REGIONAL PATTERN AND DETERMINANTS OF FERTILISER USE IN INDIAN AGRICULTURE : ANALYSIS AND POLICY

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MASTER OF PHILOSOPHY

SHAKTI PAL

Centre for the Study of Regional Development
School of Social Sciences
Jawaharlal Nehru University
New Delhi-110067

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जवाहरलाल नेहरू विश्वविद्यालय
JAWAHARLAL NEHRU UNIVERSITY
NEW DELHI - 110 067

CENTRE FOR THE STUDY OF REGIONAL DEVELOPMENT
SCHOOL OF SOCIAL SCIENCES

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CERTIFICATE

Certified that the dissertation entitled "**REGIONAL PATTERN AND DETERMINANTS OF FERTILISER USE IN INDIAN AGRICULTURE : ANALYSIS AND POLICY**" submitted by **Shakti Pal** in partial fulfilment of the requirements for the award of the Degree of **Master of Philosophy** is his original work. This dissertation has not been submitted for any other degree to this University or to any other University to the best of our knowledge.

We recommend that this dissertation be placed before the examiners for evaluation.

Gmchadha

Prof. G.K. Chadha
SUPERVISOR
18.07.97

Nangia

Prof. S. Nangia
CHAIRPERSON
CHAIRPERSON
Centre for the Study of Regional Dev
School of Social Sciences
Jawahar Lal Nehru University
New Delhi—110067

DEDICATED

TO

HAPPY & HARSH

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SHAKTI PAL

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CHAPTER 1

INTRODUCTION

The role of chemical fertilisers in increasing agricultural production is well established and needs no special emphasis. All proven yield–increasing technologies, whether for irrigated or unirrigated areas, depend on high levels of fertiliser application. This is not surprising because the limits of growth in yield are eventually determined by soil fertility. In raising soil fertility, chemical fertilisers have become increasingly important as the experience world over suggests. Even China with its examplary performance in mobilising organic sources of nutrients, is no exception (Tang and Stone 1980). Incidentally, fertiliser consumption in China had crossed 18 mmts in 1983–84 even though in the early 1950s it was no more than that in India, namely less than 100,000 tons.

The widespread deficiency of nitrogen in Indian soils is well known. The availability of phosphorus and potash is also low and there is a growing evidence of deficiency in sulphur and micro–nutrients at growing number of locations (Randhawa and Tandon, February 1982). Obviously, yield based growth in agricultural production cannot be sustained without removing these nutritional constraints of the soil. This is no less applicable to unirrigated than to irrigated land (Tandon, June

1981; Tomar, Gupta & Khanna, April 1983; Desai, August 1983). To remove these constraints, Indian govt. has been emphasizing widespread use of chemical fertilisers since the inception of 'New Agricultural strategy' in the mid 1960s. As a consequence, fertiliser application increased from a mere 0.66 million tonnes in 1951–52 to 13.84 million tonnes in 1995–96 (FAI, Fertiliser Statistics 1995–96). It has been supplemented with significant increase in the intensity of fertiliser use from 0.55 kg/hectare in 1951–52 to 74.6 kg/hec in 1995–96 (FAI, Annual Review, 1995–96, p.118).

Now an obvious question that comes into mind is what are the underlying factors behind such a tremendous growth of fertiliser use? But before investigating these underlying factors, it is essential to know the regional pattern of fertiliser use. Therefore to understand regional pattern and determinants of fertiliser use, this study poses the following few questions for empirical verification :

1. Whether the growth of fertiliser use is confined to certain regions;
2. Whether the intensity of fertiliser use varies much across regions: and
3. Whether the small and marginal farmers are lagging much behind in comparison to large farmers with respect to fertiliser use.
4. Whether the fertiliser use is confined to a fewer crops.

5. Which among rainfall, irrigation, HYV seeds, cropping pattern, relative prices, and availability of credit are more significant variables in determining the level of fertiliser use.

6. Whether the qualitative aspect of irrigation (as reflected in assurance and timeliness of water supply) is a significant variable in the efficient absorption of plan nutrients, and so on.

The first four questions have been examined in chapter 3. The last two questions have been tested with the help of correlation and regression analysis, based on cross section and time series data in chapter 5.

Due to statistical limitations and non availability of data, some more important variables which capture maximum variation in the fertiliser use in unirrigated areas, could not be fitted into the above mentioned models. Observing their vital importance to sustain the growth of fertiliser use required to achieve the foodgrain target, they have been explained in a separate (Chapter 6).

Broadly, the thesis is organised along the following lines. Chapter 1 introduces the problem of fertiliser - use and expansion in the Indian context. In chapter 2, a brief review of literature is attempted. Chapter 3 deals systematically with the regional pattern of fertiliser use in Indian agriculture. An attempt is made here to examine (i) growth of fertiliser use since independence; (ii) zonewise and seasonwise diffusion of fertiliser use; (iii) regional variation in the fertiliser use; (iv) fertiliser use according to the size of the farm; and (v) cropwise fertiliser use. The crucial issue of nutritional balance in fertiliser use has also been examined with the help of empirical data. In the final section of this chapter, implications of these findings for policy purposes both for irrigated and unirrigated areas, have been explained. The analysis in this chapter is carried out with the support of such empirical data that command a fairly high degree of reliability and acceptance.

Chapters 4, 5 and 6 are devoted to identify the determinants of fertiliser use. While chapter 4 explains possible determinants of fertiliser use, chapter 5 explains conventional (mostly demand side) and chapter 6 explains non conventional (basically supply side) determinants of fertiliser use.

The purpose of discussing conventional factors (Chapter 5) is to estimate a relationship in which fertiliser consumption is considered a function of such agro-economic variables as weather conditions, irrigation, area sown to fertiliser responsive crop varieties, cropping pattern and relative prices of crops to that of fertilisers; in other words, these are the variables which determine farmer's returns on and hence their demand for fertilisers. The estimated coefficients of different explanatory variable are then used to draw policy conclusions.

Quite apart from the instability of statistical results obtained in such exercises, the above approach has a few other limitations as well. First, it views growth in fertiliser consumption as a sole outcome of growth in farmer's demand for fertiliser. This implies that fertiliser supply and distribution systems exert no influence of their own on growth in fertiliser consumption except through fertiliser prices, and that these systems respond instantaneously to changes in farmer's demand for fertiliser. Such an assumption is clearly too simplistic if not totally unrealistic. Moreover, with such an assumption one bypasses the consideration of policies required to remove deficiencies in fertiliser supply and distribution systems which constrain the pace of growth in fertiliser use. This would be most unfortunate.

Second, although these variables are important to determine farmer's returns on fertiliser use, it seems absurd to say that continuous changes in them are necessary to sustain growth in fertiliser demand under all circumstances. Both a priori reasoning and empirical evidence clearly suggest that such an interpretation of growth in fertiliser demand is highly mechanical.

Third, this approach could lead to imprudent – if not altogether unrealistic – price policy prescriptions since growth in fertiliser consumption is specified as a function of the relative prices of fertilisers to those of crops besides variables behind fertiliser response functions like irrigation, area under HYVs etc.

Viewed thus, to discuss policies required for acceleration of fertiliser use, one needs an approach which incorporates all essential elements and relationships which determine growth in fertiliser consumption. An analytical attempt has been made in chapter 6 to incorporate such essential elements to sustain the growth of fertiliser use. Chapter 7 gives some concluding remarks.

CHAPTER-2

REVIEW OF LITERATURE

Given the importance of fertilisers in agricultural growth, there is a surprising paucity of careful studies, either theoretical or impirical, of regional pattern and determinants of fertiliser use in India. Again, while the earlier studies are basically demand projections to estimate the quantum of fertilisers needed to realise the given targets of crop production, the recent studies have broadened their perspective to include the strength of the extension network, supply and distribution networks and the availability of credit facilities. This shift is due to the fact that when the use of fertiliser was relatively new (as indeed it was in the early 1960s), the limitations on supply and distribution systems were not apparent as its use was confined to a small area. But, with diffusion of fertiliser use across crops/regions, there availability at the right time and in adequate quantities has proved to be an important factor in determining the growth of fertiliser use.

Some systematic studies on fertilizer use in Indian agriculture are those by G.M.Desai (1969), Ashok Parikh (1965), Desai & Singh (1973), NCAER (1974, 1979), G.M.Desai (1982), ICAR-IFPRI research work (1994), to name a few. On the other hand, some exercises apparently attempting to answer questions on the use of this input, seem to lack clear a priori reasoning behind the relationships they have tried to establish. This chapter presents a brief review of some of the major studies to provide a point of departure for further investigation into the regional pattern and determinants of fertiliser use.

In a pioneering study Desai (1969), analysed the .factors that govern cultivator's fertiliser use behaviour in order to enquire into the likelihood of farmer's demand growing continuously to attain the need based targets. Based on the insights thus obtained he estimated the likely growth of fertiliser demand for the seventies and concluded that the official targets were rather over optimistic.

Viewing the problem as one of the demand for an input in the agricultural production process, Desai argued that the principal determinants of feriliser consumption are (a) the spread of fertiliser practices and increase in rates of application an land already fertilised; (b) development of irrigation; (c) growth of area under high yielding varieties; and (d) changes in the relative prices.

Desai carried out his empirical analysis at three levels of aggregation: farm level survey data, district level cross section data and statewise cross section data as well as time series data. With farm level data for Gujarat and India as a whole, he tried to trace the diffusion of fertilisers (in terms of the characteristics of users and non users) and attempted analysing underlying reasons for the observed pattern of usage.

He found that a majority of non-users had land holding with less than two hectares in size, growing mostly inferior cereals. The major proportion of fertilisers were applied on nonfood crops like sugarcane, banana etc., while the cereals like rice and wheat were much less fertilised. Bajara the dominant crop in the taluks surveyed, received the least amount of the fertilisers. The observed pattern of fertiliser use was found to be consistent with the relative profitabilities of crops.

An interesting result is that the principal impetus to growth in fertiliser use seems to come from its spread to fertiliser intensive crops, with favourable relative price rather than from increased intensity of its use.

To test the generality of the proposition that interregional variations in fertiliser use is governed by croping pattern and the area under irrigation, Desai estimated a districtwise cross section multiple regression model for several states by taking the absolute levels of the variables. The estimated regression equations have a high R^2 with expected positive signs for most of the coefficients which provide further support to Desai's earlier findings. This influence is, however, questionable because it relates the absolute levels of nitrogen used to the absolute area under different crops and irrigation. Since the size of the districts are not uniform, variations in fertiliser consumption may simply reflect differences in size. A more reliable test of the hypothesis would probably require the variable to be deflated by total cropped area in each district.

Desai attempted to explain inter-state variations in nitrogen consumption by the proportion of area irrigated and the relative price. The cross section relationship, estimated for the year 1957-58 to 1964-65 has given a consistently good R^2 (ranging from 0.53 to 0.76) with a greater proportion of the variations in the dependent variable being explained by irrigation in all the years. However, he seems to be aware that irrigation measured as a proportion of cropped area does not capture the qualitative dimension of water supply. Finally, using simple scatter diagrams, Desai sought to find out the influence of growth of irrigation and changes in relative price on growth of nitrogen consumption.

Desai's analysis, notwithstanding the shortcomings discussed above, has provided a systematic explanation for the interregional variation in fertiliser use in the sixties. It demonstrated that the need based targets are considerably higher than the effective demand for fertilisers. The author, however, has made no attempt to explain this divergence. Even his later study (Desai & Singh 1973) undertaken to explain the reasons for (a) the gap between the target and the actual fertiliser use and (b) the slowing down of fertiliser consumption since 1969, did not provide a satisfactory analysis of the problem.

The major drawback of both these analysis is that the author has used absolute levels of fertilisers consumed and not per hectare consumption of nutrients. As pointed out earlier, the differences in absoluted levels of fertiliser use could be simply because of variation in total cropped area across districts. The study could have attempted more rigorous statistical analysis to establish the relationships which seems possible with the data available to them. The study presents only tabulation of the information in grouped form or frequency distributions of relatively fewer class intervals. This precludes us from attempting different statistical analysis of the problem.

Ashok Parikh made, perhaps, one of the earliest attempts to identify and measure the quantitative significance of the factors, regionwise and all Indiawise, that were responsible for rapid increase in fertiliser consumption during the period 1951-61. The explanatory variables Parikh considered were: total irrigated area, relative price and the trend variable. He tried two variants of the model: one with irrigation in the current year (t) and one with lagged value of irrigation (t-1) in the other. The dependent variable is the absolute value of nitrogen consumed in each state. The relative price variable in any year is taken to be the ratio of price of nitrogen to the farm harvest price in the same year instead of a one year lagged value of latter, as is normally the practice.

The results of the regression shows that although all of them have a high explanatory power, the estimated coefficients of irrigation and relative price are not statistically significant in most of the cases. Multi-collinearity between irrigation and the trend variable is observed and the presence of autocorrelation is not ruled out. As a result of these statistical problems no valid inferences could be drawn from the estimated equations. A more serious limitation of this study is in the specification of the variables in terms of the absolute values of nitrogen consumed and irrigated area which, as pointed out earlier, cannot give valid tests of the hypothesis implicit in the model.

The two studies by NCAER (1974, 1979), both based on state level cross section sample survey data, are also attempts to explain cultivator's fertiliser use behaviour. The 1974 study's objective was to estimate rates of fertiliser application while the later one (1979), is a demand projection exercise. Both the studies seem to lack a clear analytical framework as they tend to be purely empirical exercise. Thus the NCAER's 1974 study has as many as 14 variables to explain inter-regional variations in fertiliser use per unit of cropped area, but relative price does not figure in the list. The R^2 is generally low despite the large number of explanatory variables. The results show that only the spread of irrigation and HYVs are positively associated with the dependent variable, while the proportion of cropped area fertilised, cropping pattern, and cropping intensity have a negative association, the later being quite contrary to one's a priori expectation.

The NCAER study (1979) goes somewhat deeper into the underlying relations and selected the following variables as being of greater relevance: relative price, credit received for fertiliser purchase, distance travelled by the farmer to get fertiliser (or the transportation cost), size of operational holding, and the ratio of leased in land to the operational holding. The cross section relationship is estimated for each state and for a number of crops, separately for irrigated and unirrigated conditions as well as for HYVs and traditional varieties.

This study estimated 129 equations, with widely varying explanatory power, ranging from 0.04 it 0.64. In a large number of cases only relative price turns out to be a statistically significant variable: the credit variable seems to be the next important explanatory factor: the size of the operational holding has negative association with fertiliser use, while the cost of transport and the proportion of operated area under tenancy seem to be of little significance.

A recently published (in 1994), research work, conducted by the Indian Council of Agricultural Research and International Food Policy Research Institute, (ICAR-IFPRI) planned its research programme "Future growth in Indian Agriculture" in 1988. The principal concern at that time in the policy circle was how to sustain the growth in fertiliser use required to achieve the targets of agricultural production. According to both official and nonofficial estimates, annual fertiliser consumption needed to grow from about 8.5 million tons in 1985–87 to about 20 million tons by the turn of the century. It was clear that, given the worsening fiscal situation (due partly to the rising burden of fertiliser and food subsidy), the policy of stimulating fertiliser use by subsidies, would not be sustainable. Therefore, it was decided to focus research on those aspects where analylitical understanding would be helpful in developing non price policies for further growth of fertiliser use. Three specific areas were selected to develop the research agenda: -

(a) Fertiliser-response-function environment, especially on land with a reasonably assured water supply. Fertiliser use had become nearly universal on irrigated land and the intensity had also reached quite high levels. Therefore, with recent data, research on fertiliser response on such lands was expected to indicate the scope for raising per-hectare yields through raising rates of fertiliser application and also through improving efficiency of its use.

(b) Fertiliser use by small and marginal farmers. It was decided to systematically investigate the relation between farm size and fertiliser use to check the varacity of the apprehension that the small and marginal farmers could not exploit the full potential of fertiliser use.

(c) Determinants of growth in fertiliser use on unirrigated land, especially in regions with low and uncertain rainfall. This was selected because of the importance of unirrigated land is sustaining overall yield-based agricultural growth and soil fertility constraints on such lands. Here, the objective was to understand both the place of organic manures vis-a-vis fertilisers in fertility management practices of farmers, and to identify major factors influencing growth of fertiliser use on rainfed land.

To pursue the research agenda described above, three major considerations were kept in view while specific studies were launched: (i) the need for detailed, disagglegated data; (ii) the extent to which such data were available from previous investigations, and the interest of Indian Researchers and institutions to share the data and collaborate in the planned research; and (iii) time and budget constraints. The programme that eventually emerged comprised the following studies:-

1. Fertilisers in Agricultural Growth : an Agro-climatic-environment-based Perspective

This study by Gunwant M. Desai and Suman Rustagi provides a macro view of the importance of fertiliser in yield based agricultural growth in different agro-climatic environments between the early 1960's and early 1980's. This study is based on the districtwise data thrown up by Bhalla-Tyagi study (1989) on the value of agricultural output (at constant prices) grouped according to major agro-climatic regions delineated by the Planning Commission and major agro ecological regions delineated by the National Burean of soil survey and land use planning.

The Desai-Rustagi study estimates that both the level of irrigation in 1962-64 and the subsequent growth in it exerted a strong positive influence on the growth of fertiliser use. Growth of output per hectare was more strongly associated with growth of fertiliser use than with the two irrigation variables. The overall average contribution of one kilogram of nutrient from fertilisers (costing about Rs 1.90 at 1967-69 prices) was an extra output worth Rs 10.40 (again at 1967-69 prices). This varied widely across different agro-climatic regions and was lower in regions with relatively higher rainfall and more humid climate, even where alluvial soils predominate and irrigation is relatively well developed. The association between growth in output per hectare and the ratio of incremental output to incremental fertiliser use, though not very strong, was positive. This indicates that faster growth of output per hectare goes with more efficient feriliser use.

This study argues that, so far, the efforts to promote technology based growth have focused mainly on increasing irrigation, and increasing fertiliser use and diffusion of high yielding varieties. Neither proper development and use of land and water resources, nor farmer's education in prudent management of these resources and efficient use of inputs have received sufficient attention. The latter is highlighted with findings based on about 1600 paddy plots in Punjab. By 1981-82 fertiliser use was vitually universal and the average rate had reached 126kg of nutrients per hectare. But 57% of paddy fields were receiving only N (Nitrogen), 32% NP (Nitrogen plus Phosphorus) and only 7% NPK (Nitrogen plus Phosphorus plus Potash). Five years later, when the average rate had reached 153 kg/hectare, still 37% of plots had received only N, and just 5% plots had received NPK. The plots receiving only N were spread over all districts, and about 75% of them had received more than 100kg of N per hectare.

Two findings of this study - relatively poor impact of growth in fertiliser use on yield based growth in high rainfall regions, and imbalanced application of nutrients (even in an agriculturally advanced state like Punjab) - deserve serious attention. Improvement in the efficiency of input use requires not only farmer's education but also a shift away from the policy of ensuring cheap inputs through subsidies to a policy than encourages prudent management of land and water resources.

2. Fertiliser-response-function-Environment and Future growth of Fertiliser use on Wheat and Rice

This study, by Vasant.P.Gandhi, Gunwant M.Desai, S.K. Raheja and Prem Narain, provides estimates of the response of wheat and rice to nitrogen(N), nitrogen plus phosphorus (NP) and nitrogen plus phosphorus plus potash (NPK) fertilisers under conditions of assured water supply. It is based on the data pertaining to more than 11,000 fertiliser trials on cultivator's fields is about 80 districts spread over India during the period 1977-78 to 1981-82.

On the basis of these data and response functions as mentioned above, the study provides some important insights regarding the scope of raising per hectare yields of wheat and rice through higher rates and more balanced application of fertilisers. It shows that there is a scope to increase wheat production by 6 million tons and rice production by 15 million tons through increases in yields per hectare if further growth of fertiliser use on these crops satisfies two conditions. First, there is balanced application of different nutrients; and second, most of the additional growth of about 700,000 tons of fertiliser use on wheat, and nearly 3 million tons of fertiliser use on rice, is in Uttar Pradesh and the central and eastern regions.

Three other findings are also worth a special mention. First, about 40 to 50% of cross sectional variation in observed yield is due to field to field differences in control yield (that is yield with no fertilise use). Furthermore, the association between control yields and fertiliser response, though weak, is negative. This suggests that it would be a mistake to persist in targeting growth of fertiliser use to regions with high observed yield.

Second, there is scope for substantial improvement in yield response per unit of nutrient by more balanced application of nutrients, both at high and at relatively low rates of use. Taken together with the previous finding, this has important policy implications with respect to extension and pricing as well as to supply of different nutrients.

Third, the available evidence on response, estimated from trials on cultivator's fields, indicates no downward shift over time. This means that lower than expected impact of growth in fertiliser use has been due to a persistently high spatial concentration in consumption, deficiencies in fertiliser practices, and other similar reasons rather than to a downward shift in fertiliser-response functions.

The analysis, thus, suggests that even with removal of the subsidy and a substantial increase in fertiliser prices, it would be possible to sustain the tempo of yield based production growth in the case of rice and wheat through more balanced application of nutrients and through regional reallocation of fertilisers.

3. Fertiliser Use Patterns in India During the Mid 1980s: Micro-Level-Evidence on Marginal and Small Farms

This study, by Praduman Kumar and Gunwant M.Desai, is based on the sample of more than 3000 farmers (about two-thirds of whom were marginal and small) located in 54 districts of 14 major states. The survey, conducted by the division of Agricultural Economics of the Indian Agricultural Research Institute, provides information on the extent of diffusion, intensity and continuity of the use of fertilisers; and on fertiliser supply and transport for different holding-size classes in different regions. It also provides information on some aspects of the use of organic manures.

This study shows that fertiliser use was quite widespread among farmers-irrespective of the size of their farms and the presence or absence of irrigation. Nor was the use confined to a few commercial crops or just high-yielding varieties. The rates of application, especially of nitrogen, on irrigated land, had also reached a fairly high level.

The study identifies four categories of factors behind widespread adoption and use of fertilisers: (i) the need to raise per hectare yield of crops and scarcity of organic manures in overcoming soil fertility constraints to high yields; (ii) growth of irrigation and spread of high yielding varieties; (iii) spread of fertiliser awareness among farmers due to both agricultural extension and demonstration effect of fetiliser use on high-yielding varieties under irrigated conditions, and (iv) increasingly easy access to fertilisers as a result of expansion of the fertiliser distribution system and sustained growth in total fetiliser supply.

