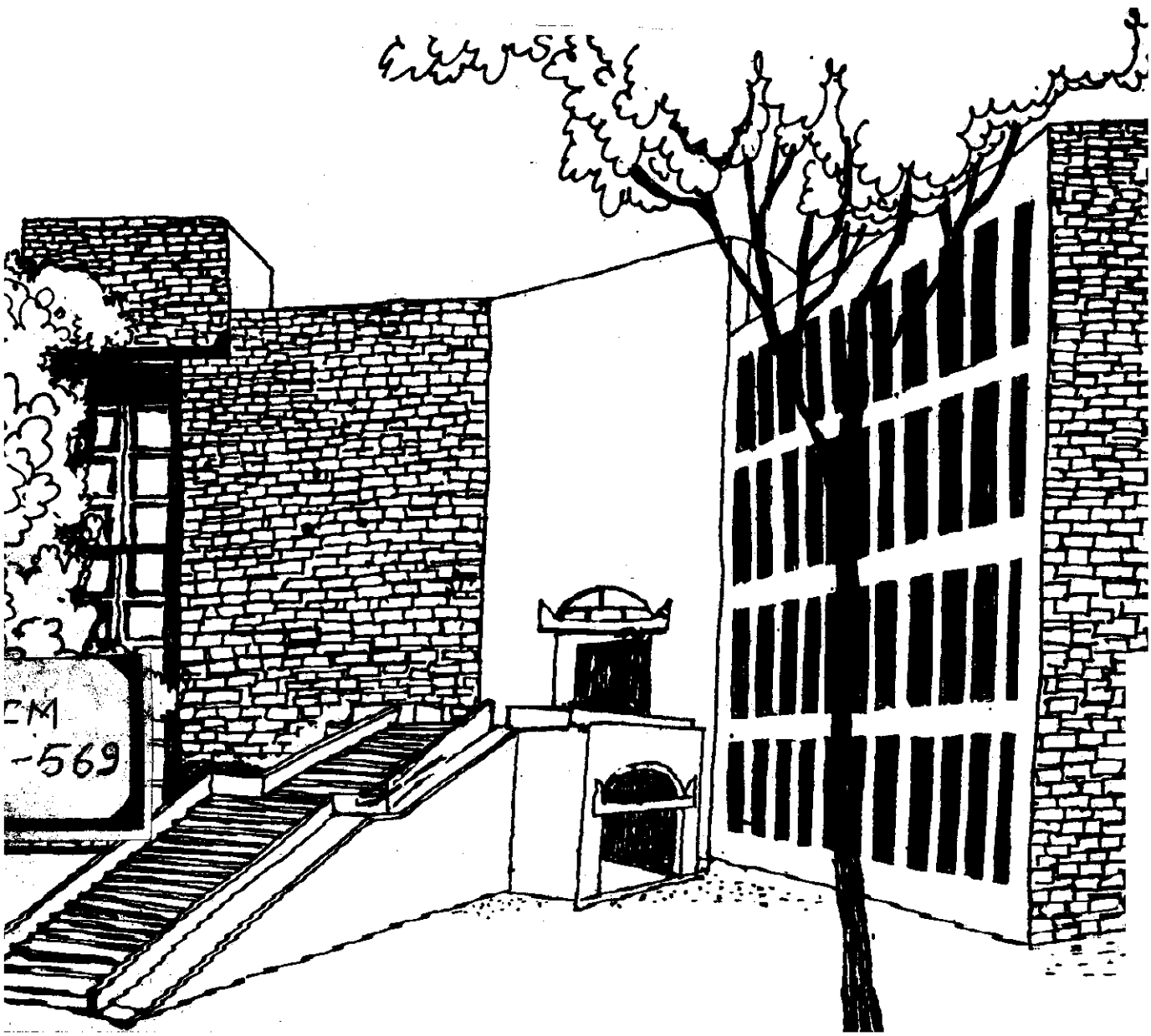
Working Paper



POLICIES FOR RAPID GROWTH IN USE OF MODERN AGRICULTURAL INPUTS: THE CASE OF FERTILIZERS

By

Gunvant M. Desai

W P No. 569

July 1985

INDIAN INSTITUTE OF MANAGEMENT
AHMEDABAD-380015
INDIA

POLICIES FOR RAPID GROWTH IN USE OF MODERN AGRICULTURAL INPUTS

THE CASE OF FERTILIZERS

Gunvant M. Desai
Centre for Management in Agriculture,
Indian Institute of Management, Ahmedabad

INTRODUCTION

Accelerated growth in agricultural production of developing countries depends on fuller exploitation of the existing production potential and continuously raising the potential through technological changes. This requires sustained rapid growth in the use of inputs like seeds of better quality, fertilizers, pesticides, and farm implements and machinery. In discussions on how to increase the use of these inputs, price policy issues dominate. Often these issues are discussed without sufficient attention to certain non-price factors and policies which also influence growth in the use of inputs. This paper demonstrates that such an approach is lop-sided, and could be misleading in examining the role and limitations of price policy in growth of use of modern agricultural inputs in developing countries.

