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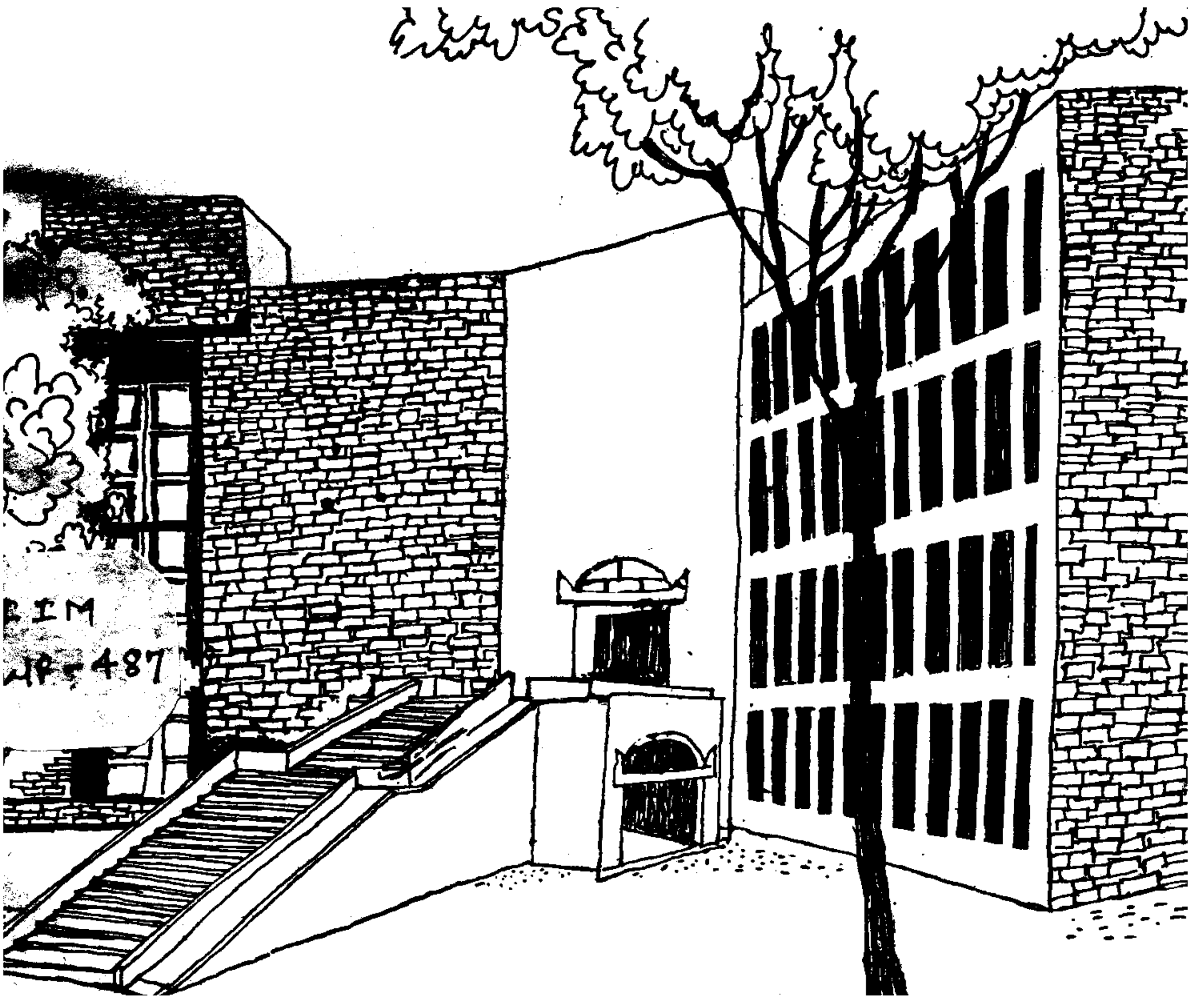

# ECONOMICS OF SUSTAINED RAPID GROWTH IN INDIA'S FERTILISER CONSUMPTION

By

Gunvant M. Desai



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# ECONOMICS OF SUSTAINED RAPID GROWTH IN INDIA'S FERTILISER CONSUMPTION

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

This paper presents a framework to discuss economics of sustained rapid growth in India's fertiliser consumption. Major considerations suggested by the framework are then discussed against the backdrop of the past growth in fertiliser use to identify key policy issues and draw conclusions.

