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FERTILISER USE IN INDIA : THE NEXT STAGE IN POLICY

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India used about 9 million metric tons (mmts) of nutrients in the form of chemical fertilisers in 1985-86. The Seventh Five-Year Plan aims at raising it to 13.5 to 14 mmts by 1989-90. The consumption should reach about 20 mmts by the year 2000 to achieve the need-based targets of agricultural production.

The past growth in fertiliser use is indeed impressive (Table I). India now ranks fourth in total fertiliser consumption after U.S.A., the U.S.S.R., and China.[1] Its record in raising fertiliser use to about 50 kilograms per cultivated hectare (ha.) in less than four decades also compares quite favourably with many countries.

There is, however, no room for complacency in policies required to raise consumption to the target levels because of three kinds of reasons. Raising fertiliser consumption from 9 mmts in 1985-86 to about 14 mmts by 1989-90 implies an annual increment of more than one mmts in four consecutive years.[2] Against this, annual growth in consumption has exceeded one mmts only once so far. Similarly, the target of 20 mmts by the year 2000 implies an average increment of 733,000 tons every year for a decade and a half against the past record of growth exceeding 700,000 tons in only four years. Thus, by any standard, the task ahead is formidable. More so because the two major forces behind the past growth in fertiliser consumption have weakened, and there are hardly any degrees of freedom to *lower* the real price of fertiliser through budgetary subsidies. The bulk of the past growth in fertiliser use was an outcome of diffusion of fertiliser use on irrigated land and upward movements in the rates of application due to replacement of local varieties by high-yielding varieties (HYVs). The latter was facilitated by containing upward pressures on real price of fertiliser through budgetary subsidies on fertilisers and food. All evidence suggests that both fertiliser use and HYVs have spread to virtually all irrigated land; and, at least on a subset of this land, the rates of application have also reached fairly high levels. In the meanwhile, the burden of food and fertiliser subsidies has grown reaching Rs.

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1. India's fourth rank is of course due to its large size. But the same applies to U.S.A., U.S.S.R. and China. All rank much lower on the basis of consumption per hectare. Even on total consumption basis, India was behind many much smaller countries until the 1970s.

2. The magnitude of the task is highlighted in absolute rather than in percentage terms because of vast changes in the base level in recent years. This is also more helpful in inferring the implied dimensions of many tasks in such systems as agricultural research, extension, credit, and fertiliser distribution and supply to generate the required growth in consumption.

Table I. Fertiliser Consumption in India, 1951-52 to 1984-85

Year	Consumption[a] ('000 tons)				Consumption[b]
	N	P_2O_5	K_2O	Total	per ha. (kg.)
1951-52	59	7	8	74	0.6
1956-57	123	16	15	154	1.0
1961-62	250	61	28	339	2.2
1966-67	738	249	114	1,101	7.0
1973-74	1,830	650	360	2,839	16.7
1974-75	1,766	472	336	2,573	15.7
1975-76	2,149	467	278	2,894	16.9
1976-77	2,457	635	319	3,411	20.4
1977-78	2,913	867	506	4,286	24.9
1978-79	3,420	1,106	592	5,117	29.3
1979-80	3,498	1,151	606	5,255	31.0
1980-81	3,678	1,214	624	5,516	31.8
1981-82	4,069	1,322	676	6,067	34.3
1982-83	4,224	1,436	727	6,387	36.2[c]
1983-84	5,204	1,730	775	7,710	43.6[c]
1984-85	5,486	1,886	839	8,211	46.4[c]

Source: Fertiliser Statistics, 1984-85, Fertiliser Association of India, New Delhi, 1985.

a. Distribution taken as consumption for 1951-52 and 1956-57.

b. Based on *gross* cropped area.

c. Based on gross cropped area in 1981-82.

3,700 crores in 1985-86. In just three years between 1982-83 and 1985-86, these subsidies have gone up from Rs. 1,316 crores to Rs. 3,700 crores.[3]

Thus, there is a need for dispassionate discussion of three questions: Is there a need for substantial further growth in fertiliser use ? What should be the strategy to achieve further rapid growth in fertiliser use ? What policies are required to implement the strategy ?

NEED FOR FURTHER GROWTH

Although the considerations behind raising fertiliser use are generally known and seldom disputed, a brief recapitulation seems a useful starting point to discuss the above questions.

Substanital additional growth in agricultural production is needed to meet the basic necessities of a large and growing population. It is also needed to generate agricultural surpluses required for economic development with emphasis on employment and equity. The bulk of the growth in agricultural production will have to come from continuous increases in the productivity of land. Yield-based growth cannot be sustained without removing soil fertility constraints and promoting technological change. For both these purposes, substantial growth in fertiliser use is necessary.

The widespread deficiency of nitrogen in Indian soils is known since long. The availability of phosphorus and potash is also low. Furthermore, the evidence on deficiencies of sulphur and micro-nutrients at a growing number of locations is accumulating.[4]

Surely, chemical fertilisers are only one of the sources of plant nutrients. Similarly, the productivity of land depends on many factors besides the availability of plant nutrients. But, as the experience world over suggests, chemical fertilisers have become increasingly important in removing soil fertility constraints and continuously raising land productivity through facilitating technological change. Even China, with its exemplary performance in mobilising organic sources of plant nutrients, is no exception.[5] Incidentally, China's fertiliser consumption has reached 18 mmts against India's 9 mmts. Both were using less than one lakh tons in the early 1950s.

The need for further growth in fertiliser use is also underscored by the dependence of proven yield-increasing technologies on fertilisers. This is obvious from the experience of high-yielding varieties (HYVs) on irrigated land.

3. The following observations of the Union Finance Minister are pertinent in this context: "Food and fertiliser subsidies have now reached Rs.3,700 crores and have increased by over 40 per cent per annum in the last three years. Even with buoyant tax revenues, this order of increase is simply not sustainable. At present rates of growth, these subsidies would have reached Rs. 14,000 crores by the end of the Seventh Plan. At this rate, total subsidies would exceed Rs. 41,000 crores for the Plan period. This is equal to the entire Central Plan for the first two years. To put it in another way, this amount would be sufficient to provide one deep tube-well and one primary school building in each village of the country. The issue is what balance to strike." See Speech of Shri Vishwanath Pratap Singh, Union Finance Minister, Presenting Central Government's Budget for 1986-87, Part A, Paragraph 17, February 1986.

4. See Randhawa and Tandon (1982). Also, other papers in the same publication brought out on the occasion of the 12th International Congress of Soil Science, Tandon (1976), Ghosh (1980), Roy *et al.* (1978), Takkar and Randhawa (1978), and Biswas *et al.* (1985).

Even on unirrigated land, the complementarity between HYVs and fertilisers is clear wherever suitable varieties were available. This is not surprising. Low fertility of soils is as severe a constraint as any other in promoting technological change on unirrigated land. Unless efforts are made to raise fertility of unirrigated land through judicious use of fertilisers, the farmers would have little incentive to invest in dryland technologies irrespective of their form and content.[6]

When the above arguments are considered together with the fact that as much as half of the cultivated land is yet to come under fertiliser use, it becomes clear that the pertinent question concerning the future is not *whether* but *how* to raise fertiliser consumption.

In discussing this question, it is important to recognise that the growth in fertiliser use is not an end in itself; the end is growth in agricultural production. More importantly, further growth in agricultural production must facilitate growth in employment and alleviate the incidence of poverty. In the present context, what this really means is that the growth in fertiliser consumption, although indispensable, must occur with maximum economic efficiency Without this perspective, the discussion on how to raise fertiliser consumption seems to generate fruitless controversies, especially on policy issues concerning agricultural prices and fertiliser subsidies.