Appreciable growth in the use of modern agricultural inputs in the developing world is a phenomenon of last three decades. There is still a sizeable untapped potential for further growth in their use and it will increase with technological changes in crop production. The gap between actual

---

Revised version of the paper prepared for IFPRI workshop on Food and Agricultural Price Policy, Belmont Estate, Elkridge, Maryland, April 29-May 2, 1984.

and potential levels of use imply that the pace of growth in actual use is governed by the level of development and efficiency in the workings of such systems as agricultural research, extension, credit, input supply, and distribution. Together, they work towards converting the potential into farmers' effective demand for inputs and satisfying the demand at growing numbers of geographically dispersed locations. In developing countries, these systems have many deficiencies. Therefore, it seems rather simple-minded to let price policy issues dominate the discussions on how to achieve rapid growth in the use of inputs. This is especially so because both development and working of the above-mentioned systems are more strongly influenced by such factors as public expenditure on agricultural research and extension, investment in relevant physical infrastructure, and institutional setup plus administrative arrangements for supply and distribution of inputs than by prices of crops or inputs.

This paper briefly reviews past growth of fertilizer use in developing countries. It then presents a heuristic framework which brings out the policy requirements for sustained rapid growth of fertilizer use. The usefulness of such a framework is demonstrated by focusing on the experience of India. Major conclusions of the paper which highlight the role and limitations of price policy in growth of fertilizer use in the developing world are brought together in the last section.

- Fertilizer is chosen as an example because of its dominance among modern inputs and also because a substantial proportion of further growth in agricultural production is expected from raising fertilizer use. Growing budgetary burden of fertilizer subsidies in many developing countries also justify the choice of fertilizer among modern inputs to discuss the price policy issues. The experience of India seems relevant because fertilizer use in India has increased from less than one kilogram to about 40 kilograms per hectare over a period of three decades --- levels which are typical of many developing countries. The Indian scene is characterized by persistent geographical concentration in fertilizer use and wide variations in the growth in use on different crops --- features which are common in the developing world. Yet other major similarities between India and many developing countries are the impact of the high yielding varieties (HYVs) on growth in fertilizer use, circumstances affecting the development of fertilizer distribution and supply systems, and a growing burden of fertilizer subsidies in recent years.

PAST GROWTH AND FUTURE NEEDS OF FERTILIZER USE IN DEVELOPING COUNTRIES

Chemically manufactured fertilizers were first used about 140 years ago.[1] At the end of 100 years, annual world fertilizer consumption had grown to about 10 million metric tons (mmts) of nutrients.[2] Appreciable fertilizer use was,

however, confined to some countries of Europe, the United States, and Japan. The share of the developing countries of Asia, Africa, and Latin America was less than five percent in the total fertilizer consumption.

Fertilizer consumption in the developing world really began after the Second World War. Gathering momentum over time, it reached 40 mmts in 1982/83.[3] Five features of this growth are worth noting. First, the share of developing countries in world fertilizer consumption increased from about 7 percent in the early 1950s to about 12 percent in the early 1960s, about 22 percent in the early 1970s, and about 35 percent in the early 1980s. Second, the levels of fertilizer consumption and the pace of its growth have varied widely among developing countries. Its importance, however, has been recognised even in countries with low rates of application and poor growth in consumption. Third, China, India, and Brazil have emerged in the group of the top 10 countries of the world both as consumers and producers of fertilizers. None of them was in this category, even as a consumer, until the 1960s. Fourth, even in the decade characterized by two Oil Crises, fertilizer consumption in the developing world increased substantially -- from 17 mmts in 1972/73 to 40 mmts in 1982/83. The growth of 23 mmts in just 10 years was more than twice the growth in the entire world's fertilizer consumption during the first 100 years of its use. Equally significantly, it accounted for 63 percent of

the growth in total world consumption between 1972/73 and 1982/83. Finally, the vast growth in fertilizer use has been accompanied by mounting burden of fertilizer subsidies in many developing countries.

Despite such an impressive growth, the amount of fertilizer used in the developing world is still quite low --- about 48 kilograms of nutrients per hectare of arable land. A majority of developing countries use less than 25 kilograms per hectare. These levels are considerably lower than the per hectare averages of more than 200 kilograms for the Western Europe, more than 100 kilograms for the Eastern Europe and USSR, and more than 90 kilograms for North America. Thus, there is a clear need to raise fertilizer use in the developing world. Growing pressure of population on land, persistent food deficits, depleted soil fertility, and the dependence of proven yield-increasing technologies on high levels of fertilizer application all point to the urgency of the need.

The magnitude of the task involved in rapidly raising fertilizer consumption in developing countries can be illustrated with data from India. India was using less than 50,000 metric tons of nutrients in the late 1940s. This grew to about 800,000 metric tons by 1965/66, 2.8 mmts by 1973/74, and 7.3 mmts by 1983/84.[4] Fertilizer consumption must grow to between 15 and 20 mmts by the year 2000 --- i.e., by 450,000

to 750,000 tons every year -- to raise the agricultural production to desired level. So far, the annual increment in fertilizer consumption has exceeded 500,000 tons only five times. Growth in fertilizer consumption by more than 500,000 tons per year is imperative because about four-fifths of the additional food-grains production required by the year 2000 will depend on increased use of fertilizers.[6] It is, therefore, pertinent to ask what policies are required to accomplish the task.

A HEURISTIC FRAMEWORK TO DISCUSS THE POLICY REQUIREMENTS[7]

One way to discuss the above question would be to view growth in fertilizer consumption as an outcome of growth in farmers' demand for fertilizers due to changes in variables which affect their returns on its use. This approach underlies a number of empirical studies which consider fertilizer consumption as a function of such agro-economic variables as irrigation, area sown to fertilizer-responsive crop varieties, cropping pattern, and prices of crops as well as fertilizers. The estimated growth parameters of different explanatory variables are then used to draw policy conclusions.[8]

This approach raises three questions: Changes of what magnitude are required every year in the variables that shift fertilizer response functions upwards or in the prices of fertilizers to increase fertilizer consumption by the desired

amount? Which policies will produce these changes? Are these policies substantial? The last question is no less relevant than the other two because every change in fertilizer consumption is treated as causally determined only by changes in variables behind fertilizer response functions and prices of fertilizers and crops.