The main problem areas in fertiliser use emerging from this study are (i) discontinuous use (nearly one fourth of all farmers, and as many as 45% of them all without any irrigation reported it, and it was more common among small and marginal farmers); (ii) a relatively low spread of use on unirrigated areas under many crops; and (iii) deficiencies in fertiliser practices (especially unbalanced application of different nutrients).

This study also provides a broad picture of the use of organic manures in Indian agriculture. Overall, manures contributed only 13% of the total nutrients (NPK) used by the sample farms, the proportion being somewhat higher (18%) among unirrigated holdings and among marginal and small farmers (about 20%). Even in the case of marginal and small farms without any irrigation, only about 30% of the nutrients applied came from organic manures; the remaining 70% came from chemical fertilisers.

4. Demand versus Supply Factors in Growth of Fertiliser Use : Gujarat's Experience

This study by N.V. Nampoothiri and Gunwant M.Desai focuses on the relative roles of demand and supply side factors in growth of fertiliser use during the period 1960 to 1990, when fertiliser prices, and the aggregate supply and allocation of fertilisers among states, were controlled by central government . The study is based on the state and district level data as well as data from 25000 operational holdings, collected for the 1981-82 Agricultural Input Survey on fertiliser diffusion and application rates on various crops in Gujarat, a state with relatively low irrigation and a poor rainfall environment.

By the early 1980s fertiliser use in Gujarat had spread to 76% of irrigated and 37% of unirrigated area, with application rates of 134 and 54 kg/hectare of fertilised land respectively. Even on unirrigated area, fertiliser diffusion was not confined to high yielding varieties or high value commercial crops. Under unirrigated conditions, although the percent of area fertilised on operational holdings below 1 hectare was marginally lower than on holdings above 10 hectares, the rates were higher.

Overall per hectare fertiliser consumption in Gujarat by the early 1980s was higher than in many states with higher irrigation and a better rainfall environment. Such impressive growth in fertiliser use, it is argued, was attributable to certain strengths on the supply side. At the state level, the main factors were:

(i) the Gujarat govt's proactive role in enlarging aggregate availability of fertilisers under the arrangements evolved by the government of India;

(ii) development of fertiliser industry within the state, which eased transportation and warehousing bottlenecks in fertiliser distribution; and

(iii) impressive performance of the state cooperative marketing federation in off-take of fertilisers allotted to Gujarat by the central government.

At the district and lower levels, the expansion of the multiagency distribution network, and the ability of the cooperative system to ensure production credit (in the form of fertilisers) to farmers and working capital to lower-level cooperatives for timely procurement of fertilisers have been important contributory factors. The variation in growth of fertiliser use among districts was influenced more by strengths and weaknesses on the supply side than those operating on the demand side.

5. Farmer's Fetiliser Practices and Soil Testing Services: Evidence from Gujarat

This study by D.C.Shah and Amita Shah is based on the research undertaken by the Gujarat Institute of Development Research on various aspects of fertiliser use in Gujarat. The study aims at developing an analytical understanding of fertiliser practices in respect of about 220 farmers with very little irrigation as well as 330 farmers with exceptionally high irrigation. The latter group had also received recommendations based on soil tests. The supply side of the soil testing services is then examined in the light of factors behind farmer's fertiliser practices.

6. Soil Fertility Management and Fertiliser Use in Semi-Arid Tropical Regions of India

This in-depth study by Gunwant M. Desai, Suman Rastagi and R.P.Singh is based on data collected over nine years from a panel of farmers by the International Crops Research Institute for the semi-arid tropics from a sample of farmers located in six villages of India's typical semi-arid tropical regions. It focusses on such aspects as the incidence of non use of either manures or fertilisers; adoption and regularity in manure and feriliser use; nutrient use patterns on irrigated versus unirrigated land, in a single-versus mixed crop system, and on different individual corps; and the impact of these patterns on crop yields.

To sum up, the available studies on the growth and pattern of fertiliser use seem to do reasonably well in explaining inter-regional variations but rather poorly in explaining the simultaneous importance of both demand and supply side factors in it. The attempt of some of them, though, successful in providing some insights into the problem, seem to lack in many respects, especially in respect of giving a systematic analysis on supply side variables, significance of dryland techniques, bio-fertilisers and conjunctive use of farmyard manure and chemical fertiliser. Since the spread of fertilisers has a critical bearing on the growth of agricultural output, and hence on the economy as whole, it is worthwhile exploring this area in greater depth.

CHAPTER 3

REGIONAL PATTERN OF FERTILISER USE IN INDIA

3.1 Fertilisers have a central place in the agricultural development strategy of India. This is because there is no further scope for extending the cultivated area and future agricultural growth has to rely basically upon higher yield per unit area. The empirical evidences show that the planted area in foodgrains declined somewhat during the 1980s. [Bhalla G.S. & D.S. Tyagi (1989); Gulati. Ashok and Anil Sharma (1994); Govt. of India, Area and production of principal crops in India, Ministry of Agriculture]. The entire increase in the foodgrains output during that period is, therefore, the result of the rise in productivity per hectare as a result of increase in yield raising inputs. By now, it is well established that yield based growth requires increasing application of nutrients, especially chemical fertilisers. In India it has been estimated that a fairly sizeable proportion of the incremental output of foodgrains between 1960–63 and 1987–90 is attributed to fertiliser [Vaidyanathan (1993); Mellor (1976); Vaidyanathan (1978); Sarma & Roy (1979); Sarma & Gandhi (1992)].

3.2 Growth of Fertiliser Use in India

Fertiliser use has gone under significant changes during the planning period. It increased from 0.066 million tonnes in 1951–52 to

13.84 million tonnes in 1995–96 [Table 1]. The breakthrough came around 1966–67, when the New Agriculture Technology was adopted. The total fertiliser consumption ($N+P_2O_5+K_2O$) increased from 0.066 million tonnes in 1951–52 to 0.785 million tonnes in 1966–67, a mere increase of 0.719 million tonnes. But from 1966–67 onwards, it has shown a tremendous increase of 12.739 million tonnes from 1.101 million tonnes in 1966–67 to 13.84 million tonnes in 1995–96.

Table 1 : Fertiliser Consumption in the Pre HYV and HYV era

	Period	Fertiliser Consumption per unit of GCA in (Kg/hectare)	Total Fertiliser Consumption ($N+P_2O_5+K_2O$) in million tonnes
1.	1951–52 to 1965–66 (Pre HYV era)		
	(a) 1965–66	5.05	0.785
	(b) 1951–52	0.55	0.066
	Increase (a–b)	4.5	0.719
2.	1966–67 onwards (HYV era)		
	(a) 1995–96*	74.6	13.840
	(b) 1966–67+	7.0	1.101
	Increase (a–b)	67.6	12.739

Note : + = HYVs were introduced in 1966–67.
* = Provisional

Source : *Fertiliser Association of India, New Delhi, Annual Review 1995–96, p.118.*

The intensity of fertiliser use has also increased significantly in the post HYV period (1966–67 to 1995–96). While in the pre HYV phase

(1951–52 to 1965–66), it increased only from 0.55 Kg per hectare in 1951–52 to 5.05 Kg/hectare in 1965–66, in the post HYV period it increased significantly from 7.0 Kg/hectare in 1966–67 to 74.6 Kg/hectare in 1995–96 (Table 1).

3.3 Spread of fertiliser use in recent years

Empirical studies have shown that during the early phases of Green revolution, consumption of fertiliser increased at a faster rate in the Northern states (particularly Punjab, Haryana and Uttar Pradesh) and Southern states (notably Tamil Nadu and Andhra Pradesh). It happened due to the fact that these states were better endowed with irrigation and HYV seeds suitable to these regions. But during the 1980s, the consumption of fertilisers increased faster in the Eastern and Western regions than in the Northern and Southern regions (Table 2). This trend continues even in 1990s as is clearly indicated by Table 2. While the average growth rate of NPK consumption in 1980s in Eastern and Western regions was 11.18% and 10.24% respectively, in the Northern and Southern regions it was 6.67% and 8.15% respectively. Reflecting the same trend in 1990s, the average growth rate of NPK consumption in Eastern and Western regions is 3.81% and 4.35% respectively, while in the Northern and Southern regions it is 3.36% and 1.78% respectively. It indicates broadening of the base of fertiliser use from few nucleus states to other parts of the country.

One more fact emerging quite clearly from Table 2 is that the rate of growth of NPK consumption in all the zones in 1990s is lower than that during the 1980s. To some extent it may be attributed to increased fertiliser prices and lowering of fertiliser use response (Vidya Sagar 1995).

Table 2 : Zonal Percentage Year–to–Year Variation in the NPK consumption in 1980s & 1990s

Period	**East**	**North**	**South**	**West**
1980–81	14.5	9.5	–2.2	–2.6
1981–82	–2.6	8.7	9.2	19.5
1982–83	1.4	7.9	3.3	–4.1
1983–84	34.4	13.2	24.7	31.0
1984–85	16.6	1.7	13.0	0.2
1985–86	14.1	6.3	–6.1	5.0
1986–87	11.96	0.84	–1.68	2.79
1987–88	3.0	–3.0	4.6	5.9
1988–89	15.8	21.4	31.4	32.4
1989–90	2.7	0.2	5.3	12.4
Average	11.18	6.67	8.15	10.24
1990–91	8.3	6.5	6.8	13.1
1991–92	0.5	2.7	0.7	1.3
1992–93	–2.9	–3.5	–7.3	–3.6
1993–94	1.2	4.3	0.4	0.2
1994–95	4.6	7.5	7.1	18.0
1995–96@	11.2	2.7	3.0	–2.9
Average	3.81	3.36	1.78	4.35

Note : @ – Provisional

Source : *Fertiliser Association of India, New Delhi – Fertiliser Statistics (From 1980–81 to 1995–96)*

Seasonwise growth rate of NPK consumption (Table 3 to 6) shows that unlike the early phases of the green revolution, in recent years, growth rate of NPK consumption in all the zones is higher for Kharif Crops than that for rabi crops, which indicates the spread of new technology to rainfed and other unfavourable areas (Kharif friendly areas). Clearly the importance of fertilisers relative to irrigation as a source of growth has increased considerably in recent years. This fact becomes more clear when we look at the Kharif : Rabi ratio of NPK consumption during the last three decades. Table 7 clearly indicates that at all India level, barring a few abnormalities, in general, the share of Kharif crops in total NPK consumption has been increasing steadily over time. During the period 1971–72/1982–83, the share of Kharif crops has been hovering around 36–37 percent while during the post 1982–83 years, it climbed up roughly to 46–47 percent. The zonal Kharif : Rabi ratio of NPK consumption (Table 8) shows that an increasing proportion of Kharif crops in NPK consumption has been experienced by all the zones in 1980s and 1990s. The most significant increase is shown by the eastern zones. Therefore we see that there is clear indication of the spread of new technology towards the rainfed and the hitherto lagging regions, the process commenced in early 1980s and continued well into the middle of the 1990s.

Table 3 : Seasonwise percentage year to year variation in the NPK consumption in the East Zone

Period	Kharif Season	Rabi Season
1980–81	15.0	14.6
1981–82	8.2	–8.2
1982–83	3.5	0.3
1983–84	26.7	39.0
1984–85	23.1	12.5
1985–86	17.1	12.0
1986–87	10.45	13.05
1987–88	–14.2	15.1
1988–89	38.0	4.1
1989–90	10.4	–2.6
Average	13.82	9.98
1990–91	0.7	14.3
1991–92	3.7	–1.8
1992–93	4.3	–8.2
1993–94	–6.4	7.5
1994–95	14.2	–2.3
1995–96@	16.0	7.1
Average	5.41	2.76

Note : @ – Provisional

Source : *Fertiliser Association of India, New Delhi – Fertiliser Statistics (From 1980–81 to 1995–96)*

Table 4 : Seasonwise percentage year to year variation in the NPK consumption in the North Zone

Period	Kharif Season	Rabi Season
1980–81	3.4	12.5
1981–82	6.4	9.8
1982–83	0.1	11.4
1983–84	18.8	10.5
1984–85	9.1	–2.1
1985–86	15.6	1.0
1986–87	–1.47	2.34
1987–88	–12.2	2.7
1988–89	38.6	12.2
1989–90	–4.3	3.1
Average	7.40	6.34
1990–91	4.3	7.9
1991–92	1.8	3.2
1992–93	–0.3	–5.4
1993–94	5.1	3.8
1994–95	16.8	1.7
1995–96@	7.0	–0.4
Average	5.78	1.8

Note : @ – Provisional

Source : *Fertiliser Association of India, New Delhi – Fertiliser Statistics (From 1980–81 to 1995–96)*

Table 5 : Seasonwise percentage year to year variation in the NPK consumption in the South Zone

Period	Kharif Season	Rabi Season
1980–81	1.8	–5.1
1981–82	–2.9	18.8
1982–83	7.8	0.4
1983–84	9.8	41.8
1984–85	34.0	–5.7
1985–86	–10.0	–0.8
1986–87	–9.2	7.06
1987–88	2.9	5.1
1988–89	48.8	14.5
1989–90	–2.5	15.0
Average	8.95	9.10
1990–91	7.6	6.0
1991–92	–0.3	1.7
1992–93	–3.8	–11.0
1993–94	–8.2	10.0
1994–95	11.3	3.1
1995–96@	6.4	–0.6
Average	2.16	1.55

Note : @ – Provisional

Source *: Fertiliser Association of India, New Delhi – Fertiliser Statistics (From 1980–81 to 1995–96)*

Table 6 : Seasonwise percentage year to year variation in the NPK consumption in the Western Zone

Period	Kharif Season	Rabi Season
1980–81	2.7	–8.3
1981–82	18.8	20.5
1982–83	–10.9	3.7
1983–84	19.0	45.9
1984–85	3.2	–3.7
1985–86	14.1	–4.8
1986–87	3.9	1.33
1987–88	1.7	11.7
1988–89	23.8	42.9
1989–90	16.6	8.0
Average	9.29	11.72
1990–91	11.3	15.1
1991–92	6.3	–4.2
1992–93	–0.1	–7.7
1993–94	–7.3	10.1
1994–95	15.8	20.4
1995–96[@]	6.6	–13.2
Average	5.43	3.41

Note : @ – Provisional

Source : *Fertiliser Association of India, New Delhi – Fertiliser Statistics (From 1980–81 to 1995–96)*

Table 7 : All India Kharif : Rabi Ratio of Fertiliser Nutrients (NPK) Consumption

Period	Kharif : Rabi Share
1971–72	41 : 59
1972–73	39 : 61
1973–74	43 : 57
1974–75	44 : 56
1975–76	35 : 65
1976–77	35 : 65
1977–78	36 : 64
1978–79	38 : 62
1979–80	39 : 61
1980–81	39 : 61
1981–82	38 : 62
1982–83 (Feb. to Jan.)	35 : 65 & April to March – 44 : 56
1983–84	42 : 58
1984–85	46 : 54
1985–86	47 : 53
1986–87	46 : 54
1987–88	43 : 57
1988–89	47 : 53
1989–90	46 : 54
1990–91	46 : 54
1991–92	46 : 54
1992–93	48 : 52
1993–94	45 : 55
1994–95@	47 : 53
1995–96@	50 : 50

Note : @ – Provisional

Source : *Fertiliser Association of India, New Delhi – Fertiliser Statistics – 1995–96.*

Table 8 : Zonewise Kharif : Rabi Ratio of Feriliser Nutrient (NPK Consumption)

Period	East	North	South	West
1980–81	33 : 67	32 : 68	44 : 56	54 : 46
1981–82	37 : 63	31 : 69	39 : 61	54 : 46
1982–83	41 : 59	36 : 64	54 : 46	62 : 38
1983–84	38 : 62	34 : 66	47 : 53	50 : 50
1984–85	41 : 59	36 : 64	55 : 45	52 : 48
1985–86	42 : 58	39 : 61	54 : 46	57 : 43
1986–87	41 : 59	37 : 63	49 : 51	57 : 43
1987–88	36 : 64	35 : 65	49 : 51	55 : 45
1988–89	41 : 59	40 : 60	56 : 44	51 : 49
1989–90	44 : 56	38 : 62	52 : 48	53 : 47
1990–91	41 : 59	37 : 63	52 : 48	52 : 48
1991–92	42 : 58	37 : 63	51 : 49	55 : 45
1992–93	45 : 55	38 : 62	53 : 47	57 : 43
1993–94	42 : 58	38 : 62	49 : 51	53 : 47
1994–95	46 : 54	42 : 58	51 : 49	52 : 48
1995–96	48 : 52	44 : 56	52 : 48	57 : 43

Note : @ – Provisional

Source : *Fertiliser Association of India, New Delhi – Fertiliser Statistics (From 1980–81 to 1995–96)*

3.4 Wide Variations in Fertiliser Use Across Regions

The intensity of fertiliser use has gradually gone up from about 0.55 kg/hectare in 1950–51, to 2.17 kg/hectare in 1960–61, to 13.61 kg/hectare in 1970–71, to 31.95 kg/hectare in 1980–81, finally to about 74.8 kg/hectare in 1995–96 (Tabie : 9).

There are, of course, wide variations across states, districts and crops (Table 10, Table 12, Table 15) – both in how widespread and intensive fertiliser use is, and also in the pace at which the fertiliser diffusion and rate of application are changing over time. While these differences have narrowed, they still remain substantial. The actual rate of application in the 1994–95 ranged from a mere 9.6 kg/hectare in Assam to 167 kg/hectare in Punjab (Table 10). Three states of North West India (Haryana, Punjab, and U.P.), which are among the most intensive fertiliser users and account for about 21 to 22% of country's gross cropped area, absorbed over a third of the total fertiliser use in 1995–96 (Table 11). At the other extreme, Assam, Orissa, Madhya Pradesh and Rajasthan, with 30% of total cropped area, account for just about 10% of total fertiliser consumption in India.

Table 9 : All India Consumption of Plant Nutrients per unit of GCA (Kg./hec.)

Period	Consumption of Plant Nutrients per unit of GCA in kg./hec.
1951-52	0.55
1954-55	0.84
1955-56	0.89
1956-57	1.03
1957-58	1.26
1958-59	1.47
1959-60	1.99
1960-61	1.93
1961-62	2.17
1962-63	2.88
1963-64	3.56
1964-65	4.86
1965-66	5.05
1966-67	7.00
1967-68	9.40
1968-69	11.05
1969-70	12.21
1970-71	13.61
1971-72	16.08
1972-73	17.07
1973-74	16.71
1974-75	15.67

Continued....

1975–76	16.89
1976–77	20.38
1977–78	24.88
1978–79	29.27
1979–80	30.99
1980–81	31.95
1981–82	34.33
1982–83	37.06
1983–84	42.94
1984–85	46.57
1985–86	47.48
1986–87	49.00
1987–88	51.45
1988–89	60.57
1989–90	63.47
1990–91@	67.49
1991–92@	69.84
1992–93@	65.67
1993–94@	66.67
1994–95@	73.12
1995–96@	74.81

Note : @ – Provisional

Source : *Fertiliser Association of India, New Delhi – Fertiliser Statistics 1995–96.P.I–116.*

Table 10 : Statewise Consumption of Plant Nutrients per unit of Gross Cropped Area – 1994–95 & 1995–96[@]

States		Consumption of Plant Nutrients in kg./hec.	
		1994–95	1995–96[@]
1.	Arunachal Pradesh	2.2	1.5
2.	Assam	9.6	12.8
3.	Bihar	69.8	77.0
4.	Orissa	23.4	25.2
5.	West Bengal	88.2	99.3
6.	Haryana	121.7	123.7
7.	Himachal Pradesh	30.7	30.5
8.	Jammu & Kashmir	43.1	47.5
9.	Punjab	170.2	167.3
10.	Uttar Pradesh	96.6	101.4
11.	Andhra Pradesh	128.9	137.3
12.	Karnataka	66.3	75.5
13.	Kerala	65.4	66.7
14.	Tamil Nadu	123.8	106.9
15.	Gujarat	74.4	68.5
16.	Madhya Pradesh	37.6	34.7
17.	Maharastra	66.1	65.3
18.	Rajasthan	29.9	31.9

Note : @ – Provisional

Source : *Fertiliser Association of India, New Delhi – Fertiliser Statistics 1995–96. P.I–117.*

Table 11 : Share of Gross Cropped Area and Fertiliser Consumption to All India - Statewise - 1995-96 (Provisional)

Zone/State	State's Share of All India GCA (%)	State's Share of All India NPK Consumption (%)	NPK Consumption Per hectare of GCA (kg/hec.)	Col.(3) Vs. Col. (2)#
(1)	(2)	(3)	(4)	(5)
East Zone	17.6	13.8	58.4	Lower
Assam	2.1	0.4	12.8	Lower
Bihar	5.0	5.2	77.0	Higher
Orissa	5.1	1.7	25.2	Lower
West Bengal	4.6	6.1	99.3	Higher
North Zone	22.2	33.8	113.9	Higher
Haryana	3.2	5.2	123.7	Higher
Himachal Pradesh	0.5	0.2	30.5	Lower
Jammu & Kashmir	0.6	0.4	47.5	Lower
Punjab	4.1	9.1	167.3	Higher
Uttar Pradesh	13.8	18.8	101.4	Higher
South Zone	19.1	26.4	103.7	Higher
Andhra Pradesh	6.9	12.6	137.3	Higher
Karnataka	6.7	6.7	75.5	Higher
Kerala	1.6	1.5	66.7	Lower
Tamil Nadu	3.8	7.67	106.9	Higher
West Zone	41.1	26.0	47.3	Lower
Gujarat	5.9	5.4	68.5	Lower
Madhya Pradesh	12.8	6.0	34.7	Lower
Maharastra	11.3	9.9	65.3	Lower
Rajasthan	10.9	4.6	31.9	Lower
All India	100.0	100.0	74.8	

Note : # – In a state where total nutrients (NPK) consumption share is higher than or equal to its share in gross cropped area consumption of plant nutrients (NPK) in that state kg/hec. above All India Average of 74.8 kg/hec and vice versa.