Economics of fertiliser use is usually discussed in terms of factors which determine its profitability to farmers. Among these factors, prices of crops and fertilisers receive maximum attention since they can be altered by policy interventions. From this it follows that to discuss economics of growth in fertiliser use, we should concern ourselves with the necessary changes in the factors influencing farmers' profitability of fertiliser use. The main thrust of this paper is that such an approach is not appropriate because it bypasses many considerations which are equally, if not more, important.

The paper is divided into five sections. Section I highlights the need to generate sustained rapid growth in India's fertiliser consumption. Section II briefly summarises the conventional approach to discuss economics of fertiliser use and brings out the questions it raises. Section III presents an alternative approach which shows why the conventional approach and questions raised by it constrain the discussion of how to generate the desired rate of growth in fertiliser use. Section IV draws attention to certain major features of the past growth in fertiliser consumption which have important implications in discussing economics of further growth in its use. Finally, Section V draws some policy conclusions.

Paper invited for the FAI-FAO Annual Seminar on "Systems Approach to Fertiliser Industry", organised by The Fertiliser Association of India to be held in New Delhi on December 9-10, 1983.

## Section I

## Need for Sustained Rapid Growth in Fertiliser Use

By 1982/83 India's total fertiliser consumption rose to about 6.5 million tons of nutrients from less than 100,000 tons in the early 1950s. Incidentally, it now ranks fourth after that of the U.S.A., the U.S.S.R., and China.[1]

The need for substantial further growth in India's fertiliser consumption is indicated by its relatively low consumption per hectare in comparison with the levels in countries with high crop yields.[2] More importantly, it is revealed by future requirements of agricultural production since most of these will have to come from continuous increases in yields. For instance, according to the National Commission on Agriculture (NCA), about four-fifth of the additional foodgrain production required by the year 2000 will depend on increased use of fertilisers alone.[3] This is stressed because it highlights a simple axiom: Limits of growth in yields, whether on irrigated or on unirrigated areas, with or without varietal improvements, are finally determined by soil fertility. Perhaps no one has emphasised this axiom more tellingly than John Augustus Voelcker did nearly a hundred years ago:

> Improvement in the system of land tenure, improvement of the land by expenditure of public and private capital on it, and similar measures, may alleviate the condition of the Indian cultivator, but they will not give him larger crops, and they will not provide the food that the people must have to live upon. For this the soil itself must be looked to, as it alone can produce the crops, and manure alone can enable it to bring forth the necessary increment. The question of manure supply is, accordingly, indissolubly bound up with the well-being and even the bare existence of the people of India.[4]

Widespread deficiency of nitrogen in Indian soils is well-known. Low availability of phosphorus and potash is no more rare, and evidence on deficiency of micro-nutrients at growing number of locations is accumulating.[5] Obviously, yield-based growth in agricultural production cannot be sustained without removing these constraints.

Chemical fertilisers are only one of the sources of plant nutrients but they have become increasingly important in supplying growing quantities of plant nutrients as revealed by the experiences in India and elsewhere. Even China, with its examplary performance in mobilising other sources of plant nutrients, has not been an exception.[6]

Estimates of required fertiliser use by the year 2000 vary between 15 and 20 million tons.[7] To achieve such levels, total consumption must go up by 450 to 750 thousand tons <u>every year</u> during the 1980s and 1990s.[8] Only four times in the last three decades annual increment in fertiliser consumption exceeded 500,000 tons. It is, therefore, pertinent to ask what requires to be done to generate sustained rapid growth in fertiliser use by the desired magnitude. In discussing this question, economic considerations are obviously most important.

## Section II

## The Conventional Approach and Questions

Economics of fertiliser use is most commonly discussed from the viewpoint of cultivators' profitability on its use. This is natural. Total fertiliser use is ultimately an outcome of individual cultivators' decisions about whether, on which crops and at what rates to use it.[9] Since fertiliser is an input, in the final analysis, these decisions are governed by farmers' net returns from fertiliser use. It is, therefore, natural to think of economics of fertiliser use as being governed by factors' affecting farmers' profitability on its use.