Important as fertilizer response functions and prices are, it is absured to say that continuous changes in them are necessary to sustain growth in fertilizer use under all circumstances. Both a priori reasoning and experience of many countries (including India as discussed later) clearly suggest that such an interpretation of growth in fertilizer consumption is mechanistic. More importantly, it could lead to imprudent -- if not altogether unrealistic -- price policy prescriptions if possibilities of continuous upward shifts on response functions are limited in the short run. Thus, to discuss policy requirements for sustained rapid growth in fertilizer use, it is crucial to have an approach which does not limit the discussion to changes in response functions and prices. This is especially so in the context of developing countries where there is untapped potential of fertilizer use.

The agronomic potential of fertilizer use in a country is determined by fertilizer response functions. Its economic viability is determined by prices of crops and cost of

fertilizers. We shall call variables behind fertilizer response functions, prices of crops and cost of fertilizers agro-economic variables. They determine economic potential of fertilizer use. Actual fertilizer use is an outcome of both the conversion of the economic potential into farmers' effective demand for fertilizers and satisfaction of this demand by fertilizer supply and distribution systems.

Viewed thus, besides agro-economic variables, three processes and interactions among them influence the level of actual fertilizer use and changes in it. First is the process which converts the economic potential into farmers' effective demand for fertilizers. This involves generation of knowledge about fertilizer response function, its spread among farmers, and provision of credit to them. Agricultural research, extension and credit systems are involved in this process. The second process relates to the flow of fertilizers from factories and ports to geographically dispersed locations. Fertilizer distribution system is behind this process. The *third process determines aggregate supply of fertilizers.* Domestic fertilizer factories and institutions importing fertilizers are involved in this process.

The identification of the above-mentioned processes and systems drives home a simple point: Growth in fertilizer use is determined not only by changes in agro-economic variables behind the economic potential of fertilizer use, but also by

factors which influence development and workings of the above systems. To be sure, empirical evidence from many countries indicates that until actual use reaches the full economic potential, the pace and pattern of growth in fertilizer use are influenced more decisively by the development of the above-mentioned systems than by marginal changes in prices of either crops or fertilizers. This is not surprising because farmers, though rational, are not omniscient. For their decisions like whether to adopt fertilizer, which crops to fertilize, and at what rates, even rational farmers need location-specific information on the responses of crops to fertilizer use and details of fertilizer practices to judge the profitability of fertilizer use. Agricultural research system which generates such information and the extension system which delivers it to farmers thus influence farmers' decisions in an important manner. Similarly, supply of sufficient credit is often necessary to convert farmers' perceptions of profitability on fertilizer use into their effective demand schedules for fertilizers. But even this is not enough. Actual use of fertilizers would still depend on whether adequate fertilizers are available to farmers at the right place and time — something which depends on the level of development and efficiency in the workings of fertilizer distribution, production, and import systems.

Empirical evidence reveals that since it was invented, fertilizer use in each country has begun with a few farmers fertilizing selected crops at limited locations. Such a beginning implies a vast untapped potential of fertilizer use under the prevailing response functions and prices. The existence of the untapped potential of fertilizer use manifest as less than complete diffusion of fertilizer use on land where it is potentially profitable, and also in sub-optimal rates of application on fertilized land. Growth in fertilizer consumption in all countries has been an outcome of further spread of fertilizer use and upward movements in rates of application. And these, in turn, have been governed by the speed with which the systems behind the three processes have developed, and the efficiency with which they have operated.

Development of the above systems have influenced growth in fertilizer consumption not only by exploiting the untapped potential but also by raising the profitability and economic potential of fertilizer use. Agricultural research and extension systems have been behind upward shifts in response functions by developing and spreading new technologies in crops production and educating farmers in judicious use of fertilizers. Reductions in farmers' fertilizer cost have been governed by technological breakthroughs and operationsl efficiencies in fertilizer supply and distribution systems. Experiance clearly reveals that sustained growth in fertilizer use

has occurred through these types of developments coupled with higher prices of crops resulting from expansion in demand for agricultural output due to rapid economic growth. Such developments cannot be substituted indefinitely by proping up prices of crops or lowering fertilizer prices through subsidies to raise profitability of fertilizer use. Such measures have usually distracted attention of the policy makers from the more demanding tasks of developing the systems which generate sustained growth in fertilizer consumption.

The above framework is especially relevant for developing countries because of three reasons. First, aggregate fertilizer consumption in most of them is below the potential as determined by prevailing response functions-cum-price environment. Second, various systems which influence growth in fertilizer use are inadequately developed and have many inefficiencies in their working. And third, interactions between these systems are usually not governed by the price mechanism. Hence, price policy interventions are at best a poor substitute for the real tasks of adequately developing these systems.

It is thus clear that policy requirements of <u>further</u> growth in fertilizer consumption cannot be correctly identified without interpreting the past growth in fertilizer consumption in the framework outlined. The usefulness of such an approach is demonstrated below by focusing on the Indian experience.

