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NEEDED INFORMATION AND ECONOMIC ANALYSIS FOR FERTILIZER POLICY FORMULATION

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Appropriate information on the likely implications of alternative economic policies is basic to their rational design. The lack of such information can result in policies which are ineffective or even counter-productive in achieving the desired policy goals. Furthermore, such policies can also lead to an enormous financial burden and social cost which relatively few governments can afford.

In countries with dominant agricultural sectors, the level and speed of economic development is determined by sustained growth in the agricultural sector. The available evidence suggests that agricultural growth in the Asian context depends heavily upon the increase in agricultural productivity resulting from land augmenting technological change and appropriate economic incentives. The process of agricultural modernization thus involves increased use of fertilizer, fertilizer responsive crop varieties and irrigation, coupled with appropriate incentives.

The body of coherent knowledge about the micro-and macro-economic implications of different fertilizer policies is not adequate. Yet, there is widespread use of these policies in the developing countries, suggesting the need to evaluate alternative fertilizer policies with respect to their effectiveness and economic implications. There is also a need to estimate the likely trade-off between the net social and private benefits of these policies. The information generated from such analysis will provide sound guidelines for formulating fertilizer policies better suited to meeting stated goals. Hopefully, such policies will be more effective in stimulating increased food and agricultural production through efficient and economic use of fertilizers.

The objectives of this paper are (1) to delineate relevant information for national fertilizer policy formulation, (2) to demonstrate the appropriateness of sound data and economic analysis for generating that information, and (3) to demonstrate the appropriateness of that information for fertilizer policy formulation.

DIMENSIONS OF FERTILIZER POLICY FORMULATION

Fertilizer policy refers to public policy which directly influences the performance of fertilizer sector or any of its components. Since the fertilizer sector is closely linked with other economic sectors, fertilizer policies are an integral part of economic development policies affecting agriculture, industry and trade. An appropriate fertilizer policy can be viewed as a policy which

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achieves the stated national goal at the least cost and satisfies all the exogenously specified constraints with respect to its implications and implementation.

Role of Fertilizer in Economic Development

Fertilizer use increases land productivity through yield increases and eases the nutrient constraint to multiple cropping and land development programmes. As a result, it relaxes the land constraint.[1] Since the yield increase is proportionately more than the corresponding incremental labour applied, fertilizer use increases labour productivity. As fertilizer production, distribution and consumption increase, backward and forward linkages create additional employment which is extremely important in labour surplus countries. Fertilizer use also contributes to foreign exchange by facilitating export expansion and/or import substitution of agricultural commodities. According to Pinstrup-Andersen (29), during the 1948-52 to 1972-73 period, about 15 per cent of total cereal production, 30 per cent of incremental cereal production, and 56 per cent of incremental cereal yield in developing market economies can be attributed to fertilizer use. Mellor (22) estimated that 53 per cent of incremental foodgrain production in India during 1973-74 was attributable to fertilizer use, and its contribution is expected to increase to 79 per cent during 1983-84.

Fertilizer Use Levels and Sources of Variation

On the average, fertilizer use during 1974-75 in Asia was 32 kg./ha. which is 8 per cent that of Japan and 4 per cent that of the Netherlands (Appendix 1). Except for South Korea, Japan and Sri Lanka, average fertilizer use in other Asian countries is lower than the Asian average. The fertilizer use levels in India and Bangladesh are less than one-half the Asian average. Clearly, there is large potential for expansion in fertilizer use. Despite low levels, the compound annual growth rate in fertilizer use from 1964-65 to 1974-75 is very impressive ranging from 6.3 per cent for Sri Lanka to 24.8 per cent for Nepal with an Asian average of 10 per cent (the high growth rates in countries such as Nepal are partly due to low initial levels of fertilizer use). The question faced by the policy-makers is how to expand fertilizer use at the farm level. There is a need to identify key potential constraints to expand fertilizer use, and to design policies which will relax those constraints and provide the required economic incentives. There is also a need to determine the sources of variation in fertilizer use across time and space. These sources of variation generally fall within the domain of agro-climatic, socio-economic, and

1. Based on average cross-country data for 1956-58, much before the so-called green revolution in developing countries, Williams and Couston (44)* found a strong positive relationship between fertilizer use and value of crop yields produced per acre. According to White (43), fertilizer use also improves photosynthetic efficiency of cereal plants, thus facilitating an increase in crop yields through an efficient use of solar energy. The National Academy of Sciences (25) has indicated that an improvement in photosynthetic efficiency may be one of the greatest potential sources to raise crop yields.

* Figures in brackets denote references cited at the end of the paper.

managerial factors, some of which can be manipulated through alternative fertilizer policies.

Degree of Fertilizer Self-Sufficiency

Major Asian countries depend heavily on imports to meet their domestic fertilizer requirements (see Appendix 1). Import levels range from 100 per cent in Nepal and Sri Lanka to 28 per cent in Pakistan, with an Asian average of 40 per cent. Despite its large domestic production capacity, India imported 51 per cent of its fertilizer requirements in 1974-75. Most countries depend almost exclusively on imports for potash requirements. Those countries with heavy dependence on fertilizer imports face uncertainty with respect to international fertilizer prices, fertilizer availability and domestic financial capacity to import fertilizer due to scarcity of foreign exchange. Furthermore, heavy import dependence can create a situation where it becomes difficult to maintain stability in domestic fertilizer policies, as demonstrated by the events of 1972-75.

International Developments in the Fertilizer Sector

Given universal demand for fertilizers and relatively localised concentration of commercial sources of fertilizer raw materials, fertilizer sectors in developing countries are greatly influenced by international events in the spheres of fertilizer technology research and development and market development. Consequently, domestic fertilizer policies in a particular country are heavily dependent on these international trends. Policy-makers must keep themselves apprised of these developments and hence be prepared to gradually adjust their domestic policies in response to these events such that the existing economic relationships do not change drastically. During the dramatic rise in world fertilizer prices from 1972 to 1974, the importing countries suffered heavy drains on their foreign exchange supplies and experienced drops in agricultural output due to a decline in fertilizer use. Many governments created large inventories through panic purchases of imports at inflated prices and intervened to help farmers sustain their levels of fertilizer use on food crops through various programmes such as subsidies, credit, price supports and fertilizer rationing. The fertilizer industry responded with plans to expand fertilizer production capacity. However, due to the equally dramatic fall in world fertilizer prices after the 1974 peak, governments are gradually modifying their domestic production plans and fertilizer policies.

MICRO-ECONOMIC ANALYSIS FOR FERTILIZER POLICY FORMULATION

Since, in general, the farmer is the target of most fertilizer policies, it is important to understand farmers' decision-making process regarding fertilizer use and to evaluate the economic implications of alternative policies at the farm level. Ironically, this simple fact is not fully appreciated by researchers and policy-makers alike. We discuss in this section the needed information and economic analysis at the micro level which forms the basis for fertilizer policy formulation.

Economics of Fertilizer Use and Policy

The knowledge about yield response to applied fertilizer forms the analytical basis for the economic analysis of fertilizer use at the farm level which, in turn, forms the basis for fertilizer policy formulation at the national level. The fertilizer response is determined by a large number of factors, including crop, crop variety, irrigation, soil quality, type of fertilizer material, management, and other agro-climatic factors. Given the fertilizer response function, the optimum level of fertilizer use is determined by economic factors, including constraints faced by the farmer. The process of determining economically optimum level of fertilizer use can now be illustrated by the following analytical framework.

Let us first assume that the farmer (1) is a profit maximizer; (2) is an owner-operator; (3) faces no budget constraint; (4) faces no fertilizer constraint; (5) knows with certainty the fertilizer response function; and (6) knows with certainty fertilizer and crop prices.[2] Given these assumptions the profit maximizing level of fertilizer use will be determined by the behavioural rule implied by the equality between marginal value product and marginal cost of fertilizer. In other words, profit will be maximum when the marginal product of fertilizer use is equal to the price ratio of fertilizer and crop output. The profit maximizing behavioural rule can be derived as follows. Let the profit function for a particular crop from applying fertilizer be

$$(1) \quad \pi = Y . P_Q - F . P_F$$

where π is profit per hectare, Y is yield per hectare, P_Q is output price, P_F is fertilizer price, and F is fertilizer use per hectare. The π will be maximum when first order condition with respect to F is set equal to zero and second order condition is negative. The first order condition is

$$(2) \quad (d\pi/dF) = (dY/dF) . P_Q - P_F = 0, \quad MP = (dY/dF), \quad M_C = P_F, \quad MVP = MP.\ P_Q,$$

where MP refers to marginal physical product from incremental fertilizer use and MC refers to marginal cost of using an additional unit of fertilizer.[3] This simplifies to $MP . P_Q = P_F$ which is the same as MVP=MC or $MP = (P_F/P_Q)$. The underlying economic logic is demonstrated graphically in Figure 1. The MP curve slopes downward due to the law of diminishing marginal returns, *i.e.*, successive increments in fertilizer use result in successi-

2. Other decision rules include risk minimization, satisficing, cost minimization, profit maximization with risk constraint, and profit maximization with subsistence consumption constraint.

