisation has been induced not by subsidy but by increases in producer prices. The fact that benefit-cost ratios in Kenya are notably higher than 1 means that the "Price-Pull" has not brought about "efficient" use of fertilizers. The fact that the ratios for Kenya are in the same range as those for other countries — or, depending on the quality of land, higher — suggests that, whatever the level of output price, fertilizer is applied in such a fashion as to roughly maintain VCRs.

In other words, *relative* underconsumption of fertilizer seems independent of output-price, or output-price/fertilizer-price ratios. Policies of increasing output prices will probably not, it seems, induce an intensification in the use of fertilizers.

### **7. Fertilizer Subsidy Removal in Practice**

Instructive insights may be gleaned from examining the effects of subsidy removal.

A rough indication of the prospects for demand for fertilizer is given by the influence of subsidy upon benefit-cost ratios of fertilizer utilisation. Table 14 shows that this ratio falls below the "critical" value of 2 when subsidies are removed, and one can expect that the demand for fertilizers will fall abruptly if subsidies are removed.

**Table 14****Benefit-Cost Ratios of Fertilizer Utilisation with and without Subsidies**

Country	Crop	Sub.	Non sub.
Tanzania	Hybrid Maize	2.9-3.4	1.0-1.2
	Rice	4.7-5.3	1.6-1.8
	Wheat	1.2-3.0	0.4-1.0
Senegal 1987	Rice	2.6	1.8
	Sorghum	1.5	1.0
	Millet	2.7	1.8
Malawi 1988	Hybrid Maize	1.9-3.6	1.5-2.9
Cameroon 1987	Maize	5.1	1.3

Source: U. Lele, 1989, Tables 23 & ff., computed from FAO figures.

As things stand currently, fertilizer subsidy is essential in maintaining benefit-cost ratios above the threshold inducing purchase and utilisation. Of course, these indications are extremely crude since they do not take into account the possibility of offsetting the losses from subsidy removal through output-price increases. This however does not appear as such a simple option, as illustrated by the evolution of Tanzania's fertilizer policy.

The fertilizer subsidy scheme, which was in operation in 1984, was abolished in 1986/87 and producer prices were multiplied by three. Even so, benefit-cost ratios decreased (see Table 15). Subsequently, the combination of domestic price increases and devaluations resulted in the restoral of an explicit subsidy in 1988/89 (last line of table 15).

**Table 15****Benefit-Cost Ratios for Fertilizer use in Tanzania 1984, 1987, 1988**

	Hybrid Maize		Rice		Wheat	
1984 (with fertilizer subsidy)	3.4-4.0		6-7		1.9-4.8	
	<i>a</i> with implicit	<i>b</i> without subsidy	<i>a</i> with implicit	<i>b</i> without subsidy	<i>a</i> with implicit	<i>b</i> without subsidy
1987 (no explicit subsidy)	2.7-3.1	1.5-1.8	4-4.6	2-3	1-3	0.7-1.8
	subs	non sub	sub	non sub	sub	non sub
1988 (with fertilizer subsidy)	2.9-3.4	1.0-1.2	4.7-5.3	1.6-1.8	1.2-3.0	0.4-1.0

*Source:* as for table 14. Figures for 1987 correspond to the situation where no explicit subsidy was in operation, but an implicit subsidy was gradually introduced when the domestic price of fertilizer was maintained although devaluations increased the border price of fertilizers. Figures labelled 1987*b* show the impact that the removal of implicit subsidies would have exerted upon benefit-cost ratios.

This illustrates two difficulties in policies of compensating output price increases. The first one is that very large increases in output prices are required to compensate for the removal of fertilizer subsidies. In 1986/87, a 300 per cent increase of producer prices was necessary to maintain benefit-cost ratios above the critical level of 2.

The second is that such schemes are difficult to maintain over time. Price relationships between input and output are subjected to conflicting influences: continuous devaluation pushes the border price of imported fertilizers upward, while increased production of domestic food crops lowers their market price. If fertilizer prices actually charged to farmers had reflected the evolution of border prices, incentives would have deteriorated and fertilizer demand would have contracted sharply. Consequently, although border prices increased, domestic prices of fertilizers were maintained. This amounted to the introduction of an "implicit subsidy" which proved essential to maintain the benefit-cost ratios above the critical value of 2 (Table 15, figures for 1987, option b). Finally, following further devaluation and cost increases, subsidies were re-introduced in 1988, without which the benefit-cost ratio would have fallen below 2 for all crops (Lele, 1989, pp. 42 & sq.).