Source : *Fertiliser Association of India, New Delhi – Fertiliser Statistics 1995-96. P.I-119.*

A Districtwise analysis (Table 12) brings about the clear picture of the wide variations in the fertiliser use. As shown in Table 12, out of the total of 398 districts, only 165 districts were using fertilisers above the national average (74.8 kg/hec), the remaining i.e. 233 districts were using fertilisers below national average. Even within these two broad categories of districts, there are wide variations in the fertiliser use. In the former category (the districts using fertilisers above the national average), there are a few districts using as high as 200 kg/hectare or more while a large number of districts using below 100 kg/hectare fertiliser. Not only that, in latter category of districts (the districts using fertiliser less than national average), there is a large number of districts which use less than 25 kg/hectare fertilser. In the three most intensive fertiliser using states (Punjab, Haryana and U.P.), out of a total of 94 districts, 70 districts were using fertilisers above 75 kg/hectare. At the other extreme in the states of Assam, Bihar, Orissa, Madhya Pradesh, and Rajasthan out of 136 districts, only 13 districts were using fertilisers above 75 kg/hectare. It shows that there is ample scope for a higher use of fertiliser.

Table 12 : Classification of districts according to ranges of fertiliser consumption ($N+P_2O_5+K_2O$) of gross cropped area in kg/hectare. Period – 1993–94 and 1994–95.

Zone/State	No. of Districts	Ranges of Fertiliser Consumption (Kg/hectare) above and upto								
		Above 200	150 to 200	100 to 150	75 to 100	50 to 75	25 to 50	10 to 25	5 to 10	upto 5
East Zone										
1. Assam	10 (10)	- (-)	- (-)	- (-)	- (-)	- (-)	- (1)	5 (4)	1 (2)	4 (3)
2. Bihar	39 (39)	1 (1)	- (-)	3 (4)	6 (5)	5 (6)	6 (4)	9 (13)	4 (4)	5 (3)
3. Orissa	13 (13)	- (-)	- (-)	- (-)	- (-)	- (-)	5 (5)	4 (6)	4 (2)	- (-)
4. West Bengal	17 (17)	1 (1)	1 (1)	4 (4)	7 (7)	4 (3)	1 (1)	- (-)	- (-)	- (-)
North Zone										
1. Haryana	16 (16)	- (-)	5 (4)	5 (6)	2 (4)	2 (2)	1 (2)	- (-)	- (-)	- (-)
2. Himachal Pradesh	12 (12)	- (-)	- (-)	- (-)	- (1)	2 (1)	6 (7)	4 (3)	- (-)	- (-)
3. Punjab	14 (12)	1 (1)	10 (7)	3 (4)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
4. Jammu & Kashmir	14 (12)	- (-)	- (-)	- (-)	- (1)	4 (3)	4 (4)	3 (3)	1 (-)	2 (1)
5. Uttar Pradesh	64 (64)	2 (1)	7 (4)	17 (19)	17 (14)	6 (9)	7 (7)	2 (4)	1 (3)	5 (3)
South Zone										
1. Andhra Pradesh	22 (22)	3 (2)	7 (6)	3 (5)	4 (3)	3 (4)	2 (2)	- (-)	- (-)	- (-)
2. Karnataka	20 (20)	1 (1)	1 (1)	3 (4)	5 (7)	4 (2)	4 (4)	2 (4)	- (-)	- (-)
3. Kerala	14 (14)	- (-)	- (-)	1 (1)	5 (8)	5 (5)	3 (5)	- (-)	- (-)	- (-)
4. Tamil Nadu	21 (21)	2 (-)	3 (4)	9 (8)	3 (6)	2 (1)	2 (2)	- (-)	- (-)	- (-)

Continued....

West Zone										
1. Gujarat	19 (19)	- (-)	1 (1)	2 (3)	6 (6)	5 (6)	4 (5)	- (2)	- (-)	1 (1)
2. Madhya Pradesh	45 (45)	- (-)	- (-)	- (-)	- (2)	11 (9)	19 (16)	10 (13)	5 (4)	- (1)
3. Mahrashtra	29 (29)	1 (1)	- (-)	2 (3)	6 (-)	6 (10)	13 (12)	1 (3)	- (-)	- (-)
4. Rajasthan	29 (28)	- (-)	- (-)	1 (1)	3 (-)	6 (4)	10 (10)	6 (9)	2 (3)	1 (1)
Total	398 (393)	13 (6)	35 (28)	53 (60)	64 (52)	65 (68)	86 (85)	46 (62)	18 (18)	18 (14)

Note : ( ) – For 1993–94 and figures outside brackets are for 1994–95.

Source : *Fertiliser Association of India, New Delhi – Fertiliser Statistics 1995–96. PP.1–154, 155.*

Comparing the statewise consumption of total fertiliser ($N+P_2O_5+K_2O$), (Table 13), we find that Uttar Pradesh continued to be the largest consumer of fertilisers accounting for a 18.8% share to all India consumption of total nutrients in 1995–96. The next 3 states i.e. Andhra Pradesh (2^{nd}), Maharashtra (3^{rd}), and Punjab (4^{th}) had a share of 12.7%, 9.9% and 9.1% respectively. The next three states in order i.e. Karnataka, West Bengal, and Madhya Pradesh had share of 6.5%, 6.1% and 6.0% respectively. These 7 states thus had an aggregate share of 69% in the All India consumption of fertiliser nutrients. The next 5 states i.e. Tami Nadu. Gujarat, Haryana, Bihar and Rajasthan had an aggregate share of 26.2%. Hence total share of the first 12 states is around 95.2%. Remaining 5 states in order i.e. Orissa, Kerala, Jammu and Kashmir, Assam and Himachal Pradesh accounted for 4% share to all India consumption. In other words 17 major fertiliser consuming states had an aggregate share of 99.2% in total consumption of fertiliser nutrients. Remaining 0.8% was consumed in small states, U.Ts, and plantation crops.

Table 13 : States in descending order of share of consumption to all India Consumption ($N+P_2O_5+K_2O$) in 1994–95 and 1995–96@

Ranking		States	Share of All India Total (%)	
1994–95	1995–96@		1995–96@	1994–95
1	1	Uttar Pradesh	18.82	18.29
2	2	Andhra Pradesh	12.65	12.12
3	3	Maharashtra	9.86	10.25
4	4	Punjab	9.13	9.47
7	5	Karnataka	9.46	6.07
9	6	West Bengal	9.13	5.56
5	7	Madhya Pradesh	5.97	6.61
6	8	Tamil Nadu	5.68	6.45
8	9	Gujarat	5.44	6.03
10	10	Haryana	5.23	5.25
11	11	Bihar	5.20	4.81
12	12	Rajasthan	4.64	4.44
13	13	Orissa	1.62	1.62
14	14	Kerala	1.46	1.47
15	15	Jammu & Kashmir	0.37	0.34
16	16	Assam	0.35	0.27
17	17	Himachal Pradesh	0.21	0.22

Note : @ – Provisional.

Source : *Fertiliser Association of India, New Delhi, Annual Review of Fertiliser Production and Consumption 1995–96. P.109.*

Such a wide variations across the regions is due to the part that the growth processes of fertiliser use started earlier and spread faster on irrigated–land, high value commercial crops (such as sugarcane and tabacco); and subsequently on high yielding variaties, especially of rice and wheat (Desai 1969, NCAER 1978 and Nagraj 1983). By agricultural year 1970–71, an estimated 52% of irrigated area was fertilised at an average rate of 55 kg/hectare compared to 9 percent of unirrigated area fertilised at an average rate of 38 kg/hectare (Desai 1982). By 1988–89, 87% of irrigated land was fertilised and the average rate had risen to 129 kg./hectare (NCAER 1991). Fertiliser use continued to be much less diffused and intensive on rainfed land. But the more important point is that the pace of diffusion accelerated on rainfed areas too during the last two decades, and by the late 1980s about 50% of the unirrigated area was fertilised at an average rate of 63 kg/hectare. Surveys conducted by NCAER show that while the share of rainfed areas in total fertiliser use has nearly doubled (from 15 to 31%) between 1975–77 and 1988–89, irrigated areas, which accounted for about 30% of total cropped area in 1988–89, still absorbed 69% of total fertiliser. Gujarat is perhaps the only state which despite its low rainfall and low irrigation, had adopted fertiliser consumption on a fairly high scale by the early 1980s. This success was primarily due to an efficient state machinery, which in seeking to develop fertiliser industry, streamlined transportation and stocking of fertilisers and cooperative agencies, which distributed fertilisers.

Thus, the irrigated rainfed differential (in relative terms) in diffusion has considerably narrowed but, in the matter of rate of application on fertilised land, the differential has increased. Unirrigated areas, however, still suffer from discontinuity in the use of fertilisers (Table 16.c). As is shown in table 16.C, one out of four (27%) adopters reported discontinuous fertiliser use. Its incidence was the highest (41% of adopters) among farmers located in the high rainfall regions, followed by those in the low rainfall regions (27%) then those in the medium rainfall environment (20%). About 45% of adopters on unirrigated farms used fertilisers discontinuously. And the phenomenon was not confined to such farms. More than one fifth of farmers with partially irrigated farms and nearly one fifth of those with fully irrigated also reported discontinuous use. Similarly discontinuous use is not confined to marginal and small farmers. About 20 to 25% of adopters with medium and large farms were also discontinuous users. The three most common reasons given by farmers for discontinuous use were lack of irrigation (or inadequate irrigation), high price of fertiliser in relation to prices of crops and credit constraints.

3.5 Fertiliser Use on Different Categories of Farm Size

According to the NCAER study (1978), 45.1% of farmers were using fertilisers during the period 1975–76 (Table 14). This percentage has gone up during the subsequent decades. As shown in table 16(a), about 79% of farmers have used fertilisers at one time or the other.

The adoption of fertiliser is somewhat lower among small farmers than large farmers, owing mainly to the credit constraint. According to an NCAER study (1980) as shown in table 15, the marginal farmers were using 12.1% of total fertiliser use, small farmers 18.5% whilte the large farmers were using 29.5%. This ratio is more or less maintained in the recent years also (IFPRI–ICAR research study of mid 1980s).

But, those small farmers who do adopt tend to use higher doses of fertilisers than the large farmers. As is shown in table 15, the fertiliser input per fertilised hectare for marginal farmers (below 1 hectare holding) is 92.3 kg, for small farmers (between 1 and 2 hectares holding) it is 85 Kg/hectare, for medium farmers (between 2 to 4 hectare holding) 80.1 Kg and for large farmers (above 10 hectare) it is 59.0 Kg. Therefore the intensity of fertiliser use per fertilised hectare is above the national average of 78.0 kg (Table 14) for small category farmers and below the national average for large farmers and below the national average for large farmers. This fact is also proved by the fact that the proportion of

Table 14 : Statewise Fertiliser Consumption per hectare of Fertilised land : 1975-76

	State	Ratio of Fertiliser users to total cultiva-ting households (%)	Ratio of Fertilised area to total cropped area (%)	Fertiliser use per hectare of fertilised land (kg.)
1.	Andhra Pradesh	61.8	41.7	111.7
2.	Assam	6.5	4.9	49.4
3.	Bihar	42.3	35.3	49.4
4.	Gujarat	62.3	43.1	45.8
5.	Haryana	69.2	48.7	76.6
6.	Himachal Pradesh	33.8	27.6	28.4
7.	Jammu & Kashmir	40.5	28.5	46.9
8.	Karnataka	49.9	33.4	104.6
9.	Kerala	65.3	72.6	92.0
10.	Madhyra Pradesh	15.4	10.8	46.5
11.	Maharastra	42.2	27.3	77.3
12.	Orissa	21.4	20.7	90.8
13.	Punjab	91.9	76.3	90.8
14.	Rajasthan	30.8	20.1	55.5
15.	Tamil Nadu	69.7	55.4	128.1
16.	Uttar Pradesh	44.2	32.1	64.6
17.	West Bengal	66.0	49.8	89.5
18.	All India	45.1	32.9	78.0

Source : *NCAER, Fertiliser Demand Study 1975-76.*

Table 15 : Pattern of Fertiliser Consumption by size of Farm

	Item	Size of Farm (in hectares)					
		Below 1	1–2	2–4	4 to 10	All above 10	house-holds
1.	Distribution of Cultivator's households (%)	40.7	24.8	19.8	12.1	2.6	100
		= 65.5					
2.	Area Cultivated (%)	9.7	15.7	24.3	31.6	18.7	100
		= 25.4					
3.	Cultivator households using ferilisers (Percent)	36.8	44.8	55.3	55.4	58.8	45.2
4.	Proportion of ferilised area to GCA (%)	31.3	32.7	36.1	35.2	34.2	34.4
5.	Proportion of fertilised area to GCA of households using fertilisers (%)	79.9	70.3	62.4	58.9	49.8	61.5
6.	Fertiliser input per fertilised hectare (kg.)	92.3	85.8	80.1	71.1	59.0	76.4
7.	Distribution of fertiliser consumption (%)	12.2	18.5	28.2	29.9	11.2	100

Source : *T.K. Roy & H.Y. Siddiqi, "Fertiliser use in India : Role of small and marginal farmers." (NCAER) – Fertiliser Marketing News, October 1980.*

fertilised area to GCA of households using fertilisers is higher for marginal and small farmers than the large farmers. As is shown in row 5 of table 15, the proportion of fertilised are to GCA of households using fertilisers is 79.9% for marginal farmers, 70.3% for small farmers, 62.4% for medium size farmers and 49.8% for large farmers i.e. as the size of farm decreases the proportion of fertilised area to GCA of households using fertilisers is increasing. Therefore, although the share of small farmers in total fertiliser consumption is low, but the small farmers who do adopt fertiliser tend to use higher doses of fertiliser than the large farmers. Hence, the higher proportion of large farmers in total consumption of fertiliser is not due to higher use per fertilised area, but rather due to their large number in total cultivators using fertiliser. As shown in row 3 of table 15, the proportion of large farmers to total cultivators using fertilisers was 58.8% while the small farmers' proportion was only 44.8% in the late 1970s. The proportion of large farmers increased to 89% and that of small farmers 79% in mid 1980s (Table 16.a).

The above mentioned relationship is more pronounced on unirrigated and partially irrigated plots, but breaks down on irrigated plots, where infact large farmers use higher doses of fertilisers. As is shown in table 16(b), the rate of fertiliser application on unirrigated farms of marginal farmers is 33 kg/hectare; it is 28 kg/hectare for small farmers; 22 kg/hectare for medium size farmers and 13 kg/hectare for large farmers. On partially irrigated farms, the intensity of fertiliser use of marginal farmers is 65 kg/hectare, of small farmers it is 59 kg/hectare, of medium farmers 57 kg/hectare and of large farmers it is 44 kg/hectares. Therefore, on unirrigated and partially irrigated plots, as the farm size decreases, the per hectare use of fertiliser increases. But this relationship breaks down on fully irrigated farms. As is obvious in table 16(b), that for fully irrigated land, the per hectare fertiliser use is 125 kg/hectare for marginal farms, 127 kg/hectare for small farms, 140 kg/hectare for medium farms and 146 kg/hectare for large farms. Hence there is positive relationship between farm size and fertiliser use on fully irrigated plots. It is possible that the small farmers improve the quality of their unirrigated plots through the use of surplus labour, whereas the quality of irrigation is better on large farms on account of higher investment in minor (controlled) irrigation.

Table 16 (a) : Adoption of fertiliser (percent of sample farmers) in mid 1980s.

	Variables	Unirrigated	Partially Irrigated	Fully Irrigated	All Groups
1.	Farm Size				
	Marginal	55	73	85	72
	Small	60	86	89	79
	Medium	68	90	91	85
	Large	71	93	96	89
2.	All Farms	61	87	88	79

Table 16 (b) : Rate of Fertiliser ($N+P_2O_5+K_2O$) Application (Kg/hec. of operated land).

	Variables	Unirrigated	Partially Irrigated	Fully Irrigated	All Groups
1.	Farm Size				
	Marginal	33	65	125	82
	Small	28	59	127	77
	Medium	22	57	140	77
	Large	13	44	146	70

Table 16 (c) : Discontinous User of Fertiliser (% of fertiliser adopters).

	Variables	Unirrigated	Partially Irrigated	Fully Irrigated	All Groups
1.	Rainfall				
	Low	37	35	16	27
	Medium	32	19	17	20
	High	60	35	24	41
2.	Farm Size				
	Marginal	54	34	22	33
	Small	43	31	22	30
	Medium	34	25	9	21
	Large	48	24	12	24
	All Farms	45	27	18	27

Note : The above data is based on the micro level study of fertiliser use in the mid 1980s.

Source : *ICAR–IFPRI, "Strategic issues in Future Growth of Fertiliser use in India." Edited by – Gunvant M. Desai and A Vaidyanthan, pp.111, 117, 120.*

3.6 Cropwise Fertiliser Use

While cropwise and groupwise data on such inputs as irrigation and HYV are available, it is not the case with fertilisers. Except for estimates for a few time points e.g. NSS in 1970–71, NCAER in 1975–76, 1976–77, IFPRI–ICAR research study of mid 1980s, cropwise estimates for fertiliser use are not available. The study of NCAER [Table 17.(a)] shows that around mid 1970s, about two–third of the fertiliser use was used for two crops (namely rice and wheat), and this proportion does not seem to have changed much during the subsequent period (Vaidyanathan 1993).

Table 17(a) : Share of Consumption of N, P_2O_5 & K_2O by Main Crops (in percentage) – 1977–78

Crops	**N**	**P_2O_5**	**K_2O**
Kharif Paddy	31.68	27.47	36.09
Jowar	1.50	1.21	1.65
Bajara	1.28	1.40	0.80
Maize	2.15	0.63	0.52
Goundnut	1.87	5.02	4.46
Cotton	5.71	5.43	4.44
Rabi Paddy	7.59	10.16	14.38
Wheat	27.64	29.22	15.37
Sugarcane	8.39	7.20	7.55
Other Crops	12.11	12.26	14.74
	100.0	100.0	100.0

Source : *NCAER, New Delhi, Fertiliser Demand Study, Final Report, Vol.I, 1977–78.*

Table 17(b) : Rate of Fertiliser ($N+P_2O_5+K_2O$) application cropwise in mid 1980s (in Kilograms/hectare of operated land)

Crop/Variety	Cropped Area ($N+P_2O_5+K_2O$) Consumption in Kg/hec.	Fertilised Area ($N+P_2O_5+K_2O$) Consumption in Kg/hec.
Unirrigated		
Paddy LV	16	42
HYV	53	78
Wheat HYV	40	64
Maize LV	49	55
Jowar LV	3	26
HYV	40	68
Bajara LV	8	17
HYV	21	34
Ragi LV	20	57
Groundnut LV	10	23
HYV	37	45
Cotton LV	20	39
HYV	71	98
Irrigated		
Paddy HYV	122	133
Wheat HYV	113	120
Maize LV	50	55
HYV	177	193
Jowar LV	1	14
HYV	56	74
Bajara LV	13	47
HYV	20	37
Ragi LV	27	98
Groundnut LV	25	79

Continued....

HYV	101	112
Cotton LV	28	81
HYV	150	160
Sugarcane LV	96	97
HYV	111	116

Note : LV is local varieties; HYV is high-yielding varieites.

Source : *ICAR (New Delhi) and IFPRI (Washington D.C. USA), "Strategic issues in Future Growth of Fertiliser use in India." Edited by – Gunvant M. Desai and A Vaidyanthan, p.126.*

Irrigation and HYV seeds have played critical roles in the cropwise variation of the fertiliser use, supported by a widespread distribution network. As is shown in table 17(b), even on unirrigated areas, the rates of application are substantial : 23 to 55 kg per hectare on local varieties and 34 to 98 kg/hectare or more on HYVs. Generally the rates on irrigated areas are twice as high. On a number of crops, they range between 100 and 200 kilograms/hectare on HYVs. About three-fourth of total fertiliser is absorbed by foodgrains, with rice and wheat alone accounting for about two-thirds of total fertiliser use, as pointed out earlier.

3.7 Balance of Fertiliser Use

The imbalanced use of nutrients (N : P_2O_5 : K_2O) have been widely debated in the recent years. The ideal average nitrogen (N), phosphate (P_2O_5) and potash (K_2O) ratio use in India is 4:2:1. As against this the ratio in India in 1991-92 was 5.9:2.4:1 (Table 18). However, due to distortion in fertiliser pricing policy in 1991–92, which has made nitrogen (urea) cheaper vis–a–vis phosphate and potash, the use ratio became 9.5:3.2:1 in 1992–93. The impact of distortion was still more visible in the rabi season of 1992–93 when the NPK ratio was reported to be 15.1:4.6:1. It further distorted to 9.7:2.9:1 during 1993–94 and marginally improved to 8.5:2.6:1 during 1994–95. In the year 1995–96 it stood at 8.4:2.5:1. The state level data on nutrient ratio as shown in table 19, indicates that this balance is highly distorted in Northern States (agriculturally advanced) particularly Haryana (212.6:57.2:1), Punjab (64.1:16.2:1) and Uttar Pradesh (26:5.5:1) followed by western states particularly Rajasthan (56:17.7:1), Madhya Pradesh (19.7:9.2:1) and Gujarat (11.4:3.9:1). The eastern and southern states have shown better balance except Bihar (14.1:2.7:1) and Andhra Pradesh (9.5:3.2:1).

The balanced use of fertilisers is directly related to the fertiliser use response with more balanced use of fertilisers, the fertiliser use response can be improved. An International Food Policy Research Institute and Indian Council of Agricultural Research (IFARI–ICAR) study of 14 out of the 15 agroclimatic regions delineated by the Planning Commission shows that for wheat, a balanced use of NPK could increase production by about 2 million tons, and regional adjustment of fertiliser use to optimal levels with the existing mix could increase production by another 1.6 million tons. If the best mix of fertiliser is used at optimal levels, the current production of wheat could potentially rise as much s 12%, with use of an additional 0.5 million tons of fertiliser. For rice, the potential is even greater, an anticipated increase of about 20% over current production with an additional fertiliser consumption of 1.5 million tons.