3. In other words, MC is not the derivative of total cost with respect to output, rather the derivative of total fertilizer cost with respect to fertilizer input. Throughout this paper, the concept of MC is used to imply the latter.

vely small increments in crop yield.[4] Given the MP curve, the optimum level of fertilizer use corresponding to $(P_F/P_Q)_1$ is F_1. At $(P_F/P_Q)_1$, F_2 is not the optimum level since the corresponding $MP_2 < MP_1 = (P_F/P_Q)_1$ and the farmer is losing money. On the other hand, F_3 is also not economical since $MP_3 > MP_1 = (P_F/P_Q)_1$ and the farmer is foregoing potential profit. However, F_2 is optimum at $(P_F/P_Q)_2$ and F_3 is optimum at $(P_F/P_Q)_3$ price ratios.

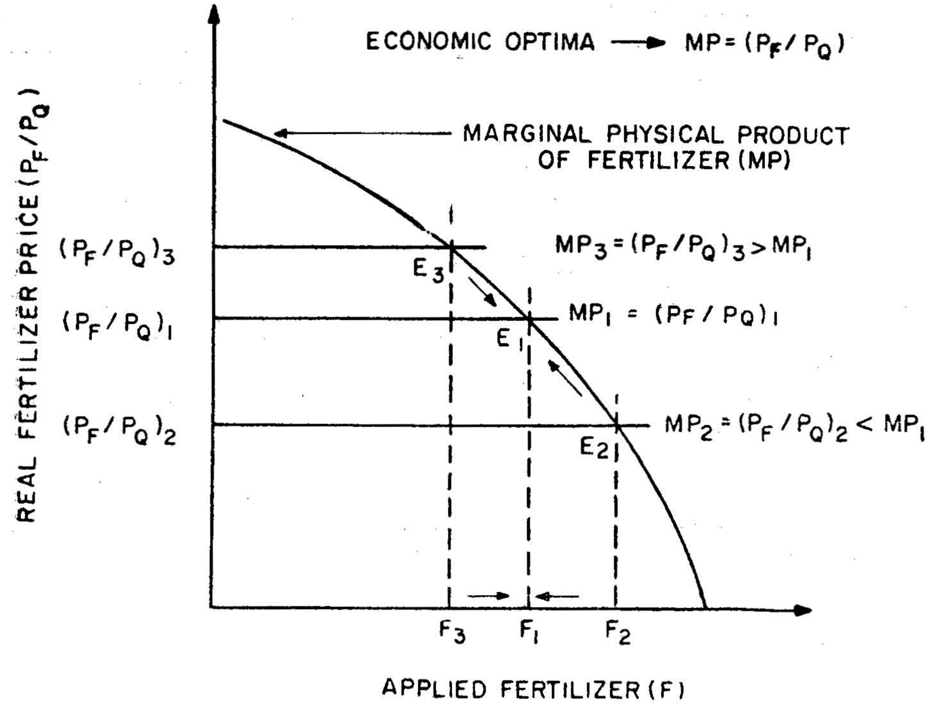


Figure 1—Determination of Economically Optimum Level of Fertilizer Use for a Given Fertilizer Response Function

Algebraically, the profit maximizing level of fertilizer use can be determined as follows. Let us assume that the yield response to fertilizer is quadratic polynomial such that

(3) $Y = a + bF + cF^2,\ a, b > 0,\ c < 0,$

where a, b, c are the response function coefficients.[5] Using the profit maximizing rule, the optimum level of fertilizer use is determined by

(4) $F^* = (1/2c)\ [\,(P_F/P_Q) - b]$.

By substituting the value for b, c, P_F and P_Q in equation (4), we can estimate the optimal dose of F*. By substituting F* in equation (3), the corresponding

4. This assumes that all other factors of production, except fertilizer, are held constant at predetermined levels. Other laws which determine agronomic and economic efficiency of fertilizer use are law of minimum, law of interaction, and law of substitution.

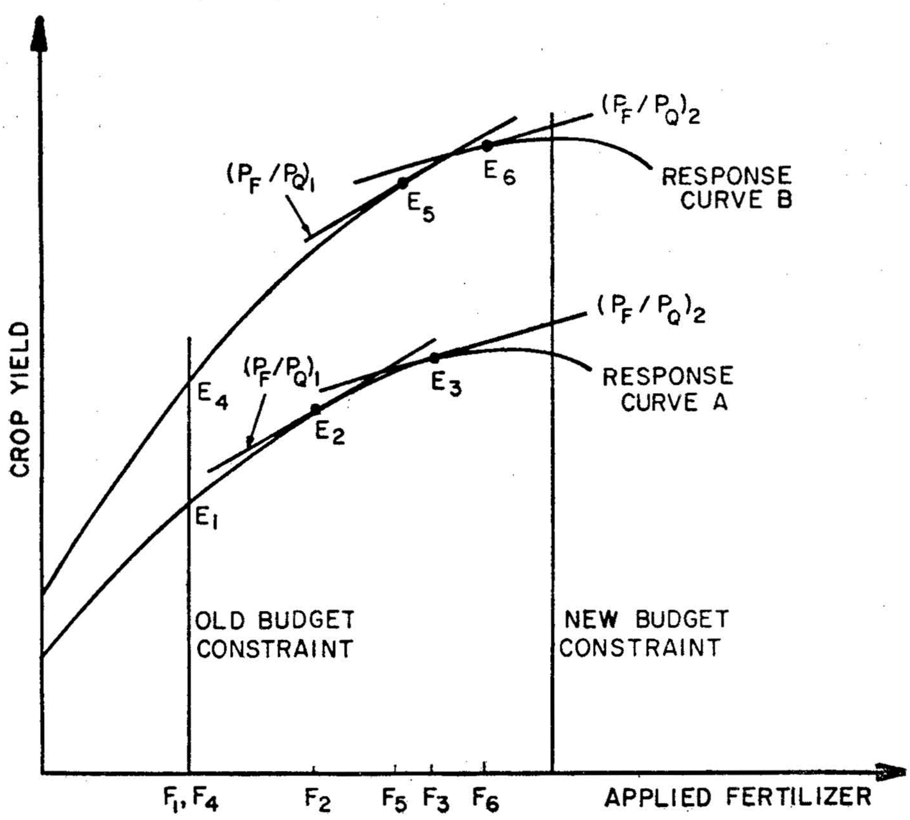
5. The quadratic polynomial is a commonly used form for fertilizer response functions. Other relevant forms are cubic polynomial, Cobb-Douglas, and Mitscherlich.

crop yield can be obtained. Similarly, other relevant variables can be estimated as

(5) $MP = (dY/dF) = b + 2cF^*$,
(6) $AP = (Y/F) = b + cF^*$,
(7) $\triangle Y = Y^* - a$, and
(8) $r = [\,(\triangle Y . P_Q / F^* . P_F) - 1\,]\ 100$,

where r is the average rate of return on total fertilizer investment. Clearly, in order to derive F^* we need estimates for a, b, c, P_Q and P_F.

The information generated from the economic analysis on a given fertilizer response function forms the basis for fertilizer policy formulation since it provides a framework to evaluate different policies. The likely implications of alternative fertilizer policies on the economics of fertilizer use at the farm level are analysed in Figure 2. Earlier we had made the often unrealistic



Alternative Policies { Credit and Insurance Policies.
Price, Subsidy and Support Policies.
Research and Irrigation Policies.

Figure 2—Implications of Alternative Fertilizer Policies on the Economics of Fertilizer Use

assumption that farmers face no capital constraint. Now suppose a budget constraint is imposed either due to lack of ability to purchase fertilizer or due to risk aversion due to the farmer's perception of losing money on his fertilizer investment. Given the budget constraint, the optimum level of fertilizer use is F_1. However, fertilizer use can be expanded by relaxing these constraints through appropriate credit and/or insurance policies.

Given no budget constraint and a fertilizer-output price ratio of $(P_F/P_Q)_1$, the optimum level of fertilizer use is F_2. This is determined by a point of tangency (E_2) between $(P_F/P_Q)_1$ and fertilizer response curves. Optimum fertilizer use can be increased from F_2 to F_3 by lowering the price ratio from $(P_F/P_Q)_1$ to $(P_F/P_Q)_2$. The real fertilizer price can be lowered either through fertilizer subsidy and/or crop price support policies. However, the price policy is effective only up to a limit imposed by the technical nature of the fertilizer response function. In the long-run, fertilizer use can be increased by raising its productivity through an upward shift in the response function, let us say from A to B. This can be accomplished through developing better fertilizer materials, better management practices, and better crop varieties with higher fertilizer response. Finally, water, being a key complementary input to fertilizer use, can shift the response function through better irrigation facilities and water management.