GROWTH OF FERTILIZER USE: INDIAN EXPERIENCE

Fertilizer use began in India on tea plantations in the 1920s. It spread little outside the plantation sector until 1943 when the government launched the Grow More Food Campaign in the wake of the Japanese occupation of Burma (from where India was importing rice) and the Bengal famine. This marked the beginnings of efforts to promote fertilizer use in the non-plantation sector to raise food production rapidly. These efforts, which gathered momentum after India became independent in 1947, had five major aims: (1) To create farmers' demand for fertilizers by generating and spreading the knowledge about responses of crops to fertilizer use through thousands of trials on farmers' fields. (2) To improve the response function environment through development of irrigation and spread of high yielding varieties (the latter from the mid 1960s). (3) To develop fertilizer distribution system interlinked with agricultural credit system. (4) To enlarge fertilizer supplies through developing domestic fertilizer industry and imports. (5) To control fertilizer prices.

The fertilizer price policy was marked by the following major features: uniform prices throughout the country, virtual absence of subsidies until the mid-1970s, and growing fiscal burden of these subsidies in recent years. Incidentally, the real price of fertilizer (that is price of fertilizer relative to prices of crops) in India has been generally higher than in many countries during the last three decades.

Because of the nature of above efforts and the existence of vast untapped potential, India recorded an impressive growth in fertilizer consumption - from 0.5 kilograms of nutrients per hectare in the late 1940s to more than 40 kilograms of nutrients per hectare in the early 1980s. It now ranks fourth in total fertilizer consumption after the USA, the USSR, and China.[10]

Despite such impressive growth, total fertilizer consumption has been below the potential indicated by the response functions-cum-price environment.[11] This means that growth in fertilizer consumption could have been faster. That there was sufficient scope for faster growth is indicated by less than complete diffusion of fertilizer use in all crops, even on irrigated areas, until at least the mid-1970s.[12] Similarly, slow but steady growth in fertilizer use under unirrigated conditions, even on traditional varieties, clearly suggests farmers' willingness to use fertilizer under unirrigated conditions. Thus, it is as necessary to ask why the past growth in fertilizer use was not faster as to figure out the forces behind the observed pace and pattern of growth. Obviously, the answer to this question lies in various deficiencies in fertilizer promotion, distribution, and supply systems. Among these deficiencies, inadequate efforts to convert the potential into farmers' demand for fertilizers through meaningful extension activities, slow expansion of

and various inefficiencies in the fertilizer distribution system, repeated shortfalls in planned domestic fertilizer production, and wide annual fluctuations in fertilizer imports clearly stand out.

Virtually all empirical research shows that the observed pace and pattern of growth in fertilizer use is influenced more by variables behind fertilizer response functions than by prices of either crops or fertilizers. To illustrate, fertilizer diffusion has been most rapid on crops and varieties which respond to fertilizer use dramatically despite these crops and varieties not being the ones with best price environment. The concentration of fertilizer use on irrigated areas and HYVs also indicates the strong influence of fertilizer response functions on growth of fertilizer use. Slower growth in fertilizer use on oilseeds and pulses than on rice and wheat despite better price environment for the former than for the latter, and faster diffusion of fertilizer use on the same crop on irrigated areas than on unirrigated areas further confirm that variables behind fertilizer response functions have been more important than prices.

Although fertilizer use was more profitable on irrigated areas, it was not confined to them. More importantly, there was slow but steady growth of fertilizer use on unirrigated areas under virtually all crops even when there was scope for further diffusion on irrigated areas. Thus, for instance

by 1976/77 fertilizer use had spread to about 18 percent of total unirrigated area, even though about one-third of the irrigated area was still not fertilized. The explanation for this obviously lies in relatively better development of the systems influencing growth in fertilizer consumption in certain regions with low irrigation than in those with high levels of irrigation. The experience of Gujarat State clearly reveals this.

In 1981/82, with less than 20 percent area irrigated and relatively poor rainfall environment, Gujarat had the highest level of fertilizer consumption per hectare among all states and union territories with irrigation levels up to 40 percent. This was an outcome of faster diffusion of fertilizer use on unirrigated areas which accounted for more than half of total fertilizer consumption in the state in the mid-1970s. Against this, the share of unirrigated areas in the country's total fertilizer consumption was only about 20 percent. Relatively faster growth of fertilizer use on unirrigated areas of Gujarat was mainly due to certain strengths of the fertilizer distribution system and the pressure from the supply side, especially from the fertilizer factories located in the State.[13]

Yet another feature which deserves attention is the wide variation in the rates of growth in fertilizer consumption among different districts within states.[14] This has been

commonly attributed to the inter-district variations in irrigation, cropping pattern, and spread of HYVs. In addition to these, inter-district differences in the development of fertilizer distribution system and supply of agricultural credit have also been responsible. Recognition of this is obviously useful in evolving policies to broaden the geographical base of growth in fertilizer use.

The persistence of regional concentration in fertilizer use suggests that both fertilizer diffusion and rates have reached fairly high levels in regions which have accounted for bulk of the past growth in fertilizer use.[15] This being so, continued dependence of the government machinery and fertilizer industry on these same regions for further growth in fertilizer consumption has started generating pressures for higher prices of crops and lower prices of fertilizers because of diminishing marginal production from additional fertilizer use. These pressures could be effectively countered only if promotion and distribution systems are developed in other regions and fertilizer response functions are shifted upwards in regions where fertilizer use is concentrated.