Table 18 : All India Consumption Ratio of $N_1 P_2 O_5$ in Relation to K_2O

Year	N	:	P_2O_5	:	K_2O
1951–52	7.9	:	0.9	:	1
1954–55	8.5	:	1.4	:	1
1955–56	10.0	:	1.3	:	1
1956–57	8.3	:	1.1	:	1
1957–58	16.6	:	1.7	:	1
1958–59	7.7	:	1.3	:	1
1959–60	10.8	:	2.5	:	1
1960–61	7.3	:	1.8	:	1
1961–62	8.9	:	2.2	:	1
1962–63	9.1	:	2.3	:	1
1963–64	7.4	:	2.3	:	1
1964–65	8.0	:	2.1	:	1
1965–66	7.4	:	1.7	:	1
1966–67	6.5	:	2.2	:	1
1967–68	5.5	:	2.0	:	1
1968–69	7.1	:	2.2	:	1
1969–70	6.5	:	2.0	:	1
1970–71	6.3	:	2.3	:	1
1971–72	6.0	:	1.4	:	1

Continued....

1972–73	5.3	:	1.7	:	1
1973–74	5.1	:	1.8	:	1
1974–75	5.3	:	1.4	:	1
1975–76	7.7	:	1.7	:	1
1976–77	7.7	:	2.0	:	1
1977–78	5.8	:	1.7	:	1
1978–79	5.8	:	1.9	:	1
1979–80	5.8	:	1.9	:	1
1980–81	5.9	:	1.9	:	1
1981–82	6.0	:	1.9	:	1
1982–83 Feb.–Jan.	5.8	:	2.0	:	1 & April–March 5.8:2.0:1
1983–84	6.7	:	2.2	:	1
1984–85	6.5	:	2.2	:	1
1985–86	7.0	:	2.5	:	1
1986–87	6.7	:	2.5	:	1
1987–88	6.5	:	2.5	:	1
1988–89	6.8	:	2.5	:	1
1989–90	6.3	:	2.6	:	1
1990–91	6.0	:	2.4	:	1
1991–92	5.9	:	2.4	:	1
1992–93	9.5	:	3.2	:	1
1993–94	9.7	:	2.9	:	1
1994–95	8.5	:	2.6	:	1
1995–96	8.4	:	2.5	:	1

Source : *Fertiliser Association of India, New Delhi, Fertiliser Statistics 1995–96. P.I–112.*

Table 19 : Statewise Consumption Ratio of N and P_2O_5 in relation to K_2O in 1944–95 and 1995–96[@]

	States	1994–95					1995–96[@]				
		N	:	P_2O_5	:	K_2O	N	:	P_2O_5	:	K_2O
1.	Assam	2.1	:	0.4	:	1	1.2	:	0.3	:	1
2.	Bihar	14.1	:	2.7	:	1	12.7	:	2.7	:	1
3.	Orissa	6.5	:	1.3	:	1	6.3	:	1.3	:	1
4.	West Bengal	3.6	:	1.4	:	1	3.7	:	1.4	:	1
5.	Haryana	212.6	:	57.2	:	1	185.8	:	42.3	:	1
6.	Himachal	12.6	:	1.2	:	1	11.1	:	1.1	:	1
7.	Jammu & Kashmir	30.7	:	5.9	:	1	85.3	:	13.7	:	1
8.	Punjab	64.1	:	16.2	:	1	64.5	:	14.4	:	1
9.	U.P.	26.0	:	5.5	:	1	30.0	:	5.9	:	1
10.	Andhra Pradesh	9.5	:	3.2	:	1	8.3	:	2.9	:	1
11.	Karnataka	3.9	:	1.6	:	1	3.5	:	1.6	:	1
12.	Kerala	1.0	:	0.5	:	1	1.2	:	0.6	:	1
13.	Tamil Nadu	1.9	:	0.8	:	1	2.1	:	0.7	:	1
14.	Gujarat	11.4	:	3.9	:	1	13.3	:	3.9	:	1
15.	Madhya Pradesh	19.7	:	9.2	:	1	15.2	:	6.9	:	1
16.	Maharastra	5.2	:	2.0	:	1	5.0	:	1.9	:	1
17.	Rajasthan	56.0	:	17.7	:	1	85.0	:	26.3	:	1

Note : @ – Provisional

Source : *Fertiliser Association of India, New Delhi, Fertiliser Statistics 1995–96. P.I–113.*

Table 20(a) : Wheat – Regional Average and Marginal Products of Fertiliser Application at 100 kg/hectare (NPK only).

Region	No. of Districts	Average Product of NPK Use	Marginal Product of NPK Use
North	8	11.21	9.46
Uttar Pradesh	8	13.51	10.79
East	8	13.80	10.72
Central	10	13.86	10.92
West	12	7.05	6.19
South	5	5.97	5.97
All India	51	12.64	10.06

Table 20(b) : Rice – Regional Average and Marginal Products of Fertiliser Application at 100 kg/hectare (NPK only).

Region	No. of Districts	Average Product of NPK Use	Marginal Product of NPK Use
North	5	8.72	7.24
Uttar Pradesh	5	7.59	6.69
East	9	7.07	6.09
Central	2	9.81	7.48
West	3	6.79	5.20
South	27	8.13	6.28
All India	51	7.76	6.39

Source : *ICAR (New Delhi and IFPRI (Washington, D.C., U.S.A.), "Strategic issues in Future Growth of Fertiliser Use in India." Edited by G.M. Desai & A. Vaidyanathan. pp.82, 90.*

The response (average and marginal) of wheat and rice to fertiliser consumption are to highest in Central (Madhya Pradesh and Rajasthan) and Eastern regions (Bihar, Orissa. West Bengal, Assam and other north eastern states), and Uttar Pradesh (Table-20). This indicates that there is a considerable scope for increasing wheat and rice production simply by inducing a redistribution in the consumption of fertilisers in favour of high response regions and by promoting balanced use of N, P and K through appropriate policy measures.

3.8 Policy Implications

It is now clear from the preceding discussion that fertiliser use was quite widespread among formers - irrespective of the size of their farms and presence or absence of irrigation facilities. Nor was the use confined to a few commercial crops or just high yielding varieties. The rate of application, especially of nitrogen on irrigated land, had also reached a fairly high level. With respect to all these features, marginal and small farmers were not lagging much behind medium or large farms. Nor were they lagging behind in the use of fertilisers containing phosphorus and potash, even though the use of these fertilisers was generally less common than of fertilisers containing only nitrogen. This could become possible, perhaps, due to the development of dryland technology and in particular, moisture conserving techniques. The latter development clearly shows a switchover from intensive irrigated technology to moisture conserving technology or broadly speaking dryland technology.

The main problem areas in fertiliser use emerging from the findings of earlier sections are – (i) discontinuous use (the break in use is more common among small and marginal farmers); (ii) a relatively lower proportion of area getting fertilized among unirrigated crops; and (iii) deficiencies in fertiliser practices (especially imbalanced application of different nutrients.)

Fertiliser policy reforms should, therefore, aim at effectively tackling these problem areas rather than be guided by outdated issues, such as promoting fertiliser use among small and marginal formers, spread of fertiliser use under unirrigated conditions or very low rates of application. That stage in the growth of fertiliser use has long passed. Implications of these findings for policy are, thus, explained as under.

1. Policies for Unirrigated Areas

It is now, clear that at the existing level of irrigation and available improved varieties, the bulk of the unexploited potential to raise crop-yields through growth of fertiliser use is largely concentrated on unirrigated areas, spread over environments with high, medium or low rainfall. The realisation of this potential requires a for more sophisticated approach than the one adopted in the past, when most of the growth in fertiliser consumption occurred as a result of rapid spread of its use on irrigated land, and rapid upward movement in rates of application on this land.

Three key elements in policies are required for viable growth in fertiliser use on rainfed land. First, a more shophisticated extension service than the one that exists at present, supported by research and soil testing services to generate location specific recommendations regarding fertiliser practices (e.g. levels, use of different nutrients, time of application) is required. Second, a timely and adequate supply of fertiliser containing different nutrients recommended by the research based extension system is needed. Finally, serious attention must be paid to moisture conservation and better management practices that affect efficiency of fertiliser use. Furthermore, these elements need to be viewed as critical parts of an integrated strategy of technology based intensive agriculture in rainfed areas.

2. Policies for irrigated areas

There is scope for further growth in yield on irrigated lands too. To explore this potential, a shift in emphasis from indiscriminate increases in rates of application to improving the efficiency of fertiliser use is urgently needed.

To improve efficiency of fertiliser use, what is really needed is enhanced location-specific research on efficient fertiliser practices (such as balanced use of nutrients, correct timing and placement of fertilisers, and wherever necessary, use of micronutrients and soil amendments). The latter task needs to be addressed vigorously by both the agricultural extension system and also fertiliser manufacturers and distributors. The latter is no less important because private dealers have been identified as a dominant source of information on fertiliser use. Furthermore, balanced application of different nutrients is perhaps the most crucial aspect in raising fertiliser use efficiency. Involving the fertiliser industry and the distribution system also, ensures the supply of fertiliser products suited to local conditions.

The scale and success of these efforts depend on removing distortions in the relative prices of different nutrients introduced by recent price policy reforms. By retaining control on nitrogenous fertilisers and removing it from phosphatic and potassic fertiliser, these reforms have made phosphatic and potassic fertiliser far more expensive than nitrogenous fertilisers. Consequently, the task of promoting balanced application of fertilisers have become even more difficult than in the past.

Furthermore, in raising fertiliser use efficiency, timely availability of appropriate fertilisers is no less crucial than farmer's education in efficient fertiliser practices, or an enabling relative price environment for different nutrients. To ensure timely supplies, it is not enough to have a wide-spread network of fertiliser outlets. Adequacy of aggregate supply of different nutrients is equally necessary. This should be a matter of concern because recent policy reforms have created an atmosphere of uncertainty in the upstream supply arrangements for phosphatic and potassic fertilisers. All these aspects deserve careful attention in carrying out fertiliser policy reforms.

This shift in policy focus to more efficient use of fertilisers is desirable both from the economic point of view (of conserving the use of scarce resources for supplying fertilisers) and also to prevent potential environmental damage (such as soil degradation and chemical pollution of groundwater) due to excessive and unscientific fertiliser use. Moreover, given the necessity to reduce subsidies, the price of fertilisers will inevitably rise, and in all probability fairly substantially. Improvement in efficiency is an effective way to neutralise the adverse impact of higher fertiliser prices on farmer's costs and returns, and therefore on growth of aggregate output. A clear commitment based on a concrete programme of efficiency improvement through integration of location specific issues in research and extension and in resource management, backed by adequate resources will also help to counter the political resistance to withdrawal of fertiliser subsidy.

Fertiliser policy reforms guided by the above considerations are also relevant in accelerating the spread of fertiliser use under unirrigated conditions because the size and certainty of returns to fertiliser use on unirrigated land certainly depend on the timely supply and efficiency of fertiliser use. What is additionally needed here is to enlarge the efforts in promoting available dryland technology, in increasing the stock of this knowledge and in removing pro-irrigation biases in public investment and expenditure, as well as credit flows, for technology based agricultural growth. Such an orientation in policies will be more crucial than ever before if fertiliser is to continue playing its role in technology-based growth in Indian agriculture.

CHAPTER 4

POSSIBLE DETERMINANTS OF FERTILISER USE

4.1 Background

The relevance of fertiliser use for rapid agricultural growth hardly needs an emphasis. While fertiliser consumption has gone up from 66 thousand tons in 1951–52 to 12.7 million tons in 1991–92, a distinct deceleration in its trend rate of growth is discernible in the early years of 1990s. The total fertiliser consumption of 12.7 million tons in 1991–92, 12.2 million tons in 1992–93 and 12 million tons in 1993–94 may appear satisfactory against the consumption of 12.5 million tons in 1990–91 in the midst of the policy changes. However, such a conclusion would be hasty for two main reasons:–

Firstly total fertiliser consumption got stalled around 12.5 million tons in the early 1990s. More importantly, the rate of growth of NPK consumption in all the zones in 1990s is lower than that during the 1980s, as has been explained in detail in the proceeding chapter. This does not augur well for achieving the Eighth Plan's need based targets of fertiliser consumption of 18.3 million tons in 1996–97. Total production of foodgrains in 1996–97 stayed back at 191.1 million tons against the eighth plan target of 210 million tons.

Second, total fertiliser consumption did not decline mainly because the decline of 14% in P consumption and 35% in K consumption in 1992–93 from their 1991–92 levels and a further decline of 6 percent in P consumption in 1993–94 from its level in 1992–93 was offset by the growth in N consumption. Incidentally, the 1993–94 level of P consumption was about 2% lower than in 1988–89. And 1992–93 and 1993–94 are the first two years during the preceding two decades when the upward trend in P consumption was reversed (FAI, Annual Review, Fertiliser Production & Consumption 1992–93 and 1993–94). The negative effects of setback to P consumption may not be visible in aggregate agricultural production because of its residual effects and the geographical cropwise use pattern of this nutrient. However, this cannot go for many years because of widespread deficiency of P and high rates of N application on fertilised land (Desai and Gandhi 1990, Tandon 1993).

In the light of the above facts, the question arises if our understanding of the factors affecting fertiliser use in Indian agriculture is adequate. So far, determinants of fertiliser use have been studied guided by such issues as promoting fertiliser use among small and marginal farmers, spread of fertilisers use under unirrigated conditions or very low rates of application. That stage in the growth of fertiliser use has long passed. As explained in the preceding chapter, by the mid

1980s, fertiliser use was quite widespread among farmer. This was irrespective of the size of their farms or whether or not irrigation was available. Nor was the use confined to a few crops and high yielding varieties. The rates of application, specially of nitrogen on irrigated fertilised land, had also reached a fairly high level. With respect to all these features, marginal and small farmers were not lagging much behind medium or large farmers. Therefore adoption and widespread use of fertiliser by farmers are no more the real problem issues. The real problem areas are discontinuous use by many farmers; relatively little spread of use on unirrigated areas under many crops; and deficiencies in fertiliser practices (especially imbalanced application of different nutrients), which lowers efficiency of fertiliser use under both irrigated and unirrigated conditions. It is, therefore, in the fitness of things that determinants of fertiliser use should be studied in the light of these problem areas rather than be guided by outdated issues. Hence an analytical framework which fully explores various factors affecting fertiliser use is warranted. This is attempted in the following section. It needs to be pointed out rightaway that our analysis is not free from the limitations of regression and correlation methods for analysing determinants of fertiliser use and that of data availability, particularly in respect of supply side factors. All this becomes more evident as our analysis proceeds.

4.2 Analytical Framework

Factors determining fertiliser use can broadly be classified under two heads – off–farm (that is village level) factors and on–farm (or household level) factors. While the off–farm factors are common to all producers of agricultural products located in the same village, the on–farm factors vary across farms.

Off–farm factors :– Commonly the village level factors are school, communication; electrification, human health services; bank; distance to nearest town; agricultural processing industry, and non agricultural processing industry; traditional markets (hats in the village, weekly markets); procurement centres; regulated markets – cooperative market society and input markets (fertiliser outlets); seed outlets; and pesticide outlets.

On farm factors :– In addition to village level factors, there are other on farm variables that influence the farmers' decisions on fertiliser adoption, intercrop allocation, and level and extent of use. The variables that have been considered important are farm size, level and type of irrigation facilities, rainfall, use of organic manners, varieties of seeds, cropping pattern, availability of credit, quantum of marketed surplus and cash acquisitions, non–farm income, tenancy status, cooperative membership, educational background of the household, especially of the cultivator himself, family size, and so on.

In this study, for analytical convenience, the determinants of fertiliser use are grouped into four categories – (i) Agro–climatic factors (Rainfall, climate & soils); (ii) Technological factors (irrigation and high yielding varieties of seeds); (iii) Economic factors (the relative of crop and fertiliser prices); (iv) Institutional factors (Land tenure, size of holding and agricultural credit). It does not mean that these categories of variables are mutually exclusive in their effect on fertiliser consumption. In fact, as we shall see later, there could be considerable interaction among them.

Agroclimatic Factors :– Rainfall is the most important agro climatic factor that influences the level of fertiliser use. Areas with high, assured and evenly distributed rainfall are more favourable to greater use of fertilisers than those endowed with a low and uneven distribution of rainfall. The greater the year–to–year variation of rainfall, the higher would be the uncertainty in the expected yield and hence lower would be the fertiliser use. To capture all these aspects, rainfall should be considered in all its relevant dimensions–i.e. the quantum of annual rainfall, its distribution over the years, and its year to year variability.

Technological Factors

Introduction of <u>irrigation</u> helps to increase the quantum and assurance of moisture supply, to achieve better distribution of its supply during the crop season most especially during the crucial phases of plant growth, and also in some cases to extend it by allowing cultivators to choose longer duration crops. The effect of irrigation in general would be to increase (i) the base yield i.e., the yield obtained without application of fertilisers, (ii) the response to nutrients (marginal productivity of nutrients would be higher), and (iii) the level of physical yield. As a consequence, the optimal fertiliser doses for a given relative price would be higher for the irrigated crops than for their dry–farming counterparts.

However, it needs to be appreciated that crop–production is a process through time, in which the eventual outcome (in terms of yields) is, to a considerable extent, dependent on the quantum of moisture available and its time distribution over the crop season. For realising the full potential of nutrients, moisture supply should be consistent with the requirement of the crop during the critical phases of its growth : Fertiliser use (and crop yield) is an increasing function of the quantum of moisture supply up to a point, beyond which additional supply of moisture could be harmful for plant growth, just as insufficient water could adversely affect the productivity of nutrients. Although very little is known about the exact nature of the effect of variations in timing and quantum of water–supply on absorption of nutrients (and their productivity), the existing evidence seems to suggest that "yield response to a given dose of fertilisers is a function of time pattern of water input"

– (Vaidyanathan. A; water management and Efficient use of fertilisers, p.3). Also a recently published ICAR–IFPRI research study has pointed out that "serious attention must be paid to moisture conservation and better management practices that effect efficiency of fertiliser use" (p.14).

It is therefore evident that the classification of moisture status of crops, as irrigated or unirrigated, completely misses the crucial 'qualitative' dimension of water supply. Probably, a satisfactory way of recording this is to use data on the volume of water delivered to fields at various phases of crop growth. In the absence of such information, it seems desirable to distinguish between various sources of irrigation which are different in terms of the extent of control over timing and quantum of water supply to crops.

The large and medium scale irrigation projects, which divert water from mostly perennial rivers, are constructed and operated by the govt. Tanks have a relatively small command area, and since they are dependent on rainfall their water supply is highly variable. The govt. has tried to develop canals and field channels in the decades since independence, but still there exists large interregional variations. The surface water sources have other problems too such as flooding of fields which are nearer to canals due to poor drainage systems. On the other hand, fields far removed from canals face a high degree of uncertainty of water supply. Moreover, water release from large irrigation systems are regulated according to more or less fixed schedules. The limited flexibility in this respect does affect the efficiency of water supply.

In contrast, wells and tubewells, being located on farms, and designed mostly to irrigate the area operated by the owner, are more efficient in the sense that a high proportion of water pumped out is actually available to plants and permit greater flexibility in adjusting the timing and quantities of water supplies. The availability of groundwater is more reliable, since it is not dependent on that year's rainfall as is the case of surface water. Therefore, in order to capture the qualitative differences in irrigation it seems desirable to distinguish between various sources of irrigation. Such an attempt has been made in this study.

The high yielding variety (HYV) seeds of wheat, rice and other cereals introduced in the sixties, command a significantly higher output/yield potential than the traditional varieties. The effect of HYVs on fertiliser response is similar to that of irrigation. HYVs make quantum jump in yields possible because (a) they have a lower straw-grain ratio, (b) they do not lodge at high levels of fertiliser application and (c) they make more efficient use of fertilisers. However, it is likely that the performance of HYVs is far more sensitive to variations in moisture conditions. They are believed to be more demanding of adequate moisture at the right time and some of them are also more susceptible to pests and diseases. Therefore, the yields of HYVs, more than those of local varieties, seem to be affected by the cumulative interaction of seversal factors, especially those of water and fertilisers.

Cropping pattern is another technical factor that determines the fertiliser use. As all crops are not equally responsive to fertiliser application, an alteration in the crop–mix can also bring about a change in the aggregate demand for fertilisers. Crop combinations are, to a large extent, determined by the suitability of soil and climatic conditions, availability of irrigation facility and relative profitability of individual crops. A shift in crop pattern over time in favour of (or away from) fertiliser responsive crops, can increase (decrease) the growth in fertiliser consumption.

Economic Factors

The logic of profit maximisation would show that the quantity of fertilisers used by farmers would depend on, other things remaining the same, the fertiliser response function and the ratio of fertiliser and output prices. They would use fertilisers upto the point where its marginal costs are equal to the marginal returns. If the output price increases (decreases) relative to the fertiliser price, the response function remaining the same, farmers would use more (less) of the input. Similarly, the relative price remaining the same, the higher the fertiliser response the greater would be the optimum doses of fertilisers. Since the irrigated fields and those growing HYVs have higher responses, the optimal doses for them would be higher than for unirrigated crops and traditional seed varieties. However, there are innumerable uncertainties in a country such as India, which affect the expected yield (and output); such production uncertainties do have a depressing effect on fertiliser consumption.

Institutional Factors

The discussion of factors affecting fertiliser use would be incomplete without a proper understanding of the influence of the institutional framework of agriculture. Specifically, the highly skewed distribution of land not only places the large landowners in a more advantageous position in and outside markets, and gives them disproportionate economic and social power to exploit economically weaker sections both through market and non market means (Ashok Rudra, 1978). Smaller farmers may not have timely access to inputs like HYV seeds, pesticides, fertilisers etc. Unlike large farmers, they may have to bear larger cost per unit of output on account of transport and other overhead costs. The problem of smaller farmers is compounded by their weak bargaining power in the output market also. It is not uncommon that small farmers are forced to sell their produced to the big landowners/merchants at relatively lower prices.

Costs and availability of credit have a significant bearing on returns to fertiliser use. Given the distribution of land and also the control of institutions like cooperatives by the rural elite, the extent and intensity of fertiliser application is likely to be restricted among bigger farmers. Inputs like fertilisers are scale neutral in the technological sense but they may not be scale neutral in an economic sense as small and marginal farmers with a limited resource base are necessarily dependent on borrowing for working capital. This conclusion is commonly reported by numerous studies, e.g. A. K. Sen, Ashok Rudra, A. M. Khusro, C. H. Hanumantha Rao, Krishna Bharadwaj, G. R. Saini, G. K. Chadha, A. P. Rao, Usha Rani and Deepak Majumdar.