CONVENTIONAL APPROACH TO DISCUSS POLICY REQUIREMENTS

Policies for growth in fertiliser use are often discussed by estimating the relationships in which the observed growth in fertiliser consumption is considered a function of such variables as level of irrigation, area sown to HYVs, cropping pattern, and prices of crops as well as fertilisers, that is, the variables which determine the farmers' returns on and hence their demand for fertilisers. The estimated coefficients are then used to draw conclusions on policies required to generate the desired pace of growth in fertiliser use.

Obviously, identifying the sources of the past growth in fertiliser consumption is the first step in discussing policy requirements for the future. But the above methodology is inappropriate because of two basic reasons.

First, by viewing growth in fertiliser use as an *outcome* of growth in fertiliser demand, the methodology implies that supply and distribution of fertilisers exert no influence of their own on the growth in fertiliser use except through fertiliser prices. When these prices are determined administratively rather than by forces of demand and supply, this means there are no constraints on the supply and distribution side to adjust to changes in fertiliser demand. More often than not, these assumptions are not justified. Thus, to interpret the observed growth in consumption as a phenomenon driven *only* by the farmers' demand for fertilisers seems simple-minded. Furthermore, with such an interpretation, one bypasses the policies required to remove the deficiencies in fertiliser supply and distribution systems which may constrain future growth in fertiliser use.

6. See Tandon (1981), Tandon and Kanwar (1984), Rajendran *et al.* (1982), Jha *et al.* (1981), and Desai (1983).

Second, interpreted even as an outcome of growth in the farmers' demand for fertilisers, it seems illogical to use the analytical framework of comparative statics and attribute the growth in fertiliser consumption to only *changes* in the variables like irrigation, HYVs, and prices of fertilisers and crops. These variables certainly influence the farmers' demand for fertilisers. But that does not necessarily mean that, under all circumstances, the growth in fertiliser demand is *causally* determined only by *changes* in them. As shown in the next section, until consumption reaches the potential determined by a given set of conditions with respect to the variables like irrigation, HYVs, and prices, there is a disequilibrium between the farmers' demand for fertiliser and these variables. The growth in fertiliser demand, therefore, depends more crucially on changes in the factors behind the disequilibrium than in the variables behind response functions and prices.

Thus, there are serious epistomological questions in choosing a methodology to identify the forces behind the observed growth in fertiliser use. It seems erroneous to bypass them by estimating simplified relationships based on assumptions of comparative statics. Because of the 'specification errors', the statistical results of such exercises often lead to imprudent—if not altogether unrealistic—policy prescriptions especially with respect to prices. To draw meaningful policy lessons from the past experience, therefore, what we first need is an approach to interpret growth in fertiliser use—an approach which incorporates all major variables and relationships behind the growth.

UNDERSTANDING GROWTH IN FERTILISER USE: A HEURISTIC APPROACH[7]

The agronomic potential of fertiliser use in a country is determined by factors like soil quality, climatic environment, cropping pattern, genetic characteristics of crops, and use of inputs other than fertilisers. Together, these factors determine physical responses of crops to fertiliser use, and thus the maximum amount of fertiliser which could be used to increase agricultural production. The economic viability of fertiliser use is determined by both the above factors behind fertiliser response functions as well as prices of crops and fertilisers.

We shall call all these determinants of economic potential 'agro-economic variables'. Each set of these variables determines the maximum amount of fertiliser which could be used most profitably. The economic potential is less than agronomic potential because fertiliser is not a free input. Clearly, the term 'potential' as defined here is not a fixed quantity. Nor would it be correct to view it as 'potential demand'. It represents the maximum quantity of fertilisers which *could* be profitably used under a given set of agro-economic variables.

Actual fertiliser use is an outcome of both the conversion of the economic potential into farmers' effective demand for fertilisers and fulfilment of this demand by fertiliser supply and distribution systems. Besides agro-economic variables, three 'processes' and their interactions influence the level of actual fertiliser use. First is the process which converts the economic poten-

7. For elaboration, see Desai (forthcoming).

tial into farmers' effective demand for fertilisers. This involves generation of knowledge about fertiliser 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 fertilisers from factories and ports to geographically dispersed locations. Fertiliser distribution system is behind this process. The third process determines aggregate supply of fertilisers. Domestic fertiliser factories and institutions importing fertilisers are involved in this process.

Examining the questions related to the growth in fertiliser use by distinguishing between agro-economic variables and the three *indispensable* processes as well as a number of systems behind them drives home a simple point: Growth in fertiliser use is determined not only by changes in the agro-economic variables behind the economic potential of and farmers' demand for fertiliser but also by factors which influence the development and working of the various systems which convert the viable potential into actual fertiliser use. This simple point is the crux of the matter in understanding the *dynamics* of growth in fertiliser consumption because the use begins way below the economic potential.

Empirical evidence from several countries consistently reveals that fertiliser use begins with a few farmers using it on selected crops at limited locations. There is less than complete diffusion of fertiliser use on land where the use is potentially profitable. Even on fertilised land, the rates are sub-optimal. Thus, when the use begins, there is a vast untapped potential of use under the prevailing response functions and price environment. Actual fertiliser consumption grows over time as a consequence of the tapping of the unexploited potential through diffusion of use on unfertilised land (where the use is potentially profitable) and increases in the rates of application on fertilised land toward the optimum levels.

The pace and geographical-cum-cropwise pattern of growth in fertiliser use are influenced by initial conditions with respect to agro-economic variables, subsequent changes in them, and the developments of the various systems involved in the three processes which convert the viable potential into actual use. Until the economic potential is substantially tapped, the growth in fertiliser use is influenced more decisively by the pace of developments of the systems behind the three processes than by marginal changes in the agro-economic variables. This is not surprising because farmers, though rational, are not omniscient. They need location-specific information on the responses of crops to fertiliser use to judge which of the crops could be profitably fertilised and to work out the details of fertiliser practices. Agricultural research system which generates such information and the extension system which delivers it to the farmers influence these decisions of the farmers. Similarly, sufficient credit is often necessary to convert the farmers' perceptions of profitability on fertiliser use into their *effective* demand for fertilisers. But even this is not enough. The actual use of fertilisers would still depend on whether adequate fertilisers are available at the right place and time. This depends on the level of development and efficiency in the work-

ing of fertiliser distribution, production, and import systems. All these systems are seldom adequately developed until fertiliser consumption reaches a fairly high level. It is, therefore, easy to see why their development and working exert greater influence on the pace and pattern of growth in fertiliser use than marginal changes in the agro-economic variables.[8]

The development of the above systems influences the growth in fertiliser consumption not only by tapping the unexploited potential but also by raising the profitability and economic potential of fertiliser use. Historical experiences of countries with high levels of fertiliser use show that agricultural research and extension systems have been behind the upward shifts in response functions. Similarly, reductions in the farmers' fertiliser cost have resulted from technological breakthroughs and operational efficiencies in fertiliser production and distribution systems. And higher prices of crops have come from expansion in demand for agricultural output due to rapid economic growth. Changes in the price environment resulting from these developments need to be distinguished from those based on price support and subsidy policies. While these policies make fertiliser use more profitable to the farmers, they usually distract attention of the policy makers from the more demanding tasks of developing the systems which are indispensable to growth in fertiliser consumption in a viable manner. Worse still, by constraining the resource position, such policies often restrict public expenditure on the development of such systems.