Among these factors, prices of crops and cost of using fertiliser are obviously important. Also important are factors which determine fertiliser response functions since they determine incremental crop production due to fertiliser use. Thus, economics of fertiliser use depends on economic as well as agronomic factors. This cannot be overemphasised especially because very often the latter are more important than the former.[10] We may call all these determinants of farmers' profitability of fertiliser use "agro-economic variables" for brevity, and also to stress that they include both economic and agronomic variables.

For a given set of agro-economic variables, farmers' het returns on fertiliser use are maximum when the rates of fertiliser application are "optimum" (i.e., when marginal cost of using fertiliser is equal to marginal revenue from fertiliser use). Since farmers are interested in maximising their profits, they aim at the optimum rates of application. For fertiliser use to go beyond the optimum rates, one or more agro-economic variables must change in such a manner as to raise the optimum rates.

The conventional approach to discuss economics of growth in fertiliser use is based on the above considerations. It treats growth in fertiliser consumption as being casually determined by changes in the agro-economic variables. In practical terms, this means that for growth in fertiliser consumption to occur (a) fertiliser response functions must shift upwards through such changes in agronomic variables as increase in irrigation, changes in cropping pattern and replacement of traditional crop varieties by fertiliser responsive varieties, and/or (b) prices of crops must go up, and/or (c) cost of using fertiliser must go down.

The above approach underlie many empirical researches to identify variables governing growth in fertiliser consumption and to measure the impact of changes in different agro-economic variables on growth in fertiliser consumption.[11] These results are then used to draw policy conclusions to generate desired growth in fertiliser use.

Viewed thus, economics of increasing India's fertiliser consumption by more than 500,000 tons every year raise the following questions: What changes in the agro-economic variables are necessary to generate the required growth in fertiliser consumption? What is the relative importance of changes in agronomic vis-a-vis economic variables? Which policies are necessary to bring about the required changes in the agro-economic variables?

## Section III

## An Alternative Approach[12]

The above approach and questions raised by it constrain the discussion of factors behind growth in fertiliser consumption, and also of policies required to generate a desired rate of growth in fertiliser use. This is mainly because it considers growth in fertiliser use as being causally determined by changes in only agro-economic variables. Both a priori reasoning and historical experiences of many countries clearly indicate that such an interpretation is incorrect. This is not to downplay the importance of variables which determine profitability of fertiliser use. But to recognise their importance is quite different from concluding that growth in fertiliser consumption is determined by changes in only agro-economic variables.

The economic potential of fertiliser use in a country is determined by fertiliser response functions, prices of crops and cost of fertiliser, i.e., the agro-economic variables which determine profitability of fertiliser use. Actual fertiliser use is an outcome of the conversion of the potential into farmers' demand for fertiliser, and this demand being met by fertiliser supply and distribution systems. Thus, besides agro-economic variables, three types of processes influence actual fertiliser use. First, the processes which convert the potential into farmers' fertiliser demand by generating knowledge about fertiliser response functions, spreading this knowledge among farmers, and enabling them to purchase fertiliser by providing credit. Second, processes which establish fertiliser distribution system, and govern its working in making fertilisers available to farmers at geographically dispersed locations. Third, processes which determine aggregate supply of fertilisers through domestic production and imports. These three processes are governed by the workings of certain sub-systems. These are agricultural research, agricultural extension, agricultural credit, fertiliser distribution, domestic fertiliser industry, and the sub-system involved in fertiliser imports. Viewed thus, it is clear that actual level of fertiliser consumption is determined not only by the agro-economic variables but also by the level of development and workings of all these sub-systems. Even farmers' decision with respect to fertiliser use are influenced by both agro-economic variables and the working of agricultural research, extension and credit systems which generate the knowledge about responses of different crops of fertiliser use and spread it among farmers. Similarly, given the farmers' decisions, actual fertiliser use depends on whether adequate fertilisers are available to them at the right place and time -- something which depends on fertiliser distribution and supply systems.