The tenurial arrangement has an important bearing on the pattern of input usage, since it determines the way in which the risks of production and the produce are shared. For example, under a system of proportional sharing of output, a small tenant has little incentive to incur expenses in yield-raising innovations like fertilisers, since its benefit would not accrue to him but to the landowner. Moreover, if the tenant is not assured of getting the same plot of land for cultivation in future, he would be least interested in undertaking any productivity augmenting investment. On the other hand, in a fixed rent system, the tenant would be motivated to undertake productive investment since he is likely to reap full benefits of his investment effort.

CHAPTER 5

DETERMINANTS OF FERTILISER USE IN INDIAN AGRICULTURE

5.1 Background

In the preceding chapter we discussed a wide range of factors that can possibly influence fertiliser use in a growing agricultural economy, especially the one where a clear switchover from the traditional to a modern production technology, has already ensued, and is well on its way to an expanding regional use of this most crucial input. It is time to seek empirical validation of such explanatory influences. The present chapter seeks to do the same. In particular we focus on the relationship between (i) Rainfall and the fertiliser use (ii) the technological factors and fertiliser use and (iii) relative price and fertiliser use. The nature and scope of this exercise is circumscribed by the availability of suitable data and statistical problems of estimation.

Limitations of data and problem of estimation

For a proper testing of the hypothesis, ideally, cropwise data on all the relevant varibales separately for each agro–climatic region would be needed. Unluckily the available data do not meet this requirement. For example, information on cropwise fertiliser consumption is not available except for estimates for a few time points e.g. NNS in 1970–71, NCAER in 1975–76. Hence the analysis is confined to explaining (mostly, statewise) variations in fertiliser consumption per hectare of cropped area in terms of a set of explanatory variables. However, where possible, district level data are also drawn upon and analysed. The data is taken from various issues of the following serial publications:– (i) Fertiliser statistics, (ii) Statistical abstract of India, (iii) Statistical abstract of the states under consideration, (iv) Agricultural statistics of India, (v) Estimates of Area, Production & Yield of Principal crops of India, (vi) Agricultural prices of India, (vii) Agricultural situation in India, (viii) Annual Review, Fertiliser production and consumption FAI.

Auto–correlation and multicollinearity pose considerable problem in estimation. When two or more variables increase (or decrease) over time in the same (or opposite) direction, multicollinearity becomes a serious problem. This problem gets compounded, as will be clear later, by the complex interrelationships between various factors affecting fertiliser use. Usually, there is no statistical procedure to circumvent the problem of mulicollinearity other than dropping one of the intercorrelated variables.

To overcome the statistical problems and the limitations posed by the data, the following procedure is adopted the relationship between each explanatory variable and fertiliser use is tested against cross section data. Then a similar 'partial' analysis is carried out, wherever possible, with time series data. In the later, partial correlation coefficients are computed to isolate the effect of 'time' in the variables. To determine the generality of the inferences drawn on the basis of the partial analysis, a 'complete' model is estimated–separately against sets of statewise cross section data, districtwise crcss section data and statewise time series data.

5.2 Results of the 'partial' analysis

Rainfall : We have argued in the preceding chapter that total rainfall, its distribution over the crop season and its year to year variability could affect fertiliser use. A simple correlation analysis is attempted between fertiliser used per unit of cropped area (herefater simply fertiliser use) and (i) annual rainfal, (ii) proportion of rainfall during June–September (which roughly corresponds to south west monsoon), (iii) coefficient of variation of annual rainfall and (iv) coefficient of variation of rainfall during June–September. The first two sets of correlations are computed using district level cross–section data and the last two using all India level time series data. Although the states choosen represent diverse rainfall regimes, and the years selected represent more or less 'normal' rainfall years, none of the estimated coefficients (Table 1) are statistically significant.

Table 1 : Correlation Coefficients Between Fertiliser use and Annual Rainfall Characteristics : Cross-Section Analysis

Item	Correlated Variables	Correlation Coefficient	Year	Number of Observations
1.	Fertiliser use and Annual Rainfall			
	a. Punjab	-0.0172	1992	15
	b. Haryana	0.0123	1993	16
	c. Maharastra	0.0145	1990	25
	d. Gujarat	0.4797	1988	19
	e. Andhra Pradesh	0.1825	1986	24
2.	Fertiliser use and Proportion of Rainfall during June-September			
	a. Punjab	0.0052	1992	15
	b. Haryana	-0.5066	1993	16
	c. Maharastra	-0.1482	1990	25
	d. Gujarat	0.1679	1988	19
	e. Andhra Pradesh	-0.0994	1986	24
3.	Fertiliser use and coefficient of variation of rainfall (annual) All India	0.1031	1980 to 1994	14
4.	Fertiliser use and coefficient of variation of rainfall during June-September (All India)	0.1481	1980 to 1994	14

Note :

1. Fertiliser use is measured in kg/hectare of NPK.
2. Annual rainfall is measured in millimeters.
3. For item 1 and 2, districtwise cross section data of different states mentioned at a particular point of time has been taken into account.
4. For item 3 and 4, time series data (from 1980 to 1994) of All India level has been taken into consideration.
5. Coefficient of variation of rainfall has been measured as year to year percentage variation in rainfall.

In Table 2, we have also estimated the multiple regressions for inter–state cross–section data for 1974–75, 1984–85 and 1991–92 with annual rainfall (TR) and proportion of rainfall during June–September (RJS) as the explanatory variables, and with fertiliser use as the dependednt variable. The F–test shows that none of the equations is statistically significant. Moreover, in all but two cases – and RJS for 1984–85 and 1991–92 – the t test does not reject the null hypothesis of the coefficients being not different from zero. The results perhaps cannot be considered conclusive since the specification of the variables and their relationships among them are admitedly crude. More important, it is possible that the level of aggregation is too high to capture the real effect of rainfall on fertiliser consumption.

Table 2 : Estimated Regression Equation: Fertiliser use and Rainfall characteristics: cross section Analysis.

Year	Estimated Equation	R^2	F–value	N
1974–75	Y= 14.594 + 0.089TR + 0.033RJS (0.267) (0.115)	0.034	0.142	17
1984–85	Y = 82.174 – 0.05TR – 0.209RJS (0.137) (0.718)	0.065	0.282	17
1991–92	Y = 94.459 + 0.107TR – 0.155RJS (0.322) (0.577)	0.155	0.737	17

Note : Y = Fertiliser used per unit of gross cropped area.
TR = Annual Rainfall
RJS = Proportion of rainfall during June–September
Figures in paratheses are 't' value of the coefficient under consideration.

Irrigation : We have attempted to determine the influence of variations in spread of irrigation (I_T) on consumption of fertilisers (variant I). Then to test our hypothesis regarding the qualitative aspect of irrigation discussed in the previous chapter. We have introduced the proportion of gross cropped area irrigated by canal (I_C), by tank (I_{Ta}), by tubewell(I_{Tu}), by other well (I_{ow}), and by other source (I_{os}) [variant II] (Table 3).

The relations are estimated with statewise cross section data for 1971–72, 1981–82 and 1992–93. Variant I of all the three years shows that I_T is a fairly significant variable. It indicates that in all the years under consideration I_T has remained a significant determinant of inter state variation of fertiliser use in Indian agriculture. Variant II shows the significance of different irrigation sources in the inter–state variation of fertiliser use. It shows that tubewell irrigation (I_{Tu}) has been a significant variable in all the three years whereas tank (I_{Ta}) irrigation has become a significant variable in 1981–82 and 1992–93. Variant II has a slightly higher R^2 than for variant I for all the three years since the former has more explanatory variables.

The correlation coefficient between fertiliser use and I_T is fairly high in all the three years as indicated by variant I. Variant II shows that in all the three years fertiliser use and tube–well irrigation has been significantly correlated. Therefore, it is legimate to infer that in general, it is irrigation and in particular, it is tubewell irrigation, that explains a greater proportion of the inter–regional variation in fertiliser use than other sources of irrigation, or irrigated cropped area in general.

To ascertain if the above inference holds true over time partial correlation coefficients between the irrigation variables and fertiliser use are computed, isolating the effect of time for all India, Punjab, Haryana and Uttar Pradesh. The results (Table 4) show that, in all the four cases the partial correlation coefficient between Y & I_{Tu} is positive. In case of Uttar Pradesh it is statistically significant as well. The negative association between canal irrigation and fertiliser use may be due to conjunctive use of water from various sources of irrigation. Moreover, the growth of tubewells is also phenomenal since the mid 1960s. These changes imply a steady improvement in assurance and timeliness of water supply at the aggregate level which has created an immense potential for feritliser use.

Table 3 : Estimated Regression Equations: Fertiliser use and Irrigation variables: Cross–Section Analysis.

Year	Estimated Equation	R^2	N	Correlation Coefficients between
1971-72	$Y = 0.074 + 0.718\ I_T$	0.156	17	Y & $I_T = 0.718$**
	(4.001)			
	$Y = 33.764 - 0.400 I_c$			
	(0.869)			
	$+ 0.073 I_{Ta} + 0.576 I_{Tu}$ -	0.562	17	Y & $I_c = -0.0417$
	(0.256) (2.319)			Y & $I_{Ta} = 0.1084$
	$- 0.323\ I_{ow} - 0.523\ I_{os}$			Y & $I_{Tu} = 0.6541$*
	(0.697) (1.118)			Y & $I_{ow} = 0.0374$
				Y & $I_{os} = -0.3303$
1981-82	$Y = 1.394 + 0.768\ I_T$	0.590	17	Y & $I_T = 0.7682$**
	(4.648)			
	$Y = 9.644 - 0.715 I_c +$	0.641	17	
	(0.362)			Y & $I_c = -0.1597$
	$0.508 I_{Ta} + 0.886\ I_{Tu}$ -			Y & $I_{Ta} = 0.0751$
	(2.361) (3.911)			Y & $I_{Tu} = 0.6554$
	$0.035\ I_{os}$			Y & $I_{ow} = -0.1557$
	(0.165)			Y & $I_{os} = -0.3078$
1992-93	$Y = 17.516 + 0.719\ I_T$	0.518	17	Y & $I_T = 0.7199$**
	(4.017)			Y & $I_c = -0.1323$
	$Y = 17.345 + 0.059\ I_c +$	0.528	17	Y & $I_{Ta} = 0.2101$
	(0.252)			Y & $I_{Tu} = 0.5666$*
	$0.454\ I_{Ta} + 0.715\ I_{Tu}$ -			Y & $I_{ow} = -0.1426$
	(1.844) (2.819)			Y & $I_{os} = -0.3866$
	$0.091\ I_{os}$			
	(0.373)			

Note: Y = Fertiliser consumption per unite of gross cropped area.
I_T = Proportion of net cropped area irrigated.
Ic = Proportion of net cropped area irrigated by canal.
I_{Ta} = Proportion of net cropped area irrigated by Tank.
I_{Tu} = Proportion of net cropped area irrigated by Tubewell.
I_{ow} = Proportion of net cropped area irrigated by other well.
I_{os} = Proportion of net cropped area irrigated by other source.
Figures in parentheses are 't' value of the coefficient under consideration.

Table 4 : Correlation Coefficients: Fertiliser use and irrigation variables: Time series Analysis.

Year	State	Variables	Value of Correlation Cofficient
1982-83 to 1992-93	All India	rYI_c	-0.8870**
		rYI_{Ta}	-0.6460
		rYI_{Tu}	0.0466
		rYI_{ow}	-0.0081
		rYI_{os}	0.6098
1982-83 to 1992-93	Punjab	rYI_c	-0.8203**
		rYI_{Ta}	0.0000
		rYI_{Tu}	0.5620
		rYI_{ow}	-0.6665
		rYI_{os}	0.5691
1982-83 to 1992-93	Haryana	rYI_c	-0.0038
		rYI_{Ta}	0.4114
		rYI_{Tu}	0.2245
		rYI_{ow}	0.678
		rYI_{os}	0.5956
1982-83 to 1992-93	Uttar Pradesh	rYI_c	-0.6324
		rYI_{Ta}	-0.6377
		rYI_{Tu}	-0.7338*
		rYI_{ow}	-0.8258**
		rYI_{os}	-0.5281

Note : Y = Fertiliser consumption per unit of gross cropped area.

rYI_c = Correlation cofficient between Fertiliser use and proportion of net canal irrigated area.

rYI_{Ta} = Correlation cofficient between Fertiliser use and proportion of net tank irrigated area.

rYI_{Tu} = Correlation cofficient between Fertiliser use and proportion of net tubewell irrigated area.

rYI_{ow} = Correlation cofficient between Fertiliser use and proportion of net otherwell irrigated area.

rYI_{os} = Correlation cofficient between Fertiliser use and proportion of other source irrigated area.

High Yielding Varieties

A linear regression of fertilisers use on the proportion of gross cropped area under HYV seeds (A_{HYV}) fitted to statewise cross section data (Table 5) gives a statistically significant coefficient with expected positive sign, though the explanatory power (R^2) is small (0.13). It shows that there are several other, perhaps more important factors, contributing to the inter–regional variations in fertiliser use. When the different sources of irrigation variable are included in the regression equation, the explanatory power increases from 0.13 to 0.63. It is quite clear from the latter equation that along with the coefficient for the proportion of gross cropped area under HYVs (A_{HYV}), tubewell irrigation and tank irrigation turns out to be statistically significant, which indicates that these three variables explain a greator proportion of the interregional variation in fertiliser use. The input complementarity is clearly validated.

Table 5 : Estimated Regression Equations : Fertiliser Use, Area under HYV seeds and irrigation variables : Cross Section Analysis.

Year	Estimated Euqations	R^2	N
1992–93	(a) $Y = 35.326 + 0.367\ A_{HYV}$	0.13	17
	(1.532)		
	(b) $Y = 5.692 + 0.370\ A_{HYV}$	0.637	17
	(1.743)		
	$-0.080\ Ic + 0.465\ I_{Ta}$		
	(0.353) (2.049)		
	$+ 0.558\ I_{Tu} - 0.193\ I_{os}$		
	(2.233) (0.840)		

Note : Y = Fertiliser use per hectare of gross cropped area.

I_c, I_{Ta}, I_{Tu}, I_{os} has the same meaning as defined earlier.

A_{HYV} = Area Under High Yielding Varities of Seeds.

Figures in Parantheses has same meaning as earlier.

Crop Pattern : A simple correlation between the crop-pattern index (CPI) and fertiliser use (Table 6) for statewise cross-section data for 1992-93 is positive but very weak (0.2105). The same is true about the correlation between crop pattern within the irrigated area (ICPI) and fertiliser use, which suggcsts that neither the crop pattern index, nor the irrigated crop pattern index is a significant variable to explain the interregional variation in the fertiliser use. To find out if the growth in fertiliser use is associated with changes in crop pattern index over a

Table 6 : Correlation Coefficient between Fertiliser use and cropping pattern index : Cross Section Analysis

	Correlated Variables	Correlation Coefficient	Year	Number of Observation
	Cross Section Analysis (Statewise)			
1.	Fertiliser use and cropping pattern index (CPI)	0.2105	1992-93	17
2.	Fertiliser use and irrigated cropping pattern index (ICPI)	0.1999	1992-93	17
	Time Series Analysis (All India)			
1.	Fertiliser use & CPI	0.9343**	1980-81 to 1989-90	10
2.	Fertiliser use & ICPI	0.4811	1980-81 to 1989-90	10

Note : 1. CPI = Crop patter index i.e. proportion of gross cropped area under fertiliser intensive crops.

2. ICPI = Irrigated crop pattern index, i.e. proportion of gross cropped area under fertiliser intensive crops within the irrigated area.

3. For computing the crop pattern index the crops selected are rice, wheat, maize, sugarcane, oilseeds and cotton. It has been choosen using NSS estimates (1978) of cropwise fertiliser use.

period of time, a partial correlation coefficient between fertiliser use and crop pattern index is computed in the same table, for all India for the period 1980–81 to 1989–90. The coefficient is positive and statistically significant. Therefore, it is legitimate to infer that while CPI has not been a significant variable in explaining the interregional variation at a point of time (1992–93), in general, over a period of time it has been a significant variable in the variation of fertiliser use.

The Relative Price

Table 7, presents time series figures of "Gross Financial Return" for wheat and paddy. It may be observed from the table that fertiliser prices remained virtually stagnant throughout the decade between 1981 and 1991 (i.e. from 11–7–81 to 24–7–91) except for a brief period of two and a half years (i.e. 29–6–83 to 31–1–86). However, procurement prices of various crops including paddy and wheat kept on increasing throughout the period. This maintained an attractive return to fertiliser application over the years. But the decontrol (in 1992) of phosphatic and potassic fertilisers changed the complexion of the economics of fertiliser application with respect to various crops. Forinstance for paddy, gross financial return from P_2O_5 through DAP went down from Rs.2.50 prior to decontrol to Rs.1.52 to Rs.1.60 immediately after decontrol. Government of India raised considerably the procurement prices of various crops

Table 7 : Economics of application of N, P_2O_5 and K_2O on paddy and wheat – 1971–72 to 1995–96

Item Description	1971–72	1974–75	1981–82	1983–84	1985–86 Effective 31.1.86 +	1991–92 Effective 14.8.91 +	1992–93 Prior to + 25.8.92 +	1992–93 Effective 25.8.92@	1993–94	1994–95 Kharif	1994–95 Rabi	1994–95 Kharif	1994–95 Rabi
A. Nutrient Price (Rs./Kg.)													
1. N based on Urea	2.01	4.35	5.11	4.67	5.11	6.65	6.65	6.00	6.00	7.22	7.22	7.22	7.22
2. P_2O_5 based on DAP	1.86	4.83	5.83	5.46	5.83	7.57	7.57	11.78 to 12.43	11.13 to 12.87	12.18 to 14.07	13.58 to 16.30	17.07 to 18.48	18.11 to 19.45
3. K_2O based on MOP	0.89	2.05	2.17	2.00	2.17	2.83	2.83	7.50	6.00 to 6.67	5.94 to 6.50	6.13 to 6.57	6.03 to 7.52	7.00 to 8.00
B. Output Prices (Rs./Kg.)													
1. Procurement Price of Paddy	0.53	0.74	1.15	1.32	1.42	2.30	2.70	2.70	3.10	3.40	3.40	3.60	3.60
2. Procurement Price of Wheat	0.76	1.05	1.30	1.51	1.57	2.25	2.75	2.75	3.30	3.50	3.60	3.60	3.80
Gross Financial Return on Every Rupee invested in Fertilisers (Rs.)													
C. Paddy													
1. Return on nutrient N	2.64	2.04	2.70	3.39	3.33	4.15	4.87	5.40	6.20	5.65	5.65	5.98	5.98
2. Return from P_2O_5 based on DAP	1.71	1.07	1.38	1.69	1.70	2.13	2.50	1.60 to 1.52	1.95 to 1.69	1.95 to 1.69	1.75 to 1.46	1.48 to 1.36	1.39 to 1.30
3. Return from K_2O based on MOP	2.38	1.80	2.65	3.30	3.27	4.06	4.77	1.80	2.58 to 2.32	2.86 to 2.62	2.77 to 2.59	2.99 to 2.39	2.57 to 2.25

Continued....

Item Description	1971–72	1974–75	1981–82	1983–84	1985-86 Effective 31.1.86 +	1991-92 Effective 14.8.91 +	1992-93 Prior to + 25.8.92 +	1992-93 Effective 25.8.92@	1993-94	1994-95 Kharif	1994-95 Rabi	1994-95 Kharif	1994-95 Rabi
D. Wheat													
1. Return from Nutrient N	3.78	2.90	3.05	3.88	3.69	4.06	4.96	5.50	6.60	5.82	5.98	5.98	6.32
2. Return from Nutrient P_2O_5 based on DAP	2.45	1.52	1.56	1.94	1.89	2.08	2.54	1.63 to 1.55	2.08 to 1.79	2.01 to 1.74	1.86 to 1.55	1.48 to 1.36	1.47 to 1.37
3. Return from nutrient K_2O	3.42	2.56	3.00	3.78	3.62	3.98	4.86	1.83	2.75 to 2.47	2.95 to 2.69	2.94 to 2.74	2.99 to 2.39	2.71 to 2.38

Note :

1. Incremental response ratio (kg of extra product per additional kg of nutrient) for paddy and wheat assumed for analysis are as under –

Nutrient	Incremental Reponse Ratio 1971-72	Incremental Reponse Ratio 1974-75 onwards
N	10	12
P_2O_5	6	7
K_2O	4	5

2. Prices of decontrolled fertilisers as given in the above table are informal indicative prices.
3. Prices of fertilisers mentioned against years 1971-72 and 1974-75 are as on 1st April.
4. + = Represent dates from which particularly the fertiliser prices changed.

   @ = Urea price reduced by 10%, P_2O_5 and K_2O price decontrolled.

Source : *FAI, Annual Review of Fertiliser Production and Consumption 1995-96, pp.126, 127.*

during the subsequent periods. However, the gross financial return on every rupee spent on nutrients achieved before decontrol is yet to be achieved. The gross financial return from nutrient P_2O_5 through DAP was Rs.2.50 as on 25–8–92 compared to Rs.1.30 to Rs.1.39 during Rabi 1995–96 and Rs.1.36 to Rs.1.48 during Kharif 1995–96. Similarly, the gross financial return for K_2O declined from Rs.4.77 as on 25–8–92 to Rs.2.25 to Rs.2.57 during Rabi 1995–96 and Rs.2.39 to Rs.2.99 in Kharif during 1995–96. Similar was the trend of gross financial return on wheat. However, in the case of N through urea, gross financial return remained quite attractive despite increase in urea price by 20% during 1994–95. This may be one reason for high consumption of N and reduced consumption of P and K as described earlier.

5.3 Testing of Complete Model

The results of the foregoing analysis has yielded some useful insights. However, since these explanatory factors are simultaneously influencing fertiliser use behaviour, one can not fully discuss the relative signficance of the variables and the interrelationship among them from the preceding partial analysis. We try to overcome this problem by a multiple regression model, in which all the relevant factors are included.

Cross–Section Analysis – Statewise : The complete specification of the model is as follows :

$$Y = \alpha + \beta_1 I_T + \beta_2 A_{HYV} + \beta_3 CPI + \beta_4 TR$$

Where Y = nutrients consumed per hectare of gross cropped area.

I_T = Proportion of net cropped area irrigated.

A_{HYV} = Proportion of gross cropped area under HYVs.