The impact of subsidies on benefit-cost ratios does suggest that the removal of subsidy will contract demand for fertilizers.

A more direct investigation of the overall economic effects of reforms of fertilizer pricing has been conducted in the case of Senegal by Braverman & Hammer (1986). Table 16 summarises some of their results.

The direct effect of increases in the price of fertilizers on production is unambiguously negative (policy options 1,2 & 3) except on maize, which is not a major staple food in Senegal and a crop on which fertilizers are not used significantly. Bringing in both output price (cotton) and fertilizer prices in line with market values (world price and cost of production) (option 5) has generalised negative effects on supply, except for cotton itself. Whereas a decrease in the price of fertilizer coupled with a decrease in the output price of the major export crop (groundnut) (Option 6) has overall positive effects on production (except for groundnuts), and on food import. Budgetary costs, however, vary widely across options, and invariably fall as fertilizer subsidies are removed.

**Table 16**

**Consequences of Policies Implying Fertilizer Subsidy Reforms in Senegal**

Policy option	Supply Reaction (%)					Macroeconomic Impact (%)		
	Ground-nut	Rice	Cotton	Millet	Maize	Ag. Xp Earning	G. def Ag.	Rice Imp.
1)FePx2	-2.3	-2.3	-16.3	-0.6	0.6	-5.2	-10.4	1.0
2)FePx3	-3.6	-3.7	-24.6	-1.0	0.8	-8.1	-14.1	1.6
3)FePx4	-4.5	-4.7	-30.1	-1.2	1.0	-10.1	-16.0	2.0
4)CotPW	-7.0	-23.3	191.2	-2.1	-11.8	8.6	72.3	12.4
5)Fe.Cot	-10.1	-22.9	119.6	-3.0	-8.2	-3.5	34.1	12.0
6)Fe.Gr	-0.4	13.4	64.8	5.4	1.5	12.3	61.0	-13.3

Source: adapted from Braverman & Hammer p.244-245.

Notes: **Policy Options:**

**Options 1, 2 and 3: (FePx2,3 or 4.):** Fertilizer price increased 100, 200 or 300 per cent (Initial subsidy on fertilizer price around 75 per cent of cost).

**Option 4: (CotPW):** price of cotton raised at world level (+118 per cent).

**Option 5: (Fe.Cot):** Combination of policy courses 3&4: price of cotton raised 118 per cent (world level) and fertilizer price 300 per cent (subsidy=0).

**Option : (6/Fe.Gr):** Fertilizer price lowered from 25 to 5 FCFA per Kg., Groundnut price reduced by 5FCFA per Kg.

**Supply reaction :** impact on supply of products in per cent.

**Macroeconomic Impact .(%):** **Ag.Xp. Earng:** Agricultural exports earnings; **G.Def.Ag:** Government deficit in Agriculture;

**Rice Mp:** Rice imports.

## 8. Conclusion to Chapter IV

This Chapter has examined the question of domestic pricing policies in connection with fertilizer utilisation. The present section briefly summarises the main findings.

Fertilizer demand is particular in that price elasticities of demand are quite high. This introduces the possibility of increasing both the volume of agricultural production and the degree of utilisation of fertilizers either by an increase in producer prices of output — referred to as the Price-Pull option — or by a decrease in fertilizer prices — the Subsidy-Push option. These two options were compared. Although they are theoretically equivalent as to intention, they differ markedly in practice.

First, the proportion by which domestic output-prices must be increased to bring about an increase in production is very high. This is due to the low value of output-price elasticities.

Second, the increases in output prices required to maintain the profitability of fertilizer utilisation will not generally be self-sustaining, but will require intervention for one or other of the following reasons: either (a) because, due to devaluation, the domestic procurement cost of fertilizers will increase, thus lowering benefit-cost ratios; or (b) because increases of the volume of production of food crops will push output prices down. In the first case fertilizer subsidies will have to be maintained or reintroduced, while in the second case, an output price support policy will have to be implemented to keep producer prices at an attractive level<sup>32</sup>.