POLICY REQUIREMENTS OF FUTURE GROWTH IN INDIA'S FERTILIZER CONSUMPTION

By drawing on the above understanding, this section discusses policy requirements to increase India's fertilizer consumption by 500,000 tons every year in the future. These

policy requirements follow from the strategy which aims at both rapidly converting the untapped potential into actual fertilizer use as well as continuously raising the economic potential of fertilizer use.

The scope for growth in fertilizer consumption through tapping the unexploited potential lies largely on more than 70 percent of unirrigated land.[16] This land accounts for more than 80 percent of the production of jowar, bajra, pulses, *and oilseeds, about 67 percent of cotton production, and 30* to 40 percent of the production of rice and wheat. Therefore, raising productivity of unirrigated areas is crucial to sustain yield-based growth in agricultural production. Among the constraints hampering the efforts to raise productivity of unirrigated areas, low soil fertility is as severe as any other. Unless concerted efforts are made to raise soil fertility through judicious use of fertilizers, farmers would have little incentive to invest in other dryland technologies.

Since agro-climatic environments of unirrigated areas differ from one another, location specific knowledge on fertilizer response functions, fertilizer practices and other agronomic matters need to be generated through strengthening decentralized research. Such knowledge should be then spread among farmers through improving coordination between agricultural research and extension systems to speed up fertilizer diffusion in these areas.[17] These efforts should be simultaneously

supplemented by adequate and timely flow of credit to farmers and development of efficient fertilizer distribution system. Small increases in distribution margins (a price policy measure) may not suffice to accelerate expansion of fertilizer distribution system in rainfed areas especially if vigorous efforts to promote fertilizer use are absent and fertilizer turnover remains low.

Neither promotional efforts nor expansion of distribution system in unirrigated regions would sustain unless growth in aggregate fertilizer supply stays ahead of growth in market for fertilizers under irrigated conditions (i.e, in the presently and newly irrigated areas). For quite some time to come, this would depend on fertilizer import policy. So far the policy has been governed by short-term considerations of clearing inventories and savings in foreign exchange. This needs to be replaced by an understanding of the role of the supply side in converting untapped potential into actual fertilizer use. The experience of Gujarat state clearly demonstrate how sustained pressure from the supply side works in opening up fertilizer markets in rainfed regions. A policy of "liberal" imports of fertilizers will most likely to be resented by the domestic fertilizer industry. It may also lead to an increase in inventories in the short-run. But this calls for evolving effective mechanisms to resolve conflicts of interest between different segments of the fertilizer system rather than

foregoing the use of a potential instrument to spread fertilizer use on rainfed areas and thus raise production of commodities like oilseeds and pulses which are in short supply.

Raising rates of application on fertilized land from sub-optimal to optimum levels is another way of generating growth in fertilizer consumption through tapping the unexploited potential. Efforts in this direction should concentrate in educating farmers in various details of fertilizer practices like balanced use of different nutrients, correct timing and placement of fertilizers, and wherever necessary, use of micro-nutrients and soil amendments. There is ample evidence of deficiencies in fertilizer practices in these respects even in regions which have attained high levels of fertilizer use. Raising rates of application through changes in fertilizer practices will increase the efficiency of fertilizer use and thus raise returns on it. Clearly this is a superior alternative to using price policy to raise rates of fertilizer application.

For sizeable growth in fertilizer consumption to sustain, the economic potential of fertilizer use must be increased. Its urgency is revealed by virtually complete diffusion of fertilizer and currently available high yielding varieties on presently irrigated land. Rates of fertilizer application on this land are also fairly high. While there is scope to raise them further, efforts in this direction should be through

improvements in fertilizer and other agronomic practices as well as through better water management. Without such efforts, the strategy to increase fertilizer use on land which is already fertilized at fairly high rates leads to pressures for lower fertilizer prices and higher support prices of crops as the experience in recent years clearly indicates.

To increase the economic potential of fertilizer use, accelerated development of irrigation potential and its fuller utilization are a must. In addition to this, agricultural research system needs to be strengthened to continuously improve the response function environment on both irrigated and unirrigated areas. The importance of these policies is well recognized and needs no elaboration. It must, however, be noted that these policies increase the economic potential of fertilizer use. Its rapid exploitation depends on removal of various deficiencies in agricultural extension and credit as well as fertilizer supply and distribution systems. Therefore, a distinction between policies which aim at increasing the potential and those which aim at rapidly converting the potential into actual fertilizer use seems necessary. Inadequate appreciation of the complementarity between these two sets of policies eventually results into long time lags in full exploitation of the potential as revealed by the past experiences.

Thus far the discussion has focused on a wide range of non-price policies. This is mainly due to three reasons. First, as the previous section shows, the past growth in fertilizer consumption was determined more importantly by the variables behind response functions and agricultural research, extension, credit, fertilizer supply and distribution systems than by changes in prices of either crops or fertilizers. Second, future rapid growth in consumption crucially depends on further development of these systems and continuously raising the fertilizer potential through technological change in agriculture. Third, India does not seem to have much scope to continuously lower relative prices of fertilizers to crops through price policy interventions, at least in the short run. The following discussion on fertilizer and agricultural price policies highlights the major constraints.

Since 1943, when it launched the efforts to spread fertilizer use on food crops, the government has controlled prices of most fertilizers at factory, port, and farm-gate levels.[18] Besides keeping them at reasonable levels, two features of the policy have been equalization of the cost of domestic and imported fertilizers, and uniformity at farm-gate levels all over the country by pooling transportation cost and fixing distribution margins. For nearly three decades, there was no major budgetary subsidy on fertilizers. In fact, there was surplus in all years except a few. Incidentally, this distinguished India from many other developing countries.