So far we have demonstrated that fertilizer response data forms the basis for sound economic analysis which in turn forms the basis for fertilizer policy design. However, the farmer makes his decision to use fertilizer in a more difficult environment than previously assumed. Consequently, in order to design sound fertilizer policies we also need information on (1) associated fertilizer costs; (2) credit costs (if fertilizer is purchased on credit); (3) farmers' perception about risk and the probability distribution of prices and crop yields to calculate risk; (4) tenancy arrangements and costs; (5) residual effects of fertilizer applications; (6) appropriate fertilizer response functions; and (7) fertilizer supply situation at the farm level.

Economics of Fertilizer Use for Rice

The purpose of this section is to demonstrate empirically the application of the theory developed in the preceding section to the economics of fertilizer use for rice (see Appendix 1). Based on *experimental data*, Herdt and Mellor (16) estimated fertilizer response functions for rice in Orissa (India) and Arkansas (U.S.A.). It was found that the highest point on the response function for Arkansas was achieved at a nitrogen dose which was 2.7 times that of the dose which achieved the peak in Orissa. Furthermore, the economic relationships facing the farmer were much more favourable in Arkansas than in Orissa. The economically optimum dose was 3.7 times higher in Arkansas than in Orissa. The corresponding rates of return on fertilizer investment for Arkansas and Orissa were 305 per cent and 86 per cent respectively. Such differences illustrate the need to understand the agronomic and economic relationships under field conditions for rice grown in different areas. It is especially important to understand the interaction between rice and fertilizer policies in those countries which are dominated by rice in the food sector.

Evaluation of Alternative Fertilizer Policies

In Figure 2, we have demonstrated graphically the implications of selected fertilizer policies on fertilizer use. It is our purpose here to demonstrate empirically the economic implications under alternative assumptions and policy regimes. The fertilizer response function for rice (Orissa, India) as estimated by Herdt and Mellor (16) is used as an example for analysis. The results are reported in Table I. Given the underlying assumptions and a single fertilizer response function for rice, we cannot draw many conclusions. However, some tentative conclusions can be stated. (1) In order to increase economic efficiency of fertilizer use, fertilizer recommendations should be based on economically optimum rather than agronomically optimum fertilizer doses. As compared to the agronomic optima, N is 74 per cent lower and r is 128 per cent higher under economic optima. (2) Fertilizer recommendations should be determined by incorporating associated fertilizer costs, credit cost and risk, in addition to response coefficients and price ratios. When all the relevant variables are incorporated, it turns out that N is 66 per cent and r is 62 per cent of the corresponding levels obtained in the absence of these variables. Thus, the recommended doses are not economically optimum under conditions faced by farmer's decision environment. Consequently, based on their own perceptions, farmers discount the recommended doses to account for left out variables. (3) Crop insurance programmes reduce uncertainty by eliminating yield and price risks and make it more profitable for the farmer (owner or tenant) to use higher levels of fertilizer.[6] (4) The farmer might prefer price support to fertilizer subsidy; however, results are partial and seem to be inconclusive. (5) As compared to the owner-operator, it is not very profitable for a tenant to use fertilizer if he pays 50 per cent of his produce to the landlord as rent and the landlord does not share the fertilizer-related costs.[7]

Grain-Nutrient Ratio: A Popular Rule-of-Thumb

In estimating the contribution of fertilizer to foodgrains production it is often assumed that one unit of NPK nutrients produces ten units of foodgrains, implying 10:1 grain-nutrient ratio. It is not clear whether this grain-nutrient ratio refers to average physical product or marginal physical product of fertilizer, and what the analytical basis is for using this rule-of-thumb. The marginal and physical product of nitrogen calculated from experimental data from Orissa, India, on rice under alternative assumptions is reported in Table I.

6. Based on limited empirical data during 1970-71, Roumasset (33) concluded that risk does not play an important role in determining nitrogen fertilizer use by Filipino rice farmers. There is a need to empirically test this hypothesis in other regions and countries and for other crops.

7. This may also hold true at other levels of share-cropping. However, as discussed by Cheung (4), there exists a growing volume of literature which indicates that share tenancy does not result in inefficient allocation of resources. Clearly, there is a need to empirically examine the implications of alternative tenancy regimes on fertilizer use by tenants.

TABLE I—ECONOMIC ANALYSIS OF FERTILIZER RESPONSE FUNCTION FOR RICE UNDER ALTERNATIVE ASSUMPTIONS AND POLICY REGIMES*

Case	Policy related assumptions	Economic variables†								
		P_N (cents)	P_R (cents)	N (lbs)	Y (lbs)	△Y (lbs)	MP (lbs)	AP (lbs)	r (per cent)	AVCR
I	Standard	16·40	2·84	38·60	2,433·0	532·0	5·77	13·78	138·0	2·38
II	I and associated costs ..	19·60	2·84	35·86	2,415·6	514·6	6·90	14·35	107·9	2·08
III	II and cost of credit ..	22·80	2·84	33·14	2,395·3	494·3	8·03	14·92	86·0	1·86
IV	III and 20 per cent discount for yield risk	22·80	2·84	28·30	2,261·4	360·4	8·03	12·74	58·6	1·59
V	IV and 10 per cent discount for rice price risk	22·80	2·556	25·63	2,238·8	337·8	8·92	13·18	47·8	1·48
VI	V and 10 per cent subsidy on fertilizer price	21·16	2·556	27·57	2,255·5	354·5	8·28	12·86	55·3	1·55
VII	IV and 10 per cent subsidy on fertilizer price	21·16	2·84	30·07	2,275·1	374·1	7·45	12·44	67·0	1·67
VIII	IV and 10 per cent subsidy on rice price	22·80	3·124	30·52	2,278·5	377·5	7·30	12·37	69.5	1·70
IX	III and share tenancy @ 50 per cent of produce	22·80	2·84	13·80	2,031·6	130·6	9·03	9·47	17·9	1·18
X	III and 10 per cent discount for rice price risk plus share tenancy @ 50 per cent of produce	22·80	2·556	9·50	1,955·2	94·2	8·92	9·91	11·1	1·11
XI	IV and share tenancy @ 50 per cent of produce	22·80	2·84	4·15	1,935·8	34·8	8·03	8·38	4·3	1·04

*Based on quadratic polynomial response function obtained from Herdt and Mellor (16) for Orissa (India) with a = 1,091, b=1·8, and c= —0·2077. The underlying behavioural rule is profit maximization.

† P_N=price of nitrogen, P_R=price of rice, N= nitrogen use per acre, Y=yield per acre, △Y= increase in yield due to fertilization, MP=marginal product, AP = average product, r = rate of return, and AVCR = average value cost ratio.

In all the cases, neither the marginal product nor the average product is equal to 10:1 grain-nutrient ratio. The average product is 1.04 to 2.39 times higher than the corresponding marginal product of nitrogen. In adjusted risk-neutral model, as represented by case III in Table I, the marginal and average product corresponding to optimum fertilizer use are 8.03 and 14.92. The 10:1 grain-nutrient ratio is satisfied at N = 56 .8 which falls in the irrational stage III of the response function where the marginal product is negative and the total product is declining. This dose is 1.7 times the economically optimum dose determined in case III. The marginal and average product estimates for Arkansas further corroborate these observations.

Based on these results it seems that 10:1 grain-nutrient ratio might be a very crude approximation of the average product of fertilizer. The foodgrains production estimates based on 10:1 ratio should be carefully interpreted. The true grain-nutrient ratio may be higher or lower depending on crop, crop variety, soil type, agro-climatic conditions, risk, fertilizer-related costs, nutrient-output price ratios, and level of fertilizer use. Based on empirical evidence, Herdt and Barker (15) conclude that average yield response to fertilizer applied to modern varieties of rice in Asia is between 10 and 15 kg. of grain per kilogram of fertilizer. There is a need for further analysis in this area.

Rationality, Fertilization, and Convergence to Marginalism

In the literature on fertilizer adoption and use it is common to find that a farmer will adopt fertilizer only if MVP $\geqslant$ 2 MC of fertilizer, and/or that a farmer will use fertilizer only up to a point where MVP $\geqslant$ 2 MC. It has been pointed out earlier (Figure 1) that a farmer will maximize profits by using fertilizer to a point where MVP = MC or MP = (P_F/P_Q). At first glance, when the farmer makes a decision to use fertilizer based on MVP $\geqslant$ 2 MC decision rule, he is making an irrational decision. It is irrational because the farmer can increase his profit by using more fertilizer up to a point when the MVP = MC equality is satisfied. However, farmers in Asia, Africa, and Latin America are economic men (and women) and make rational decisions within their decision environment. In their own calculations farmers tend to use fertilizer to a point which roughly equates MVP with MC, in the absence of budget and fertilizer constraints.