CPI = Crop pattern index i.e. proportion of gross cropped area under fertiliser intensive crops.

TR = Annual rainfall.

The model is tested against three sets of statewise cross–section data at three different points of time – 1972–73, 1982–83 and 1992–93. We have adopted a step–wise regression model, since it enables one to discern the incremental explanatory power of each variable.

The results (Table 8.a, 8.b, 8.c) show that in all the three years R^2 is fairly high, but at the same time it is declining gradually from 1972–73 to 1992–93. It may be due to the fact that in the successive years variables other than those included here have become significant in the variation of fertiliser use, which will be clear in our successive analysis.

While A_{HYV} is the most significant variable to explain the interregional variation of fertiliser use in 1972–73, in the successive years I_T and CPI have also become signficant. Annual rainfall is statistically significant only in 1982–83, while at other two points of time, it is not statistically different from zero. Even the sign pattern of this variable does not enable us to draw any valid inference.

The inter–correlation matrix in all the three years shows a high correlation between area under HYV and irrigation. The association between the spread of HYVs and irrigation perhaps points to the complementarity in their usage that has been discussed earlier.

Table 8.a : Estimation of Complete Model : Statewise Cross–Section Analysis

Period 1972–73

Inter–correlation Matrix

	Y	I_T	A_{HYV}	CPI	TR
Y	1.000	0.809	0.897	0.326	–0.072
I_T		1.000	0.870	0.393	–0.067
A_{HYV}			1.000	0.363	–0.115
CPI				1.000	0.665
TR					1.000

Steps	Variables Entered	β_1	β_2	β_3	β_4	R^2	N
1	A_{HYV}		0.896			0.803	
2	I_T	0.118	0.793			0.807	
3	TR	0.114	0.800		0.024	0.808	
4	CPI	0.132	0.820	–0.080	0.084	0.810	12
Constant =	–6.135 (0.641)	(0.389)	(2.389)	(0.290)	(0.328)		

Continued....

Table 8.b : Estimation of Complete Model : Statewise Cross–Section Analysis

Period 1982–83

Inter–correlation Matrix

	Y	I_T	A_{HYV}	CPI	TR
Y	1.000	0.854	0.506	0.443	–0.244
I_T		1.000	0.609	0.517	–0.147
A_{HYV}			1.000	0.803	0.421
CPI				1.000	0.586
TR					1.000

Steps	Variables Entered	β_1	β_2	β_3	β_4	R^2	N
1	I_T	0.853				0.728	
2	TR	0.835			–0.121	0.743	
3	CPI	0.658		0.287	–0.316	0.766	
4	A_{HYV}	0.649	0.024	0.275	–0.320	0.766	12
Constant	3.436 (0.130)	(2.108)	(0.072)	(0.723)	(1.060)		

=

Continued....

Table 8.c : Estimation of Complete Model : Statewise Cross–Section Analysis

Period 1992–93

Inter–correlation Matrix

	Y	I_T	A_{HYV}	CPI	TR
Y	1.000	0.759	0.786	0.535	0.026
I_T		1.000	0.844	0.677	–0.007
A_{HYV}			1.000	0.707	0.224
CPI				1.000	0.565
TR					1.000

Steps	Variables Entered		β_1	β_2	β_3	β_4	R^2	N
1	A_{HYV}			0.786			0.618	
2	I_T		0.329	0.507			0.649	
3	TR		0.258	0.591		–0.104	0.658	12
	Constant =	1.459 (0.053)	(0.621)	(1.386)		(0.459)		

Note : 1. Variable "CPI" is not included in the equation in table 8.c.

2. Twelve major agricultural states of India has been taken into consideration for the cross section analysis.

3. Y, I_T, A_{HYV}, CPI and TR has the same meaning as defined earlier.

4. Figures in parentheses are 't' value of the coefficient under consideration.

Cross–Section Analysis – Districtwise : The Complete specification of the model is as follows :

$$Y = \propto + \beta_1 I_C + \beta_2 I_{Ta} + \beta_3 I_{Tu} + \beta_4 I_{ow} + \beta_5 I_{os}$$
$$+ \beta_6 A_{Hyv} + \beta_7 AC + \beta_8 TR.$$

where, Y = nutrient consumed per hectare of gross cropped area.

I_c = proportion of net cropped area irrigated by canal.

I_{Ta} = proportion of net cropped area irrigated by Tank.

I_{Tu} = proportion of net cropped area irrigated by Tubewell.

I_{ow} = proportion of net cropped area irrigated by other well.

I_{os} = proportion of net cropped area irrigated by other source.

A_{Hyv} = proportion of gross cropped area under HYVs.

AC = per hectare availability of Agricultural credit.

TR = Annual rainfall.

The model is tested against three sets of districtwise cross-section data-one each for Gujarat, Madhya Pradesh and Maharastra. Here again a step-wise regression method is used.

The results (Table 9.a, 9.b and 9.c) show that R^2 is fairly high in case of Gujarat (0.83), but not so high in case of Madhya-Pradesh and Maharastra, which may be due to non inclusion of some important locational factors. Annual rainfall is statistically significant in all the three states which indicates that in the western zone, rainfall plays a significant role in the inter-district variation of fertiliser use.

If we look at the irrigation variables, canal irrigation, tank irrigation and other sources of irrigation (I_{os}) are statistically significant in the case of Gujarat which indicates that surface water plays an important role here in the variation of fertiliser use whose water availability depends upon rainfall. In the case of Madhya Pradesh, tank and other sources of irrigation are statistically significant. A_{HYV} is statistically significant in case of Gujarat and Maharastra. While agricultural credit is not a significant variable in case of Gujarat, it is fairly significant in case of Madhya Pradesh and Maharastra.

Time Series Analysis

To analyse the growth of fertiliser consumption, the complete specification of the model is tested agianst statewise time series data. The following variants of the model are estimated for 12 states.

$$Y = \alpha_1 + \beta_{11} I_T + \beta_{12} A_{HYV} + \beta_{13} CPI + \beta_{14} AC + \beta_{15} TR \quad \text{........(1)}$$

$$Y = \alpha_2 + \beta_{21} I_T + \beta_{22} A_{HYV} + \beta_{23} ICPI + \beta_{24} AC + \beta_{25} TR \quad \text{........(2)}$$

$$Y = \alpha_3 + \beta_{31} I_c + \beta_{32} I_{Ta} + \beta_{33} I_{Tu} + \beta_{34} I_{ow} + \beta_{35} I_{os} + \beta_{36} A_{HYV} + \beta_{37} CPI + \beta_{38} AC + \beta_{39} TR \quad \text{........(3)}$$

$$Y = \alpha_4 + \beta_{41} I_c + \beta_{42} I_{Ta} + \beta_{43} I_{Tu} + \beta_{44} I_{ow} + \beta_{45} I_{os} + \beta_{46} A_{Hyv} + \beta_{47} ICPI + \beta_{48} AC + \beta_{49} TR \quad \text{........(4)}$$

Note : All the variables has the same meaning as explained earlier.

Table 9.a : Estimation of Complete Model : Districtwise Cross–Section Analysis

Gujarat – 1993–94

Intercorrelation Matrix

	Y	I_c	I_{Ta}	I_{Tu}	I_{ow}	I_{os}	A_{HYV}	AC	TR
Y	1.000	0.67	–0.019	0.089	–0.520	–0.101	0.508	-0.095	-0.055
I_C		1.00	0.246	-0.212	-0.506	0.367	0.447	-0.114	0.206
I_{Ta}			1.00	-0.079	-0.202	0.866	0.556	0.081	-0.010
I_{Tu}				1.000	-0.729	-0.098	0.240	-0.170	-0.131
I_{ow}					1.000	-0.262	-0.568	0.216	-0.023
I_{os}						1.000	0.513	0.045	0.070
A_{HYV}							1.000	0.001	0.073
AC								1.000	-0.292
TR									1.000

Steps	Variables Entered	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	R^2	N
1	I_c	0.678								0.46	
2	Ios	0.827				–0.404				0.60	
3	A_{HYV}	0.670				–0.616	0.524			0.78	
4	TR	0.713				–0.615	0.519		–0.196	0.82	
5	I_{Ta}	0.743	0.226			–0.800	0.474		–0.184	0.83	
6	I_{Tu}	0.769	0.252	0.066		–0.806	0.434		–0.177	0.83	
7	AC	0.761	0.250	0.054		–0.803	0.441	–0.039	–0.189	0.83	19
Constant = 9.08		(4.817)	(0.930)	(0.369)		(3.103)	(2.430)	(0.298)	(1.430)		

Continued....

Table 9.b : Estimation of Complete Model : Districtwise Cross–Section Analysis

Madhya Pradesh – 1993–94

Intercorrelation Matrix

	Y	I_c	I_{Ta}	I_{Tu}	I_{ow}	I_{os}	A_{HYV}	AC	TR
Y	1.000	–0.084	–0.283	0.376	0.166	–0.440	0.014	0.434	–0.232
I_C		1.000	0.257	–0.353	–0.682	–0.220	0.447	0.088	0.182
I_{Ta}			1.000	–0.166	–0.343	–0.097	0.282	0.088	0.109
I_{Tu}				1.000	–0.130	–0.025	–0.165	0.184	0.007
I_{ow}					1.000	–0.288	–0.334	–0.047	–0.343
I_{os}						1.000	–0.148	–0.299	0.237
A_{HYV}							1.000	0.036	–0.071
AC								1.000	0.067
TR									1.000

Steps	Variables Entered	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	R^2	N
1	I_{os}					–0.440				0.19	
2	I_{Tu}			0.365		–0.431				0.32	
3	I_{Ta}		–0.274	0.319		–0.459				0.40	
4	AC		–0.302	0.261		–0.373		0.301		0.47	
5	TR		–0.284	0.262		–0.330		0.321	–0.146	0.49	
6	A_{HYV}		–0.303	0.272		–0.322	0.075	0.321	–0.140	0.50	
7	I_c	–0.027	–0.309	0.264		–0.328	0.085	0.322	–0.133	0.50	
8.	I_{ow}	–0.241	–0.359	0.144	–0.240	–0.452	0.078	0.320	–0.141	0.50	45
Constant = 62.59		(0.590)	(2.235)	(0.576)	(0.562)	(1.755)	(0.573)	(2.531)	(1.092)		

Continued....

Table 9.c : Estimation of Complete Model : Districtwise Cross–Section Analysis

Maharastra – 1991–92

Intercorrelation Matrix

	Y	A_{HYV}	AC	I_T	TR
Y	1.000	–0.094	0.559	0.135	0.046
A_{HYV}		1.000	0.020	0.568	0.247
AC			1.000	0.328	–0.334
I_T				1.000	–0.146
TR					1.000

Steps	Variables Entered	β_1	β_2	β_3	β_4	R^2	N
1	AC		0.558			0.31	
2	TR		0.645		0.261	0.37	
3	A_{HYV}	–0.184	0.667		0.314	0.40	
4	I_T	–0.261	0.636	0.124	0.341	0.41	29
	Constant = 40.26	(1.250)	(3.642)	(0.583)	(1.912)		

Note : 1. Variable "I_{ow}" is not entered in the equation in table 9.a.

2. AC = Agricultural Credit; other variable have to same meaning as defined earlier.

3. Figures in Parantheses are the 't' value of coefficient under consideration.

The result of this statewise time-series analysis are presented in table 10. All the equations have a very high explanatory power (R^2)

ranging from 81% to 99%. Annual rainfall (TR) has a little explanatroy power-except in four states i.e. West Bengal, Gujarat, Maharastra and Rajasthan. For all these four states, the estimated coefficients are statistically significant with expected positive sign. The result of Gujarat and Maharastra supports our earlier finding of districtwise cross-section data.

The proportion of area under fertiliser intensive crops (CPI) seems to be statistically significant with positive sign in the states of Bihar, haryana, Uttar Pradesh, Andhra Pradesh and Madhya Pradesh. However, crop pattern within irrigated area is found to be of greater significance in Haryana, Bihar and Tamil Nadu. A possible reason for getting a non-significant coefficient for crop pattern in many states is that the set of fertiliser intensive crops choosen for this purpose (rice, wheat, maize, sugarcane, cotton and oilseeds), does not take into account regional differences in the crops grown; for example jute, an important fertiliser intensive crop in West Bengal, is left out.

That the growth of fertiliser consumption is determined to a greater extent by the irrigation is evidened of by the consistently high explanatory power of irrigation variable (I_T) in all the states except in Tamil Nadu. The tubewell and other well irrigation, being a source of adequate water at right intervals of time is statistcally significant only in few states like Punjab and Haryana. It is puzzling to notice that in some states like Bihar, Tamil Nadu, Andhra Pradesh and Gujarat, this variable is having statistically significant negative coefficients. We are inclined to argue that the negative coefficients could be the result of the nature and strength of correlations between the explanatory variables. Moreover, the conjunctive use of water from different sources could complicate the problem.

In all the states except Rajasthan the area under Hyv (A_{Hyv}) is a fairly significant variable. However, in case of Bihar after first two variants, the coefficient of A_{Hyv} not only becomes insignificant but also turns out to be negative. This is probably due to a high correlation between the A_{Hyv} and the irrigation variables. Perhaps this is also reflective of the fact that there is high complementarity between fertiliser use and availability of irrigation. The same reasoning also holds in the case of Haryana where in all the four variants the A_{Hyv} is having significant negative coefficient.

Agricultural credit (AC) as an explanatory variable is statistically significant with positive sign in the states of Bihar, Haryana, U.P, Andhra Pradesh, Tamil Nadu, Gujarat and Maharastra. It is not statistically significant in the states of Punjab, Madhya Pradesh and Rajasthan. In case of West Bengal it is statistically significant with negative sign for which we do not have proper explanation.

Table 10 : Estimation of Complete Model : Statewise Time Series Analysis

States/ Year	Steps	Constant Terms	I_c	I_{Ta}	I_{Tu}	Estimated I_{ow}	Coefficient I_{os}	of I_T	A_{HYV}	CPI	ICPI	AC	TR	R^2	DF
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16
1. Bihar 1972–73 to 1992–93	1	–183.83						0.499 (1.737)	0.224 (1.282)	0.238 (0.665)		0.138 (1.162)	–0.094 (0.856)	0.85	15
	2	202.98						0.710 (4.949)	0.394 (2.611)		–0.134 (0.820)	0.162 (1.417)	–0.135 (1.324)	0.86	15
	3	–285.35	–0.014 (0.102)	0.185 (1.608)	–0.071 (0.300)	–0.688 (4.101)	–0.736 (0.273)		–0.118 (0.783)	0.549 (2.497)		0.075 (0.930)	–0.034 (0.430)	0.95	12
	4	–601.35	0.975 (0.086)	0.123 (1.128)	0.629 (0.116)	–0.921 (5.247)	–0.017 (0.167)		–0.193 (1.072)		0.345 (2.407)	0.104 (1.294)	–0.026 (0.326)	0.94	12
2. Orissa 1972–73 to 1992–93	1	–16.93						0.494 (3.169)	0.646 (3.952)	0.158 (1.192)		–0.135 (1.368)	0.026 (0.359)	0.93	15
	2	–7.263						0.450 (2.390)	0.648 (2.546)		0.070 (0.437)	–0.193) (2.112)	0.032 (0.417)	0.93	15
	3	0.770	–0.046 (0.109)	0.194 (1.327)	0.524 (1.222)	0.043 (0.048)			0.612 (3.645)	–0.014 (0.118)		–0.044 (0.553)	0.053 (0.972)	0.96	13
	4	–3.504	–0.022 (0.060)	0.193 (1.290)	0.540 (1.346)				0.633 (3.752)		0.803 (0.067)	–0.039 (0.540)	0.051 (0.868)	0.96	13

Continued....

States/ Year	Steps	Constant Terms	Estimated Coefficient of											R^2	DF
			I_c	I_{Ta}	I_{Tu}	I_{ow}	I_{os}	I_T	A_{HYV}	CPI	ICPI	AC	TR		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
3. West Bengal 1972-73 to 1992-93	1	54.79						0.306 (4.118)	0.889 (8.619)	-0.122 (2.174)		-0.346 (3.622)	0.144 (2.359)	0.96	15
	2	-128.60						0.330 (4.060)	0.831 (7.752)		0.065 (1.183)	-0.256 (2.752)	0.167 (2.524)	0.96	15
	3	124.58		-0.063 (0.332)		0.090 (0.772)	-0.388 (2.633)		0.661 (8.063)	-0.044 (1.131)		-0.182 (2.687)	0.117 (3.320)	0.99	13
	4	91.44		-0.117 (0.611)		0.048 (0.421)	-0.371 (2.417)		0.606 (8.399)		0.132 (0.037)	-0.133 (2.427)	0.118 (3.166)	0.99	13
4. Haryana 1972-73 to 1992-93	1	-28.07						0.042 (0.188)	-0.430 (2.553)	0.460 (1.677)		0.845 (4.004)	0.033 (0.461)	0.94	15
	2	-188.14						0.418 (2.090)	-0.520 (2.954)		0.398 (2.154)	0.704 (3.164)	-0.073 (0.924)	0.94	15
	3	-16.60	0.755 (0.031)	0.012 (0.138)	0.323 (1.132)	-0.048 (0.463)	-0.059 (0.532)		-0.543 (1.960)	0.509 (1.662)		0.950 (3.384)	0.023 (0.269)	0.94	12
	4	-22.53	-0.330 (1.827)	0.096 (1.255)		0.013 (0.143)	0.017 (0.164)		-0.579 (2.385)		0.540 (2.291)	0.819 (2.972)	-0.164 (1.717)	0.95	12

Continued....

States/ Year	Steps	Constant Terms	Estimated Coefficient of I_c	I_{Ta}	I_{Tu}	I_{ow}	I_{os}	I_T	A_{HYV}	CPI	ICPI	AC	TR	R^2	DF
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
5. Punjab 1972-73 to 1992-93	1	-250.36						0.268	0.626	0.097		0.015	-0.031	0.95	15
								(1.498)	(1.628)	(0.202)		(0.110)	(0.459)		
	2	-301.77						0.297	0.603		0.097	0.018	-0.034	0.95	15
								(1.719)	(2.149)		(0.388)	(0.138)	(0.511)		
	3	-204.51	-0.310		0.443	0.316	-0.045		0.722	0.421		-0.122	-0.052	0.96	13
			(2.343)		(1.715)	(1.973)	(0.716)		(1.539)	(0.945)		(0.856)	(0.816)		
	4	-51.20	-0.282		0.478	0.356	-0.027		1.059		0.064	-0.045	-0.038	0.96	13
			(2.118)		(1.889)	(2.239)	(0.445)		(3.461)		(0.283)	(0.385)	(0.621)		
6. Uttar Pradesh 1972-73 to 1992-93	1	-142.15						0.230	0.370	0.189		0.250	0.069	0.95	15
								(1.795)	(1.921)	(1.277)		(1.742)	(1.037)		
	2	-84.65						0.268	0.462		0.057	0.247	0.063	0.95	15
								(1.968)	(2.465)		(0.454)	(1.647)	(0.906)		
	3	36.40	-0.041	-0.416	0.032	0.231	-0.107		0.534	0.283		0.171	0.072	0.95	13
			(0.362)	(1.047)	(0.113)	(0.623)	(0.651)		(2.292)	(1.022)		(1.066)	(0.928)		
	4	144.58	0.016	-0.501	0.005	0.072	-0.109		0.540		-0.222	0.174	0.068	0.95	12
			(0.086)	(1.079)	(0.017)	(0.130)	(0.639)		(2.238)		(0.392)	(1.046)	(0.839)		

Continued....

States/ Year	Steps	Constant Terms	Estimated Coefficient of											R^2	DF
			I_c	I_{Ta}	I_{Tu}	I_{ow}	I_{os}	I_T	A_{HYV}	CPI	ICPI	AC	TR		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
7. Andhra Pradesh 1972-73 to 1992-93	1	-243.18						0.138 (0.981)	0.117 (1.229)	0.656 (5.004)		0.102 (1.165)	0.031 (0.647)	0.97	15
	2	954.72						0.327 (1.833)	0.261 (2.034)		-0.227 (2.543)	0.232 (2.107)	0.089 (1.387)	0.95	15
	3	142.42	-0.278 (2.249)	-0.420 (2.357)	-0.487 (2.234)		0.097 (1.333)		0.399 (3.217)	0.394 (2.253)		0.171 (1.331)	0.038 (0.770)	0.98	12
	4	938.17	-0.398 (3.666)	-0.555 (3.433)	-0.524 (2.290)		0.130 (1.783)		0.589 (8.089)		-0.125 (1.791)	0.128 (0.921)	0.075 (1.527)	0.98	12
8. Tamil Nadu 1972-73 to 1992-93	1	-106.62						-0.020 (0.139)	0.493 (2.711)	0.071 (0.488)		0.560 (3.603)	-0.058 (0.380)	0.81	15
	2	-785.62						0.016 (0.146)	0.294 (1.832)		0.320 (2.757)	0.631 (4.964)	-0.104 (0.917)	0.87	15
	3	364.03	-0.257 (1.251)	-0.943 (2.183)	-0.131 (1.254)	-0.251 (0.667)	-0.279 (2.354)		0.116 (0.992)	0.039 (0.401)		0.143 (1.128)	0.481 (3.078)	0.94	11
	4	163.68	-0.266 (1.370)	-0.956 (2.273)	-0.149 (1.468)	-0.279 (0.764)	-0.179 (1.159)		0.099 (0.862)		0.106 (0.846)	0.214 (1.392)	0.424 (2.524)	0.95	11

Continued....