In both cases, government intervention will be necessary, and will assume the form of a subsidy, either on the input or on the output side. Thus, although in principle it contradicts the objectives of SAPs, the Barker-Hayami/ Sidhu-Sidhu approach — whereby fertilizer utilisation and output increases are brought about by a mix of subsidies on input and output — proves very relevant to the analysis and design of fertilizer policy, even within the SAP framework. In any case, although output-price increases will be necessary, they will have to be complemented by fertilizer subsidy schemes if the level of utilisation is to be maintained.

While this applies to domestic food crops, the situation of export crops is in principle quite different. Producer prices of export goods can be increased lastingly by a combination of reforms of CAISTABS or Marketing Boards, and devaluation. However, some form of public intervention on producer prices will also be required in the case of export crops, if only to avoid price instability. The fertilizer subsidy issue will thus also probably concern export crops.

## V. CONCLUSIONS

Fertilizer policy is a very sensitive issue and constitutes a fragile segment of agricultural reform.

Fertilizers draw upon a resource considered as extremely scarce and precious by small farmers, namely cash. They embody most of the risks and uncertainties governing agricultural production: natural risks, and economic uncertainties. They reflect social differentiation, and will largely determine increases in productivity which are the key to survival in SSA countries more than anywhere else.

Current policy options are governed by short-term considerations, while agriculture requires long-term perspectives. Structural adjustment reforms rely on rapid adaptation to changes in the economic environment, while behaviours of agricultural producers are prudent, and diffusion of new practices is slow.

Finally, economic analysis, especially microeconomic analysis, relies on behavioural assumptions which are ill-fitted to the reality of agriculture in Africa. Moreover, empirical investigations of the possible consequences of reforms of fertilizer policy have been insufficiently developed.

Consequently, the first conclusion to be drawn from this study is that a great deal of caution should be exerted when devising new policies for fertilizer supply and distribution, and that theoretical microeconomic arguments be not used for policy formulation unless they have been very closely examined and adapted to the specific context of African agriculture.

### **1. *The "Efficiency/Distortion" Argument Reconsidered***

Considerable concern has been expressed as to possible distortions induced by fertilizer subsidy schemes. Although text-book microeconomics unambiguously establishes that subsidies and price manipulations induce misallocation of productive resources, one should ask what, in practice, are the inefficiencies dreaded in this precise context. Or, to put it another way, what are the distortions that subsidies can bring about?

The first is over-consumption. But the major problem in Africa is quite the opposite, i.e. under-consumption. Since even the highest recommendations for fertilizer use in SSA agricultures are well below the point of diminishing return, "distortions" induced by subsidy necessarily push in the right direction.

This suggests that the distortion argument should be reconsidered. If, disregarding the reasons for under-consumption of fertilizers, actual behaviours of farmers are taken as a datum, and if the policy objective is to increase utilisation of fertilizers, then attitudes leading to under-consumption should be considered as "distortions" — because they result in private decisions which move equilibrium point away from optimality, or contradict the "social preference function". The general

principle that correction should be applied at the point where distortion originates should then lead to recommendations in favour of an active policy of fertilizer subsidy.

Another distortion lies in possible *misutilisation of fertilizers*. But action on prices is not likely to correct this misutilisation, since it results principally from lack of knowledge. This is clearly an issue calling for reform or intensification of the extension network, and does not depend on pricing policies. Furthermore, even taking into account that no "all-purpose" fertilizer is available, but given the generalised level of under-consumption, misutilisation (i.e. applying a given fertilizer to the wrong crop,) still exerts positive effects, except where misuse results in aggravation of soil condition. In any case, controlling such misuse by price increase alone will imply reduction of misutilisation through reduction of utilisation, which is a very drastic cure.

*Leakages from subsidised to unsubsidised programmes* are often considered as a wastage of resources, and as a possible cause for misutilisation. One should however note that leakages do not result from subsidy, but from discrimination. Subsidy schemes as such are not responsible for leakages which only occur if multiple distribution programmes for fertilizer co-exist, some of which are subsidised while others are not. They would disappear if the same policy were implemented throughout a country — or in neighbouring countries. If one seeks to unify fertilizer policy at country or regional level, the simplest and cheapest policy will be to curtail subsidies altogether. If however specific schemes have to be kept in operation, then costs of leakages, if unavoidable, should be weighed against possible advantages. The decision will depend upon the nature of the argument against leakages, viz. whether it is one of economic efficiency, or one of equity.