What then explains the discrepancy between farmers' decision rule of MVP = MC to determine the level of fertilizer use and the perception that in determining fertilizer use farmers are guided by the decision rule of MVP $\geqslant$ 2 MC? There are two possible explanations. First, the alleged decision rule is not a correct representation of farmers' decision-making process for fertilizer use. Secondly, the rule is correct but oversimplifies the process of determining optimum fertilizer dose. These explanations are tested by using nitrogen response function for rice reported in Table I. For standard risk-neutral model (case I) the optimum fertilizer dose is determined by assuming (1) MVP = MC decision rule, (2) no yield or price risk, (3) no fertilizer or budget constraint, (4) no credit cost, and (5) no other fertilizer-related costs. Under these assumptions, the derived optimum fertilizer dose is very high and the corresponding MVP/MC ratio is one. This is the most common approach.

In order to test MVP $\geqslant$ 2 MC (or MVP/MC $\geqslant$ 2) decision rule, we must first estimate optimum level of N from adjusted risk-neutral model (case III). Next, we must estimate MVP and MC from standard risk-neutral model by using N determined by the adjusted risk-neutral model. The corresponding MVP/MC ratio turns out to be 1.39 which is less than two. Similarly, if we estimate the optimum level of N from the adjusted risk-aversion model (case V) and estimate MVP and MC from standard risk-neutral model by using this value of N, the corresponding MVP/MC ratio turns out to be 1.94 for Orissa. For Arkansas this ratio is 1.67. In both cases MVP $<$ 2 MC. However, for Orissa the values of MVP and 2 MC are so close that one is tempted to accept the validity of MVP $\geqslant$ 2 MC decision rule for fertilization. This could also be a mere coincidence. There is a need to estimate these coefficients under different conditions (crops, varieties, soil types, and environment) to further test the hypothesis. It may not be the best strategy to generalise the MVP $\geqslant$ 2 MC decision rule to determine farmers' fertilizer adoption and use criteria. Rather all the relevant variables need to be incorporated since their importance varies across farms, cropping systems, regions, and policy programmes.

MACRO-ECONOMIC ANALYSIS FOR FERTILIZER POLICY FORMULATION

Micro-economic analysis at the farm level provides the feedback to design macro policies which will achieve the desired national level objectives. However, micro-economic analysis alone cannot provide all the information required by policy-makers. Given the inherent conflict between private and public interests, a policy directed towards the maximization of private benefits may not lead to maximum social benefit or to the attainment of such goals as food self-sufficiency, reduction in unemployment and inflation, equitable share of national resources, and expansion in foreign exchange earning capacity. Some of these issues can best be analysed at the macro level for the results to be relevant to the policy-makers.

Production Capacity Creation and Utilization Policies

According to Okita and Takase (26), doubling rice production in Asia will require 11.5 million tons of additional fertilizer (NPK) and 3.6 million tons of additional nitrogen alone in Asia between 1976 and 1990. This will require $8.8 billion (1975 prices) in fertilizer plant investment costs to meet additional fertilizer requirements.[8] Furthermore, UNIDO (42) estimated that the demand for fertilizer (NPK) in developing countries will increase over five-fold (5.7) by the year 2000 over 1974 levels, requiring a direct investment of at least $53 billion (1975 prices) between 1980 and 2000 to construct the required production facilities to achieve self-sufficiency as a group. In order to reduce import dependency and still meet the growing demand for fertilizer, developing countries must increase domestic production through creation of new capacity and efficient utilization of new and existing capacity.

For food-and fertilizer-deficit countries, the decision to expand capacity is complex. It involves a choice between importation of food, importation

8. These estimates have been corroborated by the Trilateral Food Task Force (41). Furthermore, Stangel (37) estimated that, under the existing physical and biological environment for rice, the additional potential current nitrogen requirements will be 4·9 million metric tons for 20 major rice growing countries (including the People's Republic of China). Clearly, there is a need for appropriate policies to meet the potentially large fertilizer demand.

of fertilizer, domestic fertilizer production, or a combination of these. Furthermore, countries may either import finished fertilizer, fertilizer intermediates or fertilizer raw materials or they may develop domestic sources of raw materials. Finally, there is a need to make decisions on the size, location and ownership of fertilizer plant.[9] There are trade-offs among these alternatives. No general rule can be prescribed regarding the best decision. Since these decisions involve large investments and have a long-term impact on the economy, they must be based on sound economic and technological information. This includes information on prices for raw material, intermediate and finished products; and cost data for each activity involving investment, production, transportation, and handling. There is also a need to analyse the interaction between the fertilizer, petroleum, natural gas, and energy-using sectors, including agriculture. The knowledge of these interactions may be the key to the long-run solution of world food and fertilizer problems.

Government intervention may be needed to facilitate exploration and utilization of raw material and expansion of domestic production capacity. The specific intervention will vary among countries, but in general, governments will be faced with making the major decisions regarding the fertilizer sector. These include but are not limited to (1) the degree of desired public participation, (2) the scarcity of capital and infrastructure, (3) the need for protection from foreign competition, (4) the scarcity of technology and skilled manpower, (5) the degree of import substitution, (6) the need for indigenization, and (7) the need to capture economies of scale. The type of policy instruments available to governments include tax concessions, subsidised credit, foreign trade regulations, price incentives and improvements in infrastructure.

The capacity utilization rate in most developing countries is often low and its improvement offers good possibilities to expand domestic supplies. Capacity utilization rates of fertilizer production facilities have averaged about 60 per cent in developing countries, even in countries where fertilizers were in short supply and imports were required to make up the deficit. There also exist differences in the utilization rate between (1) plants located in the private and public sectors and (2) nitrogen and phosphate fertilizer plants. If such differences are serious and common, there is need to determine the underlying factors for these performance differentials and then to initiate appropriate policy programmes to remove barriers which inhibit efficient performance. As demonstrated in Table II, an increase in the utilization rate can have far-reaching implications for the national economic growth.

Marketing and Distribution Policies

The marketing margin is the difference between import or ex-factory price and the retail farm price. It consists of wholesalers' commissions, retailers' commissions, transportation costs, storage costs, insurance, interest stocks and facilities, and other overhead costs. Marketing margins vary a

9. The selection of product and the development of fertilizer grades must be compatible with soil requirements reflected in soil maps in order to reduce waste and assure balanced use of nutrients.

TABLE II—ECONOMIC IMPLICATIONS OF IMPROVEMENTS IN CAPACITY UTILIZATION RATE (CUR) FOR NITROGENOUS FERTILIZER INDUSTRY IN INDIA*

Year	Estimated capacity ('000 tons)	Estimated production ('000 tons)	Implied capacity utilization rate (per cent)	Incremental nitrogen production ('000 tons) due to CUR improvements at			Estimated gap† ('000 tons)	Estimated gap implied by 10 per cent CUR improvements ('000 tons)
				1 per cent	5 per cent	10 per cent		
1977-78 ..	3,531	2,145	60·8	35	177	353	—842	—489
1978-79 ..	4,503	2,814	62·5	45	225	450	—485	—35
1979-80 ..	4,782	3,329	69·6	48	239	478	—409	+69
1980-81 ..	5,285	3,884	73·5	53	264	529	—324	+205
1981-82 ..	5,285	4,189	79·3	53	264	529	—519	+10
1982-83 ..	6,700	4,639	69·2	67	335	670	—599	+71
1983-84 ..	7,425	5,779	77·8	74	371	743	—20	+723

* Nitrogen fertilizer capacity, production, and gap estimates are obtained from Fertiliser Association of India (8).

† Estimated gap = estimated consumption—estimated production.

great deal across countries and fertilizers. As reported in Table III, marketing margins range between 5.2 per cent in Taiwan to 62.2 per cent in Thailand. There is a need to determine the share of each of the components which comprise the marketing margins and to determine the factors responsible for high marketing margins. In India 71 per cent of the marketing margin is accounted for by dealers' commissions (35 per cent), transportation costs (20 per cent), handling costs (10 per cent) and storage costs (6 per cent). Some of the reasons for high marketing margins are (1) monopoly profit, (2) high transportation and storage costs, and (3) high risk premiums on investment. The retail fertilizer price can be lowered by reducing market-

TABLE III—ESTIMATED MARKETING MARGINS FOR MAJOR FERTILIZERS IN SELECTED DEVELOPING COUNTRIES

(per cent of the farm price)

Country	Year	Ammonium sulphate	Urea	Phosphate fertilizers	Other
Africa					
Ghana	1971	50·8	—	—	—
Kenya	1972	34·7	—	21.1	—
Morocco	1972	42·7	—	37·2	—
Senegal	1971	—	—	—	30·0
Zambia	1972	32·0	25·4	33·7	—
Latin America					
Argentina	1973	—	—	—	—
Brazil	1972	—	57·3	31·3	—
Colombia	1972	—	—	52·8	25·0
Mexico	1970	19·0	11·4	19·5	17·2
Venezuela	1971	23·2	19·9	—	—
Asia					
India	1972	10·0	8·3	—	9·5
Iran	1971	—	22·7	—	—
Jordan	1972	—	—	15·4	26·0
Nepal	1971	27·7	24·5	—	24·0
Taiwan	1972	20·0	15·0	—	5·2
Thailand	1971	56·7	62·2	—	—

Source: Derived from FAO (10).

ing margins through an increase in marketing efficiency.[10] One way to improve economic efficiency of fertilizer use is through optimum allocation of available supplies of fertilizer across regions and crops. This requires sound knowledge of fertilizer productivity for different regions and crops in formulating appropriate tax, investment and distribution policies to achieve the desired national objectives of efficiency and equity. Finally, there is a need to determine the economic implications for distribution of fertilizer through public, private, and co-operative institutions.