States/ Year	Steps	Constant Terms	Estimated Coefficient of											R^2	DF
			I_c	I_{Ta}	I_{Tu}	I_{ow}	I_{os}	I_T	A_{HYV}	CPI	ICPI	AC	TR		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16
9. Gujarat 1972-73 to 1992-93	1	-34.78						0.330	0.258	-0.011		0.496	0.753	0.89	15
								(1.789)	(1.883)	(0.105)		(3.001)	(0.604)		
	2	83.01						0.515	0.285		-0.209	0.253)	0.131	0.91	15
								(2.564)	(2.245)		(1.654)	(1.265)	(1.126)		
	3	167.60	-0.164	0.120	-0.325	-0.413	-0.356		0.186	-0.021		0.378	0.080	0.96	12
			(2.045)	(1.162)	(1.143)	(2.482)	(3.114)		(2.376)	(0.254)		(2.651)	(1.141)		
	4	198.56	-0.127	0.181	-0.470	-0.411	-0.359		0.227		-0.087	0.363	0.082	0.96	12
			(1.315)	(1.333)	(1.805)	(2.847)	(3.454)		(2.344)		(0.713)	(2.934)	(1.202)		
10. Madhya Pradesh 1972-73 to 1992-93	1	-110.82						0.472	0.475	0.481		0.064	0.023	0.97	15
								(3.181)	(0.048)	(3.218)		(1.341)	(0.591)		
	2	86.42						0.505	0.399		-0.162	0.020	0.030	0.98	15
								(4.018)	(3.185)		(4.312)	(0.483)	(0.880)		
	3	-19.43	-0.200	-0.148	0.071	-0.041	0.116		0.263	0.308		0.049	-0.956	0.98	12
			(1.142)	(1.560)	(0.237)	(0.736)	(0.647)		(1.521)	(1.842)		(0.972)	(0.129)		
	4	58.66	0.190	-0.111	0.023	-0.040	0.224		0.610		-0.087	0.060	-0.120	0.98	12
			(0.644)	(1.373)	(0.152)	(0.581)	(1.743)		(4.262)		(1.201)	(1.112)	(0.026)		

Continued....

States/ Year	Steps	Constant Terms	I_c	I_{Ta}	I_{Tu}	I_{ow}	I_{os}	I_T	A_{HYV}	CPI	ICPI	AC	TR	R^2	DF
						Estimated Coefficient of									
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16
11. Maharastra 1972-73 to 1992-93	1	4.74						0.305	-0.040	-0.071		0.761	0.112	0.94	15
								(3.007)	(0.256)	(0.751)		(6.759)	(1.813)		
	2	32.08						0.279	0.130		-0.116	0.664	0.122	0.95	15
								(3.084)	(0.826)		(1.688)	(5.562)	(2.105)		
	3	516.66	0.143	-0.130		-0.491	-0.132		0.239	-0.032		0.461	0.140	0.94	13
			(0.503)	(0.243)		(0.910)	(0.703)		(1.583)	(0.192)		(3.051)	(1.751)		
	4	596.72	0.101	-0.194		-0.509	-0.103		0.319		-0.092	0.405	0.147	0.94	13
			(0.354)	(0.390)		(1.085)	(0.680)		(2.012)		(1.095)	(2.645)	(1.953)		
12. Rajasthan 1972-73 to 1992-93	1	-22.16						0.573	0.577	-0.069		-0.127	0.243	0.81	15
								(2.151)	(2.316)	(0.261)		(0.599)	(2.062)		
	2	-34.22						0.477	0.325		0.232	-0.057	0.210	0.82	15
								(2.636)	(0.910)		(0.882)	(0.261)	(1.732)		
	3	98.62	-0.217	-0.670		-0.410	-0.148		0.171	0.150		-0.124	0.459	0.84	12
			(1.064)	(1.955)		(2.176)	(1.049)		(0.451)	(0.632)		(0.480)	(1.881)		
	4	109.23	-0.272	-0.555		-0.455	-0.195		0.837		0.283	-0.067	0.296	0.85	12
			(1.736)	(1.533)		(2.636)	(1.601)		(0.016)		(0.968)	(0.252)	(1.094)		

5.4 Some Conclusion

The correlation and regression analysis–based on cross section and time series, 'partial' as well as the 'complete' testing of the model–shows that annual rainfall, in any of its dimensions, is emerging as a relatively unimportant variable in explaining the observed variations in fertiliser use. Much more disaggregated data most essentially the seasonal pattern of rainfall so very impotant for regions with low or no sources of irrigation, would perhaps enable us to capture the relationship between rainfall and fertiliser use. Irrigation, on the other hand, is uniformally a dominant influence. In the case of sourcewise irrigation, tubewell and other wells have come out to be significant, most strikingly in Punjab and Haryana. This lends strength to the hypothesis regarding the significance of irrigation quality - as reflected in assurance and timeliness of water supply - for efficient obsorption of plant nutrients. In the case of other high fertiliser consuming states, perhaps due to conjunctive use of water from different sources of irrigation, this source of irrigation has not came out to be significant. Therefore, a general view about the above mentioned hypothesis needs to be framed in a qualified manner.

Spread of HYVs, fertiliser intensive crops and agricultural credit are found to have a positive effect on fertiliser consumption. Use of fertiliser nutrients and relative price, as expected, are inversely related.

The latter fact has become more clear in the early years of 1990s. Higher relative price of P and K nutrients in comparison to N nutrient is perhaps the sole reason behind a unbalanced use of NPK in the early 1990s.

While the potential for absorption of nutrients has increased considerably as a result of rapid growth of irrigation facilities and qualitative improvements in it (due to the phenomenal growth of energised wells and rise in the share of ground water) as well as a sharp increase in the proportion of cropped area under HYVs and fertiliser intensive crops, the growth of fetiliser consumption has decelerated in all the zones of India in early 1990s as witnessed earlier in chapter 3. This question which has implications for agricultural development, needs further inquiry. Concern over this deceleration raises the issues like fertiliser use efficiency, environmental degradation etc. Though our study yielded some useful insights into the factors that affect fertiliser use by the cultivators, it does not provide any clues to the above question. Moreover, it brought out the limitaions of regression and correlation analysis in understanding the complete interactions in agricultural production.

The overall view that now emerges is that the conventional factors considered by us could not effectively capture variation in fertiliser use in unirrigated areas. This contention is supported by the fact that irrigation, being the most dominant variable in the determination of fertiliser use, is not adequately developed in these areas. It is further supported by the fact that rainfall, in any of its dimensions, is not a statistically significant variable either. Then the question arises what are the factors that have really led to the rapid spread of fertiliser use in unirrigated areas in the last two decades? Recognition of these factors is of vital importance because the future growth of fertiliser use required to achieve the targets of agricultural production depends upon exploitation of untapped potential of these unirrigated regions.

Some possible factors could be – (i) the need to raise per hectare yield of crops and scarcity of organic manures to overcome soil fertility constraints to high yields; (ii) development of dryland techniques particularly of moisture conserving technique; (iii) spread of HYVs; (iv) spread of fertiliser awareness among farmers due to both agricultural extnesion and demonstration effect of fertiliser use on high yielding varieties under irrigated conditions; (v) increasingly easy access to fertilisers as a result of expansion of the fertiliser distribution system and sustained growth of total fertiliser supply. This indicates two kinds of emerging trends in the fertiliser consumption behaviour – (i) Technological switchover from intensive irrigated technology to dryland technology; and (ii) increasing importance of supply and distribution network in the determination of fertiliser use. If this is any indication, then there is an urgent need to change our orientation on this line and suggest some useful future course of action. Also, there is urgent need to think over the increasing importance of bio–technologies, particularly the use of bio–fertilisers for sustainable agricultural development. Conjunctive use of farmyard manure and chemical fertiliser is another urgent issue to be considered. An analytical attempt has been made in the next chapter to capture all these vital aspects so very crucial for sustaining the growth of fertiliser use.

CHAPTER 6

LOOKING BEHIND FORMAL EQUATIONS : NEW CONTEXTS AND NEW DIRECTIONS

The determinants of fertiliser use explained in the previous chapter focus our attention basically on the conventional 'demand' oriented agroeconomic varibles. Due to the limitations of statistical techniques and nonavailability of data, our earlier explanation could not capture some more important nonconventional factors on which the future growth of fertiliser use depends. Given the necessity to increase fertliser use on continuous basis to step up crop yields, a deeper knowledge of factors affecting its use is imperative. Accordingly a considerable modification of conventional framework for analysing fertiliser use is required. This is because unlike the initial years where agro economic factors have had a dominant role to play, the future growth of fertliser use would be mainly determined by spectrum of processes which fall in the non price domain. Without a proper understanding of these processes and accompanying policy measurees, the task of attaining optimum levels of fertiliser use would be formidable. Keeping in view these facts the policy makers should not forget to consider the following factors which have to play a major role in the future growth of fertiliser use.

1. Development of Institutional Infrastructure

Aggregate fertiliser use is a function of demand, supply and distribution networks. Fertiliser consumption increases when there is an increase in the farmer's demand for fertilisers and when this demand is met by adequate supplies and distribution (G.M.Desai 1982,1988). In other words, farmer's demand for fertilisers cannot be made 'effective' if adequate quantities are not made available on time. Similarly, fertilisers use would be restricted if there is inadequate demand in spite of well developed supply and distribution system. Thus the interaction between these three processes determines the actual level of fertiliser use at a given point of time.

Often, the growth in demand for fertilisers is attributed to changes in variables like irrigation, HYV seeds, fertiliser prices and output prices. These variables certainly influence fertiliser use but to assume that fertiliser demand is causally determined, at all times and in all regions, exclusively by changes in these variables may not be the right way of looking at the phenomenon of fertiliser growth. For example, when the use of fertilisers was relatively new (as it was in the early 1960's), the limitations on supply and distribution systems were not appparent as its use was confined to a small area. But then, with diffusion of fertiliser use across crops/regions, their availability at the right time and in adequate quantities is proving to be an important factor in determing the growth of fertiliser use.

Similarly, fertilisers being costly, increase in its use has necessitated adequate credit availability and proper extension services appropriate to the adopted technology. In the event of non availability of those inputs/facilities the method of cultivation and efficieny of fertiliser use would be affected, thus, depressing returns to fertilisers.

In this context, the example of Gujarat state agricultural development is quite useful. Despite a state with low irrigation and poor rainfall, the overall level of per hectare fertiliser consumption in the state is higher than in many state with higher irrigation and a better rainfall environment, as explained earlier in chapter 2. Such impressive growth in fertiliser use, it is argued, is attributable to certain strengths on the supply side. At the state level, lthe main factors were: 1) the Gujarat government's proactive role in enlarging aggregate availability of fertilisers under the arrangements evolved by the government of India; 2) development of fertiliser industry within the state, which eased transportation and warehousing bottlenecks in fertiliser distribution; 3) impressive performance of the State Cooperative Marketing Federation in ensuring an effective off take of fertilisers allotted to Gujarat by the central government. At the district and lower levels, the expansion of the multiagency distribution network, and the ability of the cooperative system to ensure production credit (in the form of fertilisers) to farmers and working capital to lower level cooperatives for timely procurement of fertilisers have been important contributory factors.

Hence, in reality, the growth of fertilisers would not only be dictated by agro-economic variables but would also be governed by the strength of the extension network, supply and distribution network and the availability of credit facilities.

2. Development of New Dryland Techniques

As has been explained in chapter '2', in the recent years, fertiliser use was quite widespread among farmers-irrespective of the size of their farms and whether or not they had irrigation. Nor was the use confined to a few commercial crops or just high yielding varieties. The rates of application had also reached a fairly high level. Such a rapid spread of fertiliser use on unirrigated areas could become possible perhaps, due to the development of water conserving techniques and in general dryland technieques. It shows a clear switchover from intensive irrigated technology to dryland farming technology. In the light of this fact the government should concentrate on developing dryland technologies which will dictate the future growth of fertiliser use.

A substantial breakthrough in dryland agriculture was a key component in the agricultural strategy proposed for the eighth plan

(Planning Commission, 1990) and is emphasized with added vehemence for the Ninth Plan (Planning Commission Approach to the Ninth Plan, 1997) This is important not only for sustaining agricultural growth over the coming decades but, even more so, to locate agricultural growth processes in vast areas where the growth potential is big but is lying unexplored.

The rainfed land account for about one half of India's total cropped areas and 60 to 80 percent of area under coarse grains, pulses, oilseeds and cotton. (ICAR-IFPRI research work, 1994). Therefore, the pace of agricultural growth in these regions affects the overall agricultural growth rate and regional inequalities in a major way. Several components of dryland technology have been developed after the establishment of the All India Coordinated Research Project for Dryland Agriculture (AICRPDA) in 1970 and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in 1972. However, their impact on yield-based growth has been limited.

In order to examine the nutrient-use-practices recent years in these areas, ICRISAT has collected village level survey data from a panel of 105 farmers from 1975-76 to 1983-84. The sample farmers were spread over two villages in the Mahbubnagar district of Andhra Pradesh, and four villages of Solapur and Akola districts of Maharshtra. Obviously, the quantitative findings cannot be generalised for millions of farmers in the dryland regions on the basis of the sample of this size. However, the broad features and "deeper" understanding of the nutrient–use practices are quite instructive because they relate to farmers located in typical semi–arid tropical regions of India, characterised by low and uncertain rainfall; low irrigation; dominance of coars cereals, pulses, oilseeds, and cotton in the cropping pattern; and a widespread tradition of mixed cropping. Furthermore, the findings relate to the same farmers for nine consecutive years, and it is possible to trace nutrient use on the same plot of land over time.

As is evident from table 6.1, typically 20 to 30 percent of farmers did not use any nutrient in a given year during the nine year reference period. About 60 to 70 percent of cultivated area did not receive any nutrient application. Even in the early 1980s, when 85% of farmers were using some nutrient, nearly 60% of the cropped area remained unfertilised. Such a high incidence of nonuse of nutrients on land was due to both a significant proportion of farmers not using any nutrient as well as those using nutrients not applying them to more than half of their cultivated land. Between the two, the latter was more important.

The percentage of cultivated land that did not receive any nutrient application dropped from about 70 in the mid 1970s to about 60 by the early 1980s, and the trend was mildly declining (Table 6.1). Since about

Table 6.1 : Extend to nonuse of any nutrient, 1975-76 to 1983-84

Year	Farmers (Percent)	Area (Percent)
1975-76	32	66.9
1976-77	22	66.5
1977-78	30	75.5
1978-79	32	73.3
1979-80	32	72.4
1980-81	19	58.1
1981-82	18	63.2
1982-83	17	61.2
1983-84	10	53.9
Average 1975-77	28	69.7
Average 1981-83	15	59.3
Average 1975-83	24	65.8

Source : *ICAR (New Delhi) - IFPRI (Washington D.C., USA), "Strategic Issues in Future Growth of Fertiliser Use in India", Edited by G.M. Desai and A. Vaidyanathan, p.187.*

85% of farmers were using some nutrient by the early 1980s, clearly "adoption" of nutrient (even fertiliser) use by farmers is not the main issue in tackling soil-fertility constraints. The main issue is to use fertiliser regularly and are the whole of cultivated land possessed by a farmer.

Table 6.2 : Relative importance of manures versus fertilsers in total nutrient used, 1975-76 to 1983-84

Year	Use in Metric Tons of $N+P_2O_5+K_2O$			Use in Total Kgs/hectare		
				F	M	Total
1975-76	4.410 (27%)	11.794 (73%)	16.204	6	17	23
1976-77	6.011 (34%)	11.748 (66%)	17.759	8	17	23
1977-78	7.725 (50%)	7.776 (50%)	15.501	10	10	20
1978-79	8.629 (57%)	6.570 (43%)	15.199	12	9	21
1979-80	8.469 (69%)	7.726 (31%)	12.332	12	6	18
1980-81	n.a.	12.686	n.a.	n.a.	18	
1981-82	n.a.	10.016	n.a.	n.a.	15	
1982-83	n.a.	15.766	n.a.	n.a.	23	
1983-84	18.468 (54%)	15.032 (46%)	34.234	26	21	47

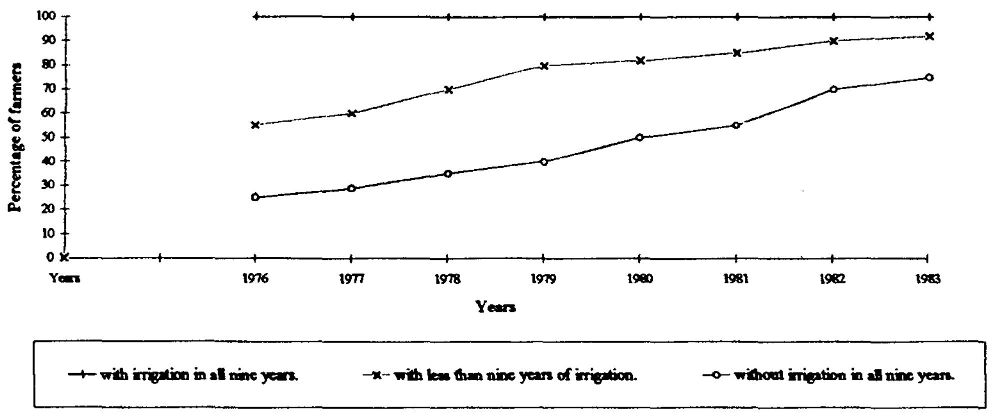
Note : F means fertiliser; M means Manure; and n.a. means data are not available; figures in parentheses are percentage of total.

Source : *ICAR-IFPRI, "Strategic Issues in Future Growth of Fertiliser use in India:, Edited by G.M. Desai and A. Vaidyanathan. p.196.*

Table 6.2 shows, the total amount of nutrients used by sample farmers in the form of manures and fertilisers during different years. As can be seen by averaging the values in table 6.2, the share of organic manures was only marginally higher (53%) than that of fertilisers (47%) in total nutrients used by sample farmers during the six reporting years. More importantly, the relative share of manures declined sharply over time – from 73% in 1975–76 to 46% in 1983–84. There were also sharp year to year fluctuations in manure use, with no clear trends; and the set backs to total nutrient used in 1977–78, 1978–79, and 1979–80 were solely due to a decline in manure use. On the other hand, there was a clear increasing trend in total fertiliser use as well as its relative importance. Finally, whereas nutrient use in the form of fertiliser increased from 6 kg/hectare in 1975–76 to 26 kg/hecture in 1983–84, nutrient use in the form of manure fluctuated between 6 kg/hectare and 23 kg/hectare during the same period. All these findings clearly show the growing importance of fertiliser in such areas.

This very study has examined the association between fertiliser adoption and irrigation by dividing sample farmers into three categories : (1) those with irrigation in all nine years; (2) those with irrigation in less than nine years; and (3) those without any irrigation in any of the nine years. As shown in figure 6.1, adoption was complete in the first category by 1976–77. By that time, a little over one-half in the second and about one-fourth in the third category had also adopted fertiliser. The difference between the second and the third category was quite significant untill 1979–80, but after that the third category caught up with the second. By 1983–84, more than 80% of the farmers without any irrigation too had started using fertilisers at one time or the other.

Figure 6.1: Irrigation status and adoption of fertiliser.



Source: *ICAR-IFPRI, "strategic Issues in Future growth of Fertiliser use in India", Edited by, G.M. Desai and A.Vaidyanathan, p.198.*

This finding further confirms that adoption of fertilisers use by farmers, even those without any irrigation, was no longer a real issue by the early 1980s. The more important points are irregularity of use at farmer level, and the use being confined to small proportions of cultivated land at the farm level.

Wether a farmer had continued to use fertiliser every year after its first adoption and whether he used it discontinuously or stopped using it, the 105 sample farmers were divided into the following categories :-

1.	Non adopters	–	8
2.	Adopters	–	97
	2.1 Continuous users	–	44
	2.2 Discontinuous users	–	39
	2.3 Adopters of 1983–84	–	7
	2.4 Dropouts	–	7
3.	Total	–	105

Clearly, the discontinuous (or irregular) use of fertilisers was as common as continuous (or regular) use. However there were very few dropouts (farmers who did not use it afterwards having once used it during the nine year period). This is stressed because it reveals that a vast majority of farmers did not discontinue the use permanently after trying it out, which in turn means that they must have found it viable even in their uncertain rainfall environment.

Two messages emerge from this study. First, vast proportions of unirrigated area did not receive either manure or fertiliser. Second, the importance of fertilisers was growing in farmer's struggle to overcome soil fertility constraints in the face of chronic scarcity of manure. Over the nine years, adoption of fertiliser by farmers had grown from 50 to 92% even though about a third of them were without any irrigation throughout the period. Equally as important, fertiliser use was not confined to either irrigated or single cropped area. Nearly 20% of fertilisers and over 40% of total manures were used on mixed cropped area even though virtually all of it was unirrigated.

Thus, fertiliser adoption by farmers is no longer the relevant issue. What is needed is rapid fertiliser diffusion on unirrigated land under both single and mixed cropping. Here, the pertinent question is not whether but how to increase diffusion of fertiliser use on such areas. In this perspective, the policies and programmes to accelerate fertiliser diffusion becomes integral parts of the agricultural development strategy for the dry land areas rather than haphazard efforts by either government or the private sector to encourage fertiliser use on unirrigeted cropped area viewed thus, certain non-price factors both on the demand and supply sides seem very important.

Three factors are considered crucial on the deamnd side : (1) development of appropriate dryland technologies and rapid diffusion of all its major elements (moisuture conservation, fertility management, HYVs, and pest control); (2) farmer's technical knowledge of correct fertiliser and other agronomic practices under site-specific rainfed conditions; and (3) adequate and timely provision of production credit for dryland crops.

It needs to stressed that the above factors rather than price incentives are more important for sustainable growth in farmer's demand for fertilisers. First, because of the importance of high-income elasticity crops-such as pulses, oilseeds and cotton - in the dryland areas; and second, because deficiencies in the factors mentioned above have been more important than the price environment in constructing growth of farmer's demand for fertilisers.

On the supply side, development of distribution networks deserves more attention than it has received so far. Often, the deficiencies in the distribution systems have been due to inadequate flow of fertilisers to dryland regions, which in turn is due to the demand pull from regions with high levels of irrigation. Thus the task of improving fertiliser distribution systems in the dryland regions is tied to increasing the pace of growth in aggregrate fertiliser supply so that it is faster than the growth in fertiliser demand in irrigated regions.

3. Use of Bio-Fertilisers

Bio-fertilisers will gain increasing importance in agricultural propduction, as it is a less energy-intensive input. Adequate development of these fertilisers would reduce the mounting burden on our economy created by chemical fertilisers.

A large number of microbes inhabit the soil. Although these form an insigificant part of total soil, they are responsible for many chemical transformations in the soil, like building and maintaining soil fertility and providing important micro elements to the soil. There are two main groups of nitrogen fixing bacteria, i.e. Azotobacter and Rhyzobium. The former live freely in the soil and are called non-symbiotic bacteria. These bacteria are capable of fixing nitrogen for non-legume crops. The second group of microbes live within the plant and are called symbiotic bacteria. In this group, most important in rhyzobium which causes the formation of small nodules within the roots of most legumes. It is possible to isolate and multiply the strains of these nitrogen-fixing bacteria and harbour them in suitable media in the laboratory. This inoculation is called bacterial fertilisers or bio-fertilisers.