There are four main advantages in using the above approach to examine the past experience of growth in fertiliser consumption. First, it distinguishes between the economic potential and actual use of fertilisers and identifies all essential variables and relationships behind the two. Second, it recognises that fertiliser use begins below the economic potential and differentiates beween geographical-cum-cropwise diffusion and upward movements in the rates on fertilised land in describing the growth in actual fertiliser consumption.[9]

8. In other words, the genesis of disequilibrium between actual fertiliser consumption and the agro-economic variables lies in the actual consumption being way below the potential when the use begins. The pace of correction in this disequilibrium depends on the variables behind the three processes which convert the potential into farmers' *effective* demand for fertilisers *and* fulfil the demand by making fertilisers available to them. This is not to argue that changes in agro-economic variables have no influence on the pace of these processes. Our contention is that at least until actual consumption reaches fairly close to the potential, many other factors affect the pace of correction in the disequilibrium more decisively than *marginal* changes in the agro-economic variables. These other factors are such as public expenditure on development of various systems behind the processes, and institutional arrangements as well as physical infrastructure which affect the working of these processes. This is especially true in developing countries where the various systems are inadequately developed and their working is *not* governed only by market forces of demand for and supply of fertilisers.

9. It is analytically useful to differentiate between geographical-cum-cropwise diffusion and upward movements in the rates of application per unit of land. A little reflection will show that the 'causal' variables behind the two determinants of growth in total consumption are not identical. This is especially important in evaluating the past policies to draw lessons for the future as shown in the paper in the subsequent sections.

Third, without belittling the influence of agro-economic variables like irrigation, HYVs, and prices on the farmers' demand for fertilisers, it explains why the pace and pattern of growth in fertiliser use also depend on many more factors. And this it does by drawing attention to the three *indispensable* processes behind growth in fertiliser consumption, namely, conversion of economic potential into farmers' effective demand for fertilisers, timely supply of fertilisers at geopgraphically dispersed locations, and enlargement of aggregate fertiliser supply. Fourth, by viewing growth in fertiliser consumption in such logical terms, the approach covers the entire gamut of relevant policies. These advantages are real and not just hypothetical as shown in the next two sections.

PAST GROWTH IN FERTILISER USE

The focus is on three questions: What were the main forces behind the past growth in consumption ? What role did the government policy play ? With the benefit of hindsight, what can be said about the main strengths and weaknesses of the past policies ?

The use of chemical fertiliser began in India on tea plantations during the first quarter of the century. It spread little outside the plantation sector until the mid-1940s when the Government launched the Grow More Food Campaign in the wake of the Japanese occupation of Burma (from where rice was imported) and the Bengal Famine.[10] In the subsequent four decades, annual fertliser consumption grew from less than 50,000 tons to about 9 million metric tons. One or the other aspect of this growth has received the attention of many researchers. Perhaps, in no other country has the fertiliser scene been researched into as extensively as in India.

Reviewing the accumulated research in the heuristic framework leads to three unmistakable conclusions: First, Government policies to accelerate food production have exerted a far greater influence on growth in fertiliser consumption than is generally recognised. Second, between price and non-price factors, the latter have been more important in determining the pace and pattern (cropwise as well as geographical) of growth in fertiliser use. Third, under the prevailing environment with respect to fertiliser response functions and prices, the growth in fertiliser consumption could have been faster but for the deficiencies in the three processes which convert the economic potential into actual use.

As mentioned above, until the Government launched the Grow More Food Campaign, fertiliser use was largely confined to the plantation sector. With the impact of the partition on the food problem, efforts to raise food production gathered momentum. The importance of accelerating food production was further underscored by factors like increased growth rate of population, need to conserve foreign exchange, difficulties in getting food aid, droughts of the mid-1960s, and the concern to alleviate poverty. Surely, raising fertiliser consumption was only one element in the policies followed to increase food production. But these policies had the most far-reaching imp-

10. For historical perspective, see Desai (1969, 1979 *a*).

act on the growth in fertiliser use in the non-plantation sector. This can best be seen in terms of their impact on the economic potential of fertiliser use as well as on the three processes converting the potential into actual fertiliser use. Thus, for instance, the development of irrigation facilities and policies pursued to propagate HYVs substantially raised the potential of fertiliser use. They also facilitated the conversion of the potential into farmers' demand for fertilisers by making the use more profitable. Similarly, the establishment of a nationwide agricultural extension system, thousands of fertiliser trials on the farmers' fields, and the development of co-operatives and other institutions to supply an increasing amount of credit to the farmers contributed to generating growth in demand for fertilisers. In meeting this demand, policies pursued to establish and expand the fertiliser distribution system, enlarge the availability of fertilisers through domestic production and imports, and control regional allocation of supplies have played a key role in determining the past pace and pattern of growth in fertiliser use. Thus, the forces behind the past growth in fertiliser consumption cannot be correctly deciphered without taking into account the *whole set* of policies pursued to combat the *food problem*. More so, because the processes generating growth in either demand for or supply of fertilisers (at micro or macro level) in India have neither originated from nor operated under free market conditions.

Between price and non-price factors behind the growth in fertiliser use, the latter have been more important. Several features of the pace and pattern of growth clearly reveal this:[11] The bulk of the growth in fertiliser consumption has occurred after the introduction of HYVs. Diffusion of fertiliser use on the same crops has been faster under irrigated than under unirrigated conditions. Its use on oilseeds and pulses began in the 1950s but the growth has been much slower than on rice and wheat despite better price environment for the former. Although fertiliser prices have been uniform throughout the country, the pace of growth in consumption has varied widely among States, districts, and talukas (or blocks) due to variations in irrigation, cropping pattern, spread of HYVs, and the level of development of fertiliser distribution and agricultural credit systems.

The importance of non-price factors is also brought out by the experience of the Sixth Plan period.[12] Between 1979-80 and 1984-85, fertiliser consumption grew by 3 mmts. This increment was 32 per cent larger than the growth in consumption during the Fifth Plan period. The acceleration in consumption was *not* due to the price environment becoming more favourable to the farmers (Table II). In fact, the farmers needed more units of crops to buy a unit of fertiliser during the Sixth Plan period than in the years immediately preceding it. The accelerated growth in consumption was due to further expansion of irrigation and area sown to HYVs, pressure of 'excess' supply of fertilisers leading to greater promotional efforts and expansion of

11. For details, see Desai (1982).
12. For elaboration, see Desai (1986 *b*).

Table II. Relative Prices of Fertilisers to Crops, 1977-78 to 1984-85

Year	Ratio of urea based nitrogen price to minimum support price of							
	Paddy[a]	Wheat	Coarse grains	Gram	Groundnut (Shell)	Sugar-cane	Seed cotton	Jute
1977-78	4.38	3.00	4.55	3.55	2.11	39.65	1.32	2.39
1978-79	3.96	2.93	3.96	2.70	1.93	33.70	1.32	2.25
1979-80	3.32	2.69	3.32	2.25	1.66	25.20	1.15	2.03
1980-81	4.14	3.35	4.14	3.00	2.11	33.46	1.43	2.72
1981-82	4.44	3.65	4.41	*b*	1.89	39.31	*b*	2.92
1982-83	4.19	3.38	4.33	*b*	1.73	39.31	1.34	2.92
1983-84	3.53	3.07	3.77	1.99	1.48	34.59	1.17	2.52
1984-85	3.41	2.97	3.59	1.95	1.37	33.36	1.14	2.39

Source: Developed from information available in Indian Agriculture in Brief (20th Edition), Economic Survey, 1984-85, and Fertiliser Statistics, 1984-85.

a. Coarse variety of paddy.
b. Minimum price not announced.