Price, Subsidy, and Support Policies

In the absence of any price policy, the retail fertilizer price is the sum of import or ex-factory price and marketing margins. The retail price paid by the farmer can be lowered by improving production efficiency, marketing efficiency, or through fertilizer subsidies and support policies. Fertilizer price and the quantity demanded are inversely correlated.[11] The quantitative relationship between the quantity of fertilizer demanded and the price is expressed by the price elasticity of demand. The available empirical evidence, as reported in Table IV, indicates that for each one per cent increase in fertilizer price, the quantity demanded would decrease by 0.17 to 2.03 per cent in the short-run and by 0.34 to 6.63 per cent in the long-run.[12] The implications for fertilizer price policy are substantial and clear.

TABLE IV—SUMMARY OF FERTILIZER DEMAND STUDIES IN DEVELOPING COUNTRIES

Country	Fertilizer	Time period	Elasticity of demand		Adjust-ment co-efficient	Source
			Short-run	Long-run		
Brazil*a*	NPK	1949-71	—1·12*b*	—	—	Larson and Cibautos (20)
Brazil	NPK	1949-71	—0·33*c*	—1·94	0·17	
India*a*	N	1953/54-67/68	—0·31*d*	—0·34	0·92	Rao (31)
India	N	1953/54-67/68	—0·53*c*	—6·63	0.08	
India*a*	N	1958/59-63/64	—1·20*d*	—2.50	0·50	Parikh (27)
Japan*a*	NPK	1883/1937	—	—0·74*b*	—	Hayami (14)
Korea*a*	NPK	1960-72	—0·17	—0·88	0·20	Sung, Dahl and Shim (38)
Korea*a*	NPK	1971	—0·70*b*	—	—	Shim, Dahl and Sung (36)
Pakistan	N	1959/60-72/73	—0·52*b*	—	—	Salam (34)
Philippines*a*	N	1958-72	—0·59*b*	—	—	Rodriguez (32)
Taiwan*a*	N	1950-66	—0·55*c*	—	—	Hsu (17)
Taiwan	N	1950-66	—2·03*b*	—2·99	0·68	
Thailand	NPK	1954-72	—0·29*c*	—	—	Puapanichya (30)
Thailand	NPK	1954-72	—0·27*c*	—0·37	0·72	
U.S.A.	NPK	1911-56	—0·53	—2·99	0·23	Griliches (13)

a. Adapted from Timmer (39).
b. Denotes significance at 0·9 or higher.
c. Denotes significance between 0·8 and 0·9.
d. Denotes significance between 0·7 and 0·8.

10. Another real cost to the farmer is loss of fertilizer in transit. According to ESCAP (7), fertilizer loss in transit ranges from 2 to 30% in Indonesia. One way to improve marketing efficiency is by reducing fertilizer loss.

11. Prices play a major role in economic development. According to Mellor (21), prices perform three functions: allocation of resources, distribution of income, and influence on capital formation.

12. The large variation in elasticity estimates, which casts some doubt on their credibility for policy purposes, is due to differences in data, time-period, methodology, and domestic policies. Some of the empirical problems in estimating fertilizer demand functions are discussed in Shields (35) and Timmer (39).

The relevant price for estimating fertilizer use at the farm level and aggregate fertilizer demand at the national level is the *real* fertilizer price, *i.e.*, the ratio between fertilizer and output prices. However, the real fertilizer price is only one of the major determinants of fertilizer demand. The other important determinant of fertilizer demand is technological change in the agricultural sector. Consequently, if the objective is to expand fertilizer use, public policies should be designed to reduce the real fertilizer price and to promote technological change. As reported in Mudahar and Pinstrup-Andersen (24), the available empirical evidence for Asian countries indicates that two-thirds of the variation and growth in fertilizer consumption is explained by technological progress in the agricultural sector, and the rest by the differences in fertilizer-output price ratios. As reported in Table V, the experience of major rice growing Asian countries indicates that there is a strong inverse relationship between real fertilizer price and rice yields, real fertilizer price and fertilizer use, and a strong positive relationship between fertilizer use and rice yields. The degree of these relationships becomes even stronger when fertilizer price subsidies are taken into account.

TABLE V—THE INTERACTION BETWEEN REAL FERTILIZER PRICE, FERTILIZER USE AND RICE YIELDS IN SELECTED COUNTRIES DURING 1973*

Country	Nitrogen/ rice price ratio	Rice yield (metric ton/ha.)	N use (kg./ha.)	N subsidy rate (per cent)
Japan	0·77	6·02	145·4	—
South Korea	0·66	4·95	172·3	31
U.S.A.	1·20	4·79	40·9	—
Malaysia (W)	2·08	2·98	36·6	—
Indonesia	2·43	2·56	18·9	—
Pakistan	2·55	2·44	17·2	—
Sri Lanka	1·23	2·30	25·9	50
Thailand	4·03	1·92	4·3	—
Bangladesh	1·82	1·81	13·9	44
Burma	4·84	1·76	3·5	—
India	3·73	1·73	11·1	—
Philippines	2·63	1·63	14·8	68

* Rice refers to paddy.

Source: Estimated on the basis of data reported in FAO (9, 11 and 12), Asian Productivity Organization (1), Timmer-Falcon (40), and International Rice Research Institute (19).

There has been very little work done to generate information on the economic impact of unfavourable fertilizer price policies on economic development and expected pay-offs from alternative price policies.[13] Two such attempts along these lines deal with Argentina. Peterson (28) estimated that Argentina lost 1.15 billion bushels of corn during 1950-74 by following an unfavourable price policy as represented by the nitrogen and corn price ratio. The foregone average annual internal rate of return on investment on an alternative price policy was estimated to be 206 per cent. Likewise de Janvry (6) estimated that lowering fertilizer-wheat and fertilizer-corn price ratios from 8 to 3

13. This is one of the high priority areas in IFDC's fertilizer policy research, along with the economic implications of fertilizer subsidies and price supports. See Mudahar (23).

would have resulted in an annual net return of $23 million for an indefinite period over a $25 million total cost of shifting to an alternative price policy. The implied internal rate of return from alternative policies in a single year would have been 92 per cent. There is a need for similar studies in other countries.

Fertilizer price subsidies are very common in most developing countries. The rate of subsidy varies across countries and fertilizers but it can be as high as 80 per cent of unsubsidised price. These subsidies may be paid to the manufacturer, to the wholesaler, to the retailer, or to the farmer. The use of a fertilizer subsidy is justified on the grounds that it reduces fertilizer price and hence fertilizer cost to the farmer. This, in turn, provides the required economic incentive to induce expanded fertilizer use.[14] However, since only those farmers who use fertilizer benefit from the subsidy, income disparities may widen through both direct impact on income and also through an indirect impact on increased land values.[15] The use of fertilizer subsidies can also result in an enormous cost to the treasury and hence increased tax burden. Finally, subsidy programmes are difficult to terminate or phase out because of increased expectations by farmers.

The expenditure on fertilizer subsidies for selected Asian countries, reported in Table VI, is compared with expenditure on agricultural research. The expenditure on fertilizer subsidies far exceeds the expenditure on agricultural research even though the investment in agricultural research generates a stream of economic returns for an indefinite period as compared to investment in the form of fertilizer subsidies. These disparities point to basic economic and political problems regarding allocation of scarce resources

TABLE VI—FERTILIZER SUBSIDY, AGRICULTURAL RESEARCH EXPENDITURE IN SELECTED COUNTRIES (1969-1975)

Country	Subsidy expenditure (million $)	Agricultural research expenditure (million $)	Subsidy as per cent of agricultural research expenditure (per cent)
Afghanistan	15·10	0·63	2,397
Bangladesh	14·63	1·40	1,045
Indonesia	71·90	3·42	2,102
Iran	36·08	16·66	217
South Korea	27·26	2·44	1,117
Pakistan	20·97	1·26	1,664
Philippines	36·77	7·96	462
Sri Lanka	5·25	2·44	215

Source: Estimated on the basis of data reported in Boyce-Evenson (3), Dalrymple (5) and FAO (9 and 12).