Since it was invented in the middle of the last century, fertiliser use in every country has begun at some time with a few farmers fertilising selected crops at limited locations. Such beginnings of fertiliser use imply vast untapped potential of fertiliser use under the prevailing response functions and prices. Empirically, the existence of the untapped potential of fertiliser use is manifested as less than complete diffusion of fertiliser use on land where it is potentially profitable and sub-optimal rates of application on fertilised land. In country after country growth in fertiliser consumption has been an outcome of further spread of fertiliser use and upward movements in rates of application from sub-optimal to optimum levels. The pace and pattern of growth in fertiliser consumption have been governed by the rate at which the sub-systems behind the three processes have developed, and the efficiency with which they have operated to spread fertiliser use and raise rates of application.

The various sub-systems have influenced growth in fertiliser consumption not only by exploiting the untapped potential but also by raising the profitability and potential of fertiliser use. Thus, for instance, agricultural research and extension systems have been behind raising the responses of crops to fertiliser use. Similarly, reductions in farmers' fertiliser cost have been governed by technological breakthroughs and operational efficiencies in fertiliser supply and distribution systems. Historical experiences clearly reveal that sustained growth in fertiliser use has occurred through these types of changes coupled with higher prices of crops resulting from rapid economic development. They cannot be substituted by propping up prices of crops or lowering fertiliser prices through subsidies to raise profitability and potential of fertiliser use. Such measures cannot be undertaken indefinitely. Worse still, they distract attention from real tasks of generating sustained growth in fertiliser consumption.

Viewed thus, economics of growth in fertiliser use cannot be meaningfully discussed only in terms of agro-economic variables or changes in the price environment brought about by policy interventions. What is required is an examination of economic and non-economic aspects concerning the development and working of the various sub-systems which influence growth in fertiliser consumption. This is especially so in developing countries like ours where (a) total fertiliser consumption is below the economic potential, (b) higher prices of crops or lower cost of fertiliser through subsidies add to inflationary pressures, (c) sub-systems influencing growth in fertiliser use are inadequately developed and have many inefficiencies, and

(d) interactions between various systems involved in growth of fertiliser consumption are not governed by the price mechanism.

## Section IV

## Features of Past Growth and their Implications

This section draws attention to major features of growth in India's fertiliser consumption which have important implications while discussing economics of further rapid growth in the use of this input.

All available evidence suggests that despite impressive growth, actual total fertiliser consumption has been below the potential indicated by the response functions-cum-price environment.[13] This means that growth in fertiliser consumption could have been faster than it occurred. That there was sufficient scope for this is indicated by less than complete diffusion of fertiliser use on all crops, even on irrigated areas, until at least the mid-1970s.[14] Similarly slow but steady growth in fertiliser use under unirrigated conditions, even on traditional varieties, clearly suggests a viable potential and farmers' willingness to use it. Thus, it is just as necessary to ask why the past growth in fertiliser use was not faster as to figure out the forces behind the observed rate of growth. Obviously, answer to this question lies in various deficiencies in fertiliser promotion, distribution and supply systems. Among these, inadequate efforts to convert potential of fertiliser use on unirrigated areas, slow expansion of and various inefficiencies in the distribution system, repeated shortfalls in domestic fertiliser production and wide year-to-year fluctuations in fertiliser imports clearly stand out.

Virtually all empirical research shows far greater influence of variables behind fertiliser response functions than that of prices (either of crops or of fertilisers) on the observed pace and pattern of growth in fertiliser use. This is clearly revealed by close positive association between responses of different crops to fertiliser use and the pace of fertiliser diffusion on them. It is also revealed by concentration of fertiliser use on irrigated areas and the impact of fertiliser responsive varieties on growth of fertiliser use. Slower growth in fertiliser use on oilseeds and pulses despite faster rise in prices of these crops as compared to many others, and faster diffusion of fertiliser use on the same crop on irrigated areas than on unirrigated areas further confirm that variables behind fertiliser response functions have been more important than prices.