Table III. Percentage of Area Fertilised according to Irrigation Availability and Type of Variety, Selected Crops, 1976-77

Crop	IA-HY and IV	IA-TV	UA-HY and IV	UA-TV	HY and IA	HY and UA	HY and IV	HY and TV	All
Rice	84.9	61.6	63.1	19.0	72.4	20.6	83.1	33.1	44.9
Wheat	81.4	49.4	19.4	9.1	70.2	10.5	77.3	30.9	55.1
Jowar	71.4	33.2	61.8	7.6	42.7	13.0	64.5	10.8	17.3
Bajra	30.2	13.6	21.5	6.4	18.7	7.3	26.9	7.7	11.5
Maize	86.1	45.9	61.5	12.8	54.6	18.0	78.1	28.5	36.5
Sugarcane	82.4	65.9	52.0	18.8	74.1	34.5	79.1	60.4	69.7
Cotton	85.2	51.1	76.9	13.5	73.6	27.0	81.9	20.0	42.4
Groundnuts	52.8	53.1	68.4	34.7	53.0	35.4	63.0	37.8	38.6
All crops above	81.2	51.9	53.3	15.7	66.6	18.8	76.8	27.6	41.3

Source: Based on NCAER's Fertiliser Demand Study (Survey on Pattern of Fertiliser Use on Selected Crops), New Delhi, October 1978. For Methodology and other details, see Desai (1982).

Notes:– IA = Irrigated area; UA = Unirrigated area; HY and IV = High-yielding and improved varieties; TV = Traditional varieties.;

the distribution system, increased flow of credit to the farmers, and more than seven-fold increase in the supply of quality seeds.[13]

The above evidence is not cited either to argue that price environment did not matter in the past growth of fertiliser use or to suggest that price policies did not have any role. That would be preposterous. What is stressed is that non-price factors (like cropping pattern, crop varieties and irrigation, on the one hand, and development and working of the agricultural research, extension, and credit as well as fertiliser supply and distribution systems, on the other hand) have been more important in determining the past pace and pattern of growth in fertiliser use than prices of crops or fertilisers. The reasons behind this are easy to see once the heuristic framework is used to understand *how* the growth in fertiliser use occurs.

Although the past growth in total fertiliser consumption was impressive, it could have been faster under the prevailing environment with respect to fertiliser response functions and prices.[14] That there was sufficient scope for faster growth is indicated not only by the total consumption being less than the economic potential but also by certain features of growth in consumption.[15] Thus, for instance, fertiliser diffusion was not complete on any crop, even under irrigated conditions, until at least the mid-1970s (Table III). Available evidence also shows that fertiliser use on none of the crops was confined to irrigated areas or HYVs. More importantly, the use on even traditional varieties sown on unirrigated areas grew over time, albeit slowly. Nor was the use confined to large and medium size farms, or to only owner cultivators. All this suggests the existence of a viable potential of fertiliser use and the farmers' willingness to tap 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* pace and pattern of growth.

13. The importance of increased supply of quality seeds in influencing the growth of fertiliser use cannot be over-emphasised. The spread of HYVs shift fertiliser response functions upwards and thus shift fertiliser demand curves outwards (see Desai, 1979 *b*). These shifts, however, can be sustained only if there is commensurate growth in the supply of quality seeds because seeds of even non-hybrid varieties should be replaced at regular intervals to maintain their genetic potential. A review of the literature on the seed system clearly suggests that the impact of the spread of HYVs on the demand for fertiliser (and eventually on yields) critically depends on rapid removal of various deficiencies in this system.

14. 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 metric tons of nitrogen (Panse, 1964). Actual nitrogen consumption in the early 1960s was only about 300 000 tons. It crossed 3.57 million tons only in 1980-81 but by then the potential must have gone up substantially because of vast growth in irrigated area and widespread diffusion of high-yielding varieties (see Parikh and Srinivasan, 1974; Parikh, 1980 for the response function environment in India). The level of fertiliser use is still below the potential. This is suggested by the findings of All India Coordinated Agronomic Research Project (AICARP) on crop responses to fertilisers in different soil and agro-climatic regions (see Pillai *et al*., 1985) and fertiliser consumption statistics by districts and States.

15. These features emerge from dozens of micro level studies, and also from nationwide sample surveys conducted by the National Sample Survey Organisation, the National Council of Applied Economic Research, and the Indian Agricultural Statistics Research Institute. For a summary of the findings, see Desai (1982) and Sah (1984).

The answer lies in certain weaknesses of the processes which converted the viable fertiliser potential into actual use. Among these, the following stand out: inadequate efforts to convince the farmers about returns on fertiliser use under unirrigated conditions, irrigation and HYV bias in the supply of production credit, slow expansion of and various inefficiencies in the working of fertiliser distribution systems, repeated shortfalls in planned domestic fertiliser production, and wide annual fluctuations in fertiliser imports. Wherever the systems behind the processes which generate growth in actual fertiliser consumption were relatively strong, the growth in consumption has been faster despite the not so favourable environment with respect to response functions. The experience of Gujarat clearly reveals this.[16] Despite less than 20 per cent of its area irrigated and poor rainfall environment, Gujarat had a higher level of fertiliser consumption per hectare than many States with more irrigation and superior rainfall environment. This was mainly due to faster diffusion of fertiliser use under not only irrigated but also unirrigated conditions. A fairly widespread network of fertiliser distribution system, its efficient working, and the pressure from the supply side, especially fertiliser factories located in the State were the main reasons behind Gujarat's superior performance in raising its fertiliser use.

STRATEGY AND POLICIES FOR FUTURE GROWTH IN FERTILISER USE

To discuss the strategy and policies for future growth in fertiliser use meaningfully, it is not enough to understand *how* and *why* of the past growth. It is just as important to bear in mind two more points.

First, the nature of the challenge in increasing agricultural production has changed. It is no more a question of substituting imports of cereals through rapid growth in their domestic production. More production of cereals is of course needed. But it is needed to alleviate hunger of the poor whose main source of income is employment and whose main item of expenditure is food. Therefore, additional production of cereals has to be in the most cost-effective manner to facilitate employment-oriented economic growth. Obviously, the price policy implications of this are quite different from that of increasing production to substitute imports.[17] In terms of import substitution, the focus has to be on oilseeds and pulses. And here, price incentives are not sufficient as the past experience clearly shows.

Second, the bulk of the past growth in fertiliser consumption has remained concentrated in less than one-fourth of all districts. Furthermore, most of these districts are located in about one-third of the States. Both diffusion and rates have reached fairly high levels in these regions. Consequently, continued dependence on these regions for further growth in fertiliser consumption would lead to greater pressures for higher prices of crops and lower prices for fertilisers. This is natural because of diminishing marginal production from additional fertiliser use. The fertiliser industry and trade have been generally sympathetic to such pressures because these are the markets they have developted and catered to.

16. See Government of Gujarat (1983).

17. For discussion of these issues, see Mellor and Desai (1986), especially papers of Ahluwalia, Dantwala, Mellor, Rao, Sen, and Mellor and Desai.