The situation changed from 1973/74. Since then fertilizer subsidies in the budget of the central government has grown to over Rs. 10,000 million by 1983/84. Three factors have contributed to this: (1) enhanced cost of fertilizer imports, (2) introduction of Fertilizer Retention Price Scheme for domestic manufacturers, and Fertilizer Freight Subsidy Scheme, and (3) growth in fertilizer consumption from about 3 million tons in 1973/74 to nearly 8 million tons in 1983/84. In 1983/84, domestic and imported fertilizers accounted for 86 and 14 percent of the total fertilizer subsidy respectively. In the subsidy on domestic fertilizers, payments made by way of retention prices dominated.

The retention price scheme has origins in the enhanced cost of fertilizer production after the oil crisis of the early 1970s and the strategy to meet fertilizer requirements through growth of domestic fertilizer industry. (The scheme assures a manufacturer 12 percent post-tax returns on net worth provided certain norms with respect to capacity utilization etc., are achieved.) The average cost of supplying domestic fertilizers has been higher than prices fixed for farmers. In recent years, it has also been higher than the cost of imported fertilizers. Unless the cost of domestic production falls or prices charged to farmers are raised, with the targetted growth in fertilizer consumption, fertilizer subsidies will raise to Rs. 70,000 million by 1990.[19] There is scope to lower cost of production

through raising the capacity utilization and efficiency of many fertilizer plants, and pricing as well as fiscal policies for fertilizer raw materials, feedstocks and equipments.[20] On the other hand, average cost of domestic fertilizers may still rise because of higher investment costs of new plants from which growing proportions of domestic supply will come.

It is beyond the scope of this paper to discuss merits of meeting fertilizer requirements from expansion in domestic fertilizer industry. The issue is complex, involving implications of importing large and growing requirements,[21] the technological capability and experience gained in fertilizer production,[22] and the place of fertilizer industry in the economic development strategy. One thing, however, seems clear: Given the strategy of fertilizer supply, the growing burden of fertilizer subsidies on the budgetary resources clearly suggests that there is hardly any scope to lower the prices of fertilizers charged to farmers, at least in the short run.

In the past, the price policy for crops have played a key role in accelerating the spread of HYVs and thus increasing the spread of HYVs and thus increasing farmers' demand for fertilizers. In the absence of public procurement operations, large marketable surplus might have lowered the prices and thus slowed down diffusion of HYVs with consequent adverse

impact on growth in demand for fertilizers. But this kind of impact of agricultural price policy on demand for fertilizer seems to be over. The diffusion of currently available HYVs and rates of fertilizer application on them have reached fairly high levels. As argued earlier, further growth in demand for fertilizer for use on HYVs require additional technological breakthroughs, improvements in fertilizer practices through adaptive research and more effective extension, and not price interventions. Yet another constraint on the agricultural price policy to support prices of crops at higher and higher levels is that of effective demand for foodgrains. This has resulted into larger procurement and stock holding by the government and growing burden of food subsidies. The removal of demand constraint depends on rapid growth in employment, and this calls for containing upward pressures on agricultural prices. Thus, there are important constraints in the use of support price policy to contribute sizeable increments in future fertilizer consumption.

Because of the above constraints in lowering fertilizer prices or increasing support prices of crops, non-price policies will be crucial, perhaps more than ever before, in determining the pace of future growth in India's fertilizer consumption.

ROLE AND LIMITATIONS OF PRICE POLICY IN GROWTH OF FERTILIZER CONSUMPTION

The above discussion provides a useful perspective to examine the role and limitations of price policy in generating sustained rapid growth of fertilizer consumption in developing countries. Eight major propositions emerge. Although largely based on interpreting the Indian experience within the heuristic frameworks, they seem to have relevance for many developing countries because of reasons pointed out in Introduction.

First, while economic potential of fertilizer use is determined by fertilizer response functions and prices of crops and fertilizers, actual fertilizer use is determined by these variables as well as agricultural research, extension, credit, fertilizer supply, and distribution systems. These systems are also important because they convert the potential into farmers' demand for fertilizers and satisfy this demand under a given response functions-cum-price environment.

Second, until fertilizer consumption reaches the potential, there is a disequilibrium between actual consumption and variables behind the response functions-cum-price environment. The rate of growth in actual consumption (that is, the speed of correction in the disequilibrium) is determined not only by changes in the variables behind the response functions-cum-price environment but also, and often more importantly, by development of the systems mentioned above.

Third, the above proposition is especially relevant to developing countries where actual consumption is below the potential and the various systems which influence growth in it are inadequately developed. Thus there is a fundamental error in judging the influence of changes in prices on growth of fertilizer consumption from fertilizer demand models. These models usually specify fertilizer consumption as a function of variables behind fertilizer reponse functions and prices of crops and fertilizers. In other words, they leave out many other variables which influence the development and workings of the systems which convert the potential into actual consumption.

Fourth, besides prices of crops and fertilizers, the development and working of agricultural research, extension, credit, fertilizer supply, and distribution systems are governed by many factors like physical infrastructure, various institutional and administrative arrangements, and the nature of development policies.

Fifth, the pace of growth in fertilizer consumption and its geographical-cum-cropwise pattern are more powerfully influenced by variables behind fertilizer response functions like irrigation, cropping pattern and crop varieties than by prices of crops or fertilizers. Notwithstanding this, various deficiencies in the systems influencing consumption often

constrain rapid utilization of the full potential even on areas characterized by superior response functions. Conversely, better development of these systems in regions with not-so-good response functions often induce rapid exploitation of the fertilizer potential.