It is equally instructive to note than despite greater profitability of fertiliser use under irrigated conditions and on areas sown with HYVs, the use was not confined to such situations. As mentioned above, there was slow but steady growth of fertiliser use on unirrigated areas under virtually all crops. And this was so even though diffusion on irrigated areas was not complete. Thus, for instance, by 1976/77 fertiliser use had spread to about 18 percent of total unirrigated areas even though about one-third of the irrigated area was still not fertilised, i.e., it was available for further diffusion of fertiliser use under irrigated conditions. The explanation for this lies in relatively better development of the sub-systems influencing growth in fertiliser consumption in certain regions with low irrigation than in those with high levels of irrigation. The experience of Gujarat clearly reveals this.

In 1981/82, with less than 20 percent area irrigated and relatively poor rainfall environment, Gujarat had the highest level of fertiliser consumption per hectare among all states and union territories with irrigation levels up to 40 percent. This was an outcome of faster diffusion of fertiliser use on unirrigated areas which accounted for more than half of total fertiliser consumption in the state in the mid-1970s. Against this, the share of unirrigated areas in the country's total fertiliser consumption was only about 20 percent. Relatively impressive growth of fertiliser use on unirrigated areas of Gujarat has been mainly due to certain strengths of the fertiliser distribution system and pressure from the supply side, especially from the fertiliser factories located in the state.[15]

Yet another feature which deserves attention is the geographical concentration in fertiliser use resulting from wide variation in the pace of growth in fertiliser consumption among different states, and also among different districts within most of the states.[16] This has been commonly attributed to inter-district variations in irrigation, cropping pattern and spread of high yielding varieties. What is not so commonly recognised is that it is also associated with inter-state and inter-district differences in development of different sub-systems, especially fertiliser distribution and promotion systems. The persistent regional concentration in fertiliser use suggests that both fertiliser diffusion and rates have reached fairly high levels in regions which have accounted for bulk of the past growth in fertiliser use.[17] This being so, continued dependence on these same regions for further growth in fertiliser consumption have started generating pressures for higher prices of crops and lower prices of fertilisers because of diminishing marginal production from additional fertiliser use. It is important to note that this dependence on regions which have dominated the past growth in fertiliser consumption cannot be broken without developing fertiliser promotion and distribution systems in the other regions in a vigorous and sustained manner.

## Section V

## Policy Issues and Conclusions

Further rapid growth in India's fertiliser consumption depends on converting the untapped potential into actual fertiliser consumption, and continuously raising the potential of fertiliser use.

Accordingly, there are two central questions in meaningfully discussing economics of further rapid growth in fertiliser consumption. First, what efforts are required to convert the untapped potential into actual fertiliser use? Second, what changes in agro-economic variables are necessary to continuously raise the potential of fertiliser use? In discussing these questions, economic implications from the viewpoints of farmers, fertiliser sub-systems, and society as a whole need to be brought out.

Generating growth in fertiliser consumption through tapping the unexploited potential depends on (1) diffusion of fertiliser use on land which has remained unfertilised even though it is potentially profitable from farmers' viewpoint, (2) raising rates of application from sub-optimal to optimum levels on already fertilised land.

Most of the scope for further diffusion of fertiliser use is on unirrigated area spread all over the country in different agro-climatic environments.[18] To speed up fertiliser diffusion on these areas, location specific knowledge on fertiliser response functions, details of fertiliser practices and other agronomic matters need to be generated and spread among farmers.[19] These efforts should be simultaneously supplemented by adequate and timely flow of credit to farmers, and development of efficient fertiliser distribution system. In other words, what is required is to strengthen the processes which convert the potential into farmers' effective demand for fertilisers and make fertilisers available to them. Price incentives alone are not adequate for this task. For sustained growth in fertiliser demand, what is lacking is widespread conviction among farmers about significant additional production from fertiliser use plus the knowledge about how to use fertilisers most advantageously under rainfed conditions. Similarly, small increases in distribution margins will not suffice to accelerate geographical expansion of fertiliser distribution system in rainfed areas if vigorous efforts to promote fertiliser use are absent and fertiliser turnover remains low. Hence, the emphasis on strengthening agricultural research and extension activities.