14. In Punjab, India, fertilizer subsidies are given to correct imbalance in nutrient use, especially the use of more P_2O_5. Similar policies also exist in other parts of India.
15. In the long-run, however, fertilizer subsidies may result in a significant shift in the aggregate product supply curve to the right and, thus, a fall in product prices and even land values. The latter needs to be tested empirically.

between short-term strategies such as fertilizer subsidies and longer-term strategies such as agricultural research, including fertilizer research. There is a need to estimate the rate of return on fertilizer subsidies and compare it with returns from alternative investment opportunities. It is important that decisions on public investment be based on sound information about expected returns and equity implications of alternative uses of such funds.

Crop price support policies, which can reduce real fertilizer price, are also common in developing countries. While some policies are aimed at price stabilisation, others are focused on increasing product prices above free market prices to accelerate agricultural production and transfer income to the farm sector. The price support policy stimulates expanded fertilizer use by making it more profitable and reducing the risk of product price decline. Unlike fertilizer subsidies, all price support programmes have a direct bearing on the price received by farmers, input use, and their income. Farmers with large marketable surplus usually benefit more than the small farmers.

One problem facing the policy-maker is to choose between fertilizer subsidy and price support policy options, if in fact, there is a choice. Very little analytical work has been done in the developing countries to evaluate these policies as far as their farm and national level implications are concerned. Barker and Hayami (2) evaluated fertilizer subsidy and rice price support programmes as two competing policy alternatives to achieve self-sufficiency in rice production in the Philippines. The results indicate that the use of fertilizer subsidy is preferred to achieve the stated goal. This is mainly due to the high marginal product of fertilizer since its current use is relatively low. There is a need to conduct similar studies for different crops in other countries.

In the past, the Philippines has followed two-tier fertilizer pricing scheme, one for food crops and the other for export crops. However, recently they have resorted to single price scheme, partly to facilitate the implementation process. On the other hand, it is quite common to follow a uniform price scheme across regions in order to administer it effectively. The differences in transportation costs, a major component of marketing margins, is either paid by the government in the form of transportation subsidy or are shared by farmers and government. The implications of alternative uniform pricing rules are illustrated in Appendix 2.

However, pricing policies in most countries are quite unique to meet specific national goals within a given set of constraints. For example, based on the Marathe Committee's recommendations, India has decided to follow 'retention' price policy in fertilizer manufacturing. Assuming an 80 per cent capacity utilization rate, 12 per cent post-tax return on net worth, a retention price will be fixed for each individual plant which will also take into account some other factors specific to that plant. The selling price of different fertilizers will be fixed uniformly across fertilizer plants. Plants with a low retention price will pay the difference to the Government which will go into a pool which in turn will be used to subsidise plants with higher retention price. This policy reduces uncertainty with respect to returns on investment and hence might encourage investments. Some of the economic implications of retention pricing policy are analysed in Figure 3 which need to be empirically estimated to test the feasibility of this scheme.

Credit, Insurance, and Land Tenure Policies

The lack of fertilizer credit is considered to be one of the serious constraints on expanded fertilizer use by small farmers. As a result, increasing credit availability can increase fertilizer use. This, of course, depends on whether the additional credit is in fact used to purchase additional fertilizer. Consequently, there is a need not only to estimate the amount of fertilizer credit actually used to purchase fertilizer but also to estimate the credit elasticity of demand for fertilizer. Positive credit elasticity reflects the quantity effect of credit on demand for fertilizer. On the other hand, the rate of interest on institutional fertilizer credit is often subsidised through low nominal interest rate. In some cases, the inflation rate may be higher than the subsidised interest rate, leading to a negative real rate of interest. This reduces the real fertilizer price paid by the farmer who purchases fertilizer on credit, and hence expands fertilizer use.[16] The proportional fall in fertilizer price due to a negative real rate of interest reflects the price effect of credit on demand for fertilizer. However, subsidised credit may misallocate the limited capital at the national level by diverting it away from investment opportunities with higher potential rate of return. The empirical knowledge about the quantity and price effects of credit on fertilizer consumption is very limited despite its importance.

Farmers in low income countries face not only high risk but also tend to be risk averse due to their low risk-bearing ability. Two major sources of risk which affect fertilizer use are yield risk and price risk. Eliminating these risks through appropriate crop insurance programmes can lead to higher levels of fertilizer use.[17] However, the desirability of crop insurance at the national level depends on the magnitude of social benefits, social costs, and their distribution. The empirical information on these issues is virtually non-existent. Moreover, there is a need to estimate the contribution of irrigation, research, and price policies on reducing yield and price risks. This is especially important since crop insurance requires an extremely high administrative skill and capacity, especially for the assessment of crop damages. The implementation of a viable system of crop insurance may not be economically feasible in many developing countries.

In general, a tenant has lower maximum credit limit, loan repayment capacity, and risk-bearing ability as compared to an owner-operator. Furthermore, the benefits from fertilization often extend beyond one crop season.

16. We must recognize, however, that inflation also results in many undesirable consequences for the fertilizer, agricultural, and other sectors of the economy. Furthermore, it may distort fertilizer and crop output-price ratios, especially when crop prices are fixed by the government.

17. In order to account for risk in making decisions to use fertilizer, farmers normally discount crop yields and prices. However, the implict discount rate may vary from one farmer to the other depending on their economic situation and perceptions about risk.

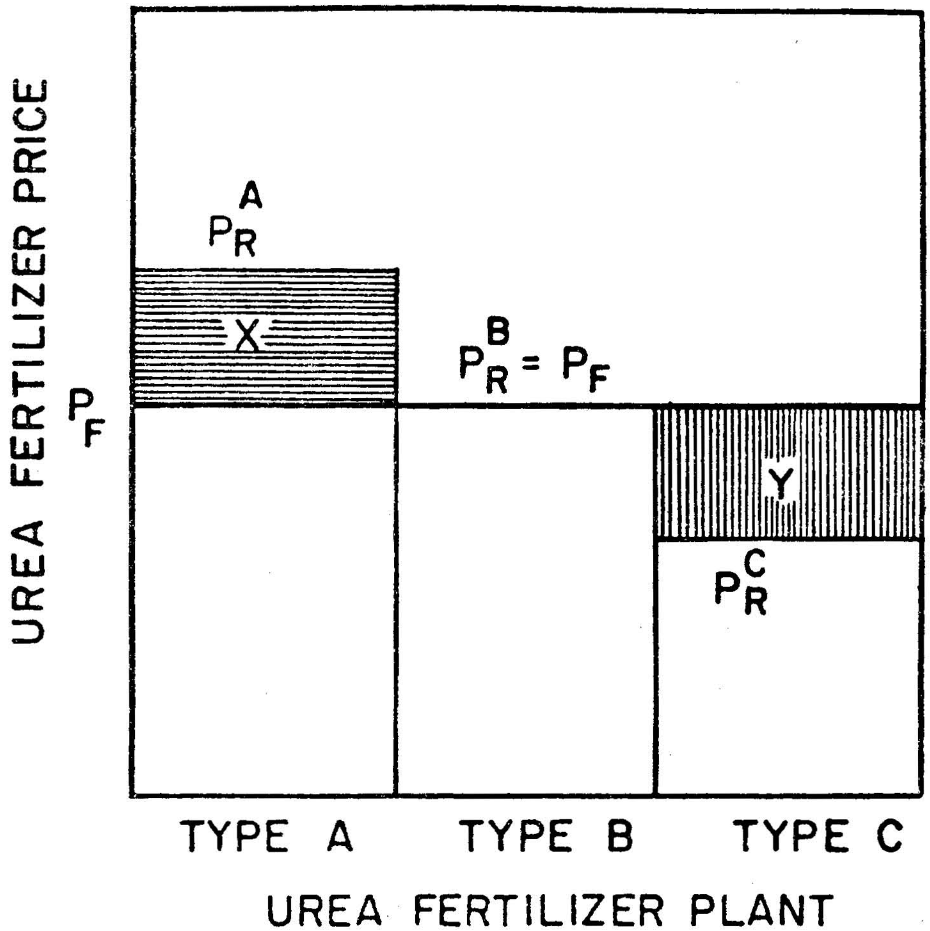


Figure 3—Economic Implications of Fertilizer Retention Pricing Policy in India

Plant type	Fixed price	Retention price	Difference	Fertilizer production	Total cost/revenue to government
A	P_F	P_R^A	$P_F - P_R^A < 0$	F_A	$X = F_A (P_F - P_R^A) < 0$
B	P_F	P_R^B	$P_F - P_R^B = 0$	F_B	$F_B (P_F - P_R^B) = 0$
C	P_F	P_R^C	$P_F - P_R^C > 0$	F_C	$Y = F_C (P_F - P_R^C) > 0$

If $[\, F_C (P_F - P_R^C) - F_A (P_F - P_R^A) \,]$ $\begin{cases} > 0 & \text{Net revenue to government.} \\ = 0 & \text{No net revenue or cost.} \\ < 0 & \text{Net cost to government.} \end{cases}$

A tenant who is not assured of leasing the same piece of land next year may not apply fertilizer or apply less than the optimum quantities. As a result, uncertainty resulting from tenancy arrangements are disincentives to fertilizer use. This uncertainty can be reduced by providing security to tenants for any loss from fertilization and making the landlord share part of the loss since he is going to share part of the incremental output from fertilizer use. Otherwise, the society as a whole may be losing by foregoing potential output through sub-optimal utilization of existing fertilizer and land resources. These issues need sound economic analysis in order to derive national implications for alternative tenancy arrangements.