Sixth, in the course of growth in fertilizer consumption towards the potential, geographical pockets of concentration in consumption develop. These are mainly regions with superior response function environment or better development of systems facilitating growth in consumption or both. Continued dependence on these regions for further growth in aggregate fertilizer consumption generates pressures for more favourable price environment due to diminishing marginal productivity of fertilizer use. Price policies which respond to these pressures may be effective in raising total fertilizer consumption in the short-run, but they do not sustain the growth in total consumption for long because they do not generate commensurate growth in agricultural production. Nor do they broaden the geographical base of growth in fertilizer consumption since it is constrained by inadequate development of systems which facilitate growth in fertilizer use.

Seventh, in widening the base of growth in fertilizer use, geographical expansion of fertilizer distribution and agricultural credit systems, removal of various inefficiencies

in them, location-specific research on response function environment and judicious fertilizer practices, and spread of this knowledge among farmers through agricultural extension and commercial fertilizer promotion systems play a key role. The success of these efforts, however, critically depends on growth in total fertilizer supply keeping ahead of growth in demand for fertilizers in regions of high consumption. This may necessitate public expenditure on carrying larger fertilizer inventories. But such expenditure will have more favourable impact on sustaining growth in fertilizer consumption and increments in agricultural production than the budgetary burden of price policies which aim at raising fertilizer use in regions which have already reached fairly high levels.

Eighth, once growth in fertilizer consumption gets under way, for sustained rapid growth in fertilizer consumption it is also necessary to raise the potential of fertilizer use. This calls for acceleration in development of irrigation potential and enhanced efforts to evolve technologies which improve the response function environment.

The above propositions point out a wide range of public policy issues relevant to generating sustained growth of fertilizer consumption in developing countries. These issues cannot be effectively tackled through price policy interventions like high fertilizer subsidies and support prices of crops.

This is not to argue that prices of crops or fertilizers do not matter in growth of fertilizer use. Obviously they do; they determine farmers' returns on fertilizer use. Thus, other things remaining the same, better the price environment, faster the growth in fertilizer use. Furthermore, once actual consumption reaches the potential, growth in fertilizer use becomes sensitive to changes in the price environment as the experience of many developed countries during the 1970s clearly illustrates. But this is quite separate from the role and limitations of price policy in generating sustained growth of fertilizer consumption in developing countries with large unexploited fertilizer potential.

By definition, the existence of unexploited potential implies that there is scope for growth in fertilizer consumption under the prevailing price environment. Hence the thrust of our argument has been that acceleration in the growth of actual consumption should be achieved through policies which develop the systems facilitating growth in consumption rather than price policy interventions which raise farmers' returns on fertilizer use. Obviously, such interventions cannot benefit farmers or generate acceleration in total fertilizer consumption if adequate fertilizers are not available at right time and place due to various deficiencies in the fertilizer supply and distribution systems which characterize the developing countries. Similarly higher support prices of crops can

have a sustained impact on growth in total fertilizer use only if marketing systems for agricultural output are well developed and efficient; and there are no major constraints on growth in effective demand for these crops.

While many non-price policies seem more effective than price policies to accelerate growth of fertilizer consumption in developing countries, there are two situations in which price policy interventions may be necessary. The first relates to a situation in which the prevailing price environment is not very conducive to rapid spread of technologies like HYVs. Even though returns on fertilizers would be larger due to upwards shifts in response functions, a positive price policy for crops may be necessary to accelerate the diffusion of technologies since their adoption involve yield and price uncertainties as well as increased cost of cultivation on many other inputs besides fertilizers. The other situation relates to an environment in which there is a dramatic increase in price of fertilizer due to such events like the oil crisis or substantial devaluation of the currency. A time-bound fertilizer subsidy may be necessary in such a situation to insulate the process of growth in fertilizer consumption from dramatic increase in fertilizer prices. Even in these situations, a great deal of prudence seems necessary lest such interventions become permanent features of agricultural policy with growing burden on budgetary resources of the government as suggested by the Indian experience.

FOOTNOTES

[1]The use of chemically manufactured fertilizer began in the 1840s with the establishment of the first fertilizer factory in Rothamstead, England. For details, see Mirko Lamer, The World Fertilizer Economy (Stanford, California: Stanford University Press, 1957), Chapter 3.

[2]Food and Agricultural Organization of the United Nations, Fertilizers, A World Report on Production and Consumption (Rome: FAO, 1951)

[3]The terms "Developing World" and "Developing Countries" include countries classified as "Developing Market Economies" plus "Asian Centrally Planned Economies" by Food and Agriculture Organization of the United Nations in its statistical literature. Estimates of fertilizer consumption used in the paragraph are based on various issues of Fertilizer Yearbook (Rome:FAO)

[4]Fertilizer Association of India (FAI), Fertiliser Statistics 1982-83 (New Delhi: FAI, 1983), pp 1-80 and Fertiliser News, Vol. 29, No.12, December 1984, p. 102.

[5]India, Ministry of Agriculture and Irrigation, Report of the National Commission on Agriculture (New Delhi:Controller of Publications, 1976), Part III, pp.75-80, and UNIDO, Draft Worldwide Study of the Fertiliser Industry: 1975-2000, 1976, Chapter 2.

[6]India, Ministry of Agriculture and Irrigation, Report of the National Commission on Agriculture (New Delhi: Controller of Publications, 1976), Part III, pp.75-80.