Meaningful efforts to generate growth in fertiliser use on unirrigated areas will not sustain unless growth in total fertiliser supply stays ahead of growth in market for fertilisers under irrigated conditions (i.e., in the presently and newly irrigated areas). For quite some time to come, this would depend on fertiliser import policy. It should be based on an understanding of the role of the supply side in converting untapped potential into actual fertiliser use under rainfed conditions through pressures on fertiliser promotion and distribution systems rather than on short-term considerations of clearing inventories and saving foreign exchange.

Raising rates of application on fertilised land from suboptimal to optimum levels is another way of generating growth in fertiliser consumption through tapping the unexploited potential. Efforts in this direction should concentrate on farmers' education in various details of fertiliser practices like balance among different nutrients, correct timing and placement of fertilisers, and use of micro-nutrients and soil amendments wherever they are necessary. All available research indicates that changes in fertiliser practices resulting from these efforts will increase the efficiency of fertilisers in crop production. This would benefit both farmers and society as a whole.

To strengthen efforts in the above direction, location specific research on optimal fertiliser practices and meaningful use of this knowledge by agricultural extension system are a must. It is also necessary to remove various deficiencies in the working of soil testing service.[20]

For <u>sustained</u> rapid growth in fertiliser consumption, tapping of unexploited potential through above efforts is not enough. It is also important to raise the potential of fertiliser use. The urgency of this is clear from the need to increase fertiliser consumption by more than 500,000 tons every year when diffusion of fertiliser and HYVs is virtually complete on presently irrigated land, and the rate of fertiliser application on such land is fairly high.

Theoretically, potential of fertiliser use goes up as a result of upward shifts in the response functions, and/or fall in the ratios of fertiliser to crop prices. Thus, there are two alternatives in policies required to raise potential of fertiliser use. Among these, shifting response functions upwards is superior to either raising prices of crops through unrealistic price support programmes or lowering fertiliser price through subsidies on fertiliser use. This is especially so in developing countries such as ours because injudicious use of price policy instruments generate inflationary pressures, and distract attention from tasks required to raise productivity of fertiliser use.

To increase potential of fertiliser use through continuous upward shifts in fertiliser response functions, it is necessary to accelerate the development of irrigation facilities and also to strengthen agricultural research and extension systems. There is considerable scope for enhanced efforts in both these directions which would benefit farmers as well as society as a whole. As for better price environment, what is necessary is to improve the working of fertiliser supply and distribution systems to lower the "real" cost of fertiliser to farmers by making it available to farmers at the right time and place.

Concerted efforts in the above directions would continuously raise the potential of fertiliser use. Its conversion into sustained rapid growth in fertiliser use, however, would depend on simultaneous development and coordinated functioning of the fertiliser promotion, distribution and supply systems. This can not be over-emphasised, especially in view of the past experience of time-lags in covering even irrigated areas by fertiliser use and pushing optimal fertiliser practices on them.

The above discussion points at the nature of efforts required to convert the untapped potential into actual fertiliser use and increase the potential continuously. Efforts in both these directions are simultaneously required. This is stressed because one could be hesitant about investing in massive efforts to spread fertiliser use on unirrigated areas and raise rates of application on fertilised land through research on and extension of optimal fertiliser practices. Without such efforts, one cannot raise India's fertiliser consumption by more than 500,000 tons every year. This can be seen easily. Assume irrigated areas increase every year by 2.5 to 3 million hectares, that is by 50 to 75 percent more than the average annual increment in the 1970s. Further assume that the newly fertilised areas are unfertilised until they receive irrigation and that upon receiving irrigation they are fertilised without any time-lag at 100 kilograms per hectare. Even with these heroic assumptions, fertiliser consumption would go up by only 250,000 to 300,000 tons every year. Thus to raise fertiliser consumption by more than 500,000 tons year after year, it is just as important to convert the untapped potential into actual fertiliser use as to raise it continuously.

The case for rapidly spreading fertiliser use on unirrigated areas and raising rates of application fertilised land can also be built up on other grounds.