Protection and Tariff Policies

As has been discussed earlier, most of the developing countries meet part of their domestic needs from domestic production. However, due to relatively high per unit costs, the domestic fertilizer industry finds it difficult to compete with exporting countries. Consequently, importing countries make use of tariff policies to protect their domestic fertilizer industry. These tariffs can be a good source of revenue to the government, if they are not used in turn to lower retail fertilizer prices. However, the protection of inefficient and inappropriate domestic industry makes no economic sense. The economic consequences of such a policy could be disastrous through its debilitating effects on fertilizer use and slowing of the process of agricultural modernization. High tariffs, implicit or explicit, can result in high cost fertilizer industry. According to Rao (31), the cost of protection to the nitrogen fertilizer industry in India during 1961-71 was very high. Since such policies are quite common there is a need for sound economic analysis to generate information on social costs and benefits.

REQUISITES FOR FERTILIZER POLICY INFORMATION SYSTEM

The generation of information appropriate for the design of a particular policy depends to a large extent on the quality of data and soundness of economic analysis to transform that data into useful policy information. An appropriate set of data must also be (1) relevant, (2) reliable, (3) complete, (4) consistent, (5) timely, and (6) relatively easy and economical to collect. The policy information generated from sound economic analysis performed on poor quality data can be very deceptive and misleading.

Data Collection, Storage, and Retrieval

In order to generate information appropriate for fertilizer policy design there is a need to collect economic and technological data. These data could be time-series, cross-sectional, experimental, or non-experimental. The nature of data required for generating fertilizer policy information has already been discussed. It is useful to summarise key data needs, although the following is not a complete list:

1. Fertilizer response data by crops, crop varieties, soil types, and agro-climatic conditions.
2. Fertilizer production and raw materials by types, quality, amount, location and plant investment costs by location, product type, size, and process.
3. Fertilizer production units by product, number, capacity, daily production, operating days, employment, feedstock, production costs, and input-output ratios by production process.
4. Fertilizer distribution by source and cost per unit.
5. Fertilizer transportation and storage by mode, product, and per unit cost.
6. Fertilizer consumption by product, region, and crop.
7. Fertilizer use by crops per unit of land.
8. Fertilizer prices by finished product, intermediate, and raw material.

Finally, it needs to be emphasized that fertilizer is an integral part of the economy. Consequently, there is a need to collect other relevant data from sectors which are closely linked with the fertilizer sector. Efforts should be directed to integrate farm, industry, region, and national level data. These data will be useful not only to the policy-makers, but also to planners, researchers, and extension agents. The data need to be stored such that these are easily (and economically) accessed. The developments in modern computer technology (including mini-computers) has greatly facilitated the process of storage and retrieval of data.

Appropriateness of Information for Policy Design

The steps involved in generating appropriate policy information are developed in Figure 4. In order to answer a particular policy problem there is a need to state it in a testable hypothesis, collect relevant statistics, carry out sound economic analysis, and interpret the results in relatively simple language. This process takes time. Often policy-makers expect instant results to very serious policy issues, partly because of real or imagined urgency for its need. There is a need for dialogue between policy-makers and researchers to impress upon each other the value of timely and accurate information. The fertilizer policy impact matrix delineating selected policy instruments and impact variables is developed in Table VII.

World Fertilizer Information System

There is a need at the international level to store all the relevant data and information in such a way that is readily accessible. Currently, many international institutions are involved in these activities in a general way. The IFDC has established a World Fertilizer Information System which is quite unique in scope and quite comprehensive in expected coverage. The main purpose is to supplement existing international data systems by collecting and storing fertilizer-specific information which is not readily available. It is quite unique in the sense that in addition to market development data, it has (or will have) agronomic (fertilizer response data), engineering (fertilizer

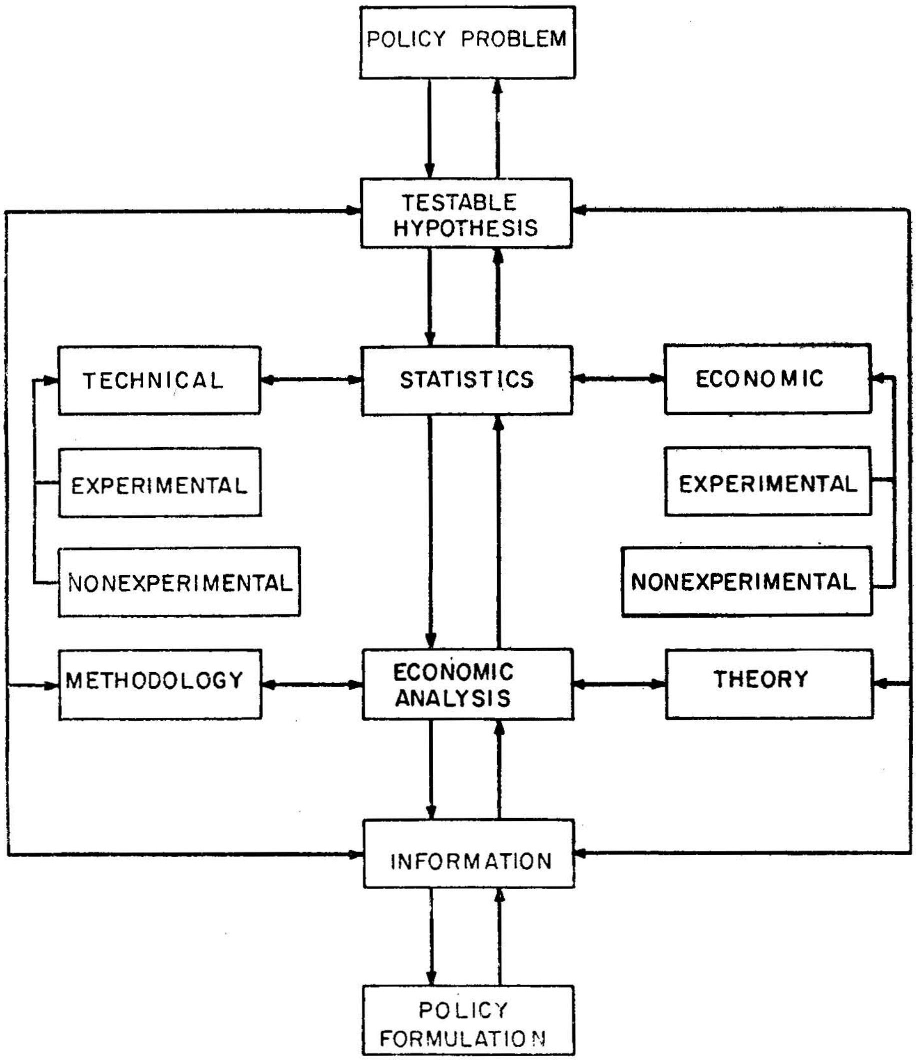


Figure 4—Generating Appropriate Information for Fertilizer Policy Formulation: A Conceptual Framework

plant investment analysis), and raw material (location, quantity, quality) components. This information can be accessed via a world-wide computer network.

SUMMARY AND CONCLUSIONS

The purpose of this paper has been to demonstrate the need for good quality data and sound economic analysis to generate appropriate information to formulate rational fertilizer policies. Specific analytical examples are provided to illustrate the relevance of information and analysis. For empirical

TABLE VII—FERTILIZER POLICY IMPACT MATRIX DELINEATING SELECTED POLICY INSTRUMENTS AND IMPACT VARIABLES

Government programmes and policy instruments	Fertilizer-related activities							Food production and nutrition	Employment	Foreign exchange savings/earnings	Social benefits	Social costs	Distribution of social benefits/costs	Administrative cost/feasibility	Miscellaneous implications
	Raw material development	Investment	Production	Transportation	Storage	Consumption	Trade								
Price															
Credit															
Insurance ..															
Tax															
Trade															
Foreign exchange															
Distribution ..															
Land reform ..															
Irrigation ..															
Energy ..															
Research ..															
Extension ..															
Infrastructure ..															
Mechanization ..															
Wage rate ..															

analysis, the paper draws heavily from the experience of developing countries in Asia. Even though the discussion revolves around fertilizer, the basic issues analysed are also relevant for forumulating economic development policies. Some of the key conclusions follow.