These two considerations taken together with the discussion in the previous sections suggest that the strategy of further growth in fertiliser consumption should simultaneously aim at exploiting the remaining untapped potential *and* raising the economic potential of fertiliser use through improving the response function environment. This strategy is not very different from what is implied by the tentative Statewise break-up of the aggregate fertiliser consumption target of the Seventh Plan (Table IV). Such a strategy, however, cannot be implemented successfully by a fragmented ad hoc approach to fertiliser policy issues. What is needed is a new orientation in which complementarities between different aspects of fertiliser policies are fully understood. Similarly, policy matters in the domain of the State Governments are considered as crucial as the policies of the Central Government. The following paragraphs elaborate these points.

Most of the unexploited potential is on more than 70 per cent of unirrigated land. This land accounts for more than 80 per cent of the production of jowar, bajra, pulses, and oilseeds, about 67 per cent of cotton production, and 30 to 40 per cent of the production of rice and wheat. Therefore, raising the productivity of unirrigated areas through judicious fertiliser use is crucial to sustain yield-based growth in *aggregate* agricultural production. It is also important to increase production of those commodities which are in short supply. For this, location-specific knowledge on fertiliser response functions, fertiliser practices, and other agronomic matters (like sowing time, choice of variety and plant population) need to be generated through strengthened, decentralised research. Improved co-ordination between agricultural research and extension systems is also needed to effectively spread the knowledge among the farmers. What makes these considerations critical in rainfed areas is that without appropriate fertiliser and agronomic practices, the returns on fertiliser use are lower and more uncertain than on irrigated areas.[18] On the other hand, available research clearly indicates that with appropriate practices, the returns to fertiliser use on rainfed areas could be considerably enhanced.[19] Therefore, strengthening the research and extension activities is crucial in the efforts to tap the potential of fertiliser use on unirrigated areas and continuously raise it through technological change. It is also a more sound way than crop insurance schemes to overcome the farmers' resistance in using fertilisers under unirrigated conditions especially because such schemes are generally not viable and difficult to administer.

18. It may be added that the problem of raising fertiliser consumption under unirrigated conditions should not be viewed as occurring only with low rainfall. During the 1960s, districts with low irrigation located in *high* rainfall regions, particularly in Eastern India, performed the worst among all districts with little irrigation (see Desai and Singh, 1973, Chapter 4). A scrutiny of fertiliser consumption trends by districts during the 1970s and early 1980s also suggests a similar pattern. Available evidence also reveals that the districts in Eastern India have in general the least developed fertiliser distribution and agricultural extension and credit systems. That constraints on the distribution and supply rather than on the demand side have been more important behind relatively slow growth in fertiliser use in districts with good response function environment is also brought out by the findings of the Study Group on Agricultural Strategy in the Eastern Region of India appointed by the Planning Commission (see Rao and Singh, 1986).

19. See Tandon (1981), Barker and Herdt (1979), Umrani and Patil (1983), and Tomar *et al.* (1983), and Venkateswarlu (1986).

Table IV. Growth in Fertiliser Consumption in Different States and Union Territories during the Sixth Plan Period and Tentative 1989-90 Targets in the Seventh Plan

Zone, State/ Union Territory	Consumption in ('000 tons)			Average annual increment ('000 tons)		Compound growth rate (per cent)	
	1979-80 Actual	1984-85 Actual	1989-90 Target	1979-80 to 1984-85	1984-85 to 1989-90	1979-80 to 1984-85	1984-85 to 1989-90
Northern							
Punjab	682	1,047	1,326	72.8	55.8	9.0	4.8
Haryana	216	337	545	24.2	41.6	9.3	10.1
Uttar Pradesh	1,009	1,613	2,863	120.8	250.0	9.8	12.2
Himachal Pradesh	14	22	24	1.6	0.4	9.5	1.8
Jammu & Kashmir	21	29	59	1.6	6.0	6.7	15.3
Sub-total	1,942	3,048	4,817	221.0	353.8	9.4	9.6
Southern							
Tamil Nadu	538	691	715	30.6	4.8	5.1	0.7
Andhra Pradesh	535	981	1,782	89.2	160.2	12.9	12.7
Karnataka	366	591	796	45.0	41.0	10.1	6.1
Kerala	106	128	204	4.4	15.2	3.8	9.8
Sub-total	1,545	2,391	3,497	169.2	221.2	9.1	7.9
Western							
Gujarat	378	505	746	25.4	48.2	6.0	8.1
Maharashtra	421	581	1,469	32.0	177.6	6.7	20.4
Madhya Pradesh	160	373	839	42.6	93.2	18.4	17.6
Rajasthan	147	207	449	12.0	48.4	7.1	16.7
Sub-total	1,106	1,666	3,503	112.0	367.4	8.5	16.0
Eastern							
Bihar	184	382	927	39.6	109.0	15.7	19.4
West Bengal	241	406	755	33.0	69.8	11.0	13.2
Oriss	67	114	206	9.4	18.4	11.2	12.6
Assam	7	14	140	1.4	25.2	14.9	58.5
Manipur	3	4	13	0.2	1.8	5.9	26.6
Meghalaya	2	3	7	0.2	0.8	8.4	18.5
Tripura	2	3	9	0.2	1.2	8.4	24.6
Sub-total	506	926	2,057	84.0	226.2	12.8	17.3
All-India	5,255	8,211	14,007	591.2	1,159.2	9.3	11.3

Sources: Based on data available in different volumes of Fertiliser Statistics, Fertiliser Association of India, New Delhi, and Seventh Five Year Plan, 1985-90, Planning Commission, Government of India, New Delhi, 1985.

The above efforts should be *simultaneously* supplemented by adequate and timely flow of credit to the farmers and the development of an efficient fertiliser distribution system. Small increases in distribution margins may not suffice to accelerate the expansion of fertiliser distribution system in rainfed areas especially if vigorous efforts to promote fertiliser use are absent and fertiliser turnover remains low. The working capital requirements of the input distribution systems also need special attention since *timely* availability of seeds and fertilisers is more critical under unirrigated conditions [20]

Neither promotional efforts nor expansion of the distribution system in unirrigated regions would sustain unless aggregate fertiliser supply stays ahead of growth in fertiliser demand in current and newly irrigated areas. This would depend on fertiliser import policy during the Seventh Plan period, and perhaps for a decade more. Despite planned dependence on imports, more often than not, this policy has been governed by such short-term considerations as clearing inventories, savings in foreign exchange, and various insitutional and infrastructural constraints in distribution of imported fertilisers. Consequently, imports have fluctuated widely (Table V). Given the dependence of fertiliser supplies on imports, the policy should be based on an understanding of the role of the supply side in accelerating growth of fertiliser use through sustained pressures on various systems. A policy of 'liberal' imports of fertilisers will most likely be resented by the domestic fertiliser industry. It may also lead to an increase in inventories in the short run because of many deficiencies in the systems handling the distribution of imported fertiliser. But this calls for developing effective mechanisms to tackle the problem areas rather than rejecting a policy which would accelerate the diffusion of fertiliser on unirrigated areas. More so when the budgetary burden of fertiliser subsidies on imported fertilisers is often lower than on domestic fertilisers and could be further reduced if the distribution cost of imported fertilisers are brought down through improvements in the systems handling imports. [21]

Raising the rates of application on fertilised land to optimum levels is another way to tap the unexploited potential. It must, however, be recognised that low rates are often due to sub-optimal fertiliser *practices* which in turn are due to the farmers' lack of knowledge. There is ample evidence of deficiencies in these practices even in States and districts with high levels of fertiliser use. Efforts in this direction should, therefore, concentrate on educating farmers in efficient fertiliser practices such as balanced use of nutrients, correct timing and placement of fertilisers, and wherever necessary, use of micro-nutrients and soil amendments. Adoption of correct practices would increase the efficiency of fertiliser use and thus raise returns on it. Without such efforts, the strategy to increase fertiliser use on land which is already fertilised at fairly high rates (especially of nitrogen) would aggravate the pressure for lower fertiliser prices and higher support of crops.