More than 70 percent of India's cultivated land is unirrigated, and about half of this will remain so even after developing the entire irrigation potential. Over 80 percent of the production of jowar, bajra, small millets, pulses and oilseeds plus two-thirds of cotton production come from unirrigated areas. Even in the case of wheat and rice, unirrigated areas account for 30 to 40 percent of total production. Therefore, raising productivity of unirrigated areas is crucial to generate sustained yield-based growth in total agricultural production. Low soil fertility of these areas is as important a constraint as any other to raise their productivity. In fact, one could argue that unless concerted efforts are made to raise their soil fertility through rapidly promoting judicious fertiliser use, there would be little incentive on the part of farmers for investment in dryland technologies.

The need for raising rates of application on irrigated and unirrigated fertilised land is seldom disputed. Our emphasis, however, is on accomplishing this through research on and extension of optimal fertiliser practices rather than through manipulation of prices. Clearly, high rates of fertiliser use cannot be an end by itself. They must contribute maximum possible additional agricultural production. Only then could they be viable in the long run. Optimal fertiliser practices like balance among nutrients, correct timing and placement, and wherever necessary the use of soil amendments and micro-nutrients increase response of crops to fertiliser use and thus raise rates of application.

The above efforts to tap the potential of fertiliser use and raise it continuously call for public investment in different directions. Equally importantly, they need effective mechanisms to resolve conflicts between different segments of the fertiliser system, and also between short-term expediencies and long-term goals. Thus, these efforts are neither costless nor easy. But then what other less costly and equally effective alternatives are there to raise India's fertiliser consumption by more than 500,000 tons year after year?

# FOOTNOTES

1 India's fourth rank is of course due to its large size. But the same applies to the first rank of the U.S.A., the second rank of the U.S.S.R., and the third rank of China because they rank much lower on a per hectare basis. What is important to note, however, is that until the 1960s, neither China nor India came in the top 15 countries. India's record in raising its fertiliser consumption from less than one kilogram per hectare in the early 1950s to 35 kgs. per hectare by 1981/82 is quite impressive when compared with the time taken by many developing and developed countries to raise their per hectare fertiliser consumption in this range. On the other hand, it is considerably poorer than that of China.

2. This is clear from data on yields of different crops and fertiliser consumption per hectare of arable land available from FAO's Production Yearbook and Fertilizer Yearbook respectively. It may, however, be noted that comparisons of fertiliser consumption per hectare of arable land based on FAO's data exaggerates the differences between India and many other countries, notably those where a substantial proportion of total fertiliser consumption is on pasture land as in some European countries, Australia, and New Zealand, and those with a high degree of multiple cropping as in some Asian countries, including China. There is hardly any fertiliser use on hay and pastures in India. The data for India in the FAO statistics relate to gross cropped area (which includes multiple cropped area) whereas those for many other countries (including China) relate to arable land which excludes multiple cropped area.

3 The estimates made by the National Commission on Agriculture show that 102 million tons out of 126 million tons of additional foodgrain production depends on raising fertiliser consumption. Against this, the contribution of increased irrigation, command area development and dry farming programme

taken together is estimated at 24 million tons. For details, see India, Ministry of Agriculture and Irrigation, Report of the National Commission on Agriculture, New Delhi, 1976, Part III Pp 75-80.

4 Voelcker, John Augustus, Report on the Improvement of Indian Agriculture, Eyre and Spottiswoode, London, 1893, P.41.

5 Randhawa, N.W., and H.L.S.Tandon, "Advances in Soil Fertility and Fertiliser Use Research in India," Fertiliser News, Vol.27, No.2, February 1982, Pp.11-26. Also see other articles in this Special Number brought out on the occasion of 12th International Congress of Soil Science held in New Delhi, February 8-16, 1982.

6 Tang, Anthony M., and Bruce Stone, Food Production in the People's Republic of China, International Food Policy Research Institute, Washington D.C., May 1980, especially P.47.

7 For examples, see the estimates made by NCA and UNIDO. For NCA's estimate, see source cited in (3) above. For UNIDO's estimate, see UNIDO, Draft Worldwide Study of the Fertiliser Industry: 1975-2000, 1976, Chapter 2.