If economic efficiency considerations prevail, then costs of leakages should be taken into consideration *ex ante*, and considered as part of the budgetary costs of targeted programmes.

Furthermore, education regarding fertilizer utilisation could reduce leakages. If the small farmers find it more profitable to use the subsidised fertilizer to increase production rather than to resell it to larger farmers, the motive for leakage could be reduced. Improved extension (information about ways to apply fertilizers most productively) would increase profitability to small-holders, hence further contribute to reduce leakages.

## **2. Policy Conclusions of this Study**

With the lowest degree of fertilizer utilisation in the world, Africa needs a *policy which will increase that utilisation*. Whatever strategy is adopted, chemical fertilizers will prove extremely important in redressing the productive potential of African agricultures.

Among the factors determining demand for fertilizers, attitudes toward risk are pre-eminent, and induce under-consumption of fertilizers by farmers. Consequently, *fertilizer policies should specifically address the issue of risk*.

Since risk aversion is unevenly distributed among farmers, and bears most heavily on the behaviour of small farmers, failure to take risk into consideration would *increase social differentiation* in agriculture, which would probably reduce its cohesion and its ability to withstand shocks. By enlarging the gap between various categories of farmers, it would also influence adversely the speed and scope of *diffusion of innovation* and "best cultivation practices", which spreads from better-off to more marginalised households.

Risk-minimising policies will also have important implications on *credit policy*. Credit availability will directly command the adoption of new techniques and the demand for fertilizers. Credit should be made available to all producers, and credit schemes devised accordingly. Depending upon the conditions under which it is available, credit can equally increase risk by extending economic uncertainty in the future. *Reassuring forms of credit* should then be favoured, perhaps along "credit-in-kind" lines. This has implications in terms of "network reforms", and should probably favour "integrated programmes", where one and the same agent supplies inputs and credit, and commercialises output. From that point of view, some form of monopoly might be recommendable.

Regarding pricing policies, this study has stressed the great potential for *increasing fertilizer utilisation through subsidy programmes*.

Policies of guaranteed prices, when they have succeeded in increasing output, have not induced intensification of production, and *increases in output prices are a necessary ingredient* in policies aimed at increasing the utilisation of fertilizers. However, increases in output prices will not alone induce sufficient utilisation of fertilizers, and specific subsidy programmes will also be required.

In any case, *government price interventions will remain necessary*, either to maintain the output prices of domestic food crops at an attractive level or to cushion the variations of prices of export crops on the world market. Consequently, *pricing schemes relying on a mix of input subsidy and output-price support*, along the lines of the Barker-Hayami/ Sidhu-Sidhu approach, should be investigated more thoroughly, even though they apparently contradict the SAP philosophy.



## NOTES AND REFERENCES

1. The Malaysian experience is sometimes referred to for its "educational" potential. Started in 1955, and generalised in 1961, the 50 per cent fertilizer subsidy programme for rice producers was intended to last until 1966, subsidies being reduced by 10 per cent each year. It was extended to 1971 (30 per cent rate) when it was abolished on the basis that rice farmers were sufficiently educated to purchase their own fertilizer at full cost. Rising world prices in 1973 prompted resumption of the subsidy programme until 1976 when abolition was again contemplated. However, since 1980, a new subsidy scheme for small-scale farmers has regularly been in operation. All in all, subsidy schemes with an "educational" aim have been in operation for the last 30 years, i.e. longer than it takes for a generation of producers to succeed its predecessor. See Jenkins & Lai, 1989, pp. 94-99.
2. Which, as will be seen, do not arise here from market imperfections, but from specific behavioural patterns. Although this confuses the terminology, it does not alter the substance of the argument: if one accepts the notion of "behavioural distortion", then the usual "distortion-intervention" argument applies. See conclusions to Section 2.
3. After the initials of the World Bank research programme Managing Agricultural Development In Africa. Countries covered by the MADIA project are: Malawi, Tanzania, Cameroon, Senegal, Nigeria, Kenya.
4. Estimated at somewhere between 17 per cent and 25 per cent of total supply to small-holders.
5. See description in Lele, 1989, pp. 28ff and 70ff.
6. One should equally note that, although he found no correlation between the rate of growth of agricultural output and the *absolute level of utilisation* of fertilizer, there would most probably be one between the *rate of growth of utilisation* of fertilizers and rate of growth of output. Since subsidisation influences rates of growth of fertilizer, one can wonder whether inclusion of subsidisation *as such* in the analysis would not have yielded a positive correlation.
7. *World Development Report* (WDR), World Bank, 1986 Ch.5 Section 4 pp.105-111 of French edition; World Bank 1989b, Ch.4 pp.114ff. Segura et al., 1986, Part I; Tolley et al. 1982 Ch.7.
8. For a general elaboration of this tendency in WDRs, see Lipton, 1986.
9. Such derivation has been attempted by Tolley *et al.* (1982), but omission of factors listed below weakens considerably the relevance of their results.
10. "Marginally suitable" lands are defined as those where yields are not more