20. See Sikder (1984), Subbaro (1985), and Desai (1985).

21. See Ramaswamy (1985), especially Chapter 13, and Sikder (1984).

Table V. Fertiliser Imports in India, 1952-53 to 1984-85

Year	Total imports ('000 tons) of nutrients	Per cent share of			Value of total imports (Rs. million)	Value of one ton (Rs.)
		N	P_2O_5	K_2O		
1952-53	47	94	—	6	45.6	970
1953-54	26	73	—	27	25.2	969
1954-55	31	65	—	35	30.2	974
1955-56	63	84	—	16	73.3	1,163
1956-57	72	79	—	21	77.7	1,079
1957-58	123	89	—	11	158.8	1,291
1958-59	119	82	—	18	113.1	950
1959-60	179	79	2	19	162.9	910
1960-61	419	95	—	5	121.8	291
1961-62	382	80	—	20	141.2	370
1962-63	295	83	3	14	236.9	803
1963-64	281	81	5	14	187.1	666
1964-65	301	77	4	19	220.8	734
1965 66	413	79	3	18	411.9	997
1966-67	898	70	16	14	1,288.2	1,434
1967-68	1,487	58	23	19	1,933.0	1,300
1968-69	1,195	71	11	18	1,622.9	1,358
1969-70	881	75	11	14	1,197.7	1,359
1970-71	629	76	5	19	767.8	1,221
1971-72	997	48	25	27	899.7	902
1972-73	1,194	56	17	27	1,212.6	1,016
1973-74	1,242	53	17	30	1,767.5	1,423
1974-75	1,607	55	18	27	5,991.3	3,728
1975-76	1,635	61	22	17	7,227.7	4,421
1976-77	1,051	71	2	27	2,203.6	2,097
1977-78	1,521	50	11	39	3,064.4	2,015
1978-79	1,994	62	12	26	4,600.3	2,307
1979-80	2,006	65	12	23	5,545.0	2,765
1980-81	2,769	55	16	29	9,252.2	3,341
1981-82	2,042	50	17	33	7,166.3	3,509
1982-83	1,132	38	6	56	2,735.3	2,417
1983-84	1.355	48	11	44	3,650.5	2,694
1984-85	3,625	55	21	24	14,350.0	3,959

Source: Compiled from various issues of Fertiliser Statistics.

To increase the economic potential of fertiliser use, accelerated development of irrigation potential and its fuller utilisation are a must. In addition, the agricultural research system needs to be strengthened to improve the response functions on both irrigated and unirrigated areas. The importance of these policies is well recognised and needs no elaboration. In order to exploit the economic potential of these policies, however, deficiencies in agricultural extension (especially with respect to its interface with the research system) and credit as well as fertiliser supply and distribution systems must be removed. Past experience indicates that inadequate appreciation of the complementarity between policies which increase fertiliser potential and those which rapidly convert it into actual use through developing various systems eventually results into long time lags in full exploitation of the potential.[22]

The discussion thus far has focussed on non-price policies for three reasons. First, past growth in fertiliser consumption was determined more by non-price factors and policies behind the processes which converted the potential into actual consumption than by changes in prices of either crops or fertilisers. Second, future growth in consumption crucially depends on further development of these systems and on technological change which improves the response function environment. Third, the scope to raise the profitability of fertiliser use through price policy seems very limited, at least in the short run.

Since 1943, the Government has controlled fertiliser prices at factory, port, and farm-gate levels.[23] The major features of fertiliser price policy have been insulation of domestic farm-gate prices from fluctuations in the world market, equalisation of the cost of domestic and imported fertilisers for farmers, and uniformity in prices all over the country. Until the early 1970s, there was no major budgetary subsidy on fertilisers (Table VI). In fact, there was surplus in all but a few years. This distinguished India from many other developing countries.

The situation has changed since 1973-74 with fertiliser subsidies in the 1985-86 budget of the Central Government crossing Rs. 2,000 crores (Table VII). Initially, subsidies were necessitated by the dramatic impact of the oil crisis on the cost of imported fertilisers. After 1975-76, however, both imported and domestic fertilisers were subsidised. The subsidies on domestic fertiliser have risen rapidly since the introduction of the Retention Price Scheme in 1977. In 1985-86 domestic fertilisers accounted for 78 per cent of the total fertiliser subsidies.

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22. This is especially helpful in understanding why growth in fertiliser use in the eastern States has lagged behind despite a relatively more favourable environment with respect to irrigation and rainfall. It also points at the importance of the role of the State Governments.

23. For a detailed discussion of the evolution of fertiliser price policy, its relationship with fertiliser supply and distribution policies, and the circumstances leading to rapidly growing burden of fertiliser subsidies, see Desai (1986*c*). This paper shows how and why the fertiliser price policy has been deeply embedded in fertiliser supply and distribution policies. Also see Pratap Narayan (1986), Sohbti (1979), and Gupta (1986).

Table VI. Profits and Losses under "The Scheme for Purchase of Chemical Fertilisers," 1944-45-1963-64

Year	Net profit or loss (Rs.)
1944-45	671,583
1945-46	2,564,061
1946-47	−440,316
1947-48	1,429,857
1948-49	142,639
1949-50	1,963,799
1950-51	1,143,466
1951-52	444,627
1952-53	340,158
1953-54	6,870,760
1954-55	−4,547,472
1955-56	875,985
1956-57	2,258,216
1957-58	15,478,413
1958-59	35,050,140
1959-60	63,707,000
1960-61	74,481,063
1961-62	94,719,930
1962-63	85,006,580
1963-64	51,433,663
Total (1951-52 to 1963-64)	426,119,053

Source: Report of the Committee on Fertilisers, Government of India, New Delhi, 1985, p. 184.

Table VII. Fertiliser Subsidies in the Budgets of the Central Government

(Rs. crores)

Year	Imported fertilisers	Domestic fertilisers	Total
1971-72	−20	—	−20
1972-73	−18	—	−18
1973-74	33	—	33
1974-75	371	—	371
1975-76	242	—	242
1976-77	52	60	112
1977-78	159	107	266
1978-79	169	173	342
1979-80	282	321	603
1980-81	335	170	505
1981-82	100	275	375
1982-83	55	550	605
1983-84	142	900	1,042
1984-85	632	1,200	1,832
1985-86 (RE)	450	1,600	2,050
1986-87 (BE)	250	1,700	1,950

Sources: Compiled from Government of India: Report of the Committee on Controls and Subsidies, Ministry of Finance, New Delhi, May 1979, and budget documents.

RE = Revised Estimates; BE = Budget Estimates.