8 The dimension of the task of generating "desired" growth in fertiliser consumption is more clearly brought out in absolute rather than in percentage terms because of the vast changes in the base level. Thus, for instance, 5 to 7 percent growth rate in fertiliser consumption is needed to raise it to 15 to 20 million tons by the year 2000. In the last three decades, fertiliser consumption grew by a rate considerably higher than 7 percent in 20 years. Viewed thus, the task does not appear formidable. Inasmuch as 5 to 7 percent growth rate imply more than 500,000 tons of annual increments in consumption, however, the task does not seem all that easy.

9 It is necessary to distinguish between cultivators' decisions about whether to use fertiliser and which crops to fertilise because fertiliser is a divisible input. Available evidence

clearly indicates that cultivators seldom fertilise more than one crop when they begin fertiliser use, and do not fertilise quite a few other crops on which the use is potentially profitable for a number of years. See Gunvant M.Desai, Chary P.N., Bandopadhyay S.C., Dynamics of Growth in Fertiliser Use at Micro Level, Centre for Management in Agriculture, Indian Institute of Management, Ahmedabad, 1973, (Mimeographed).

10 The dominant influence of agronomic factors in governing growth of fertiliser use is clear from relatively faster diffusion of fertiliser use on crops like sugarcane, potatoes, sugarbeets and vegetables which more responsive to fertiliser use than many others. Similarly, it is clear from faster diffusion of fertiliser use on the same crop when grown under agro-climatic environment where its response to fertiliser use is superior than when it is grown in relatively poor agro-climatic environment (e.g., crop grown with irrigation as opposed to same crop grown without irrigation). Experiences of virtually all countries indicate this.

11 For example, see researches on fertiliser demand in India during the last two decades. For a more recent example, see the fertiliser demand study of NCAER. 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, International Food Policy Research Institute, Washington D.C., 1982, Chapter 6 and Appendix.

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

13 For instance, under the fertiliser 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, Teachnical and Economic Possibilities of the Use of Nitrogen Fertiliser in India, IARI, New Delhi, 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.

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

15 For details, see Report of the Working Group on Fertiliser Distribution System in Gujarat, Government of Gujarat, 1983.

16 See various issues of Fertiliser Statistics, Fertiliser Association of India, New Delhi, for data on fertiliser consumption by states and districts.

17 Thus, for instance, districts accounting for about one-fifth of the country's gross cultivated area have been dominant in the past growth of fertiliser consumption with a share of about 55 percent. Average rates of fertiliser 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 fertiliser use, rates of application on fertilised land in these districts, which have dominated the past growth, must have reached considerably higher levels (probably 75 to 80 kgs. per hectare) by late 1970s.

18 The problem of raising fertiliser consumption under unirrigated conditions should not be viewed as occurring only with low rainfall. A study based in the fertiliser 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. See, Gunvant M.Desai and Gurdev Singh, Growth of Fertilizer "se in Districts of India, Performance and Policy Implications, Centre for Management in Agriculture, Indian Institute of Management, Ahmedabad, 1973, Chapter 4. Scrutiny of the trends in the 1970s indicates a similar pattern. Also, see 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 organised by ICRISAT and Indian Society of Agricultural Economics in Hydrabad from August 22 to 24, 1983.

19 This cannot be overemphasised because the quantum of additional production due to fertiliser use depends on such things as timing and method of fertiliser 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 fertiliser use are considerably lower than on irrigated areas. On the other hand, available research clearly indicates that with appropriate practices, returns to fertiliser use on rainfed areas could be considerably enhanced.

20 For various deficiencies in the working of soil testing service and how their removal will increase efficiency of fertiliser use, see C.H. Babaria, Economics of Soil Testing

Service in Gujarat, Unpublished Ph.D. thesis, Department of Economics, Sardar Patel University, Vallabh Vidyanagar, 1977. Also see, Trailokya Nath Saikia, Use of Soil Testing Services in Assam, Agro-Economic Research Centre for North-East India, Jorhat, 1982; R.D. Sevak, Soil Testing Service in Rajasthan, Agro-Economic Research Centre, Vallabh Vidyanagar, 1982; and T.S. Sohal and others, "Adoption of Soil Testing in Ludhiana," Fertiliser News, Vol.XVII, No.6