[7]Complete exposition of this approach would appear in Gunvant M. Desai, Understanding the Process of Growth in Fertilizer Consumption: A Conceptualization (Washington D.C.: International Food Policy Research Institute, forthcoming research report).

[8]For example, see literature on fertilizer demand. For a discussion of the "specification error" in this type of models, see Gunvant M. Desai, Sustaining Rapid Growth in India's Fertilizer Consumption: A Perspective Based on Composition of Use (Washington, D.C.: International Food Policy Research Institute, 1982), Chapter 6 and Appendix.

[9]For evolution of fertilizer price policy, its interrelationships with fertilizer supply and distribution policies, and circumstances leading to rapidly growing burden of fertilizer subsidies in recent years, see Gunvant M. Desai, "Growth in Fertilizer Consumption: Price and Non-Price Policies". Paper presented at the International Seminar on Fertilizer Pricing organized by the World Bank in Washington, D.C., March 27-30,1984.

[10]India's fourth rank is of course due to its large size. But the same applies to the U.S.A., the U.S.S.R., and China.

All of them rank much lower on a per hectare basis. India's record in raising its fertilizer consumption from less than one kilogram per hectare in the late 1940s to more than 40 kilograms per hectare by 1983/84 is impressive when compared with the time taken by many developing and developed countries to raise their per hectare fertilizer consumption in this range. On the other hand, it is much less impressive than that of China.

[11]For instance, under the fertilizer response functions-cum-price environment prevailing in the early 1960s, Panse estimated that it was possible to use 3.57 million tons of nitrogen. (See V.G. Panse, Technical and Economic Possibilities of the Use of Nitrogen Fertiliser in India, New Delhi: Indian Agricultural Research Institute, 1964). Actual nitrogen consumption in the early 1960s was about 300,000 tons. It crossed 3.57 million tons (Panse's estimate of potential which must have gone up considerably because of growth in irrigation and widespread diffusion of HYVs) in only 1980/81.

[12]For this and other such findings and elaboration of the arguments of this section, see Gunvant M. Desai, Sustaining Rapid Growth in India's Fertilizer Consumption: A Perspective Based on Composition of Use (Washington D.C.: International Food Policy Research Institute, 1982).

[13]For details, see Report of the Working Group on Fertilizer Distribution System in Gujarat, Government of Gujarat, 1983.

[14]See various issues of Fertiliser Statistics, (New Delh: Fertiliser Association of India), for data on fertilizer consumption by states and districts.

[15]Thus, for instance, districts accounting for about one-fifth of the country's cultivated area have been dominant in the past growth of fertilizer consumption with a share of about 55 percent. Average rates of fertilizer application in these districts have reached more than 50 kgs. per hectare by the late 1970s. In one-fourth of these districts, they have crossed 100 kgs. per hectare. Since all cultivated land in a district seldom comes under fertilizer use, rates of application on fertilized land in these districts must have reached considerably higher levels.

[16]The problem of raising fertilizer consumption under unirrigated conditions should not be viewed as occurring only with low rainfall. A study based in the fertilizer growth performance of districts during the 1960s clearly showed that districts with low irrigation located in high rainfall regions, particularly in eastern India (including parts of Madhya Pradesh), performed the worst among all districts with little irrigation. Available evidence also

reveals that the districts in eastern India have the least developed fertilizer distribution and agricultural credit systems. See, Gunvant M. Desai and Gurdev Singh, Growth of Fertilizer Use in Districts of India, Performance and Policy Implications, (Ahmedabad: Centre for Management in Agriculture, Indian Institute of Management,)1973, Chapter 4. Scrutiny of the trends in the 1970s indicates a similar pattern. See also, Gunvant M. Desai, "Fertilizer Use on India's Unirrigated Areas: A Perspective Based on Past Record and Future Needs," Paper presented at the seminar on "Technology Options for Dryland Agriculture: Potential and Challenge," jointly organized by International Crops Research Institute for the Semi Arid Tropics and Indian Society of Agricultural Economics in Hyderabad from August 22 to 24, 1983.

[17]This cannot be overemphasized because the quantum of additional production due to fertilizer use depends on such things as timing and method of fertilizer application, balance among nutrients, sowing time, choice of variety and plant population. What makes these considerations critical in rainfed areas is that without appropriate agronomic practices, returns on fertilizer use are considerably lower and more uncertain in those areas than on irrigated areas. On the other hand, available research clearly indicates that with appropriate practices, returns to fertilizer use on rainfed areas could be considerably enhanced.

[18]For details, see Gunvant M. Desai, "Growth in Fertilizer Consumption: Price and Non-Price Policies". Paper presented at the International Seminar on Fertilizer Pricing organized by the World Bank in Washington D.C., U.S.A., March 27-31, 1984.

[19]"Subsidising Fertilizers," by a correspondent, The Economic Times, January 3-4, 1984.

[20]B.K. Jain and Satya Nand, "Productivity in the Indian Fertilizer Industry," Fertiliser News, December 1980, pp.7-18; S. Venkitramanan, "Government Policy Issues and Implications on Fertiliser Plant Costs," Fertiliser News, May 1983, pp.21-26.

[21]Even at present India ranks either first or second (after China) in net import of fertilizers among both developed and developing countries. See Food and Agriculture Organization of the United Nations, Fertilizer, FAO Fertilizer Yearbook (Rome: FAO, 1983).

[22]See various papers in Fertiliser Association of India, Development of Fertilisers in India, (New Delhi: FAI, 1980).