The Retention Price Scheme originated in the enhanced cost of fertiliser production after the oil crisis of the early 1970s and the strategy to meet fertiliser requirements through encouraging the growth of domestic fertiliser industry. The scheme assures a manufacturer 12 per cent post-tax returns on the net worth provided certain norms with respect to capacity utilisation and consumption of raw materials are achieved. The average cost of supplying domestic fertiliser has been higher than the prices fixed for the farmers. The difference between the two has also grown over time due to (i) high investment cost of new fertiliser factories, (ii) escalation in the administered prices of virtually everything which goes into fertiliser production, and (iii) increased cost of fertiliser distribution. This plus nearly a four-fold growth in fertiliser production has resulted into a mounting burden of subsidies on domestic fertilisers—from Rs. 60 crores in 1976-77 to Rs. 550 crores in 1982-83 and to Rs. 1,600 crores in 1985-86.

The subsidy on imported fertilisers during the mid-1970s was mainly due to the high cost of fertilisers in the world market. In recent years, it has been mainly due to a relatively much higher cost of distributing imported as compared to domestic fertilisers.[24] Because of fluctuations in both the volume of imports and world market prices of fertilisers, subsidies on imported fertilisers fluctuated between Rs. 52 crores and Rs.632 crores during the last decade (Table VII). In 1985-86 they amounted to Rs. 450 crores.

The targeted growth in fertiliser consumption is expected to cause fertiliser subsidies to rise substantially by 1990, perhaps to as high as Rs. 7,000 crores.[25] It must, however, be noted that all these estimates do not represent *economic* subsidy on fertilisers. As stated above, the cost of production of domestic fertilisers is very largely governed by administered prices, and some of these prices are much higher than in other countries.[26] For the same reason, there is scope to contain the growth in the budgetary burden of fertiliser subsidies through rationalisation in the pricing and fiscal policies for fertiliser raw materials, feed-stocks, and capital equipments.[27] But even with concerted efforts in these directions, the average real cost of fertilisers supplied by the domestic industry is likely to rise over time because the investment cost of newer plants are higher.

It is beyond the scope of this paper to discuss the relative merits of domestic production vis-a-vis imports of fertilisers. The issue is complex, involving the technology capability and experience gained in fertiliser production,[28] the place of fertiliser industry in the development strategy, and foreign

24. For evidence, see Ramaswamy (1985, Chapter 13). Of the various components of distribution cost, inventory costs are much higher for imported as compared to domestic fertilisers. This, in turn, seems to be due to poor planning, inadequate physical infrastructure at ports, and various inefficiencies in the distribution of imported fertilisers. All these cannot be corrected without a long-term strategy and policy with respect to fertiliser imports.

25. See the articles on "Subsidising Fertiliser" in *The Economic Times* January 3 and 4, 1984.

26. See Desai (1986 *c* and Satya Nand (1986).

27. See Venkitaramanan (1983), Jain and Satya Nand (1980), Satya Nand (1986), and "Experts Debate: Cost Rationalisation the Key" in *The Economic Times* , January 29, 1986

28. See Fertiliser Association of India (1980).

exchange requirements of large scale imports every year. At present, India ranks either first or second to China in net imports of fertilisers among all countries. Thus, India's presence in the world fertiliser market influences the prices. Moreover, these prices do not always reflect the real cost of production in the countries exporting fertilisers. Nor can they be directly compared with the cost of domestic production because the latter is governed by administered prices of fuel and feed-stocks which are higher than in other countries. One thing, however, seems clear: Given the strategy of meeting fertiliser requirements through growth in domestic production, the growing burden of fertiliser subsidies on the *budgetary* resources clearly suggests that there is hardly any scope to *lower* the prices of fertilisers charged to the farmers and thus raise the profitability of its use. This conclusion is also supported by the Long Term Fiscal Policy Paper of the Government.

In the last two decades, the price policy for crops has played a key role in generating the growth of fertiliser use through accelerating the spread of HYVs, Due to their superior response functions, fertiliser use is more profitable on HYVs than on traditional varieties.In the absence of public procurement operations, large marketable surplus might have lowered the prices of wheat, rice, etc., and slowed down the diffusion of HYVs with consequent adverse impact on the growth of fertiliser use. But such impact of agricultural price policy on the growth of fertiliser use is virtually over. Currently, available HYVs are widely diffused. While there is scope to raise the rates of fertiliser application on land sown with HYVs, what is needed to exploit this potential are various non-price measures because the 'low' rates are due to deficiencies in fertiliser and agronomic practices. Another constraint on the policy of supporting prices of crops at higher and higher levels is the relatively slow growth in effective demand for foodgrains and the inability of the surplus production to compete in the world markets without export subsidies. This has resulted in larger procurement and stock holding by the government and growing burden of food subsidies. Removal of the domestic demand constraints depends on rapid growth in employment, and this calls for containing the upward pressures on agricultural prices.

Because of these constraints on lowering *real* prices of fertilisers, non-price policies will be more crucial than ever before in determining the pace of future growth in India's fertiliser consumption. This, however, is no ground for pessimism about the future growth of fertiliser consumption or defeatist attitude in evolving policies required for this purpose. The relative prices of fertilisers and crops are reasonable. They need not become more favourable to the farmers for further growth in fertiliser consumption to occur unless we assume that under the prevailing price environment, there is neither untapped potential of fertiliser use nor scope to raise the profitability of fertiliser use through improving the response functions environment. Clearly, such assumptions are totally unjustified.

But, at the same time, there is no room for complacency either. The task ahead, though feasible, is not easy. It calls for tapping the relatively more difficult unexploited potential of fertiliser use in regions and on crops which have largely remained outside the mainstream of the past growth in use. Similarly, it calls for raising the rates of application on fertilised land through the relatively more difficult task of farmers' education in location-specific optimal fertiliser practices. Therefore, policies to tap the unexploited potential will have to be based on a correct understanding of the deficiencies in various systems and the complementarities between different aspects of fertiliser policies. Also, far more co-ordination between the efforts of the Central and State Governments will be needed than in the past because many aspects of the proceses affecting further growth in fertiliser use are in the policy domain of the State Governments. More importantly still, to raise fertiliser consumption to the targets set for 1990 (or for the year 2000), in ways which are consistent with the ultimate objective of growth in agricultural production, the economic potential of fertiliser use needs to be increased through continuous technological change. The urgency of recognising all this is clear from the implications of the growing fiscal burden of food and fertiliser subsidies for sound economic development.

REFERENCES

Randolph Barker and Robert W. Herdt: Rainfed Lowland Rice as a Research Priority — An Economist's View, International Rice Research Institute, Los Banos, Philippines, March 1979.

B C. Biswas, D.S. Yadav and Satish Maheshwari, "Role of Calcium and Magnesium in Indian Agriculture", *Fertiliser News*, Vol. 30, No. 7, July 1985.

Gunvant M. Desai: Growth of Fertiliser Use in Indian Agriculture: Past Trends and Future Demand, New York State College and Life Sciences, Cornell University, Ithaca, New York, 1969.

Gunvant M. Desai and Gurdev Singh: Growth of Fertiliser Use in Districts of India: Performance and Policy Implications, Centre for Management in Agriculture, Indian Institute of Management, Ahmedabad, 1973.

Gunvant M Desai, "Fertiliser in India's Agricultural Development", in C.H. Shah (Ed.): Agricultural Development of India—Policy and Problems, Orient Longman Ltd., Bombay, 1979 *a*, pp. 379-426.

Gunvant M. Desai, "Impact of the New Rice Technology on Fertiliser Consumption", in Economic Consequences of the Development and Diffusion of Modern Rice Varieties, International Rice Research Institute, Los Banos, Philippines, 1979 *b*.

Gunvant M. Desai: Sustaining Rapid Growth in India's Fertiliser Consumption: A Perspective Based on Composition of Use, International Food Policy Research Institute, Washington, D.C., 1982.