than half of those from "suitable" lands.

11. The complexity of use is illustrated by soil problems in Cameroon where extensive use of ammonium sulphate rather than urea or ammonium nitrate increased soil acidification. In all cases acidity-compensating elements have to be introduced (calcium carbonate), but the doses vary from 1.8 Kg per Kg in the case of urea or ammonium nitrate to 5.2Kg/Kg in the case of ammonium sulphate. Quoted by U.Lele, footnote 56, p.27.
12. See for instance *Afrique Agriculture* N° 177, Nov/Dec 1990 pp. 12-14).
13. In the case where biological fixation of nitrogen is mostly substituted for fixation of mineral nitrogen, biological fixation will preserve the mineral potential of soils, but will not increase the total amount of nitrogen fixed by the crop and yields will not increase.
14. This was apparently the case in colonial Africa. Brett (1973) notes that this attitude was common in Tanganyika until the mid 1930s.
15. A value of 1 denotes efficient allocation. If the VCR is lower than 1, the output is over-utilised; if VCR is greater than 1, then the input is under-utilised: an increase in the use of an input with a  $VCR > 1$  would yield more income than its acquisition would cost.
16. What this actually means is that a  $VCR > 2$  is considered as the threshold below which it will not be adopted by farmers. This "minimal norm" is used to determine pricing policies, i.e. to determine the price differentials between inputs and outputs.
17. Even this "weak" version of Schultz's hypothesis has however been very strongly questioned by Shapiro (1983) who reviewed existing statistical evidence, and proved it to be statistically non-significant, and also produced very convincing counter-evidence.
18. This complexity is illustrated by the use of matrix analysis to trace allocations of cash (Ancey, 1983).
19. Mixed-cropping, for instance, associates a variety of plants which will respond differently to the utilisation of fertilizers. Since no "all-purpose" fertilizer has yet been discovered, the overall result can be disappointing, reinforcing the feeling that money spent on fertilizers will bring only limited extra income.
20. The consumption of fertilizer per hectare does not always increase with income, wealth or size of farms, either because larger farms adopt more land-extensive practices, or because attitudes toward risk do not differ significantly (Roumasset, 1976, quoted by Feder, 1980).
21. This point came up in interviews with M. Gaye (DIRE, Dakar), and

J.J. Pesquet (APROMA). Following the reform of the fertilizer distribution network in Senegal, a number of farmers were unable to borrow to buy fertilizers, after defaulting on previous debts, and the demand for fertilizers fell significantly. A counter-example was quoted in Côte d'Ivoire: the CIDT (*Compagnie Ivoirienne du Coton*) runs a scheme of credit-in-kind, whereby the price of fertilizers supplied is deducted from the payments made to farmers at harvest. This point is also argued in U Lele, 1989, pp. 27 ff., based on the examples of Senegal and Cameroon where the advantages of integration of fertilizer supply, credit and commercialisation are stressed.

22. Which keeps operations on the lower part of the production function curve, i.e. where marginal productivity is high.
23. Our own rough estimates for Africa were established on the following basis: VCRs vary from 2.5 to 3.5, (Coursier, 1981, - Maize, Lesotho: 2.4, Burkina Faso: 3.2- Blas, 1984, - Maize Rwanda: 2.2 to 2.7- Kallavi & Durr). Theoretical yield is 10-20 kg of maize, say 15, per kg of fertilizer. With a cost of fertilizer (unsubsidised in Kenya) in terms of maize (kg/kg) between 2.5 and 3, 1 kg of fertilizers costs 1/3 of increase in production value, yielding a VCR of 3. All these estimates are consistent with FAO/FIAC 1979, which estimates yields on maize and wheat at about 10-17kg per kg of fertilizer. Actual outcome is estimated to be 60 per cent of theoretical outcome (depending on actual sub-optimal husbandry practices) which brings yields in the 1 to 9 bracket.