Experiments conducted at research stations have proved that the use of bacterial fertilisers can result in significant yield increase of some major crops such as pulses and paddy (N. S. Subba Rao, 'Bio Fertilisers in Indian agriculture, Problems & Prospects' Fertiliser News vol 24(9), September 1979, p.86).

Its use in improving the nitrogen status of compost has also been established (A.C. Gaur 'Organic Recycling : Prospects in Indian agriculture', Fertiliser News, Vol 24 (12), Dec. 1979 pp.53-55). At the same time, the cost of production of these fertilisers is low. However, in spite of these advantages, there use in the country has been very little. The data available for Gujarat reveal that less than 0.5 percent of their potential has been tapped. The position in other states should not be much different.

The agricultural technology associated with the green revolution has made an enormous contribution to food production in the country. However, its ability to increase food production in the future is limited.

The upward trend in per capita food production has already levelled off in many areas. Even in the irrigated fields, grain yields have improved only marginally or have not improved at all in the recent years. These technologies are also associated with accelerated soil erosion and pollution and over-exploitation of ground water (see Robert Engelman and Pamela LeRoy, conserving land : Population and Sustainable Food Production, Population and Environment Programme, Population Action International, Washington 1995). Clearly, there is a need for a major break-through in agricultural technology to solve some of these problems which have gradually piled up in the post green revolution years.

The development of molecular biology is likely to provide the next generation of agricultural technologies. They enable scientists to transform the characterstics of plants through genetic manipulation. Grouped under the term 'biotechnology' these technologies could be used for genetic improvement of crops, transfer of genes with specific properties, disease diagnosis, developing plants more adopted to diverse ecological conditions etc. Attempts to develop rice varieties resistant to tungro disease, disease resistant cutivars of papaya, developing virus disease resistance by genetic transformation in various crops etc. are cited as practical examples. Similarly, it is expected that applications of biotechnology would result in reduction in the quantity of chemicals applied in agriculture and environmentally benign and safe alternatives would be developed. For example, microbial inoculants can be used as biocontrols and would be good substitutes for chemicals. Biological nitrogen fixation has been identified as another promising application, particularly in developing nations.

It has often been suggested that the emerging biotechnology is likely to be particularly useful in boosting agricultural production in developing countries. However, there area a number of reasons to suspect a slip between the cup and the lip.

Firstly, a huge proportion of agricultural biotechnology research is concentrated in the hands of about 15 large private firms in the US and Europe.

Secondly, the current research in this field is dictated by the commercial interests of these firms and is only marginally relevant to the problems faced by developing countries. The crops and traits developed, are those which are important primarily in the markets of developed countries.

They are unlikely to be of much use in enhancing agricultural productivity in developing countries. ('What is coming to Market? An update on commercialisation', Gene Exchange Vol. 5, No. 1, December 1995, 8-9).

Thirdly, the cost of getting access to agricultural biotechnology is likely to be too high for most developing countries. There is an increased trend towards patenting biotechnology products and processes, which is very different from the days when most agricultural research was carried out by international and public sector research institutes, and was ungrudgingly placed in the public realm. The results of this research, not patented, was freely available to the farmers of the developing countries. But in the context of current economic scenario, as a result of widespread patenting, most agricultural biotechnologies are owned by a handful of American and European Companies, and can be acquired only on a hard commercial basis. Most developing countries will be unable to afford them (Toenniessen, Gary H, 'Plant Biotechnology and developing Countries', Tibtech, Vol 13, Sept. 1995).

Therefore, in the light of the present international economic scenario, the govt. should step up investment to develop biotechnology. Although some advanced centres of research in biotechnology have been established in India, it is not clear how such priorities find their place in the existing agricultural research system. A fresh look at the priorities of the Indian agricultural research system is necessary in the light of these emerging prospects. India is currently investing only 0.3% of its agricultural G.D.P to agricultural research, as against 0.7% in the developing countries as a whole and 2–3% in the developed countries.

Therefore, there is considerable scope for diverting incremental outlays to the priority areas in research.

Hence, with the emerging prospects of biotechnologies which is likely to provide the next generation of agricultural technologies, the role of bio-fertilisers becomes vital in the future development of Indian agriculture, observing several benefits of the use of biofertilisers as explained earlier steps should be taken to encourage its use.

4. Conjunctive Use of Chemical Fertisers and Organic Manures

In view of the steady deterioration of the soil productivity of our humid tropical soils with continuous and increased use of only chemical fertilisers, serious thought has to be given to an agricultural strategy to utilise organic wastes as fertilisers on a large scale.

Although the usefulness of organic matter in crop production is well recognised, this has for long been a controversial issue in India. It is feared in some quarters that, most of the organic manure added to the soil gets oxidised due to the prevailing tropical temperature and hardly any benefits is obtained from it. In fact, experiments carried out in the agriculturally advanced countries, including those in the temperate regions as well as some in India, have proved beyond doubt that the application of organic manure in combination with inorganic fertilisers helps not only to increase crop production but also to maintain soil productivity on an enduring basis. The need for balanced use of organic manurers and inorganic fertiliser devolves on some fundamental principles of crop nutrition, relating to the interrealtionship as well as the effects of one on the other.

The use of organic manures or compost alone has the following primary drawbacks :

a) Its relatively low content of major nutrients, i.e. N, P_20_5 and K_20.

b) Its slow nutrients release characteristics

c) Its bulky nature preventing long distance transportation.

The use of chemical fertilisers alone has the following primarily disadvantages.

a) It does not contain all the nutrients in balanced quantities required by the crop plants.

b) It depletes the soil's organic matter, and thereby makes adverse soils' physical properties.

c) It reduces the soil's fertility in the long run.

A combined application of organic manures and chemical fertilisers in the form of organo-mineral-fertiliser-complex would, therefore, have the following basic advantages.

a) It will supply nutrients readily and steadily over the entire growing period of crops.

b) It will supply all the nutrients in balanced quantities and, therefore, improve the percentage utilisation of nutrients added in fertilisers as required by the crop plants, since organic matter is basically of plant origin and contains all the nutrients required for optimum plant growth.

c) It will help maintain the soil's organic matter at a steady level, thereby, ensuring ideal soil physical properties and fertility status.

d) It will prevent the losses of nutrients because of the high exchange capacity of the organic matter.

e) It will have significant residual effects on the succeeding crops and help to maintain soil health, and hence sustained crop productivity.

f) It will be economical to transport the material over longer distances since it will be enriched in N, P_2O_5 and K_2O and will contain more plant nutrients per unit volume as compared to compost.

Therefore, the future thrust in this sensitive area of technological adjustment is to go by a conjuctive use of farm yard manures and chemical fertilisers. The region specific use-mixes would have to be carefully drafted. It would hardly be an exaggeration to say that among the remedial measures directed at sustaining the tempo of regional agricultural growth in India, the level of fertiliser use and its optimum combination with farm yard manure would constitute a major thrust area for future policy intervention.

5. Balanced Use of Nutrients (N, P, K)

In the present economic scenario, balanced application of fertiliser nutrients is one of the most crucial but controversial issue. The issue has been debated much since the adoption of partial decontrol of nutrient prices in 1992. The critics of partial decontrol, however, argue that it has created a lopsided nutrient price structure. This has worsened the already lopsided pattern of application of urea, phosphate and potash. The present N,P,K ratio of 8.5 : 2.6 : 1 is far from the ideal average N,P,K ratio use of 4 : 2 : 1 recommended for the Indian soils. Such an imbalance in N,P,K use may aggravate soil fertility problems and adversely affect crops productivity in future.

This imbalance in nutrient use is much more in agriculturally advanced states like Punjab and Haryana as has been pointed out in Chapter 3. One study made by V. P. Gandhi, G. M. Desai, S. K. Raheja and P. Narain, based on about 1600 paddy plots in Punjab, has pointed out that by 1981–82 fertiliser use was virtually universal and the average rate had reached 126 kg/hectare. But 57% of paddy fields were receiving only N, 32% NP, and only 7% NPK. Five years later, when the average rate had reached 153 kgs/hectare, still 37% of plots received only N and just 5% of plots received NPK. Interestingly, the plots received only N were spread over all districts, and about 75% of them had received more than 100 Kg of N per hectare (ICAR-IFPRI research work, 1994, Ch.3).

More important, the research shows that there is a sizeable scope for increasing wheat and rice production simply by promoting balanced use of N, P, K and by inducing a redistribution in the consumption of fertiliser in favour of high response regions of Uttar Pradesh and Central India (Bihar, Orissa, West Bengal, Assam and other North-Eastern states).

In case of wheat, significant gains are possible with improvements in the N:P:K ratios to the 2:1:1 level, and regional reallocations of fertiliser use on wheat and targeting further growth mainly in favour of the U.P. and Central region. With these changes, additional production of about 6 million tons is possible with 0.7 million tons of additional fertiliser use on wheat. About 62% of the 6 million ton increment in wheat production comes from U.P. region, followed by Central region (14%). In the northern region, fertiliser use declines (due to reallocation) but the production actually increases (nearly 100 kgs/hectare) because of balanced application. The increment in production would be larger with fertiliser-to-wheat price ratio below 5.

In the case of rice, far greater gains are possible from improvements in the N : P : K ratios to the 2 : 1 : 1 level, and reallocation of fertiliser use of optimal levels in different regions, even with the fertiliser to rice price ratio of 3. A regional shift to optimal use levels, even in terms of 1989-90 N : P : K ratios, could yield an additional rice production of 9.4 million tons with an increase of 1.8 million tons of fertiliser use on rice. With a further change of the N : P : K ratio to 2 : 1 : 1, an estimated production increase of 15.4 million tons results from an additional fertiliser consumption of about 2.9 million tons. The major reallocation in fertiliser consumption is away from the southern regions and towards both the eastern and Uttar Pradesh regions. these two regions contribute about 84% in the total increment of 15.4 million tons of rice production.

These findings are of vital significance for the future policy implications. these results indicate that an increase of 21 million tons in wheat plus rice production would be possible with the above changes, even under the existing technology and fertiliser-to-crop price ratios. However, to realise these gains, a major improvement in the regional distribution of fertiliser use and a substantial change towards balanced nutrient application are essential.

CHAPTER 7

CONCLUSION

India's agricultural development programme has assigned high priority to fertiliser – use as a crucial ingredient of the technology. Under the present changing economic scenario, the overriding concern is how to sustain the growth in fertiliser use, so much compulsively required to achieve the targets of agricultural production. Although numerous 'need based' demand projection studies have been conducted, there is a dearth of careful analysis which sheds light on the current problem. An exception is ICAR–IFPRI research work (1994) that has investigated the problem in great depth and suggested some useful remedial measures to come out of the current problem. This study is also an attempt to provide a systematic record of the pattern of fertiliser use in Indian agriculture and has suggested some policy measures to sustain the growth in fertiliser use.

Empirical studies pertaining to the Indian fertiliser sector reveal that diffusion of fertiliser consumption has been quite widespread. By 1988–89 Fertiliser was being used on more than 85% of irrigated land and on about 50% of unirrigated land. During the preceding two decades (1970–71 to 1988–89), the growth rate of diffusion to the unirrigated land was much higher, taking the unirrigated land fertilised from as low as from 9% to as high as 50%, thus narrowing the irrigated–rainfed differential in fertiliser diffusion. Unirrigated areas however, still suffer from discontinuity and irregular pattern in the use of fertilisers.

The intensity of fertiliser use has gradually gone up from about 3 kg/hectare in the early 1960s to about 16 kg/hectare in the early 1970s to 34 kg/hectare in the early 1980s to more than 70 kg/hectare in the early 1990s. It has been relatively higher in irrigated region (129 kg/hectare by 1988–89), which leads to skewed consumption of fertilisers in the country in favour of irrigated areas. Irrigated areas which accounted for about 30% of total crop area, used as much as 69% of the total fertilisers used in the country. Gujarat is perhaps the only state that had adopted fertiliser consumption on a sufficiently wide scale by the early 1980s despite low rainfall and on extremely limited irrigation base. This success was primarily due to an efficient state machinery, which in seeking to develop the fertiliser industry, streamlined transportation and stocking of fertilisers, and cooperative agencies responsible for distributing fertilisers.

The study finds that the rate of adoption of fertiliser use is somewhat lower among small farmers than large farmers, owing mainly to credit constraints. However, those small farmers who do adopt tend to use higher doses of fertilisers than the large farmers. This relationship is more pronounced on unirrigated and partially irrigated plots, but breaks down on irrigated plots, where in fact, farmers use higher doses of fertilisers. It is possible that small farmers improve the quality of their unirrigated plots through the use of surplus labour, whereas the quality of irrigation is better on large forms on account of higher private investment in minor (controlled) irrigation.

Wheat and rice account for about 60% of fertiliser consumption (NPK), and this ratio appears to have remained more or less the same over the last decade. The use of N, P and K is quite imbalanced, not only in low consumption areas but even in high consuming and advanced areas. The responses (average and marginal) of wheat and rice to fertiliser consumption are highest in central (Madhya Pradesh and Rajasthan) and eastern regions (Bihar, Orissa, West Bengal, Assam and other North Eastern states) and Uttar Pradesh. This indicates that there is sizeable scope for increasing wheat and rice production simply by facilitating higher levels of the consumption of fertilisers in favour of high–response regions, and by promoting balanced use of N, P and K through appropriate policy measures.

More specifically, there is evidence to show that for wheat, a balanced use of NPK could increase production by about 2 million tons, and regional adjustment of fertiliser use at optimal levels with the existing mix could increase production by another 1.6 million tons. If the best mix of fertiliser is used at optimal levels, the current production of wheat could potentially rise as much as 12%, with use of an additional fertiliser consumption of 0.5 million tons. For rice, the potential is even greater; an increase of about 20% over current production with an additional fertiliser consumption of 1.5 million tons.

Regarding the determinants of fertiliser use in Indian agriculture, conventionally, they can be grouped under four categories, namely (i) Agro–climatic factors, (ii) Technological factors, (iii) Economic factors and (iv) Institutional factors. Among the agro–climatic factors, rainfall, in its relevant dimensions, can account for a part of the variations in fertiliser use. Among the technological factors, irrigation is generally recognised as the most important determinant. However, it seems useful to take a distinction between the different sources of irrigation in an attempt to capture the effect of assurance and timeliness of water–supply on fertiliser use. An increase in the proportion of area under HYVs (in other words, fertiliser intensive crops) would also have a positive influence on the level of fertiliser use.

Among the economic factors the ratio of fertiliser price to crop out put price is expected to have a negative association with the rate of fertiliser application. Larger the yearly variation in price of output and yield response, greater are the risks and hence lower would be the levels of fertiliser use. Variations in the later are of course, influenced by weather factors, but it could also be systematically associated with the level of technology itself; for instance, yields of HYVs may be more variable than that of local varieties.

However, a highly skewed distribution of assets (and hence of income) could depress fertiliser use by small cultivators as they are unfavourably placed, both in the input and the output markets. The operation of credit market, in particular, which is of vital significance for rapid spread of fertiliser practices, could discriminate against the small farmers. Depending upon the way in which risks of investment and production are shared between land–owners and the actual tiller, levels of fertiliser could vary considerably under different tenurial arrangements.

Hypothesis relating to technological/physical factors are tested using all India, state and district level data. The correlation and regression analysis based on cross section and time series 'partial' as well as 'complete' testing of the model show that rainfall, in any of its dimensions, is a relatively unimportant variable in explaining observed variations in fertiliser use. Irrigation is uniformally a dominant influence. More striking is the influence of groundwater (tubewell and other well irrigation) in the agriculturally developed states like Punjab and Haryana which lends strength to the hypothesis regarding the significance of irrigation quality (as reflected in the assurance and timeliness of water supply) for effective absorption of plant nutrients. The proportion of area under HYVs (in other words, fertiliser intensive crops) are found to have a positive effect on fertiliser consumption. Fertiliser use and relative price, as expected, are inversely related. The intensity of fertiliser use is also significantly associated with availability of credit, in most of the cases.

However, the rapid spread of fertiliser use on unirrigated areas could not properly be explained by these conventional factors. It is so not only because irrigation is absent or low in these regions but rainfall also is inadequate and irregular in its seasonal outfit. Some possible factors behind the rapid spread of fertiliser use in unirrigated areas could be (i) the need to raise per hectare yield of crops and scarcity of organic manures in overcoming soil fertility constraints to high yields; (ii) development of dryland techniques; (iii) spread of HYVs; (iv) spread of fertiliser awareness among farmers due to both agricultural extension and demonstration effect of fertiliser use on high yielding varieties under irrigated conditions; and (v) increasingly easy access to fetilisers as a result of expansion of the fetiliser distribution system and sustained growth of total fertiliser supply.

These emerging trends necessitate the development of dryland technologies with all their relevant dimension (moisture conservation, fertility management, HYVs and pest control) because the future growth of fertiliser use depends more on these untapped potentials of unirrigated regions. It is also necessary to understand the increasing importance of supply and distribution network. Development of bio–technology, particularly of bio–fertilisers as an engine of sustainable development of agriculture and conjunctive use of manures and chemical fertiliser are other vital ingredients for boosting fertilisers use.

Policies to accelerate the growth in fertiliser consumption should be based on a strategy which aims at both rapidly converting the untapped potential into actual use and continuously raising the economic potential of fertiliser use, through upward shifts in the response function.

Most of the unexploited potential is on more than 70 percent of unirrigated land. This land accounts for more than 80% of the production of jowar, bajara, pulses and oilseeds, about 67% of cotton production, and 30 to 40% of production of rice and wheat. Therefore raising productivity of unirrigated areas is crucial to sustain yield–based growth in agricultural production. Among the constraints on efforts to raise productivity of unirrigated areas, low soil fertility is as severe as any other factor. Unless concerted efforts are made to raise soil fertility through judicious use of fertilisers, farmers would have little incentive to invest in other dryland technologies.

Since agroclimatic environment of one unirrigated area differs sharply from that of another, location specific knowledge on fertiliser response functions, fertiliser practices and other agro economic matters need to be generated through strengthened, decentralised research. Improved coordination between agricultural research and extension systems also is needed so that research information can be effectively spread among farmers. This cannot be overemphasised because additional production due to fertiliser use depends on such things as timing and method of application, balance among nutrients, sowing time, choice of variety, and plant population. What makes these considerations critical in rainfed areas is that without appropriate agro–economic practices, returns on fertiliser use are considerably lower and more uncertain on unirrigated areas. On the other hand, available research clearly indicates that with appropriate practices, returns to fertiliser use on rainfed areas could be considerably enhanced. These efforts should be simultaneously supplemented by adequate and timely flow of credit to farmers and development of efficient fertiliser distribution system.

Neither promotional efforts nor expansion of distribution system in unirrigated regions would sustain growth unless the aggregate fertiliser supply stays ahead of growth in market for fertiliser, in current as well as newly irrigated areas. The experience of Gujarat state clearly demonstrates how sustained pressure from the supply side opens us fertiliser markets in rainfed regions.

Raising rates of application on fertilised land to optimum levels is another way to generate growth in consumption. Effort to tap this unexploited potential should concentrate on educating farmers in efficient fertiliser practices such as the balanced used of nutrients, correct timing and placement of fertilisers, and wherever necessary, use of micro nutrients and soil, amendments. there is ample evidence of existing deficiencies in these practices, even in states and districts with high level of fertiliser use. Adoption of correct practices would increase the efficiency of fertiliser use and thus raise returns on it. Clearly, this is a superior alternative to using price policy to raise rates of fertiliser application.

Diffusion of fertiliser and currently available high yielding varieties on presently irrigated land seems virtually complete. Rates of application are also fairly high at many locations. While there is still scope to raise them further, efforts to do so should be accompanied by improvements in fertiliser and other agro-economic practices and better water management. Without such efforts, the strategy to increase fertiliser use on land which is already fertilised at fairly high rates would aggravate the pressure for lower fertiliser prices and high support prices of crops as is happening today in the agriculturally developed areas such as Punjab, Haryana, Western Uttar Pradesh, parts of other states and so on.

To increase the economic potential of fertiliser use, accelerated development of irrigation potential and its fuller utilisation are 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 economic potential of these policies, however, deficiencies in agricultural extension and credit as well as in fertiliser supply and distribution systems must be removed as has been initiated in recent years. Thus, in discussion policies, it is necessary to distinguish between policies which aim at increasing the potential (through, say, growth in irrigation and research on varieties) and those which aim at rapidly converting it into actual fertiliser use through removing deficiencies in extensions credit, distribution and supply systems. Past experiences indicate that inadequate appropriation of the complementarity of these sets of policies eventually results into long time lags in full exploitation of the potential.

The discussion thus far has focussed on non-price policies for three reasons. First, past growth in fertiliser consumption was determined more by the non-price factors and processes than by changes in prices of either crops or fertilisers. Second, rapid growth in consumption crucially depends on further development of these systems and on continuing technological change which raise the potential for fertiliser use. Third, India does not seem to have much scope to continuously lower prices of fertilisers relative to those of crops, at least in the short run.

Identification of all factors, behind the above processes requires considerably more information than what is readily available. But an interpretation of the available information within the framework of this study suggests that the following would play a major role :

(1) Pressure from the supply side on fertiliser industry and distribution system to push fertiliser consumption.

(2) Improvements in fertiliser distribution system especially with respect to growth in number of sale points, delivery of fertilisers at locations without rail heads, of fertilisers at locations without rail heads, and upward revision of outdated distribution margins.

(3) Substantial increase in institutional credit supplied to farmers.

(4) Improvements in agricultural extension system prompted the spread of T and V system.

(5) Increase in the supply of quality seeds.

To conclude, the task ahead is to further evolve and strengthen the non price policies which affect the pace of growth in fertiliser consumption. In as much as the relative prices of fertilisers and crops are still reasonable, and there is vast scope to improve the efficiently of fertiliser use, shift response function upwards, and remove deficiencies in fertiliser supply and distribution systems, the task is clearly feasible. Its urgency is obvious from the magnitude of acceleration in growth of fertiliser consumption required to raise agricultural production to desired levels and to reduce the mounting budgetary burden of food and fertiliser subsidies.

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