1. Appropriate information on the likely implications of alternative fertilizer policies is basic to their rational design. In the developing countries large gaps exist in the knowledge about the economic implications of different fertilizer policies.
2. Good quality data is the key to develop a sound information base. It must be relevant, reliable, complete, consistent, and timely. Even though there exist large bodies of data it is not adequate to meet the specific needs for policy analysis. For example, despite its importance, the data on credit, subsidies, and farm level prices is not readily available. There is a need to bridge these gaps. Since fertilizer is a major input into the agricultural production process there is a need to collect agronomic, economic, and engineering data. The micro level and macro level data should be considered supplementary rather than competitive.
3. Good quality data by itself does not guarantee that it will result in sound information. There is thus a need for sound economic analysis to transform data into appropriate policy information. A sound economic analysis does not necessarily imply a sophisticated mathematical model. The existing body of literature and policy studies indicates two extremes between descriptive analysis and complex simulation models. There is a need to bridge this gap by developing simple but analytically sound methodologies and to demonstrate their relevance for policy analysis.
4. There is a need to establish a World Fertilizer Information System which will either collect or be a repository for all relevant data, methodologies, and information related to fertilizer. This information should be readily available and easily accessible. The IFDC has established such a system to supplement the existing data collection agencies.
5. The equity implications of alternative policies have not received proper attention in past economic analyses. Many policies which lead to efficient utilization of fertilizer may widen the existing income disparities. Considering that over half of the population in developing countries lives below the poverty line, there is a need to design policies which will uplift the living standards of these people, thus reducing the gap between the rich and the poor.
6. Finally, there is a need for analytical work to evaluate the implications and provide guidelines to design sound fertilizer policies. Fertilizer-related agronomic, technology, and economic research is needed to provide the relevant information on technological relationships. The knowledge of these relationships is vital for fertilizer policy formulation.

APPENDIX 1

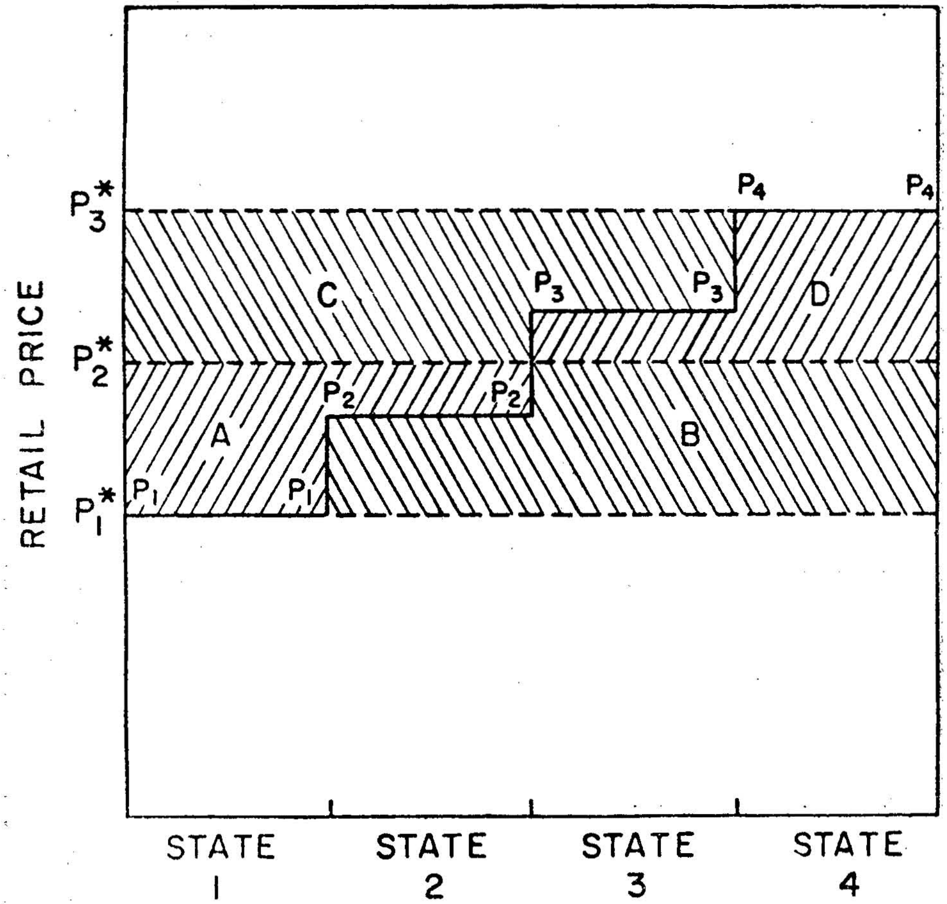
ECONOMIC INDICATORS OF POPULATION, RICE AND FERTILIZER SITUATION IN SELECTED ASIAN COUNTRIES

Country	1970 population in agriculture[a] (per cent)	Paddy rice[a] (1975)				N+P+K fertilizer[e] (1974-1975)							
		Harvested area ('000 ha.)	Proportion of cereal area (per cent)	Proportion of Asian rice area (per cent)	Yield[d] (kg./ha.)	Consumption[f] (kg./ha.)	Compound annual growth (per cent)	Consumption ('000 mt.)	Production ('000 mt.)	Net imports ('000 mt.)	Change in inventory ('000 mt.)	Imports[g] dependency (per cent)	Nutrient balance (N:P:K)
India ..	69	38,600	37·6	30·3	1,826	15·7	13·1	2,591	1,518	1,608	535	51	5·1:1·4:1
Pakistan ..	59	1,695	17·7	1·3	2,271	20·6	16·4	401	317	122	38	28	185·0:21·0:1
Bangladesh ..	86	10,117	99·8	7·9	1,825	14·2	11·0	129	47	92	10	66	7·6:3·3:1
Sri Lanka ..	55	597	86·3	0·5	1,933	65·0	6·3	129	—	133	4	100	2·1:0·4:1
Philippines ..	54	3,700	54·6	2·9	1,760	27·7	9·8	285	95	373	183	80	3·0:0·8:1
Indonesia ..	66	8,599	75·2	6·8	2,686	29·5	17·9	545	131	962	548	88	12·1:3·3:1
South Korea ..	51	1,218	54·0	1·0	5,324	350·4	7·8	848	680	280	112	29	2·9:1·6:1
Malaysia ..	56	575	99·3	0·5	3,009	103·2	17·7	297	75	222	—	77	0·8:0·3:1
Burma ..	60	5,111	91·9	4·0	1,827	4·3	16·9	45	44	—6	—7	—	18·5:2·0:1
Nepal ..	94	1,240	59·0	1·0	2,082	6·4	24·8	13	—	19	6	100	11·5:3·5:1
Thailand ..	80	8,520	86·7	6·7	1,771	13·4	18·8	190	6	184	—	97	1·9:1·6:1
Asia[b] ..	65	127,280	38·4	62·9[c]	2,456	32·4	10·0	15,423	12,971	4,395	1,943	40	4:2:1·7:1

a. FAO (9 and 11).
b. Includes People's Republic of China, Philippines, Indonesia, Malaysia, and Thailand are ASEAN countries.
c. Rice area in Asia is 90·3 per cent of the rice area in the whole world.
d. According to International Food Policy Research Institute (18), the projected cereal deficit in 1985-86, measured in million metric tons (mt.) will be 14·2 in India; 5·3 in Bangladesh; 1·5 in Philippines; and 6·7 in Indonesia (based on low income growth).
e. FAO (9 and 11)
f. Per hectare of arable land and land under permanent crops. Consumption levels in Japan and Netherlands are 375 and 757 kg., respectively.
g. Imports as proportion of available domestic supply (consumption + change in inventory) of fertilizer.

APPENDIX 2

Alternative Fertilizer Pricing Policies in the Light of Differences in Inter-State Transportation Cost



Assumptions: (1) Differences in inter-State retail fertilizer prices reflect differences in transportation cost.
(2) Inter-State equality in fertilizer consumption in aggregate.
(3) Uniform quality of fertilizer across States.

	Price policy	Government cost	Government revenue	Net cost	Net revenue
Uniform ..	$P = P_1^*$	B+D	—	B+D	—
Uniform ..	$P = P_2^*$	D	A	—	—
Uniform ..	$P = P_3^*$	—	A+C	—	A+C
Non-uniform ..	—	—	—	—	—

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