The weight of fertilizers in total priced inputs varies between 0.09 (Zaire) and 0.45 (Kenya) or 0.50 (Zimbabwe), but normally stays in the 0.15-0.30 bracket. (Own calculations from data in "World Agriculture toward 2000": wheat, maize, mill, sorghum). If total priced costs are assumed to represent 1/3 to 1/2 value of production, and VCRs are interpreted as marginal value products, then  $\epsilon_{s,i} = (dY/dF_e) * (F_e/Y) = VCR * (\text{Fertilizer Consumption/Value of output}) = 0.125-0.55$ .

24. From  $\epsilon_{s,p_i} = \epsilon_{s,i} * \epsilon_{i,p_i}$ , (where  $\epsilon_{s,p_i}$  refers to the unknown supply response to fertilizer price in elasticity form,  $\epsilon_{s,i}$  to supply — or production — elasticity of fertilizer, and  $\epsilon_{i,p_i}$  the demand elasticity of fertilizer with respect to fertilizer price) and using the range of estimates presented above ( $\epsilon_{s,i} = [0.2; 0.3]$  and  $\epsilon_{i,p_i} = [0.3; 0.7]$ ), one finds an elasticity of production with respect to fertilizer price ranging from 0.06 to 0.21, which is quite close to aggregate output-price elasticities presented by Bond (1983), which averaged 0.12 on the entire sample.
25. Starting from an unspecified production function  $S = S(f, a)$ , (where S is supply, f fertilizer and a other inputs), applying usual partial equilibrium conditions, i.e.  $P_f = P * S_f$  and  $P_a = P * S_a$ , (where  $P_f$  and  $P_a$  are input prices, P output price and  $S_f$  denotes partial derivative of S with respect to f) they derive the impact on S resulting from a fall in fertilizer price  $P_f$ . This leads them to the general condition  $\epsilon_{s,p} = \epsilon_{s,p_a} + \epsilon_{s,p_f}$ , (where  $\epsilon_s$  denotes absolute value of supply elasticity with regard to prices p,  $p_a$  and  $p_f$ ). or  $\epsilon_{S,p_f} = \epsilon_{S,p} - \epsilon_{S,p_a}$ . This

- implies that  $\varepsilon_{S,pf} < \varepsilon_{S,p}$ , since both the production and demand elasticities of other inputs (a) are different from zero. (Tolley *et al.*, p. 159).
26. In Shapiro's re-examination of data presented in support of the "Poor but Efficient" hypothesis, fertilizers rank second (after seed and before land) in terms of under-utilisation relative to optimal use.
  27. Based on a change in technical coefficients in a SAM framework rather than on demand elasticities.
  28. And as long as rates of exchange in CFA countries and/or world prices for export crops made it possible to maintain real producer prices over time.
  29. Acknowledgements are due to J.M. Boussard for this remark made at a conference in Clermont-Ferrand in February 1991.
  30. This point was raised by J.J. Pesquet (APROMA) in an interview. His calculations of earnings per day of labour with fertilizers, and without fertilizers but extension of area, concluded that at the going price of 400 FCFA per Kg, use of fertilizer did not significantly improve returns to labour.
  31. Input equilibrium condition is  $(dY/df)=(P_f/P_y)$ , (or  $P_f \cdot P_y^{-1}$ ) where Y and f refer to output and fertilizer consumption,  $P_f$  and  $P_y$  to fertilizer and output prices. In Cobb-Douglas form,  $dY/df = \alpha \cdot K \cdot f^{1-\alpha}$  (where K is a constant) which gives constant elasticity of f with respect to  $P_f$  or  $P_y$ , and  $\varepsilon_{f,pf} = -\varepsilon_{f,py}$ .
  32. See for instance the conclusions of FAO, 1988 (Dakar) and 1989 (Arusha).

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25. In Shapiro's re-examination of data presented in support of the "Poor but Efficient" hypothesis, fertilizers rank second (after seed and before land) in terms of under-utilisation relative to optimal use.

26. And as long as rates of exchange in CFA countries and/or world prices for export crops made it possible to maintain real producer prices over time.