Gunvant M Desai, "Fertiliser Use on India's Unirrigated Areas: A Perspective Based on Past Record and Future Needs", Paper presented in the Seminar on Technology Options for Dryland Agriculture: Potential and Challenge held at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Andhra Pradesh, Aughust 22-24, 1983.

Gunvant M. Desai, "Market Channels and Growth of Fertiliser Use in Rainfed Agriculture: Conceptual Considerations and Experience in India", in Agricultural Markets in the Semi-Arid Tropics, ICRISAT, Patancheru, Andhra Pradesh, October 1985, pp. 41-52.

Gunvant M. Desai, "Understanding Fertiliser Price and Subsidy Policy Issues, Retention Price of Domestic Urea", Paper presented in the Workshop on Fertiliser Consumer Prices held at the Institute for Social and Economic Change, Bangalore, April 25-26, 1986 *a*,

Gunvant M. Desai, "Policies for Growth in Fertiliser Consumption: The Next Stage", *Economic and Political Weekly* , Vol. XXI, No.21, May 24, 1986 *b*, pp. 928-933.

Gunvant M. Desai, "Growth in Fertiliser Consumption: Price and Non-Price Policies", in Edilberto L. Segura, Y.T. Shetty and Meiko Nishimizu (Eds.): Fertiliser Producer Pricing in Developing Countries: Issues and Approaches. The World Bank, Washington,D.C., 1986*c*, pp. 109-136.

Gunvant M. Desai: Understanding the Process of Growth in Fertiliser Consumption: A Conceptualisation (forthcoming).

Economic Times Research Beareau (A Correspondent), "Subsidising Fertiliser", *The Economic Times*, January 3 and 4, 1984.

Economic Times Research Bureau, "Experts Debate: Cost Rationalisation the Key", *The Economic Times* January 29, 1986.

Fertiliser Association of India: Development of Fertilisers in India, New Delhi, 1980.

A.B. Ghosh, "Sulphur in relation to Soil and Crop Situations in India", *Fertiliser News*, Vol.25, No.12, December 1980.

Government of Gujarat: Report of the Working Group on Fertiliser Distribution System in Gujarat, Gandhinagar, 1983.

Anand P. Gupta,"Fertiliser Subsidies", Paper presented in the Workshop on Fertiliser Consumer Prices held at the Institute for Social and Economic Change, Bangalore, April 25-26, 1986.

B.K. Jain and Satya Nand, "Productivity in the Indian Fertiliser Industry", *Fertiliser News,* Vol. 25, No. 12, December 1980.

D. Jha, S.K. Raheja,R. Sarin and P.C. Mehrotra: Fertiliser Use in Semi-Arid Tropical India: The Case of High-Yielding Varieties of Sorghum and Pearl Millet, International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh,1981.

John W. Mellor and Gunvant M Desai (Eds.): Agricultural Change and Rural Poverty: Variations on a Theme by Dharm Narain, Oxford University Press, New Delhi, 1986.

Pratap Narayan, "Fertiliser Pricing in India", in Edilberto L. Segura, Y.T. Shetty and Meiko Nishimizu (Eds.): Fertiliser Producer Pricing in Developing Countries: Issues and Approaches, The World Bank, Washington, D.C. 1986, pp. 137-155.

V.G. Panse: Technical and Economic Possibilities of the Use of Nitrogen Fertiliser in India, Indian Agricultural Research Institute, New Delhi, 1964.

Kirit S. Parikh: HYV and Fertilisers—Synergy or Substitution: Implications for Policy and Prospects for Agricultural Development, International Institute for Applied Systems Analysis, Laxenburg, Austria, 1980.

Kirit S. Parikh and T.N. Srinivasan: Optimum Requirements of Fertilisers for the Fifth Plan Period, Indian Statistical Institute and Fertiliser Association of India, New Delhi, 1974.

K. Gopalakrishna Pillai *et al.:* Crop Response to Fertilisers and Fertiliser Use Efficiency in Different Soil and Agro-Climatic Regions of India, AICARP, University of Agricultural Sciences, Bangalore, 1985.

S. Rajendran, D. Jha and J.G. Ryan: Fertiliser Responsiveness of Chickpeas in India: An Analytical Review, International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh, 1982.

V.S. Ramaswamy: A Study of the Marketing of Fertilisers in India, P. Madhavan, Madras, 1985.

N.S. Randhawa and H.L.S. Tandon,"Advances in Soil Fertility and Fertiliser Use Research", *Fertiliser News*, Vol. 27, No.2, February 1982, pp. 11-26.

C.H. Hanumantha Rao and Padam Singh, "Strategy of Diffusion", *The Economic Times* , January 29, 1986.

R.N. Roy, S. Seetharaman and R.N. Singh: Soil and Fertiliser Potassium in Crop Nutrition: A Review, Fertiliser Association of India, New Delhi, 1978.

D.C. Sah: Fertiliser Use in Indian Agriculture: An Economic Evaluation, Unpublished Thesis submitted to the Gujarat University for the Degree of Doctor of Philosophy in Economics, Ahmedabad, 1984.

Satya Nand, "Productivity in the Indian Fertiliser Industry—A Reappraisal", *Fertiliser News*, Vol. 31, No. 3, March 1986.

B.P. Sikder, "Some Suggestions for Developing a Strategy for Marketing Inputs for Rainfed Agriculture", *Fertiliser Marketing News,* April 1984.

G.K. Sohbti, "Fertiliser Prices—Historical Perspective", *Fertiliser Marketing News*, April 1979.

Bruce Stone, "Chinese Fertiliser Application in the 1980s and 1990s: Issues of Growth, Balance, Allocation, Efficiency and Response", in U.S. Congress Joint Economic Committee (Ed.): China's Economy Looks Toward the Year 2000, Vol. I, The Four Modernisations, U.S. Government Printing Office, Washington, D.C., 1986, pp 453-496.

K. Subbarao, "Institutions, Infrastructure, and Regional Variation in India's Input Delivery System", in Agricultural Markets in the Semi-Arid Tropics, International Crops, Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh,1985, pp. 29-40.

P. N. Takkar and N. S. Randhawa: Micronutrients in Indian Agriculture: A Review, Fertiliser Association of India, New Delhi, 1978.

H.L.S. Tandon: Phosphorus in Indian Agriculture, European Nitrogen Service Programme, New Delhi, 1976.

H.L.S. Tandon, "Research and Development of Fertiliser Use in Dryland Agriculture", *Fertiliser News*, Vol. 26, No.6, June 1981.

H.L.S. Tandon and J.S. Kanwar: A Review of Fertiliser Use Research on Sorghum in India, International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh, 1984.

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

N.K. Tomar, A.P. Gupta and S.S. Khanna, "Evaluation of Fertiliser Needs for Wheat under Rainfed Conditions", *Fertiliser News*, Vol. 28, No.4, April 1983.

N.K Umrani and C.B. Patil,"Fertiliser Use Efficiency in relation with Management in Drylands", *Fertiliser News,* Vol. 28, No.4, April 1983.

J. Venkateswarlu, "Fertiliser Use in Drylands—A Prospect", Paper presented in the Workshop on Fertiliser Consumer Prices held at the Institute for Social and Economic Change, Bangalore, April 25-26, 1986.

S. Venkitaramanan, "Government Policy Issues and Implications on Fertiliser Plant Costs", *Fertiliser News*, Vol. 28. No.5, May 1983.